Atlantic States Marine Fisheries Commission

PUBLIC HEARING DOCUMENT FOR
DRAFT AMENDMENT 3 TO THE ATLANTIC HERRING
INTERSATE FISHERY MANAGEMENT PLAN
FOR PUBLIC COMMENT

ASMFC Vision: Sustainably Managing Atlantic Coastal Fisheries

The Atlantic States Marine Fisheries Commission
Seeks Your Input on Atlantic Herring Management

The public is encouraged to submit comments regarding this document during the public comment period. Comments will be accepted until **January 20, 2016 until 5:00 PM**. Regardless of when they were sent, comments received after that time will not be included in the official record. The Atlantic Herring Section will consider public comment on this document as it finalizes Amendment 3.

You may submit public comment in one or more of the following ways:

1. Attend public hearings held in your state or jurisdiction.
2. Refer comments to your state's members on the Atlantic Herring Section or Atlantic Herring Advisory Panel, if applicable.
3. Mail, fax, or email written comments to the following address:

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Fax: (703) 842-0741
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If you have any questions please call Ashton Harp at 703.842.0740.

Commission's Process and Timeline

February 2014	Atlantic Herring Section Initiates Plan Amendment and Tasks PDT to Develop Public Information Document (PID)
May 2014	Atlantic Herring Section Approves Draft PID for Public Comment
Summer 2014	Section Solicits Public Comment on the PID and States Conduct Public Hearings
August 2014	Atlantic Herring Section Tasks Plan Development Team to develop draft Amendment 3
November 2015	Atlantic Herring Section Approves Draft Amendment 3 Public Hearing Document for Public Comment
December 2015-January 2016	**Section Solicits Public Comment on Draft Amendment 3 Public Hearing Document and States Conduct Public Hearings**
February 2016	Atlantic Herring Section Selects Management Options and Recommends Final Approval for FMP; Commission Approves Amendment 3 to the FMP

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PUBLIC HEARING DOCUMENT

The public hearing document is a sub-segment of Draft Amendment 3. The public is encouraged to submit comments regarding this document during the public comment period. In particular, the Atlantic Herring Section (Section) is seeking input on the proposed options outlined in **Section 4: Management Program Implementation**. The Section will review public comment and select options to be included in Amendment 3 at the February 2016 Section meeting. The final version of Amendment 3 will include sections from Amendment 2 and associated addenda, as well as Section-selected management options from this document. As a result, Draft Amendment 3 will contain all current management sections. If approved, it will be the primary management document moving forward.

1.0 INTRODUCTION

The Atlantic States Marine Fisheries Commission (ASMFC) is developing an amendment to its Interstate Fishery Management Plan (FMP) for Atlantic Herring (*Clupea harengus*) under the authority of the Atlantic Coastal Fisheries Cooperative Management Act (ACFMA). The U.S. Atlantic herring fishery is currently managed as a single stock through complementary FMPs by ASMFC and the New England Fishery Management Council (NEFMC). ASMFC has coordinated interstate management of Atlantic herring in state waters (0-3 miles) since 1993—currently managed under Amendment 2 and its associated Addenda I-VI. Management authority in the exclusive economic zone (EEZ, 3-200 miles from shore) lies with the NEFMC and NOAA Fisheries.

1.1 Statement of the Problem

The Commission initiated Draft Amendment 3 to propose management measures which reflect changes in the stock structure, integrate recent data into management decisions, and respond to changes in the fishery.

Spawning Area Efficacy

While Atlantic herring reproduce in the same general season each year, the onset, peak and duration of spawning may vary by several weeks annually because of changing oceanographic conditions (e.g., sea temperature, plankton availability). In an effort to protect the integrity of the spawning stock and allow for the potential of increased recruitment, the ASMFC developed a system of seasonal spawning closures that accounted for this annual variability in spawning time. At the time of development, in the early 1990s, the available data to derive the spawning closure system was limited.

The Technical Committee has since analyzed over a decade of data to improve upon the current spawning closure system. Analysis indicates the current population of herring is quite different today, as the stock has rebuilt since the early 1990s. There is a broader range of age classes with older and larger fish when compared to the stock during overfished conditions. Given a broad range of age classes, fish arrive at the spawning grounds at different times (e.g., larger fish can swim faster and arrive earlier than smaller fish).

There are concerns the timing of spawning closures do not adequately protect spawning fish in the areas they spawn. Samples are collected from the commercial fishery, which is dependent upon interactions with spawning fish. However, it is not always possible to collect sufficient data to inform the start of the spawning closure. In addition, samples from Maine and Massachusetts are analyzed separately, and sometimes contain too few fish to confidently characterize spawning stages.

Fixed Gear Set-Aside Provision
Draft Amendment 3 also includes options to remove the fixed gear set-aside provision. Currently, the set-aside of 295 mt is available to fixed gear fishermen up to November 1, after which the remaining set-aside becomes available to the rest of the Area 1A fishery. November 1 was initially set because, traditionally, herring have migrated out of the Gulf of Maine by that time of the year. Anecdotal evidence suggest herring are in the Gulf of Maine after November 1, therefore fixed gear fishermen requested the set-aside be available to them through the entire calendar year (January 1 through December 31).

Empty Fish Hold Provision
Lastly, Draft Amendment 3 considers a requirement for fish holds to be empty of fish prior to trip departures. Concerns have been raised that unsold herring are dumped at sea if there is not enough market demand for the resource. Additionally, fish from multiple trips can be mixed if the holds are not completely emptied—this has the potential to compromise landings data used to inform harvest control measures and bycatch avoidance programs, particularly for river herring. Furthermore, leaving fish in the vessel's hold prevents portside samplers from observing the entire catch. Options are proposed to encourage less wasteful fishing practices by creating an incentive to catch amounts of herring as demanded by markets. NEFMC included a complementary empty fish hold provision in its Framework Adjustment 4 to the Federal Atlantic Herring FMP.

1.1.2 Benefits of Implementation

This amendment proposes to enhance spawning protections for Atlantic herring in the Gulf of Maine and create an incentive for better managed fishing practices to reduce impacts to species which are ecologically associated with Atlantic herring while minimizing adverse effects on participants in the fishery.

1.1.2.1 Social and Economic Benefits

The goal of the Atlantic herring fishery management plan is to enhance spawning protections for Atlantic herring, incentivize sustainable fishing practices, and improve accountability measures for directed catch and incidental bycatch of river herring. Adequate protections of the reproductive stock of Atlantic herring is intended to result in better recruitment during favorable environmental conditions. Spawning closures therefore help ensure a stable fishery over time and in turn provides a measure of security to individuals and communities dependent on the resource. Presumably, the outcomes will be continued availability and accessibility to the fish, and better quality and prices. The empty fish hold provision proposes to incentivize market-appropriate catches (better business planning) and make conditions aboard the vessel safer. For more information on socioeconomic impacts, see Section 1.5.2.

1.1.2.2 Ecological Benefits

Amendment 3 proposes to update the current spawning closure system based on decades of observed data and spawning behavior identified in the scientific literature. This would allow fisheries biologists in Maine and Massachusetts (where spawning analysis is conducted) to pool samples for monitoring and use the information to forecast the onset of spawning by year. Thereby addressing the inter-annual variability in spawning events as dictated by oceanographic conditions, such as sea temperature. A forecasting system would help alleviate timing concerns associated with the current method. The empty fish hold option creates an incentive to harvest more sustainably to meet market demands, thereby reducing the removal of fish that will not be used (and discarded at sea). It also ensures better accounting of Atlantic herring catch as well as bycatch monitoring of river herring species by preventing double-counting of trips. For more information on biological and ecological impacts, see Section 1.5.1.

1.2 Description of the Resource

Atlantic herring are distributed along the east coast of North America from Canada to North Carolina occupying major estuaries, coastal waters and offshore waters to the continental shelf. There are three recognized stocks in the Atlantic herring complex: 1) Southwest Nova Scotia-Bay of Fundy, 2) coastal waters of the Gulf of Maine, and 3) Georges Bank, including Nantucket Shoals. Due to inter-seasonal mixing, herring are assessed in the U.S. as a single coastal stock at this time.

Evidence for separate stocks are derived from separate larval distribution patterns (Iles and Sinclair, 1982), differences in spawning times and locations (Boyar et al., 1973; Haegele and Schweigert, 1985) and distinct biological characteristics, such as growth rates (Anthony and Waring, 1980), physical characteristics (Anthony, 1981; Safford, 1985) and the incidence of parasites (McGladdery and Burt, 1985). Attempts to further differentiate geographically isolated fall spawning stocks in eastern Canada and the northeast U.S. on the basis of genetic characteristics have been unsuccessful (Kornfield et al., 1982; Kornfield and Bogdanowicz, 1987; Safford and Brooke, 1992).

The most compelling evidence supporting the existence of separate stocks was the collapse of the large Georges Bank-Nantucket Shoals stock in the early 1970s after several years of heavy fishing by foreign fleets. This stock remained in a depressed state for approximately ten years, while the smaller Gulf of Maine stock continued to support a strong coastal fishery.

Major spawning areas are restricted to the northern region (Cape Cod to Newfoundland) of the Atlantic herring distribution. The Gulf of Maine-Georges Bank stock complex contains three major spawning areas: 1) Georges Bank, 2) Nantucket Shoals, 3) coast of Gulf of Maine.

Each major spawning area is composed of smaller, discrete spawning sites—some are as close as 10-15 miles of each other (e.g., Trinity Ledge and Lurcher Shoals off the southwest coast of Nova Scotia). Observations of year-to-year changes in the abundance of adults (and age-structure) on individual spawning sites, in response to fishing pressure, tends to support discrete spawning aggregations (or sub-stocks) of herring (Stephenson, 1998). Thus, appropriate fishing levels may not be the same within the stock complex.

In recent years there has been increasing emphasis on preserving all aspects of biodiversity, including within species diversity. The biological rationale for preserving this diversity is that such variation allows adaptation to changing conditions. The economic rationale is that the decrease or elimination of population richness may lead to the loss of fisheries, such as those occurred during the mid-1970s when the Georges Bank-Nantucket Shoals herring stock collapsed (Overholtz et al., 2004).

1.2.1 Species Life History

1.2.1.1 Herring as a forage fish and predator

Throughout its life stages from egg to adult, Atlantic herring serve as: (1) a source of protein for a variety of marine wildlife in the North Atlantic, (2) competition for other plankton feeders, and (3) as predators of other species eggs. Herring eggs, deposited in unprotected thick mats on the sea floor, incubate for about 10 days. They are subject to predation by a variety of demersal fish species, including winter flounder, cod, haddock, and red hake. Egg predation that results in high mortality can be a driving force on herring population trends (Richardson, et. al, 2011).

Atlantic herring is an important prey species for a large number of piscivorous fish, elasmobranchs (sharks and skates), marine mammals and seabirds in the northeastern U.S. Unlike other pelagic fishes such as Atlantic mackerel, herring are smaller and vulnerable to predation over most, if not all, of their life (Overholtz et al., 2000). Juvenile herring, especially "brit" (age-1 juveniles) are preyed upon heavily due to their abundance and small size. According to the Northeast Fisheries Science Center's Food Habits Database (NEFSC 2012), the top 13 predators of Atlantic herring are:

Spiny dogfish (*Squalus acanthias)*
Winter skate (*Leucoraja ocellata)*
Thorny skate (*Amblyraja radiate)*
Silver hake (*Merluccius bilinearis)*
Atlantic cod (*Gadus morhua)*
Pollock (*Pollachius virens)*
White hake (*Urophycis tenuis)*
Red hake (*Urophycis chuss)*
Summer flounder (*Paralichthys dentatus)*
Bluefish (*Pomatomus saltatrix)*
Striped bass (*Morone saxatilis)*
Sea raven (*Hemitripterus americanus)*
Goosefish (*Lophius americanus)*

Although its primary diet is plankton, herring are also known to prey on cod eggs when zooplankton levels are low. Cod larvae, however, is not significantly affected by herring predation due to limited spatial overlap between the two species.

1.2.1.2 Age and Growth

In U.S. waters, Atlantic herring reach a maximum length of about 39 cm (15.6 inches) and an age of about 15-18 years (Anthony, 1972; NEFMC, 2005). Male and female herring grow at about the same rate and become sexually mature beginning at age-3, with most maturing by age-4 (NEFMC, 2005). Growth rates vary greatly from year-to-year, and to some extent from stock-to-stock, and appear to be influenced by many factors, including temperature, food availability and population size. Juvenile growth is rapid during the first year of life, with a marked slowing at the onset of maturity. Juveniles in coastal Maine waters reach 90-125 mm (3.5–5 inches) by the end of their first year of life. There has been a marked reduction in size and weight-at-age of adult herring in U.S. waters of the northwest Atlantic beginning in the mid-1980s (Overholtz et al., 2004), a trend that appears to be related to increased population size and recovery of the Georges Bank spawning stock.

