Sustainable Fishery Management Plan for New York River Herring Stocks

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Executive Summary

Amendment 2 to the Atlantic States Marine Fisheries Commission Shad and River Herring Interstate Fishery Management Plan requires member states to demonstrate that fisheries for river herring (alewife and blueback herring) within their state waters are sustainable. A sustainable fishery is defined as one that will not diminish potential future reproduction and recruitment of herring stocks. If states cannot demonstrate sustainability to the Atlantic States Marine Fisheries Commission (ASMFC), they must close their herring fisheries.

New York State proposes to maintain a restricted river herring (alewife and blueback herring) fishery in the Hudson River and tributaries and to continue closures of river herring fisheries elsewhere in the State. This proposal conforms to Benefit 4 of the New York State Hudson River Estuary Action Agenda.

<u>Stock Status</u>

Alewife and blueback herring are known to occur and spawn in New York State in the Hudson River and tributaries, the Bronx River, and several streams on Long Island. The Hudson River is tidal to the first dam at Troy, NY (rkm 245). Data on stock status are available for the Hudson River and tributaries. Few data are available for river herring in streams in Bronx County, southern Westchester County, and on Long Island. River herring are rarely encountered in the New York portion of the Delaware River.

Hudson River: Commercial and recreational fisheries exploit the spawning populations of river herring in the Hudson River and tributaries. Most river herring taken in the Hudson and tributaries are used as bait in the recreational striped bass fishery. Recreational fishers are allowed take of river herring with a variety of small nets as well as hook and line. The magnitude of the recreational fishery for river herring is unknown for most years. However, we have estimated recreational harvest from 2007-2015 using data obtained from our Cooperative Angler Program and a statewide creel survey conducted in 2007. Estimated recreational herring harvest ranged from 78,491 fish in 2007 to 386,915 fish in 2015, with an average of 312,036 herring from 2013-2015. Based on average weights of river herring collected during that time period (2013-2015), this equates to approximately 103,300 pounds annually. To put this estimated recreational harvest in context, run counts from Black Creek, a small tributary with approximately 1.8 km of available spawning habitat, averaged 409,234 alewives (approximately 139,000 pounds) annually during the same time period. Black Creek is just one of the 68 primary tributaries to the Hudson River.

Data on commercial harvest of river herring in New York State are available since the early 1900s. Several peaks occur during the time period. The first peak was in the early 1900's (501,438 pounds) followed by a lull until the period prior to World War II when landings peaked a second time in 1935 (274,405 pounds). Post WW II there was another period of low landings until a final peak in 1982 (229,201 pounds). Combined ocean and river landings in New York waters has remained relatively low, with some data gaps, during the rest of the 1980s through present.

Since 1995, landings have been separated between the Hudson and other waters (marine) but due to optional participation and minimal enforcement of commercial reporting, any in-river reporting from 1995-1999 is unreliable. From 2000 to 2012, landings averaged 15,061 pounds, peaking in 2002 at 20,346 pounds. Following regulation changes in 2013, reported commercial landings declined to roughly 45% of the average from 2000 through 2012.

From 2013-2015, an average of 156 fishers annually purchased commercial gill net permits and approximately 121 purchased commercial scap net permits. According to the required annual reports, an average of 35% of these permitees actively fished from 2013 to 2015, and of those that used the commercial gears, roughly half of gill net users and the majority of scap net users reported catches as taken for "personal use" or "personal bait".

Fishery dependent data on river herring status since 2000 are available from commercial reports and from on-board monitoring. Annual scap net efforts were relatively steady through 2012, but dropped dramatically in 2013 when net use became prohibited in tributaries. Scap net CPUEs declined from 2000 to 2007, but have increased from 2007 to present. Drift gill net CPUEs have increased steadily since 2000, with efforts declining since 2006. Fixed gill net effort in the lower river has decreased steadily since 2000, but CPUEs have been increasing since 2010.

The extent of the loss of New York's river herring stocks through bycatch in ocean commercial fisheries remains largely unknown; however, the recent increase in the occurrence of repeat spawn marks in both species of river herring are indicative of reduced mortality while at sea.

Fishery independent data on size and age composition of river herring spawning in the Hudson River Estuary are available from 1936, intermittently since the late 1970s and annually beginning in 2012. Prior to 2012, the intermittent effort expended to catch river herring resulted in relatively low and variable catches. Data collected in 1936 (Greeley 1937) are used as reference only due to very small sample sizes. However, these data provide a historic perspective of potential maximum sizes of both species of river herring.

Mean total length and mean length at age of both river herring species in the Hudson River have increased since 2012 when sampling efforts increased and became consistent. Maximum total lengths and mean length at age of both species are approaching or have exceeded those reported in 1936 by Greeley. Since 2012, mean length at age for both species across all ages have been either stable or increasing with the majority increasing. The increases in mean length and mean length at age are indicative of reduced mortality both within river and during ocean residency.

Mortality estimates derived from age and repeat spawning data have followed similar trends in most years. Mortality estimates for alewives declined from 2012-14. In 2015, age based mortality estimates increased while repeat spawn based mortality estimates decreased. This may be due to a large year class moving through the fishery resulting in over dispersion of older fish, and is further compounded by fewer age three and age four fish observed in 2015. Mortality estimates for blueback herring have declined or remained stable since 2012.

Young-of-year (YOY) production has been measured annually by beach seine since 1980. CPUE of alewife remained low through the late 1990s and has since increased erratically. CPUE of young of year blueback herring has varied with a very slight downward trend since 1980; however, the 2014 index value was the highest in the history of the survey.

Streams on Long Island, Bronx and south shore of Westchester County:
Limited data that have been collected for Long Island river herring populations are not adequate to characterize stock condition or to choose a measure of sustainability.

Delaware River in New York:
River herring in the New York portion of the Delaware River are very rare. While there have been individual YOY fish occasionally found (Horwitz et al. 2014), we have no record of any fishing effort for either species.

Proposed Fishery for the Hudson River and Tributaries

Given the measures of stock status described above, we are proposing a continuation of the Hudson River fishery at this time. This includes a continuation of the restricted fishery in the main-stem Hudson River, a partial closure of the fishery in tributaries, and annual stock monitoring as described in the previous SFMP (Hattala et al. 2011a). As outlined in the previous plan, we propose to continue to use the sustainability target for juvenile indices which is defined as three consecutive juvenile index values below the 25th percentile of the time series. We will monitor, but not set targets for mean length and mean length at age from fishery independent spawning stock sampling as well as the CPUE in the commercial fixed gill net fishery in the lower river below the Bear Mountain Bridge. We will also monitor the frequency of repeat spawning and total mortality from fishery independent sampling. Once an adequate time series of data is collected, we will investigate appropriate methods to develop mortality based benchmarks to be used as sustainability targets in future sustainable fishing plans.

A summary of existing restrictions are provided in Appendix 1. Restrictions to the recreational fishery include: a 10 fish per day creel limit for individual anglers with a boat limit of 50, a 10 fish creel limit per day for paying customers with a boat limit of 50 for charter vessels, no use of nets in tributaries, and the continuation of various small nets in the main river. Restrictions to the commercial fishery and use of commercial gears include: a net ban in the upper 28 km of the main-stem estuary, on the American shad spawning flats, and in tributaries; gill net mesh and size restrictions; a ban on fixed gears or night fishing above the Bear Mountain Bridge; seine and scap/lift net size restrictions; 36 hour lift period to all commercial net gears; and monthly mandatory reporting of catch and harvest.

Proposed Moratorium for streams on Long Island, Bronx County, the southern shore of Westchester County, and the Delaware River and its tributaries north of Port Jervis NY

Due to the inability to determine stock condition for these areas, New York State proposes to continue a closure of all fisheries for river herring in Long Island streams and in the Bronx and Westchester County streams that empty into the East River and Long Island Sound and New York's portion of the Delaware River as outlined in the previous SFMP (Hattala et al. 2011a).

This SFMP does not directly address incidental catch in the ocean, but focuses on fisheries managed exclusively by New York State. New York is working with the National Marine Fisheries Service, the New England Fishery Management Council and the Mid-Atlantic Fishery Management Council to reduce incidental river herring harvest in fisheries managed by these groups.

CONTENTS

1 INTRODUCTION

Amendment 2 to the Atlantic States Marine Fisheries Commission Shad and River Herring Interstate Fishery Management Plan was adopted in 2009. It requires member states to demonstrate that fisheries for river herring (alewife and blueback herring) within state waters are sustainable. A sustainable fishery is defined as one that will not diminish potential future reproduction and recruitment of herring stocks. If states cannot demonstrate sustainability to ASMFC, they must close their herring fisheries.

In response to Amendment 2 New York State proposed, and ASMFC approved, a Sustainable Fishery Management Plan (SFMP) (Hattala et al. 2011a). This SFMP included an experimental five year restricted fishery in the Hudson River, a partial fishery closure in tributaries, and annual stock monitoring. Monitoring includes young of year indices, and for adults: age and length characteristics, mortality estimators, and commercial fishing catch per unit effort (CPUE).

The following proposes a new five year SFMP for river herring in waters of New York State. The goal of this plan is to ensure that river herring resources in New York provide a source of forage for New York's fish and wildlife and provide opportunities for recreational and commercial fishing now and in the future.

The fisheries that existed back in colonial days in the Hudson Valley of New York undoubtedly included river herring among the many species harvested. River herring, comprised of both alewife (*Alosa pseudoharengus*), and blueback herring (*Alosa aestivalis*) were among the fish mentioned by early explorers and colonists – the French Jesuits, Dutch and English. Archaeological digs along the Hudson in Native American middens indicates that the fishery resources in the river provided an important food source to Native Americans.

Written records for river herring harvest in New York begin in the early 1900. Landings peaked in the early 1900s and in the 1930s and then declined through the 1980s. Landings increased again through 1998, but have since declined. Factors in addition to fishing have affected the stocks: habitat destruction (filling of shallow water spawning habitat; loss of access to tributary spawning habitat through the construction of dams and culverts) and water quality problems associated with pollution that caused oxygen blocks in major portions of the river (Albany and New York City). Water quality has improved over the last 30 years.

New York State does not augment wild river herring stocks with hatchery progeny. The New York City Parks Department initiated an experimental restoration program in which alewife were captured in a Long Island Sound tributary in Connecticut and released in the Bronx River above the first barrier. Limited returns to the river suggest that some reproduction has occurred from these stockings. A variety of non-governmental organizations along with state and federal agencies are working on development of fish passage for river herring on Long Island streams and Hudson River tributaries.

2 MANAGEMENT UNITS

The management unit for river herring stocks in New York State comprises three sub-units. All units extend throughout the stock's range on the Atlantic coast.

- The largest consists of the Hudson River Estuary from the Verrazano Narrows at New

York City to the Federal Dam at Troy including numerous tributary streams (Figure 1).

- The second is made up of all Long Island streams that flow into waters surrounding Long Island and streams on the New York mainland (Bronx and Westchester Counties) that flow into the East River and/or Long Island Sound (Figure 2).
- The third subunit consists of the non-tidal Delaware River and tributaries upriver of Port Jervis, NY.

2.1 Description of the Management Unit Habitat

2.1.1 Hudson River and tributaries

Physical description and habitat use:

The Hudson River flows from Lake Tear of the Clouds in the Adirondacks to the Battery in New York City. It is influenced by tides to the Federal Dam in Troy, 245 km from the Battery. The salt front moves, depending on freshwater inputs from Hudson River tributaries and tidal flow, and generally varies in location from Tappan Zee (rkm 45) to Newburgh (rkm 95). The river includes two major estuarine bays: Haverstraw Bay (rkm 55) and Tappan Zee Bay (rkm 45). These bays are mainly shallow water less than four meters deep where the river extends up to five and a half kilometers from shore to shore. The river also includes a narrow and deep section, the Hudson Highlands, where the river is less than one kilometer wide and over 30 meters deep (Stanne et al., 2007).

The Hudson River below the Federal Dam at Troy has approximately 68 primary tributaries, most of which provide some spawning habitat for river herring (Schmidt and Lake 1996). The largest of these tributaries is the Mohawk River, which enters the Hudson two kilometers north of the Troy Dam. Diadromous fish access to the Mohawk River, and portions of the non-tidal Hudson above the Federal Dam, is possible only through the Erie Canal and Champlain lock system. Fish passage for migratory species at the Troy dam is required by a 2009 FERC relicensing settlement agreement and is in the design phase. Other major tributaries of the Hudson River, all in the estuary, include the Croton River, Wappingers Creek, Rondout Creek, Esopus creek, Catskill Creek, and Stockport Creek.

River herring in the Hudson River spawn in the spring. Alewives are the first to enter the estuary, arriving as early as mid-March and spawning through mid-May. Blueback herring arrive slightly later, generally in April and spawning into early June (Hattala et al. 2011a; Eakin, Cornell University, unpublished data). River herring spawn in the entire freshwater portion of the Hudson and its tributaries up to the first impassible barrier. Adults of both species spawn in Hudson River tributaries, but also spawn in shallow waters of the main-stem Hudson. The nursery area for river herring includes the spawning reach and extends south to Newburgh Bay (rkm 90) encompassing the freshwater portion of the estuary.

Some river herring migrate upstream of the Federal Dam through the Champlain and Erie Canal lock systems. We do not know: 1) if a significant number of river herring move upstream of the dam relative to the entire Hudson River spawning population 2) how many post-spawn adult river herring survive their return trip out of the canal system or 3) if the juvenile herring are able to survive and return to the Hudson River below the Federal Dam. Construction of passage on the Federal Dam will facilitate upstream and downstream migration.

2.1.2 Long Island and Westchester County

Physical description and habitat use:

Freshwater tributaries in the New York portion of the Atlantic Ocean and Long Island Sound watershed are also important for New York river herring (Figure 2). This watershed drains most of the New York City Metropolitan Area, all of Long Island, and portions of Westchester County. The Atlantic Ocean coastline extends 189 kilometers from Rockaway Point to Montauk Point. The watershed includes 840 kilometers of freshwater rivers and streams.

The herring runs in streams on Long Island are comprised almost exclusively of alewife (B. Young, NYSDEC retired, personal communication). Most streams are relatively short runs to saltwater from either head ponds (created by dammed streams) or deeper kettle-hole lakes. Either can be fed by a combination of groundwater, run-off, or area springs. Spawning occurs mid-March through May in the tidal freshwater below most of the barriers. Natural passage for spawning adults into the head ponds or kettle lakes is present in very few streams.

There have been limited efforts to understand river herring runs on Long Island since 1995. Several known runs of alewives on Long Island occur in East Hampton, Southampton, Riverhead and Brookhaven. With the advent of a more aggressive restoration effort in Riverhead on the Peconic River other runs have come to light. Since 2006, an annual volunteer alewife spawning run survey has been conducted. This volunteer effort predominantly documents the presence or absence of alewives in Long Island coastal streams. In 2010, a volunteer investigation was initiated to quantify the Peconic River alewife run. Size and sex data have been collected annually since 2011. A first order estimate of the Peconic River spawning run size has been attempted since 2010; attempts have been made to improve these observations with video counts with limited success. These efforts have been undertaken to understand the Long Island coastal streams and to improve the runs that exist there.

We have no record of river herring in any of the streams in southern Westchester County. In the Bronx River (Bronx County) alewives were introduced to this river in 2006 and 2008 and some adult fish returned in 2009 (Jackman and Ruzicka 2009). Monitoring of this run is in its early stages.

2.1.3 Delaware River

River herring in the New York portion of the Delaware River are very rare. While there have been individual young-of-year (YOY) fish occasionally found (Horwitz et al 2014), we have no record of any fishing effort for either species.

2.2 Habitat Loss and Alteration

Hudson River Estuary

Hudson River tributaries provide important habitat to both migrating and resident fishes, as well as other wildlife. Barriers to upstream and downstream movement exist in tributaries to the Hudson River, many of them in relatively short distance upstream from the confluence with the

Hudson River. While many of these barriers are natural features, such as waterfalls and ledges, there exist numerous anthropogenic barriers, including dams (some opportunistically built on top of existing natural barriers), undersize and improperly positioned culverts, and undersized bridges. Thus, many opportunities exist to remove man-made barriers in order to restore historical upstream and downstream access to important habitats for both diadromous and resident fishes. Based on NOAA's 2009-2014 evaluation of 67 lower Hudson tributaries, the first barrier upstream from the Hudson are man-made on 27 tributaries, while 37 are natural and three are undetermined (Alderson and Rosman 2014). After further assessment to consider where barrier removal is practical and beneficial to river herring, this research estimated that 56 tributary kilometers have the potential to be opened to river herring via the removal of 27 barriers on 14 tributaries. The largest gains in total stream miles can be found on the following five tributaries: Claverack, Croton, Moodna, Rondout, and Sparkill Creeks. Restoration opportunities on these five tributaries could enhance access to river herring habitat for an estimated 35.8 kilometers. Removal of man-made barriers in the Hudson River Estuary is a high priority because of the potential for habitat gains and the perceived limitation of number of opportunities for large-scale restoration.

The introduction of zebra mussels in the Hudson in 1991, and their subsequent explosive growth in the river, quickly caused pervasive changes in the phytoplankton (80% drop) and micro- and macro-zooplankton (76% and 50% drop respectively) communities (Caraco et al. 1997). Water clarity improved dramatically (up by 45%) and shallow water zoobenthos increased by 10%. Given these massive changes, Strayer et al. (2004) explored potential effects of zebra mussel impact on YOY fish species. Most telling was a decrease in observed growth rates and abundance of YOY fishes, including open-water species such as alewife and blueback herring. A decade later, Strayer et al. (2014), reporting on the improvement in zooplankton and macrobenthos inhabiting deep water indicated that abundance of juvenile alewives increased during the late zebra mussel invasion period while post-yolk sac larval abundance did not. The abundance of post-yolk sac and juvenile American shad and post-yolk sac river herring declined during the early to later zebra mussel invasion period. It is not yet clear how this constraint affects annual survival and subsequent recruitment.

Another factor that is not well researched or understood is the potential barriers posed by the railroads along both the east and west sides of the Hudson River. Tributaries once flowed freely, with unobstructed hydraulics, from the upland valley to the wide estuary. While these connections still exist, they are much different today than they were historically. Tributaries are forced through bridge and culvert constrictions under the tracks as they make their way to the Hudson River. The impact of this funneling effect on access from the Hudson into tidal tributary mouths is not well understood.

Long Island and Westchester County

Most streams on Long Island and in Westchester County were impacted by human use as the population expanded. Many streams were blocked off with dams to create head ponds, initially used to contain water for power or irrigation purposes for agriculture. The dams remain; only a few with passage facilities. Many streams were also negatively affected by the construction of highways, with installations of culverts or other water diversions which impact immigrating fishes.

2.3 Habitat Restoration

Hudson River Estuary

The Hudson River Estuary Habitat Restoration Plan (Miller 2013) has identified a number of river and tributary restoration activities that will benefit river herring, including barrier mitigation and side channel restoration. Recent research has highlighted important barrier removal opportunities for river herring habitat in the Hudson River Estuary (Alderson and Rosman, 2014). Mitigation of these barriers is an important priority for many researchers, non-profits, and local governments in the estuary, and features prominently in the Hudson River Estuary Program's Action Agenda 2015-2020 (2015).

In May 2016, the first dam upstream of the confluence with the Hudson River was removed from the Wynants Kill, a relatively small tributary in Troy, NY, downstream of the Federal Dam. Within days of the May 2016 removal, hundreds of herring moved past the former dam location into upstream habitat. Subsequent sampling efforts yielded river herring eggs, providing evidence that river herring were actively spawning in the newly available habitat. This dam removal will provide an additional half kilometer of spawning habitat for river herring that has not been available for 85 years.

There are also a number of side-channel restoration projects under development that will improve habitat for river herring in the estuary. Side channels within the river bed provide important shallow water and intertidal habitats that are isolated from the higher energy regime of the main channel. These side channels historically occurred in the northern third of the estuary as part of a braided river-channel system dominated by vegetated shallows and intertidal wetlands. These habitats were destroyed on a large scale in the early twentieth century, particularly in the upper estuary, as a result of dredge and fill activities associated with construction of the federal navigation channel.

Gay's Point (rkm 196) has been identified as a potentially suitable location for side channel creation. The site consists of an artificially created tidal embayment that is separated from the main river channel by dredge spoils. Contiguous backwaters, such as those at Gay's Point, typically have lower current velocities, greater sediment deposition resulting in finer substrates, higher water temperatures, and lower dissolved oxygen levels than side channels with relatively unimpeded flow. Increasing tidal flow through the embayment at Gay's Point is anticipated to improve water quality, provide coarser-grained bed materials, and ultimately create more productive spawning, nursery, and foraging habitat for river herring. This project is currently under way and is being overseen by the New York State Department of Environmental Conservation.

Long Island and Westchester County

Initial barrier mitigation to benefit river herring was summarized in the last SFMP, and included restoration of herring runs on the Carmans and Peconic Rivers (Hattala et al. 2011a), and rudimentary fish passage at Beaver Lake, Oyster Bay. Since 2011, additional completed barrier mitigation projects that benefit alewife include the installation of passage devices at five locations (Canaan Lake, Brookhaven; Twin Ponds, Centerport; Argyle Lake, Babylon; Udall's Mill Pond, Saddle Rock; and Massapequa Creek, Massapequa); a box culvert modification at Alewife creek, Southampton; and a dam removals at Harrison Pond in Smithtown and at Crab

Meadow. Additionally, the installation of fish passage devices on the Bronx River and at the Edwards Avenue dam in Riverhead may provide additional spawning habitat once further barriers have been mitigated.

Barrier mitigation remains a priority for a number of environmental groups and local, state, and federal agencies. We are aware of at least six additional projects that are likely to occur in the next five years.

3 STOCK STATUS

Following is a description of all available data for the Hudson's river herring stocks, plus a brief discussion of their usefulness as stock indicators. Sampling data are summarized in Tables 1 and 2. Sampling was in support of Benefit 4 of the Hudson River Estuary Action Agenda and was partially funded by the Hudson River Estuary Program.

3.1 Fisheries Dependent Data

3.1.1 Commercial Fisheries

Ocean Harvest

Range of the New York river herring along the Atlantic coast is from the Bay of Fundy, Canada and Gulf of Maine south to waters off Virginia (NAI 2008; Eakin 2016).

Directed Ocean Harvest

Directed ocean harvest within state waters of river herring was effectively eliminated through the passage of Amendment 2 to the Atlantic States Marine Fisheries Commission Shad and River Herring Interstate Fishery Management Plan in 2009. The amendment requires member states to demonstrate that fisheries for river herring within their state waters are sustainable. As of 2016, five states (Maine, New Hampshire, New York, North Carolina, and South Carolina) have approved plans in place and none of these plans identifies directed ocean harvest as a component of their sustainable fishery management plan.

Incidental Ocean Harvest

Quantifying the impact of bycatch and incidental fisheries on Hudson River herring remains difficult. Two Federal councils have identified alternatives to reduce catch of river herring in their Fishery Management Plans (FMP). The Mid Atlantic Fisheries Management Council's (MAFMC) Amendment 14 of the Atlantic Mackerel, Squid and Butterfish FMP and the New England Fishery Management Council's (NEFMC) Amendment 5 to the Atlantic herring FMP both identified shad and river herring as incidental catch in these directed fisheries and acknowledged the need to minimize catch of shad and river herring. Both of these plans, through the amendments identified above and subsequent framework adjustments:

- Implemented more effective monitoring of river herring and American shad catch at sea
- Established catch caps for river herring and American shad

- Identified catch triggers and closure areas

Fishery observer data are used to estimate and monitor the river herring and American shad captured by Atlantic herring and Atlantic mackerel vessels that land more than three metric tons (mt) per trip using methodology developed by the Greater Atlantic Regional Fisheries Office (GARFO), of the NOAA Fisheries. River herring and American shad bycatch and bycatch quotas are presented in Table 3 and Table 4.

