RIVER HERRING HABITAT RESTORATION NEEDS

Final Report to the National Fish and Wildlife Foundation

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The Atlantic Coast Fish Habitat Partnership

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Executive Summary

In 2014 the Atlantic Coastal Fish Habitat Partnership (ACFHP) and The Nature Conservancy (TNC) received funding from the National Fish and Wildlife Foundation (NFWF) to develop habitat restoration priorities for river herring populations in select watersheds along the Atlantic Coast. These watersheds included the Chesapeake Bay, Gilbert Stuart (Narrow), Connecticut, Hudson, and Delaware rivers, and the Santee-Cooper river system.

In each of the priority geographies the project team employed a variety of formats to gather information from river herring experts including: a workshop; a webinar; a panel discussion at a regional fisheries conference; individual outreach to state fisheries biologists, watershed councils, commissions, etc.; and a review of current literature and reports.

General themes of restoration needs across all watersheds included addressing upstream and downstream fish passage barriers, water quality, water quantity and flow alteration, and excessive predation (especially related to passage barriers).

Chesapeake Bay was a key focal area and in May 2014, ACFHP and TNC hosted a 2-day river herring expert workshop in Annapolis, Maryland. Chesapeake Bay's watershed had a few key themes emerge from the workshop: impacts to streams due to impervious surfaces, land development/conversion, dams/barriers, predation by invasive catfish, and sedimentation issues were widespread.

On January 26, 2015, a webinar with engaged stakeholders brought river herring threats and restoration potential to the forefront for the Gilbert Stuart River (Narrow River) in Rhode Island. The general concerns were fish passage, water quality, ocean bycatch, sedimentation, and sea level rise. The restoration and needed research projects of this once thriving spawning population were prioritized during the webinar.

The Connecticut River Atlantic Salmon Commission (CRASC) River Herring Subcommittee was the group that identified river herring threats to the Connecticut River watershed; climate change, presence and operation of dams, and ocean bycatch were ranked as high threats; degradation of water quality and habitat due to development in the watershed and presence of inadequately designed culverts ranked as medium threats in TNC's 2013 business plan.

A short presentation at the 2015 Southern Division-American Fisheries Society Meeting in Savannah, Georgia, followed by a discussion of restoration needs in the Santee-Cooper system with experts determined that the threats to river herring were barriers to fish passage, predation, and destruction of submerged vegetation beds. The dams on this system were identified as the major threat to blueback herring.

The 2014 Hudson River Habitat Restoration Plan guided the priority restoration understanding for the Hudson River Estuary, as well as input from the Hudson River Estuary and TNC. The common threats were defined as the loss of shallow water habitats, loss of habitat complexity, introduction of zebra mussels, sea level rise, urbanization, and barriers. However, along with the common restoration themes of the other watersheds, other restoration and research options were expressed; such as restoration to reconnect old side channels which will restore floodplains and provide shallow water habitat for juvenile river herring.

Information on priorities was shared by state fisheries biologists and other stakeholders during a meeting of the Delaware River Fish and Wildlife Management Cooperative for the Delaware River. Although the mainstem Delaware is free of dams, the Northeast Aquatic Connectivity Project evaluated 1,547 dams on 12,626 miles of river in the Delaware River Basin. This corresponds to a density of one dam for every 8 miles of river. Other concerns identified were altered prey/predator relationships, impingement and entrainment issues, urbanization, habitat loss, and water quality. The forefront restoration potential and research needs centered on barrier removals.

Since river herring spend the majority of their lives at sea, complementary strategies to address habitat and fishery impacts (both directed and incidental catches) in estuarine and marine portions of the range are equally important. Given the many threats that river herring face across their complex life cycle, conservation must be holistic, and coordination is essential.

Contents

BACKGROUND

The Atlantic Coastal Fish Habitat Partnership (ACFHP) received funding from the National Fish and Wildlife Foundation (NFWF) to develop restoration priorities to conserve anadromous river herring spawning populations in key watersheds along the Atlantic Coast, with a focus on the Chesapeake Bay. NFWF's River Herring Initiative and the resulting Business Plan for River Herring Conservation describes a comprehensive 10-year strategy to guide NFWF conservation investments to achieve an increase in river herring spawning runs in key rivers along the eastern seaboard. River herring, collectively alewives and blueback herring, are managed by Atlantic States Marine Fisheries Commission (ASMFC) under Amendment 2 to the Interstate Fishery Management Plan for Shad and River Herring (ASMFC, 2009). Over the past 15 years river herring populations have decreased in many watersheds and recovery has been sporadic across the species' range. In response, several states closed fisheries to river herring harvest, and ASMFC mandated closures coast-wide with exceptions for states with approved sustainable fishery plans. Caps on the number of river herring that can be caught incidentally in the Atlantic herring and mackerel fisheries were implemented by National Oceanic and Atmospheric Administration (NOAA) Fisheries (National Marine Fisheries Service, NMFS) in 2014.

In 2013, NMFS completed a comprehensive review of the status of river herring in response to a petition to list the species as threatened under the Endangered Species Act. The assessment used data gathered for ASMFC's 2012 stock assessment, which determined the stock status of river herring was "depleted" (ASMFC, 2012; NMFS, 2013). Of the 52 stocks of alewife and blueback herring for which data were available for use in the assessment, 23 were depleted relative to historic levels, one stock was increasing, and the status of 28 stocks could not be determined because the time-series of available data was too short. Estimates of abundance and fishing mortality could not be developed. The "depleted" determination was used instead of "overfished" because habitat loss, predation, and climate change contributed to the declining abundance of river herring.

NOAA Fisheries considered numerous threats impacting river herring; several related to habitat. They ranked threats range-wide and regionally as determined by the Status Review Team (SRT). Threats were ranked as High to Moderately High (H) and Moderate to Moderately Low (M). The most important threats impacting river herring habitat (all stock complexes) are summarized below, with select passages noted with italics.

- Dams and Other Barriers (H) --- *The SRT identified dams and barriers as the most important threat to alewife and blueback herring populations both range wide and across all stock complexes.*
- Dredging (M)
- Water Quality (M)
- Water Withdrawal/Outfall (M)
- Wetland Alterations (M)
- Climate Change and Climate Variability (M)

The top three are briefly described here; please see Chesapeake Bay background documents in Appendix A for additional information.

Dams and Other Barriers

Dams and other man-made barriers have contributed to the historical and current declines in abundance of both blueback and alewife populations...result[ing] in significant losses of historical spawning habitat for river herring. They...block or impede access to habitats necessary for spawning and rearing; can cause direct and indirect mortality from injuries incurred while passing over dams, through downstream [fish] passage facilities, or through hydropower turbines; and can degrade habitat features necessary to support essential river herring life history functions.

Dredging

Amendment 2 noted the following dredging impacts: *Channelization can cause significant environmental impacts (Simpson et al., 1982; Brookes, 1988), including bank erosion, elevated water velocity, reduced habitat diversity, increased drainage, and poor water quality...through the release of contaminants…resulting in bioaccumulation, direct toxicity to aquatic organisms, or reduced dissolved oxygen levels (Hubbard, 1993; Morton, 1977). Disposal of spoils along the shoreline can also [impact habitat by blocking] access to sloughs, pools, adjacent vegetated areas, and backwater swamps (Frankensteen, 1976). Spoil banks are often unsuitable habitat; …it is too unstable. Suitable habitat is often lost when dredge disposal material is placed on natural sand bars and/or point bars.*

Water Quality

The NOAA Fisheries report primarily highlighted nutrient impacts to water quality, but water quality is impacted by land use patterns and increasing amounts of impervious surfaces that can impact river herring in a multitude of ways. Development can lead to “flashy” stream flows--lower flows between rainfall events and extreme high flows during storms, resulting in more flooding, stream channel erosion, and downstream sedimentation. Excess nutrients washed from developed lands can cause algae blooms that deplete oxygen, and toxins such as metals (lead, cadmium, etc.) and organic pollutants (oil, grease, and pesticides) enter waterways in urban runoff and wastewater. In a 1990 study of Hudson River tributaries, Limburg & Schmidt (1990) found that an index of urbanization provided the strongest relationship with density of eggs and larvae of 23 species of fish (93% of fish sampled were alewife). Recent studies in Chesapeake Bay tributaries have shown similar results, with threshold values around 10-14 percent impervious cover, beyond which spawning success is severely limited (Jim Uphoff, presentation at Chesapeake Bay workshop, 2014). Numerous studies (Armstrong et al., 2011 and references therein) show negative impacts of impervious surface on the abundance and diversity of invertebrate and fish communities, but the mechanism of impacts are poorly understood. Current research aims to “unpack” the effects of impervious surface, e.g., is there a key driver in terms of flow, temperature alteration, pollutants, or physical habitat changes (Allison Roy, pers. comm.)?

Amendment 2 identified land use changes including agriculture, logging/forestry, urbanization and non-point source pollution as threats to river herring habitat… *careless land use practices may lead to erosion, which can lead to high concentrations of suspended solids (turbidity) and substrate (siltation) in the water following rainfall events. This can displace larvae and juveniles to less desirable areas downstream and cause osmotic stress (Klauda et al., 1991b; ASMFC, 2009).* For additional details on water quality, see Appendix B.

In August 2013, NMFS found that listing river herring under the Endangered Species Act was not warranted (NMFS, 2013), but also committed to some immediate steps including addressing information gaps and expanding collaborations. NMFS and ASMFC are leading a group of diverse partners (Technical Expert Working Group for River Herring-TEWG[1]) and utilizing their expertise in the development and implementation of a dynamic conservation plan for river herring that identifies key research needs and conservation efforts range wide, tracks project implementation, and monitors the progress of restoring these important species.

The TEWG Habitat Subgroup (co-chaired by Alison Bowden) is charged with considering the impacts from various factors affecting river herring habitat including, but not limited to, connectivity (e.g., fish passage), water quality and quantity, and appropriate habitat characteristics. To date the TEWG Habitat Subgroup has focused on refinement of threats and priorities for applied research and monitoring to fill key data gaps.

WATERSHED EVALUATIONS

For summary of the river herring status in select watersheds, see Appendix C.

Chesapeake Bay Watershed

Overview of System

The 64,000 square mile Chesapeake Bay watershed resides in six states—Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia. A short description of the major tributaries follows. The sub basins discussed in detail were selected by NFWF and are the focus of this report. The sub basins include all of the major tributaries. Although most of the large mainstem rivers are free of barriers (aside from the Susquehanna), dams on tributaries are still problematic. A 1965 assessment showed that relatively abundant populations, including a large percentage of river herring, spawned at least twice and some many more times than twice (Joseph and Davis, 1965). River herring were once abundant in most of the tributaries, however by the late 1980’s populations had declined significantly and today are considered depleted and near historic lows (Klauda et al., 1991; ASMFC, 2012).

Chester River

The 43-mile long Chester River is a major tributary of the Chesapeake Bay on the Delmarva Peninsula. The Chester River watershed is dominated by agriculture. A Maryland Department of Natural Resources Report (Maryland Department of Natural Resources, 2005) that characterized the watershed showed that river herring were documented in the Chester River mainstem past Millington, in an unnamed tributary immediately north of Route 291, and in Andover Branch. Spawning also extends into several tributaries including Red Lion Branch, Mills Branch and in unnamed tributaries to the west of Mills Branch. Numerous barriers exist in tributaries to the Chester River.

Choptank River

The 68-mile long Choptank River is the largest river on the Delmarva Peninsula. The watershed consists of 509,000 acres, which drain portions of Caroline, Dorchester, Queen Anne’s, and Talbot County, Maryland, and Kent County, Delaware. Agriculture and poultry production comprise roughly 60% of the

[1] http://www.greateratlantic.fisheries.noaa.gov/protected/riverherring/tewg/

land use in the watershed. Anthropogenic changes to the natural channel structure of streams in the watershed have resulted in degraded in-stream habitat conditions. Agricultural runoff has led to increased settling of sediment in the stream substrate throughout the watershed. It is considered critical habitat for river herring and as a result, NOAA has chosen the Choptank River watershed as the next Habitat Focus Area under NOAA's Habitat Blueprint[2]. The Habitat Blueprint is NOAA's strategy to integrate habitat conservation throughout the agency, focus efforts in priority areas, and leverage internal and external collaborations to achieve measurable benefits within key habitats such as rivers, coral reefs, and wetlands. Within each of the NOAA regions, there has been effort to form habitat focus areas. The Delmarva/Choptank River is one of ten Habitat Focus Areas that has been selected as part of NOAA's Habitat Blueprint Framework.

Nanticoke River Watershed

The 64.3-mile long Nanticoke River is a major tributary of the Chesapeake Bay on the Delmarva Peninsula. The river was dredged in 1990 to facilitate shipping travel along the course. Maryland's best estimate of adult river herring relative abundance comes from the Nanticoke River (ASMFC, 2012). As of 2012, a project to dredge the channel once again is on hold for financial reasons. It is one of the most biologically diverse watersheds on the Delmarva Peninsula and was one of The Nature Conservancy's (TNC) "Last Great Place". Marshyhope Creek is a major tributary to the Nanticoke River where the Smithsonian Environmental Research Center (SERC) project will be monitoring river herring in the spring of 2015.

Pocomoke River Watershed

The Pocomoke River stretches approximately 66 miles from southern Delaware through southeastern Maryland. At its mouth, the river is essentially an arm of Chesapeake Bay. The upper river flows through a series of relatively inaccessible wetlands called the Great Cypress Swamp, largely populated by loblolly pine, red maple and bald cypress. The Pocomoke is the easternmost river that flows into Chesapeake Bay and is reputed to be one of the deepest rivers for its width in the world. Historically the Pocomoke supported river herring fisheries.

Susquehanna River

The 464-mile long Susquehanna River is the longest river on the Atlantic Coast, as well as the largest watershed. It was once home to massive shad and river herring runs. "Enormous" catches of river herring were reported in 1899 (Pennsylvania State Commissioners of Fisheries, 1900): "*The Susquehanna River is without question, the finest herring river in Pennsylvania. The catch far outnumbers that of the Delaware and the industry is very large, much greater in fact than on that stream.*" Wilkinson (1840) reported that herring ran up to Binghamton, NY with the shad; these were likely blueback herring (St. Pierre, 1979). By 1928, four large hydropower dams blocked the mainstem, starting with the Conowingo Dam located at river mile 10, eliminating access to this critical system for migratory species. Based in part on information derived from other rivers, St. Pierre (1979) calculated probable habitat carrying capacities of five million adult river herring in the free flowing reaches above

[2] http://www.habitat.noaa.gov/habitatblueprint/about.html

York Haven, Pennsylvania. In addition to eliminating migratory fish access to upstream spawning and nursery habitat, these dams also altered river habitat by creating impoundments that inundated and eliminated 36 miles of riverine spawning and rearing habitat in the lower portion of the Susquehanna River (Susquehanna River Anadromous Fish Restoration Cooperative [SRAFRC], 2010).

Although fish passage facilities are present, the dams are still a major threat to migratory fish. Like most hydropower facilities, the Susquehanna River hydroelectric projects (with the exception of York Haven) tend to generate power when it is most needed, during the daytime peak use period, and refrain from generation at night when water storage in the impoundment is replenished with incoming river flows. This results in unnatural flow conditions, which can vary from flood to drought, flow conditions within minutes during any given day (SRAFRC, 2010). River herring catches at the Conowingo Dam fish lifts have varied dramatically since the West Fish Lift began operating in 1972, ranging from zero to more than 300,000; however, since 2002, catches have been consistently low (ASMFC, 2012).

Three dams (Conowingo, Muddy Run, and York Haven) are currently undergoing the Federal Energy Regulatory Commission's re-licensing process on the Susquehanna River. Improved fish passage will be a requirement of the new license, although specific river herring passage needs are not being addressed at this time. The status of river herring below Conowingo Dam is unknown (SRAFRC, 2010).

Potomac River

The Potomac River is 405 miles long, however, only the lower Potomac River and its tributaries that lie below the fall line at Great Falls are accessible to river herring. It was once considered one of the most important rivers on the Atlantic coast of the United States for river herring (Cummings, 2012). The 8.7-mile Anacostia River is a tributary to the Lower Potomac and is the focus of an extensive watershed restoration plan and associated projects. Numerous types of restoration projects including fish passage have been identified and ranked, and include cost estimates. Upper Beaverdam Creek is a tributary to the Anacostia where river herring stocking is occurring. It is one of the few tributaries that is free flowing and has some of the lowest impervious surface percentages in the watershed. There is extensive information available on barriers and other restoration opportunities in this watershed[3]. Mattawoman Creek is a 30-mile-long coastal-plain tributary to the tidal Potomac River with a mouth at Indian Head, Maryland, 20 miles downstream of Washington, DC. It is considered one of the most productive tributaries to the Chesapeake and still has a river herring run, though the run seems to be reduced as a result of increasing urbanization. Reeder Run is a priority tributary in the Mattawoman watershed.

Rappahannock River

The Rappahannock River, located in eastern Virginia, is approximately 195 miles in length. With the removal of the Embrey Dam in 2004, the Rappahannock is the longest free flowing river in the Chesapeake Bay. Much of the watershed is rural and forested, but it has experienced increased development in recent decades because of the southward expansion of the Washington, DC suburbs, creating nitrogen loading issues.

[3] http://www.anacostia.net/plan.html

James River

The lower James River is 348 miles long. Only 90 miles from the mouth to Richmond, Virginia, (the fall line) is accessible to river herring. Two major tributaries, the Chickahominy and Appomattox rivers, are also important river herring streams. In 2014, the Harvell Dam was removed on the Appomattox River at Petersburg, Virginia, opening up over 127 miles of spawning and rearing habitat.

Approach

In May 2014, ACFHP and TNC hosted a workshop at the Chesapeake Bay Foundation in Annapolis, Maryland. Twenty-nine river herring experts and stakeholders attended the two-day meeting (Appendix D). Meeting materials were sent prior to the meeting to help the participants prepare for the discussions during the workshop (Appendix A). Workshop participants were divided into geographical groups and asked to list key threats and priority restoration opportunities for river herring in their geographies. In addition, facilitated whole group sessions were held to answer questions related to research needs and obstacles to recovery.

Determined Watershed-wide Threats and Restoration Needs for River Herring Restoration

Although the Chesapeake Bay's sub-watersheds have their own threats and opportunities, a few key watershed-wide themes emerged from the interactive workshop.

- **Impacts to streams due to impervious surfaces-** This was a key point of the workshop and potentially a significant threat to restoring river herring in many suburban and urban streams. Determining how to reduce the impacts of impervious surfaces should be a priority strategy to protecting and/or restoring river herring in the Chesapeake Bay (Figure 1).
- **Land development/conversion-** Many of the last land strongholds are under threat from development or conversion from agriculture to suburban. Land protection/easements to protect streams that still have decent river herring runs are critical.
- **Dams/barriers-** Many mainstem dams have been removed (aside from the Susquehanna) and there are still many barriers on tributaries, however, lack of knowledge about the presence of river herring in many tributaries of mainstem rivers makes it challenging to prioritize removals (Figures 2, 3). In addition, dam removal funding needs to include incentives for dam owners to increase the rate of dam removals.
- **Predation by invasive catfish-** Invasive flathead and blue catfish are quickly altering the Chesapeake Bay ecosystem and predation on river herring appears to be very high. Eradication is not feasible, but developing commercial markets for these fish is one possible way of managing the populations of these species while giving harvesters a new fishery. Educating the public on the impacts of these catfish to the bay is another key strategy.
- **Sedimentation-** Sedimentation was brought up in almost every sub-watershed workgroup as an issue from causes such as rapidly urbanizing communities, agriculture, or in some cases from

unknown sources. Floodplain forest restoration, riparian buffers, and reconnecting rivers to their floodplains are some key strategies for addressing this threat.

Specific Sub-watershed Threats and Restoration Needs for River Herring Restoration

(Sub sections reflect divisions made by workshop breakout groups)

Susquehanna and Upper Potomac

Threats (prioritized by workshop experts)

Lower Susquehanna: (1) Dams (2) Land conversion/development (3) Impervious surface
Upper Potomac: (1) Impervious surface (2) Land conversion/development (3) Invasive species

Restoration Needs

- *Barriers[4]:*
  - **Lower Deer Creek, Maryland: Wilson Mill Dam ID # MD SU004:** Although there is a state of the art fish ladder, it is often clogged with debris and requires constant maintenance, reducing its effectiveness at passing river herring. At the workshop it was considered highest priority and second only to Conowingo Dam. Chesapeake Bay Fish Passage Prioritization[5] (CBFPP) Tier 1 dam. HUC 12 ID: 02050361604
  - **Winters Run, Maryland:** a tributary to Bush Creek in Maryland. HUC 12 ID: 020600030102
  - **Van Bibber Dam ID # MD_BU016:** Would need to address water quality as well. River herring are present. CBFPP Tier 3 dam.
  - **Atkisson Dams Id # MD_12095:** This dam is located on Aberdeen Proving Ground (APG), a United States Army facility. Atkisson Dam is filled with sediment and therefore could be a very expensive removal. However, the APG natural resource staff is interested in removal if funding is available. This is a CBFPP ranked Tier 2 Dam.