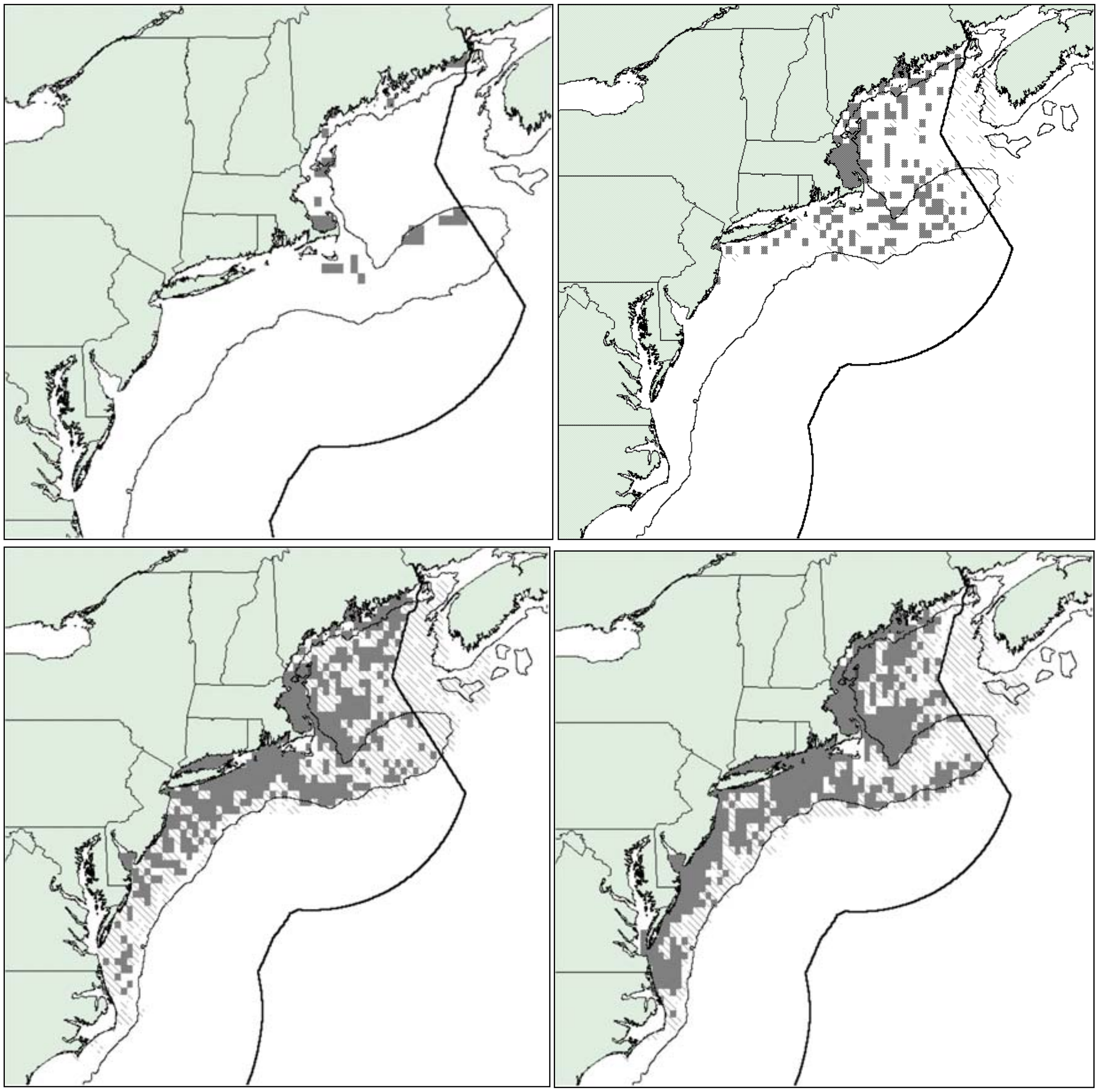
1.2.1.3 Spawning, Reproduction, and Early Life History

While Atlantic herring reproduce in the same general season each year, the onset, peak and duration of spawning may vary by several weeks annually (Winters and Wheeler, 1996) due to changing oceanographic conditions (e.g, temperature, plankton availability, etc.).

Atlantic herring are believed to return to natal spawning grounds throughout their lifetime to spawn (Ridgeway, 1975; Sinderman, 1979; NEFMC, 2005). This behavior is fundamental to the species' ability to maintain discrete spawning aggregations and is the basis for hypotheses concerning stock structure in the northwest Atlantic Ocean. Evidence for this homing behavior is provided by a tagging study in Newfoundland which showed a 73% return rate of adult Atlantic herring to the same spawning grounds where they were tagged (Wheeler and Winters, 1984) and by observations of year-to-year changes in the abundance and age composition of spawning aggregations on discrete banks and shoals off southwest Nova Scotia (Stephenson et al., 1998).

Spawning occurs in specific locations in the Gulf of Maine in depths of 20-50 meters (about 60-300 feet), on coastal banks such as Jeffreys Ledge and Stellwagen Bank located 8-40 km offshore, along the eastern Maine coast between the U.S.-Canada border and at various other locations along the western Gulf of Maine. Herring also spawn on Nantucket Shoals and Georges Bank, but not further south. In Canada, spawning occurs south of Grand Manan Island (in the entrance of the Bay of Fundy) and on various banks and shoals south of Nova Scotia (Figure 2). Spawning occurs in the summer and fall, starting earlier along the eastern Maine coast and southwest Nova Scotia (August-September) than in the southwestern Gulf of Maine (early to mid-October in the Jeffreys Ledge area and as late as November-December on Georges Bank) (Reid et al., 1999; NEFMC, 2005). Herring in the Gulf of Maine region usually reproduce at relatively high temperatures (10-15° C) and at high salinities (NEFMC, 2005). Herring do not spawn in brackish water.

Figure 1. NEFMC EFH designation for Atlantic herring eggs (top left), larvae (top right), juveniles (bottom left), and adult (bottom right).

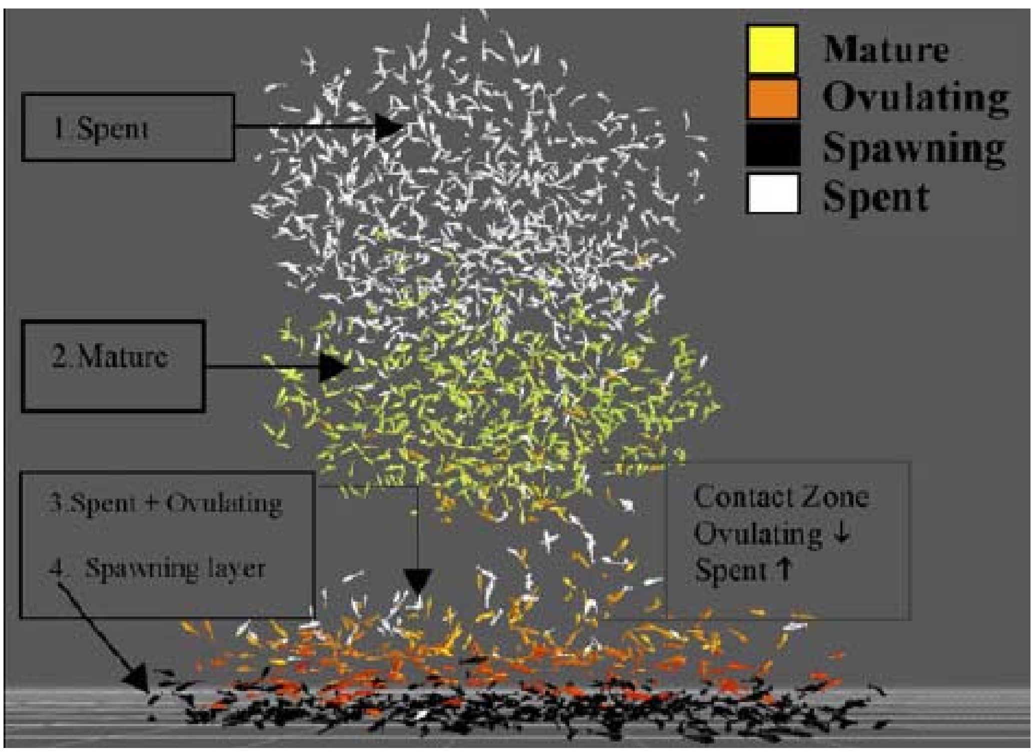


The eastern Maine-Grand Manan spawning ground is an important source of larvae, which are transported to the southwest along the Maine coast (Graham and Townsend, 1985; Townsend et al., 1986). The larvae overwinter in bays, estuaries and nearshore waters and become juveniles in the spring. Those juveniles that survive until the following spring and summer (age-2) are harvested as sardines in the coastal fishery. Larvae that hatch on Jeffreys Ledge, another important coastal spawning ground in the Gulf of Maine, are mostly transported shoreward (Cooper et al., 1975), although some overwinter in nearshore waters on the Maine coast (Lazzari and Stevenson, 1991).

In some cases, the same spawning sites are used repeatedly, sometimes more than once a year (Stevenson, 1989; NEFMC, 2005). Jeffreys Ledge appears to be the most important spawning ground in the Gulf of Maine based on the number of spawning and near-spawning adults found there (Boyar et al., 1973).

Atlantic herring spawn on the bottom in discrete locations by depositing adhesive eggs that stick to any stable bottom substrate, including lobster pots and anchor lines. Eggs are laid in layers and form mats or carpets. In the Gulf of Maine region, egg mats as thick as 4-5 cm have been observed in discrete egg beds that have varied in size from 0.3-1.4 km^2. One very large egg bed surveyed on Georges Bank in 1964 covered an area of about 65 km^2 (Noskov and Zinkevich, 1967). Herring eggs in the Gulf of Maine region are deposited on gravel and rocky substrate, but are also found on sand, shells and shell fragments and occasionally on macroalgae (Figure 3). Spawning sites are located in areas with strong bottom currents (1.5-3 knots), which prevent the accumulation of fine sediment and provides circulation to supply oxygen and remove metabolites (Reid et al., 1999; NEFMC, 2005). Hatching success remains relatively high down to 20-25% dissolved oxygen (Aneer, 1987; NEFMC, 2005).

Figure 3. Vertical stratification by maturity stage within a school of spawning Atlantic herring (Vabo and Skaret, 2008).



Atlantic herring are synchronous spawners, producing eggs once a year after they reach maturity. Depending on their size and age, female herring can produce from 55,000 to 210,000 eggs (Kelly and Stevenson, 1983). Once they are laid on the bottom, herring eggs are preyed upon by a number of fish species, including cod, haddock, red hake, sand lance, winter flounder, smelt, tomcod, cunner, pollock, sculpins, skates, mackerel and even herring themselves (Munroe, 2002;

NEFMC, 2005). Egg predation and adverse environmental conditions often result in high egg mortalities. Egg incubation periods are temperature dependent and range from 10-15 days in the Gulf of Maine (Munroe, 2002; NEFMC, 2005). Hatching success is also temperature dependent; in experimental studies, all eggs held at 15° C hatched and none hatched at 0-5° C or at 20° C.

Larvae are about 4-10 mm (0.25 in) in length at hatching, which occurs 10-15 days after the eggs are deposited on the bottom (Fahay, 1983). The pelagic larval phase is relatively long in Atlantic herring, lasting 4-8 months in the Gulf of Maine, depending on the timing of spawning (Reid et al., 1999; NEFMC, 2005). Larvae are transported long distances from spawning grounds where they over-winter in coastal bays and estuaries. In the Gulf of Maine, the prevailing surface currents flow westward, transporting larvae that hatch in eastern Maine to the Sheepscot estuary in mid-coast Maine, a straight-line distance of about 150 km (Graham, 1982; Townsend, 1992). Boyar et al. (1973) reported that most of the recently hatched larvae from the southern end of Jeffreys Ledge are transported shoreward. Herring larvae from Nantucket Shoals and Georges Bank are widely dispersed and tend to drift to the southwest (Sindermann, 1979; Lough et al., 1980; Grimm, 1983; NEFMC, 2005). Metamorphosis occurs in the spring at a length of about 40 mm (1.5 in). Schooling behavior begins in the late larval and early juvenile, or "brit," stages. Young-of-the-year herring undergo a general offshore movement in the summer and fall and they are believed to spend the winter in deep coastal waters.

The persistence of discrete aggregations of larvae for several months after hatching over tidally mixed continental shelf spawning grounds in the Gulf of Maine and elsewhere, despite the presence of fairly strong longshore currents, has provided the basis for a larval "retention hypothesis" (Iles and Sinclair, 1982). This hypothesis states that Atlantic herring stock structure in an area like the Gulf of Maine is determined by larval distribution and retention patterns and that the maximum stock size in that area is determined by the number, location and extent of geographically stable retention areas. Such retention areas have been described off southwest Nova Scotia, around Grand Manan Island and on Georges Bank (Iles and Sinclair, 1982). In addition, they have been described in eastern Maine waters adjacent to Grand Manan (Chenoweth et al., 1989).

Mortality of Atlantic herring in the larval stage is very high since the larvae remain vulnerable to very low temperatures and a limited food supply for a prolonged period during winter, especially in shallow nearshore and estuarine waters (Townsend and Graham, 1981; Graham et al., 1991). Campbell and Graham (1991) developed an ecological model in order to examine which factors affected larval survival to the early juvenile stage. Some of the conclusions of that study were:

- Larval herring recruitment in Maine coastal waters is the result of a complex interaction of many processes, no one of which is truly dominant;
- Two year-old recruitment to the Maine herring fishery is established in the larval stage in some years and not until the brit stage in others;
- Larval food supply in autumn and winter, along with the quantity and distribution of spawning, are primary factors controlling herring recruitment to the brit stage for those years when the larval stage is critical;

- When larval survival is above a threshold, density-dependent predation on brit can reduce year-class size (the assumption being that the brit become the food of choice for opportunistic pelagic and demersal predators when brit exceed an abundance threshold);
- Temperature and longshore transport are secondary factors determining survival that may be most important through their interaction with primary factors;
- In most years, more larvae survive the winter in the coastal areas than in the estuaries and embayments; and
- The distribution of larvae along the Maine coast in springtime is largely a function of the variable movement of larvae.

1.2.1.4 Migration

Adult herring undertake extensive seasonal migrations between summer spawning grounds on Georges Bank and in the Gulf of Maine and overwintering areas in southern New England and the mid-Atlantic region. Stock mixing occurs during the winter and spring as fish migrate south. Thermal oceanic fronts between colder, less saline continental shelf water and warmer, more saline continental slope water provide an abundance of plankton and other food sources and greatly influence the migratory behavior of this species (Sindermann, 1979; Kelly and Moring, 1986; NEFMC, 2005).

There are distinct migratory patterns for each spawning stock off the northeast coast of the U.S.:

- The Nova Scotia stock spends the summer and fall months in southwest Nova Scotia and overwinters in Chedabucto Bay in northeastern Nova Scotia, but also mixes to some extent with the two southern stocks.
- The Georges Bank/Nantucket Shoals stock overwinters south of Cape Cod, can be found feeding in the Gulf of Maine in the spring and early summer and spawn southeast of Nantucket or on Georges Bank in the fall (Sindermann, 1979; Tupper et al., 1998; Munro, 2002; NEFMC, 2005;). After spawning, adults from Georges Bank move south again to overwinter with the oldest and largest fish migrating as far south as Chesapeake Bay.
- The migratory patterns of the coastal Gulf of Maine herring stock are not as well documented. It is believed that they may migrate southwest along the coast after spawning to overwinter south of Cape Cod, in Massachusetts Bay and other coastal areas of southern New England (Tupper et al., 1998; Reid et al., 1999; NEFMC, 2005). The waters off Cape Cod seem to constitute a mixing area for these stocks, where different groups pass at various times of the year (Sindermann, 1979; NEFMC, 2005).

Migration patterns of individual herring stocks are usually persistent year to year (Creaser and Libby, 1988; Reid et al., 1999; NEFMC, 2005). The spatial and temporal isolation of these different stocks occurs chiefly during spawning, with intermixing occurring during the non-spawning phases of migration (Sinclair and Iles, 1985; Reid et al., 1999; Munro, 2002; NEFMC, 2005). Adults from the two U.S. stocks mix during their winter migration to southern New England and mid-Atlantic waters and separate out onto their respective spawning grounds following a return northward migration in the spring. Adults that spawn off southwest Nova Scotia are not believed to mix to any significant degree with herring that spawn on Georges Bank or in the Gulf of Maine (Stephenson et al., 1998; NEFMC, 2005).