While the data in Table 3 and Table 4 provide us with an estimate of the incidental catch of river herring and American shad in these fisheries, it does not identify the bycatch by species. However, Amendment 14 of the Mackerel, Squid and Butterfish FMP does present species-specific data by region and fleet from earlier years (Table 5). Observed annual alewife catch between 1989 and 2010 ranged from 2.7 mt to 484 mt with an annual average of 119 mt. Observed annual blueback herring catch between 1989 and 2010 ranged from 19.6 mt to 1,803 mt with an annual average of 290 mt. In some years, large portions of the incidental catch was not identified to species. If we apply the same annual proportion of river herring composition from the known catch to the unknown catch, the total estimated river herring catch in the period 1989-2010 ranged from 42.8 mt to 2,313 mt with an annual average of 499 mt.

We were only able to locate data that distinguished catch by species for the time period 1989-2010. More recent data present incidental harvest data by fishery, but do not distinguish among species. In order to get a general sense of the magnitude of potential harvest from these fisheries (Table 6), we applied the average proportion of known harvest that was river herring from the historic data (80%, from Table 5) to the combined river herring and American shad catch. Unfortunately, it is impossible to determine which river herring stock(s) were affected by the harvest from these mixed stock fisheries. Directed and incidental harvest from New York waters are shown in Figure 3.

Commercial Gear Use in the Hudson River

The current commercial fishery in the Hudson River exploits the spawning migration of both alewife and blueback herring. River herring may be commercially caught in the Hudson River from March 15th to June 15th, dates inclusive. The primary use of commercially caught herring is for bait in the recreational striped bass fishery. An annual commercial Hudson River permit allows use of the following gears: gill nets, scoop/dip/scap nets, seines, fyke nets, and trap nets. Permit holders are required to report effort and harvest to the Department. In response to Amendment 2, more stringent regulations were put into place in 2013. Highlights include the closure of tributaries to nets, net size restrictions for scap nets, and monthly reporting. Changes in regulation are listed in bold in the second column of Table A in Appendix 1.

Fishing effort and commercial gear use has historically been different south of the Bear Mountain Bridge (rkm 75) than in the northern reaches. This is roughly the location of the salt front in the spring. As such, this bridge is used as a demarcation for gear use. The fishery below the Bear Mountain Bridge intercepts fish moving to freshwater spawning areas, while the fishery north of the bridge targets river herring in their spawning aggregation areas.

The intercept fishery is a fixed gill net fishery that occurs in the main-stem river from rkm 40 to rkm 75 (Piermont to Bear Mountain Bridge, Figure 1). In this stretch, the river is fairly expansive (up to 5.5 km) with wide, deep-water (~ six to eight m) shoals bordering the channel. Most fishers in this portion of the fishery choose specific locations within these shoals and sample in the same locations each year. The fishermen generally fish these nets from 12-24 hours per trip. Since 2013, an average of 22 active fishers annually participated in this lower river fixed gill net fishery. Nets are 7.6 to 91 m long, with meshes ranging from 4.4 to 8.9 cm stretch.

Fishermen in the freshwater portion of the fishery, above Bear Mountain Bridge, use drift gill nets to sample the main-stem of the Hudson River. This gear is used up to rkm 225 (Castleton) where the river is much narrower (1.6 to 2 km wide). Since 2013, an average of 49 fishers annually participate in this mid river gill net fishery. Nets range in length from 6 to 183 m with mesh size ranges from 3.8 to 8.9 cm stretch. These nets must be tended at all times, and most are fished for less than two hours per trip. Though restricted from use in the 2013 regulation changes, commercial reports indicate fixed gill nets have been used in roughly 19% of gill net trips above Bear Mountain since 2013. We are working with both the fishermen and law enforcement to resolve this issue.

Scap nets (also known as lift and/or dip nets) is the other major gear used in the freshwater river herring fishery. Prior to 2013, this gear was primarily used in the major river herring spawning tributaries. The current scap/lift net fishery occurs in main-stem river from roughly rkm 90 to rkm 228 (Cornwall-on-Hudson to Port of Albany). Scap/lift nets range in size from 0.28 to 59.7 m^2. On average, 31 fishers have annually reported the use of this gear type since 2013.

It is important to note that many commercial permit holders are recreational anglers taking river herring for personal use as bait or food. Over the last three years, an average of 156 gill nets and 121 scap nets permits were sold annually. According to the required annual reports, however, only 35% of the permitees actively fished from 2013 to 2015 (Table 7), and of those that used the commercial gears, roughly half of gill net users and the majority of scap net users reported catches as taken for “personal use” or “personal bait” (Figure 4).

Commercial Landings and License Reporting

Recorded landings of river herring in New York State began in the early 1900s (Figure 3). Anecdotal reports indicate that herring only played a small part in the historic commercial fishing industry in the Hudson River. Total New York commercial landings for river herring include all herring caught in all gears and for both marine and inland waters. Several different time series of data are reported including several state sources, National Marine Fisheries Service (NMFS), and more currently Atlantic Coastal Cooperative Statistics Program (ACCSP). NMFS data do not specify river or ocean source(s) and landings are often reported as either alewife or blueback herring, but not both in a given year. It is unlikely that only one species was caught. From 1995 to the present, the Department has summarized landings and fishing effort information from mandatory state catch reports required for Hudson River marine permits. Full compliance for this reporting started in 2000. All Hudson River data are sent to NMFS and ACCSP for incorporation into the national databases.

Because of the discrepancies among the data series and the lack of information to assign the landings to a specific water body source, only the highest value from all sources is shown in Figure 4. This method limits double counting. Several peaks occur during the time period. The first peak was in the early 1900’s (501,438 pounds) followed by a lull until the period prior to World War II when landings peaked a second time in 1935 (274,405 pounds). Post WW II there was another period of low landings until a final peak in 1982 (229,201 pounds). Combined ocean and river landings in New York waters has remained relatively low, with some data gaps, during the rest of the 1980s through present. In 1966, roughly 4.2 million pounds were landed (omitted on Figure 4), followed by a series of years of low landings with another peak in 1982. Landings were low, with some data gaps during the rest of the 1980s through present.

Hudson River Landings

Since 1995, landings are separated between the Hudson and other waters (marine). However due to optional participation and minimal enforcement of commercial reporting, any in-river reporting from 1995-1999 is unreliable. It is likely that additional effort was shifted to river herring catches during this time-period than is reported. Moving forward, analyses on in-river landings begin in 2000.

The primary outlet for harvest taken by commercial Hudson River permits is for the in-river bait industry. From 2000 to 2012, nearly all reported commercial river herring landings were split between scap/lift nets (~49% of the catch) and gill nets (~16% drift and ~35% fixed) (Figure 5). From 2000 to 2012, combined landings averaged 15,061 pounds, peaking in 2002 at 20,346 pounds. Post regulation change in 2013, landings declined to roughly 45% of the average from 2000 through 2012. Scap nets accounted for the largest portion of this decline. This is a result of the ban on nets from tributaries, where most commercial scap netting occurred. As the demand for bait has probably not diminished, we expected an increase in landings for the other gears. Though there was a slight increase in drift gill net landings, a big portion of this missing harvest has likely shifted to non-commercial gears, such as hook and line, cast nets, and small scap nets. These personal use gears do not have a mandatory reporting requirement.

Commercial Discards

From 1996 to 2015, river herring were not reported as discards on any mandatory reports targeting herring in the Hudson River or tributaries.

Hudson River Commercial Harvest Rates – Mandatory Reports

Relative abundance of river herring is tracked through catch per unit effort (CPUE) statistics of fish taken from the targeted river herring commercial fishery in the estuary. All commercial fishers fill out monthly mandatory reports. Reports include catch, discards, gear, effort, and fishing location for each trip. CPUEs are calculated as total catch divided by total effort (square yards of net * hours fished), separately by gear type (fixed gill nets, drift gill nets, and scap nets). Annual mean CPUEs are summarized differently based on the location of fishing effort.

Above the Bear Mountain Bridge (rkm 75) and within the spawning reach, drift gill nets and scap nets are the primary gears. In this section of river, fishermen catch fish that are either staging or moving into areas to spawn. Gears are generally not deployed until fish are present. CPUEs for gears above the Bear Mountain Bridge are calculated as total annual catch/total annual effort. Below the Bear Mountain Bridge (rkm 75) and thus below the spawning reach, fixed gill nets are the primary commercial gear. In this section, nets are fished in roughly the same location each year by a consistent group of fishermen. These fishermen capture fish moving upriver to spawning locations and run size is determined by number (density) of spawners each week as well as duration (number of weeks) of the run. Annual CPUEs in this reach are calculated as the sum of weekly CPUEs to best capture the periodicity of run. Annual efforts and CPUEs for the main commercial river herring gears are shown in Figure 6. Values for drift gill and scap net values in Figure 6 are only for trips above rkm 75, while fixed gill net values are only for trips made below rkm 75.

As shown in Part A of Figure 6, drift gill net CPUEs have increased steadily since 2000, with efforts declining since 2006. Annual drift gill net trips by river section above the Bear Mountain Bridge are shown in Table 8. On average, 74% of drift gill net trips take place in the Saugerties and Catskill reaches. Based on historical information on spawning (Schmidt et al. 1994; Schmidt and Lake 2000) as well as the recent results from the fishery independent survey described in Section 4.2.1, these sections make up a small portion of the habitat available for spawning. In addition, there are two significant stretches of river where gill net use is prohibited. Due to the opportunistic nature of the upriver fishery (fishermen only fish when river herring are present), as well as the large amount of variability in effort within the freshwater spawning reach, we do not believe this dataset to be reliable annual abundance indicator.

Annual scap net CPUEs and efforts are shown in Part B of Figure 6. Efforts were relatively steady through 2012, but dropped dramatically in 2013 when net use became illegal in tributaries. Scap net CPUEs declined from 2000 to 2007, and have increased from 2007 to present. Due to significant changes in the fishery due to regulation, we do not think this commercial gear is a reliable relative abundance indicator.

Part C of Figure 6 shows effort and CPUEs for the lower river fixed gill net fishery. Effort in this fishery has decreased steadily since 2000, but the annual sum of weekly CPUEs has been increasing since 2010. Because most river herring must pass through this fishery on the way to freshwater spawning reaches and tributaries, it has the best chance at sampling the entirety of the spawning stocks of both species. As such, these CPUEs likely provide the best abundance indicator of the three main commercial gears.

Hudson River Commercial Harvest Rates – Monitoring Program

Up until the mid-1990s, the Department's commercial fishery monitoring program was directed at the American shad gill net fishery, a culturally historic and economically important fishery. We expanded monitoring to the river herring fishery in 1996, but remain limited by available manpower and the ability to connect with the fishers. Monitoring focuses on the lower river fixed gill net fishery since we considered it to be a better measure of annual abundance trends (see section above).

Data are obtained by observers onboard commercial fishing vessels. Technicians record numbers of fish caught, gear type and size, fishing time, and location. Scale samples, lengths and weights are taken from a subsample of the fisher's catch. CPUE is based on gear type and location and is calculated by the method used for summarizing mandatory report data (above).

Since 1996, staff monitored 107 trips targeting river herring (lower river: 93; mid and upper river: 14) (Table 9). Annually, these trips were sporadic and sample sizes were low, from zero to 20 trips per year. Because of these few annual trips and samples, the resulting CPUE is considered unreliable for tracking relative abundance. However, as shown in Figure 7, the commercial monitoring CPUE for fixed gill nets in the lower river follows the same trend as the lower river CPUE from the same gear in the mandatory commercial catch reports (correlation value 0.81, $p < 0.001$). This is indicative that our monitoring efforts capture trends in the reported fishery, and with increased sample sizes for commercial monitoring, we expect this relationship to improve. In addition, active monitoring provides the only data on catch composition of the commercial harvest and we consider these data to be useful.

Commercial Harvest Monitoring- Catch Composition, Size and Age Structure

Catch composition in the fixed gill net fishery varies annually, most likely due to small sample sizes and when the samples occurred (early or late in the run) (Table 10). Annual observed landings ranged from 44 to 2,450 fish, with alewives observed more often than blueback herring. The sex ratio of alewives was nearly equal (~ 50:50) in all years; however, female blueback herring were observed more often than male blueback herring most likely due to the size selectivity of gill nets fished.

Mean lengths and weights of dockside subsamples are shown in Figure 8. Though sample sizes are relatively low for certain years, there is an increasing trend in length and weight for both species since 2010. This trend is similar to the one observed for both species in the spawning stock survey (Section 3.2.2 below).

Age data for samples collected during the commercial monitoring program were processed and analyzed in the methods described in Appendix 2. Ages were estimated for a subsample of the scale samples in 2012 and we used an age length frequency table from these data to estimate ages for the remaining scale and length samples from the 2012 commercial fishery. Mean length at age for 2012 commercial samples were then compared to the mean length at age for fish taken in the Fishery Independent survey in 2012 (Figure 9). As there was little deviation in mean length at age for both species among the surveys, we used the annual age-length keys (see *Age and Repeat Spawn* in Section 3.2.2 below) derived from samples collected during the Fishery Independent Survey to estimate the respective year's commercial fishery age structure from 2013-2015.

Table 11 displays the age structure for dockside samples taken from 2012 to 2015. Mean age for sexes of both species is trending upward, which corresponds with the increase in mean lengths during the same time period as well as the increasing trend in the fishery independent age dataset described in Section 3.2.2.

Long Island, Bronx and Westchester Counties:

As of 2013, commercial river herring fisheries have been closed in the marine and coastal district of NY.

3.1.2 Recreational Fishery

Hudson River and tributaries: The recreational river herring fishery exists throughout the main-stem Hudson River, and its tributaries including those in the tidal section and above the Troy Dam (Mohawk River). Some recreational herring fishers use their catch as food (smoking/pickling). However, the recreational river herring fishery is driven primarily by the need for bait in the recreational striped bass fishery.

In concert with the change in commercial regulations in 2013, new regulations were put into place for the recreational fishery in response to Amendment 2. Regulations for recreational take are found in Table B of Appendix 1. The most significant changes were creel limit of 10 fish per day or 50 fish per boat, as well as the prohibition of personal net use in tributaries. All 2013 changes are denoted in bold in Table B.

The magnitude of the recreational fishery for river herring is unknown for most years. NYSDEC contracted with Normandeau Associates, Inc. (NAI) to conduct creel surveys on the Hudson River in 2001 and 2005 (NAI 2003 and 2007). Estimated catch of river herring in 2001 was 34,777 fish with a 35.2% retention rate. When the 2001 data were analyzed, NAI found that the total catch and harvest of herring was underestimated due to the angler interview methods. In the 2001 survey, herring caught by fishers targeting striped bass were only considered incidental catch, and not always included in herring total catch and harvest data. Fishers were actually targeting herring and striped bass simultaneously. Corrections were made to the interview process for the 2005 survey and estimated catch increased substantially to 152,117 herring (Table 12). We also adjusted the 2001 catch using the 2005 survey data. The adjusted catch rose to 93,157 fish.

We also evaluated river herring use by striped bass anglers using data obtained from our Cooperative Angler Program (CAP). The CAP was designed to gather data from recreational striped bass anglers through voluntary trip reports. Volunteer anglers log information for each striped bass fishing trip including fishing time, location, bait use, fish caught, length, weight, and bycatch. From 2006 through 2015, volunteer anglers were asked to provide specific information about river herring bait use. Due to the difficulties associated with differentiating between alewife and blueback herring, anglers were only asked to report the catch as river herring. The annual proportion of angler days where river herring was used for bait ranged from 25% (2007) to 57 % (2013) with a mean of 46%. The proportion of river herring used by anglers that were caught rather than purchased increased through the time period (Table 12). River herring caught per trip varied from 1.6 to 6.7 with the highest values in the last three years. Herring purchased per trip ranged from 0.63 to 1.7.

In an attempt to estimate recreational river herring harvest, we calculated the total number of herring caught or purchased by striped bass anglers as the estimated number of striped bass trips from a statewide creel survey conducted in 2007 (Connelly and Brown 2009) adjusted annually to reflect the potential change in fishing effort using CAP data multiplied by the annual proportion of angler days using herring in the CAP, multiplied by the number of herring caught or purchased per trip in the CAP. Estimates of river herring use by striped bass anglers ranged from 78,491 fish in 2007 to 386,915 fish in 2015 with an increasing trend of herring use from 2006 to 2015. To put potential recreational herring harvest in context, the average estimated annual recreational harvest from 2013-2015 was 312,036 herring. During the same time period, counts from Black Creek, a small tributary to the Hudson with approximately 1.8 km of available spawning habitat, averaged 409,233 alewives (roughly 139,000 pounds) annually (see Table 13 and *In-stream Fish Counter* in Section 3.2.1 below). Black Creek is only one of the 68 primary tributaries to the Hudson River.

This analysis should be interpreted with caution and viewed only as potential recreational river herring harvest scenarios. It should also be noted that these estimates are derived from a group of dedicated striped bass anglers who presumably exert more effort than a typical angler and thus we view these estimates as the maximum potential recreational herring harvest. Until a creel survey can be conducted, this is the Department’s best estimate of recreational herring harvest.

The number of river herring taken from the Hudson River and tributaries for personal use as food by recreational anglers is unknown but expected to be minimal.

Long Island, Bronx and Westchester Counties: As of 2013, recreational river herring fisheries have been closed in the marine and coastal district of NY.

3.2 Fishery Independent Surveys

3.2.1 Spawning Stock Surveys – Hudson River

Haul Seine Survey

In 1987, the Department added river herring sampling to the existing American shad and striped bass spawning stock survey. Sampling occurred sporadically and when time allowed. From 1987 to 1990, two small mesh (9.5 mm) beach seines (30.5m and 61m) were used with limited success. In 1998, the Department specifically designed a small haul seine (91 m) with an appropriate mesh size (5.1 cm) to target river herring. Similar to the gear design for the American shad and striped bass seine survey to minimize size and age bias (Kahnle et al. 1988), the Department designed the herring seine to capture all sizes present with the least amount of bias. The current herring haul seine design consists of two 46 m long by 3.7 m deep wings attached to a round, center-located bag measuring 1.2 meters in diameter and 3.7 m long. The entire net is 5.08 cm stretch mesh made of twisted nylon twine. The top float line includes fixed foam floats every 0.6 m and fixed chains to the lead line (bottom of seine) every 0.75 m.

To meet the requirements outlined in Amendment 2 (ASMFC 2009) for the mandatory fishery-independent monitoring programs, in 2012 New York established the river herring spawning stock survey. The objectives of the survey are to evaluate species, size, and sex composition of spawning river herring; and then develop the methodology to use the gear to perform an annual assessment of the Hudson River's river herring spawning stock. We set a sampling target of four sample days per week (March 15 to June 15). We targeted a minimum of five beaches to be sampled each day. Data were used to evaluate sample sites for future sampling use as well as collect spawning adult river herring in the area.

In 2012, we sampled sites in the river from the Tappan Zee (rkm 45) to Albany (rkm 232) (Figure 1). Despite much effort in 2012, no river herring were caught in the southern part of the river from Poughkeepsie south to the Tappan Zee. These areas were dropped in 2013, and we pared down the sampling area to the mid and upper river sections where river herring were most readily caught. Currently, we focus each sampling day of the week on one river reach from Kingston (rkm 136) to Albany (rkm 232) (Figure 1). Reaches are broken down as follows: Kingston (rkm 136-169), Catskill (rkm 170-190), Coxsackie (rkm 191-213), and Albany (rkm 214-232). Within each reach, we randomly selected sites from a map of all known beaches within the Hudson River Estuary. After scouting, we removed any sites from the list that no longer had beaches or had major sampling obstructions. We currently sample 15 fixed sites spread throughout the four reaches.

After each haul, technicians examine each fish for species, gender, and spawning condition. We take a ten fish subsample of each gender and species and measure total length, weight, and obtain a scale sample. When possible, we measure an extra 30 fish from each sex and species for each sampling event. All other incidental catch is tallied by species; we measure and remove scale samples from sport fishes.

In-stream Fish Counter

In 2013, we conducted a pilot study using an in-stream fish counter in Black Creek. Black Creek is a small tributary located at rkm 135, just south of Kingston, NY and has a known river herring spawning run. The primary objective was to determine if a fish counting device was an appropriate method to collect absolute abundance data for river herring in small tributaries. Our secondary objectives were to identify when river herring migrate into tributaries and identify parameters that may influence those migrations (i.e. moon phase, water level, water temperatures).

The study design consisted of a stream wide weir to guide river herring through a Smith Root SR-1601® multichannel fish counter. NYSDEC staff built the counting head using four inch PVC tubes stacked in two rows of four, forcing fish through one of eight individual counting tubes (Figure 10). We installed the counter system at the end of March each year, close to the head of tide, and it remained in place until the end of May. Staff attempted to visit the counter on a daily basis. During site visits, technicians recorded fish counts on the counter system, along with any applicable environmental observations, such as weather conditions, temperature, and water level. Once the daily count was recorded, the counter was reset to zero. We also conducted multiple visits during the same day in order to compare day versus night migrations of river herring into the tributary. In 2013, we incorporated a trap into the design of the weir, attached to the counter exit directly up stream of the weir to determine species composition of the fish passing through the counter and assess the accuracy of the electronic counter. The trap was closed on five occasions at various times throughout the run in 2013. We then attempted to use these trapping results as a correction factor to the final count data; however, it was very difficult to capture every fish in the trap due to the stream substrate as well as impaired visibility. At this time we do not have an accurate correction factor. To address this, we installed a video camera system in 2014 to verify counts and create an accurate correction factor. We are currently analyzing video footage to assess the accuracy of the electronic counter and develop an appropriate correction factor.

Monitoring of Black Creek has continued on an annual basis since 2013 and annual count data are reported in Table 13. Historic evidence shows the spawning run in Black Creek to be exclusively made up of alewife (Schmidt and Lake 2000). This has been verified in all years of monitoring, as all mortalities and all live captured river herring at or near the weir were identified as alewife. The annual count data from Black Creek is used as ancillary data to support trends identified in the relative abundance indices described in section 3.2.2 and provide a reference for landings in the commercial and recreational fisheries (Table 13).

3.2.2 Hudson River Spawning Stock - Characteristics

Annual Catches

Prior to 2012, the intermittent effort (n-hauls) expended to catch river herring resulted in relatively low and variable catches (Table 14). However, with the focused survey, catches and hauls have increased greatly since 2012 (Table 14).

Since 2012, alewife catches have been on average 73.6% male and 26.4% female (Figure 11). The high ratio of male alewives may indicate a possible sex bias in the sampling technique for alewives. We suspect that males either remain out in the main river close to shore whereas most female alewives could be further offshore, unavailable to our gear or they could be staging near tributary entrances. Mid-Hudson tributary sampling conducted by Schmidt and Lake (2000), as well as our own effort (see above, *In-stream Fish Counter*), resulted in more equal sex ratios.

Sex ratios of blueback herring have been more even. On average, blueback herring consisted of 44.6% males and 55.4% females (Figure 11). We suspect that bluebacks may be more susceptible to our gear because they prefer to spawn in shallow shoals of the main-stem river.

Relative Abundance Indices

In 2012, exploratory sampling was conducted to identify beaches that we could sample and catch adult river herring on a consistent basis. Based on those results, we have focused sampling efforts between the Kingston (rkm 146) and Albany (rkm 223) reaches (Table 15). We are currently exploring the most appropriate method to calculate relative abundance indices for adult river herring. We need additional years of data to be able to identify any potential biases in collection protocols or environmental conditions that may influence catches. Once an appropriate method is identified and we have an adequate time series of data, we propose to use the adult relative abundance index as sustainability target.