- *Land Protection: Acquisition/Easement:*
  - **Mattawoman Creek Watershed:** HUC 12: 020700110101, 020700110102
  - **Reeder Run:** priority tributary to Mattawoman. HUC 12: 020700110106
  - **Octorao Creek:** HUC 12: 020503061502, 020503061503, 020503061403

- *Agricultural Best Management Practices (BMP) and Easements, expand NRCS programs. Incentivize reforestation/restoration:*
  - **Gunsten Cove Watershed (Potomac):** HUC 12: 020700100401, 020700100402
  - **Lower Patapsco[6] (Baltimore County):** HUC 12: 020600031204
  - **Gunpowder tidal inlet (Maryland):** HUC 12: 020600030602

[4] Dam Id's from Chesapeake Bay Dam Prioritization Tool: http://maps.tnc.org/EROF_ChesapeakeFPP/
[5] http://www.dgif.virginia.gov/fishing/tnc-chesapeake-bay-fish-passage/
[6] Detailed SWAP: http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/lowerpatapscoswapvol1opt.pdf

Lower Potomac & Rappahannock Rivers

Threats

(1) Dams/perched culverts (2) Predation from invasive catfish (3) Water discharges: thermal, chemical, and wastewater (4) Water intake (impingement/entrainment) (5) Turbidity (6) Anoxia

Restoration Needs

- *Barriers:*
  - **Massaponax Creek (Rappahannock) Ruffins Pond Dam Removal (**Dam ID # VA95)
- *Status assessments:*
  - **Surveys below & above former Embrey Dam** should be conducted.
  - **Surveys where river herring are suspected should be conducted** to further prioritize rivers.
  - **An assessment of state of Virginia-owned dams** should be conducted to determine whether river herring are present, if dam removal is feasible, and if not, if passage should be provided.
- *Invasive catfish:*
  - **Markets should be developed** for blue catfish in the Potomac River.
  - **An Outreach and Education Marketing Campaign** on the impacts of blue catfish on river herring should be developed.
- *Water discharge & intake:*
  - **Surveys should be completed** (presence/absence) in areas of water discharges.
  - **The permit process** (e.g.; 1 mm screen to prevent impingement/entrainment) should be updated.
  - **The permitting process must address fish habitat.**
- *Turbidity:*
  - **Education and Outreach** with towns and development should be conducted.
  - **Landowner Incentive Programs** for agriculture, e.g., more on the ground projects to keep cattle out of streams should be developed.

James & York Rivers

Threats

James River: (1) Suspended sediment/turbidity (2) Dams and road crossings on tributaries (3) invasive catfish (4) Urbanization in upper watershed (Richmond, Virginia)

York River: (1) Dams and road crossings on tributaries (2) Nutrients resulting in low dissolved oxygen conditions (3) Sedimentation (4) Invasive catfish

Restoration Needs

- *Barriers:*
  - **Ashland Mill Dam** (Pumkely at Rt. 1), York River (Dam ID# VA_682). CBFPP ranked Tier 1 dam. Partners (i.e., not state biologists) are needed to approach the dam owner and open the dialogue for dam removal.
  - **All Tier 1 Dams** on Chickahominy and Appomattox rivers (James River tributaries) should be removed.
  - **Culvert/Road crossing surveys should be conducted** in the James and York watersheds.
  - **Fish passage standards for culverts and roads should be conducted:** Engage the United States Army Corps of Engineers (USACE), Virginia Department of Transportation, and Federal Emergency Management Agency (FEMA) to Northeast Models (i.e., Massachusetts) for road crossing standards. *This is underway through an Atlantic Coast LCC project*. [7]
- *Turbidity:*
  - **A watershed-Scale Assessment should be conducted** to identify sediment sources in James River.
  - **Funding for Management and Implementation of watershed plans** in the James River should be provided.
  - **Floodplain Forest Restoration** should be conducted.
  - **Herring Creek Berm:** The berm at Harrison Lake National Fish Hatchery (Charles City, VA) is causing significant turbidity issues on a good river herring stream on a James River tributary. It should be graded and stabilized.
- *Predation:*
  - **Economic Markets** for invasive catfish should be developed.
  - **A policy should be designed to make** it illegal to return caught invasive catfish to rivers.

Upper Eastern Shore

The Eastern Shore breakout group did not divide threats/restoration needs by watershed due to the similarity between these systems; however, it is important to note that the Choptank River watershed has been chosen by NOAA Fisheries as a habitat focus area and it is now developing an implementation plan for the watershed. This is a key watershed for river herring that is threatened by development.

The reaches of the Eastern Shore, Choptank, Marshyhope, Tuckahoe and Pocomoke rivers suffer from channelization. Approximately 67% of degraded stream miles in the Upper Choptank watershed are artificially straightened or channelized in some way. In addition, significant amounts

[7] See http://northatlanticlcc.org/projects/aquatic-connectivity/restoring-aquatic-connectivity-and-increasing-flood-resilience-hurricane-sandy-mitigation/

of cropland in the 60-meter riparian buffer are impacting water quality (Biological Stressor Identification [BSID] Analysis Results Upper Choptank River Watershed).

Land Protection is a key strategy to thwarting urbanization, especially in Seaford, Caroline County, MD (Figure 4). These parcels are located in HUC 12 (020801090401, 020801090402, 020801090403,020801090404,020801090405, 020801090406, 02080109102, and 020801090205)

Threats

(1) Increasing impervious surface (2) Channelization[8] (3) Loss of riparian habitat (4) Sedimentation (5) Dams (6) Flow alteration

Restoration Needs

- *Impervious surface*:

  This is caused by increased urbanization. Suggested methods to approach communities with this issue are:

  - **2016 Comprehensive Plan Development**: Focus on water management
  - **Land Protection**: fee/easement
  - **Zoning Ordinances** (e.g., setbacks to reduce impervious surfaces)

- *Riparian habitat:*

  A landscape scale effort is needed to maintain good riparian habitat. This should be partnered with existing work to make a fish habitat connection. Impervious surfaces in floodplains should be addressed with a goal of maintaining 4-8% of the area as impervious surface and more percentage of natural land cover. This can be attained with:

  - Outreach to agriculture: to implement BMPs to minimize agriculture impacts to water quality, such as reduce sediment loading with no till or low till methods.
  - Riparian restoration AND restore floodplain connectivity (through incentives) especially in the upper reaches (headwaters) of key watershed rivers.
  - Implementing municipal ordinances to restrict further channelization.
  - Restoring streams that are now drainage ditches (e.g., Upper Marshyhope).

- *Barriers:*

  - **Galestown Dam** (Id #: MD 12167): An irrigation dam classified as a Tier 1 dam in CBFPP.
  - **Higgens Mill Road Dam** (Id# MD TROO1) on the Transquaking River that drains into Fishing Bay. While there is a potential for a fish ladder to be built at this location the

[8] The Biological Stressor Identification (BSID) process has also determined that biological communities in the Upper Chester River watershed are likely degraded due to anthropogenic channelization of stream segments.

habitat and water quality issues should also be addressed[9]. It is classified as a Tier 3 dam in CBFFP.

- **Allen Pond Dam (**Id # MD 12124). This dam is ranked low in CBFPP.
- **Barren Creek Dam** (Id# MD NA001). This dam is CBFPP ranked at Tier 3.
- **Mill Pond Dam** (Id# MD TR001). This dam is CBFPP ranked at Tier 3.
- **Lake Chambers Dam** (Id# MD NA007). This dam is CBFPP ranked at Tier 3.
- **No name dam** (Id# MD CPU06) - located near Mud Mill Pond. This dam is CBFPP ranked at Tier 1.
- **Tuckahoe State Park Dam** (Id# MD 12136). This dam is CBFPP ranked at Tier 1.
- **Lake Bonnie** (Id# MD 12154). This dam is CBFPP ranked at Tier 1.
- **No name dam** (Id# MD CPU22) -west of Pasapa Landing. This dam is CBFPP ranked at Tier 2.
- **Spring Branch Dam** (Id# MD CPU16). This dam is CBFPP ranked at Tier 1.

Obstacles to Restoring River Herring

The workshop participants discussed the obstacles to achieve full restoration potential for river herring populations in the Chesapeake Bay watershed and what research needs were necessary to further identify restoration data gaps and viable projects. The following outlines the general discussion:

- *Funding:*
    - More funding is needed for the Design and Feasibility stage of projects. Time and money are necessary to assess the feasibility before being able to show success of the projects.
    - Landowner incentives are useful for dam removal projects.
    - Funders are needed in order to invest in larger scale projects (garner more public support).
    - The development of a Dam Removal/Mitigation Trust Fund could be used to fund dam removals.
- *Policy & Regulatory:*
    - The dam removal permitting process needs to be streamlined (particularly in Maryland).
    - Dam safety regulations need to be enforced.
    - There is currently too much focus on fishing impacts.
- *Outreach and Education:*
    - More public support and awareness is necessary in order to explain why river herring are important.
    - Public support is strategic to improving the political feasibility of restoration projects.
    - Community outreach is imperative for understanding the tradeoffs and creating individual alternative development plans.

[9]http://www.mde.state.md.us/programs/Water/TMDL/Documents/BSID_Reports/Transquaking_River_BSID_Report_012512_final.pdf

- *Capacity:*
  - There is a lack of staff resources at state and federal agencies; other partners are needed.
  - Fisheries biologists and land managers need to communicate better as well as develop good working relationships.
  - Fishways/ladders need to be well maintained.

Priority Research Needs

- *Basic Biology Research:*
  - What is happening along the river herring migration corridor (i.e., to and from spawning grounds)?
  - Basic biological questions such as the effects of turbidity and sound impacts to river herring need to be addressed.
  - What are the impacts of emergent containments on early life stages of river herring?
  - What is the importance of submerged aquatic vegetation (SAV) as juvenile habitat?
  - Predation studies are needed, both in freshwater and marine, to further assess natural mortality or effects of invasive species such as blue catfish.
  - What are the different life stage interactions with blue catfish (especially in the Potomac River)?
  - What are the habitat limitations where river herring and invasive species overlap?
  - Are anoxic zones barriers to migration or death zones?
  - How does groundwater/droughts affect river herring survival?
- *Surveys & Assessments:*
  - We need to know the number of river herring in a given river in order to know if they are increasing in numbers.
  - We need to know where the river herring are in order to protect and restore runs.
  - We need to use ecosystem modeling to illustrate issues or other factors other than fishing on survival.
  - We need to develop spatial maps and tools that illustrate priority places for river herring.
- *Land/Water Management:*
  - More research is needed to better understand the impacts of stormwater runoff (i.e., flash floods).
  - Research on how to reduce the impacts of impervious surfaces in key watersheds to improve water quality is needed.
  - Research on the impacts of flow alteration on small streams to better understand the water quality concerns with river herring runs is needed.
  - Other ways to show success or metrics in improving river herring runs to the Chesapeake Bay watershed needs to be determined.
- *Passage:*
  - Standards for fishways must be developed.
  - Thresholds for fish ladder efficiency need to be determined.

- Climate change events and impacts to engineered passage facilities adaptation capabilities must be addressed.

Gilbert Stuart River

Overview of System

The Gilbert Stuart (also known as the Narrow River and Pettaquamscutt River) is a seven-mile long tidal estuary of Narragansett Bay, with a total watershed area of 14.4 square miles (8,700 acres). This river is listed as a priority restoration site for the State of Rhode Island. Run counts have been sampled since 1993. In the late 1990's the river had one of the healthiest river herring spawning runs in the state; however, run counts declined starting in 2002. Rhode Island Department of Environmental Management (RIDEM) indicates the river herring fishery was closed in March 2006 (P. Edwards, pers. comm.), due to low spawning run returns. River herring spawning returns have increased since 2006, but are still 1/3 to 1/2 the historical highs as recorded between 1998 and 2001 (Table 1). The majority of river herring caught are alewife, but blueback herring were observed as well in 2008.

Table 1. Narrow River river herring spawning returns.

Year	River herring returns
1998	262,315
1999	259,336
2000	290,814
2001	254,948
2002	152,056
2003	67,172
2004	15,376
2005	7,776
2006	21,744
2007	36,864
2008	58,640
2009	34,835
2010	110,287
2011	64,500
2012	107,901
2013	91,240
2014	102,408

Approach

The project team reviewed relevant literature and maps and held one-on-one interviews with scientific experts: Phil Lake (RIDEM), John Edwards (RIDEM), and Rachel Calabro (Save the Bay, Narragansett Bay). The team created a web-based survey to elicit local expert determination of watershed and river herring life cycle threats and prioritization of restoration options in preparation for a webinar meeting. The results of the survey were presented during the webinar along with other meeting materials to help prepare the participants (Appendix E). A briefing paper on watershed threats, obstacles to restoration, and priority restoration strategies was sent to all participants prior to the scheduled two-hour webinar meeting on January 26, 2015. Sixteen nonprofit, state and federal participants attended the webinar (Appendix F).

Threats

The most important obstacles to recovery are spawning habitat access (fish passage improvement or dam removals, improved culverts/road crossings, etc.). There are three dams on the river: Gilbert-Stuart, Shady Lea, and Silver Spring Lake (Figure 5), progressing from downstream to upstream, respectively.

- *Barriers (in order of priority):*

  Fish passage at Shady Lea Mill Dam. Opening up this privately owned dam would provide access to 0.5 miles of stream and open up two acres of habitat to the next impoundment upstream, the Silver Spring Lake Dam. At this point, Save the Bay has only partial funding to remove the dam.

  Inefficient fish ladder at Gilbert Stuart Dam. This dam and associated fishway is downstream of the Shady Lea Mill Dam. While fish can access good spawning habitat in the 68-acre Gilbert Stuart Pond (also known as Carr Pond) via the existing Alaska steeppass fishway, the working historic gristmill causes attraction issues to the fishway. The migrating fish are attracted to the larger flow at the tailrace of the wheel on the east side, in an enclosed area where they are vulnerable to stranding, low dissolved oxygen, and predation. RIDEM recommends a steeppass fishway for this bypass channel.

  Efficacy of culverts located at Route 1 and Route 138.

  Fish passage at Silver Spring Lake Dam. The local experts recommended assessing the importance of removing the Silver Spring Lake Dam or constructing a fish ladder after the Shady Lea Mill Dam is removed.

- *Water quality:*

  Water quality in the Narrow River has been documented for 50 years through scientific studies and monitoring by RIDEM, as well as the Narrow River's Preservation Association's (NRPA) participation in the University of Rhode Island's Watershed Watch program (URIWW) since 1991. URIWW has been collecting data from Silver Spring Lake since 1989. The percentage of impervious surfaces and locations of protected lands throughout the watershed are shown in Figure 6. The following are results from the water quality monitoring of the Narrow River.

- **Stormwater Pollution:** Water quality in the Narrow River has been documented for the past 50 years through scientific studies and monitoring by RIDEM and the Narrow River's Preservation Association's (NRPA) participation in URI's Watershed Watch program since 1991. Watershed Watch has been collecting data from Silver Spring Lake for some time (at the northern end of the river).
- **Eutrophication:** Silver Spring Lake has experienced increased phosphorus and nitrogen due to stormwater pollution from a nearby impervious surface intersection along with failing septic systems.
- **Increased Floating Filamentous Algal Growth**: stimulated by high levels of nitrogen and phosphorus, algae has been observed since the early 1970's; the levels steadily increased from 1944 to 1980, but since then have decreased and leveled off. Nutrients in the Gilbert Stuart Pond (also known as the Carr Pond) and Gilbert Stuart Stream are moderate.
- **Pathogens**: Since 1959, Narrow River has consistently failed State standards for total coliform (bacteria) levels, with a large nonpoint source coming from Mumford Brook at the southern end of the river.
- **Low Dissolved Oxygen**: Dissolved oxygen is low below the pycnocline in the Upper Pond (the pond just below Gilbert Stuart Pond), and low midsummer in Pettaquamscott Cove. Juvenile river herring have been observed in this lower stretch of the estuary in July and August.
- **Thermal Pollution**: Warm water temperature issues have been documented especially north of the Middle Bridge (about 1/3 of the river length, downstream). Lack of cool water refugia is a concern.
- **Reduced Riverine Baseflow**: Less groundwater recharge occurs in the area now that the watershed is sewered, with the water running into Narragansett Bay. The impacts and magnitude of this problem are currently unknown.
- **Turnover Events -** Because the upper basins are highly stratified and very deep, and exhibit minimal overturn, they act as huge catch basins for pollutants. Substances introduced from the River's headwaters, surface runoff, and groundwater flow can be expected to remain in the basins for long periods of time. The northern portion of the system has an almost permanent anoxic zone in the deeper waters. When these basins do "overturn" (mix), the effect of the turnover may be much greater due to the accumulation of pollutants and their sudden release from the bottom waters causes eutrophic conditions leading to cyclical fish kills occurring every 15-20 years (Ernst et al., 1999).

o *Ocean bycatch:*

In the winter months the Atlantic herring fishery often concentrates effort near the mouth of

Narragansett Bay, which could impact local runs.

- *Sedimentation:*

  Sedimentation below Lacy Bridge (downstream half of the river) impacts the salt marsh and SAV habitat. The salt marshes have also been degraded due to excessive water ponded on the surface and shoreline erosion.

- *Sea Level Rise due to Climate Change:*

  Sea level rise is increasing both marsh loss and the associated wetland benefits needed for habitat diversity.

Restoration Needs (in order of priority, Figure 5)

- ***Improve fish passage, particularly at Shady Lea Mill Dam.*** Save The Bay has been awarded $80,000 for initial assessments and engineering designs, and has completed a conceptual design and 60% of permit level designs. Their preliminary evaluation report estimated that an additional $120,000 is needed to remove the dam and sediment behind the dam. Dam removal should increase cool-water refugia, and increase the habitat suitability for blueback herring.

- **Evaluate Rt. 1 and 138 culverts for efficiency** and fish passage potential as well as conduct a survey of watershed culverts.

- **Improve water quality** (including dissolved oxygen, temperature, and baseflow). In part, water quality can be improved through dam removal (resulting in improving thermal pollution and allowing for appropriate sediment transport) and reducing eutrophic water conditions. Additional restoration options are riparian tree-planting and land protection, eliminating non-point pollution sources, maintaining appropriate storm drain systems, and reducing impervious surfaces through local ordinances. The Narrow River Coastal Resiliency Project, a $2 million, partner-rich, Sandy-funded initiative led by the U.S. Fish and Wildlife Service (USFWS), is supporting the establishment of two BMP stormwater options to reduce pathogens.

- **Reduce sedimentation/depth issues**. The Narrow River Coastal Resiliency Project is dredging select areas for SAV replanting and to allow fish passage. They are also adding material to restore 68 acres of saltmarsh and creating runnels to restore surface drainage.

- **Prepare for climate change concerns**.

- **Assess feasibility and cost/benefit of fish passage** for Silver Spring Lake after Shady Lea Dam is removed.

Research Needs (in order of priority)

- Conduct a study of fish passage after the Shady Lea Mill Dam removal project.
- Analyze base flow data.
- Evaluate the feasibility of fish passage for Silver Spring Dam.
- Determine the impact of water quality due to “turnover events.”

- Evaluate the efficiency and improve the fish ladder at the Gilbert Stuart Dam.
- Manage stormwater and sedimentation off Rt. 1.
- Evaluate Rt. 1 and Rt. 138 culverts, along with unknown culverts for fish passage effectiveness.
- Maintain cold temperatures and limit stormwater pollution.
- Identify the significance of the watershed's drainage basin.
- Evaluate Mumford Brook road crossing at the end of Pettaquamscutt Cove.
- Carr Pond (North Kingston) water withdrawals (wells) should be closely monitored for the impact on fishery resources in Carr Pond.

Additional comments from local experts pertaining to river herring restoration potential in Rhode Island included the following:

Overall, experts felt that because restoration efforts at the Gilbert Stuart only improve a small amount of habitat, albeit for an important run, NFWF might want to consider looking at other Rhode Island rivers in the future, and consider the following actions:

- RIDEM should draft an updated Anadromous Fisheries Management Plan.
- Existing river herring runs throughout the state should be studied to see where barriers can be removed that may currently have fish ladders.
- Fish ladder efficiency studies should be conducted throughout the state to identify those that don't pass fish.
- Culvert surveys should be conducted in RI's coastal systems.
- Continue to support or increase state restoration funding.

Connecticut River

Overview of the System

The Connecticut River, the longest in New England, flows 410 miles from the Connecticut Lakes just north of the Canadian border to Long Island Sound, draining an 11,250 square mile basin (Figure 7) with roughly 2.3 million residents. Land use in the watershed is approximately 77% forested, 9% agricultural, 7% wetlands and water, and 7% developed. Land use is generally rural at the headwaters in northern Vermont and New Hampshire and transitions to densely populated urban areas such as Springfield and Hartford in the south-central river valley. Extensive tidal wetlands downstream from the city of Hartford, Connecticut received Ramsar designation in 1994 as Wetlands of International Importance. Floodplain forests and riparian wetlands line the river and its tributaries in portions of the watershed, providing habitat for migratory birds, and feeding and rearing habitat for fish.

The Silvio O. Conte National Fish and Wildlife Refuge is the only refuge of its kind to encompass an entire watershed. Conte Refuge was established in 1997 to *"conserve, protect and enhance the abundance and diversity of native plant, fish and wildlife species and the ecosystems on which they depend"* throughout the 7.2 million acre Connecticut River watershed.

The Connecticut River Coordinator's Office was established in 1967 to coordinate the cooperative, interagency, multi-state migratory fish restoration program in the Connecticut River basin. The program is guided by the Connecticut River Atlantic Salmon Commission according to a Congressional mandate. In 2012, the U.S. Fish and Wildlife Service announced that it would no longer culture salmon for restoration efforts in the Connecticut River; ongoing efforts will focus on other migratory fish and their habitats.

Migratory fish species include American shad, sea lamprey, shortnose sturgeon, striped bass, and river herring. The shad run is one of the largest in the region, with more than half a million fish passing Holyoke dam in 2012 (ASMFC, 2012). There is a shad habitat plan for the Connecticut River (Connecticut Department of Energy & Environmental Protection [CT DEEP] et al., 2014), and a shad fishery that operates under a Sustainable Fishery Plan approved by ASMFC (CT DEEP, 2012). Alewives ascend the river and tributaries up to Raspberry Brook, just above the Massachusetts/Connecticut border, and blueback herring reach Bellows Falls dam, at river mile 174 (Figure 8). A significant fishery for river herring was prosecuted on the Connecticut River until the 1970's (ASMFC, 2012), but Connecticut was the first state to establish a moratorium on fishing for river herring in 2002 in response to low counts in the 1990's. Massachusetts established a moratorium in 2006; closures in both states remain in effect.

The historical usage of the combined term "river herring" for both species prevents retrospective assessment of relative population sizes of alewives and blueback herring. The primary long-term data available for the basin are fish passage counts collected at Holyoke Dam, the first impassable barrier at river mile 87, since 1967. This dam is upstream of the apparent natural range of alewives, but provides an indication of relative abundance for blueback herring in the system. Since there is ample blueback spawning habitat in the mainstem and tributaries below Holyoke, the count does not directly reflect the population.

After a modern fishlift was installed in 1976, blueback passage increased to over 200,000 within five years and peaked in 1985 at 630,000. From 1992-2001 counts at Holyoke averaged only 44,000, dropped to 156 in 2004, and 21 in 2006. The highest count in recent years was 995 in 2013 (USFWS, 2014).