Juvenile herring in all stocks tend to remain in coastal areas throughout the year (Stewart and Arnold, 1994; NEFMC, 2005). Juveniles overwinter closer to the coast than adult herring, moving into the deeper waters of bays or offshore in the winter where they stay close to the bottom (Reid et al., 1999; Overholtz, 2004; NEFMC, 2005). Smaller fish have greater temperature tolerances and juvenile Atlantic herring have been found to produce higher levels of antifreeze proteins than adults, adaptations that may allow them to withstand the colder coastal waters in the winter (NEFMC, 2005; Munro, 2002). Tagging studies have also indicated that juveniles migrate little during the summer (Waring, 1981; Stobo, 1983; Overholtz et al., 2004; NEFMC, 2005). Juveniles from several populations may mix in a given area (Stewart and Arnold, 1994) and aggregations of juvenile herring along the coast of Maine and New Brunswick are likely derived from a variety of spawning grounds (Overholtz et al., 2004; NEFMC, 2005).

1.2.1.5 Schooling

Despite the vast amount of literature available on the herring resource, there still exists a significant lack of knowledge about herring behavior and the impacts of fishing and various activities on fish behavior. There are several important characteristics about herring to acknowledge:

- Herring are obligate schoolers. They prefer to swim in large schools and cease to act as individual fish, but rather act as one unit in a large school.
- The sensory systems of herring are very well developed. The ability of herring to hear, see, and sense movement (through the lateral line) allows them to sense other fish in the area, school in the dark, and react to changes in water pressure. These factors also influence the way herring react to fishing gear.
- Herring have sensitivity to a wide frequency range and are most sensitive to sounds in the frequency region where fishing vessels (and research vessels) have the maximum sound energy output. Herring are very sensitive to noise and have been shown to make directed responses to approaching vessels. Results of some studies indicate that the fish can hear trawlers at distances up to 3 kilometers.
- The visual senses of herring allow the fish to see at very low light levels (10^{-5} lux). Herding responses are mainly visual, and visually elicited avoidance reactions have been observed.
- Herring exhibit distinct migratory patterns, both seasonally (large-scale) and diurnally (night/day, small-scale). Migration is also affected by food availability and other environmental conditions (temperature, salinity, predators).
- Herring have very good buoyancy control. They can gulp and release air to fill and void their swim bladders as needed. The fish can sink very quickly if necessary.

Pelagic fishes school for hydrodynamic reasons, for reproduction, migration and feeding and to aid in surviving predatory attack (Freon and Misund, 1999; NEFMC, 2005). Schooling is a natural state for pelagic fishes and given a stimulus, fish like herring will react and then return to this state. When confronted by danger such as a predator or mid-water trawl, pelagic fish will quickly decrease their interfish distance (packing density) and try to avoid the stimulus (Freon et al., 1992; NEFMC, 2005). This will result in contortion, compression and stretching of the school and may result in short-term distortion or dispersion of the fish (Freon et al., 1993;

NEFMC, 2005). This avoidance behavior will cease, however, as soon as the fish are out the near field (proximity) of the trawl or predator (Freon and Misund, 1999; NEFMC, 2005).

The normal reaction of herring to a trawl or purse seine is to increase their swimming speed and dive downwards, thereby trying to avoid the gear. In a study of Finnish pair trawling, visual and acoustic observations suggest that herring displayed an avoidance reaction in 34% of 493 midwater trawl hauls where fish were near the trawl mouth (Suuronen et al., 1997; NEFMC, 2005). Fish were observed to swim rapidly downward when they were within 5 m of the trawl and then return to their previous depth as soon as the trawl had passed. Herring react to midwater trawl and purse seines in much the same manner that they react to predators by trying to avoid and then regroup.

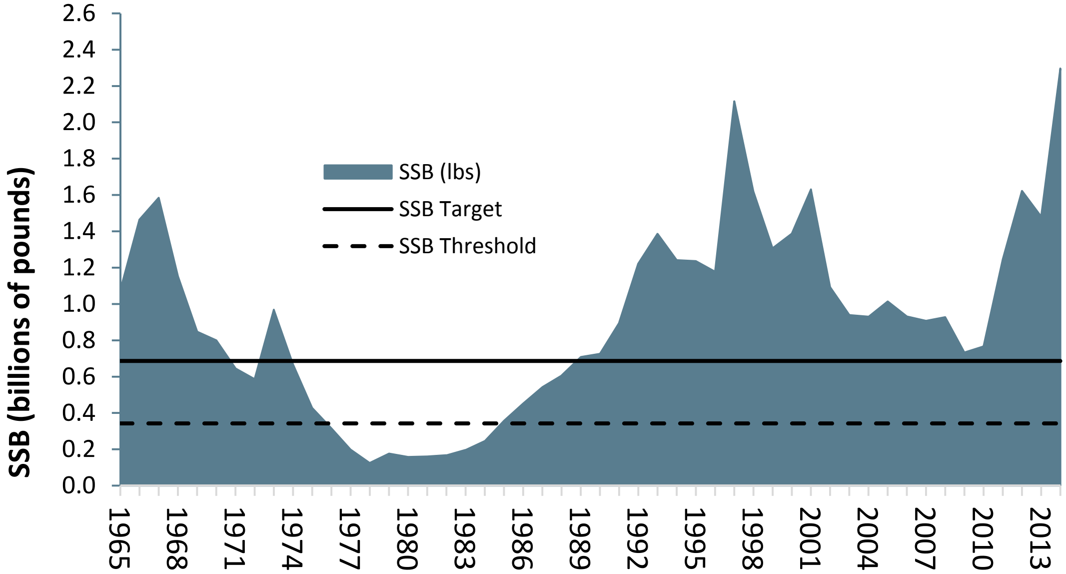
A study of the spatial dynamics of the Gulf of Maine/Georges Bank herring complex showed that herring maintained their school structure and interschool integrity in spite of very large reduction in overall biomass during the 1970s (Overholtz, 2004; NEFMC, 2005). Landings records from purse seine and midwater trawl vessels indicate that there were herring present in the Jeffreys Ledge region during all the months from April to October of 2001. Observations during herring acoustic cruises conducted by NMFS during 1997-2000 indicate nothing more than short-term disturbance of herring during midwater trawling and acoustic surveying operations. Fishing operations by at least a dozen large midwater trawlers conducted over a several month period during 2001 on Georges Bank caused no apparent changes in the distribution of pre-spawning herring as evidenced by hydroacoustic surveys conducted during September and October 2001 (NEFMC, 2005). There appears to be no scientific evidence either local or worldwide that midwater trawling or purse seining causes any long-term dispersal of herring.

1.2.2 Stock Assessment Summary

1.2.2.1. Abundance and Present Condition

The 2015 operational (update) stock assessment, using the Age Structured Assessment Program (ASAP) framework, resolved the retrospective pattern in the 2012 stock assessment for Atlantic herring (54^{th} SAW) and included data through 2014; the maximum sustainable yield (MSY) based reference points were subsequently updated; the overfishing threshold is F_{MSY} = 0.24 and the overfished threshold is ½SSB_{MSY} = 342 million lbs (155,573 mt). The results of the assessment found the stock is not experiencing overfishing and is not overfished (Deroba, 2015).

Figure 4. Atlantic Herring Spawning Stock Biomass (SSB) (Deroba, 2015)



1.2.2.2. Spawning Stock and Total Biomass

The point estimate of SSB in 1965 equaled 1 billion lbs (487,791 mt). SSB generally declined from 1965 to a time series low of 124 million lbs (56,509 mt) in 1978. SSB generally increased from 1978 through the mid-1990s. SSB generally declined during 1997-2010. The retrospective adjusted value for the 2014 SSB is 1.3 billion lbs (623,000 mt), a 40% decrease in SSB from the 2012 assessment.

1.2.2.3. Recruitment

Mean recruitment from 1965 to 2014 equaled 12.7 billion fish. With the exception of 2009, Age-1 recruitment since 2006 has been below the 1996-2011 average of 15.8 billion fish. The 2009 age-1 recruitment, however, was the largest in the time series at 62.4 billion fish. The 2012 age-1 recruitment was estimated to be the second largest in the time series and equaled 42.4 billion fish.

1.2.2.4. Fishing Mortality

Atlantic herring's fishing mortality (F) peaked in 1971 at a rate of 0.79. Since then, the F rate remained high and began declining in the 1980s, following the trend of decreasing stock biomass, until it dropped to a historic low of 0.13 in 1994. Since then, F has remained below the F_{MSY} threshold of 0.24, with a slight increasing trend until overfishing occurred in 2009 (F_{2009} = 0.32). The F in 2010 and 2011 was relatively low because of the presence of a strong cohort that increased the stock biomass. The retrospective adjusted values for the 2014 F is 0.16, a 60% increase in F from the 2011 terminal year estimates (NEFSC, 2012).

1.3 Description of the Fishery

1.3.1 Commercial Fishery

The Atlantic herring resource occurs in waters off Canada and the United States, and fisheries exist in both countries. Based on the total catch (including discards) by the U.S. fixed and mobile gear, and Canada's New Brunswick weir fisheries, a majority of the fish are caught by the U.S. commercial fleet (time series average of 87%).

In the U.S., the Atlantic herring fishery is predominantly commercial; recreational catch accounts for less than 1% of the overall catch. Over the time series from 1950 to 2014 annual commercial catch by the U.S. Atlantic herring fleet was generally flat with a slightly declining trend between 1950 through 1983, when it reached a historic low of 98.3 million lbs (44,613 mt). Annual catch averaged 244.4 million lbs (110,854 mt) from 1993, when FMP was implemented, through 2014. In 2014, catch totaled 210.1 million lbs (95,317 mt). Total catches from 2010-2014 ranged from 175.1 million lbs (79,413 mt) in 2010 to 224.0 million lbs (101,622 mt) in 2013 and averaged 198.5 million lbs (90,040 mt) (Figure 5). From 2004-2015, the sub-Annual Catch Limit (ACL) for Area 1A ranged from 58.5 million lbs (26,546 mt) to 132.3 million lbs (60,000 mt) (Table 1).

Figure 5. Atlantic Herring Total Catch (Source: ACCSP)

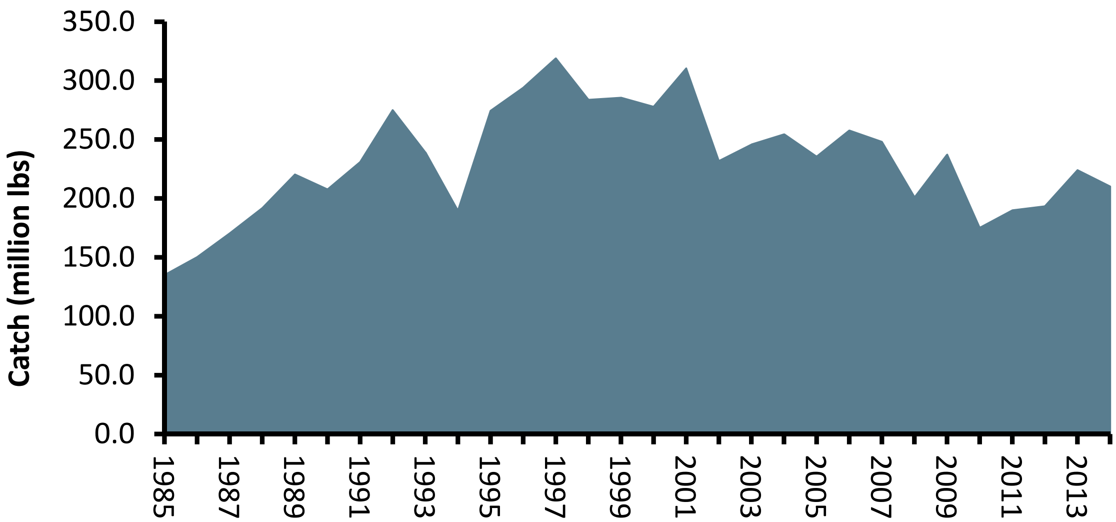


Table 1. Atlantic herring catch by year for Area 1A, 2004-2015 (Source: NMFS)

Year	Sub-ACL (lbs)**	Sub-ACL (MT)	Catch (lbs)**	Catch (MT)	% Utilized	Sub-ACL Closure
2004	132,276,000	60,000	132,485,437	60,095	100%	Nov-9
2005	132,276,000	60,000	134,705,469	61,102	102%	Dec-2
2006	132,276,000	60,000	132,251,749	59,989	100%	Oct-21
2007	110,230,000	50,000	110,212,363	49,992	100%	Oct-25
2008	96,230,790	43,650	93,159,782	42,257	97%	Nov-14
2009	96,230,790	43,650	97,196,405	44,088	101%	Nov-26
2010	58,523,312	26,546	62,663,550	28,424	107%	Nov-17
2011	64,486,755	29,251	67,628,310	30,676	105%	Oct-27
2012	60,996,873	27,668	53,576,189	24,302	88%	Nov-5
2013	65,641,965	29,775	65,741,172	29,820	100%	Oct-15
2014*	72,820,143	33,031	73,695,369	33,428	101%	Oct-26
2015*	66,777,334	30,290	64,934,288	29,454	97%	Nov-2

**Totals are preliminary*
*** 1 mt = 2,204.6 lb*

Over the past decade, the commercial Atlantic herring industry has been consistent in terms of landing states and primary gears. Based on the 10-year average from 2004-2013, a combined 88% of total sea herring catch was landed in Maine and Massachusetts. From 2011-2013, Maine harvested about 50% of the total landings each year. Atlantic herring is primarily caught by trawl gears, which accounted for nearly 70% of total landings in the past decade, followed by purse seine, accounting for 20% of landings. Table 2 shows the landings from primary gears (trawl and purse seine) by state from 2009-2013.

Table 2. Atlantic herring landings by primary gears and state. Due to data confidentiality, landings by other gears are not provided.

Year	State	Trawl (lbs)*	Trawl (MT)	Purse Seine (lbs)*	Purse Seine (MT)
2009	MA	120,247,702	54,544	2,676,384	1,214
2009	ME	19,045,539	8,639	42,193,839	19,139
2009	Other NE	2,281,761	1,035	813,497	369
2009	Mid-Atl	22,804,382	10,344	0	0
2010	MA	64,330,228	29,180	2,328,058	1,056
2010	ME	33,939,817	15,395	21,336,119	9,678
2010	Other NE	2,738,113	1,242	92,593	42
2010	Mid-Atl	12,134,118	5,504	0	0
2011	MA	54,936,427	24,919	1,084,663	492
2011	ME	51,887,466	23,536	40,813,760	18,513
2011	Other NE	1,016,321	461	496,035	225
2011	Mid-Atl	7,383,205	3,349	0	0
2012	MA	66,589,943	30,205	2,407,423	1,092
2012	ME	53,887,038	24,443	38,296,107	17,371
2012	Other NE	2,389,786	1,084	0	0
2012	Mid-Atl	12,621,335	5,725	0	0
2013	MA	65,425,914	29,677	1,252,213	568
2013	ME	49,036,918	22,243	49,047,941	22,248
2013	Other NE	1,560,857	708	0	0
2013	Mid-Atl	24,512,947	11,119	0	0

** 1 mt = 2204.6 lb*

The U.S. Atlantic herring fishery is managed as four management areas: inshore Gulf of Maine (Area 1A), offshore Gulf of Maine (Area 1B), Southern New England (Area 2), and Georges Bank (Area 3). In addition to the complementary measures in the federal plan, the Interstate Atlantic Herring FMP implements specific measures for Area 1A's fishery, which supplies bait for lobster, tuna, blue crab, and striped bass fisheries. Management measures include "days out" effort control, spawning area closures, and seasonal quota allocation. Using the annual specifications process, fisheries managers adapt these measures each year to provide herring between June and December, when demand for lobster bait is highest and fishermen can sell their herring catch for premium value.