Growth

We examined growth characteristics using the Von Bertanlanffy and Gompertz Growth models (Ricker 1975). Both models use the annual age and associated lengths and weights of aged samples from the fishery independent survey. Samples from the commercial fishery were not included due potential size and sex selectivity of the gears. We developed preliminary estimates of growth on an annual basis, by sex and species, and to include all year-classes. These provide a good snapshot of the growth characteristics of each species, but can be highly influenced by inter-year class variation and changes in fishing mortality. Once we have longer time series of ages, lengths, and weights, we will have much more robust growth estimates and associated error values.

We did not feel comfortable in presenting the growth model outputs (Linf, K and t0, etc.) in this report. Von Bertanlanffy and Gompertz growth models are often used in stock assessments to provide a smoothed estimate of length and weight at age for input into more sophisticated assessment models (i.e. use of biomass at age inputs to estimate mortality benchmarks). Data for these models require a sufficient range of values to accurately describe the growth to be estimated. A longer time series of data that includes better representation of older fish is needed to more accurately estimate representative values of growth model parameters.

Mean Total Length and Weight

Mean total length and weight of fish has been calculated when adequate sample sizes occurred (Figure 12). Prior to 2008, most sample sizes were relatively small and thus not reliable. From 2001 to 2008, mean total length of male alewife declined slightly, but then increased to present.

Mean total length of female alewife has also steadily increased since 2008. Mean total length of blueback herring has slightly increased for both sexes since 2009 to the present. Mean weights for both sexes of alewives were slightly declining from 2008 to 2013 but since have been increasing. Male blueback herring mean weights have been stable with a slight increase in 2015 while female blueback herring mean weights have been steadily increasing since 2010.

Maturity

Maturity was estimated from age at first spawn, subtracting the number of spawning marks from the age of each fish. We then calculated maturity schedule as percent mature at age present in the river for each species and sex using all sampled age classes. As with growth rates, annual variations in recruitment and fishing mortality have significant impacts on maturity schedules. To address these potential problems, we will compare inter-annual maturity estimates with those calculated by year class once enough long-term age and spawning mark data are available.

Age data from 2012-2015 indicate that alewife herring primarily begin to spawn at age three and are fully mature by age five (Figure 13). Blueback herring begin to spawn at age two and the majority reach full maturity by age four (Figure 13).

Age and Repeat Spawn

Through training sessions and workshops with aging experts such as the Massachusetts Division of Marine Fisheries and other Atlantic Coast agencies (ASMFC 2014.), we developed criteria for determining what constitutes an annulus and spawning mark in Hudson River fish. (Details in Appendix 2). We did not use prior accepted aging methods such as Cating (1953, previously used for American shad) or Marcy (1969, used for river herring) due to their reliance on transverse grooves to estimate annuli location.

We also revised the scale selection and preparation protocols. For each catch event, we took scale samples from random subsamples of ten individuals of each sex and species. We removed scales as described above in the fisheries dependent methods, from the left side of the fish directly below the dorsal fin above the midline (Rothschild 1963; Marcy 1969; Hattala 1999) and placed them in an individually identified envelope. In the lab, technicians numbered scale envelopes and entered them into a database along with the associated sampling program (fishery independent or dependent) data: gear type, species, sex, and length. As annual sample sizes were large for most projects in this study, we needed to accurately determine ages of a sub-sample of fish collected. We followed Ketchen (1950) method of selecting a stratified sub-sample of fixed numbers of fish aged per 10 mm length bin. In 2012 and 2013, we separated the scale samples by sampling program, species, and sex. Next we randomly selected 30 fish per 10 mm length bin. All fish were aged when there were fewer than 30 fish in a length bin. Due to time restraints and based on new literature (Coggins et al. 2013), we have been examining 15 fish per length bin since 2014.

The sub-sample of aged fish were used to developed annual age-length keys for each species and sex (Losech 1987; Devries and Frie 1996; Davis and Schultz 2009). Sex-specific age-length keys were then used to estimate numbers at age of each sex and species for the entire sample for each year. The resulting estimated numbers at age were used to calculate mean length at age as well as mortality estimates reported in *Mortality Estimates* below.

Age and repeat spawn data for both species of river herring are reported in Tables 16 and 17. From 2012 to 2015 during our fisheries independent sampling, we collected 4,712 scales samples from alewives and assigned ages to a stratified random subsample of 1,122 scale samples. Female alewives ranged from age two to nine with zero to five repeat spawn marks and ranged from 68% to 36% virgin fish (Figure 14). Since 2012, mean age of female alewives has been stable to slightly increasing. Male alewives ranged two to eight years of age with zero to five repeat spawn marks. Male alewives ranged from 82% to 51% virgin fish (Figure 14). Mean age of male alewives has been stable to slightly increasing since 2012.

From 2012 to 2015, we collected 2,673 scale samples from blueback herring and assigned ages to 847 of those samples. Female blueback ages ranged from three to seven with zero to three repeat spawn marks. Female bluebacks ranged from 79% to 52% virgin fish (Figure 14). Mean age of female bluebacks has remained stable without a trend since 2012. Male bluebacks ranged in age from two to six with zero to three repeat spawn marks and ranged from 92% to 59% virgin fish (Figure 14).

Alewife males and females are on average larger than blueback males and females of the same age. Max total lengths and mean length at age of both species are approaching or have exceeded those reported in Greeley 1937 (Table 18, Figure 15). Since 2012, mean length at age for both species across all ages has been either stable or increasing with the majority increasing. Along with increasing mean length at age, the overall age structure for both species has expanded with increased repeat spawning occurrence. The increase in the occurrence of repeat spawning marks (Figure 14) suggests a higher survival rate during both post-spawn emigration and during ocean residency.

Mortality Estimates

Total instantaneous mortality rates were calculated on an annual basis since 2012 for age data and 2009 for repeat spawn data using a bias-correction Chapman and Robson mortality estimator described in Smith et al. (2012).

To be consistent with the methods used in the 2012 Benchmark Stock Assessment for River Herring, the age of full recruitment was the age of highest abundance and there had to be at least three ages or spawning marks to be included in the respective analyses (ASMFC 2012).

Mortality estimates for both species were calculated using age and repeat spawn data independently (Table 19, Figure 16). Mortality derived from age data for alewives declined or remained stable from 2012-2014. In 2015, estimates for both sexes of alewives increased; however, we feel that this increase is due to a large year class moving through the fishery resulting in over dispersion of older fish and is further compounded by fewer age three and age four fish observed in 2015. Fewer age three and four year old fish may be an artifact of major weather events that severely impacted the Hudson River; Hurricane Irene and Tropical Storm Lee in 2011 and Hurricane Sandy in 2012. The impact on the survival of YOY and yearling river herring resulting from these storm events is unknown, however, the next few years of monitoring will provide insight into the potential magnitude of their effects.

Blueback herring age based mortality estimates have been stable since 2012 for both sexes with a slight increase in 2015 (Table 19, Figure 16). Since 2012, both sexes of blueback herring have been comprised of primarily three and four year old fish. Despite blueback herring being dominated by two year classes, a few older fish with increased occurrences of repeat spawning marks are beginning to appear in the fishery (Tables 16 and 17).

Mortality estimates have been derived from repeat spawning data since 2009 and have followed the same trends as mortality estimates derived from age data with the only exception in 2015 (Table 19, Figure 16). In 2015, alewife and female blueback mortality estimates derived from age data were higher than those derived from repeat spawn data. This is due to increase repeat spawn occurrence and a reduction in the number of virgin fish.

Mortality estimates derived from repeat spawn data for both sexes of alewives slightly increased from 2009-2011 and since have been declining (Table 19, Figure 16). Female blueback herring mortality estimates were stable from 2009-2012. Male blueback herring mortality estimates were increasing from 2009-2012. From 2012-present both sexes of blueback herring mortality estimates derived from repeat spawn data have been declining.

In most instances, the mortality estimates based on spawning marks were higher than those calculated from ages (Table 19, Figure 16). This may be a result of the age based method using the most abundant number at age as age at full recruitment. In doing so, we may include ages of the population that may not actually be fully recruited. Once an adequate data set is available for age based mortality estimates, we will compare long-term trends between the two methods. This will identify any potential discrepancies in our mortality estimation methods.

3.2.3 Spawning Stock Surveys – Long Island

Young (2011) sampled alewife in the Peconic River 32 times throughout the spawning season in 2010. Sampling occurred by dip net just below the second barrier to migration at the lower end of a tributary stream. A rock ramp fish passage facility was completed at the first barrier near the end of February 2010. The author collected data on total length and sex and estimated the number of fish present based on fish that could be seen below the barrier. Peak spawning occurred during the last three weeks of April. The minimum estimate of run size was 25,000 fish and was the total of the minimal visual estimates made during each sample event. Males ranged from 243-300 mm with a mean length of 263 mm. Females ranged from 243-313 mm with a mean of 273 mm.

3.2.4 Volunteer and Other River Herring Monitoring

The Environmental Defense's South Shore Estuary Reserve Diadromous Fish Workgroup (SSER) have begun to incorporate citizen volunteers into the collection of data on temporal variation and physical characteristics associated with spawning of river herring in tributaries. These data were not provided by the fishery dependent and independent sample programs discussed above. The volunteer programs also bring public awareness to environmentally important issues.

Long Island Streams

The SSER began a volunteer survey of alewife spawning runs on the south shore of Long Island in 2006. The survey is designed to identify alewife spawning in support of diadromous fish restoration projects. The survey also evaluates current fish passage projects (i.e. Carmans River fish ladder), and sets a baseline of known spawning runs. Data were available for surveys in 2006 – 2008. Monitoring occurred on six to nine targeted streams annually, with volunteer participation ranging from 24 to 68 individuals. Monitoring takes place from March through May. Alewife were seen as early as March 5 (2006) and as late as May 31 (2008). Data indicated that alewife use multiple streams in low numbers. It is not clear whether each stream supports a spawning population since total sightings were very low. The Carmans and Swan Rivers showed the most alewife activity and likely support yearly spawning migrations. The first permanent fish ladder on Long Island was installed in 2008 on the Carmans River. Information gathered during this study will aid in future construction of additional fish passage (Kritzer et al. 2007a, 2007b, Hughes and O'Reilly 2008). Byron Young continues to monitor alewife, mostly in the Peconic River. In 2016, the Peconic run was above average. Fish were first observed on March 2, and last observed on May 16, representing a nearly 10 week spawning season (B. Young, retired, NYS Deptartment of Environmental Conservation, personal communication).

In addition to the SSER, other interested individuals have also monitored Long Island runs (see Appendix Table A). Anecdotal data provides valuable information on tracking existing in-stream conditions, whether streams hold active or suspected runs, interaction with human land uses, and suggestions for improvement (L. Penney, Town of East Hampton, personal communication). A rock ramp was constructed around the first barrier to migration on the Peconic River in early 2010 (B. Young, retired, NYS Dept of Environmental Conservation, personal communication). The Seatuck Environmental Association set up an automated video counting apparatus at the upriver end of this ramp. Data are still being analyzed. A video can be viewed on their website at https://www.seatuck.org/index.php/fish-counting

The Department has conducted a similar river herring volunteer monitoring program annually since 2008 for tributaries of the Hudson River Estuary (Dufour et al. 2009, NYSDEC 2010, Hattala et al. 2011b). We designed this project to gather presence–absence and temporal information about river herring spawning runs from the lower, middle, and upper tributaries of the estuary. Between nine and 11 tributaries were monitored annually by 70 to 213 volunteers in 2008, 2009, and 2010. Herring were seen as early as 31 March and as late as 1 June. River herring were observed in all but one of the tributaries. However, several tributaries with known strong historical runs had very few sightings. Water temperature seemed to be the most important factor determining when herring began to run up a given tributary. Sightings of herring were most common at water temperature above 50 degrees F. Tributaries in the middle part of the estuary warmed the fastest each spring and generally had the earliest runs.

3.2.5 Young-of-the-Year Abundance

Since 1980, the Department has produced an annual measure of relative abundance of YOY alewife and blueback herring in the Hudson River Estuary. Although the program was designed to sample YOY American shad, it also provides data on the two river herring species. Blueback herring appear more commonly than alewife throughout the time series. In the first four years of the program, sampling occurred river-wide (rkm 0-252), bi-weekly from August through October, beginning after the peak in YOY abundance occurred. The sampling program was altered in 1984 to concentrate in the freshwater middle and upper portions of the estuary (rkm 88-225), the major nursery area for young American shad and river herring. Timing of sampling was changed to begin in late June or early July and continue biweekly through late October each year. Gear is a 30.5 m by 3.1 m beach seine of 6.4 mm stretch mesh. Collections are made during the day at 28 fixed sites in nearshore habitats spanning four reaches of the freshwater portion of the river. Catch per unit effort is expressed as the annual geometric mean of fish per seine haul for weeks 26 through 42 (July through October). This period encompasses the major peak of use in the middle and upper estuary.

From 1980 to 1998, the Department's geometric mean YOY annual index for alewife was low, with only one year (1991) having over one fish per haul. Since 1998, the index has generally increased through 2012, and has been stable at roughly one fish per haul since 2013 (Figure 17).

From 1980 through 1994, the Department's geometric mean YOY annual index for blueback herring averaged about 24 fish per haul, with only one year (1981) dropping below 10 fish per haul (Figure 17). After 1994, the mean dropped to around 17 fish per haul. The largest index value for the time series occurred in 2014, which was just over 50 fish per haul.

The underlying reason for the wide inter-annual variation in YOY river herring indices is not clear. The increased inter-annual variation in relative abundance indices of all three alosines may indicate a change in overall stability in the system. Further investigation into temporal and environmental variables that may contribute to this high variability is necessary. By the next SFMP (2022), we will evaluate different standardized models to best account for the influence of covariates, such as salinity, water temperature, and sampling week on YOY catches.

4 PROPOSED FISHERY CLOSURES

4.1 Long Island, Bronx County and Westchester County

Limited data that have been collected for Long Island river herring populations are not adequate to characterize stock condition or to choose a measure of sustainability. Moreover, there are no long-term monitoring programs in place that could be used to monitor future changes in stock condition.

For the above reasons, New York State proposes to continue a closure of all fisheries for river herring in Long Island streams and in the Bronx and Westchester County streams that empty into the East River and Long Island Sound as outlined in previous SFMP (Hattala et al. 2011a).

4.2 Delaware River

We have very limited data that suggest river herring occur in New York waters of the Delaware River. New York State proposes to continue the closure of fishing for river herring in New York waters of the Delaware River as outlined in the previous SFMP (Hattala et al. 2011a). This closure conforms to similar closures of the Delaware River and Bay by the states of Pennsylvania, New Jersey, and Delaware.

5 PROPOSED SUSTAINABLE FISHERY

5.1 Hudson River and Tributaries

New York State proposes to continue a restricted fishery in the main-stem Hudson River coupled with a continued partial closure of the fishery in all tributaries (see Appendix 1). We do not feel the current data warrant a complete closure of all fisheries. We propose that the restricted fishery would continue for an additional five years concurrent with annual stock monitoring. The additional five years will provide us with ten consecutive years of data collected under the same methodologies. Sustainability targets will be set using juvenile indices. We will continue monitor, but not yet set targets for mean length and mean length at age from fishery independent spawning stock sampling and CPUE in the commercial fixed gill net fisheries in the lower river below Bear Mountain Bridge until additional years of data are obtained. We will also monitor age structure, frequency of repeat spawning, and total instantaneous mortality (Z). Stock status will be evaluated during and after an additional five year period and a determination made whether to continue or change restrictions.

6 PROPOSED MEASURES OF SUSTAINABILITY

6.1 Targets

Juvenile Indices

We propose to set a sustainability target for juvenile indices using data from the time period of 1983 through 2015 for both species. We will use a more conservative definition of juvenile recruitment failure than described in section 3.1.1.2 of Amendment 2 to the ASMFC Interstate Fisheries Management Plan for Shad and River herring (ASMFC 2009). Amendment 2's definition is that recruitment failure occurs when three consecutive juvenile index values are lower than 90% of all the values obtained in the base period. We will be more conservative and use a 75% cut off level. The resulting sustainability target value is the 25^{th} percentile of the time series, such that three consecutive years with index values below this target would trigger management action. The target for alewife is 0.37 and the target for blueback herring is 7.53 (Figure 17).

6.1.1 Management Actions

New York State will take immediate corrective action if the recruitment failure limit is met for three consecutive years. Potential management actions may include but are not limited to: area closures, gear restrictions, and permit fee restructuring. Corrective actions will remain in place until the juvenile index value is above the juvenile recruitment failure level set in Amendment 2 to the ASMFC Interstate Fisheries Management Plan for Shad and River herring for three consecutive years.

6.2 Sustainability Measures

There are several measures of stock condition of Hudson River herring that can be used to monitor relative change among years. However, these measures have limitations (described below) that currently preclude their use as targets. These include frequency of repeat spawning, mean length, mean length at age and total mortality in fishery independent samples as well as catch per unit effort (CPUE) in the reported commercial harvest. We propose to monitor these measures in concert with the sustainability target to evaluate consequences of a continued fishery.

Mean Length and Mean Length at Age

Mean total length and mean length at age reflects age structure of the populations and thus some combination of recruitment and level of total mortality. Mean total length and mean length at age of both river herring species in the Hudson River system have been increasing since sampling efforts increased and became consistent in 2012. Max total lengths and mean length at age of both species are approaching or have exceeded those reported in Greeley (1937). The increases in mean length and mean length at age are indicative of reduced mortality both within river and during their ocean residency. However, the ocean bycatch fishery is a large unknown and not solely controlled by New York State to effect a change. We propose to continue monitoring mean total length and mean length at age during the proposed fishery.

Catch per Unit Effort in Report Commercial

We suggest that CPUE values of the reported harvest reflect general trends in abundance. However, annual values can be influenced by changes in reporting rate and thus we do not feel that CPUE should be used as a target at this time. Once we have an adequate time series of age data, we will attempt to validate the commercial CPUEs with our relative abundance surveys (YOY and adult relative abundance indices) following methods described by Hattala and Kahnle (2007).

Repeat spawning and Total Mortality

We will continue to monitor the frequency of repeat spawning and total mortality (Z). Once an adequate time series of data is collected, we will investigate appropriate methods to develop a mortality based benchmark and use that benchmark as a sustainability target in future sustainable fishery management plans.

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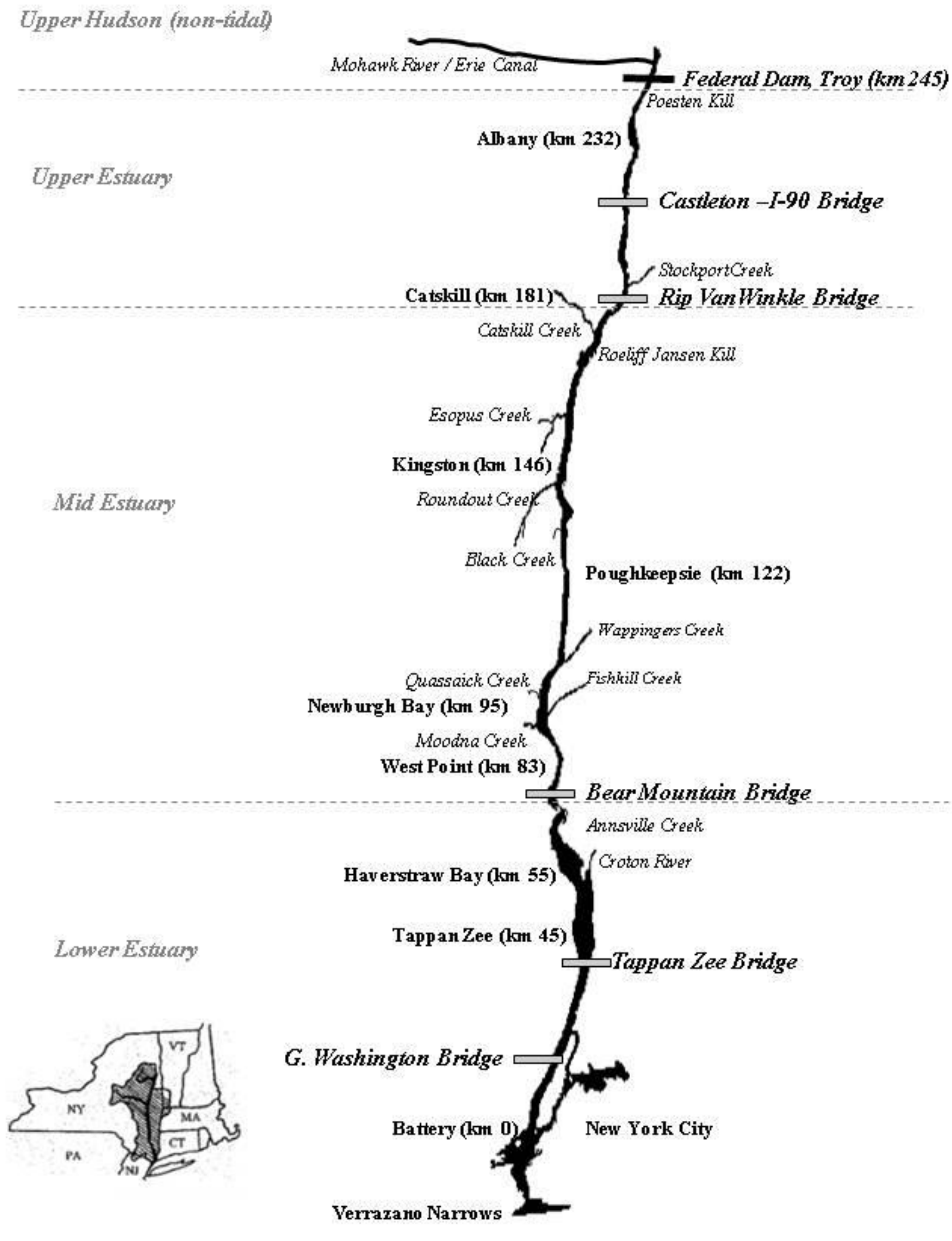


Figure 1. Hudson River Estuary with major spawning tributaries for river herring.