Juvenile indices for blueback herring have been monitored annually throughout the River since 1979 (CT DEEP, 2011). Juvenile production was high and relatively stable from 1979 to approximately 1997, but juvenile indices dropped thereafter by 50 to 95% through 2009. The blueback juvenile index (mean number/seine haul) of 11.72 in 2009 was the lowest in the time series, but 2010 had the fourth highest catch per unit effort (CPUE) in the time series (1979-2010) (ASMFC, 2012).

Alewife abundance in the Connecticut River has not been monitored directly. Passage counts of adult river herring are collected within several Connecticut tributaries. Alewife and blueback relative abundance of mixed stock age 1+, (mean catch/tow) are documented by the Long Island Sound Trawl Survey. Based on sound-wide trawl surveys 1984-2010 and fishway counts and visual estimates from several coastal streams, relative abundance of alewife in Connecticut has either remained stable or increased somewhat in recent years, in contrast to the severe decline of blueback herring in the Connecticut River (ASMFC, 2012).

The Connecticut River and its tributaries possess abundant herring habitat that should support a significant population of river herring; numbers in the millions occurred in the past and are considered a possible restoration outcome. Because of this significant potential, in 2010 the Connecticut River Atlantic Salmon Commission's Subcommittee for River Herring initiated blueback herring transfers from Wethersfield Cove on the mainstem near Hartford, Connecticut to target restoration areas on the mainstem and tributaries downstream of Turner's Falls dam in Massachusetts (USFWS, 2014) (Figure 9). In 2013 and 2014, USFWS conducted population surveys at locations shown in Figure 9. Study objectives are to: 1) obtain a minimum of 50 blueback and alewife for age structures, per target sample location; 2) obtain baseline demographic data on all sampled herring (species, length, weight, sex); 3) derive relative abundance measures with measures of variance; 4) conduct surveys across a broad geographic range of spawning aggregations and over the duration of the runs (April-June), in an attempt to adequately represent spatial and temporal variations for both species; and 5) determine fish ages from otoliths and spawning history from scale examinations. Ongoing monitoring efforts to track status and trends over time are planned. Provisional results for 2014 showed ~2600 bluebacks and 220 alewives were sampled (USFWS, 2014).

Approach

The Connecticut River Atlantic Salmon Commission River Herring Subcommittee was the primary group of experts engaged to identify restoration priorities for this project. Over 30 people representing agencies including the four basin states, USFWS, NOAA, United States Geological Survey (USGS), Conte Laboratory (USGS), University of Massachusetts Cooperative Fish and Wildlife Research Unit, TNC, and Connecticut River Watershed Council, contributed to development of priorities for fish passage, transplantation and monitoring in fall 2014 (USFWS, 2015).

TNC's Connecticut River Program developed a conservation business plan for the basin in 2013, building on assessment and strategic plan development efforts that began in 2004 and included over 50 partners. Conservation and restoration of migratory fish, including river herring, are a priority in that plan.

Threats

Climate change, presence and operation of dams, and ocean bycatch were ranked as high threats to migratory fish; degradation of water quality and habitat due to development in the watershed and presence of inadequately designed culverts ranked as medium threats in TNC's 2013 business plan.

The impacts of climate change are already apparent in the basin and include higher summer temperatures and more frequent and intense storms. In fact, the basin has experienced four 50-100 year flood events since 2006. Under the majority of climate scenarios, spring flooding, a key biological process, is expected to be reduced and overall rainfall in the basin is expected to increase. As critical life phases such as spawning are tied to natural flows and structural fishways have flow tolerances beyond which they cannot operate, migratory fish are expected to be negatively impacted by these changes.

The river's flow regime is imperative to ensuring the proper habitat, substrate, temperature, depth, velocity, biological cues, and other conditions required for migratory fish species to survive. Variation in river flow and temperature are the two main factors affecting the abundance of the young of the year river herring (Henderson and Brown, 1985; Rulifson, 1994; Gahagan et al., 2010). Early summer river flow and temperature had the greatest influence on young of year recruitment in five river systems; spring or fall conditions were also important determinants of survival in some systems studied (Tommasi et al., 2015).

The operation of large dams, those that can store greater than 10-percent mean annual flow, is also a problem. These 70 dams serve important functions such as water supply, flood damage protection, hydropower generation, and recreation; therefore it is unlikely that any of these dams will be removed. The way in which these dams store and release water differs significantly from natural flow patterns, and portions of the basin experience significant impacts from flow alteration (Figure 10). For example, some of the 100+ hydropower dams "peak", meaning they release water rapidly when energy values are high, and store water when prices are low. This cyclic variation can result in water levels changing more than nine feet in a 24-hour period. This variation is detrimental to many aquatic organisms, especially those such as juvenile fish that live at the river's edge and are subject to stranding when water levels drop rapidly. Entrainment and impingement through hydro turbines and at power station cooling systems are related concerns.

There are more than 2,300 dams (typically 6 – 10 feet in height) in the watershed; the vast majority of these were built over a century ago to power mills that are no longer in operation. There is an average of one dam for every ten river miles in the basin, raising water temperature, interrupting sediment transport, impacting water quality and blocking fish passage.

Dynesius and Nilsso (1994) ranked the Connecticut River as one of the top three fragmented rivers in North America (along with the Columbia and the Mobile), with the longest main-channel segment without a dam less than 25% of the length of the entire main channel. In addition to dams, there are over 40,000 road stream crossings basin-wide. Conservative estimates suggest that at least 10% of these culverts create passage barriers. Thus, fragmentation and altered hydrology due to both individual dams and cumulative effects of dams and culverts is a primary stressor to aquatic and riparian communities in the Connecticut River watershed.

Development in the Connecticut River watershed impacts the river and its tributaries. High levels of impervious surface in developed areas result in less infiltration of stormwater and increased runoff. Less infiltration leads to reduced groundwater recharge and lower summer base flows in the river. Increased runoff causes flash flooding and carries a variety of pollutants into water bodies. Stormwater impacts are expected to increase with increased frequency of extreme precipitation events with climate change, coupled with increasing watershed development. Traditional stormwater management using gray infrastructure typically routes runoff to water bodies as quickly as possible, and has limited water quality treatment capabilities. The main threat for the Connecticut River is the stormwater-related impacts of current and future development in urban/urbanizing areas of the watershed (from Keene, New Hampshire/Brattleboro, Vermont south) that cause water quality and water quantity problems.

Though the water quality of the Connecticut River has improved significantly since passage of the Clean Water Act, there are still many reaches of the mainstem and tributaries that, according to state reports to the Environmental Protection Agency (EPA), do not support the aquatic life use designated under the Act. Common water quality problems include high levels of metals and other toxins, nutrients, and sediment; low pH and dissolved oxygen; and elevated temperature. State reports link these issues to several causes related to development and land use including stormwater, wastewater and industrial discharges, and erosion. These issues are especially common in southern tributaries. The Connecticut River is also an important contributor of nitrogen to Long Island Sound, and the Long Island Sound Nitrogen total maximum daily load (TMDL) identifies reductions that are necessary in the Connecticut River Basin.

Flooding is also an issue along the Connecticut River. High flows have many ecological benefits, like shaping productive floodplain habitats and cuing fish to migrate. However, in developed areas, unnatural flash floods lead to erosion and increased turbidity, increased runoff of pollutants, and infrastructure damage.

The EPA's Integrated Climate and Land Use Scenarios (ICLUS) project modeled future impervious cover changes under different development scenarios. A2 shows increased impervious cover in the coming decades in Massachusetts (in the area right around the river and to the east) and in southern Vermont/New Hampshire: the model shows these areas changing from lightly stressed (1-5% cover) in 2010 to stressed (5-10% cover) in 2030.

The CT DEEP has examined the effects of fishing and predation on the recent blueback stock decline. There is evidence that enhanced predation by striped bass in the Connecticut River has played a role in the decline in Connecticut River blueback herring abundance and is affecting recovery (Savoy and

Crecco, 2004; Davis et al., 2009). Davis et al., 2009 estimated that seasonal (May-June) consumption of blueback herring by striped bass in their study reach was comparable to the numbers of herring passing Holyoke dam prior to recent declines.

Restoration Needs

- *Re-operation of large dams:*

  Five mainstem projects (four dams and one pump storage facility), in series and spanning 150 river miles, began the Federal Energy Regulatory Commission (FERC) re-licensing process in 2013. Environmental flow considerations and migratory fish passage are key aspects of relicensing. The five hydro projects included in the 2018 relicensing are Wilder, Bellows Falls, and Vernon Dams in Vermont, Turners Falls Dam, and the Northfield Mountain Pump Storage Project in Massachusetts.

  In order to better understand the Connecticut's flow regime and identify ways to better manage human uses, the USACE, TNC and their partners the University of Massachusetts, Amherst, and USGS developed a series of basin-wide hydrologic models to investigate the alternatives to managing flow for the 70 largest dams in the basin with the goal of improving aquatic habitat while maintaining human uses such as flood control, hydropower, water supply and recreation. The models were designed to generate information to help decision makers and other stakeholders comprehensively understand the positive and negative environmental, economic and social consequences of various management options. The long term ecological objectives of the project are to: increase diversity and abundance of conservation priorities such as floodplain forests, resident and migratory fish and mussel assemblages; where possible, restore the timing and magnitude of high flow events to increase floodplain inundation and restore channel processes; reduce within- day flow variability to improve the quality and quantity of aquatic habitat.

- *Barrier removal and fish passage:*

  CRASC group identified locations where fish passage exists and needs to be improved or maintained and priority locations in Massachusetts and Connecticut for barrier removal or provision of new fish passage (CRASC, 2015) (Figure 8). Passage exists at 15 dams, passage or removal is in planning stages at nine, and six more have no active efforts. Dam removal, and to some extent fish passage, is a long-term strategy that relies on cooperation of dam owners. At least two of the six dams without current plans (Lake Warner and Wiley-Russell dams in Massachusetts) have been the subject of removal efforts undone by public opposition in the recent past. Attitudes and ownership change, however, and these remain important locations to track and consider options.

  Enabling conditions for dam removal, including state permitting and dam safety requirements and state funding, have improved recently, with 30 removals completed and at least 30 more in planning stages in Massachusetts. Several removals have been completed in Connecticut, and there are proposed changes to state dam safety rules that may provide new incentives for removal of dams that are liabilities to their owners. A multi-pronged approach that combines work on policy and regulation and public communications (especially about risk reduction and resilience) with on-the-ground action is critical to restoring connectivity in this highly fragmented region.

For culverts, due to their sheer number and lack of benefits provided by inadequately designed structures, the primary focus has been on policy and strategic demonstration projects. State permits in Massachusetts, Vermont, and New Hampshire require resilient/fish friendly designs for all new and most replacement crossings, and Connecticut has guidelines. The Army Corps New England District Programmatic General Permits for each state also has requirements for design of both new and replacement crossings.

Green infrastructure is a nature-based way to manage stormwater and reduce the effects of impervious cover by replicating, maintaining, or restoring the pre-development hydrology of an area. Green infrastructure includes site-specific Best Management Practices such as bioretention systems and rain gardens, as well as larger scale conservation and restoration of natural lands like wetlands. At both scales, green infrastructure can increase infiltration of stormwater, leading to reduced peak flows, more groundwater recharge, and pollution removal. There are numerous studies showing the effectiveness of green infrastructure in reducing flooding and improving water quality.

- *Predation:*

  Since 2011, CT DEEP has operated a bonus striped bass program that allows recreational fishers to keep a specified number of 22-28” fish, a size class that frequently consumes river herring[10].

[10]http://www.ct.gov/deep/cwp/view.asp?a=2696&q=514692&depNav_GID=1647

Santee-Cooper River System

Overview of the System

The Santee River in South Carolina is 143 miles long and the second largest watershed on the Atlantic Coast (Figure 11). In the late 1930's the Santee and Cooper Rivers were dammed, forming two large impoundments, Lake Moultrie and Lake Marion. Most of the flow of the Santee was then directed into the Cooper River, which prior to the damming was a small tidal estuary. In 1986 a re-diversion canal connected both of these systems, and water flowing from the Cooper River was re-diverted back into the Santee River. Blueback herring numbers declined sharply following the re-diversion and have never recovered to pre-diversion numbers. Improvements for passage since the re-diversion have been on-going (ASMFC, 2013). Hill (2009) completed a prioritization of sub-basins in the entire Santee-Cooper System for the restoration of diadromous fish as part of the Santee River Basin Accord. The Accord is a 10-year agreement (signed in 2008) between the utilities and the USFWS, South Carolina Department of Natural Resources, and the North Carolina Wildlife Resources Commission to work to improve fish passage for diadromous fish. This prioritization highlighted the Broad basin as one of the key basins for selected migratory fish, including shad, blueback herring, and American eel; however, the Columbia Fishway was constructed in 2006 at the Columbia Hydroelectric Project and is located on the Lower Broad River approximately 23 miles downstream of the Parr Shoals Dam. No river herring to date have been detected at the Columbia Fishway.

Prior to 1985 blueback herring appeared to utilize the Cooper River, but a change in water flow management seems to have caused the majority of blueback herring to utilize the Santee River instead. Blueback herring have historically been very abundant in this system in spite of the significant alterations. A fish lock, constructed at the St. Stephen Dam on the Rediversion Canal, was designed to mitigate the decline of fish passage on the Cooper River.

Focus by the State has been on American shad in this system, with the belief that improvements for American shad would be good for blueback herring as well, and therefore blueback herring specific restoration needs are lacking.

Approach

A short presentation followed by a discussion of restoration needs in the Santee-Cooper system with experts was undertaken at the Southern Division-American Fisheries Society 2015 Meeting in Savannah, Georgia. This discussion was part of a special session on Dam Passage and Restoration of Diadromous Fishes. Approximately 15 experts on the system were in attendance and participated in the discussion.

Threats:

- *Barriers:*

  The dams on this system are by far the major threat to blueback herring. The only way to address passage improvement will be through the FERC relicensing process, which is overdue.

- *Predation:*

  Cormorants are the main river herring predator in this system. Greater than 10,000 birds at a time have been seen around the tailrace. Catfish, striped bass, and white pelicans are also predatory threats to river herring in the Santee-Cooper system.

- *Destruction of SAV beds by power companies:*

  It is thought that blueback herring are spawning in the back end of the reservoirs, where the benthos is primarily SAV.

Restoration Needs

- *Passage Improvement:*
  Since the removal of the dams on this system is not a realistic option, the focus should be on improving passage through a FERC relicensing process.

Research Needs

- Work should be conducted to determine spawning locations. The Columbia Fishway was constructed in 2006 at the Columbia Hydroelectric Project located on the Lower Broad River but blueback herring have not been detected there.
- More research on the predator (fish and bird)-prey relationships is needed.
- The use of SAV beds for spawning in reservoirs should be documented.

Hudson River

Overview of the System

The 315-mile long Hudson River flows from the Adirondacks in New York and empties into the Upper New York Bay. The Hudson River is tidal to the first dam at Troy, New York (river mile 152) (Figure 12). River herring spawn in Hudson River tributaries and in the shallow waters of the mainstem. They spawn in the tidal freshwater of the Hudson from Kingston (river mile 89) to Troy (river mile 159). The nursery area includes the spawning reach and extends south to Newburgh Bay (river mile 56) (Hattala et al., 2011). Blueback herring have expanded their range into the Mohawk River, the largest tributary in the Hudson, using the locks at the Federal Dam at Troy.

The Hudson is a drowned river valley and although there are over 307 barriers on 65 tributaries to the lower Hudson (New York City to Troy Dam), opportunities for river herring via barrier mitigation are limited. A recent updated assessment and prioritization of barriers in tributaries to the Hudson was completed by NMFS and, even if all man-made barriers on tributaries were removed, it would only result in an increase of 30 miles of habitat (Alderson and Rosman, 2013). However, the main channel and adjacent habitats of the Hudson River have been significantly altered due to both the construction of the federal navigation channel, which filled wetlands and intertidal areas, including side channels; and construction of railroads on both shores, which isolated wetlands and altered shorelines (Miller, 2013). These activities resulted in the loss of nearly 4,000 acres of shallow-water habitat, including the near-complete elimination of side channels in the upper third of the estuary (Figure 13). Many of these areas were likely important spawning, nursery, and refugia habitat for river herring. In addition, zebra mussels have had a significant impact on the Hudson, greatly reducing the availability of phytoplankton and zooplankton for river herring. Increased blue crab predation on zebra mussels may have stabilized this invasive population (Strayer et al., 2014). Additionally, as with the Chesapeake Bay watershed, urbanization may be a factor in lower recruitment of river herring as well (Limburg and Schmidt, 1990).

Approach

We primarily used current threat assessment and priorities from the Hudson River Habitat Restoration Plan (Miller, 2013)[11], which was released in 2014. This publication guides the priority restoration trajectory for the Hudson River Estuary. In addition, input from Hudson River Estuary and TNC staff was solicited. Currently, a large-scale, multi-stakeholder prioritization project for restoring the Hudson River Estuary is also underway: The Hudson River Comprehensive Restoration Plan. This plan will result in a set of shared project priorities for strategic actions and investments in the Hudson River. The four priority habitats for this project are tidal/intertidal wetlands, SAV and shallow water habitats, riparian buffers and floodplains, as well as tributary connectivity and barriers. All of these habitats are key to protecting and restoring river herring in the Hudson. For barriers priorities, we relied on a 2013 NOAA barrier removal prioritization recently completed for the Hudson (Alderson and Rosman, 2013).

[11] http://www.dec.ny.gov/docs/remediation_hudson_pdf/hrhrp.pdf

Threats (prioritized from the Hudson River Habitat Restoration Plan (Miller, 2013)

(1) Loss of shallow water habitats (2) Loss of habitat complexity (3) Zebra mussels (4) Sea level rise (4) Urbanization (5) Barriers

Restoration Needs

- *Side Channel Restoration*:

  The reconnection of large old side channels will provide shallow water habitat for juvenile river herring. These will be large-scale projects that will require significant funding and monitoring requirements, however, linkages between side channel habitat and some reproductive success of some salmonids has already be documented (Richards et al., 1992).

- *Floodplain Restoration*:

  Protection and restoration of floodplain habitat on tributaries to the Hudson River is needed.

- *Barriers*:

  Although limited, the tributaries that have greatest potential for creating river herring habitat and are most feasible to improve include (Schmidt et al., 1996, Alderson and Rosman, 2012) (Figure 14):

  - Claverack Creek - Van De Carrs Dam
  - Rondout Creek - Eddyville Dam-Northeast Aquatic Connectivity Project Tier 1 Dam.
  - Moodna Creek - Moodna Creek Development Corporation Dam (interstate container), NY_195-1206 and Orrs Mills Pond Dam: NY_195-0494
  - Croton River - Silver Lake Dam: NY_214-2956

Research Needs

- Studies that can link habitat restoration that benefits early life stages for river herring through side channel restoration are needed.
- Predator-Prey studies for both native and non-native predators are needed.

Delaware River

Overview of the System

The Delaware River begins in Hancock, New York and flows more than 282 miles before emptying into Delaware Bay. The tidal portion extends the head of the bay to near Trenton, New Jersey (river mile 133). The East and West Branches, Lackawaxen, Neversink, Lehigh, and Schuylkill rivers are the major tributaries. The 12,756 square mile basin includes parts of four states: Pennsylvania (50% of the basin), New Jersey (23%), New York (19%), and Delaware (8%) (Figure 15). The Delaware River is unique along the Atlantic Coast in that it is free flowing along the entire length of the mainstem. River herring were once present and abundant in most tributaries and the mainstem of the lower and middle Delaware River. Habitat usage above Port Jervis, New York has not been documented (ASMFC, 2012). The Schuylkill River has been the site of significant dam removals and fish passage improvements over the last decade. The Philadelphia Department of Water has over 10 years of quantitative adult river herring abundance data, as well as some length frequency data, and the fish passage data from Fairmount Fishway could be measured for success due to data availability (Joe Perillow, pers. comm.).

The Delaware River is tidal up to Trenton, New Jersey. Although free of mainstem dams, in the early 20th century the estuary was considered one of the most polluted water bodies in the United States. A recurring pollution block in the tidal portion of the upper Delaware Estuary severely hindered migratory fish runs, which were already depleted from overfishing and habitat degradation. Today the Delaware River is home to one of the largest freshwater port complexes in the world and nearly 70% of East Coast oil moves through the port. Deepening the main channel for navigation, which is ongoing, has resulted in significant changes to the mainstem channel in the lower basin from Philadelphia, Pennsylvania to the ocean. From an average depth of 17-24 feet in the mid-1800's to 45 feet by 2017 and potentially deeper in the near future, these changes to the channel allows the salt front to reach further upstream. The encroaching salt front combined with development along the river has resulted in the significant loss of side channel and shallow water habitat, likely both key habitats for juvenile and spawning river herring.

Compared with many of the other watersheds in this report, there is a lack of recent knowledge on the habitat usage and population status of river herring in the basin; however, steep declines seem to be widespread. As of January 2012 all river herring fisheries in the Delaware River and its tributaries are closed. Within the Delaware River Basin, the Delaware River Basin Fish and Wildlife Management Cooperative (DFWMC) is responsible for the management of diadromous fishes. The DFWMC was established by Charter in 1973 and primarily develops unified approaches to anadromous fish management. It is comprised of the USFWS, NMFS, Delaware Department of Natural Resources and Environmental Control (DNREC), Pennsylvania Fish and Boat Commission (PFBC), Pennsylvania Game Commission (PGC), New York Division of Fish, Wildlife, and Marine Resources (NYDEC), and New Jersey Division of Fish and Wildlife (NJDFW). A Coordinator from the USFWS serves as secretary to the DFWMC and acts as a liaison and technical specialist primarily on aquatic issues to the National Park Service (NPS), the DRBC, the Delaware Estuary Program, and the USFWS's Delaware Bay Estuary Project.

Approach

Information on priorities was solicited from state fisheries biologists and other stakeholders during a meeting (some participants used webinar due to an ice storm) of the DFWMC. This DFWMC develops unified approaches to manage migratory species of interstate significance in the Delaware River basin and at this meeting were state, federal, private, and non-governmental organization stakeholders. Additional stakeholders were reached via email or phone. Information was also gleaned from the recently completed American shad habitat plan for the Delaware River, ASMFC reports and assessments, and other relevant literature.