1.3.2 Recreational Fishery

The recreational Atlantic herring fishery accounts for less than 1% of total catch in the U.S.A small recreational fishery for Atlantic herring exists, providing late fall to early spring fishing opportunities for both shore and boat anglers. Most Atlantic herring catches are reported during March-April and November-December, with some catches reported from September-October.

The Marine Recreational Information Program (MRIP) does not sample during January-February in the north or mid-Atlantic sub-regions and because herring may be taken during this period, total recreational catch may be underestimated. The herring caught by hook and line anglers are taken as a secondary species in a mixed fishery with Atlantic mackerel (*Scomber scombrus*).

1.3.3 Subsistence Fishing

There is no known subsistence fishery for Atlantic herring along the East Coast of the U.S.

1.3.4 Non-Consumptive Factors

Non-consumptive factors for herring are indirect. It is actually herring's role as forage for marine mammals and seabirds that is important. For example, the whale watch industry has expanded in the past few years and seabirds attract additional "non-consumptive" attention.

1.3.5 Interactions with Other Fisheries, Species, or Users

1.3.5.1 Bait

Atlantic herring serves as an important bait for many commercial and recreational fisheries, including lobster, tuna, and striped bass. Increased fishing effort in the lobster fishery, along with a decrease in other sources of lobster bait, has been observed over the past three decades and lobster landings have continued to markedly increase throughout the 1980s and early 1990s, both of which place increased pressure on the herring resource.

While bait herring for the tuna fishery can be purchased from dealers or other boats, some tuna vessels are known to catch herring for use as live bait in this fishery. The use of small pelagic gillnets to catch herring for this purpose is authorized under the Northeast Multispecies Plan. There are no statistics on the extent of this practice or the amount of herring that is taken for this purpose. Some industry participants have estimated that 50-90% of the vessels fishing for tuna in New England waters may be catching herring as bait.

1.3.5.2 Forage

Atlantic herring are an important forage species for many marine finfish, marine mammals and birds in the Northwest Atlantic ecosystem. While available information to quantify the importance of herring as a forage species is not available at this time, there is a substantial amount of literature (Volume II, *The Role of Atlantic Herring, Clupea harengus, in the Northwest Atlantic Ecosystem* by the NEFMC) that describes the role that herring plays in the ecosystem and estimates the amount of herring consumed by various fish, marine mammal and seabird species. The first step to account for the importance of herring as a forage species in the herring management program is to compile and consider available information on the subject; the second step is to identify where information is lacking and prioritize research needs to fill the data gaps.

1.4 Habitat Considerations

The New England Fisheries Management Council has identified the Essential Fish Habitat (EFH) for herring and other species it manages, and is proposing updated designations through its Draft Omnibus Habitat Amendment 2. The applicable provisions of this document that relate to Atlantic herring are incorporated into this FMP by reference. This includes the description and identification of herring EFH, the threats to EFH from fishing and non-fishing activities, and the conservation and enhancement measures to protect EFH for Atlantic herring.

1.4.1 Habitat Important to the Stocks

The Northeast U.S. Shelf Ecosystem has been described as including the area from the Gulf of Maine south to Cape Hatteras, extending from the coast seaward to the edge of the continental shelf, including the slope sea offshore to the Gulf Stream (Sherman et al., 1996; NEFMC, 2005). The continental slope includes the area east of the shelf, out to a depth of 2000 m. Four distinct sub-regions comprise the NOAA Fisheries Northeast Region: the Gulf of Maine, Georges Bank, the Mid-Atlantic Bight and the continental slope. Occasionally another sub-region, southern New England, is described; however, discussions of any distinctive features of this area have been incorporated into the sections describing Georges Bank and the Mid-Atlantic Bight (NEFMC, 2005).

The Gulf of Maine is an enclosed coastal sea, characterized by relatively cold waters and deep basins, with a patchwork of various sediment types. Georges Bank is a relatively shallow coastal plateau that slopes gently from north to south and has steep submarine canyons on its eastern and southeastern edge. It is characterized by highly productive, well-mixed waters and strong currents. The Mid-Atlantic Bight is comprised of the sandy, relatively flat, gently sloping continental shelf from southern New England to Cape Hatteras, North Carolina. The continental slope begins at the continental shelf break and continues eastward with increasing depth until it becomes the continental rise. Atlantic herring do not commonly occur over the continental slope (NEFMC, 2005). A more detailed description of habitat important to herring can be found in the Source Document for Amendment 1.

1.4.1.2 Identification and Distribution of Habitat and Habitat Areas of Particular Concern (Essential Fish Habitat)

The Atlantic States Marine Fisheries Commission does not have the authority to designate Essential Fish Habitat (EFH) as required by the Magnuson Stevens Fishery Conservation and Management Act (MSFCMA). The New England Fishery Management Council has identified EFH for a range of species, including Atlantic herring, in order to meet the requirements of MSFCMA as amended by the Sustainable Fisheries Act. The ISFMP Policy Board approved a recommendation in June 1998 to include Council EFH designation for FMPs or Amendments that are developed jointly or in association with a Council. Essential Fish Habitat (EFH) for Atlantic herring is described in NEFMC (1998a) as those areas of the coastal and offshore water (out to the offshore boundary of the EEZ) that are designated in Figure 2.

Eggs: Bottom habitats with a substrate of gravel, sand, cobble and shell fragments, but also on aquatic macrophytes, in the Gulf of Maine and Georges Bank as depicted in Figure 2. Eggs adhere to the bottom, forming extensive egg beds that may be many layers deep. Generally, the following conditions exist where Atlantic herring eggs are found: water temperature below 15^{o} C, depths from 20-80 meters and salinity ranging from 32-33$^{o}/_{oo}$. Herring eggs are most often found in areas of well-mixed water, with tidal currents between 1.5 and 3.0 knots. Herring eggs are most often observed during the months from July through November.

Larvae: Pelagic waters in the Gulf of Maine, Georges Bank and southern New England that comprise 90% of the observed range of Atlantic herring larvae as depicted in Figure 2. Generally, the following conditions exist where Atlantic herring larvae are found: sea surface temperatures below 16^{o} C, water depths from 50-90 meters, and salinities around 32$^{o}/_{oo}$. Herring larvae are observed between August and April, with peaks from September through November.

Juveniles: Pelagic waters and bottom habitats in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to Cape Hatteras as depicted in Figure 5. Generally, the following conditions exist where Atlantic herring juveniles are found: water temperatures below 10^{o} C, water depths from 15-135 meters and salinity ranging from 26-32$^{o}/_{oo}$.

Adults: Pelagic waters and bottom habitats in the Gulf of Maine, Georges Bank, southern New England and the mid-Atlantic south to Cape Hatteras as depicted in Figure 2. Generally, the following conditions exist where Atlantic herring juveniles are found: water temperatures below 10^{o} C, water depths from 20-130 meters and salinities above 28$^{o}/_{oo}$.

Spawning Adults: Bottom habitats with a substrate of gravel, sand, cobble and shell fragments, but also on aquatic macrophytes. Spawning areas include the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to Delaware Bay as depicted in Figure 2. Generally, the following conditions exist where spawning Atlantic herring adults are found: water temperatures below 15^{o} C, depths from 20-80 meters and salinity ranging from 32-33$^{o}/_{oo}$. Herring eggs are spawned in areas of well-mixed water, with tidal currents between 1.5 and 3.0 knots. Herring are most often observed spawning during the months from July through November.

1.4.1.3 Present Condition of Habitats and Habitat Areas of Particular Concern

A detailed description of habitat quality and habitat areas of particular concern can be found in the Source Document for Amendment 1.

1.4.1.4. Ecosystem Considerations

Forage: Atlantic herring's role as a forage species, in association with other forage species of concern (i.e. river herring and shad species) in the northwest Atlantic ecosystem, has recently become a concern to many stakeholders.

Other Northeast Region Species: The area where the Atlantic herring fishery takes place has been identified as EFH for species managed under the following Federal Fishery Management Plans: Northeast Multispecies; Atlantic Sea Scallop; Atlantic Monkfish; Summer Flounder, Scup and Black Seabass; Squid, Atlantic Mackerel and Butterfish; Atlantic Surf Clam and Ocean

Quahog; Atlantic Bluefish; Atlantic Billfish; and Atlantic Tuna, Swordfish and Shark. All EFH descriptions and maps can be viewed on the NMFS Northeast Regional Office website (NEFMC, 2005).

Anthropogenic Impacts on Atlantic Herring and their Habitat: Habitat alteration and disturbance can occur through natural processes and human activities. Natural disturbances to habitat can result from summer droughts, winter freezes, heavy precipitation, and strong winds, waves, currents and tides associated with major storms (i.e. hurricanes and northeasters) and global climatic events such as El Nino. Biotic factors, including bioturbation and predation, may also disturb habitat (Auster and Langton MS, 1998 and in press). These natural events may have detrimental effects on habitat, including disrupting and altering biological, chemical and physical processes, and may impact fish and invertebrate populations. Potential adverse effects to habitat from fishing and non-fishing activities may include direct (e.g. contamination or physical disruption), indirect (e.g. loss of prey or reduction of species diversity), site-specific or habitat wide impacts, including individual, cumulative or synergistic consequences of the actions. Non-fishing threats to habitat may include the intentional or accidental discharge of contaminants (i.e. heavy metals, oil, nutrients, pesticides, etc.) from non-point and point sources, and direct habitat degradation from human activities (i.e. channel dredging, marina/dock construction, etc.).

Riverine, inshore and offshore habitats are subject to numerous chemical, biological and physical threats. Riparian habitat is being degraded and altered by many human activities. Inshore regions are variable environments that are threatened by many sources of degradation. Deep-sea habitats are stable and contain less resilient communities than habitats found within inshore waters (Radosh et al., 1978) that are altered by unnatural stress. Pelagic environments in coastal and offshore areas are potentially essential habitat for many marine organisms throughout substantial stages of ontogenetic development. These areas can also be disrupted. Chemical, biological, and physical threats can potentially limit survivorship, growth and reproductive capacity of fish and shellfish species and populations.

The major threats to marine and aquatic habitats are a result of increasing human population, which is contributing to an increase of human generated pollutant loadings. These pollutants are being discharged directly into riverine and inshore habitats by way of point and non-point sources. The development of coastal regions to accommodate more people leads to an increase in unwanted runoff, such as toxicants, nutrients and pesticides. Humans attempt to control and alter natural processes of aquatic and marine environments for an array of reasons, including industrial uses, coastal development, port and harbor development, erosion control, water diversion, agriculture, and silviculture. Environmental conditions of fish and shellfish habitat are altered by human activities (see Wilk and Barr, 1994 for review) and threatened by non-point and point sources of pollution.

Environmental Contaminants: The effects of copper on eggs and larvae of Atlantic herring were reported by Blaxter (1977). Mortality of newly hatched larvae was high at copper concentrations of 1,000 micrograms per liter (mcrg/l). Eggs incubated in 30 mcrg/l had relatively high mortality and premature hatching; 70% of the larvae hatched were deformed. Larvae were more resistant to copper than eggs; survival of larvae was impaired only at concentrations $\geq$ 1,000 mcrg/l. The vertical migration of larvae was impaired at copper concentrations of $\geq$ 300 mcrg/l.

Tests on the effects of sulfuric pollutants such as iron sulfate and hydrogen sulfate, showed that a dilution of 1:8,000 significantly reduced egg fertilization and hatching success, decreased egg diameter, retarded embryonic growth, shortened the incubation period, and increased the rate of structural abnormalities in newly hatched larvae (Kinne and Rosenthal 1967). Larval prey-catching ability was impaired in 1:32,000 and 1:24,000 dilutions; locomotory performance was seriously affected at a 1:16,000 dilution. Permanent deformities and death occurred within a few days at a 1:8,000 dilution.

Studies of dinitrophenol effects on herring embryonic development indicated that low concentrations (0.01 to 0.05 micromole/l) increased embryo activity and altered heart rates significantly (Rosenthal and Stelzer 1970). Various embryonic malformations were also observed. A dinitrophenol concentration of 0.1 micromole/l caused up to a 400% increase in the normal embryonic respiration rate (Stelzer et al. 1971).

Blaxter and Hunter (1982) reported that eggs and larvae held under films of crude oil in concentrations of 1 to 20 ml/l, or in emulsions, experienced toxicities that varied with the origin of the oil. For oil from a particular source, the fractions with the lower boiling points seemed more harmful (Kuhnhold 1969; cited in Kelly and Moring, 1986). In tests on oil dispersants, larvae did not avoid horizontal gradients, but swam into surface dispersant layers and were narcotized (Wilson, 1974). The survival of herring eggs and larvae was highest in water with low biological oxygen demand and low nitrate levels (Baxter and Steele, 1973).

1.4.2 Description of Programs to Protect, Restore, Preserve and Enhance Atlantic Herring Habitat

Federal marine pollution research and monitoring activities are coordinated by NOAA’s National Ocean Pollution Program Office. Short and long-term anthropogenic effects on the marine environment are also assessed. NOAA’s Ocean Pollution Program Office coordinates interagency responsibilities while the Ocean Assessments Division (OAD) of the Office of Oceanography and Marine Assessments, National Ocean Service, manages assessments.

1.5 Impacts of the Fishery Management Program

1.5.1 Biological and Environmental Impacts

The management program proposed in this amendment aims to maintain effective measures to protect Atlantic herring by updating the science known about inshore spawning events and limiting wasteful fishing practices. The inshore spawning area monitoring program is updated with a review of recent scientific literature and analysis of the spawning maturity rates utilizing data from the past decade. The proposed spawning program, based on the gonad-to-body weight index (also known as gonadosomatic index, GSI), more appropriately addresses the demographics of the current herring resource, which contains older age classes that were depleted during the collapse of the fishery in the 1970s and 1980s. As such, broader age classes result in a spawning season closer to six weeks in length, rather than four weeks, which is the allotted closure period under the current spawning protection program. An extension from four weeks to six weeks in duration is expected to minimize spawning event disruptions to the resource and reduce the probability of a spawning re-closure which is disruptive to the fishery. Adaptations to the spawning protection program are expected to enhance protections for herring during actual spawning events and reduce dependence on fixed closure dates. The amendment proposes to merge the Western Maine (WM) and Massachusetts-New Hampshire (MA-NH) spawning areas because there have been no significant differences in the starting dates of spawning events between these two areas.