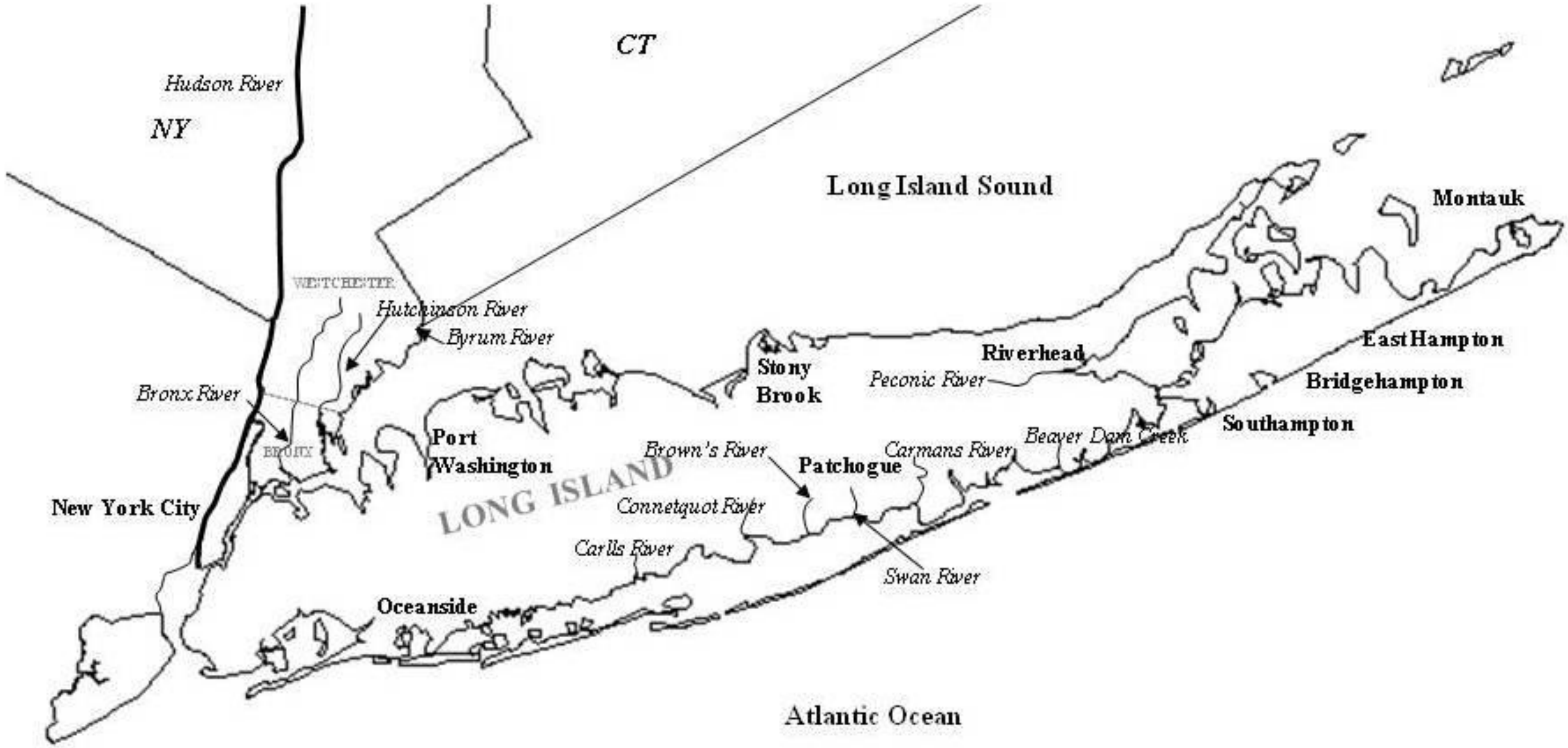


Figure 2. Long Island, Bronx and Westchester Counties, New York, with some river herring (primarily alewife) spawning streams identified.

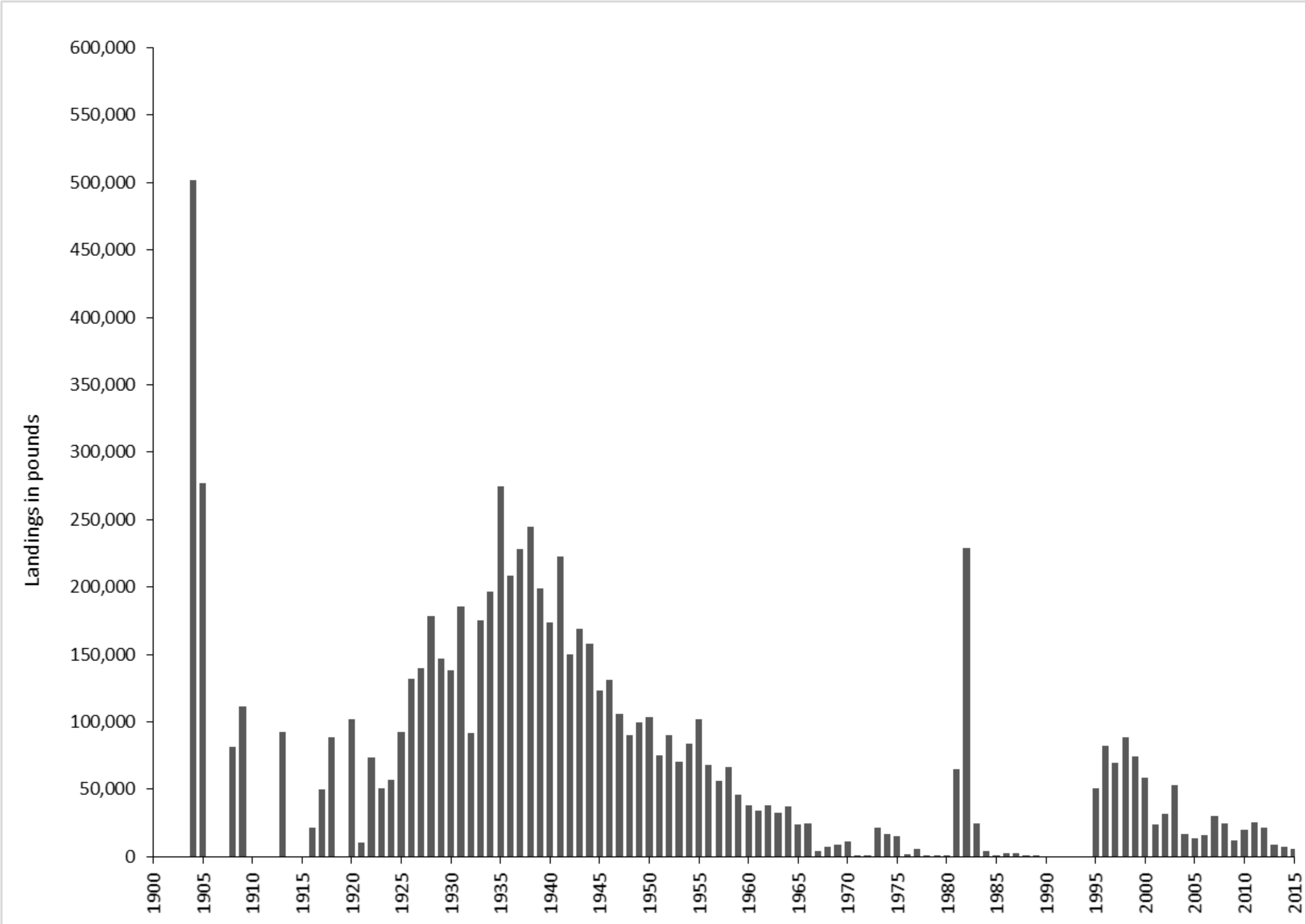


Figure 3. Pounds of river herring landed in New York waters.

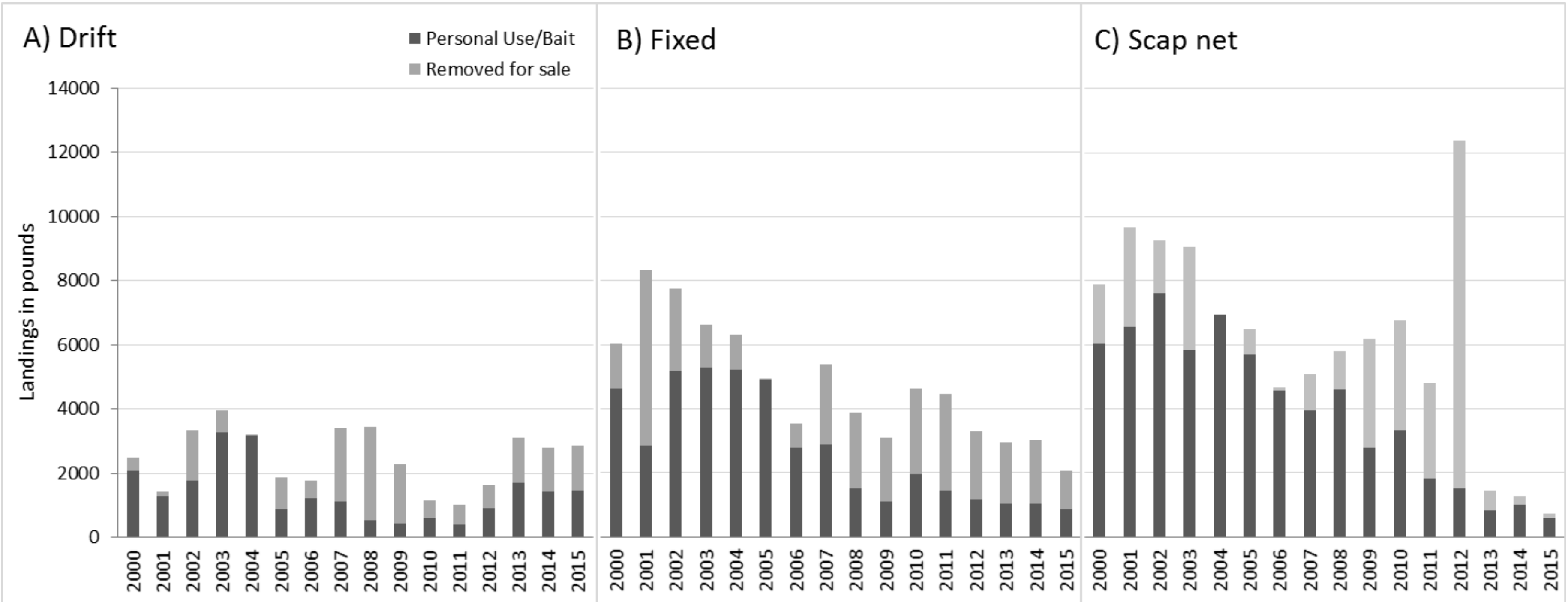


Figure 4. Dispositions of commercially caught river herring as reported in mandatory trip reports.

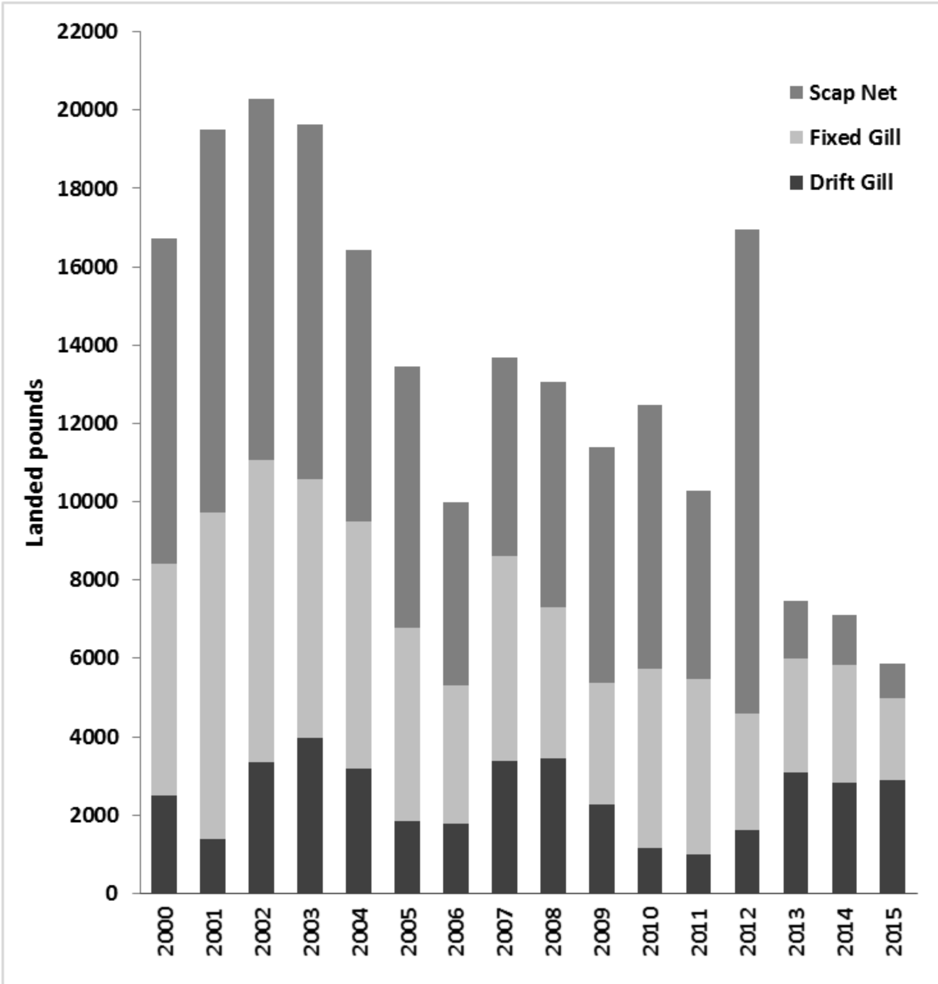


Figure 5. Annual total landed pounds of river herring separated by gear type. Catch includes targeted river herring trips only.

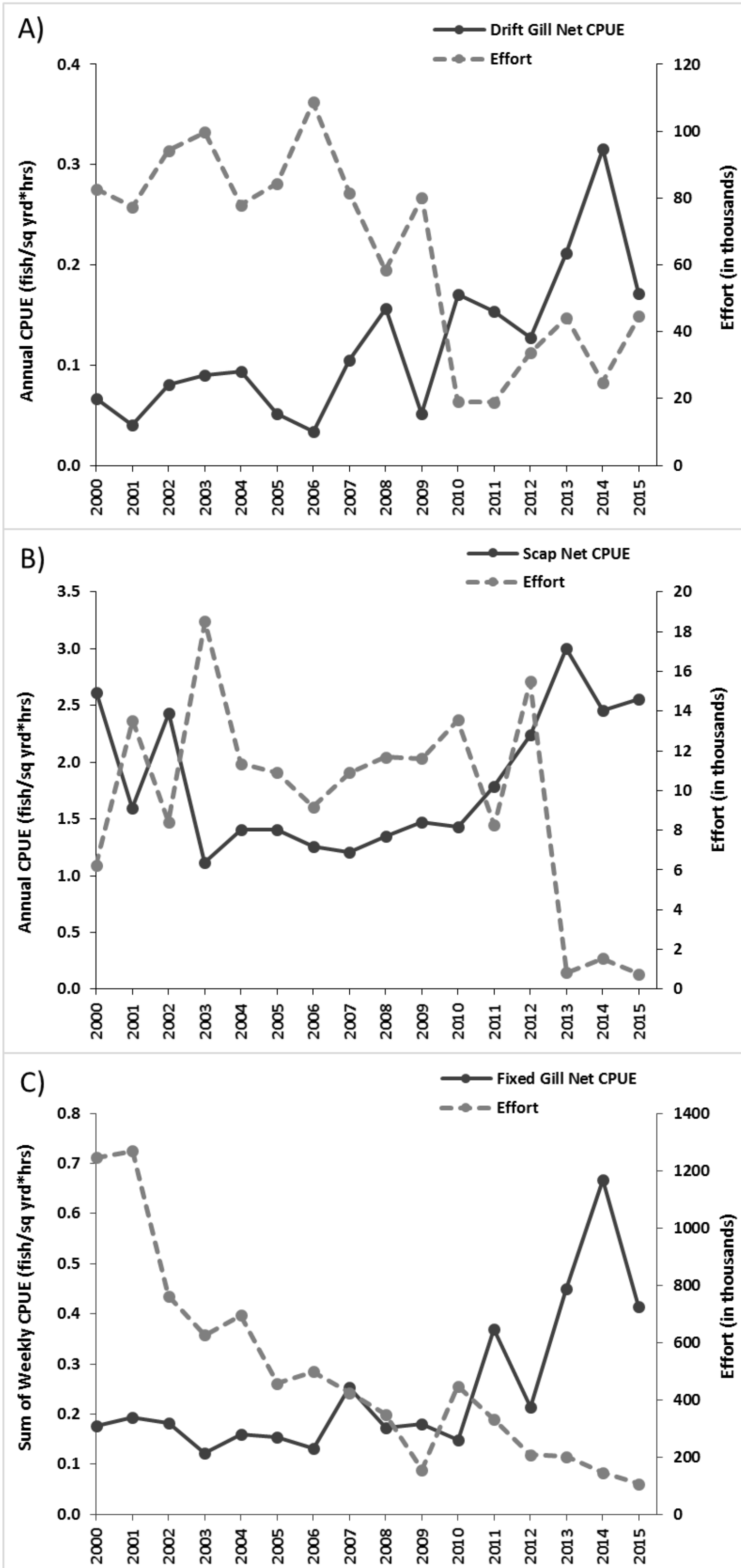


Figure 6. Efforts (sq yd net area * hours) and CPUEs from mandatory commercial reports. A) Drift gill net fishery above rkm 75; CPUE is total catch/total effort. B) Scap net fishery above rkm 75; CPUE is total catch/total effort. C) Fixed gill net fishery below rkm 75; CPUE is the sum of weekly catch/weekly effort.

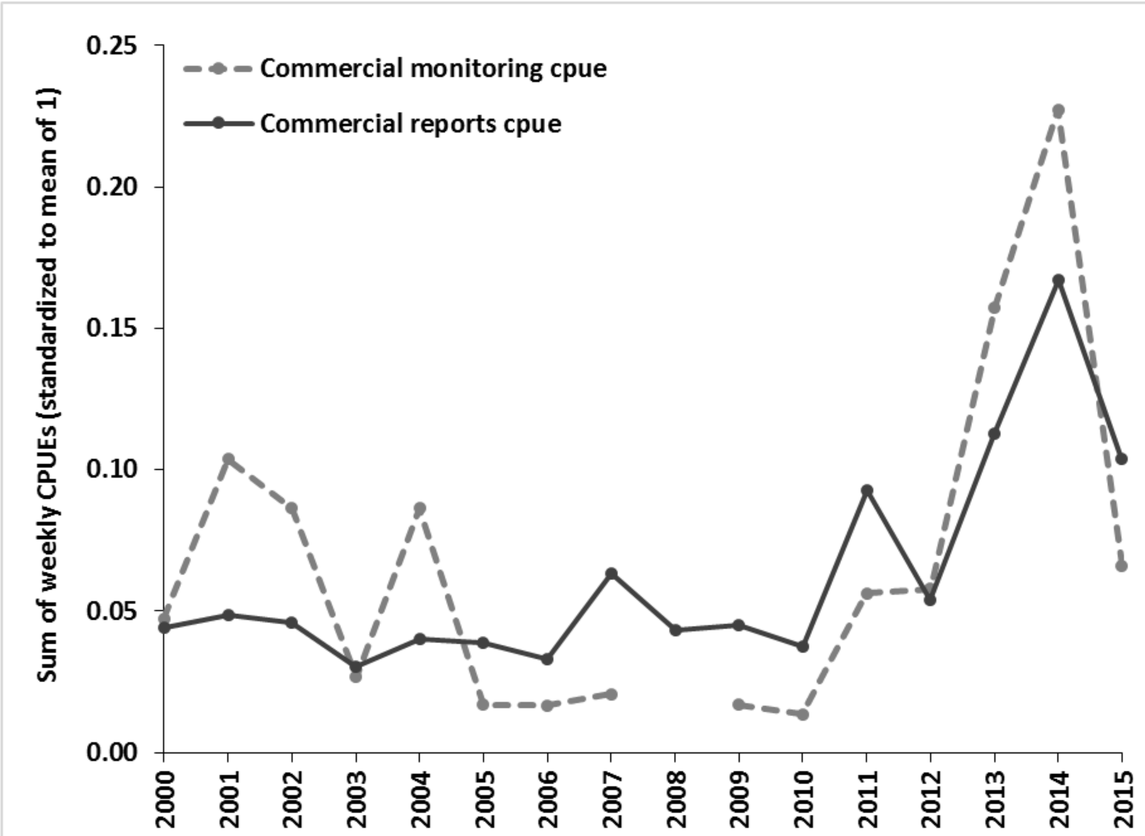


Figure 7. Comparison of the sum of weekly CPUEs calculated from commercial monitoring and mandatory commercial reports of the fixed gill net fishery below the Bear Mountain Bridge (rkm 75). Values are standardized to a mean of 1.

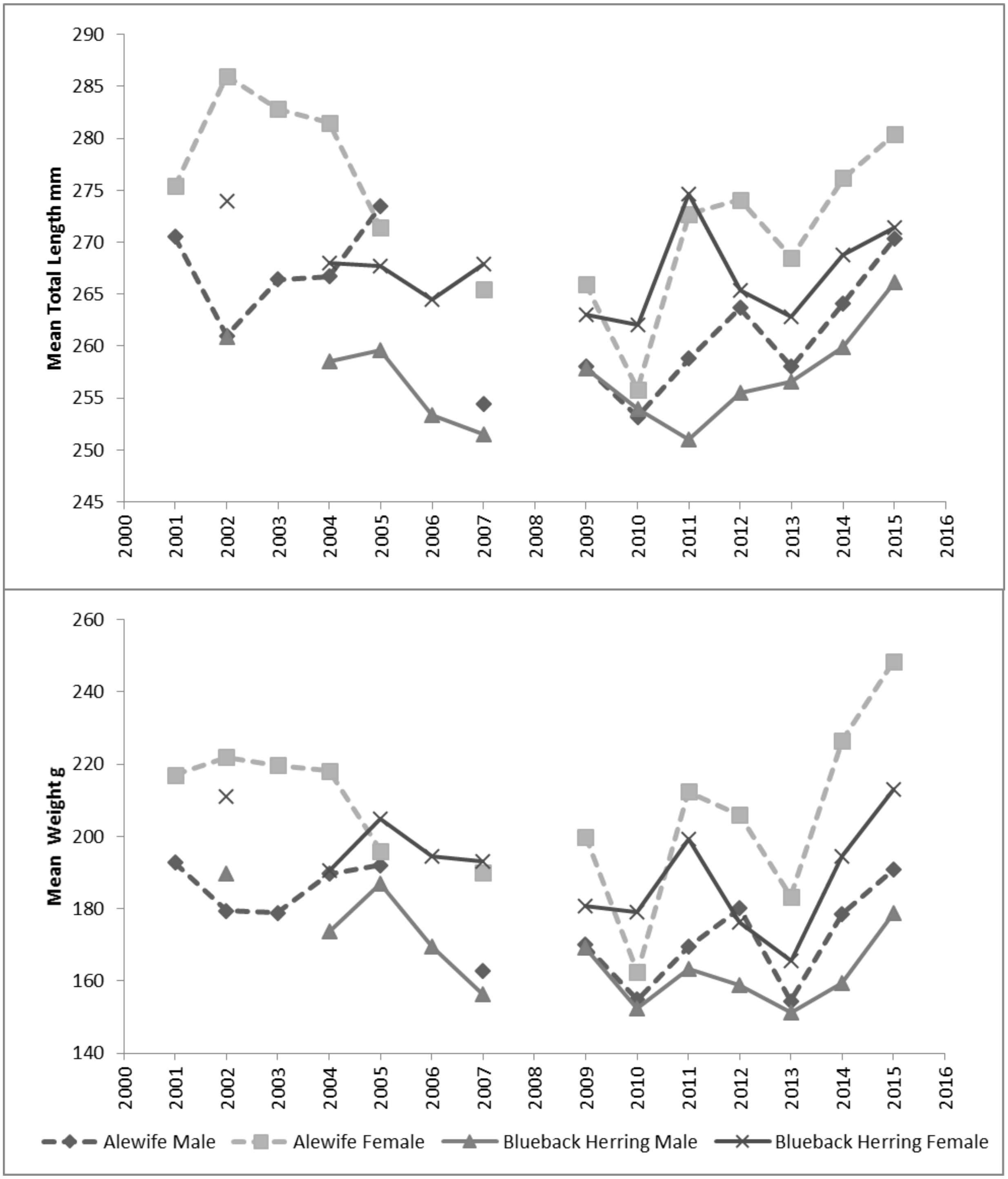


Figure 8. Mean length and weight of river herring collected in fishery dependent sampling in the commercial fishery in the Hudson River.

