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Developing a fine scale system to address river herring (*Alosa pseudoharengus*, *A. aestivalis*) and American shad (*A. sapidissima*) bycatch in the U.S. Northwest Atlantic mid-water trawl fishery

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ABSTRACT

Managers of the Atlantic herring (*Clupea harengus*) and mackerel (*Scomber Scombrus*) fisheries have a goal of reducing river herring (*Alosa pseudoharengus*, *Alosa aestivalis*) bycatch. Regulations being considered include temporarily closing 30 nm × 30 nm river herring "hotspots" or enacting these measures if a threshold amount of river herring is observed. These closures could be effective at reducing river herring bycatch, but would result in significant economic cost. The uncertainty of the effect of bycatch on river herring populations coupled with potential economic losses due to closed areas suggests a finer scale, voluntary method may be more appropriate. A collaboration between the Sustainable Fisheries Coalition, the Massachusetts Division of Marine Fisheries, and the University of Massachusetts Dartmouth School of Marine Science and Technology seeks to address this issue by implementing near real-time bycatch information systems for this fishery. The first system was implemented during the 2011 winter mid-water trawl fishery (January through March) over an approximate 60 nm × 70 nm area off the coast of New Jersey. Fifty percent of vessels landing in Massachusetts were sampled during this time period. Bycatch information from these vessels was accessed and shared with participating captains using a coded grid of smaller cells approximately 5 nm × 8 nm (10′ longitude × 5′ latitude). Industry collaboration and the appearance of small scale spatial and temporal patterns during the 2011 winter fishery suggests this is a plausible approach to reduce river herring and American shad (*Alosa sapidissima*) bycatch. The comparison of the results of this study to potential management actions displays both advantages and disadvantages of using a larger spatial scale to reduce bycatch while maintaining an active fishery.

1. Introduction

American shad, *Alosa sapidissima* and river herring (alewife, *Alosa pseudoharengus*, and blueback herring, *Alosa aestivalis*) are anadromous fishes that have an important ecological role and comprised major U.S. fisheries. During all life stages these alosines (shad and river herring) are food for a variety of river, estuary, and ocean fishes, birds and mammals (Bigelow and Schroeder, 2002; Scott and Scott, 1988). Additionally, they deposit marine-derived nutrients to their freshwater spawning grounds (MacAvoy et al., 2000). From colonial times through World War II alosines were important food for human consumption along the U.S. Atlantic coast (ASMFC, 2010; McPhee, 2003). After World War II, the Northeast U.S. shad fishery peaked between 1950 and 1970 with average harvests of about 2500 metric tons (mt) (Bigelow and Schroeder, 2002). Similarly, river herring catches peaked between 1963 and 1969 averaging close to 25,000 mt (Bigelow and Schroeder, 2002). As population decline continued to decrease landings, many states enacted fishing moratoriums and in 2005 only 260 mt of shad and 450 mt of river herring were harvested along the U.S. Atlantic coast (ASMFC, 2007, 2009, 2010). Alosine stocks are currently at historically low levels (Limburg and Waldman, 2009), river herring may be listed under the Endangered Species Act (Mooney-Sues, 2011), and directed ocean fisheries for American shad were banned in 2005 (ASMFC, 2010). The coast wide stock decline of alosines is likely caused by a combination of past overfishing, spawning habitat loss, pollution, increases in predator populations, environmental factors and bycatch (ASMFC, 2009,2010; Rulifson, 1994). Unintentional catch of alosines, bycatch, has significant potential to negatively affect both fishermen and alosine populations.

In the U.S. Northwest Atlantic ocean, the Atlantic herring (*Clupea harengus*) and Atlantic mackerel (*Scomber scombrus*) fisheries incidentally catch alosines. Both Atlantic herring and mackerel are rebuilt stocks and the value of landings has averaged about 23 and 6 million US$ respectively from 2008 to 2010 (NOAA, 2011). The increase in landings of both species in the 1990s coincide with a

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Fig. 1. Sample of typical Atlantic herring catch with alewife (*A. pseudoharengus*: center, left) bycatch. The proportion of target species compared to river herring (alewife and blueback herring, *A. aestivalis*), their similar appearance, and the speed of offloads make it difficult to quantify the amount of river herring bycatch.

shift from purse seining and weirs to mid-water trawling, which now accounts for the majority of landings (MAFMC, 2012; NEFMC, 2012a). Most of the vessels using mid-water gear fish for both Atlantic herring and mackerel. For example from 2006 to 2010, about 40% of the total revenue of primary mackerel vessels were from Atlantic herring landings (MAFMC, 2010). The dominate gear type and high volume nature of both fisheries can result in significant amounts of bycatch that is hard to quantify and classify (Fig. 1). This has lead to concerns about the potential of the Atlantic herring and mackerel fleet to capture large amounts of alosines at sea (NEFMC, 2012b). For example in most years from 2005 to 2010, estimated river herring catch by the directed herring fleet was one-half to one-tenth commercial river herring landings but in 2007 bycatch by the fleet was approximately double directed landings (NEFMC, 2012a).