As proposed, the fixed gear set-aside provision is limited to 500 metric tons each year (specified as 295 metric tons for the 2013-2015 fishing years). There is no known biological evidence of Atlantic herring in the Gulf of Maine after November 1. At this time, a removal of the set-aside expiration date of November 1 is not expected to have biological or environmental impacts.

The proposed empty fish hold provision aims to reduce waste from fishing. If effective at incentivizing market-appropriate fishing behaviors, the amount of herring caught in surplus of market demand should be reduced. This provision can benefit bycatch species, such as river herring, through better catch data and monitoring by preventing mixing of catch from multiple trips.

1.5.2 Social Impacts

1.5.2.1 Recreational Fishery

While only 1% of Atlantic herring landings are taken by the recreational fishery, it is primarily used as bait for many species. Herring management affects the recreational fishery indirectly by controlling the availability of herring for bait and for forage (drawing the target species closer to shore where they are then accessible to the recreational industry). So long as management measures work to ensure that herring is not overfished or experiencing overfishing, the recreational fishery will benefit.

1.5.2.2 Commercial Fishery

Issue 1: Spawning Area Efficacy
This amendment proposes changes to the spawning monitoring program, including boundaries, default start dates, and length of the closure period. An adjustment to the Western Maine and Massachusetts-New Hampshire spawning area closure default start date would benefit fishermen because the ability to forecast a closure can provide advanced notice of a closure date.

An extension of the closure period from four to six weeks, which represents one aspect of the potential changes, could potentially have a negative impact on the herring industry. Fishermen and bait dealers note the stock is rebuilt, therefore further protection via a six-week closure is not warranted and will reduce market opportunities. Additionally, fishermen expressed concern that effort by midwater trawlers could be displaced farther northeast, where smaller fish are located, if the spawning closure lasted for six weeks.

Issue 2: Fixed Gear Set-Aside Provision Adjustment

The federal and state FMPs allow for a 500 MT fixed gear set aside. Current specifications are 295 MT will be set-aside for fixed gear fisheries operating in Area 1A (weirs and stop seines) west of Cutler. This set-aside will be available to fixed gear fishermen in Area 1A until November 1. If the set-aside has not been utilized by the fixed gear fisheries west of Cutler by November 1, it will then be made available to the remainder of the herring fleet fishing in Area 1A until the directed fishery in 1A closes. If 92% of the Area 1A TAC has already been reached by November 1 (and the directed herring fishery in 1A is therefore closed), the set-aside will be released as part of the 5% set-aside for incidental catch in 1A (at a 2,000 lb trip limit).

Removal of the fixed gear set-aside November 1 rollover provision would have a neutral impact to the industry, but would require costs to implement consistent adjustments to the state and federal management plans. The fixed gear set-aside is a small portion of the total allowable catch (from 2013-2015, fixed gear set-aside was specified at 295 mt of the base 31,200 mt Area 1A sub-quota). There is potential for a small number of fishermen to increase utilization of fixed gears. While some fishermen have provided anecdotal evidence of Atlantic herring occurring in the Gulf of Maine after November 1, likely due to recent changes in oceanographic conditions, landings data for a ten-year period from 2004 to 2014 indicates that no Atlantic herring have been caught by fixed gear in November and December (Table 3). A removal of the rollover provision brings forth questions on year-to-year rollover if not fully utilized, and may lead to a quota allocation for the fixed gear fishery. Any adjustment to the current rollover provision will not complement the federal FMP.

Issue 3: Empty Fish Hold Provision
A requirement for fish holds to be empty of fish prior to a fishing trip departure would have a positive impact to industry. This option will be an incentive for fishermen to fish more efficiently to market demands by prohibiting vessels from returning to sea with unsold fish in the holds.

The empty fish hold provision applies to vessels departing on a fishing trip (i.e., declared into the fishery), but not for vessels transporting fish from port-to-port (i.e., not declared into the fishery). Waivers could be granted for instances where it is impossible to sell the fish (e.g., refrigeration failure or non-marketable fish). Waivers would not be required for vessels transporting fish from dock-to-dock. At this time, industry supports no limit on waivers issued for legitimate reasons to match the Council’s approved option.

1.5.2.3 Subsistence Fishery

It is uncertain to what extent herring may support subsistence fishing in the Mid-Atlantic or South and there does not appear to be subsistence fishing for herring in the Northeast. Because the amendment is attempting to control fishing on herring to smooth out the year’s landings, it is anticipated that the measures in this amendment will help maintain access to herring for subsistence needs.

1.5.2.4 Non-consumptive Factors

Herring is considered a primary forage fish for tuna, whales and various other species targeted by recreational fishermen. Consequently, as the commercial herring industry has rebuilt in the last few years, concern has developed in other sectors about whether or not too many herring are being caught. There is no reason to conclude that herring is overfished (according to the biomass estimates), but perception can affect community dynamics and governance.

2.0 GOALS AND OBJECTIVES

2.1 History of Prior Management Actions

Fishery Management Plan (FMP) (November 1993)
Management of USA Northwest Atlantic herring stocks beyond territorial waters was commenced in 1972 through the International Commission for the Northwest Atlantic Fisheries (ICNAF). The international fishery was regulated by ICNAF until USA withdrawal from the organization in 1976 with Congressional passage of the Magnuson Fishery Conservation and Management Act (MFCMA). Under the aegis of the MFCMA, the New England Fishery Management Council (Council) developed a Fishery Management Plan (FMP) for herring, which was approved by the Secretary of Commerce and was implemented on December 28, 1978. Over the interim period (1976-1978), foreign fishing for herring in USA waters was regulated through a Preliminary Management Plan (PMP) prepared by the National Marine Fisheries Service (NMFS 1995). In 1982, this plan was withdrawn by NMFS and herring was placed on the prohibited species list, eliminating directed fisheries for herring by foreign nationals within the US EEZ and requiring that any herring bycatch by such vessels be discarded. In 1983, an Interstate Herring Management Plan was adopted by the states of Maine, Massachusetts, New Hampshire and Rhode Island, which implemented a series of spawning closures. The states from Maine to New Jersey, acting through the ASMFC, adopted a new FMP in 1994 to address the growth of the herring resource and interest in Internal Waters Processing (IWP) operations.

Amendment 1 (February 1999)
ASMFC's Amendment 1 to the Atlantic Herring Fishery Management Plan (FMP) was developed to complement the NEFMC's federal management plan; it was designed to minimize regulatory differences in fisheries conducted in state and federal waters. Amendment I established management goals and objectives for the U.S. Atlantic herring resource that can only be reached through the successful implementation of both the interstate and federal management plans. The management scheme relies on a total allowable catch (TAC) with effort control measures to avoid overfishing. TACs are developed for specific management areas to reflect the current state of knowledge concerning migratory behavior and mixing rates of the sub-components of Atlantic herring.

Amendment 1 defines overfishing and biological reference points based on an estimate of maximum sustainable yield (MSY) for the entire stock complex. In order to maintain consistency between Amendment 1 and NEFMC's FMP, ASMFC's Atlantic Herring Section adopted the same overfishing definition and biological reference points as in the federal plan, which were created under guidelines stipulated in the revised Magnuson-Stevens Fishery Conservation and

Management Act (MSA) prior to the 2006 re-authorization. Both FMPs provide a process for setting annual specifications and contain institutional frameworks for developing and implementing future management action involving the ASMFC, the New England and Mid-Atlantic Councils, and (possibly) Canada. The plans also include state and federal spawning closures/restrictions and recommendations to prevent damage to herring spawning habitat and egg beds. State effort controls include specific "days out" of the week to slow the fishery's catch rates and extend the fishing season in Management Area 1A.

Addendum I to Amendment 1 (July 2000)
The Section approved Addendum I to re-address the protection of spawning areas and change the due date for annual state compliance reports to February 1. Because NOAA Fisheries disapproved the spawning closures for the federal waters of Management Area 1A (inshore Gulf of Maine), ASMFC developed Addendum I to redefine the state waters spawning areas outlined in Amendment 1. Addendum I also includes measures designed to reduce the exploitation and disruption of herring spawning aggregations by imposing a landing restriction in state ports for herring caught in the spawning areas, except that some states allow a 20% tolerance for spawn herring (Maine and Massachusetts).

Technical Addendum #1A (October 2001) was approved to change the delineation of the Eastern Maine spawning boundary because the spawning aggregations were not adequately protected in 2000.

Addendum II to Amendment 1 (February 2002)
Addendum II was developed in conjunction with NEFMC's Framework Adjustment 1 to allocate the Management Area 1A's TAC on a seasonal basis. This addendum also specifies the procedures for allocating the annual IWP quota.

Amendment 2 (March 2006)
The essential management components of ASMFC's Amendment 2 are consistent with the federal Amendment 1 (final rule published in March 2007). These provisions include identical management area boundaries, joint TAC specifications setting process between NEFMC and ASMFC, and closure of an area when 95% of TAC is harvested and reduction of the possession limit to a 5% bycatch allowance. Despite coordinated development between Amendment 2 and the federal Amendment 1, there remained some inconsistencies. The east of Cutler exemption in *Section 4.3.2.4* of Amendment 2 was not adopted in the federal plan, as it was found to be "inconsistent with National Standard 1 and 3 of the Magnuson-Stevens Act." Conversely, Amendment 1 contains a midwater trawl prohibition in Area 1A from June 1 – September 30, which is not included in the Amendment 2. It is unlikely that there are mid-water trawl vessels lacking federal permits.

Technical Addendum I to Amendment 2 (August 2006)
Upon implementation of Amendment 2, there was inconsistent interpretation of the Zero Tolerance provision. Therefore, a technical addendum was developed to clarify that prohibits any vessel from fishing for, taking, landing, or possessing "spawn" herring within a restricted spawning area except for incidental bycatch and transiting provisions.

Addendum I to Amendment 2 (February 2009)
Addendum I was intended to address effort in Area 1A. It includes a number of tools for the Section to use in order to maintain a steady supply of herring throughout the fishing season. Under Addendum I, states adjacent to Area 1A must set quotas, but can use bi-monthly, trimester, or seasonal quotas and can distribute quota from January – May to later on in the fishing season when the demand and price is greater—as best meets the need of the fishery. This addendum also includes measures to close the fishery when 95% of the quota allocation is harvested and the ability to roll quota into later periods in the event of an under harvest. States are also required to implement weekly reporting in order to manage quotas in a timely manner.

Addendum II (December 2010)
In March 2011, NOAA Fisheries approved Amendment 4 to the federal FMP, bringing it under compliance with the MSA's annual catch limit requirements. Addendum II was developed to mirror the federal Amendment 4. It revises the specifications process and definitions to be consistent with the federal management scheme, in which specifications can be set for up to three years based on best available science. Addendum II also establishes a threshold of 95% of an area's TAC for fishery closure and overage paybacks as accountability measures.

Addendum V (October 2012)
Intended to provide clarity and eliminate inconsistent spawning regulations among various interstate Atlantic herring FMP documents, Addendum V replaces all spawning regulations in previous management documents. It establishes provisions for determining spawning events and the implementation of area closures, and increases the sampling size from two samples of 50 fish to two samples of 100 fish or more. Addendum V includes new boundaries for the four management areas (Figure 1) and identifies the locations of spawning areas subject to closures.

Addendum VI (August 2013)
Developed to complement the NEFMC's Framework Adjustment 2 (final rule published in October 2013), Addendum VI established new provisions and consistent management measures for the four Atlantic herring management areas. States were allowed to seasonally split sub-ACLs for each management area to benefit the fishery. Up to 10% of unused sub-ACL can be carried over to the following fishing year after data is available, provided that the stockwide ACL has not been caught. Addendum VI also set new triggers: a directed fishery will close when 92% of an area's sub-ACL is projected to be reached, and the stockwide fishery will close when 95% of the total ACL is projected to be reached. There is a 2,000 lb. trip limit to allow for incidental bycatch of sea herring for the remainder of the fishing year. In addition, Addendum VI allows for these the directed fishery closure triggers to be set through the specification process.

2.2 Goals

The goals of Amendment 3 to the Interstate Fishery Management Plan for Atlantic Herring are:

- To achieve, on a continuing basis, optimum yield (OY) for the United States fishing industry and to prevent overfishing of the Atlantic herring resource. Optimum yield is the amount of fish that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, taking into account the protection of marine ecosystems, including maintenance of a biomass that supports the ocean ecosystem, predator consumption of herring, and biologically sustainable human harvest. Optimum yield is based on the maximum sustainable yield (MSY) as reduced by any relevant economic, social, or ecological factor, and, in the case of an overfished fishery, provides for rebuilding to a level consistent with producing MSY.
- To provide for the orderly development of the offshore and inshore fisheries, taking into account the viability of current participants in the fishery.

2.3 Objectives

To meet the goals of Amendment 3, the following objectives shall guide the development of the interstate management program for Atlantic herring:

- To harvest the U.S. Northwest Atlantic herring resource consistent with the definition of overfishing contained in Amendment 3.
- To prevent the overfishing of discrete spawning units consistent with the national standards.
- To avoid patterns of fishing mortality by age which adversely affect age structure of the stock.
- To provide adequate protection for spawning herring and prevent damage to herring egg beds.
- To promote U.S. and Canadian cooperation in order to establish complementary and real-time management practices.
- To implement management measures in close coordination with other Federal and State FMPs.
- To promote research and improve the collection of information in order to better understand herring population dynamics, biology, and ecology, improve science in order to move to real-time management and to improve assessment procedures and cooperation with Canada.
- To achieve full utilization from the catch of herring, including minimizing waste from discards in the fishery.
- To maximize domestic use, such as lobster bait, sardines, and other products for human consumption, and encourage value-added product utilization.
- To promote the utilization of the resource in a manner, which maximizes social and economic benefits to the nation and taking into account the protection of marine ecosystems and its value as a forage species.