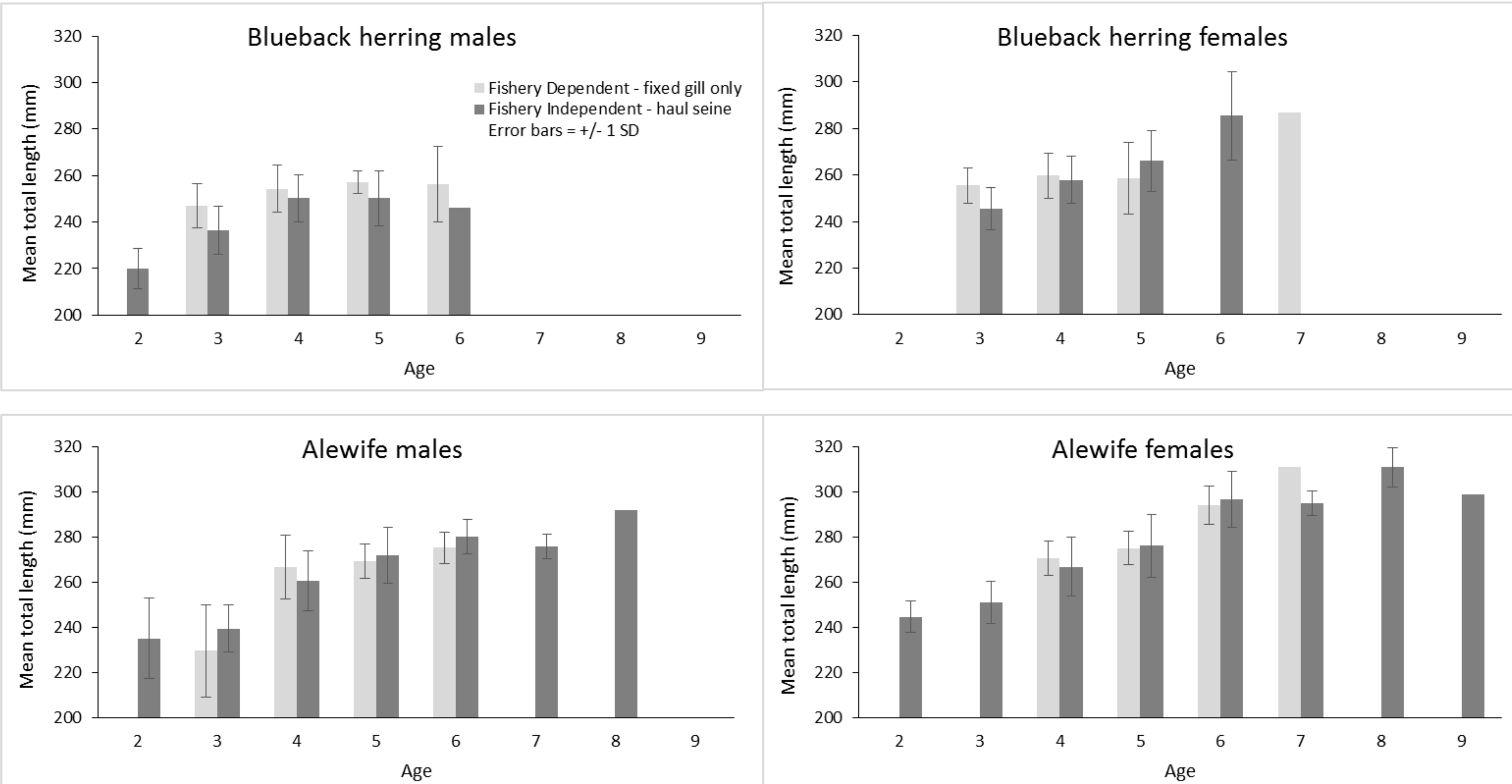


Figure 9. Comparison of length at age of river herring sampled in the lower-river fixed gill net commercial fishery versus the fishery independent survey.

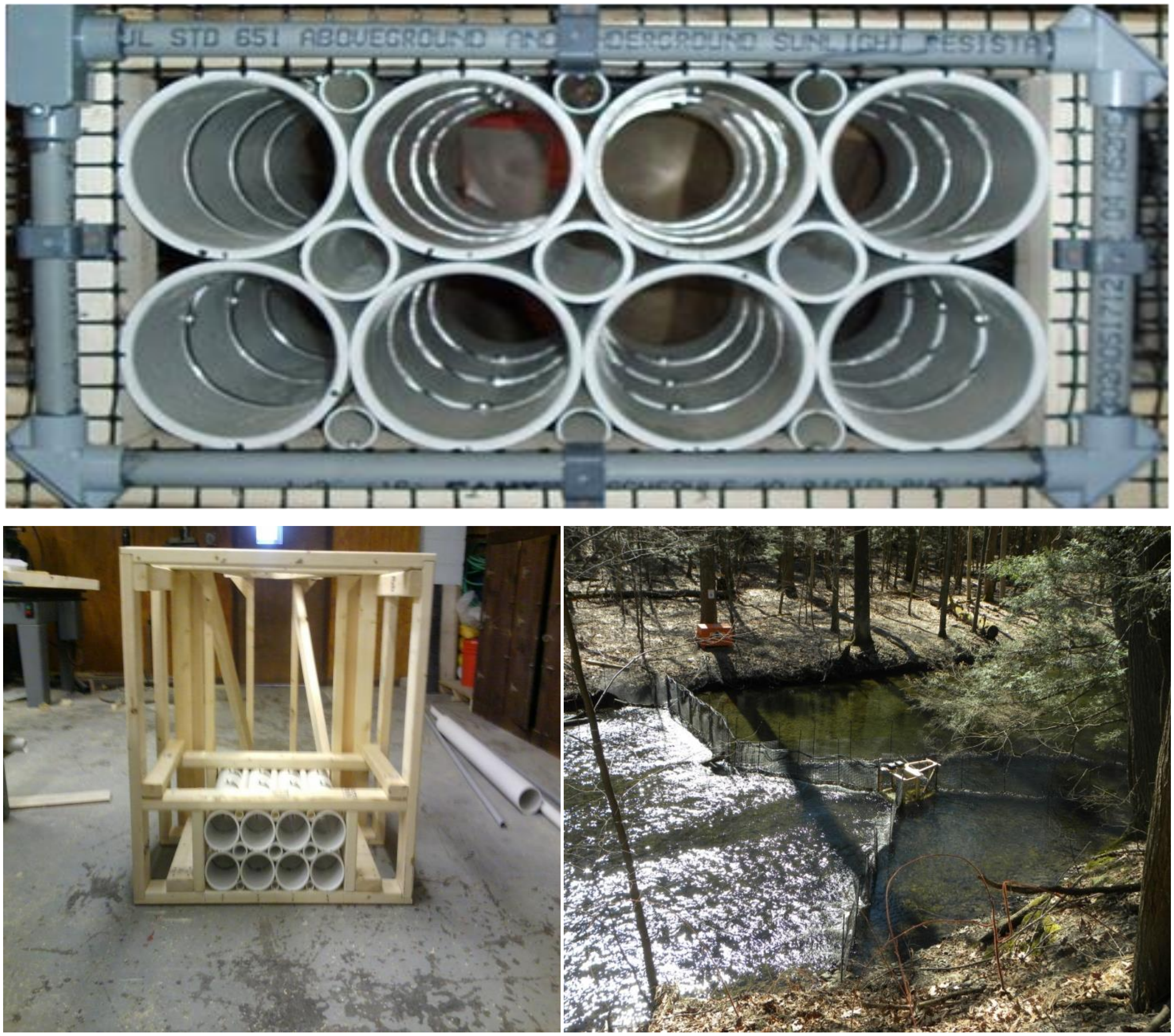


Figure 10. Top: Front view of the counter head that consists of eight four inch PVC tubes fitted with three stainless steel clamps, acting as sensors that measure water conductivity. Bottom left: View of fish counter head during construction. Bottom right: View of in-stream weir and fish counter.

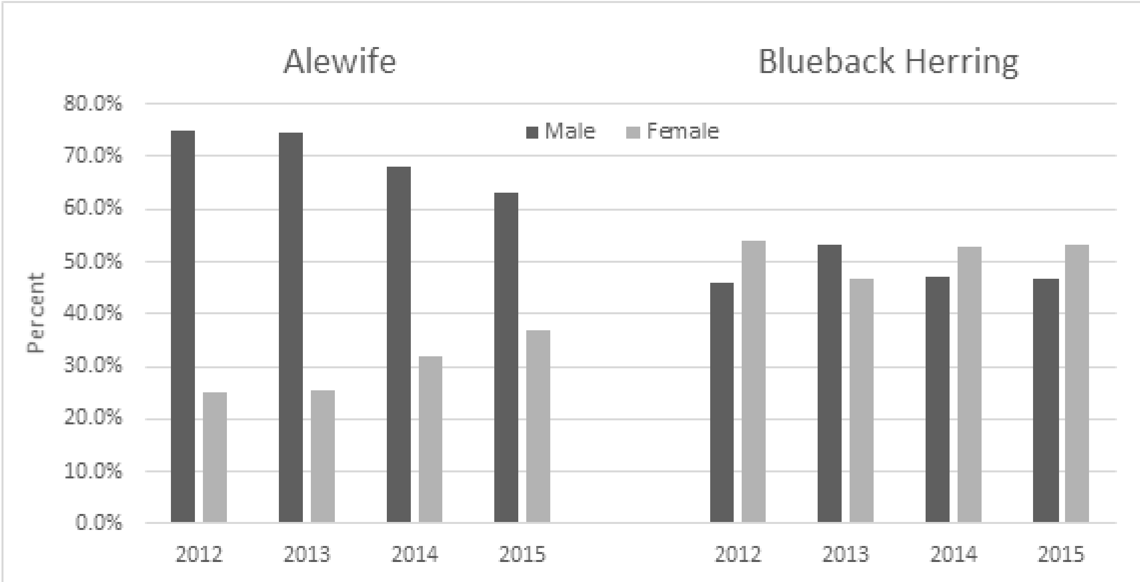


Figure 11. Annual sex ratios from river herring collected during the fisheries independent survey.

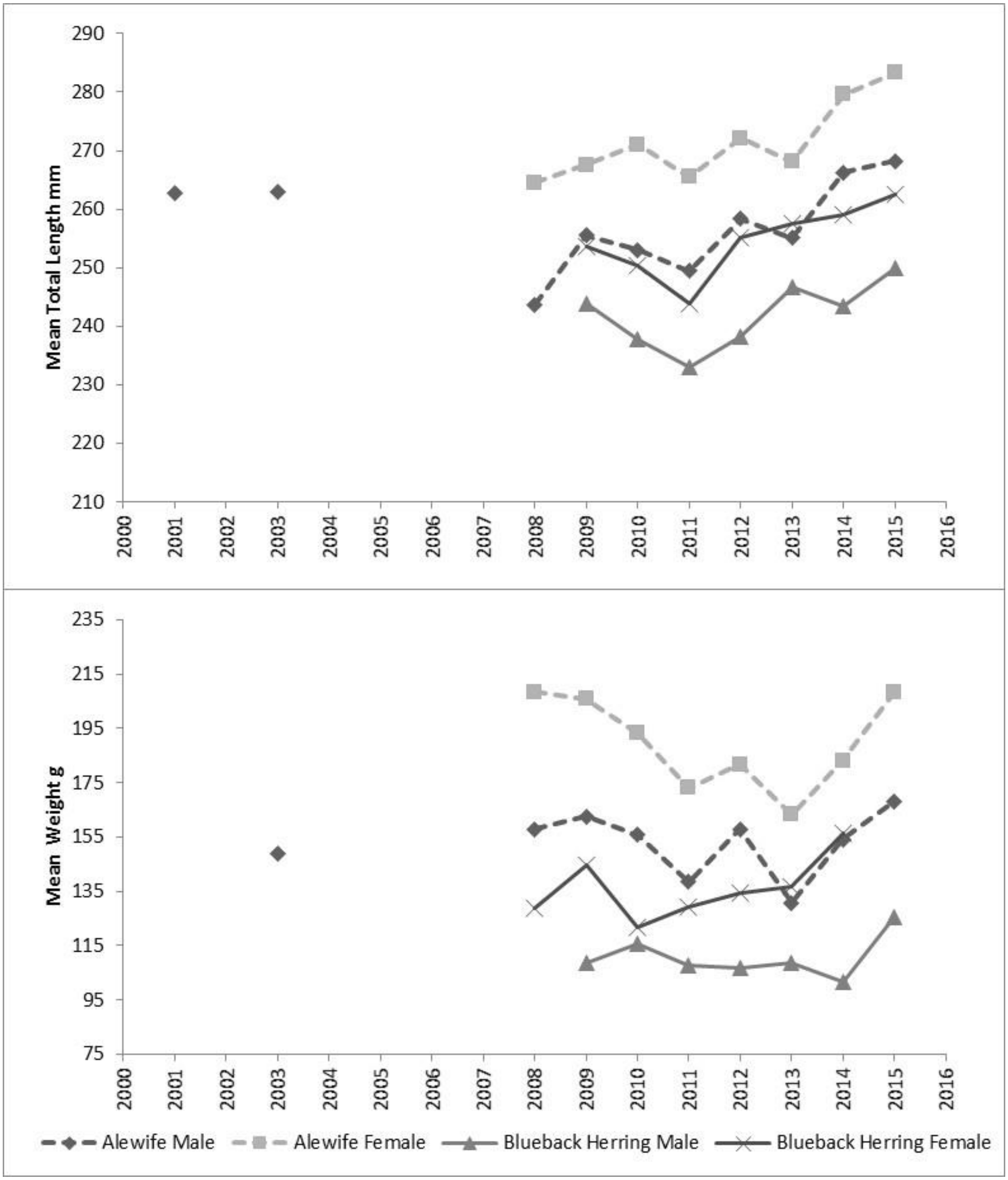


Figure 12. Mean length and weight of river herring collected during fishery independent sampling of the spawning stock survey.

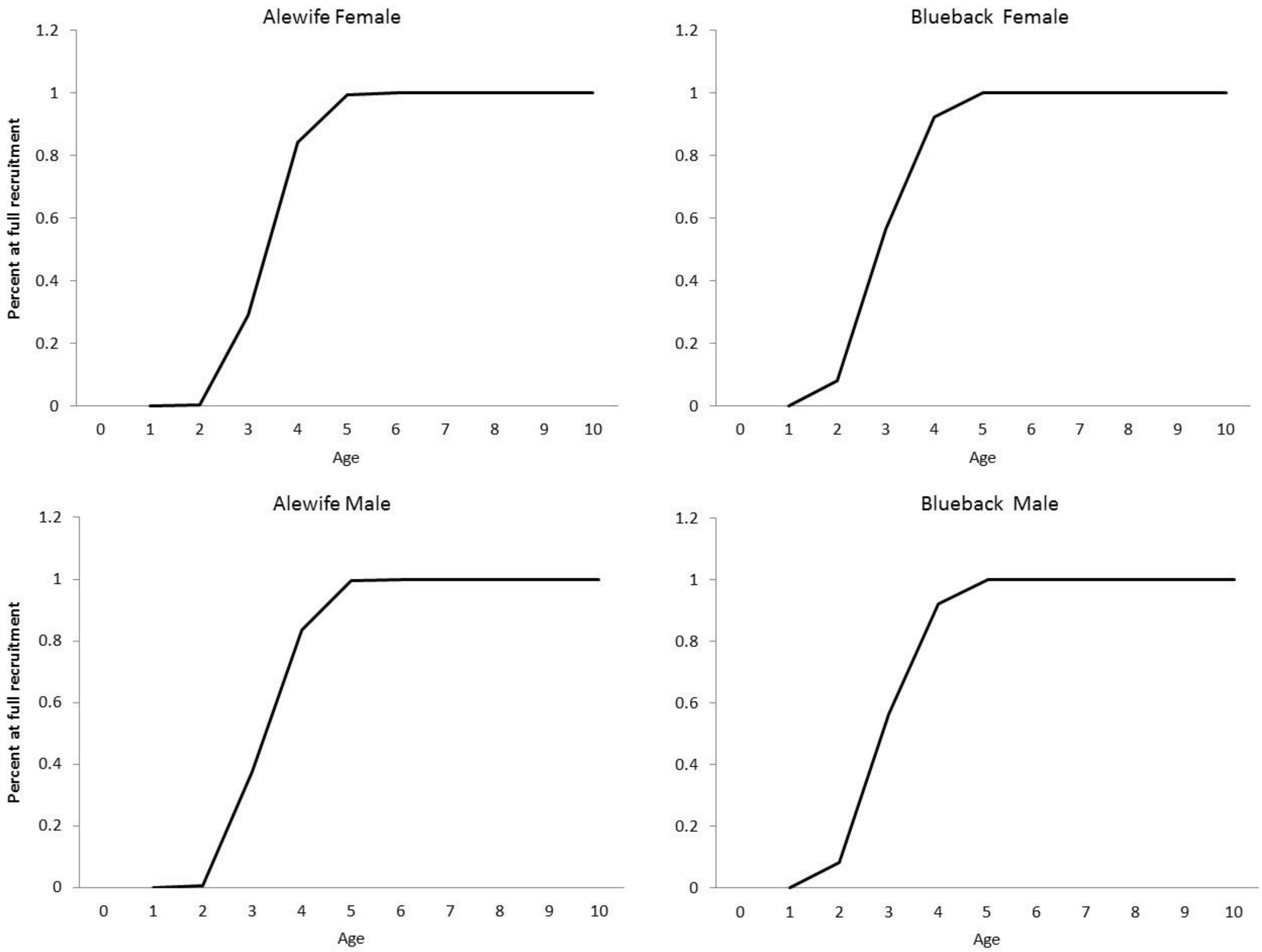


Figure 13. Maturity schedule for alewife and blueback herring derived from 2012-15 age data.

Figure 14. Frequency of repeat spawning occurrence for both species of river herring collected during fisheries independent sampling.

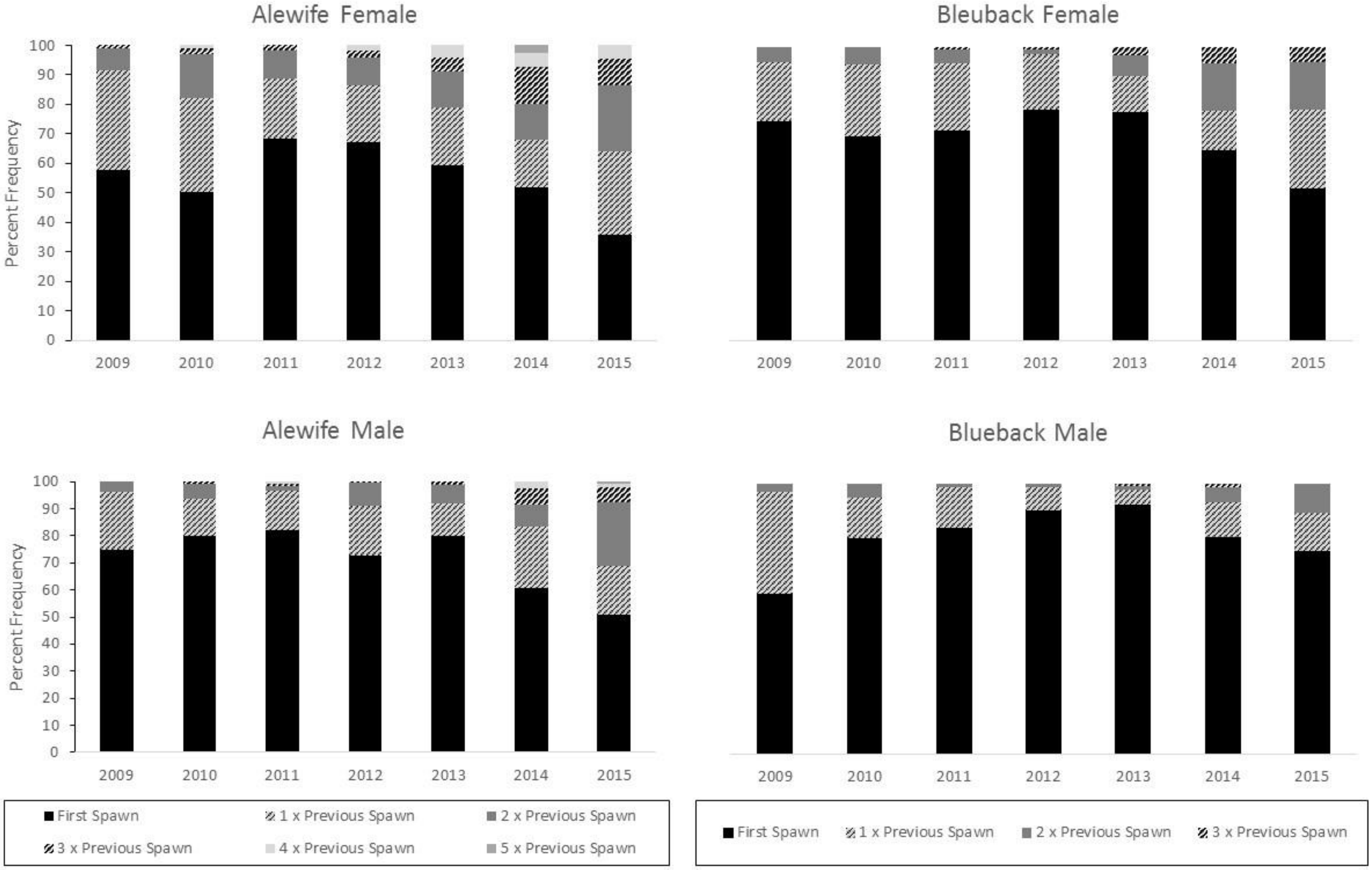


Figure 15. Mean length at age for river herring from fisheries independent sampling.

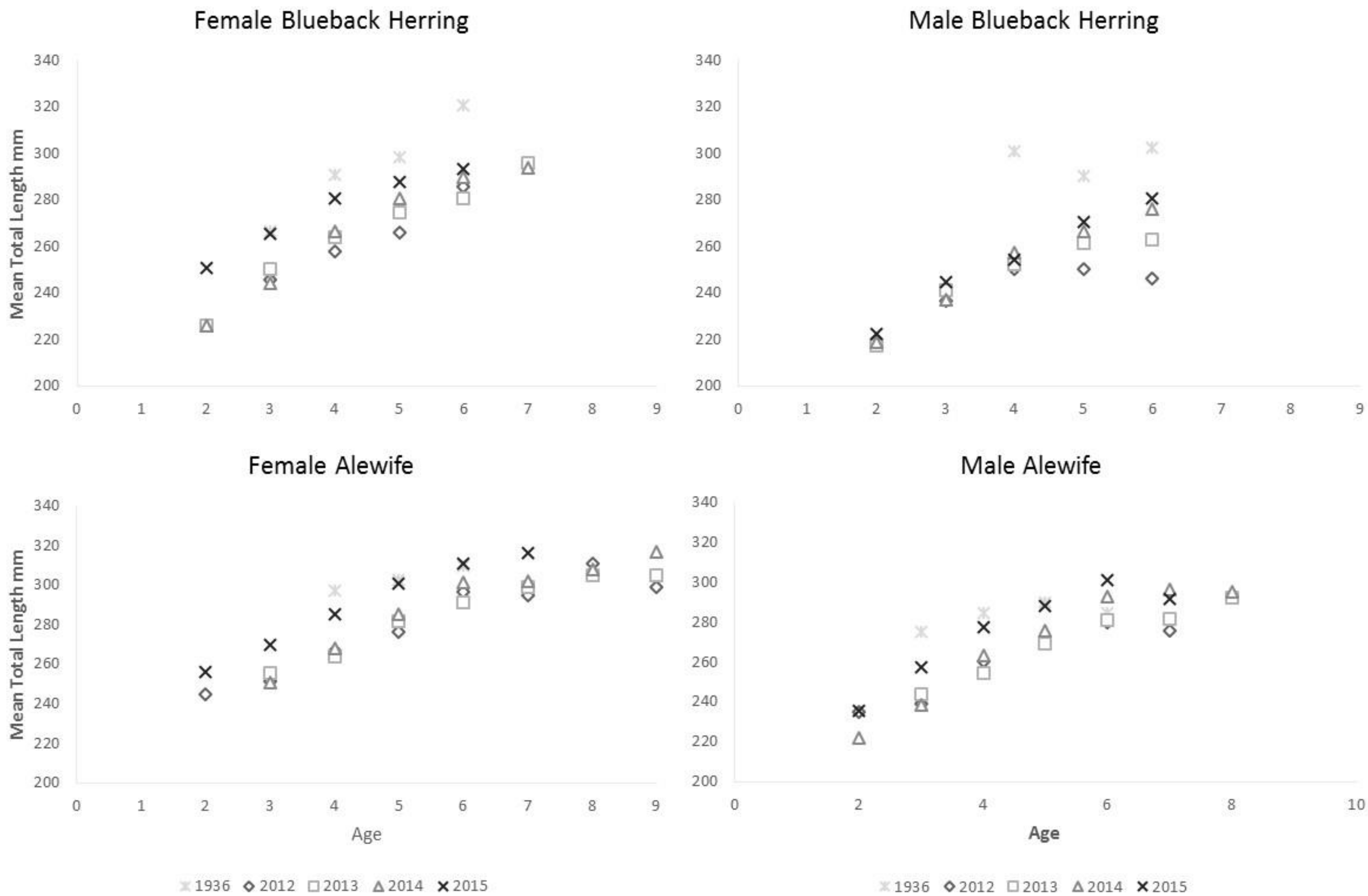


Figure 16. Chapman-Robson mortality estimates for both species of river herring collected during fisheries independent sampling.