Threats

- *Barriers:*

  Although the mainstem Delaware is free of dams, the Northeast Aquatic Connectivity Project evaluated 1,547 dams on 12,626 miles of river in the Delaware River Basin (Martin and Apse, 2011). This corresponds to a density of one dam for every 8 miles of river.

- *Altered Predator-prey dynamics:*

  In the past forage fish such as river herring in the Delaware River co-existed with fewer types of predatory fish than occur today. Since the late 1800's several species of piscivorous fish have been introduced and subsequently naturalized in the Delaware River, including: largemouth bass, walleye, smallmouth bass, muskellunge, rainbow trout, and brown trout. Others including flathead catfish, northern snakehead, and Asian swamp eels have only recently begun to invade the lower reaches of the Delaware River Basin. During 2010 fall sampling, PFBC biologists collected numerous young of year (YOY) and adult flathead catfish. The Philadelphia Water Department has documented flathead catfish inhabiting the fishway in Fairmount Dam, and these fish were likely targeting American shad and river herring as a food source during the spring spawning run. In 2008, the NJDFW documented the occurrence of Asian swamp eels in the Cooper River drainage in Silver Lake. Invasions outside of this watershed have not yet been documented. In addition, the striped bass population has increased to historic highs coast-wide and some studies have shown that river herring and shad can make up a substantial proportion of their diet (Walter et al., 2003; Savoy and Crecco, 2004). With other prey species such as rainbow smelt depleted or extirpated increased predation by striped bass and other piscivores may be limiting river herring and shad populations.

- *Impingement and entrainment:*

  The EPA performed a case study of cumulative impacts from impingement and entrainment (I & E) at numerous industrial intakes in the Delaware Estuary (EPA, 2002) and reported that fish losses (all species) were greater than 500 million age-1 equivalents annually and represented an economic loss of $23.4 - $48.5 million each year (in year 2000 dollars). The DFWMC obtained 316b reports for five companies with cooling water intake structures (CWIS) on the Delaware River or its tributaries as well as annual biological monitoring reports for the Salem Generating

Station. These reports highlighted very significant I&E impacts on river herring, especially at the Eddystone and Fairless Hills generating stations (DFWMC, 2013).

- *Urbanization*
- *Habitat Loss:*

  In addition to loss of tributary habitat from dams, only 5% of tidal freshwater marshes are still functional.

- *Water Quality:*

  Major strides have been taken to improve dissolved oxygen levels in the Delaware and by the late 1980's, dissolved oxygen began to regularly exceed the 3.5 mg/L water quality criterion set in 1967 for the urban zones of the estuary (Partnership for the Delaware Estuary [PDE], 2012). Although water quality in the mainstem has improved dramatically, dissolved oxygen sags near Philadelphia, Pennsylvania still occur during summer months. There have been many episodes since 2000 in which dissolved oxygen has dropped below 3.5 mg/L (Delaware River Basin Commission [DRBC], 2010; PDE, 2012; USGS-NWIS, 2013) creating conditions lethal to some life stages river herring. Additionally, most of the coastal tributaries that drain into the Delaware River and Bay from the State of Delaware are impaired due to nutrients and/or dissolved oxygen (Delaware Department of Natural Resources and Environmental Control [DNREC], 2005).

Restoration Needs

- *Barrier Removal (Figure 16)***:**

  - **An assessment (on-the-ground) of all barriers is needed**. All Tier 1 Dams in the Northeast Connectivity tool should be assessed for effective passage if a ladder is present, and whether there is a potential for removal or passage upgrade.
  - **Dam removals on Brandywine and White Clay Creek** should continue to be a priority for funding for improved river herring access.
  - **Red Mill Dam (Dam ID NAC # DE_23 Tier 1 Dam)** on White Clay Creek: With the removal of the Byrnes Mill Dam in 2014 this system has great potential for river herring access improvements via dam removal in Delaware. Subsequent dams in this system should be given high priority for removal and funding.

- *Inland Bay Restoration:*

  The inland bay area is comprised of Rehoboth, Indian River, and Little Assawoman Bays, which are located on the Atlantic Coast of Delaware just south of the entrance to the Delaware River Estuary. This is a highly productive area for fish and the Delaware Center for the Inland Bays has been focusing on river herring restoration and prioritizing restoration needs in this area[12] (Figure 17).

[12] http://www.inlandbays.org/wp-content/uploads/Inland-Bays-Migratory-Fish-Passage-Restoration-Feasibility-and-Planning-Study.pdf

- *Assessments and Monitoring:*
    - **Assessment of the efficiency** of fish ladders in New Jersey for passing river herring is necessary.
    - **Assessment of water quality/riparian habitat** impacts to river herring in Delaware, New Jersey and Pennsylvania is necessary.

Research Needs

- Predator-prey relationships for both invasive (e.g. flathead catfish) and native (e.g. striped bass) species should be analyzed.
- The habitat in the area should be researched further. There is an overall lack of knowledge of river herring habitat use in the Delaware and its tributaries.
- River herring production in tributaries should be investigated.
- Tagging studies in rivers with fish ladders should be conducted to estimate population numbers and passage rates.

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APPENDICES

Appendix A: Chesapeake Bay Workshop Meeting Materials

Prioritizing River Herring Restoration Needs in the Chesapeake Bay

Chesapeake Bay Foundation
6 Herndon Avenue
Annapolis, MD 21403

May 7 and 8, 2014

Agenda

Workshop objective: To develop a set of ranked "actionable" habitat focused strategies/projects to restore river herring in key watersheds of the Chesapeake Bay.

Day 1:

10:00-10:15	Welcome: Introductions and logistics - *Marin Hawk, ASMFC and Bill Goldsborough, Chesapeake Bay Foundation*
10:15-10:40	Project background and workshop overview - *Alison Bowden, The Nature Conservancy*
10:40-11:00	Priority River Systems - *Mari-Beth DeLucia, The Nature Conservancy*
11:00-11:15	Linking river herring monitoring to restoration priorities - *Matt Ogburn, Smithsonian Environmental Research Center*
11:15-11:30	River herring habitat thresholds - *Jim Uphoff, Maryland DNR*
11:30-11:45	Maryland Prioritization - *Marek Topolski, Maryland, DNR*
11:45-12:15	Questions and Clarifications
12:15-1:00	Lunch (provided)
1:00-1:30	Web Map tools and data - *Erik Martin, The Nature Conservancy*
1:30-1:45	Introduce breakout sessions and desired products/outcomes
1:45-3:15	Breakout groups – Discussion on key threats by geography
3:15-3:30	Break
3:30-4:45	Breakout groups – Discussion to identify key projects/opportunities.
4:45-5:00	Wrap up and overview of next day

Day 2:

9:00-9:45	Recap previous day and overview of Day 2
9:45-10:45	Breakout groups –feasibility and ranking of projects/strategies
10:45-11:00	Break
11:00-12:00	Identify key obstacles to restoring river herring to Chesapeake Bay (facilitated group discussion)
12:00-12:45	Lunch (provided)
12:45-1:45	Habitat research needs and gaps in knowledge (facilitated group discussion)
1:45-2:00	Next steps, workshop products, wrap up and adjourn

NFWF River Herring Habitat Restoration Needs Project
Chesapeake Bay Workshop: Background Materials

C. Shumway, M. DeLucia, C. Patterson

Background and Workshop Goals

The Atlantic Coast Fish Habitat Fish Habitat Partnership (ACFHP) received funding from the National Fish and Wildlife Foundation's (NFWF) to develop restoration priorities to conserve river herring in key watersheds along the Atlantic Coast, with a focus on the Chesapeake Bay. NFWF's River Herring Initiative and the resulting Business Plan for River Herring Conservation describes a comprehensive 10-year strategy to guide NFWF conservation investments to achieve an increase in river herring spawning runs in key rivers along the eastern seaboard. The entire plan can be found at: http://www.nfwf.org/riverherring/Documents/river_herring_business_plan_2012.pdf

The goal of this workshop is to gather river-system specific river herring information from key experts and stakeholders to prioritize, plan, and strategize river herring restoration needs in the Chesapeake Bay area. We will build on the success of the recent University of New Hampshire-organized New England River Herring Stakeholders Workshop also funded by the NFWF as well as leverage the Atlantic Coastal Fish Habitat Partnership networks.

This background paper provides a quick synopsis to help you prepare for the workshop, summarizing some pertinent literature on current threats to river herring in this area. This material is intended to help direct discussion on priority needs for river herring restoration in each river system on the eastern and western shores of the Chesapeake Bay.

We hope that you will come prepared as key experts and stakeholders to discuss the threats by region and collaboratively agree on a suite of strategies and locations that require focused effort and funding in order to meet prioritized goals for river herring recovery in Chesapeake Bay.

Threats Summary

NOAA Listing Determination and ASMFC 2012 Stock Assessment

In 2013, NOAA Fisheries (aka NMFS) completed a comprehensive review of the status of river herring (alewife and blueback herring) in response to a petition to list river herring as threatened under the Endangered Species Act. Much of the assessment was based on the Atlantic States Marine Fisheries Commission's (ASMFC) 2012 stock assessment which listed river herring as "depleted" throughout its range. Although NOAA Fisheries determined that listing was unwarranted at the time, the determination notice noted that both species were at low abundances and there were uncertainties with the data. The notice also included language from Amendment 2 to the *Interstate Fishery Management Plan for Shad and River Herring*, (ASMFC, 2009).

The full notice is at: http://www.nero.noaa.gov/stories/2013/riverherringlistingfrnotice.pdf

NOAA Fisheries considered numerous threats impacting river herring; several related to habitat. They ranked threats range wide and regionally as determined by the Status Review Team (SRT). Threats were ranked as <u>High to Moderately High (H)</u> and <u>Moderate to Moderately Low (M).</u> The most important threats impacting river herring habitat (all stock complexes) are summarized below, with select passages noted with italics.

- Dams and Other Barriers (H) - *The SRT identified dams and barriers as the most important threat to alewife and blueback herring populations both rangewide and across all stock complexes.*
- Dredging (M)
- Water Quality (M)
- Water Withdrawal/Outfall (M)
- Wetland Alterations (M)
- Climate Change and Climate Variability (M)

Dams and Other Barriers

Dams and other man-made barriers have contributed to the historical and current declines in abundance of both blueback and alewife populations...result[ing] in significant <u>losses of historical spawning habitat</u> for river herring. They...block or impede access to habitats necessary for spawning and rearing; can cause <u>direct and indirect mortality</u> from injuries incurred while passing over dams, through downstream [fish] *passage facilities, or through hydropower turbines; and can <u>degrade habitat features</u> necessary to support essential river herring life history functions.*

Dredging

Amendment 2 noted the following dredging impacts: *Channelization can cause significant environmental impacts (Simpson et al., 1982; Brookes, 1988), including <u>bank erosion</u>, <u>elevated water velocity</u>, <u>reduced habitat diversity</u>, <u>increased drainage</u>, <u>and poor water quality</u>...through the release of contaminants…resulting in bioaccumulation, direct toxicity to aquatic organisms, or reduced dissolved oxygen levels (Hubbard, 1993; Morton, 1977). Disposal of spoils along the shoreline can also <u>[impact habitat</u> by blocking] access to sloughs, pools, adjacent vegetated areas, and backwater swamps (Frankensteen, 1976). Spoil banks are often unsuitable habitat; …it is too unstable. Suitable habitat is often lost when dredge disposal material is placed on natural sand bars and/or point bars.*

Water Quality

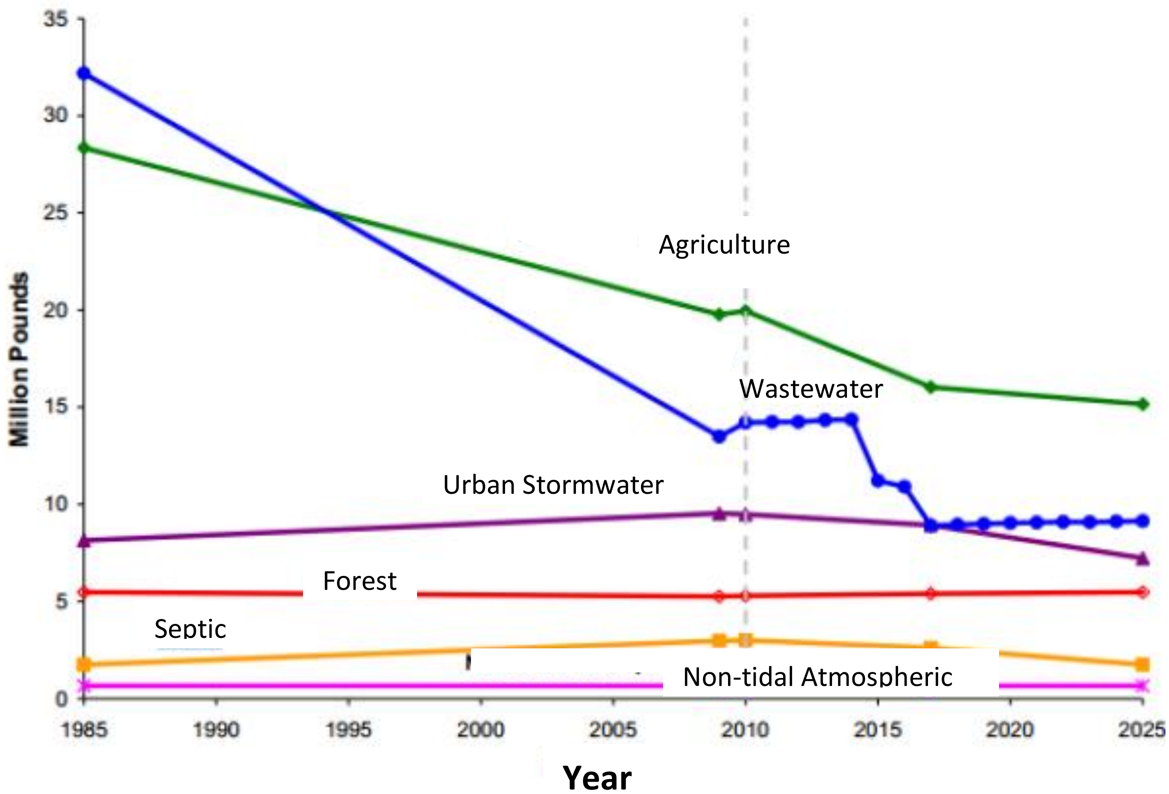
The NOAA Fisheries report highlighted primarily nutrient impacts to water quality, but water quality is impacted by land use patterns and increasing amounts of impervious surfaces which can impact river herring in a multitude of ways as described below. The report notes some of these impacts in other sections. Amendment 2 identified land use changes including agriculture, logging/forestry, urbanization and non-point source pollution as threats to river herring habitat… *careless land use practices may lead to erosion, which can lead to high concentrations of suspended solids (turbidity) and substrate (siltation) in the water following rainfall events. This can <u>displace larvae and juveniles</u> to less desirable areas downstream and <u>cause osmotic stress</u> (Klauda et al., 1991b; ASMFC, 2009).*

<u>% Impervious cover in watershed</u>

* When impervious cover increases above 5-7%, there is a corresponding drop of approximately 50% in water quality, macroinvertebrate abundance, and fish habitat quality. The greatest impact is within riparian buffers (Schiff and Benoit, 2007).
* When impervious cover levels are at 5%; the number of alewife eggs and larvae are reduced by 50%; at 10% impervious cover, there is close to total mortality of eggs and larvae (Limburg & Schmidt, 1990).

Nutrient enrichment (NO4, PO4)

The figure below summarizes the contributors of nitrogen input to the Chesapeake Bay now and over time (source: Mark Breyer, TNC).



* The largest source of nutrients to the Chesapeake Bay is farming. Construction has been shown nationally to be the second biggest source of nutrients after farming (NRC, 2009); other primary nutrient sources for the Chesapeake come from aging wastewater treatment plants and septic systems. Excessive nutrients stimulate excessive algal growth that consumes oxygen when it decays. Low dissolved oxygen levels can cause fish kill*s* (e.g., Klauda et al., 1991b). Fish eggs and larvae are particularly susceptible to poor water quality conditions (Hunter, 1984).

Turbidity due to Sediment Loading (also caused by dredging)

* Fish behaviorally avoid areas of high turbidity due to sediment suspension (ASMFC, 2009, Reine et al., 1998).

- Sediment suspension can impact respiration for filter-feeding fish such as alosines by collecting on gill tissues and clogging gills, resulting in lethal and sublethal effects to fish (Cronin et al., 1970), Sherk et al., 1974, 1975; ASMFC, 2009).
- Sediment suspension also impacts feeding behavior due to increased turbidity, significant for river herring (Kosa and Mather, 2001). Size selective predators such as blueback herring feed visually, and increased turbidity can impact the ability to locate food along with physiological consequences (Burbridge, 2011).
- River herring behaviorally emigrated from rearing pond when blue-green algae bloom occurred, (Yako, 1998).
- Transparency can impact reproductive behavior resulting in developmental issues and even mortality of eggs and larvae (Kosa and Mather, 2001).

Impacts to River Herring Food Sources

- Change in water flow can impact zooplankton biomass, a river herring food source. Zooplankton biomass significantly correlated with water residence time (Basu and Pick 1996).
- Channelization and siltation reduces quality of habitat for aquatic macroinvertebrate larvae (Iwata et al. 2003; Baxter et al., 2005). As stream banks erode, the mix of coarse and fine sediment decreases the median size... of sedimentary bed material and makes them more mobile thereby making benthic habitats less suitable for insect larvae living in the interstices.
- Loss of riparian vegetation results in fewer terrestrial insects for fish to feed upon. Terrestrial insects can provide from 15-50% of the energy budget for filter-feeding fishes, especially important in late spring/summer (Baxter et al., 2005). Known to be important for clupeids, at least for (Massman, 1963) in Virginia streams. More important upstream than downstream.

pH changes (also caused by acid rain)

- Acidic episodes (pH of 5.5-7.4) may be an important cause of early stage mortality for fish that spawn in poorly buffered habitats (Klauda and Palmer, 1987; Kosa and Mather, 2001).

Change in water flow

- Low flow reduced use of spawning habitat in blueback herring and alewife, North Carolina (Walsh et al., 2011), and impacted larval American shad (Crecco and Savoy, 2011).

Temperature

- Larval American shad impacted by rising river temperatures (Crecco and Savoy, 2011).

Water Withdrawal impacting Streamflow

Amendment 2 noted: *Large volume water withdrawals (e.g., drinking water, pumped-storage hydroelectric projects, irrigation, and snow-making) can alter local current characteristics, which can result in delayed movement past a facility or entrainment in water intakes (Layzer and O'Leary, 1978). The physical characteristics of streams (e.g., stream width, depth, and current velocity; substrate; and temperature) can be altered by water withdrawals (Zale et al., 1993). Reduced streamflow can reduce water quality by concentrating pollutants and/or increasing water temperature (ASMFC, 1985)… and decrease the quantity of both spawning and nursery habitats. Fish impinged against water filtration screens can die from asphyxiation, exhaustion,… removal of protective mucous, and descaling (DBC, 1980).*

Toxic and thermal point source discharges

Amendment 2 noted: *Industrial discharges may contain toxic chemicals, such as heavy metals and various organic chemicals (e.g., insecticides, solvents, herbicides) (ASMFC, 1999). In addition, pulp mill effluent and other oxygen-consuming wastes discharged into rivers and streams can reduce dissolved oxygen concentrations below what is required for river herring survival and… can also delay or prevent upstream and downstream migrations. Thermal effluent from power plants outside these temperature ranges* [defined in the notice] *when river herring are present can disrupt schooling behavior, cause disorientation, and may result in death. Sewage can directly and indirectly affect anadromous fish.*

Cumulative/Synergistic effects

NOAA Fisheries noted: *The combination of incremental losses of wetland habitat, changes in hydrology, and nutrient and chemical inputs produced over time can be extremely harmful to river herring, resulting in diseases and declines in the abundance and quality of the affected resources.*

> Wetland loss
>
> *Wetlands provide migratory corridors and spawning habitat for river herring. Wetland lass is a cumulative impact… result[ing] from activities related to dredging/dredge spoil placement, port development, marinas, solid waste disposal, ocean disposal, and marine mining.*
>
> Climate Change and Climate Variability
>
> Climatic change can synergistically impact other stressors, including stormwater runoff and temperature. In addition, *… changes in the amount of preferred habitat and a potential northward shift in distribution as a result of climate change may affect river herring in the future, for example in the years from 2020 through 2100 (Nye et al., 2012).*

Generalized Threats by Region in Chesapeake Bay

Eastern Shore: Water Quality, particularly nutrients from agriculture in runoff.

- Chester River Watershed: Water quality (nutrients), loss of submerged aquatic vegetation, and harmful algal blooms (HAV).
- Choptank River watershed: Water quality (nutrients, sediment, loss of riparian cover), dredging (channelized streams).
- Nanticoke River watershed: Water quality (nutrients, sediment), dredging (channelized streams).
- Pocomoke River Watershed: Water quality (nutrients and sediment).

Western Shore

- Lower Susquehanna River: Dams, water quality due to urbanization (nutrients).
- Lower Potomac River: Tributary dams, water quality due to urbanization (impervious surfaces).
- Rappahannock River: Tributary dams, water quality due to urbanization (turbidity, nitrogen, low DO), invasive catfish predation.
- Lower James River: Water quality (nutrients and sediment), flow alteration, predation.

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Directions to CBF's Philip Merrill Environmental Center

Chesapeake Bay Foundation   Ph.:410-268-8816
Philip Merrill Environmental Center
6 Herndon Avenue
Annapolis, MD 21403

From Annapolis:

- Take Route 50 West
- Exit onto Aris T. Allen Blvd (Route 665) heading East (Exit 22)
- DO NOT EXIT ONTO RIVA ROAD
- Go approximately 2.8 miles and Aris T. Allen Blvd. becomes Forest Drive
- Go approximately 2.2 miles and Forest Drive becomes Bay Ridge Road
- Go approximately 1.6 miles and turn right on to Herndon Ave. (next to sign for Bay Ridge Community and just past two curved stone walls). GO SLOWLY — Speed limit on Herndon Ave. is 25 mph and is strictly enforced.
- Go approximately .5 miles and turn right at the CBF sign. Proceed down driveway and park in the front parking lot.