2.4 Specification of Management Unit

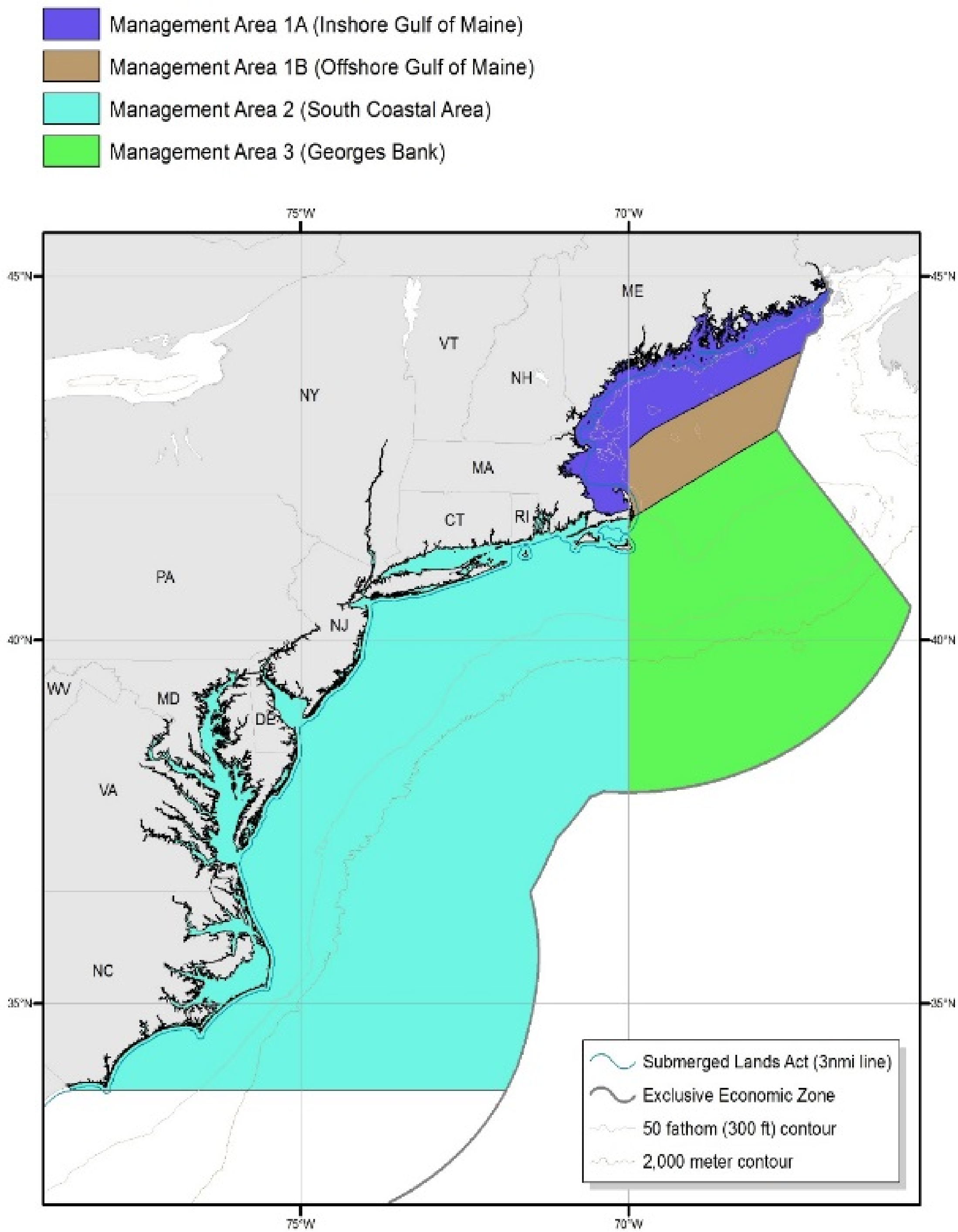
The management unit is defined as within U.S. waters of the northwest Atlantic Ocean from the shoreline to the seaward boundary of the Exclusive Economic Zone (EEZ). Because the management unit is limited to U.S. waters, it does not include the entire range of the Atlantic herring population. Various components of the stock complex migrate through Canadian waters, beyond the Atlantic States Marine Fisheries Commission's management authority. The Atlantic herring stock complex is interstate, state-federal and transboundary in nature; therefore, effective assessment and management can be enhanced through cooperative efforts with state, federal, and Canadian scientists and fisheries managers.

Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, and New Jersey, and the National Marine Fisheries Service have declared an interest in Atlantic herring.

2.4.1 Management Areas

Currently, Atlantic herring is managed under four management areas in the Gulf of Maine, Georges Bank, and Southern New England (Figure 1). The Gulf of Maine is split into an inshore area (Area 1A) and offshore area (Area 1B). The boundaries of the management areas are consistent with the federal fishery management plan.

Figure 1. Map of Atlantic Herring Management Areas



3.0 MONITORING PROGRAMS SPECIFICATIONS/ELEMENTS

Text collated from Amendment 2 and associated addenda, will be included in this section in the final version of Amendment 3.

4.0 MANAGEMENT PROGRAM IMPLEMENTATION

4.1 Issue 1: Spawning Area Efficacy

4.1.1 Spawning Area Closure Monitoring System

The PDT conducted a review of scientific literature and analyzed the female gonadosomatic index (GSI) data for a decade to inform an updated GSI-based spawning monitoring system (see Appendix 1. *Technical Report on Atlantic Herring GSI-Based Spawning Monitoring Program*). Female GSI is a calculation of the gonad (ovary) mass as a proportion of the total body mass and it is used as a tool to measure herring maturity. GSI values can be interpreted as the ratio of herring body weight that is comprised of the ovary. As such, a larger GSI value indicates advanced maturity and larger ovaries.

Currently GSI samples are obtained directly from the commercial herring fishery, however it is not always possible to collect sufficient data to inform the start of the spawning closure, therefore a system that forecasts closure dates is recommended by the PDT (Option C).

The spawning closure monitoring system options in this section have associated default closure dates in Section 4.1.2. If selecting Option C, a GSI trigger must also be specified in Section 4.1.2.

Option A. Status Quo

Closures in a given area will begin based on the spawning condition of Atlantic herring as determined from commercial catch samples. Commercial catch sampling shall begin by at least August 1 for the Eastern and Western Maine areas, and by at least September 1 for the Massachusetts/New Hampshire area. If sufficient samples are not available, closures will begin on the default dates.

Sufficient sample information shall mean at least two (2) samples of 100 fish or more, in either length category, taken from commercial catches during a period not to exceed seven days apart.

Closures in a given area will begin seven days after the determination that female herring in ICNAF gonadal stages III - V from that specific area have reached the following spawning conditions: female herring greater than 28 cm in length have reached a mean GSI of 20; or female herring greater than or equal to 23 cm and less than 28 cm in length have reached a mean GSI of 15.

Length refers to the mean natural total length, measured from the tip of the snout to the end of the caudal fin in normal position. "GSI" shall mean gonadosomatic index calculated by the following formula. Length refers to the mean natural total length, measured from the tip of the snout to the end of the caudal fin in normal position. "GSI" shall mean gonadosomatic index calculated by the following formula:

GSI = [Gonad Weight / (Total Body Weight - Gonad Weight)] x 100 percent.

Option B. Status Quo with Adjustments (updated language is underlined)
Closures in a given area will begin based on the spawning condition of Atlantic herring as determined from fishery dependent or independent samples. Sampling shall begin by August 1 for the Eastern and Western Maine areas, and by at least September 1 for the Massachusetts/New Hampshire area. If sufficient samples are not available, closures will begin on the default dates (see Section 4.1.2 for dates).

Sufficient sample information shall mean at least two (2) samples of 100 fish or more, in either length category, taken from fishery dependent or independent sources within a spawning closure area by Maine, New Hampshire or Massachusetts. The fishery will remain open if sufficient samples are available, and they do not contain female herring in ICNAF gonadal stages III – V.

Closures in a given area will begin seven days after the determination that female herring in ICNAF gonadal stages III - V from that specific area have reached the following spawning conditions: female herring greater than 28 cm in length have reached a mean gonadosomatic index (GSI) of 20%; or female herring greater than or equal to 23 cm and less than 28 cm in length have reached a mean GSI of 15%.

Length refers to the mean natural total length, measured from the tip of the snout to the end of the caudal fin in normal position. “GSI” shall mean gonadosomatic index calculated by the following formula. Length refers to the mean natural total length, measured from the tip of the snout to the end of the caudal fin in normal position. “GSI” shall mean gonadosomatic index calculated by the following formula:

GSI = [Gonad Weight / (Total Body Weight - Gonad Weight)] x 100 percent.

Option C: GSI_{30}-Based Forecast System
The closure date for a spawning area will be projected based on a minimum of three (3) fishery dependent or independent samples, each containing at least 25 female herring in ICNAF gonadal stages III-V. Because larger herring spawn first, female GSI values will be standardized to that of a 30 cm fish, (95th percentile of observed female herring lengths) using the following formula:

$$GSI_{30} = GSI_{obs} + 1.84 * (30 - TL_{cm})$$

When a significant positive relationship is detected between GSI_{30} and date, the slope of this line will be used to forecast a closure date. The forecasted closure date will be the day where GSI_{30} is projected to exceed the selected trigger value. As additional samples are collected, the forecast will be updated and fine-tuned. Once the forecasted date is within 5 days, the spawning closure will be announced. If no significant increase in GSI_{30} is detected prior to the default closure date, the default closure date would apply (see Section 4.1.2 for default dates).

GSI_{30} Trigger Value: Spawning occurs at the completion of maturity stage V. Therefore, a point near the high end of observed GSI values for stage V fish should be used as the trigger. A higher value closes the fishery later and just prior to spawning, whereas a lower value provides additional protection for maturing fish. In other words, higher GSI values indicate increased maturation and spawning readiness.

70^{th} Percentile : GSI_{30} Trigger = 23
Closes the fishery at an earlier date to provide more protection for maturing fish, but may not provide complete protection for spawning fish.

80^{th} Percentile: GSI_{30} Trigger = 25
Closes the fishery in the later stages of maturity, but before spawning.

90^{th} Percentile: GSI_{30} Trigger= 28
Closes the fishery just prior to spawning.

4.1.2 Default Closure Dates

The PDT recommends adjusting the method for triggering a closure in a spawning area. Currently GSI samples are obtained directly from the commercial herring fishery, however it is not always possible to collect sufficient data to inform the start of the spawning closure. As such, default closure dates were established for each of three spawning areas with a presumed general north-south progression of spawning.

Analysis of GSI data from 2004-2013 suggests onset of spawning can vary by five or more weeks from year-to-year. This observation is corroborated by scientific studies on herring spawning times (Boyar 1968; Grimm 1983; Stevenson 1989; Winters and Wheeler 1996). Median trigger dates were calculated for the period 2004-2013 using the formula and trigger values described under Section 4.1.1 Option C. In other words, Sub-Options C1-C3 represent the average date a GSI trigger would have been reached in previous years. Insufficient data were available for the Eastern Maine area, so a value derived from literature sources (Stephenson 1989) is used for options A through C for the Eastern Maine area.

Option A: Status Quo

If sufficient samples are not available, closures will begin on the following dates.

Eastern Maine Spawning Area:	August 15
Western Maine Spawning Area:	September 1
Massachusetts/New Hampshire Spawning Area:	September 21

Option B: Status Quo with Adjustments
If sufficient samples are not available, closures will begin on the following dates.
These dates match Option A and are associated with Option B in Section 4.1.1.

Eastern Maine Spawning Area:	August 15
Western Maine Spawning Area:	September 1
Massachusetts/New Hampshire Spawning Area:	September 21

Option C: Default Dates Associated with GSI_{30} Trigger Values
If sufficient samples are not available, closures will begin on the following dates associated with the respective GSI_{30} trigger value. *Please specify a trigger sub-option when selecting C.*

- **Sub-Option C1: 70th Percentile (GSI_{30} Trigger = 23)**
  Closes the fishery at an earlier date to provide more protection for maturing fish, but may not provide complete protection for spawning fish.

Eastern Maine Spawning Area:	August 28
Western Maine Spawning Area:	September 25
Massachusetts/New Hampshire Spawning Area:	September 25
Tri-State (WM-MA/NH) Spawning Area*:	September 25

- **Sub-Option C2: 80th Percentile (GSI_{30} Trigger = 25)**
  Closes the fishery in the later stages of maturity, but before spawning.

Eastern Maine Spawning Area:	August 28
Western Maine Spawning Area:	October 4
Massachusetts/New Hampshire Spawning Area:	October 4
Tri-State (WM-MA/NH) Spawning Area*:	October 4

- **Sub-Option C3: 90th Percentile (GSI_{30} Trigger = 28)**
  Closes the fishery just prior to spawning.

Eastern Maine Spawning Area:	August 28
Western Maine Spawning Area:	October 17
Massachusetts/New Hampshire Spawning Area:	October 17
Tri-State (WM-MA/NH) Spawning Area*:	October 17

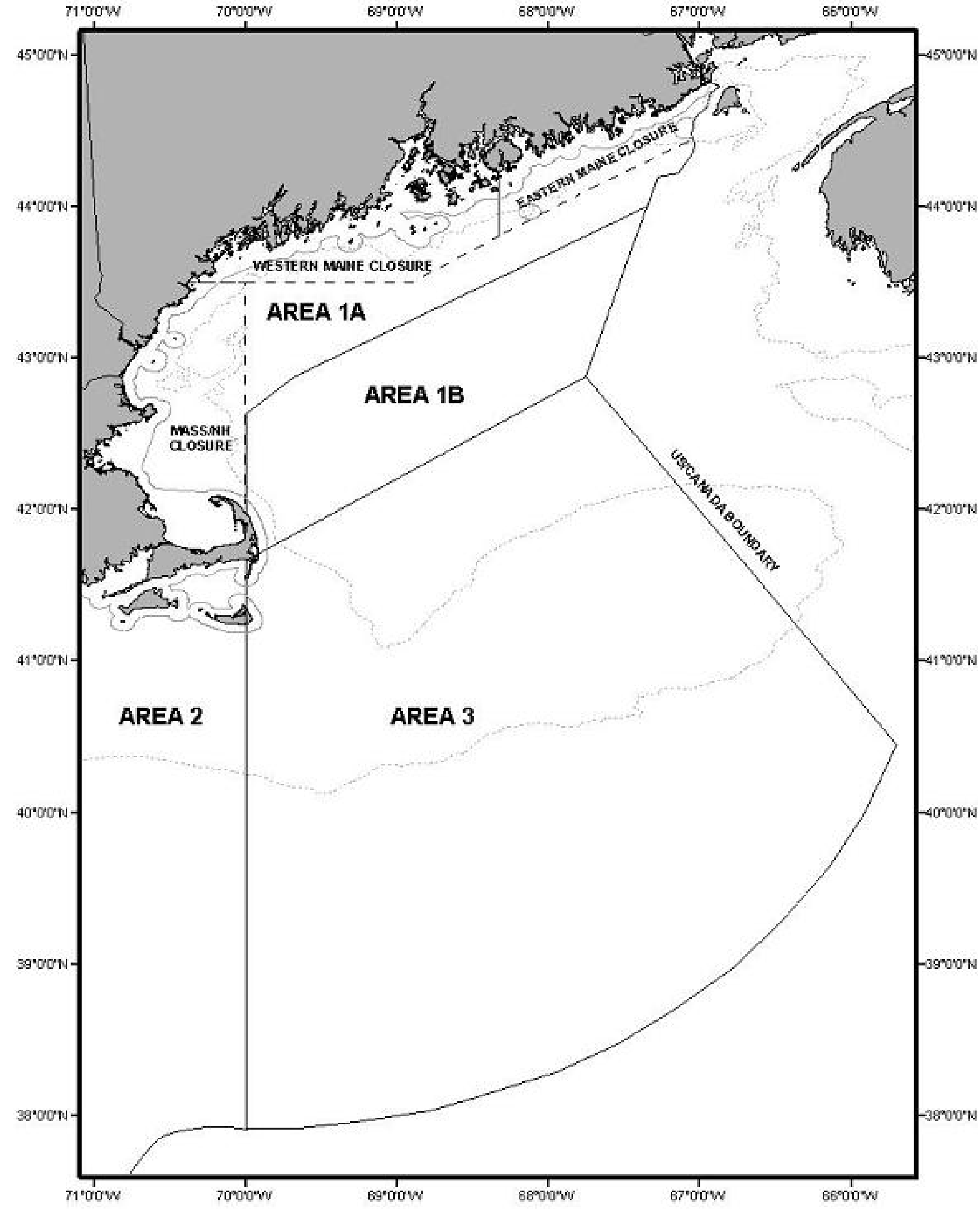
**Tri-State Spawning Area options if Option B in Section 4.1.3 is selected.*

4.1.3 Spawning Area Boundaries

The PDT evaluated 1) sub-dividing the Massachusetts/New Hampshire spawning area, and 2) combining Western Maine and Massachusetts/New Hampshire spawning areas. Anecdotal reports from industry suggested there was variation in the spawning season within the MA/NH area (i.e., spawning occurs earlier to the north). A potential alternative to sub-divide the MA/NH area was initially proposed, however, upon review of the GSI data from both the Massachusetts Division of Marine Fisheries and Maine Division of Marine Resources sampling programs, this does not appear to be needed. In fact, both programs track each other well and the combined dataset appears well-suited to continue to inform the initiation of the MA/NH spawning closure. Therefore, the PDT has found the current spawning area boundaries (Figure 6) within MA/NH are adequate and further sub-areas are not warranted.