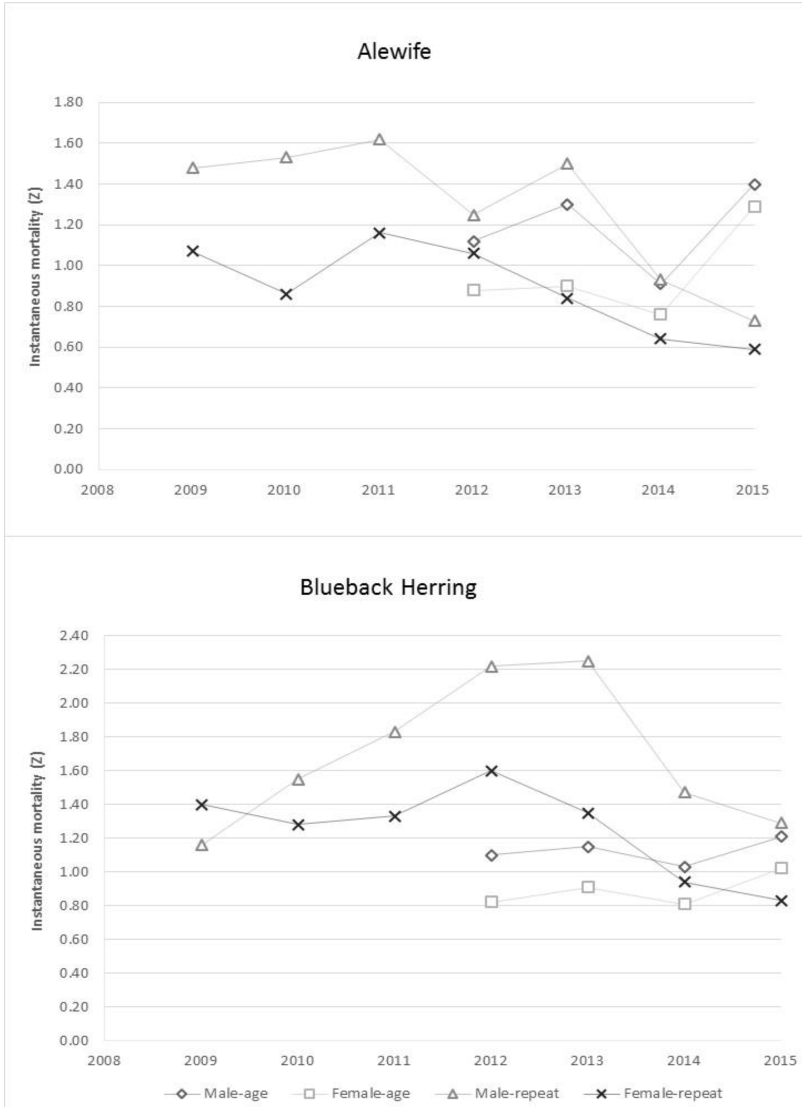


Figure 17. Young-of-year abundance indices for both river herring species.

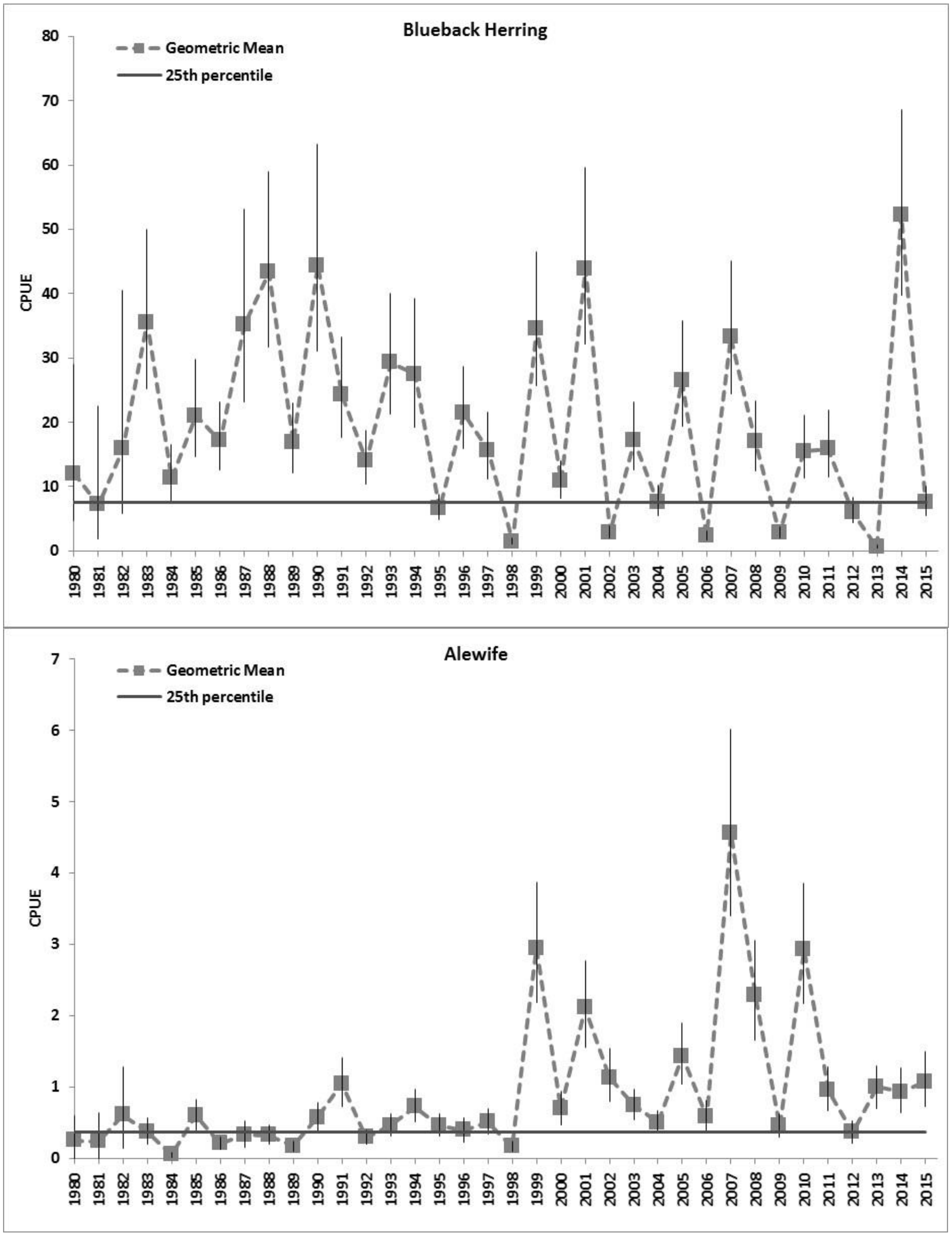


Table 1. Summary of available fishery-dependent river herring data in Hudson River and Marine District of New York.

Data Type	Time period/ Details	Description	Usefulness as index
Fishery Dependent - Commercial			
Harvest	Historic data: -1904-1994: NMFS -1994-present: Hudson (see below)- NYSDEC; Marine waters- VTR/dealer report since 2002 -1994- present: transfer of historic NMFS data to ACCSP, data available in confidential and non-confidential form	- Provide catch and effort data - Not separated by area (river v marine) - River data reporting rate unknown	- Gives historic perspective - Provides trend data for state as a whole, but does not separate river(s) from ocean until 1994.
Marine monitoring	River herring most likely occur as bycatch in variety of fisheries	No port sampling in NY for 'herring'	
Hudson River Mandatory reports	- Began in 1995 through the present - Enforcement of reports in 2000 - Catch and effort statistics	- Data from 2000 to present good - Reporting rate unknown - Data separated by gear used: - Fixed gill net below Bear Mountain Bridge (BMB); passive gear below spawning area; consistent manner of fishing; weekly sum of CPUE approximating "area under curve" method - In spawning area above BMB - Drift gill (main-stem HR only) - active gear - Fixed gill (main-stem HR only) - less effort than below BMB - Scap/lift net (main-stem HR only)	Emigration area CPUE - Fixed GN below BMB: o Good indicator of abundance o increasing trend Spawning area CPUE o Drift GN - variable o Scap - Flat
Hudson R. Fishery Monitoring	- Began in 1999 through the present - Onboard monitoring - Catch and effort statistics - Catch subsample	- Number of annual trips are low; co-occurs & staffing conflicts with FI sampling - Catch samples increased after 2012 - NEED improved sample size to be useful	- Characterize catch
Fishery Dependent - Recreational			
Harvest (primarily sought as bait for striped bass; some harvest for personal consumption)	Creel surveys: - 2001, river-wide, all year - 2005, spring only - 2007, state-wide angler survey; effort for striped bass	- 2001: provides point estimate of effort for striped bass, ancillary river herring (RH) data - 2005 provides point estimate of RH harvest & effort for striped bass	Combination of effort for striped bass and point estimate of RH harvest; combine with below CAP data to estimate magnitude of recreational harvest for 2005 to the present.
Cooperative Angler Program	Data 2006-present	Diary program for striped bass anglers; includes data for RH catch or purchase, use by trip	Good RH use per trip- used above with rec. harvest to estimate total recreational harvest

Table 2. Summary of available fishery-independent river herring data in Hudson River, New York.

Data type	Time period/Agency	Description	Usefulness as index
Fishery Independent- Hudson River			
Spawning stock	1936: Biological Survey	Historic data, low sample size of 25 fish, species, sex, length & age	Indication of size change to present
	2001 to present: NYSDEC spawning stock survey	Focused spawning stock survey; >300 fish collected most years; species, sex, length & scales (ageing complete from 2012-2015)	Early sample design precluded use for catch-per-unit-effort data. Fixed site sampling since 2012 is geared toward an adult index. Mortality estimates from scales 2012-present and from spawn marks 2009-present
Young-of-year Indices		- July-Oct sampling within nursery area - Geometric mean number per haul Catchability may be affected by habitat change 2006 to present; documents presence/absence of river herring in Hudson tributaries and in some Long Island streams - July-Oct sampling within nursery area - Geometric mean number per haul Catchability may be affected by habitat change	- Both species index variable - Alewife increasing - Blueback slight decreasing trend Selected conservative target of 25th percentileNot yet useful as index; provide a mechanism to improve future sampling for adult runs Both species index variable - Alewife increasing - Blueback slight decreasing trend Selected conservative target of 25th percentile

Table 3. River herring and American shad catch in metric tons (mt) by Atlantic Mackerel and Atlantic herring vessels, 2014 -2015. Data summarized by NMFS from vessels via the Vessel Monitoring System (VMS), the Vessel Trip Report System (VTR), Dealer Reports, and the Northeast Fisheries Observer Program.

Estimated river herring/shad catch (mt)	**2014**	**2015**
Atlantic mackerel vessels	6.42	12.87
Atlantic herring vessels - ALL	na	176.5
Atlantic herring: GOM Mid-water trawl	na	11.1
Atlantic herring: Cape Cod Mid-water trawl	na	0.7
Atlantic herring: Southern New England bottom trawl	na	100.7
Atlantic herring: Southern New England mid-water trawl	na	64

Table 4. River herring and American shad quotas for Atlantic Mackerel and Atlantic herring vessels, 2014-2015, and anticipated quota for Atlantic herring vessels 2016-2018.

Annual harvest cap for river herring/shad (mt)	**2014**	**2015**	**2016-18 (proposed)**
Atlantic mackerel vessels	236	89	82
Atlantic herring vessels - ALL	312	312	361
Atlantic herring: GOM Mid-water trawl	86	86	76.7
Atlantic herring: Cape Cod Mid-water trawl	13	13	32.4
Atlantic herring: Southern New England bottom trawl	89	89	122.3
Atlantic herring: Southern New England mid-water trawl	124	124	129.6

Table 5. Species-specific total annual incidental catch (mt) across all fleets and regions. Midwater trawl estimates were only included beginning in 2005. Modified from Amendment 14 of the Atlantic Mackerel, Squid and Butterfish Fishery Management Plan for the Mid Atlantic Fishery Management Council.

	ALEWIFE	AMERICAN SHAD	BLUEBACK HERRING	Unknown	HICKORY SHAD					
Year	**Catch (mt)**	**Catch (mt)**	**Catch (mt)**	**Catch (mt)**	**Catch (mt)**	**Total Catch (mt)**	**Total identified catch (mt)**	**Proportion of known catch that is River Herring**	**Estimated unknown catch that is River Herring (mt)**	**Total estimated River Herring catch (mt)**
1989	20.4	58.9	19.6	7.1	0.0	106.0	98.9	0.40	2.9	42.8
1990	55.3	25.8	78.9	331.3	0.0	491.4	160.1	0.84	277.9	412.2
1991	68.2	104.3	115.4	110.5	39.4	437.7	327.3	0.56	62.0	245.6
1992	30.6	79.8	458.2	387.5	0.0	956.1	568.5	0.86	333.1	821.9
1993	40.5	51.0	210.6	18.6	0.0	320.6	302.0	0.83	15.5	266.5
1994	5.5	70.3	40.2	9.8	0.2	126.0	116.2	0.39	3.8	49.5
1995	6.4	17.2	213.5	51.9	0.0	288.9	237.1	0.93	48.1	268.0
1996	482.0	40.0	1803.4	28.7	26.6	2380.8	2352.1	0.97	27.9	2313.3
1997	41.3	37.0	982.0	67.6	18.3	1146.2	1078.6	0.95	64.1	1087.4
1998	80.9	55.3	49.3	0.4	39.2	225.1	224.7	0.58	0.2	130.4
1999	3.9	15.7	206.7	128.8	56.8	411.8	283.0	0.74	95.8	306.3
2000	28.4	74.4	55.5	22.0	0.1	180.2	158.3	0.53	11.6	95.5
2001	93.0	61.9	120.1	2.1	80.6	357.8	355.7	0.60	1.3	214.4
2002	2.7	24.1	173.2	76.5	1.4	277.9	201.4	0.87	66.8	242.8
2003	248.4	21.4	332.5	15.3	14.3	631.9	616.6	0.94	14.4	595.3
2004	99.7	18.2	81.5	176.7	35.0	411.2	234.5	0.77	136.6	317.9
2005	347.4	78.2	220.0	7.2	19.4	672.3	665.1	0.85	6.1	573.6
2006	57.6	29.3	187.5	232.0	13.4	519.8	287.7	0.85	197.6	442.7
2007	484.0	55.1	180.1	105.3	4.8	829.3	724.0	0.92	96.6	760.8
2008	145.0	52.4	526.6	328.0	7.8	1059.8	731.8	0.92	301.0	972.6
2009	158.7	59.5	202.0	180.1	10.9	611.2	431.1	0.84	150.6	511.3
2010	118.5	46.1	125.0	86.5	1.1	377.3	290.8	0.84	72.4	316.0
Average	119.0	48.9	290.1	107.9	16.8	582.7	474.8	0.80	90.3	499.4

Table 6. Estimated river herring harvest (mt), based on average rate of known river herring bycatch 1989-2010 applied to actual harvest in 2014-15.

Estimated American shad catch (mt)	**2014**	**2015**
Atlantic mackerel vessels	5.14	10.30
Atlantic herring vessels - ALL	na	141.20
Atlantic herring: GOM Mid-water trawl	na	8.88
Atlantic herring: Cape Cod Mid-water trawl	na	0.56
Atlantic herring: Southern New England bottom trawl	na	80.56
Atlantic herring: Southern New England mid-water trawl	na	51.20

Table 7. Recent records of type of commercial licenses sold for the New York portions of the Hudson River Estuary.

	Gill Nets				Scap Nets		Gill net		Scap Net	
Year	N-Fishers	Shad/herring Gill Net	Gill Net	Total GN permits sold	N-Fishers	Permits sold	N-Fishers reporting herring	% Reporting	N-Fishers reporting herring	% Reporting
1995	112	47	75	122	2	2	5	4%	2	100%
1996	134	54	88	142	2	2	4	3%	2	100%
1997	112	45	74	119	35	35	22	20%	24	69%
1998	140	65	119	184	46	46	33	24%	33	72%
1999	145	77	68	145	31	31	40	28%	20	65%
2000	223	108	123	231	443	449	67	30%	124	28%
2001	190	87	83	170	345	348	67	35%	127	37%
2002	232	141	120	261	291	338	87	38%	113	39%
2003	238	144	106	250	237	278	96	40%	115	49%
2004	275	160	127	287	245	291	89	32%	106	43%
2005	255	162	111	273	215	255	68	27%	80	37%
2006	290	179	129	308	229	273	92	32%	87	38%
2007	290	178	130	308	201	244	87	30%	75	37%
2008	277	173	119	292	182	219	78	28%	85	47%
2009	254	159	108	267	168	199	76	30%	78	46%
2010	181	0	185	185	161	190	74	41%	73	45%
2011	177	0	181	181	144	164	62	35%	61	42%
2012	154	0	155	155	128	151	66	43%	51	40%
2013	157	0	166	166	112	127	77	49%	33	29%
2014	150	0	152	152	109	124	47	31%	27	25%
2015	148	0	150	150	96	112	58	39%	33	34%

Table 8. Drift gill net trips by river section above Bear Mountain Bridge (rkm 75). From mandatory commercial reports stating mesh less than or equal to 3.5” stretch mesh. Note: Kingston Flats rkm’s are not exclusive and trip rkm’s are based on fishermen descriptions, so any rkm 148-149 trips are moved to the Kingston reach and rkm 154-155 trips are listed with the Saugerties reach.

	West Point rkm 75 - 89	Cornwall rkm 90 - 98	Poughkeepsie rkm 99 - 122	HydePark rkm 123 - 135	Kingston rkm 138 - 147	Kingston Flats rkm 148 - 155	Saugerties rkm 156 - 171	Catskill rm 172 - 200	Coxsackie rkm 201 - 216	Albany rkm 217 - 245
2000			2		3		104	88	2	
2001			1	7	3		31	120	5	
2002		5	3	5	14		37	168	6	
2003				8	10		59	184	14	
2004		2		8	3		37	188	20	
2005				1	12		60	145	17	
2006			1	10	16		69	87	25	
2007		1	11	13	32	**Area closed to**	57	62	19	**Area closed to**
2008				4	24	**gill nets**	49	67	13	**gill nets**
2009			11		17		64	45	11	
2010			12	3	26		28	38	11	
2011			10	1	10		22	33	1	
2012			20	1	34		34	33	3	
2013		8	13		58		82	88	11	
2014		6	6		69		58	54	8	
2015		10	14		25		44	68	12	
Mean	0.0	5.3	8.7	5.5	22.3	0	52.2	91.8	11.1	0
% of all years	0%	3%	4%	3%	11%	0%	27%	47%	6%	0%

Table 9. Number of river herring monitoring trips and catch per unit effort (CPUE) in the Hudson River commercial gill net fishery from 1996 through 2015. Only Trips where effort was calculated. Confidential data are in red.

YEAR	Fixed gill nets below Bear Mtn Bridge					Drift gill nets			
	Trips	Effort^	Catch	Annual CPUE	Sum of Weekly CPUE	Trips	Effort^	Catch	Annual CPUE
1996	0					1	91	43	0.472
1997	5	6830.6	208	0.030	0.055	0			
1998	0					0			
1999	4	11372.2	421	0.037	0.065	0			
2000	5	15650.0	545	0.035	0.126	1	160	7	0.044
2001	7	26688.9	1221	0.046	0.276	0			
2002	8	32222.2	1328	0.041	0.230	0			
2003	2	4800.0	171	0.036	0.071	0			
2004	11	41164.4	1826	0.044	0.230	0			
2005	1	9600.0	428	0.045	0.045	0			
2006	2	5591.1	246	0.044	0.044	1	378	0	0.000
2007	4	25777.8	299	0.012	0.055	2	4767	36	0.008
2008	0					0			
2009	3	19266.7	468	0.024	0.045	0			
2010	1	4326.7	154	0.036	0.036	0			
2011	4	6531.6	329	0.050	0.150	0			
2012	20	50916.4	1066	0.021	0.154	6	7013	560	0.080
2013	4	10719.8	1382	0.129	0.419	1	178	112	0.630
2014	7	14612.8	2161	0.148	0.605	1	2843	289	0.102
2015	5	8435.0	605	0.072	0.176	1	637	197	0.309

^Sq yd net area * hours

Table 10. Observed landings and dockside subsamples for commercial river herring trips made in the Hudson River Estuary for 2001 through 2015. Only trips where effort was calculated is presented. Confidential data in red.

On-board Observations of Commercial Trips																				
		Alewife					Blueback herring					Unidentified "river herring"								
	N of	Number			Sex ratio		Number			Sex ratio		Number			Sex ratio			Percent		
Year	trips	M	F	U	M	F	M	F	U	M	F	M	F	U	M	F	Total	Alewife	Blueback	Unknown
2001	7	192	178	851	0.52	0.48											1,221	100%	0%	0%
2002	8			43			19	41	1225	0.32	0.68						1,328	3%	97%	0%
2003	2			171													171	100%	0%	0%
2004	11	124	168	8	0.42	0.58	5	6		0.45	0.55	500	796	297	0.39	0.61	1,904	16%	1%	84%
2005	1			428										28			456	94%	0%	6%
2006	3			1					246								247	0%	100%	0%
2007	6			14					53					268			335	4%	16%	80%
2008	0											44					44	0%	0%	100%
2009	3	187	179	4	0.51	0.49	37	61		0.38	0.62						468	79%	21%	0%
2010	1	23	28	1	0.45	0.55	11	88	3	0.11	0.89						154	34%	66%	0%
2011	4	163	148	0	0.52	0.48	3	5		0.38	0.63			10			329	95%	2%	3%
2012	26	439	568	121	0.44	0.56	54	70	68	0.44	0.56			383			1,703	66%	11%	22%
2013	5	615	586	1	0.51	0.49	98	305		0.24	0.76						1,605	75%	25%	0%
2014	8	750	830	5	0.47	0.53	236	629		0.27	0.73						2,450	65%	35%	0%
2015	6	202	291	12	0.41	0.59	77	185		0.29	0.71			35			802	63%	33%	4%

Table 11. Age structure of river herring samples from the commercial fishery. 2012 commercial scale samples were aged; 2013-2015 ages were estimated using age-length keys derived from fishery independent samples.