From Baltimore:

- Take Route 97 towards Annapolis, then Route 50 East.
- Immediately exit onto Aris T. Allen Blvd. (Route 665) heading East (Exit 22).
- Just after the exit ramp the highway forks. Take the right fork and stay on Aris T. Allen Blvd./665.
- Stay to the left and avoid the Riva Road exit ramp off Aris T. Allen Blvd.
- Go approximately 2.8 miles and Aris T. Allen Blvd. becomes Forest Drive.
- Go approximately 2.2 miles and Forest Drive becomes Bay Ridge Road.
- Go approximately 1.6 miles and turn right on to Herndon Ave. (next to sign for Bay Ridge Community and just past two curved stone walls). GO SLOWLY — Speed limit on Herndon Ave. is 25 mph and is strictly enforced.
- Go approximately .5 miles and turn right at the CBF sign. Proceed down driveway and park in the front parking lot.

From Virginia/Washington, D.C.:

- Take 50/301, then Route 50 East.
- Exit onto Aris T. Allen Blvd. (Route 665) heading East (Exit 22).
- Just after the exit ramp the highway forks. Take the right fork and stay on Aris T. Allen Blvd./665.
- Stay to the left and avoid the Riva Road exit ramp off Aris T. Allen Blvd.
- Go approximately 2.8 miles and Aris T. Allen Blvd. becomes Forest Drive.
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- Go approximately .5 miles and turn right at the CBF sign. Proceed down driveway and park in the front parking lot.

From Maryland's Eastern Shore:

- Go west over the Bay Bridge, then 50 West.
- Exit onto Aris T.Allen Blvd. (Route 665) heading East (Exit 22).
- DO NOT EXIT ONTO RIVA ROAD
- Go approximately 2.8 miles and Aris T. Allen Blvd. becomes Forest Drive.
- Go approximately 2.2 miles and Forest Drive becomes Bay Ridge Road.
- Go approximately 1.6 miles and turn right on to Herndon Ave. (next to sign for Bay Ridge Community and just past two curved stone walls). GO SLOWLY—Speed limit on Herndon Ave. is 25 mph and is strictly enforced.
- Go approximately .5 miles and turn right at the CBF sign. Proceed down driveway and park in the front parking lot.

Appendix B: Water Quality Impacts to River Herring and other Fishes

C.Shumway

Water quality is impacted by land use patterns and increasing amounts of impervious surfaces which can impact fish in a multitude of ways as described below.

<u>% Impervious cover in watershed</u>[i]

- When impervious cover increases above **5 to 7%** within a watershed, there is a corresponding drop of approximately 50% in water quality (WQI), macroinvertebrate abundance, (RPB, EPT) and fish habitat quality (HAB) (figure 1, right)*. Regression analyses show that both water quality and fish habitat quality are significantly correlated with impervious cover at the watershed scale (Schiff and Benoit, 2007). Impacts to macroinvertebrates are significantly correlated within the local receiving zone of the area tested and within riparian buffers (analyzed at 100m).
- When impervious cover levels are at 5%, the number of alewife eggs and larvae are reduced by 50%; at 10% impervious cover, close to total mortality of eggs and larvae occurs (Limburg & Schmidt, 1990).
- Fluvial fish species (including migratory species) show a decline in both species richness and abundance with increasing impervious cover, with species richness declining by roughly 25% at 5% impervious cover and 50% at 10% (Figure 2, page 2; Armstrong, 2011)
- USGS and other partners are currently determining the underlying important biological variables causing the effect of impervious cover in MA (A. Roy, pers. comm.).

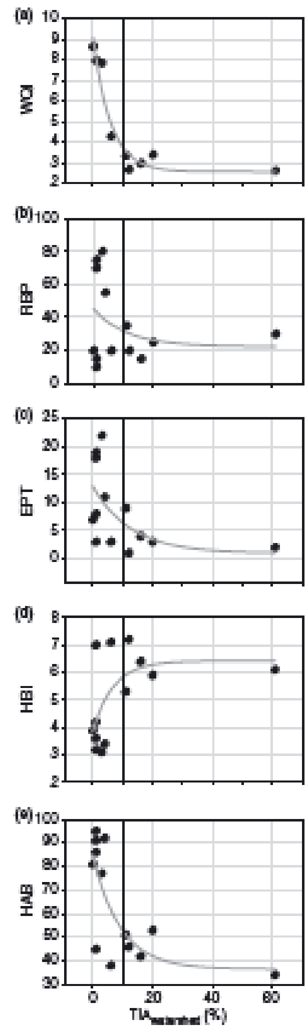

Figure 1 a). Water Quality Index (WQI), b) USEPA Rapid Bioassessment Protocol (RBP) Series, c) EPT Index (EPT), d) Hisenhoff Biotic Index (HBI), and e) Habitat Score (HAB) vs. Total Impervious Area (TIA) at the Watershed Scale. Solid vertical line is the 10% TIA level. From Schiff and Benoit (2007).

<u>Nutrient enrichment (NO4, PO4)</u>

- Nationally, construction has been shown to provide the second biggest source of nutrients to rivers after farming (NRC, 2009). Sediment from construction sites washing into wetlands and rivers carries the charged particles of phosphorus; other primary nutrient sources come from aging

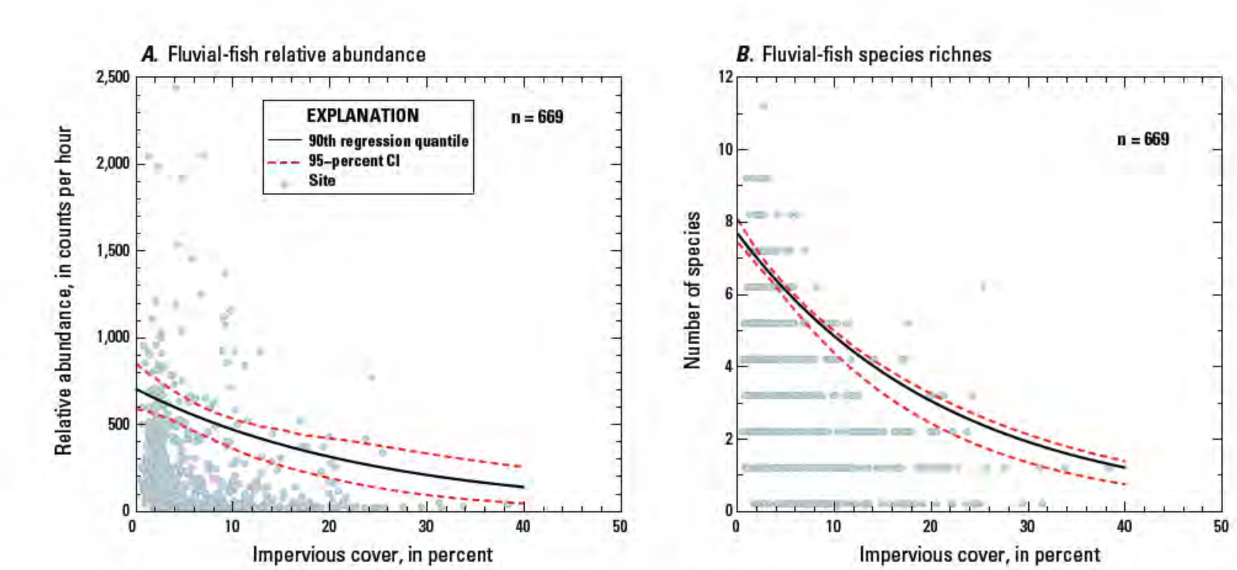

Figure. 2. Quantile regression relations between A, fluvial-fish relative abundance and B, fluvial-fish species richness and percen timpervious cover for the contributing areas to selected fish-sampling sites on Massachusetts streams. CI, confidence interval; n, number of sites. Fish samples were collected from 1998 to 2008. From Armstrong (2011).

- wastewater treatment plants, septic systems. Home fertilizer use, dog waste, and waterfowl also play a role. Excessive nutrients stimulate excessive algal growth that consumes oxygen when it decays. Low dissolved oxygen levels can cause fish kill*s* (e.g., Klauda et al., 1991b). Fish eggs and larvae are particularly susceptible to poor water quality conditions (Hunter, 1984).

<u>Turbidity due to Sediment Loading</u>

- Fish <u>behaviorally avoid</u> areas of high turbidity due to sediment suspension (ASMFC, 2009, Reine et al., 1998).
- Sediment suspension can impact <u>respiration</u> for filter-feeding fish such as alosines by collecting on gill tissues and clogging gills, resulting in lethal and sublethal effects to fish (Cronin et al., 1970), Serk et al., 1974, 1975; ASMFC, 2009).
- Sediment suspension also impacts <u>feeding behavior</u> due to increased turbidity, significant for river herring (Kosa and Mather, 2001). Size selective predators such as blueback herring feed visually, and increased turbidity can impact the ability to locate food along with physiological consequences (Burbridge, 2011).
- River herring <u>behaviorally emigrated</u> from rearing pond when blue-green algae bloom occurred, (Yako, 1998).
- Transparency can impact <u>reproductive behavior</u> resulting in developmental issues and even mortality of eggs and larvae (Kosa and Mather, 2001).

<u>Impacts to River Herring Food Sources</u>

- <u>Change in water flow</u> can impact <u>zooplankton biomass</u>, a river herring food source. Zooplankton biomass significantly correlated with water residence time (Basu and Pick 1996).

- Channelization and siltation reduces quality of habitat for aquatic macroinvertebrate larvae (Iwata et al. 2003; Baxter et al., 2005). As stream banks erode, the mix of coarse and fine sediment decreases the median size of sedimentary bed material and makes them more mobile thereby making benthic habitats less suitable for insect larvae living in the interstices.
- Loss of riparian vegetation results in fewer terrestrial insects for fish to feed upon. Terrestrial insects can provide from 15 to 50% of the energy budget for filter-feeding fishes, especially important in late spring/summer (Baxter et al., 2005). Known to be important for clupeids, at least for (Massman, 1963) in Virginia streams. More important upstream than downstream.

pH changes

- Acidic episodes (pH of 5.5 to 7.4) may be an important cause of early stage mortality for fish that spawn in poorly buffered habitats (Klauda and Palmer, 1987; Kosa and Mather, 2001).

Change in water flow

- Low flow reduced use of spawning habitat in blueback herring and alewife, North Carolina (Walsh et al., 2011), and impacted larval American shad (Crecco and Savoy, 2011).

Temperature

- Larval American shad are impacted by rising river temperatures (Crecco and Savoy, 2011).

Cumulative/Synergistic effects

Climate Change and Climate Variability

Climatic change can synergistically impact other stressors, including stormwater runoff and temperature.

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[i] Note that the physiological/behavioral threshold of fishes for percent of impervious cover may vary by location. Bob Van Dolah (personal communication) has commented that fishes within coastal watersheds appear to have a higher threshold in their sensitivity to impervious surfaces.

Appendix C: Summary of River Herring Status in Select Watersheds

Watershed	Alewife status	Blueback herring status	Current monitoring efforts	Priority threats
Chesapeake Bay Watershed				
Chester River	present	present	no current monitoring	increasing impervious surface, channelization, loss of riparian habitat, sedimentation, fish passage barriers, flow alteration
Choptank River	present	present	seine survey, run counts	increasing impervious surface, channelization, loss of riparian habitat, sedimentation, fish passage barriers, flow alteration
Nanticoke River Watershed	present	present	commercial CPUE*, seine survey	increasing impervious surface, channelization, loss of riparian habitat, sedimentation, fish passage barriers, flow alteration
Pocomoke River Watershed	present	present	no current monitoring	increasing impervious surface, channelization, loss of riparian habitat, sedimentation, fish passage barriers, flow alteration
Susquehanna River	present	present	run counts	fish passage barriers, land conversion/development, impervious surface
Potomac River	present	present	commercial CPUE, electrofishing, seine push net survey	impervious surface, land conversion/development, invasive species**
Rappahannock River	present	present	commercial CPUE; electrofishing; trawl, anchor gill-net, seine surveys	fish passage barriers, predation from invasive catfish, water discharges, water intake, turbidity, anoxia

York River	present	present	commercial CPUE, trawl and seine surveys	fish passage barriers, low dissolved oxygen conditions, sedimentation, invasive catfish
James River	present	present	commercial CPUE; electrofishing; trawl, anchor gill-net, seine surveys	suspended sediment/turbidity, fish passage barriers on tributaries, invasive catfish, urbanization in upper watershed
Gilbert Stuart River	present	present	run counts, ocean trawl and seine surveys	fish passage barriers, water quality degradation, ocean bycatch, sedimentation, sea level rise due to climate change
Connecticut River	present	present	run counts, seine and trawl surveys	climate change, fish passage barriers, ocean bycatch, water quality and habitat degradation
Santee-Cooper River System	absent	present	commercial CPUE, run counts, electrofishing	fish passage barriers, predation, destruction of SAV*** beds
Hudson River	present	present	commercial CPUE, electrofishing, seine survey	loss of shallow water habitats, loss of habitat complexity, zebra mussels, sea level rise, urbanization, fish passage barriers
Delaware River	present	present	commercial CPUE, bottom trawl, electrofishing, seine survey	fish passage barriers, altered predator-prey dynamics, impingement and entrainment, urbanization, habitat loss, water quality degradation

*Catch Per Unit Effort
**threats are for Upper Potomac, for threats in Lower Potomac, see Rappahannock threats
***Submerged Aquatic Vegetation

Appendix D: Chesapeake Bay Workshop Attendees

Name	Organization
Mark Bryer	The Nature Conservancy
Alan Weaver	VA Dept. of Game and Island Fisheries
David O'Brien	NOAA Fisheries
Howard Weinberg	UMCES/Chesapeake Bay Trust
Jim Thompson	MD Dept. of Natural Resources
Mary Andrews	NOAA Fisheries
Nancy Butowski	MD Dept. of Natural Resources
Serena McClain	American Rivers
Matthew Ogburn	Smithsonian Environmental Research Center
Margaret McGinty	MD Dept. of Natural Resources
Jim Uphoff	MD Dept. of Natural Resources
Marek Topolski	MD Dept. of Natural Resources
Bill Goldsborough	Chesapeake Bay Foundation
Ellen Cosby	Potomac Fish and Boat Commission
Eric Hilton	Virginia Institute of Marine Science
Patricia Jackson	Jackson Associates
Catherine Schlick	George Mason University
Kim De Mutsert	George Mason University
Genine Lipkey	MD Dept. of Natural Resources
George Schuler	The Nature Conservancy
Bruce Vogt	NOAA Fisheries
Julie Devers	U.S. Fish and Wildlife Service
Michael Stang	DE Dept. of Natural Resources and Environmental Control
Marin Hawk	Atlantic States Marine Fisheries Commission
Caroly Shumway	Merrimack River Watershed Council
Erik Martin	The Nature Conservancy
Alison Bowden	The Nature Conservancy
Mari-Beth DeLucia	The Nature Conservancy
Cheri Patterson	NH Fish and Game Department
Jamie Brunkow	James River Watershed Association
Anthony Chatwin	National Fish and Wildlife Foundation
Albert Spells	U.S. Fish and Wildlife Service
Lisa Moss	U.S. Fish and Wildlife Service
Michelle Magliocca	NOAA Fisheries

Appendix E: Gilbert Stuart River Webinar Briefing Materials

Prioritizing River Herring Restoration Needs in the Narrow River Watershed
Atlantic Coastal Fish Habitat Partnership sponsored webinar

January 26, 2015 2:00 – 4:30 pm

Webinar information login: https://global.gotomeeting.com/join/119623653
Conference call line: 1-888-394-8197, passcode 222918

Agenda

Webinar objective: To develop a set of ranked "actionable" habitat focused strategies/projects to restore river herring in the Narrow River watershed.

2:00-2:15	Welcome: Introductions and logistics – *Lisa Havel*
2:15-2:30	Project background and webinar overview – *Caroly Shumway*
2:30-2:45	Current Restoration Activities – State/Federal – *John Lake/Phil Edwards/Eric Schneider*
2:45-3:00	Current NGO Restoration Activities – • Rachel Calabro – Save the Bay • Other NGO's that have updates on restoration projects
3:00-3:45	Discussion - River herring habitat needs, obstacles/ gaps, and/or research needs – *Caroly Shumway*
3:45-4:15	Discussion - Strategies and Prioritization – *Caroly Shumway*
4:15-4:30	Overview, wrap up, workshop product, adjourn – *Caroly Shumway*

Webinar Contact information:

Lisa Havel – ACFHP Coordinator - lhavel@asmfc.org
Caroly Shumway – Head of Science and Data Committee, ACFHP- caroly.shumway@gmail.com
Erik Martin – The Nature Conservancy - emartin@TNC.ORG
Cheri Patterson – ACFHP member– cheri.patterson@wildlife.nh.gov

NFWF River Herring Habitat Restoration Needs Project
Gilbert Stuart/Narrow River Watershed Webinar

C. Shumway, C. Patterson, L. Havel, E. Martin

January 26, 2015

Objective of Webinar

The objective of this webinar is to develop a set of ranked "actionable" habitat-focused strategies/projects to restore river herring in the Gilbert Stuart/Narrow River watershed in Rhode Island (RI).

Background

In 2013, The Atlantic Coast Fish Habitat Fish Habitat Partnership (ACFHP) received funding from the National Fish and Wildlife Foundation's (NFWF) to develop restoration priorities to conserve river herring in key watersheds along the Atlantic Coast, including the Gilbert Stuart/Narrow River watershed. The goal of the work is to prioritize, plan, and strategize river herring needs by convening expert working groups in the Southern New England, Mid-Atlantic, and Southeast regions, focusing on six watersheds which are a priority for NFWF: Chesapeake Bay, Hudson River, Delaware River, Santee-Cooper, Connecticut River, and the Gilbert Stuart/Narrow River.

Why were these rivers a priority? NFWF's River Herring Program and the resulting NFWF Business Plan for river herring conservation describes a comprehensive 10-year strategy to guide NFWF conservation investments to achieve a 300% increase in river herring spawning runs in key rivers along the eastern seaboard from 2008. NFWS chose watersheds with historic or current important spawning runs that have a long time-series of measurable counts.

The Rhode Island Department of Environmental Management (RIDEM) indicates the river herring fishery was closed in March 2006 (P. Edwards, personal communication, January 2015) due to low spawning run returns. River herring spawning returns have increased since 2006, but are still 1/3 to 1/2 the historical highs as recorded in the late 1990s/early 2000s (Table 1).

Table 1. River Herring Abundance, Narrow River (source: P. Edwards, RIDEM)

1998	262,315
1999	259,336
2000	290,814
2001	254,948
2002	152,056
2003	67,172
2004	15,376
2005	7,776
2006	21,744
2007	36,864
2008	58,640
2009	34,835
2010	110,287
2011	64,500
2012	107,901
2013	91,240
2014	102,408

Narrow River Watershed Specific Key Threats and Restoration Needs

THREATS:

- **Impediments to spawning habitat:**
  - **Three watershed Dams: Gilbert Stuart Dam, Shady Lea Mill Dam, and Silver Spring Lake Dam.**
    - The only dam with fish passage is the Gilbert Stuart Dam which has an Alaskan Steeppass fishway with efficiency problems.
    - River herring are attracted to the river flowing through the Mill's tailrace instead of the fish ladder. However, there may be engineering solutions to improve its efficiency
  - **Culverts at road crossings throughout the watershed.**

- **Water quality.**
  - Excess Nutrients - Water quality in the Narrow River has been documented for the past 50 years through scientific studies, monitoring by RIDEM and the Narrow River's Preservation Association's (NRPA) participation in URI's Watershed Watch program since 1991. Since 1959, Narrow River has consistently failed State standards for total coliform (bacteria) levels. Increased algal growth stimulated by high levels of nitrogen and phosphorus has been observed since the early 1970's (NRPA, 2002).
  - Turnover Events - Because the upper basins are highly stratified and very deep, and exhibit minimal overturn, they act as huge catch basins for pollutants. Substances introduced from the River's headwaters, surface runoff, and groundwater flow can be expected to remain in the basins for long periods of time. When these basins do "overturn" (mix), the effect of the turnover may be much greater due to the

accumulation of pollutants and their sudden release from the bottom waters which also causes eutrophic conditions leading to fish kills (Ernst, et al, 1999).
    - Thermal Pollution – Water temperature issues have been documented especially north of the Middle Bridge.

- **Sedimentation impacting SAV and replanting efforts.**

- **Sea Level Rise** affecting marsh loss and associated wetland benefits needed for habitat diversity.

- **Bycatch**: combined effects of increased predatory fish and birds (e.g., cormorants), recreational harvesters along with ocean fisheries bycatch.

RESTORATION POTENTIAL:

1**. Priority Dam Removals and/or improve fish passage:**
   - **Shady Lea** Mill Dam - removing this dam will provide fish passage 0.5 miles upstream to next impoundment, and will open up 2 acres of habitat following dam removal. There is some amount of sediment behind Shady Lea Dam some of which will need to be removed.
   - **Silver Spring Lake Dam**- provide fish passage (either add fishway or remove dam); 18.35 acres of spawning habitat would open following dam removal.
   - **Gilbert Stuart Dam**: address fish diversion issues.

2. Improve water quality: In part may be accomplished through dam removal, ultimately improving thermal pollution, allowing for appropriate sediment transport, and reduce eutrophic water conditions. Addition improvements to consider are eliminating non-point pollution sources and build and maintain appropriate storm drain systems.

3. Improve road crossing culverts to allow for effective fish passage.

4. Other? – Such as impervious surface concerns, etc.

General Threats to River Herring

NOAA Listing Determination and ASMFC 2012 Stock Assessment

In 2013, NOAA Fisheries (NMFS) completed a comprehensive review of the status of river herring (alewife and blueback herring) in response to a petition to list river herring as threatened under the Endangered Species Act. Much of the assessment was based on the Atlantic States Marine Fisheries Commission's (ASMFC) 2012 stock assessment which listed river herring as "depleted" throughout its range. Although NOAA Fisheries determined that listing was unwarranted at the time, the determination notice noted that both species were at low abundances and there were uncertainties with the data. The notice also included language from Amendment 2 to the *Interstate Fishery Management Plan for Shad and River Herring*, (ASMFC, 2009).