Managers are considering adding regulations to reduce river herring or shad bycatch (ASMFC, 2010; MAFMC, 2012; NEFMC, 2012a). One possible regulation includes closing multiple 30 nm × 30 nm river herring protection areas on a bi-monthly basis or enacting these measures if an area specific total allowable catch (TAC, a catch limit for a specific time range and species determined by weight) is reached. Protection areas were created in quarter degree squares where a tow with >1233 lbs river herring was observed in any year from 2005 to 2009 (NEFMC, 2012a).

Bycatch reduction regulations in the form of area closures or TACs in otherwise sustainable fisheries can cause economic loss to fishermen (Dunn et al., 2011). For example, it was estimated that the creation of a haddock TAC in the Atlantic herring fishery would result in losses of 8 million US$ per year (NEFMC, 2006). In 2010, about 23,000 mt of Atlantic herring were not harvested because of concerns about exceeding the haddock bycatch TAC (NOAA, 2010; NEFMC, 2011). A preliminary evaluation of the economic effects of the river herring protection areas by the New England Fisheries Management Council Plan Development Team (PDT) concluded the closures would likely result in decreases in Atlantic herring catch and increases in fishing costs (NEFMC, 2012c). The greatest overlap between the protection areas and effort was for vessels using trawl gear as about one third of their year round effort and revenue in 2010 came from the proposed closed areas. The overlaps were predominantly during the winter. These overlaps can be seen as a general economic loss as the areas most utilized by the fleet are likely the most productive or cost effective. Thus, closing these areas would likely force trawl vessels to less familiar, less productive areas with increased search times, lower CPUE and decreased profits if they continued to fish.

Though the negative economic consequences of area closures are apparent, the biological gains of bycatch reduction are not. Alosines of different natal origins (from Florida to north of Nova Scotia, Canada) share common migratory routes and feeding grounds in the ocean (Dadswell et al., 1987; Hogans et al., 1993; Leggett, 1973; Rulifson, 1984; Rulifson et al., 1987; Talbot and Sykes, 1958). As a result, alosines caught as bycatch may not be associated with the regions or rivers they are caught near. Such movement patterns may reduce the biological significance of the bycatch by dispersing removals to many different stocks. Alternatively alosines may be of local origin, decreasing the number of stocks affected and increasing the significance of their removal. Currently the stock composition of bycatch is unknown and there are no coast-wide abundance estimates for alosines. Thus, the affect of bycatch on alosine populations is unknown. Large scale closures to protect river herring at sea may not be justifiable if the biological impact of these catches is unknown. However, any reduction in mortality may be beneficial to alosine stocks based on their depleted population status.

Voluntary alosine avoidance may be effective at reducing bycatch and less economically expensive. One approach is the near-real time communication of information on areas where bycatch species are caught in high amounts (Abbott and Wilen, 2010; Catchpole and Gray, 2010; Gauvin et al., 1996; Gilman et al., 2006; O'Keefe et al., 2010). The goal of these communication systems is to identify areas of high bycatch so vessels can avoid them and reduce their bycatch rates. This type of system has never been attempted in a fishery where both the target and bycatch species were highly migratory, pelagic, schooling fishes. For this type of system to work target and bycatch species must be spatially distinct, a critical mass of industry support must be present, and bycatch patterns must be predictable within a season (Abbott and Wilen, 2010; Gauvin et al., 1996,).

The life histories of these five species suggests there are times when alosines are spatially separated from Atlantic herring and mackerel. Alosines are anadromous as they are born in freshwater but spend most of their life at sea, only returning to freshwater when they are mature, spawning adults. Atlantic herring and mackerel exhibit oceanodromy as they spend their entire life cycle and make extensive migrations within the marine environment (McDowall, 1987; Tsukamoto et al., 2009). Anadromy and oceanodromy, represent two different evolutionary paths resulting in unique migratory patterns for alosines, Atlantic herring and mackerel in the Northwestern-Atlantic (Creaser et al., 1984; Dadswell et al., 1987; Leggett and Whitney, 1972; Neves and Depres, 1979; Neves, 1981; Sette, 1943; Sinclair and Iles, 1985; Stevenson and Scott, 2005; Studholme et al., 1999). In the fall and winter these distinct migratory routes overlap. However, fishes form schools to lower predation risk, optimize feeding, reduce energy use and for spawning purposes. These benefits could be reduced by schooling with fishes of other species (Cushing and Jones, 1968; Hoare et al., 2000; Krause et al., 2000; Parrish and Turchin, 1997; Radakov, 1973). Pelagic, forage fish prefer conspecific schools comprised of fishes of the same size, shape, or color (see Freon and Misund, 1999; Krause et al., 2000; Radakov, 1973 for a review of field studies). Mixed species schools do occur but are usually dominated by one species (Freon and Misund, 1999; Hoare et al., 2000; Krause et al., 2000). Thus, alosines may be spatially separated from Atlantic herring and mackerel on a small scale (size of schools) but occupy the same area at a larger scale (fishing grounds). Under this scenario it is plausible that mid-water trawl vessels could move from areas with high amounts of alosines to areas with few alosines but adequate amounts of Atlantic herring and mackerel.