	Age									
	2	3	4	5	6	7	8	9	Total	Mean Age
Alewife Male										
2012	4	71	110	37	4	5			231	3.91
2013		26	37	15	3	1			83	3.97
2014		32	82	102	2	1	1		221	4.37
2015		4	42	53	18	1	1		118	4.77
Alewife Female										
2012	1	30	155	121	25	11	2	1	346	4.54
2013		19	39	12	5	1			76	4.07
2014		23	106	62	18	11	3	2	225	4.58
2015		14	41	67	18	4	1		146	4.73
Blueback herring Male										
2012	2	18	40	11	3				75	3.94
2013	0.2	10	9	4	2				25	3.91
2014	0.3	17	55	25	2				99	4.11
2015		7	8	17	1				33	4.35
Blueback herring Female										
2012		32	68	34	2	2			137	4.09
2013		13	11	6	2	1			32	3.92
2014		26	63	23	13	5			130	4.29
2015		6	16	16	4	1			43	4.53

Table 12. Estimated recreational use and take of river herring by Hudson River anglers.

Year	Herring Use* % of all CAP Trips using herring as bait	N-SB Trips using RH	N bought / trip	N caught / trip	Total RH use/trip	% change in annual effort of CAP data	Estimated SB trips**	Trips using herring as bait**	Estimated Herring Use
2001							53,988	39,500	93,157**
2005	89%						72,568	64,500	152,117**
	Cooperative Angler Program Data								
2006	48%	263	1.47	2.57	4.04				
2007	25%	335	1.66	1.80	3.46		90,742	22,685	78,491***
2008	33%	474	0.86	1.64	2.50	+21%	109,557	36,154	84,969***
2009	35%	508	0.63	3.80	4.43	+9%	98,739	34,559	148,303***
2010	52%	532	0.67	4.80	5.48	+1	91,513	47,587	258,150***
2011	48%	885	0.71	4.35	5.06	+14%	103,532	49,695	251,285***
2012	53%	749	1.10	4.76	5.86	-1%	89,735	47,650	278,627***
2013	57%	611	1.04	5.23	6.27	-11%	80,703	46,001	288,579***
2014	55%	512	0.74	5.30	6.04	-14%	78,438	43,141	260,613***
2015	54%	571	0.66	6.04	6.70	+18%	106,961	57,759	386,915***

*Data from NYSDEC - HRFU Cooperative Angler Program (unpublished data)
**Creel survey data: NAI 2003, NAI 2007; 2001 estimated use modified using 2005 RH use per trip* 2001 trips using herring as bait; From 2008 to 2015 estimated using the percent change in annual effort of the CAP data*2007 SB trips from NYSDEC statewide angler survey
***Estimate calculated from the average RH/trip (CAP) and Estimated SB trips from 2007 NYSDEC statewide angler survey adjusted annually using the percent change in effort from CAP data

Table 13. Annual daily count data from Black Creek and commercial and estimated recreational herring harvest.

	Black Creek Daily Alewife Count Data							Hudson River Harvest		
	Min	Max	Mean	SD	SE	Total Counts	n (days)*	Commercial Harvest**	Recreational Harvest***	Total
2013	25	40571	4380.53	7710.69	1124.72	205,885	47	24,612	288,579	313,191
2014	294	58416	18458.75	13206.45	2334.59	590,680	32	20,805	260,613	281,418
2015	26	45186	13064.74	12146.56	2114.45	431,136	33	15,634	386,915	402,549

*Number of days count data were recorded
**Number harvested of combined river herring species from Hudson River commercial reports
***Estimated harvest numbers of combined river herring species derived from CAP data and 2007 NYSDEC statewide angler survey

Table 14. Annual catch and effort (n-hauls) for alewife and blueback herring.

Year	Annual Catch (Alewife)	Annual Catch (Blueback)	Annual Effort * (N-hauls)	Annual CPUE (Alewife)	Annual CPUE (Blueback)
			Historical survey data		
2001	1336	28	8	167.00	3.50
2003	417	7	11	37.91	0.64
2004	0	10	2	0.00	5.00
2005	120	41	12	10.00	3.42
2006	27	3	3	9.00	1.00
2007	53	0	6	8.83	0.00
2008	235	21	15	15.67	1.40
2009	660	182	20	33.00	9.10
2010	265	44	56	4.73	0.79
2011	74	80	21	3.52	3.81
			Current survey data		
2012	2146	1304	165	13.01	7.90
2013	4865	4056	117	41.58	34.67
2014	11231	3054	114	98.52	26.79
2015	4328	3030	107	40.45	28.32

*Only includes hauls when gear performed well without any major issues i.e. no hangs, rips in net, or lifting of the lead line

Table 15. Sampling efforts (n-hauls) and catches per river section from 2012-15.

	2012			2013			2014			2015		
River section	N-sites	N-hauls	N-herring caught	N-sites	N-hauls	N-herring caught	N-sites	N-hauls	N-herring caught	N-sites	N-hauls	N-herring caught
Albany	6	37	1978	3	21	4273	3	26	3440	3	21	2247
Catskill	14	52	529	9	38	1639	7	30	3118	5	33	1851
Coxsackie	15	47	477	10	34	2269	5	30	5908	5	33	2113
Kingston	14	46	468	6	32	787	5	36	1898	4	32	1178
Newburgh	4	11	-	-	-	-	-	-	-	-	-	-
Poughkeepsie	14	3	1	-	-	-	-	-	-	-	-	-
IndianPoint	5	6	-	-	-	-	-	-	-	-	-	-
Croton-Haverstraw	3	10	-	-	-	-	-	-	-	-	-	-
TappanZee	6	6	-	-	-	-	-	-	-	-	-	-
Totals	81	218	3453	28	125	8968	20	122	14364	17	119	7389

Table 16. Age structure of river herring from fisheries independent sampling.

Year	Age* 2	3	4	5	6	7	8	9	Total	Mean Age
Alewife Male										
2012	27	385	726	308	91	21	2		1559	4.08
2013		615	782	276	48	15	1		1737	3.89
2014	1	372	933	1233	61	18	29		2647	4.43
2015		105	430	544	203	12	8		1302	4.70
Alewife Female										
2012	5	76	210	175	32	11	7	2	518	4.44
2013		148	275	84	58	17	12	1	596	4.26
2014		83	537	383	137	75	27	5	1247	4.75
2015		56	179	372	114	30	8		759	4.87
Blueback Herring Male										
2012	64	157	89	16	3				329	3.20
2013	34	483	209	44	17				787	3.40
2014	83	308	205	51	1				649	3.35
2015	3	412	168	44	3				630	3.42
Blueback Herring Female										
2012		152	168	61	4				385	3.78
2013	1	364	203	97	21	1			687	3.67
2014	7	320	274	77	36	9			723	3.78
2015		248	262	162	36	9			716	4.02

* Numbers at age are estimated using age-length keys that are derived on an annual basis

Table 17. Repeat spawn data of river herring from fisheries independent sampling.

	Repeat spawn marks*									
Year	0	1	2	3	4	5	Total	Mean RS	% Virgin	% Repeat
Alewife Male										
2009	229	65	12	0			306	0.29	0.75	0.25
2010	165	28	11	2			206	0.27	0.80	0.20
2011	101	18	2	1	1		123	0.24	0.82	0.18
2012	138	35	19	1			193	0.39	0.72	0.28
2013	150	23	13	2			188	0.29	0.80	0.20
2014	52	19	7	4	2		84	0.63	0.62	0.38
2015	54	19	25	6	1	1	106	0.91	0.51	0.49
Alewife Female										
2009	70	41	9	1			121	0.51	0.58	0.42
2010	51	32	15	2	1		101	0.71	0.50	0.50
2011	84	25	12	2			123	0.45	0.68	0.32
2012	124	36	17	5	3		185	0.52	0.67	0.33
2013	116	39	24	9	8		196	0.74	0.59	0.41
2014	42	13	10	10	4	2	81	1.10	0.52	0.48
2015	32	25	20	8	4		89	1.18	0.36	0.64
Blueback Herring Male										
2009	38	24	2				64	0.44	0.59	0.41
2010	63	12	4				79	0.25	0.80	0.20
2011	66	12	1				79	0.18	0.84	0.16
2012	294	28	7				329	0.13	0.89	0.11
2013	118	7	2	1			128	0.11	0.92	0.08
2014	57	9	4	1			71	0.28	0.80	0.20
2015	48	9	7				64	0.36	0.75	0.25
Blueback Herring Female										
2009	44	12	3				59	0.31	0.75	0.25
2010	46	16	4				66	0.36	0.70	0.30
2011	80	26	5	1			112	0.35	0.71	0.29
2012	107	26	2	1			136	0.24	0.79	0.21
2013	121	19	11	4			155	0.34	0.78	0.22
2014	48	10	12	4			74	0.62	0.65	0.35
2015	41	21	13	4			79	0.75	0.52	0.48

* Numbers of repeat spawn marks are derived from actual scale readings

Table 18. Mean lengths (mm) at age for river herring from fisheries independent sampling.

	1936				2012				2013				2014				2015			
	Alewife		Blueback		Alewife		Blueback		Alewife		Blueback		Alewife		Blueback		Alewife		Blueback	
Ages	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
2					235.0	244.7	219.9				217.2	226	222.0		218.7	226.0			222.5	
3	275.0			266.2	239.3	251.0	236.5	245.7	244.1	255.7	241.3	250.3	238.6	250.4	236.8	244.0	235.5	256.2	244.6	250.9
4	284.8	297.4	301.0	290.8	260.5	266.8	250.2	257.9	254.2	263.8	252.3	263.7	263.5	267.7	257.3	266.6	257.2	269.8	254.3	265.2
5	289.8	302.8	290.1	298.2	271.9	276.1	250.2	266.0	269.2	281.7	261.2	274.8	275.5	285.5	266.3	280.4	277.4	285.1	270.3	280.6
6	284.5	309.6	302.4	320.8	280.1	296.8	246.0	285.5	280.9	291.3	263.0	280.7	292.6	301.3	276.0	289.7	288.0	300.6	280.5	287.5
7					275.8	295.0			281.4	299.2		296.0	296.3	302.0		294.0	301.0	310.9		293.3
8					292.0	311.0			292.0	304.8			295.3	307.6			291.5	316.0		
9						299.0				305.0				317.0						

Table 19. Instantaneous mortality estimates derived from age data and repeat spawn data using a bias-correction Chapman and Robson mortality estimator described in Smith et al. (2012).

	Age								Repeat Spawn							
	Alewife				Blueback				Alewife				Blueback			
	Male		Female		Male		Female		Male		Female		Male		Female	
Year	Z	SE	Z	SE	Z	SE	Z	SE	Z	SE	Z	SE	Z	SE	Z	SE
2009									1.48	0.12	1.07	0.22	1.16	0.41	1.40	0.09
2010									1.53	0.12	0.86	0.01	1.55	0.12	1.28	0.13
2011									1.62	0.21	1.16	0.09	1.83	0.13	1.33	0.10
2012	1.12	0.09	0.88	0.19	1.10	0.22	0.82	0.35	1.25	0.15	1.06	0.06	2.22	0.11	1.60	0.14
2013	1.30	0.10	0.90	0.08	1.15	0.12	0.91	0.13	1.50	0.19	0.84	0.08	2.25	0.44	1.35	0.19
2014	0.91	0.45	0.76	0.13	1.03	0.26	0.81	0.18	0.93	0.05	0.64	0.08	1.47	0.15	0.94	0.18
2015	1.40	0.22	1.29	0.04	1.21	0.15	1.02	0.20	0.73	0.13	0.59	0.17	1.29	0.28	0.83	0.12

8 Appendix 1

Table A. Summary of historical and current commercial fishery regulations for alewife and blueback herring in New York State (2013 regulation changes in bold).

Regulation	2013 to Present	Regulation link
Season	Mar 15 – Jun 15	6 CRR-NY 36.3 (a)
Creel/ catch limits	None	
Commercial Gear (Marine permit)	Gill nets as commercial gear - 600 ft or less - 3.5 in stretch mesh or smaller - No fishing at night in HR above Bear Mt Bridge - **Drift gill nets only allowable gill nets above Bear Mt Bridge** - Gill nets above Bear Mt Bridge must be tended at all times	6 CRR-NY 36.3 (c) 6 CRR-NY 36.3 (b) 6 CRR-NY 36.3 (3)(i) 6 CRR-NY 36.3 (7) 6 CRR-NY 36.3 (2)(iv) 6 CRR-NY 36.3 (5)
	Seine as commercial gear - No size restrictions below Castleton/I90	6 CRR-NY 36.3 (c)
	Scoop/Dip/Scap net as commercial gear - **10' x 10' maximum**	6 CRR-NY 36.3 (c)
	Fyke/hoop/trap nets as commercial gear - No size restrictions	6 CRR-NY 36.3 (c)
Commercial Gear (Bait license)	Cast Net as bait collection gear - 10 ft maximum diameter	*To find the law* ***click here****, on ENV, find Article 11, click on Title 13, click* ***ECL 11-1315***
Closed areas	No gill nets above I90 - Castleton Bridge	6 CRR-NY 36.3 (2)(ii)
	No nets on Kingston Flats	6 CRR-NY 36.3 (2)(i)
	No nets in any tributary (including Mohawk River)	6 CRR-NY 36.3 (2)(i)
Escapement (no fishing days)	36 hr lift period for **all commercial gears** Friday 6AM – Saturday 6PM	6 CRR-NY 36.3 (4)
Marine Permit Fees (established 1911)	Gill net $0.05/foot	6 CRR-NY 35.1
	Scap net <10 sq ft $1.00	
	Seine $0.05/foot	
	Trap nets $3 to $10	
	Fyke net $1 to $2	
Marine Permit Reporting	**Mandatory daily catch & effort; Vessel Trip Reports (VTRs) due monthly**	6 CRR-NY 36.1 (a)(1)

Transport and sale	- Commercially caught anadromous river herring must be sold and used in the Hudson River and tributaries to first impassable barrier and within the transport corridor
	- May also be sold or transferred to locations in the Marine District
	- Transport within DEC Reg. 3 requires a bait transport permit
	- Retail sale of live and frozen anadromous river herring requires
	  ○ Fish health certification on premises
	  ○ Receipt to purchaser (valid for 10 days)
	- Retail sale of dead packaged anadromous river herring requires
	  ○ Preservation other than freezing
	  ○ Each package must be labeled with
	    ▪ Name of packager-processor
	    ▪ Name of fish species
	    ▪ Quantity of fish
	    ▪ Means of preservation
		6 CRR-NY 35.3 (d)
		6 CRR-NY 35.3 (c)(1)
		6 CRR-NY 35.3 (c)(2)
		6 CRR-NY 35.3 (c)(3)(ii)
		6 CRR-NY 35.3 (c)(3)(iii)(a)
		6 CRR-NY 35.3 (c)(4)

Table B. Summary of historical and current recreational fishery regulations for alewife and blueback herring in New York State (2013 regulation changes in bold).

Regulation	2013 to Present	Regulation link
Season	Mar 15 – Jun 15	6 CRR-NY 10.10 (c)(2)
Creel/ catch limits (personal use)	**10 per day per angler or a maximum boat limit of 50 per day for a group of boat anglers (whichever is lower)**	6 CRR-NY 10.10 (c)(2)

Creel/ catch limits (party or charter)	- **10 per day per angler or a maximum boat limit of 50 per day for a group of boat anglers (whichever is lower)**
	- **Operator of party or charter north of Tappan Zee bridge may possess anadromous river herring in excess of individual recreational possession limit as long as**
	  ○ **Register with Hudson River Fisheries Unit**
	  ○ **Must display a valid Hudson River herring decal on port side of vessel**
		6 CRR-NY 10.10 (c)(4)(i)
		6 CRR-NY 10.10 (c)(4)(ii)
		6 CRR-NY 10.10 (c)(4)(iii)
		6 CRR-NY 10.10 (c)(4)(iii)(c)

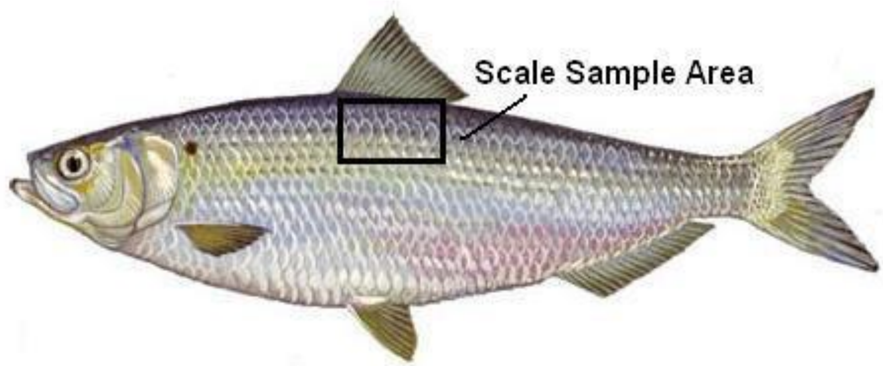
Recreational gear (personal use)	Angling	6 CRR-NY 10.10 (c)(2)
	Seine – not exceeding 36 square feet	6 CRR-NY 10.10 (c)(3)(ii)(e)
	Scap net – - **Not exceeding 16 square feet** - Only one net	6 CRR-NY 10.10 (c)(3)(ii)(d) 6 CRR-NY 10.10 (c)(3)(ii)(b)
	Dip/Scoop – - Not exceeding 14 inches in diameter or 13 inches by 13 inches square - Only one net	6 CRR-NY 10.10 (c)(3)(ii)(c) 6 CRR-NY 10.10 (c)(3)(ii)(b)
	Cast net – not exceeding 10 feet in diameter	6 CRR-NY 10.10 (c)(3)(ii)(f)
Closed areas	- **No nets in any Hudson River tributary (including Mohawk R)** ○ **Nets must be stowed prior to entering a tributary** - **All other waters of NY State closed to the take of anadromous river herring**	6 CRR-NY 10.10 (c)(3)(i) 6 CRR-NY 10.10 (c)(3)(iii) 6 CRR-NY 10.10 (c)(2)
Transport restrictions	Herring taken in the Hudson River and tributaries (up to first impassable barrier) for personal use: - May only be used in the Hudson River and tributaries up to first impassable barrier - May only transported overland within the transportation corridor	6 CRR-NY 10.1 (f)(3)(iii) 6 CRR-NY 10.1 (f)(3)(iii)(c)
Escapement (no fishing days)	None	
License	Marine Registry	6 CRR-NY 10.10 (c)(1)(i)
Reporting	None	

9 Appendix 2

River Herring (Blueback *Alosa aestivalis*, Alewife *Alosa psuedoharengus*) **Aging Protocol**
New York Department of Environmental Conservation adopted from the Massachusetts Division of Marine Fisheries

Sample Collection

- Each fish is given its own sample ID (river, year, and fish number).
- Length, weight, sex, species, capture date and sample ID number are recorded on envelopes and data sheet.
- Fork length and total length are recorded on data sheet for every sample.
- Otoliths are extracted, wiped clean, and placed in a microcentrifuge tube with corresponding sample ID number.
- Otoliths are extracted using a scalpel and forceps. Slice off the top part of the head exposing the brain cavity. Slice should be shallow starting at the back of the skull slicing forward.
- Scoop out any brain matter.
- Using forceps extract the otic membrane (otoliths should be in the otic membrane).
- Scales collected just ventral of the dorsal fin, before removal use knife to remove dirt and slime coat from scales.
- Take approximately 20 scales and place into an envelope with the corresponding sample ID number.



Structure Processing

Otoliths

- Must be careful with otolith processing structures are very fragile.
- Water is used to clean off any dried blood.
- Dried with a paper towel then placed back into microcentrifuge tube.

Scales

- Make up a Pancreatin solution 500 mL water with 3.5g Panreatin. Place on stir plate and let mix for approximately 10 mins.
- Place approximately 10 scales into a centrifuge tube (one sample per centrifuge tube).
- Avoid selecting regenerated scales.
- Fill each centrifuge tube with 15-20mL of Pancreatin solution then place in sonicator.
- Each batch will contain 10 samples, run for 15 mins.

- Remove samples from sonicator and empty scales into a fine mesh strainer one sample at a time.
- Wipe, rinse, and dry scales.
- Place scales between two glass slides tapping the ends together and labeling one side with the corresponding sample ID number.

Age Interpretation

Both aging structures are viewed using a digital camera fixed with adjustable zoom optics and Image-Pro Insight® software.

Otoliths

- Set scope lens to 1.0x with reflected light.
- Immerse otoliths in mineral oil sulcus down on top of a black background.
- Annuli counted from the middle outward, counting the edge as the last annuli.
- Annuli are identified at the edge of the hyaline bands.
- The pararostrum is the clearest part of the otolith to age.

Scales

- Set scope lens to 0.5x with transmitted light.
- Annuli are identified as continuous, concentric lines that must pass through the baseline (first transverse groove that separates the anterior and posterior portions of the scale) and are present in both the anterior and posterior portions of the scale.
- Adjust the mirror and lighting so the annuli can be viewed crossing over the baseline.
- Annuli counted from the middle outward, counting the edge as the last annuli. (Fig. 1 & 2)
- The first dark band is the freshwater zone not the first annuli. (Fig. 1 & 2)
- Slight variations in scale appearance between alewife and blueback herring in terms of aging. (Fig. 1 & 2)
- False annuli will not cross over the baseline and cannot be followed throughout the scale. (Fig. 3)
- Typically the second annulus is the “strongest” looking. (Fig. 4 & 5)
- Annuli can become crowded together at the edge of the scale, but will separate back out beneath the baseline. Should be counted as separate annuli. (Fig. 6)
- Annuli can resorb back over previous annuli, but will separate back out beneath the baseline. Should be counted as separate annuli. (Fig. 6)
- Spawning marks are identified as annuli with breaks and fractures running through the band as opposed to non-spawning mark annuli that has smooth band formation. (Fig. 6)
- Spawning marks are typically easier to identify than normal annuli due to obvious irregularities visible on the scale.
- Annuli and spawning marks must be identified on multiple scales from the same fish in order to be considered a true annulus or spawning mark.

Production Aging

Two independent age and repeat spawn mark determinations as well as agreement on age and repeats are sought for each fish. When possible, a third independent reader resolves differences, however; in the event a third reader is unavailable, the two agers will review each disagreed upon sample in an attempt to reach a consensus age. If a consensus age cannot be resolved the sample will be excluded from any further analysis.

Comparison of age and repeat spawning mark assignments among readers are analyzed using a standard precision template developed by NOAA's Northeast Fisheries Science Center. Templates can be found at http://www.nefsc.noaa.gov/fbp/age-prec/. Precision is evaluated by examination of the mean coefficient of variation (CV), percent agreement and the Bowker's test of symmetry. Aging laboratories around the world view a measure of mean CV of 5% or less to be acceptable (Compana 2001).