The full notice is at: http://www.nero.noaa.gov/stories/2013/riverherringlistingfrnotice.pdf

NOAA Fisheries considered numerous threats impacting river herring; several related to habitat. They ranked threats range-wide and regionally as determined by the Status Review Team (SRT). Threats were ranked as High to Moderately High (H) and Moderate to Moderately Low (M). The most important threats impacting river herring habitat (all stock complexes) are summarized below, with select passages noted with italics.

- Dams and Other Barriers (H) - *The SRT identified dams and barriers as the most important threat to alewife and blueback herring populations both range-wide and across all stock complexes.*
- Dredging (M)
- Water Quality (M)
- Water Withdrawal/Outfall (M)
- Wetland Alterations (M)
- Climate Change and Climate Variability (M)

Dams and Other Barriers

Dams and other man-made barriers have contributed to the historical and current declines in abundance of both blueback and alewife populations...result[ing] in significant losses of historical spawning habitat for river herring. They...block or impede access to habitats necessary for spawning and rearing; can cause direct and indirect mortality from injuries incurred while passing over dams, through downstream [fish] *passage facilities, or through hydropower turbines; and can degrade habitat features necessary to support essential river herring life history functions.*

Dredging

Amendment 2 noted the following dredging impacts: *Channelization can cause significant environmental impacts (Simpson et al., 1982; Brookes, 1988), including bank erosion, elevated water velocity, reduced habitat diversity, increased drainage, and poor water quality...through the release of contaminants…resulting in bioaccumulation, direct toxicity to aquatic organisms, or reduced dissolved oxygen levels (Hubbard, 1993; Morton, 1977). Disposal of spoils along the shoreline can also [impact habitat by blocking] access to sloughs, pools, adjacent vegetated areas, and backwater swamps (Frankensteen, 1976). Spoil banks are often unsuitable habitat; …it is too unstable. Suitable habitat is often lost when dredge disposal material is placed on natural sand bars and/or point bars.*

Water Quality

The NOAA Fisheries report highlighted primarily nutrient impacts to water quality, but water quality is impacted by land use patterns and increasing amounts of impervious surfaces which can impact river herring in a multitude of ways as described below. The report notes some of these impacts in other sections. Amendment 2 identified land use changes including agriculture, logging/forestry, urbanization and non-point source pollution as threats to river herring habitat… *careless land use practices may lead to erosion, which can lead to high concentrations of suspended solids (turbidity) and substrate (siltation) in the water following rainfall events. This can displace larvae and juveniles to less desirable areas downstream and cause osmotic stress (Klauda et al., 1991b; ASMFC, 2009).*

% Impervious cover in watershed

- When impervious cover increases above 5-7%, there is a corresponding drop of approximately 50% in water quality, macroinvertebrate abundance, and fish habitat quality. The greatest impact is within riparian buffers (Schiff and Benoit, 2007).

- When impervious cover levels are at 5%; the number of alewife eggs and larvae are reduced by 50%; at 10% impervious cover, there is close to total mortality of eggs and larvae (Limburg & Schmidt, 1990).

Nutrient enrichment (NO_4, PO_4)

- Construction has been shown nationally to be the second biggest source of nutrients after farming (NRC, 2009); other primary nutrient sources can come from aging wastewater treatment plants and septic systems. Excessive nutrients stimulate excessive algal growth that consumes oxygen when it decays. Low dissolved oxygen levels can cause fish kill*s* (e.g., Klauda et al., 1991b). Fish eggs and larvae are particularly susceptible to poor water quality conditions (Hunter, 1984).

Turbidity due to Sediment Loading (also caused by dredging)

- Fish behaviorally avoid areas of high turbidity due to sediment suspension (ASMFC, 2009, Reine et al., 1998).
- Sediment suspension can impact respiration for filter-feeding fish such as alosines by collecting on gill tissues and clogging gills, resulting in lethal and sublethal effects to fish (Cronin et al., 1970), Sherk et al., 1974, 1975; ASMFC, 2009).
- Sediment suspension also impacts feeding behavior due to increased turbidity, significant for river herring (Kosa and Mather, 2001). Size selective predators such as blueback herring feed visually, and increased turbidity can impact the ability to locate food along with physiological consequences (Burbridge, 2011).
- River herring behaviorally emigrated from rearing pond when blue-green algae bloom occurred, (Yako, 1998).
- Transparency can impact reproductive behavior resulting in developmental issues and even mortality of eggs and larvae (Kosa and Mather, 2001).

Impacts to River Herring Food Sources

- Change in water flow can impact zooplankton biomass, a river herring food source. Zooplankton biomass significantly correlated with water residence time (Basu and Pick 1996).
- Channelization and siltation reduces quality of habitat for aquatic macroinvertebrate larvae (Iwata et al. 2003; Baxter et al., 2005). As stream banks erode, the mix of coarse and fine sediment decreases the median size... of sedimentary bed material and makes them more mobile thereby making benthic habitats less suitable for insect larvae living in the interstices.
- Loss of riparian vegetation results in fewer terrestrial insects for fish to feed upon. Terrestrial insects can provide from 15-50% of the energy budget for filter-feeding fishes, especially important in late spring/summer (Baxter et al., 2005). Known to be important for clupeids, at least (Massman, 1963) in Virginia streams. More important upstream than downstream.

pH changes (also caused by acid rain)

- Acidic episodes (pH of 5.5-7.4) may be an important cause of early stage mortality for fish that spawn in poorly buffered habitats (Klauda and Palmer, 1987; Kosa and Mather, 2001).

Change in water flow

- Low flow reduced use of spawning habitat in blueback herring and alewife, North Carolina (Walsh et al., 2011), and impacted larval American shad (Crecco and Savoy, 2011).

Temperature

- Larval American shad impacted by rising river temperatures (Crecco and Savoy, 2011).

Water Withdrawal impacting Streamflow

Amendment 2 noted: *Large volume water withdrawals (e.g., drinking water, pumped-storage hydroelectric projects, irrigation, and snow-making) can alter local current characteristics, which can result in delayed movement past a facility or entrainment in water intakes (Layzer and O'Leary, 1978). The physical characteristics of streams (e.g., stream width, depth, and current velocity; substrate; and temperature) can be altered by water withdrawals (Zale et al., 1993). Reduced streamflow can reduce water quality by concentrating pollutants and/or increasing water temperature (ASMFC, 1985)… and decrease the quantity of both spawning and nursery habitats. Fish impinged against water filtration screens can die from asphyxiation, exhaustion,… removal of protective mucous, and descaling (DBC, 1980).*

Toxic and thermal point source discharges

Amendment 2 noted: *Industrial discharges may contain toxic chemicals, such as heavy metals and various organic chemicals (e.g., insecticides, solvents, herbicides) (ASMFC, 1999). In addition, pulp mill effluent and other oxygen-consuming wastes discharged into rivers and streams can reduce dissolved oxygen concentrations below what is required for river herring survival and… can also delay or prevent upstream and downstream migrations. Thermal effluent from power plants outside these temperature ranges* [defined in the notice] *when river herring are present can disrupt schooling behavior, cause disorientation, and may result in death. Sewage can directly and indirectly affect anadromous fish.*

Cumulative/Synergistic effects

NOAA Fisheries noted: *The combination of incremental losses of wetland habitat, changes in hydrology, and nutrient and chemical inputs produced over time can be extremely harmful to river herring, resulting in diseases and declines in the abundance and quality of the affected resources.*

Wetland loss

Wetlands provide migratory corridors and spawning habitat for river herring. Wetland lass is a cumulative impact… result[ing] from activities related to dredging/dredge spoil placement, port development, marinas, solid waste disposal, ocean disposal, and marine mining.

Climate Change and Climate Variability

Climatic change can synergistically impact other stressors, including stormwater runoff and temperature. In addition, *… changes in the amount of preferred habitat and a potential northward shift in distribution as a result of climate change may affect river herring in the future, for example in the years from 2020 through 2100 (Nye et al., 2012).*

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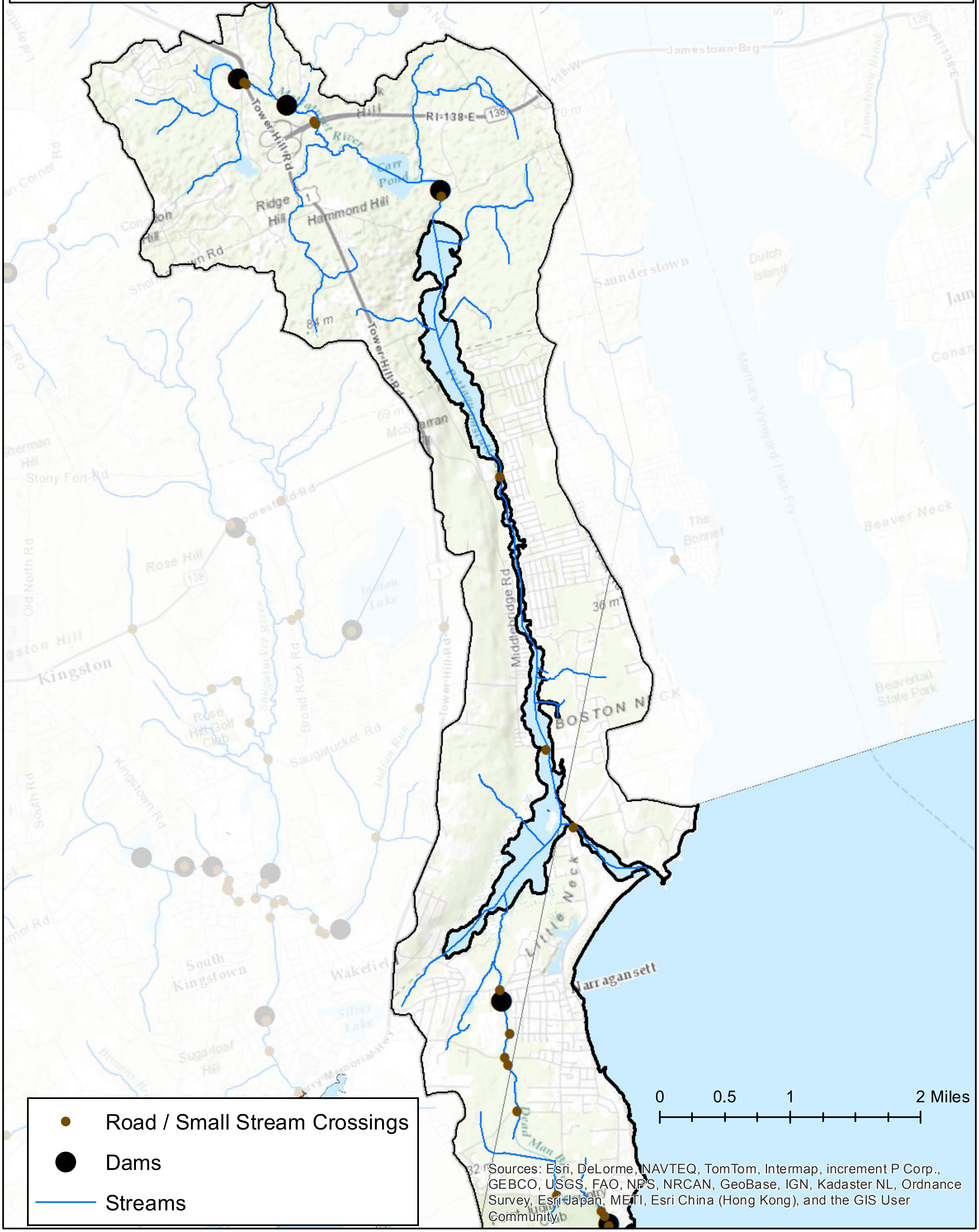
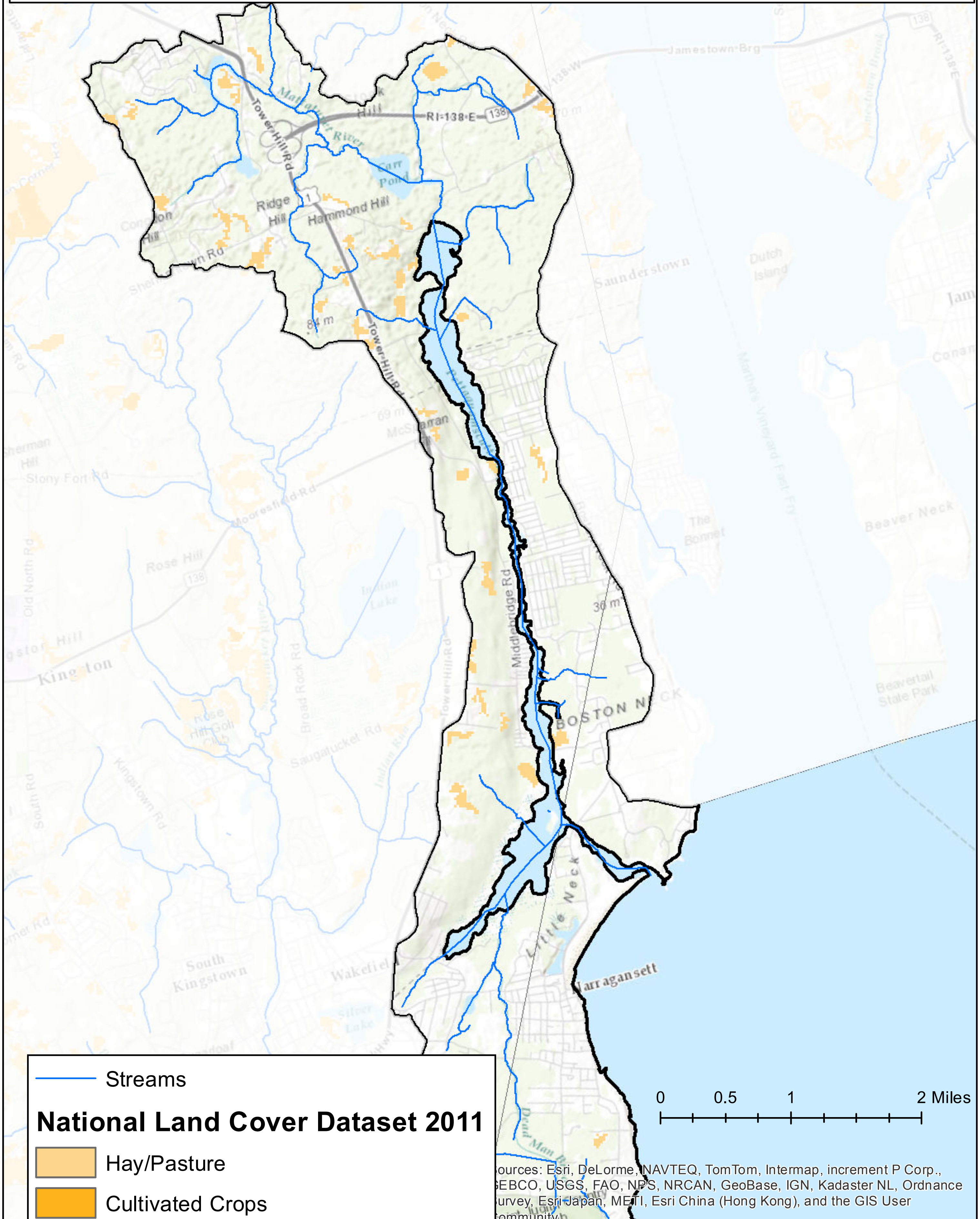
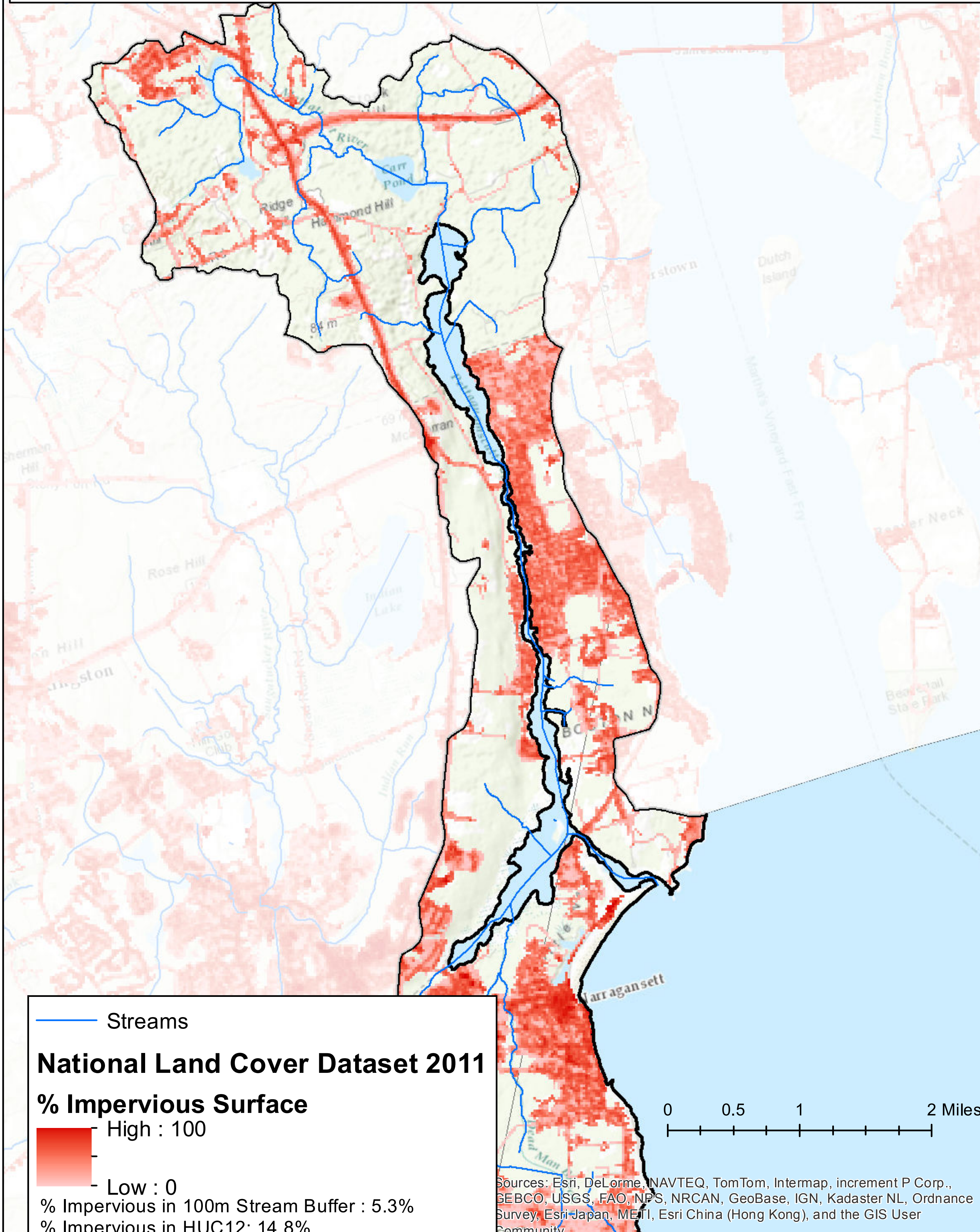
Gilbert Stuart / Narrow River: Dams and Road / Small Stream Crossings



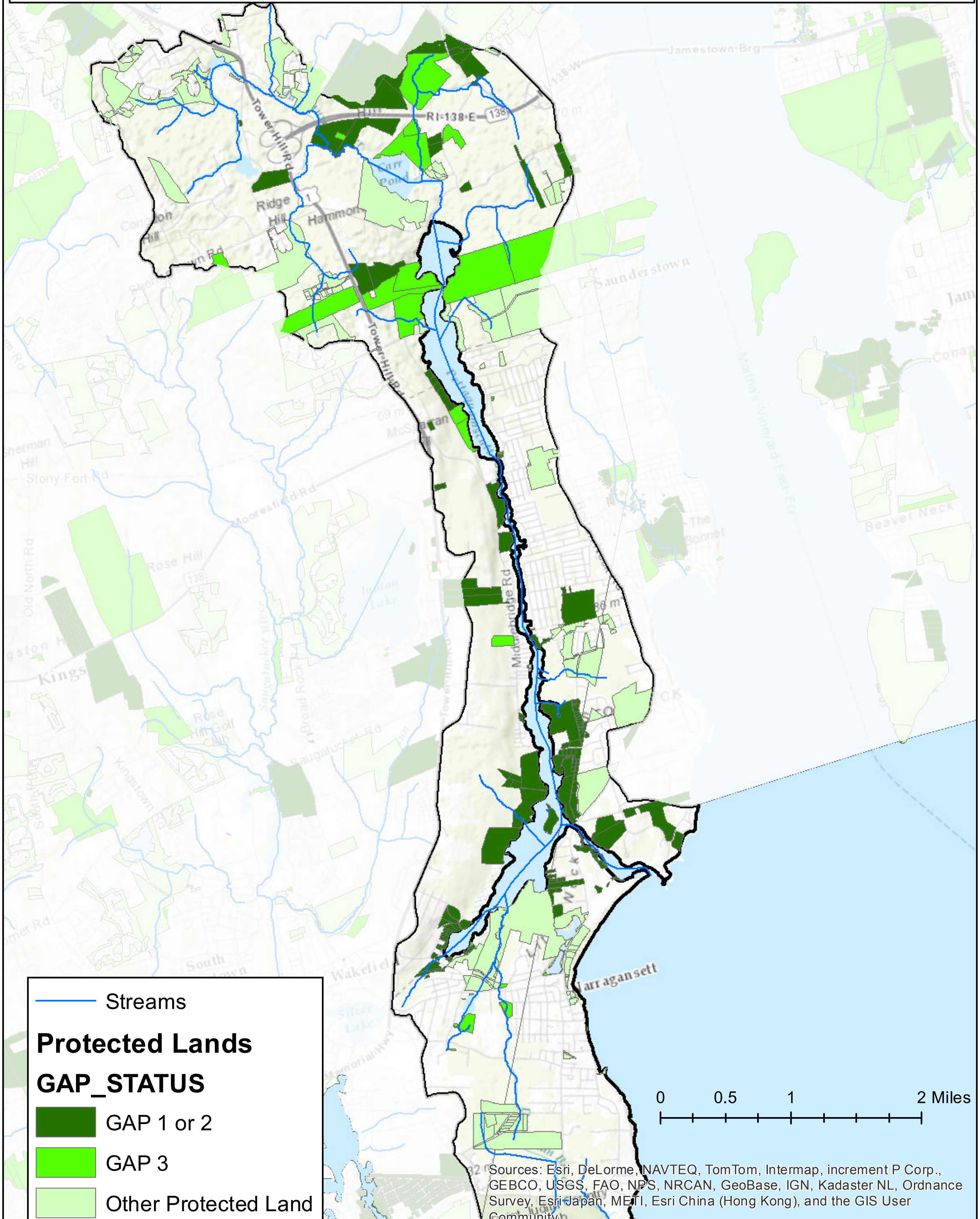
Gilbert Stuart / Narrow River: Agricultural Land Cover