The PDT also reviewed the spawning onset times in the Western Maine and Massachusetts/New Hampshire spawning areas. After adjusting to a standard 30 cm fish, there is no significant difference in the spawning onset times between the two spawning areas. The PDT recommends merging these two areas into one to increase the number of samples available to inform spawning closures (Option B). If the WM and MA/NH spawning areas were merged then the spawning area monitoring system would collect samples from two spawning areas, instead of three.

Figure 6. ASMFC Atlantic Herring Spawning Areas



Option A. Status Quo

Maintain the spawning area boundaries (Figure 6):

Eastern Maine Spawning Area
All waters bounded by the following coordinates:

Maine coast 68° 20' W
43° 48' N 68° 20' W
44° 25' N 67° 03' W
North along US/Canada border

Western Maine Spawning Area
All waters bounded by the following coordinates:

43° 30' N Maine coast
43° 30' N 68° 54.5' W
43° 48' N 68° 20' W
North to Maine coast at 68° 20' W

Massachusetts/New Hampshire Spawning Area
All waters bounded by the Massachusetts, New Hampshire and Maine coasts, and 43° 30' N and 70° 00' W

Option B. Combine the WM and MA/NH spawning areas into a Tri-State spawning area (WM-MA-NH)

Eastern Maine Spawning Area
All waters bounded by the following coordinates:

Maine coast 68° 20' W
43° 48' N 68° 20' W
44° 25' N 67° 03' W
North along US/Canada border

Tri-State (WM-MA-NH)
All waters bounded by the Massachusetts, New Hampshire and Maine coasts, and:

Cape Cod north to 43° 30' N and 70° 00' W
43° 30' N 68° 54.5' W
43° 48' N 68° 20' W
North to Maine coast at 68° 20' W

4.1.4 Spawning Closure Period

It has become evident the current GSI observations are not particularly useful for describing the duration of the spawning period because fishery-dependent (or commercial catch) samples are not available after the start of the closure. Several earlier studies in the GOM concur that the typical duration of herring spawning within a particular area is approximately 40 days. It is fairly common to find spawning herring in fishery samples after the initial four week closure. Therefore, it appears the current 4-week closure period is inadequate given the goals and objectives of this management action. Increasing to a 6-week closure (42 days) would provide a better match for the available information on the duration of GOM herring spawning.

Analysis of GSI data from 2004-2013 suggest larger fish spawn earlier than smaller fish. This finding is corroborated by studies documenting a size-dependent maturation process (Boyar 1968; Ware and Tanasichuk, 1989; Oskarsson et al., 2002; Slotte et al., 2000). As the age structure of the herring resource expands with the recovery, it is possible spawning events will lengthen.

CLOSURE PERIOD

Option A: Status Quo

By default, all spawning closures in all spawning areas selected under Section 4.1.3 will last four (4) weeks.

Option B: Six Week Spawning Closure

By default, all spawning closures in all spawning areas selected under Section 4.1.3 will last six (6) weeks.

RE-CLOSURE PROTOCOL

Option A: Status Quo

Catch sampling of the fishery will resume at the end of the initial four-week closure period. If catch sampling indicates significant numbers of spawn herring are still being harvested, closures will resume for an additional two weeks. Significant numbers of spawn herring is defined as 25% or more mature herring, by number in a catch sample, have yet to spawn. Mature or “spawn” herring are defined as Atlantic herring in ICNAF gonadal stages V and VI.

Option B: Defined Protocol

Sampling will resume in the final week of the initial closure period or at the end of the initial closure period. If one (1) sample taken from within a spawning closure area, by Maine, New Hampshire or Massachusetts, indicates significant numbers of spawn herring then closures will resume for an additional two (2) weeks. Significant numbers of spawn herring is defined as 25% or more mature herring, by number in a sample, have yet to spawn. Mature or “spawn” herring are defined as Atlantic herring in ICNAF gonadal stages V and VI. Sample is defined as a minimum of 100 randomly selected adult sized fish from a fishery dependent or independent source.

Option C: No Re-Closure Protocol
Samples will not be collected at the end of an initial closure period to inform the possibility of a re-closure.

4.2 Issue 2: Fixed Gear Set-Aside Provision Adjustment

In recent years, Atlantic herring has been known to occur along the mid-coast of Maine through November. Fixed-gear fishermen have requested to remove the rollover date, thereby maintaining access to a dedicated quota for the fixed gear fishery after November 1. Fishermen expect a demand for bait in the lobster fishery through end of the year.

Historically, the fish have migrated away from the GOM coast by November. In the past decade, fixed gear landings have not fully utilized the set aside of 295 mt (e.g., utilization over a 10-year average is 197.4 mt, or 67% of the set-aside) and landings after November 1 have been 0 mt since 1993 (Table 3).

The PDT noted, should fixed-gear fishermen exceed the 295 mt set-aside, they have access to the total Area 1A sub-quota. There is no biological basis for or against adjusting the rollover provision of the fixed-gear set aside, but there may be socioeconomic reasons. In addition, if the rollover provision is changed then there will be inconsistent set aside measures between state and federal rules.

Table 3. Atlantic Herring Landings from Fixed Gear Fishery (stop seine, weir, pound net) Before and After November 1 Rollover Date

Year	Sub-ACL Closure Date	Area 1A Sub-ACL (mt)	Cumulative Catch (mt) by Dec 31	Fixed Gear Landings (mt)	
				Jan-Oct	Nov-Dec
2004	11/19/2004	60,000	60,071	49	0
2005	12/2/2005	60,000	61,570	53	0
2006	10/21/2006	50,000	59,980	528	0
2007	10/25/2007	50,000	49,992	392	0
2008	11/14/2008	43,650	42,257	24	0
2009	11/26/2009	43,650	44,088	81	0
2010	11/17/2010	26,546	27,741	823	0
2011	10/27/2011	29,251	29,359	23	0
2012	11/5/2012	27,668	25,057	0	0
2013	10/15/2013	29,775	29,820	C	C
2014	10/26/2014	33,031	33,428	C	C

Note: "C" denotes that the value cannot be reported due to confidentiality.

Option A: Status Quo
The fixed gear set-aside will be available to fixed gear fishermen in Area 1A until November 1. If the set-aside has not been utilized by the fixed gear fisheries west of Cutler by November 1, it will then be made available to the remainder of the herring fleet fishing in Area 1A until the directed fishery in 1A closes. *Fixed gear fishermen can continue fishing and landings will count towards the Area 1A sub-quota.* If 92% of the Area 1A TAC has already been reached by November 1 (and the directed herring fishery in 1A is therefore closed), the set-aside will be released as part of the 5% set-aside for incidental catch in 1A (at a 2,000 lb trip limit).

Option B: Remove the rollover provision
The fixed gear set-aside will be available to fixed gear fishermen west of Cutler through December 31. When 92% of the Area 1A TAC has been reached, all directed Atlantic herring fisheries in Area 1A will closed. Unused portions of the fixed gear set-aside will not be rolled from one year to the next.

4.3 Issue 3: Empty Fish Hold Provision

Currently, the interstate and federal Atlantic Herring FMPs do not require an empty fish hold prior to departing the dock. However, there is concern that unsold herring are dumped at sea if there is not enough market demand for the resource. Additionally, fish from multiple trips can be mixed if the holds are not completely emptied—this has the potential to compromise landings data used to inform harvest control measures and bycatch avoidance programs, particularly for river herring. Furthermore, leaving fish in the vessel's hold prevents portside samplers from observing the entire catch.

The New England Fishery Management Council (NEFMC), in Draft Framework Adjustment 4, approved a requirement for vessel holds to be empty of fish prior to leaving a dock. The Council adopted *Alternative 2.1.2, Alternative 2, Option C in Framework 4*, which includes that a waiver may be issued for instances when there are fish in the holds after inspection by an appropriate law enforcement officer. The Council's alternative would only apply to Category A and B boats. The intent is for waivers to be issued for refrigeration failure and non-marketable reported fish. Options B1 and B2, below, match the NEFMC preferred option.

This is currently a proposed rule to the federal FMP. NMFS will be need to approve Framework Adjustment 4 for this to become effective federally. The Board could select Option B2 or C2, and then it would be the states responsibility to implement the empty fish hold provision, regardless of federal adoption.

The PDT included Options C1 and C2 to account for vessels with freezing capability, which commonly unload only when the freezer is full, and do not utilize pumps—these vessels would be exempt from the provision.

Option A: Status Quo
No empty fish hold provision. There is no requirement to empty vessel holds of fish prior to a fishing trip departure.

Option B1: Federal/State Empty Fish Hold Provision
The language in this Option mirrors the provision in Framework Adjustment 4 and is contingent on federal option. Meaning if NMFS adopts Framework Adjustment 4 then the states will implement this option.

This option would require that fish holds on Category A/B Atlantic herring vessels are empty of fish before leaving the dock on any trip when declared into the Atlantic herring fishery. A waiver may be issued for instances when there are fish in the hold after inspection by an appropriate law enforcement officer (the intent is for waivers to be issued for refrigeration failure and non-marketable fish that have been reported by the vessel). Only vessels departing on a fishing trip (i.e. declared into the fishery) are required to have holds empty of fish. As such, waivers would not be required for vessels transporting fish from dock to dock.

Option B2: State Empty Fish Hold Provision
This option is the same as B1, but it is NOT contingent on federal adoption. Meaning if NMFS does not adopt Framework Adjustment 4 then the states can still implement this option.

Option C1: Federal/State Empty Fish Hold Provision for Select Vessels
This option is similar to Option B1, with the additional underlined text, and is contingent on federal adoption. Meaning if NMFS adopts Framework Adjustment 4 then the states will implement this option instead.

This option would require that fish holds on Category A/B Atlantic herring vessels with ability to pump fish are empty of fish before leaving the dock on any trip when declared into the Atlantic herring fishery. A waiver may be issued for instances when there are a pumpable quantity of fish in the hold as determined by an appropriate law enforcement officer (the intent is for waivers to be issued for refrigeration failure and non-marketable fish that have been reported by the vessel). Only vessels departing on a fishing trip (i.e. declared into the fishery) are required to have holds empty of fish. As such, waivers would not be required for vessels transporting fish from dock to dock.

Option C2: State Empty Fish Hold Provision for Select Vessels
This option is the same as C1, but it is NOT contingent on federal adoption. Meaning if NMFS does not adopt Framework Adjustment 4 then the states can still implement this option.

5.0 COMPLIANCE

Text collated from Amendment 2 and associated addenda, will be included in this section in the final version of Amendment 3.

6.0 MANAGEMENT AND RESEARCH NEEDS

Text collated from Amendment 2 and associated addenda, will be included in this section in the final version of Amendment 3.

7.0 PROTECTED SPECIES

Text collated from Amendment 2 and associated addenda, will be included in this section in the final version of Amendment 3.

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9.0 APPENDICES

Appendix 1: Provisions for Spawning Area Closures

Addendum V to Amendment 2 to the Interstate Atlantic Herring FMP: Comprehensive Spawning Regulations (October 2012)

3.1.2 Management Program: Provisions revised under this Addendum
This language replaces part of the language in section 4.2.1.2 of Addendum I to Amendment 1:
Closures in a given area will begin seven days after the determination that female herring in ICNAF gonadal stages III - V from that specific area have reached the following spawning conditions: female herring greater than 28 cm in length have reached a mean gonadosomatic index (GSI) of 20%; or female herring greater than or equal to 23 cm and less than 28 cm in length have reached a mean GSI of 15%.

3.2.2 Management Program: Provisions revised under this Addendum
This section replaces part of the language in section 4.2.1.2 of Addendum 1 to Amendment 1. Sufficient sample information shall mean at least two (2) samples of 100 fish or more, in either length category, taken from commercial catches during a period not to exceed seven days apart.

2.2.2 Default Start Date (4.3.2.2 Spawning Closures & Default Dates of Amendment 2):
If sufficient samples are not available, closures will begin on the following dates.

Eastern Maine: August 15
Western Maine: September 1
Massachusetts/New Hampshire: September 21

2.2.3 Sampling Protocol (4.2.1.2 Determination of Starting Date for Spawning Closures of Addendum I to Amendment 1):
Closures in a given area will begin based on the spawning condition of Atlantic herring as determined from commercial catch samples. Commercial catch sampling shall begin by at least August 1 for the Eastern and Western Maine areas, and by at least September 1 for the Massachusetts/New Hampshire area. If sufficient samples are not available, closures will begin on the default dates.