References

Compana, S.E. 2001. Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods. Journal of Fish Biology 59: 197-242

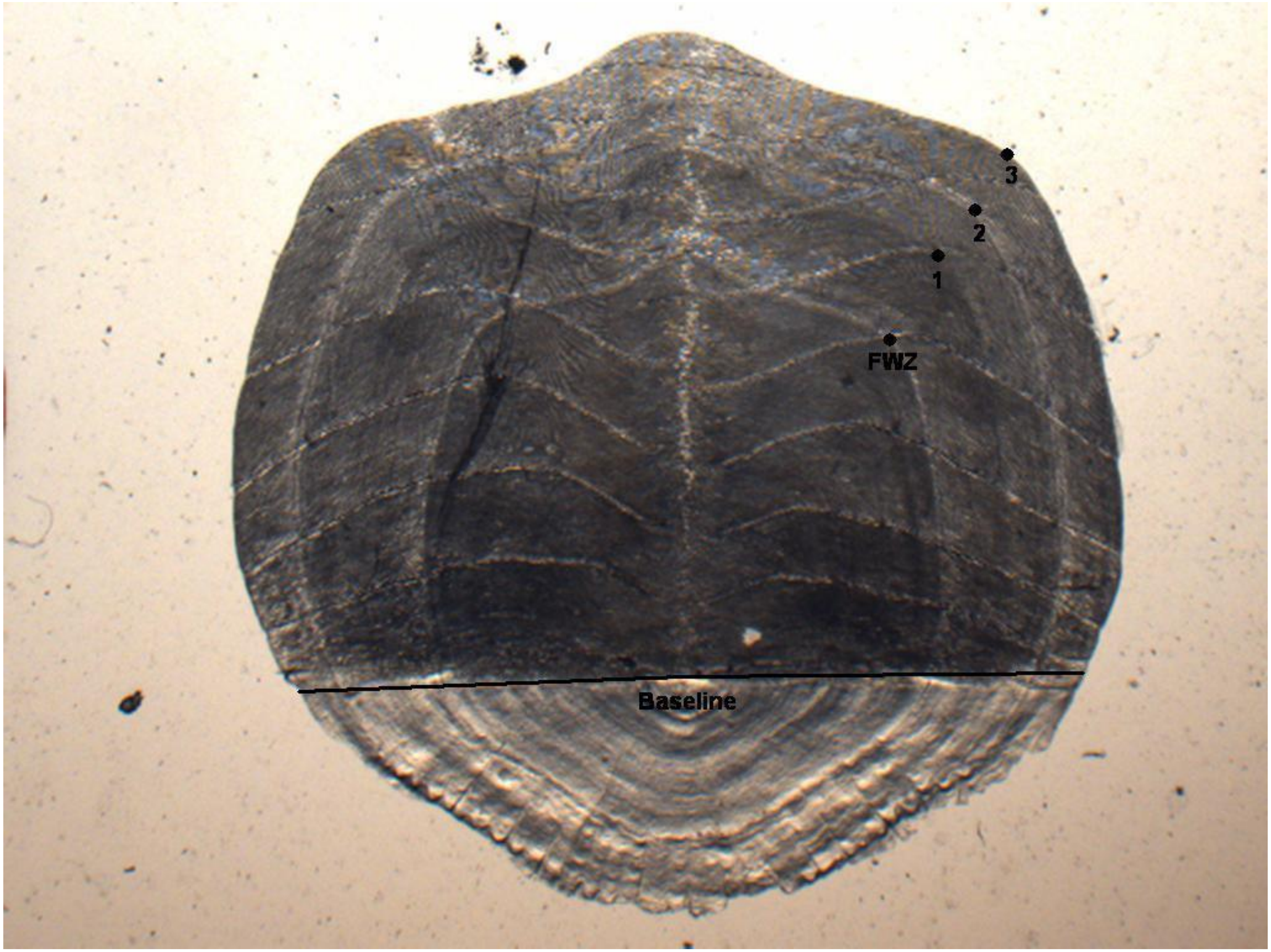


Figure 1. This 3 year old alewife has its baseline, fresh water zone (FWZ) and annuli all marked. Note the straight baseline and large FWZ typical of alewives.

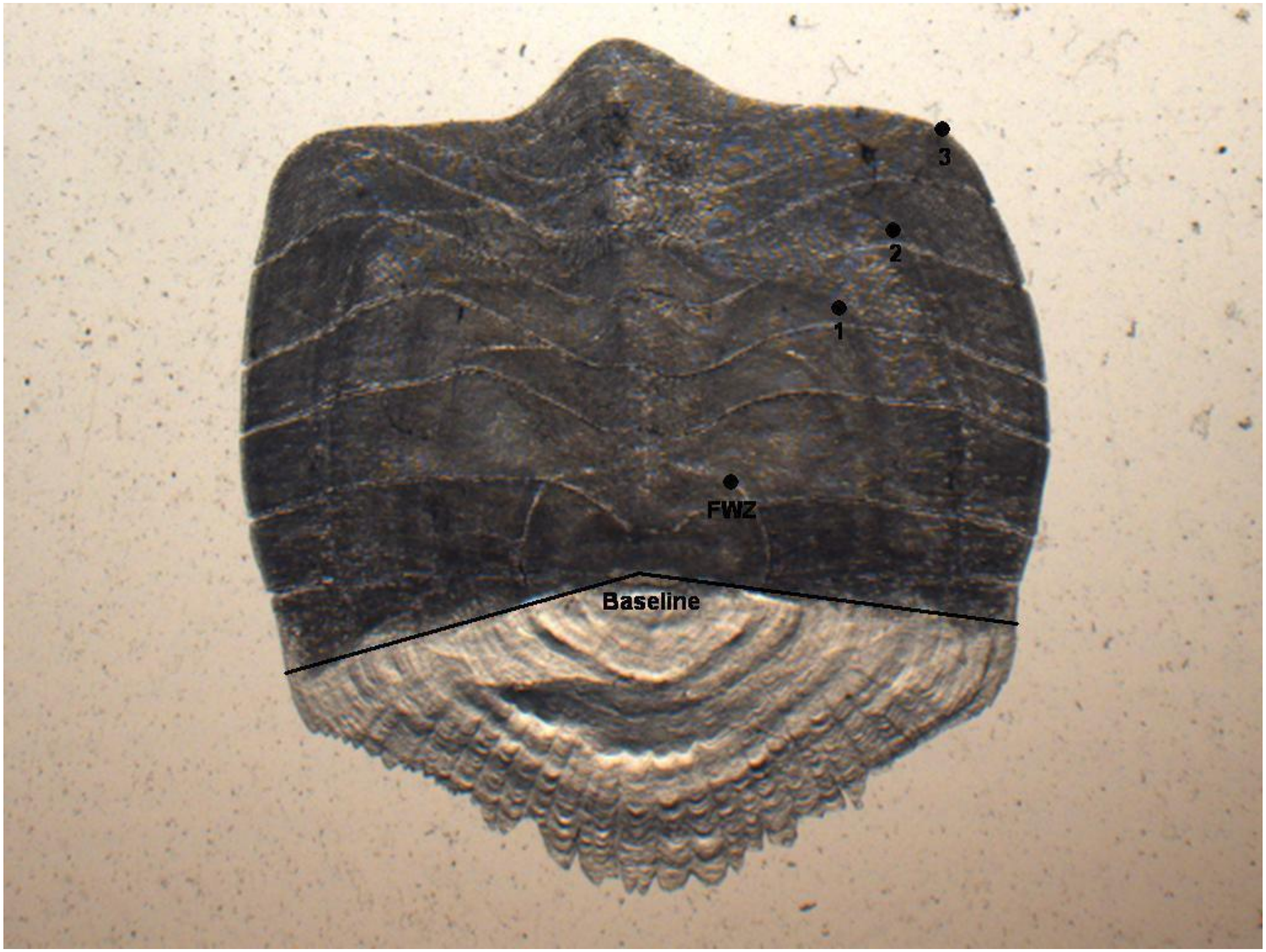


Figure 2. The baseline, fresh water zone (FWZ) and annuli are all marked on this blueback scale. Note the small FWZ and angled baseline typical of bluebacks.

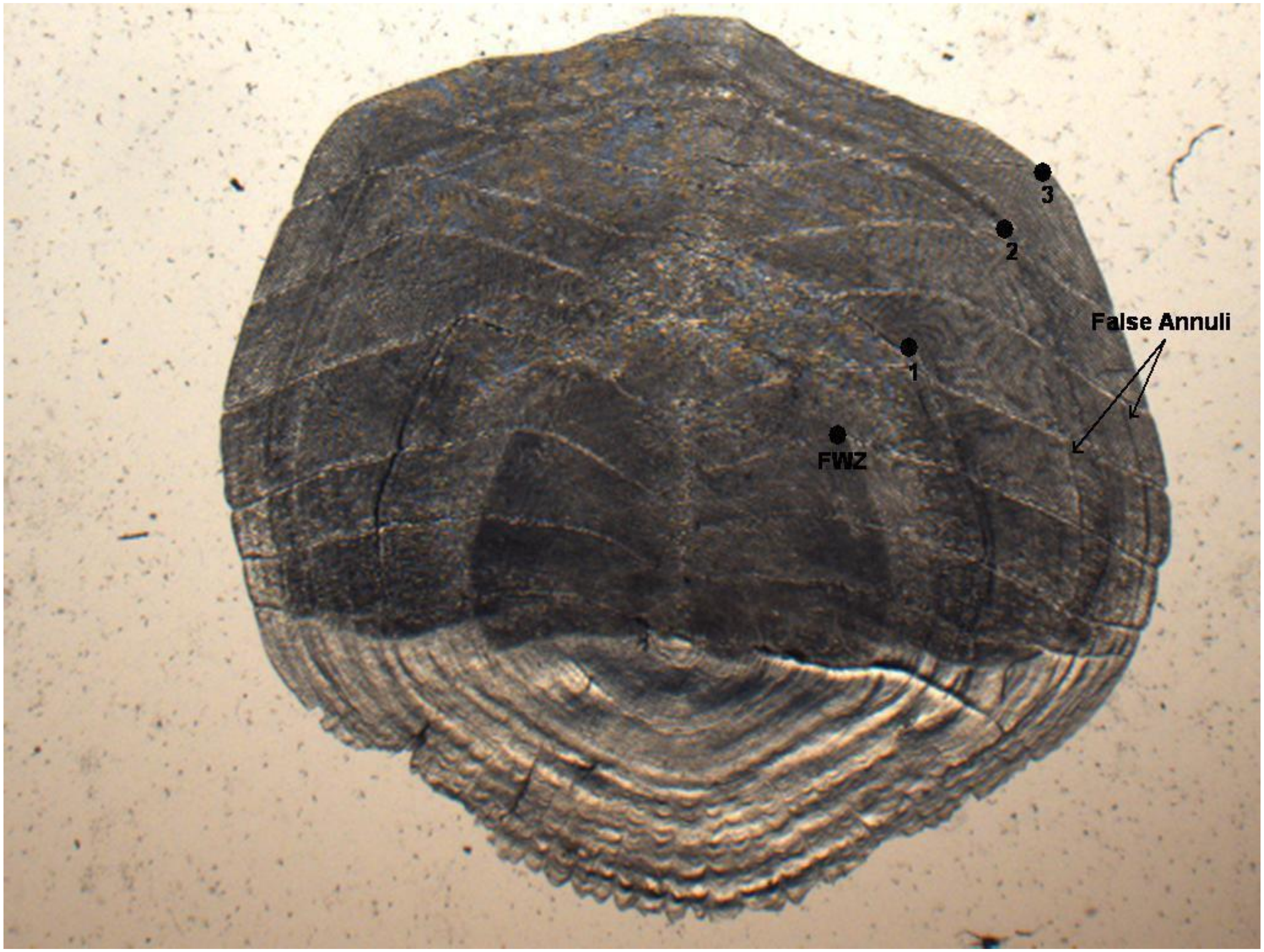


Figure 3. This three year old alewife has two false annuli, one on either side of annulus 2.

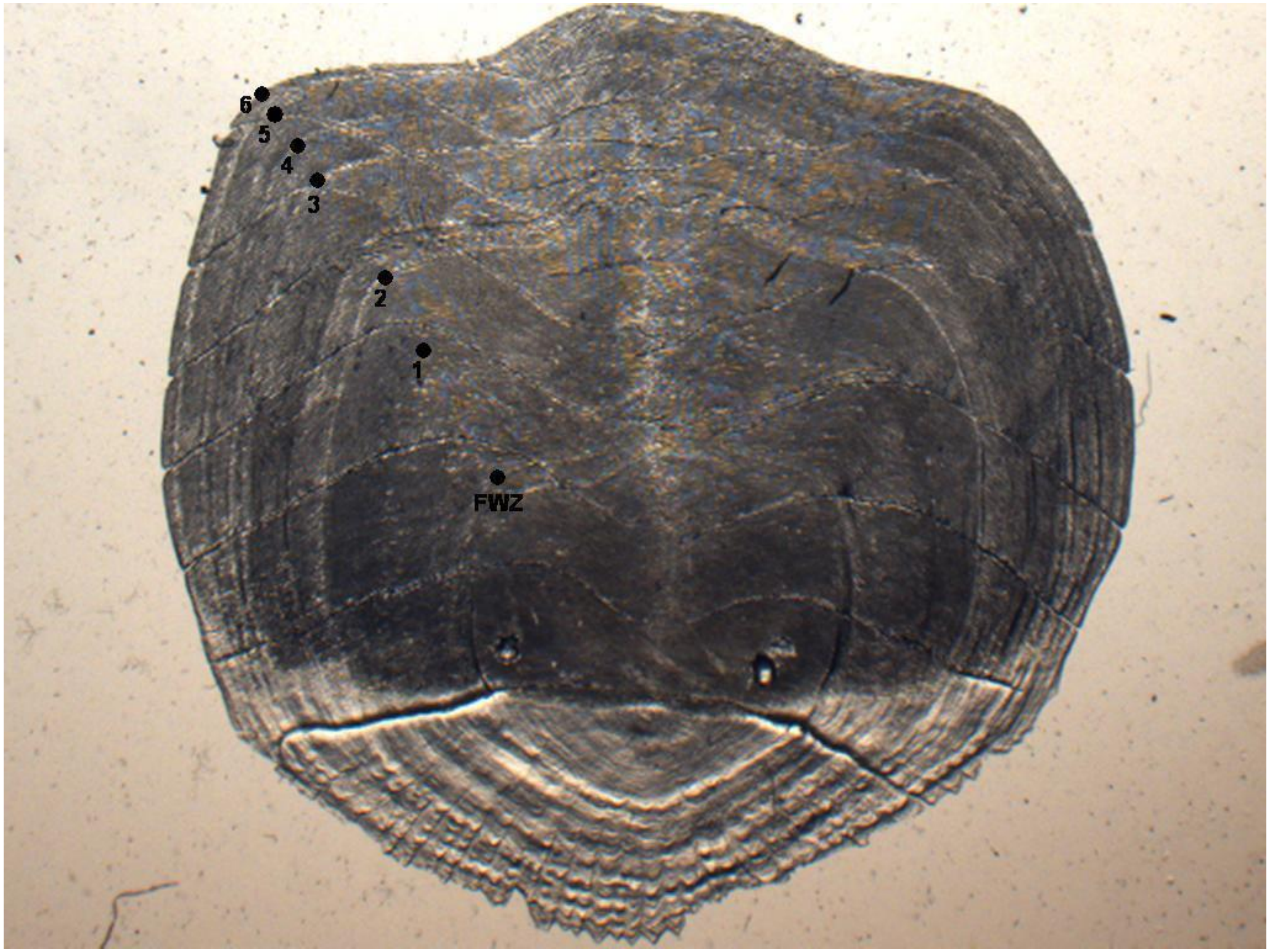


Figure 4. A six year old alewife. Note how weak the first annulus appears compared to the second.

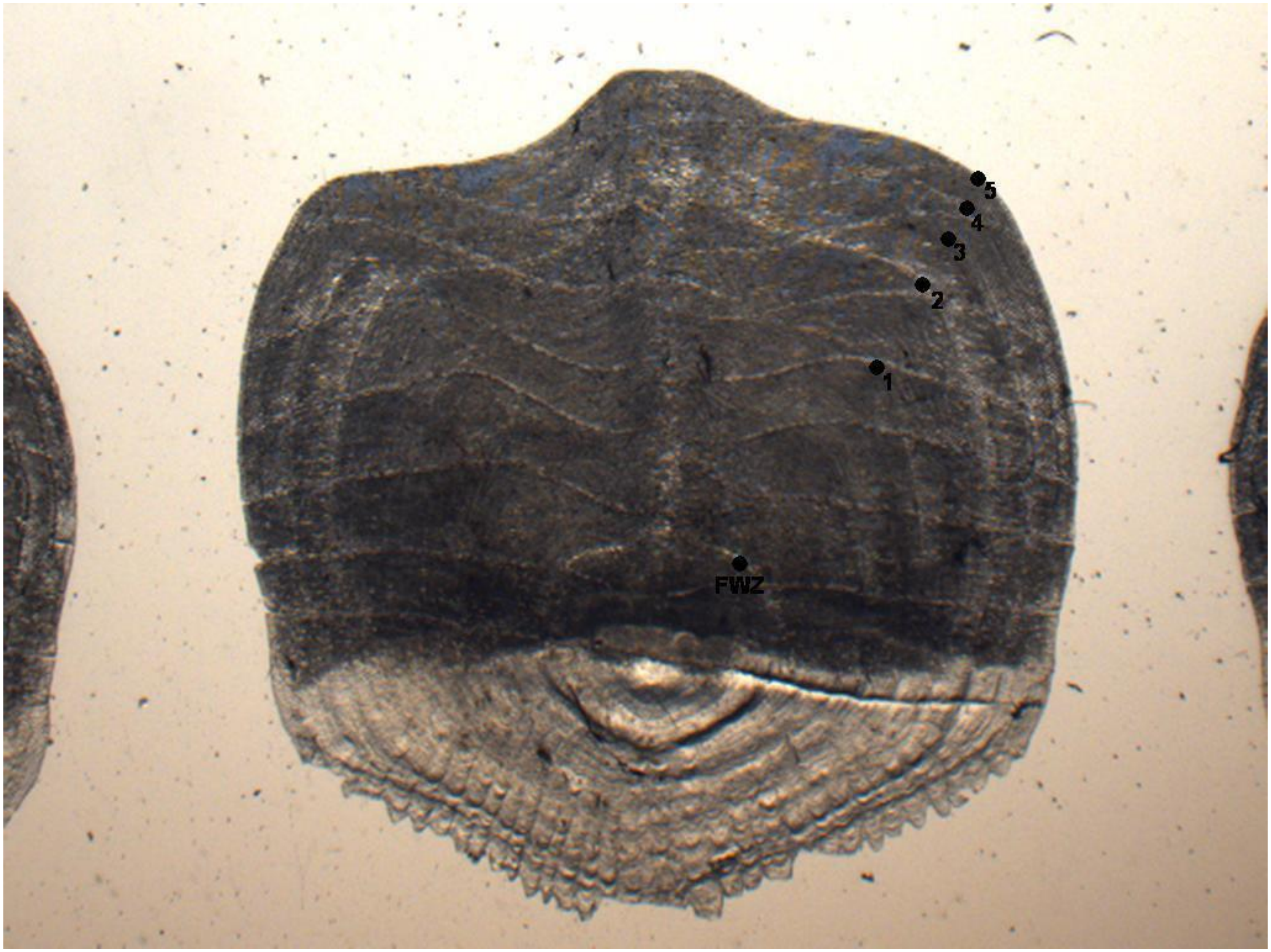


Figure 5. This five year old blueback has the typical strong second annulus.

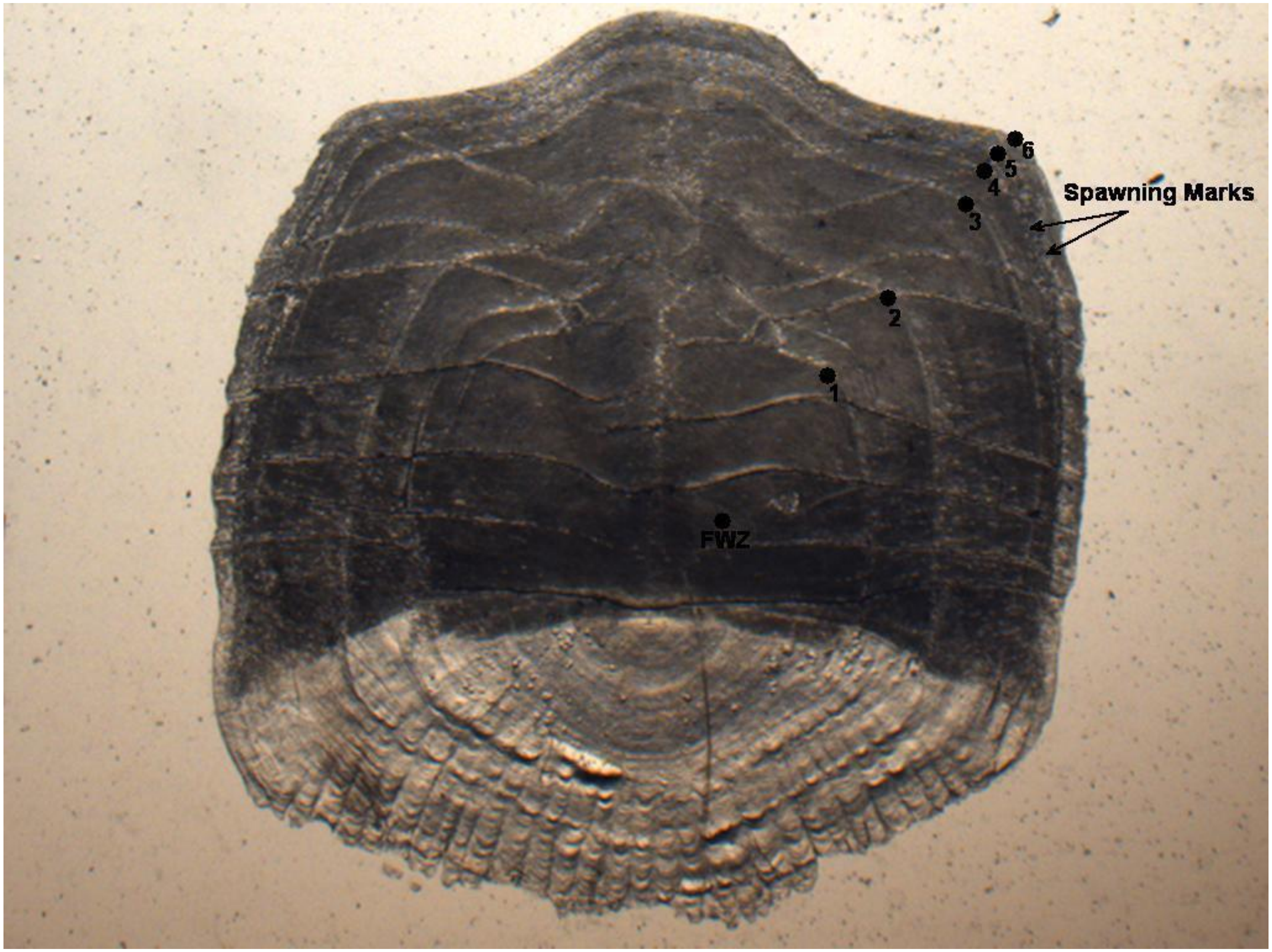


Figure 6. This six year old blueback has spawning marks at its 4th and 5th annuli.

DEFENDING NY'S WATERWAYS FOR HALF A CENTURY
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RIVERKEEPER

December 1, 2016

Ms. Nancy W. Beard
Citizen Participation Specialist I
Hudson River Estuary Program
New York State Department of Environmental Conservation
21 South Putt Corners Road
New Paltz, NY 12561

Dear Ms. Beard:

In response to your email of November 22, 2016 to the HREMAC regarding comments on the update to the Five-Year River Herring Sustainable Fishing Management Plan, Riverkeeper supports the planned submission of the update to the ASMFC Shad and River Herring Technical Committee.

Yours sincerely,

Dan Shapley
Water Quality Program Director

Paul Gallay
President and Hudson Riverkeeper

dhb:PG/DS