Gilbert Stuart / Narrow River: Impervious Surface



Gilbert Stuart / Narrow River: Protected Lands



Appendix F: Gilbert Stuart River Webinar Attendees

Name	Organization
Alisa Richardson	RI Department of Environmental Management-Office of Water Resources
Tom Ardito	Center for Ecosystem Restoration
John O'Brien	The Nature Conservancy
Steven Brown	The Nature Conservancy
Jim Turenne	USDA-Natural Resources Conservation Service
Susan Adamowicz	U.S. Fish and Wildlife Service
Wenley Ferguson	Save the Bay
Caitlin Chaffee	RI Coastal Resources Management Council
Juancarlos Giese	U.S. Fish and Wildlife Service
Laura Myerson	University of Rhode Island
Dave Reis	RI Coastal Resources Management Council
Jim Turek	NOAA Fisheries Restoration Center
Terry Sullivan	The Nature Conservancy
John Lake	RI Division of Fish and Wildlife
Rhonda Smith	U.S. Fish and Wildlife Service
Janet Freedman	RI Coastal Resources Management Council
Suzanne Paton	U.S. Fish and Wildlife Service
Cathy Wigand	U.S. Environmental Protection Agency
Todd Randall	U.S. Army Corps of Engineers
John Winkelman	U.S. Army Corps of Engineers
Larry Oliver	U.S. Army Corps of Engineers
Phil Edwards	RI Division of Fish and Wildlife
Charlie Vandemoer	U.S. Fish and Wildlife Service
Scott Ruhren	Audubon Society of Rhode Island
Sue Tuxbury	NOAA Fisheries Habitat Conservation Division
Jon Boothroyd	University of Rhode Island
Patty Kusmierski	U.S. Fish and Wildlife Service
Kevin Ruddock	The Nature Conservancy
Beth Watson	U.S. Environmental Protection Agency

FIGURES

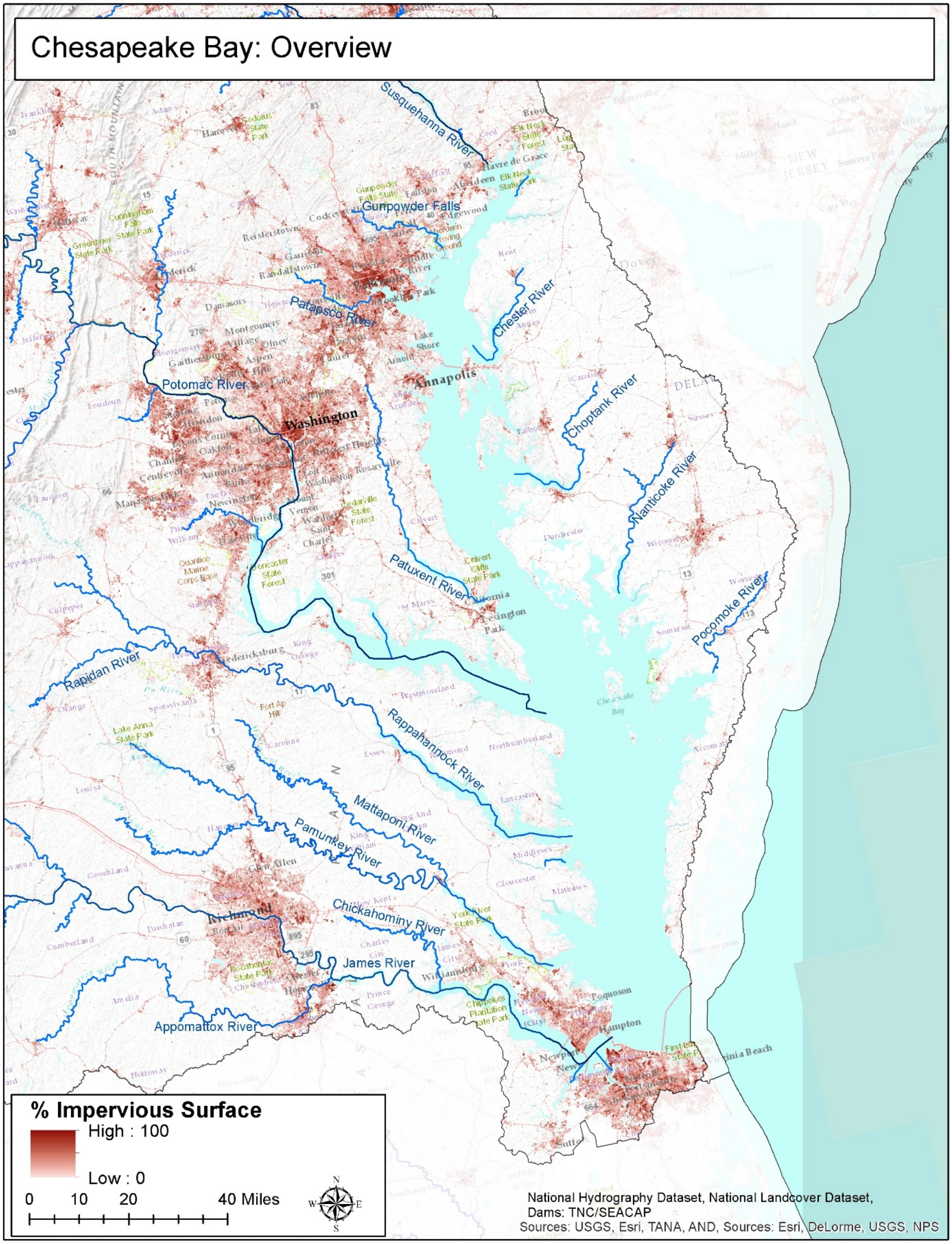


Figure 1. Major rivers and tributaries and impervious surface coverage of the Chesapeake Bay.

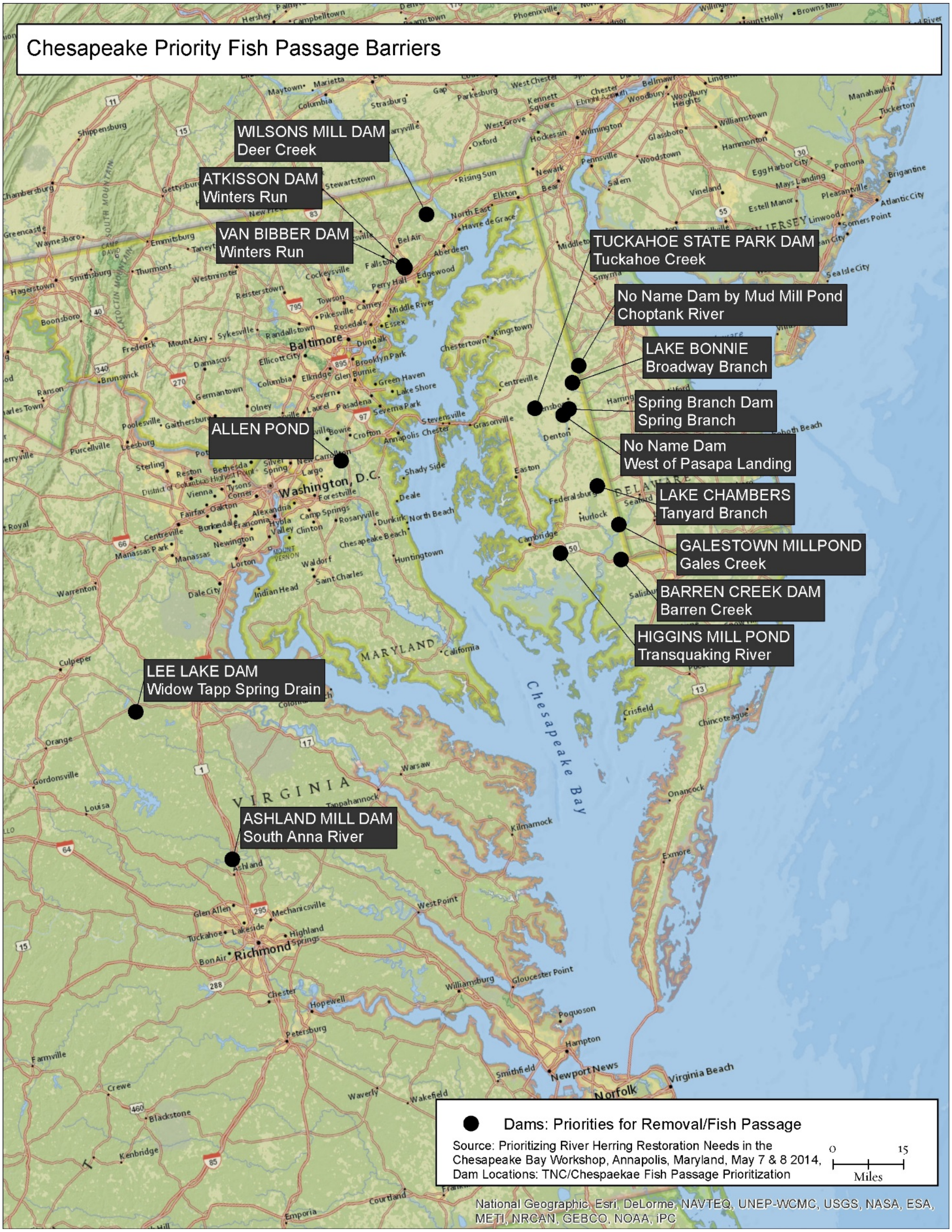


Figure 2. Priority fish passage barriers for the Chesapeake Bay.

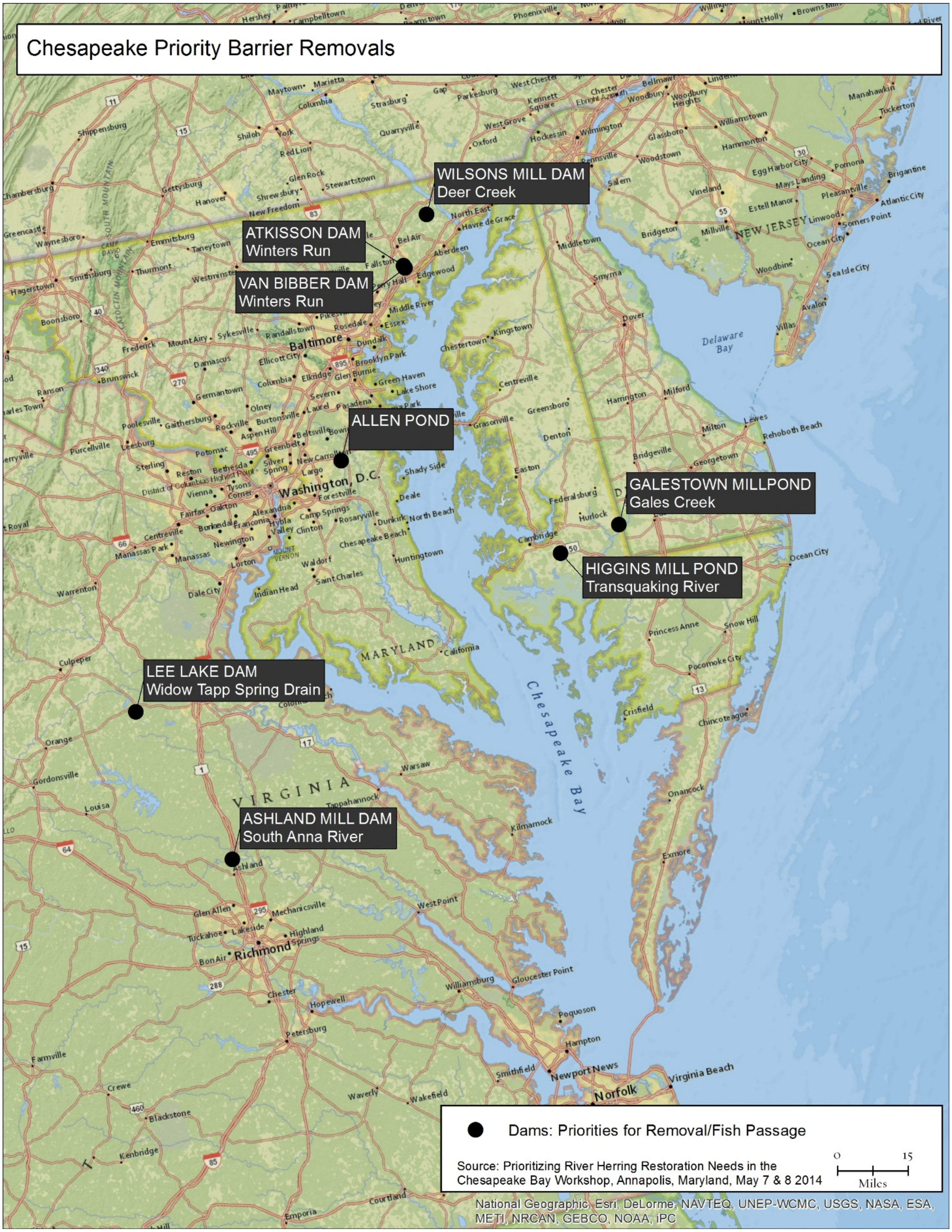


Figure 3. Priority barriers for removal on the Chesapeake Bay.

Figure 4. Priority HUC12 regions for land conservation and restoration in the Chesapeake Bay.

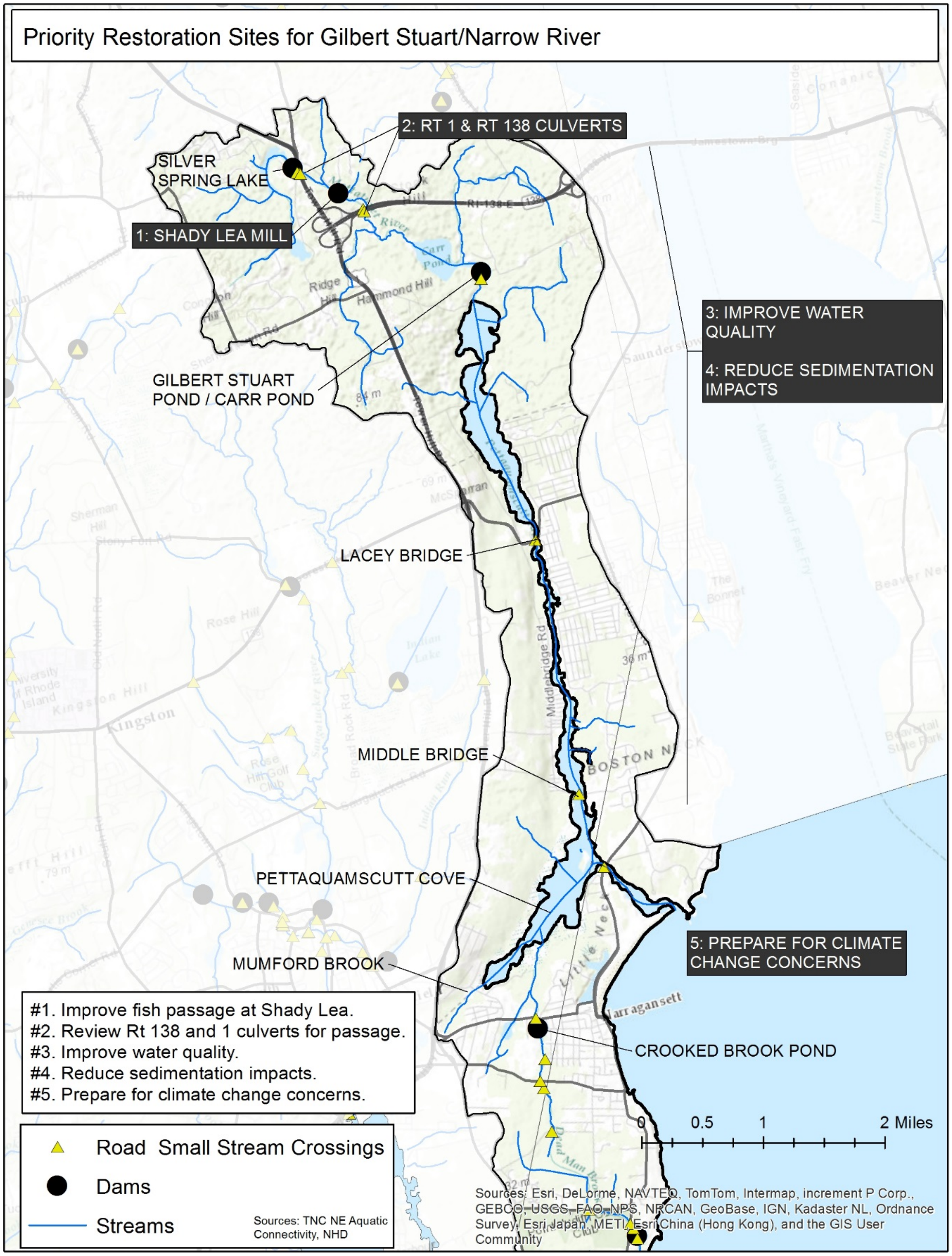


Figure 5. Barriers to fish passage and restoration priorities for the Gilbert Stuart River.

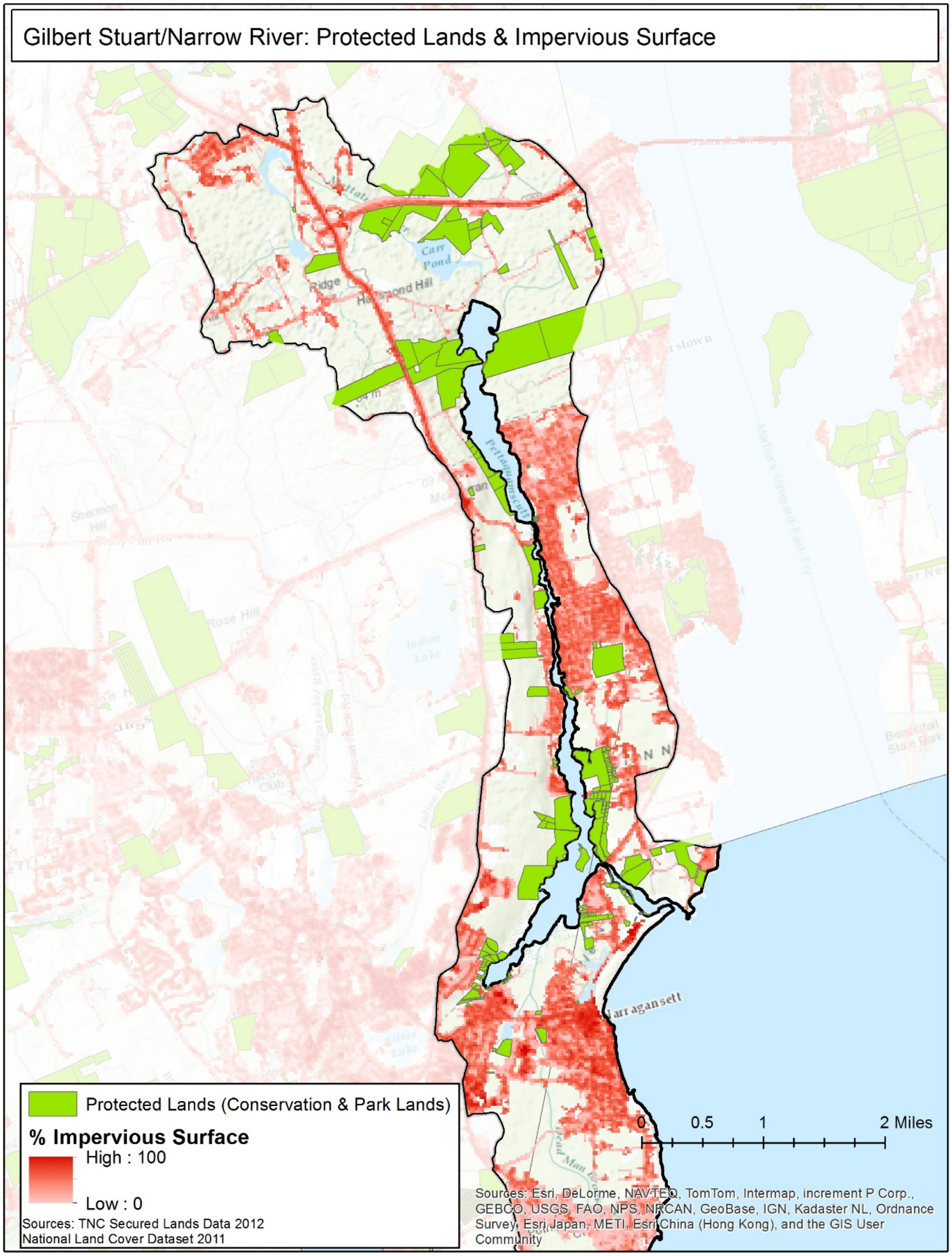


Figure 6. Protected lands and impervious surface along the Gilbert Stuart River.