Closures in a given area will begin seven days after the determination that female herring in ICNAF gonadal stages III - V from that specific area have reached the following spawning conditions: female herring greater than 28 cm in length have reached a mean gonadosomatic index (GSI) of 20% or female herring greater than 24 cm and less than 28 cm in length have reached a mean GSI of 15%. Length refers to the mean natural total length, measured from the tip of the snout to the end of the caudal fin in normal position. “GSI” shall mean gonadosomatic index calculated by the following formula. Length refers to the mean natural total length, measured from the tip of the snout to the end of the caudal fin in normal position. “GSI” shall mean gonadosomatic index calculated by the following formula:

[Gonad Weight / (Total Body Weight - Gonad Weight)] x 100 percent

2.2.5 Spawning Closure Length (4.3.2.2 Spawning Closures & Default Dates of Amendment 2):
By default, closures will last four (4) weeks. Catch sampling of the fishery will resume at the end of the initial four-week closure period. If catch sampling indicates significant numbers of spawn herring are still being harvested, closures will resume for an additional two weeks. Significant numbers of spawn herring is defined as 25% or more mature herring, by number in a catch sample, have yet to spawn. Mature or “spawn” herring are defined as Atlantic herring in ICNAF gonadal stages V and VI.

Appendix 2: Provisions for Fixed Gear Set-Aside

Regulatory language from Amendment 2 to the Interstate Atlantic Herring FMP:

4.3.4 Downeast Maine Fixed Gear Fisheries

In addition to including catch from the Downeast Maine fixed gear fishery east of Cutler as part of the assumed catch from the New Brunswick (NB) weir fishery, 500 mt of the Area 1A TAC will be set aside for fixed gear fisheries operating in Area 1A (weirs and stop seines) west of Cutler (area west of the shaded area below). This set-aside will be available to fixed gear fishermen in Area 1A until November 1. If the set-aside has not been utilized by the fixed gear fisheries west of Cutler by November 1, it will then be made available to the remainder of the herring fleet fishing in Area 1A until the directed fishery in 1A closes. If 95% of the Area 1A TAC has already been reached by November 1 (and the directed herring fishery in 1A is therefore closed), the set-aside will be released as part of the 5% set-aside for incidental catch in 1A (at a 2,000 lb trip limit).

Again, fixed gear fishermen in Area 1A will be required to report their herring catches through the Interactive Voice Response (IVR) reporting system. Currently, fixed gear fishermen are not required to report on a real-time basis through IVR reporting. However, this measure relies on real-time monitoring of fixed gear catches in Area 1A, so IVR reporting is necessary.

Under the combination of these two measures, the TAC set-aside applies to the fixed gear fisheries occurring in Area 1A west of Cutler. The fixed gear fishery occurring east of Cutler will be exempt from the Area 1A TAC.

Regulatory language from Framework 2 of the Federal Atlantic Herring FMP:

Herring regulations (§ 648.201(g)) specify that up to 500 mt of the Area 1A sub-ACL shall be allocated for the fixed gear fisheries in Area 1A (weirs and stop seines) that occur west of 44° 36.2 N. Lat. and 67°16.8 W. Long. This set-aside shall be available for harvest by the fixed-gear within the specified area until November 1 of each year; any unused portion of the allocation will be restored to the Area 1A sub-ACL after November 1. During 2010–2012, the fixed gear set- aside was specified at 295 mt. Because the Area 1A sub-ACL for 2013–2015 is not substantially different from the Area 1A sub-ACL in 2012, the Council recommended that the fixed gear set-aside remain the same. This final rule sets the fixed gear set-aside at 295 mt for 2013–2015.

Appendix 3: Technical Report on Gonadal-Somatic Index-Based Monitoring System for Atlantic Herring Spawning Closures in US Waters
January 2015

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Introduction

While Atlantic herring reproduce in the same general season each year, the onset, peak and duration of spawning may vary by several weeks annually (Winters and Wheeler, 1996). It is believed that this behavioral plasticity is an evolutionary adaptation that takes advantage of optimal oceanographic conditions (e.g, temperature, plankton availability, etc.) to maximize offspring survival (Sinclair and Tremblay, 1984; Winters and Wheeler, 1996). In an effort to protect the integrity of the spawning stock and allow for increased recruitment, the ASMFC developed a system of seasonal spawning closures in the early 1990s that accounted for this interannual variability in spawning time. Historically, managers have focused on protecting the bulk of spawning during the fall season (August through October), but Atlantic herring are also known to spawn from late July through December. Acknowledging that macroscopic identification of the maturity stage of individual fish is a somewhat subjective process, the closure rule was based on a female gonadal somatic index (GSI), which is assumed to increase linearly as herring approach full maturity (Figures 1 and 2; Equation 1).

1) $GSI = 100 \times [W_{gonad}]/[W_{gonad}\text{-}W_{total}]$

At the time of the rule's creation, it was recognized that smaller herring generally have lower GSI values than larger herring (Figure 3). Consequently, separate triggers were established for two size classes: GSI = 15 for 23-27 cm; and GSI = 20 for 28+ cm. According to the closure rule, once two consecutive samples of herring achieve an average female GSI in excess of either trigger, the fishery closes for four weeks. Because all GSI samples are obtained directly from the commercial herring fishery, it is not always possible to collect sufficient data to inform the start of the spawning closure. As such, default closure dates were established for each of three areas that presumed a general north-south progression of spawning (Table 1). Despite the design of the closure system, it is fairly common to find spawning herring in fishery samples after the closure. To counteract this, a closure extension rule was established that mandated a two-week additional closure if fishery-dependent sampling revealed that greater than 25% of a post-closure sample contained fish in spawning condition (Stage V or VI).

When the rules were first established in the early 1990s, limited data were available to derive the critical parameters of the GSI-based spawning closure system (i.e., size categories; GSI triggers; default dates; closure duration). Given recent concerns over the adequacy of the system, which initiated the development of Draft Amendment 3 to the Interstate Atlantic Herring Fishery Management Plan (FMP), the Herring Plan Development Team felt that a re-examination of these parameters was warranted in light of an additional two decades worth of GSI sampling data.

Factors Affecting GSI

There is substantial variability in average GSI from one sample to the next, and it is often unclear whether this change is tracking the expected progression of gonad development of the population or is simply a function of the fish size, sample location, gear type, or year. The combined MADMF/MEDMR dataset of fishery-dependent samples includes 8,474 GSI observations (5,435 maturity observations) from 385 samples and covers three inshore spawning areas (Eastern Maine, Western Maine, Massachusetts-New Hampshire); three gear types (purse seine, midwater trawl, and bottom trawl); 15 years (1998-2013); three months (Aug-Oct); and 13 length bins (from 22 to 34 cm). Unfortunately, data are lacking for many factor level combinations (e.g., MWT samples are generally unavailable at the same time/area as other gear types), thereby preventing an analysis of the simultaneous influence of each factor on GSI/maturity using the full dataset. Nonetheless, we can evaluate the influence of several factors by examining a subset of the data. To this end, a generalized linear model (GLM) relating the GSI of female herring to a suite of factors (GSI ~ DAY + YEAR + LENGTH + AREA) was constructed using data from non-midwater trawl trips from the years 2004-2013.

Size

The current size-based closure system assumes that smaller herring achieve full maturity at a lower GSI than larger herring. While this has been demonstrated for the closely related Pacific herring (Ware and Tasanichuk, 1989), there is little evidence for such a relationship in our sample data (Figure 4). An alternative explanation for the observed size-GSI relationship (Figure 3) is a size-dependent arrival on the spawning ground (i.e., larger herring spawn earlier). This phenomenon had been documented in several other herring populations (Boyar 1968; Ware and Tanasichuk, 1989; Oskarsson et al., 2002; Slotte et al., 2000), and is believed to be related to a size-dependent maturation process (Ware and Tanasichuck, 1989), or swimming speed (i.e. larger herring arrive earlier to spawning grounds) (Slotte et al, 2000). Regardless, there is clear evidence of a decreasing average fish size as the spawning season progresses (Figure 5).
While it is true that smaller GOM herring generally have lower GSI than larger fish (at a given point in time), it is likely that all sizes achieve a similar maximum GSI, just at different times. As expected, the GLM estimated a strong positive relationship between length and GSI (Table 2 - for every 1 cm increase in length, there is a corresponding increase in GSI of 1.84 points). This slope for the LENGTH parameter can be used to standardize GSI observations to a common herring size, thereby removing the influence of length from GSI sample data.

Year

The strongly significant year effect indicates that the GSI for a given length/date may shift by six (6) or more points from year to year (Table 3). This suggests that the onset of spawning can vary by five or more weeks, underscoring the need for a GSI-based monitoring system instead of fixed closure dates. Several other studies corroborate this level of interannual variability in spawning time (Boyar 1968; Grimm 1983; Stevenson 1989; Winters and Wheeler 1996).

Day

The slope of the DAY parameter (0.19) in the GLM model represents the rate at which GSI increases per day, after controlling for the effects of other factors. Theoretically, this rate could be used to forecast the date when GSI (after adjusting for LENGTH) exceeds a trigger value from a single sample of fish. However, there is likely some interannual variability in this rate, and it would be more prudent to use samples from within a season to estimate the slope of the DAY parameter to forecast a closure date.

Area
The Eastern Maine (EM) spawning area was identified as having a significantly higher GSI than the other two areas, meaning that spawning occurs earlier in EM than elsewhere. Interestingly, the Western Maine (WM) and Massachusetts-New Hampshire (MA-NH) spawning areas do not appear to have significantly different spawning times. This suggests that these two areas should have a similar default date, or could even be combined to increase the number of samples available for informing spawning closures. Several earlier studies describe the timing of herring spawning in the GOM through the use of fishery-dependent maturity data and direct observation of demersal egg beds (Table 3 - Boyar et al., 1973; Cooper et al., 1975; McCarthy et al., 1979; Stevenson 1989). While these investigations confirm an earlier spawning time in EM than in MA-NH, there is no historical evidence to inform the timing of spawning in the WM area.

Fishing Gear
An alternative GLM was attempted that included gear type (bottom trawl vs purse seine) as an additional predictor variable (GSI ~ DAY + YEAR + LENGTH + AREA + GEAR); While GEAR was a marginally significant predictor of GSI, this more saturated model did not improve fit to the data, as measured by the Bayesian Information Criterion (BIC). This suggests that it is appropriate to combine samples obtained from these gear types. It should be noted that mid-water trawl samples were excluded from this analysis, as this gear rarely operates at the same time/location as the other gears, preventing an objective determination of whether this gear type influences the GSI of a sample.

Proposed Changes to the Closure System
Given that larger herring spawn earlier, it makes sense to standardize GSI observations to a large size class (e.g., 30 cm – 95th percentile of observed lengths), so that the closure period is inclusive of most spawners. Therefore, the observed GSI of each individual fish should be adjusted using the formula (Formula 2), where *a* is the slope of the length parameter from the GLM (*a*=1.84) and *b* is the reference length class (*b*=30 cm):

2) $GSI_{30} = GSI_{obs} + a * (b - TL_{cm})$

Herring are determinate spawners, releasing all of their eggs in a single batch (Kurita and Kjesbu, 2008). Therefore, spawning can be considered imminent at the end of Stage V (i.e., full maturity). However, a range of GSI values has been observed within Stage V that likely represents the final progression of the maturity cycle (Figure 6). Therefore, a point near the high end of the distribution of Stage V GSI values could be considered a reasonable measure of the onset of spawning. Managers could select different points from this distribution as a trigger value, depending on their objectives or risk tolerance. A higher value would shift the fishery closure nearer to the expect onset of spawning, whereas a lower value would shift the closure earlier to provide more protection to pre-spawning fish.

Once the fishery-dependent sampling program has a sufficient number of samples (e.g., a minimum of three) with a significant positive slope to the GSI_{30}~DAY relationship ($\alpha = 0.05$), a fishery closure date could be forecasted (i.e., the date when GSI_{30} exceeds $GSI_{trigger}$). This forecast could be updated as additional samples are acquired and an official closure date selected when the forecast is within a certain number of days (e.g., 5 days). If insufficient samples are available to predict the $GSI_{trigger}$ date prior to the default closure date, the default date would apply.

Using GSI sample data from previous seasons, we can estimate the date at which a $GSI_{trigger}$ would have been reached in each year (Figure 7). The average trigger date provides some representation of what an appropriate default closure date might be (Figure 8). Depending on the trigger value used, the average date for the MA-NH area is 4-24 days later than the most robust literature account for this area, which observed the arrival of herring egg beds on Jeffreys ledge between 1972 and 1978 (Table 3 – McCarthy et al., 1979). Most of the contemporary GSI sampling effort has been focused inshore of Jeffreys Ledge, suggesting spatial and/or interannual variation of spawning time within this area. Unfortunately, there are no literature sources available to inform the default date for Western Maine. The GLM model found no significant difference between the two areas; therefore, it appears reasonable to combine the two areas, increasing the number of samples available to inform a larger Tri-State (WM-MA-NH) spawning area (Table 2). With such few GSI samples available to describe the EM area, the historical information of when herring eggs have been observed on lobster traps is likely more applicable for this area (Table 3 – Stevenson 1989).

Contemporary GSI observations are not particularly useful for describing the duration of the spawning period, because fishery-dependent samples are not available once the closure commences. However, several earlier studies in the GOM concur that the typical duration of herring spawning within a particular area is approximately 40 days (Table 3). Therefore, it appears the current 4-week closure period is inadequate and increasing to a 6-week closure (42 days) would provide a better match for the available information on the duration of GOM herring spawning.

By using the sequence of individual samples obtained in previous years, we can apply the proposed closure rules to simulate the performance of the forecasting algorithm. For example, in 2011 a September 11 closure would have been announced on September 6, assuming a choice was made to select a closure date at five days prior (Figure 9).
There are several benefits to the GSI-based closure system as outlined in this paper:

1) By providing a forecasted closure date once an increase in GSI_{30} is detected, all interested parties (samplers, managers, industry) will have advance notice as to when the spawning closure is likely to occur, allowing them to plan their activities accordingly.
2) Because the forecasting model uses the GSI information from all samples to project a closure date, there isn't pressure to obtain two consecutive samples just prior to spawning, a task that has proven difficult in many years. For this reason, default closure dates due to insufficient samples would occur less often.
3) Aligning the assumptions of the closure system with the current understanding of the reproductive ecology of herring will improve the accuracy of and maximize the effectiveness of spawning closures.
4) By directly taking into account the effect of length on GSI, perceived discrepancies between sampling programs (MADMF, MEDMR) can be reconciled.

Ideally, we would have GSI and maturity samples from before, during, and after the spawning season. This would provide a better idea of maximum GSI (i.e. appropriate trigger value), and how that coincides with the presence of Stage V (full maturity) and Stage VI (spawning) fish.

Unfortunately, because the GSI-monitoring program is entirely fishery-dependent, there are essentially no samples available once the spawning closure begins. A directed fishery-independent effort to obtain herring samples during and after the closure could provide this information and be used to further refine the parameters of the closure system in the future.