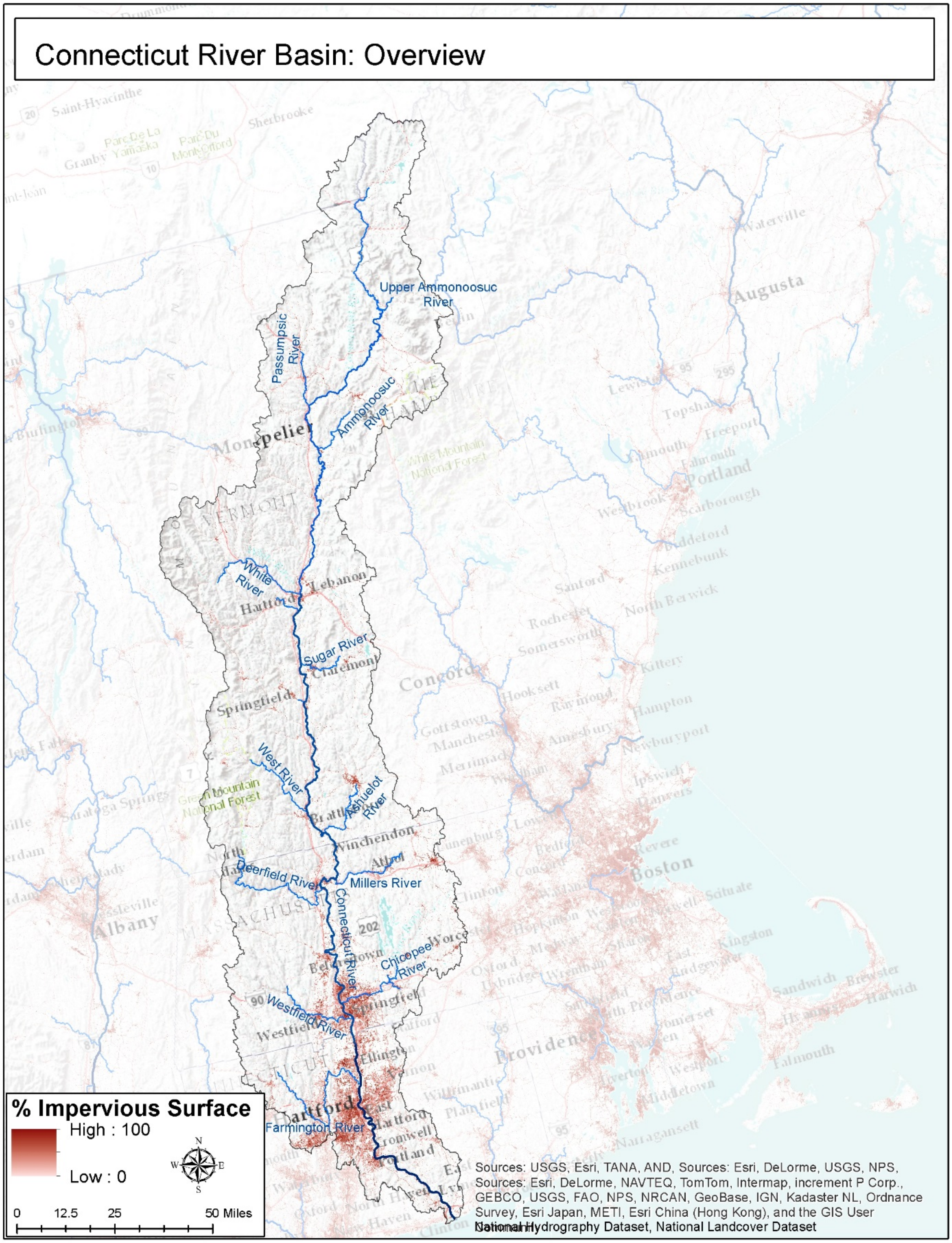


Figure 7. Overview of the Connecticut River Basin, with impervious surface.

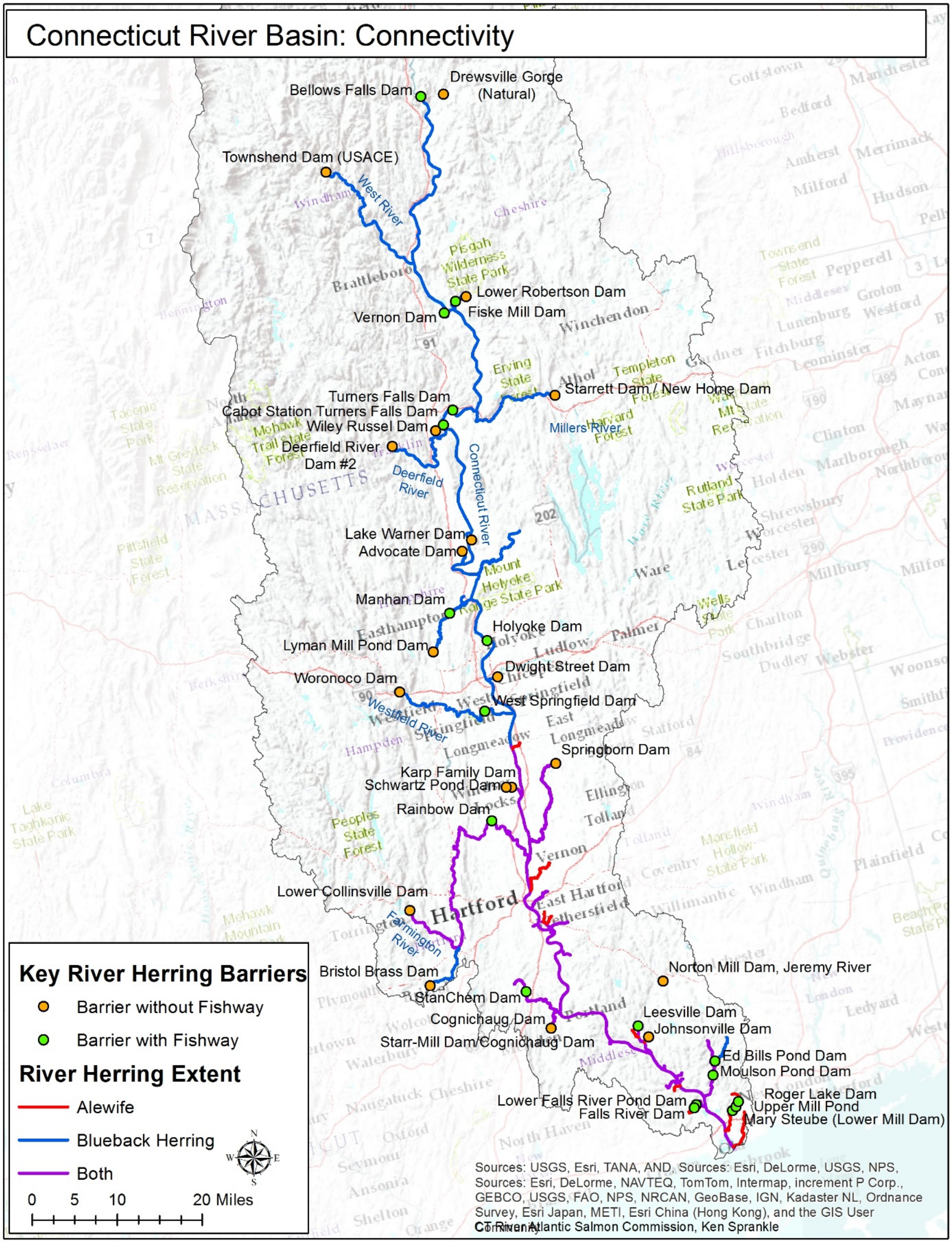


Figure 8. Connecticut River barriers and extent of river herring.

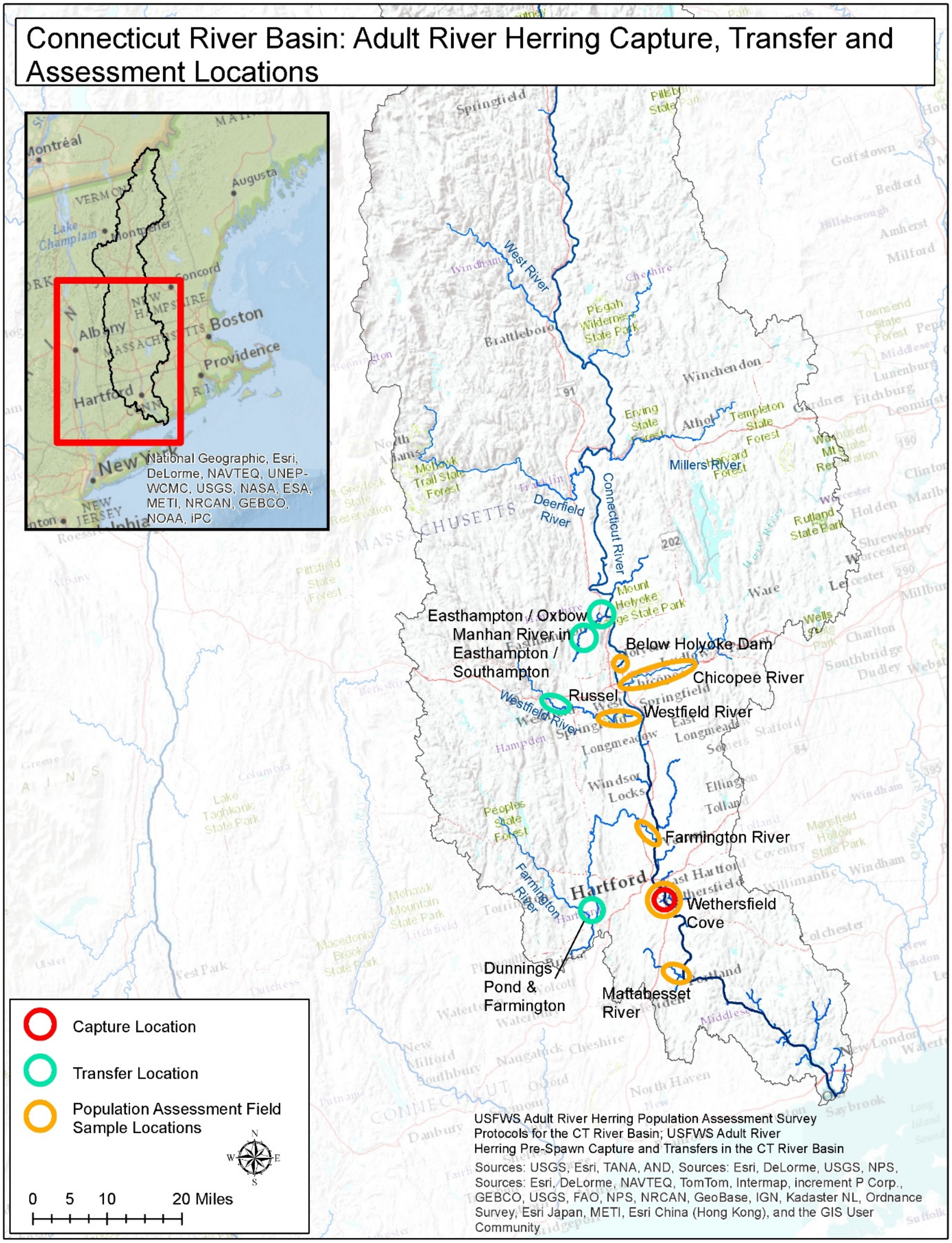


Figure 9. Adult river herring capture, transfer and assessment locations in the Connecticut River.

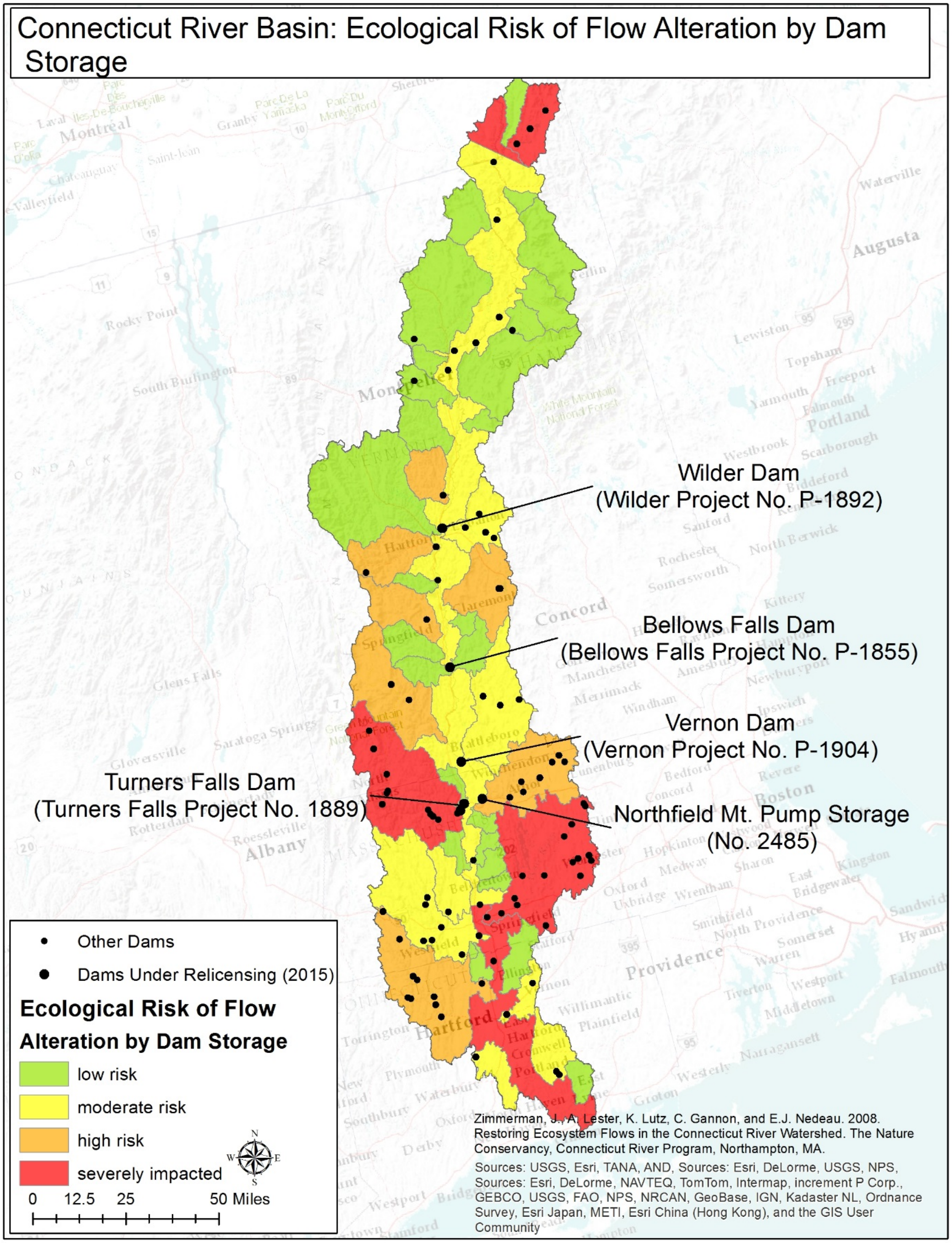


Figure 10. Ecological risk of flow alteration by dam storage in the Connecticut River.

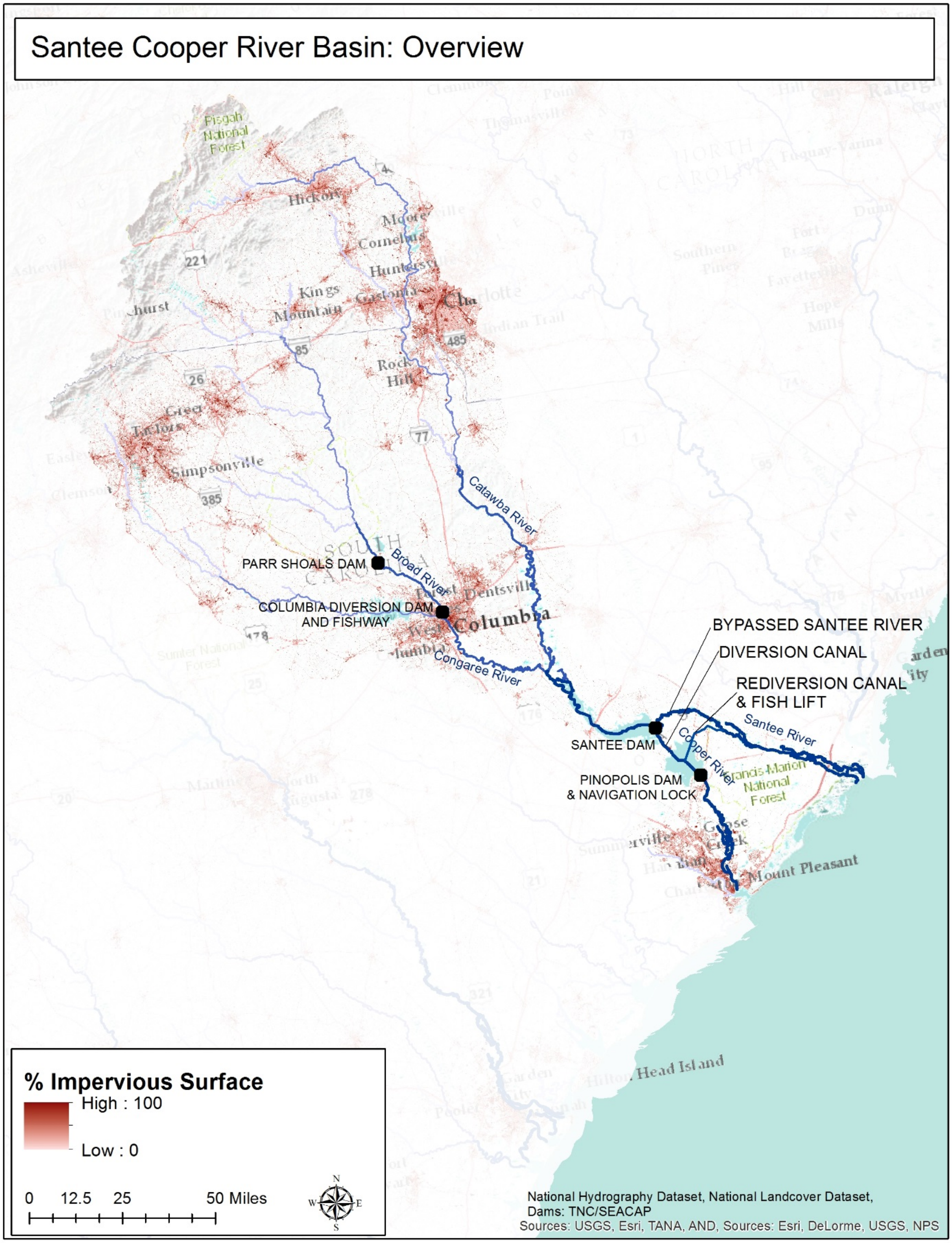


Figure 11. Overview of the Santee-Cooper River Basin, including dams and impervious surface cover.

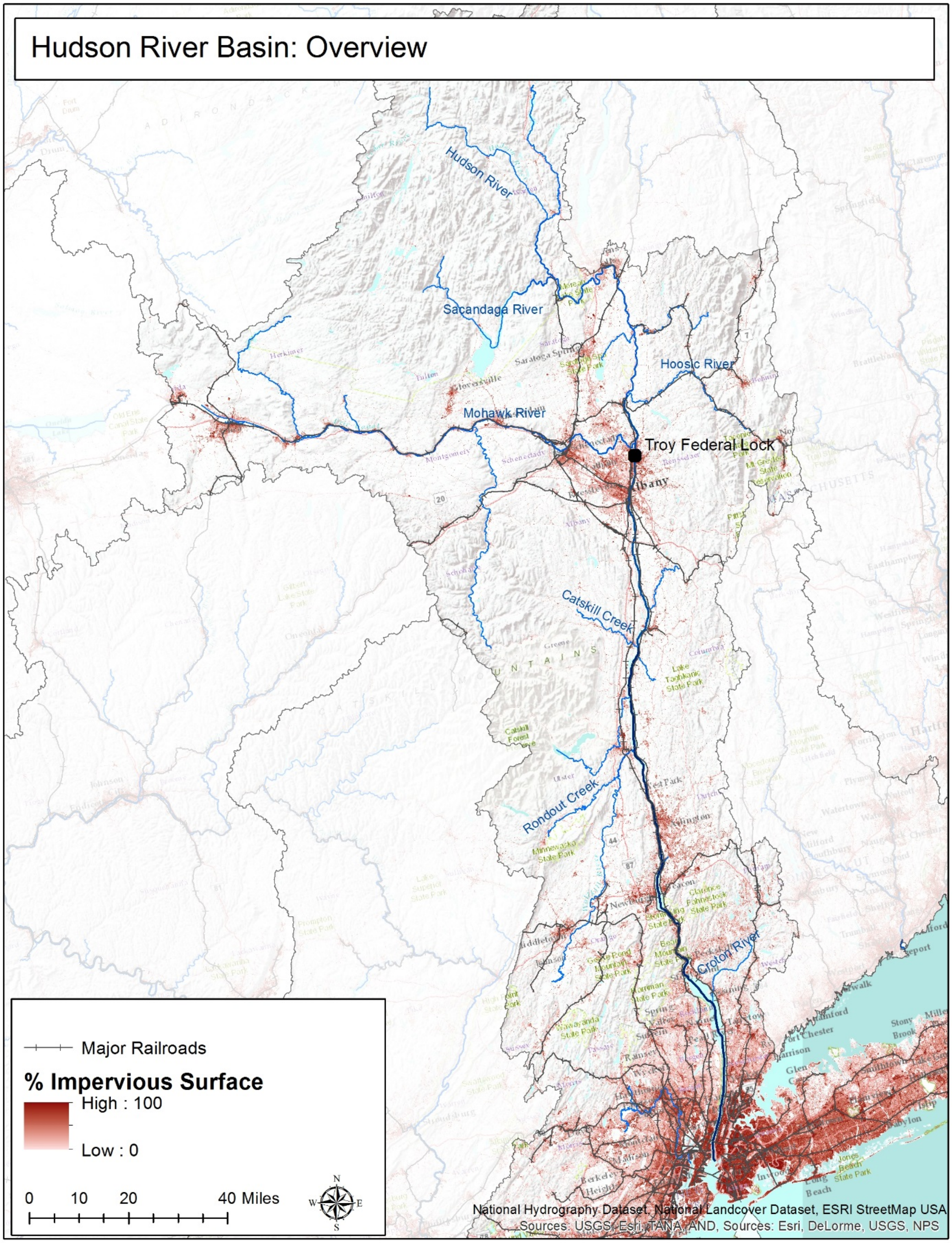


Figure 12. Overview of the Hudson River basin with impervious surface cover.

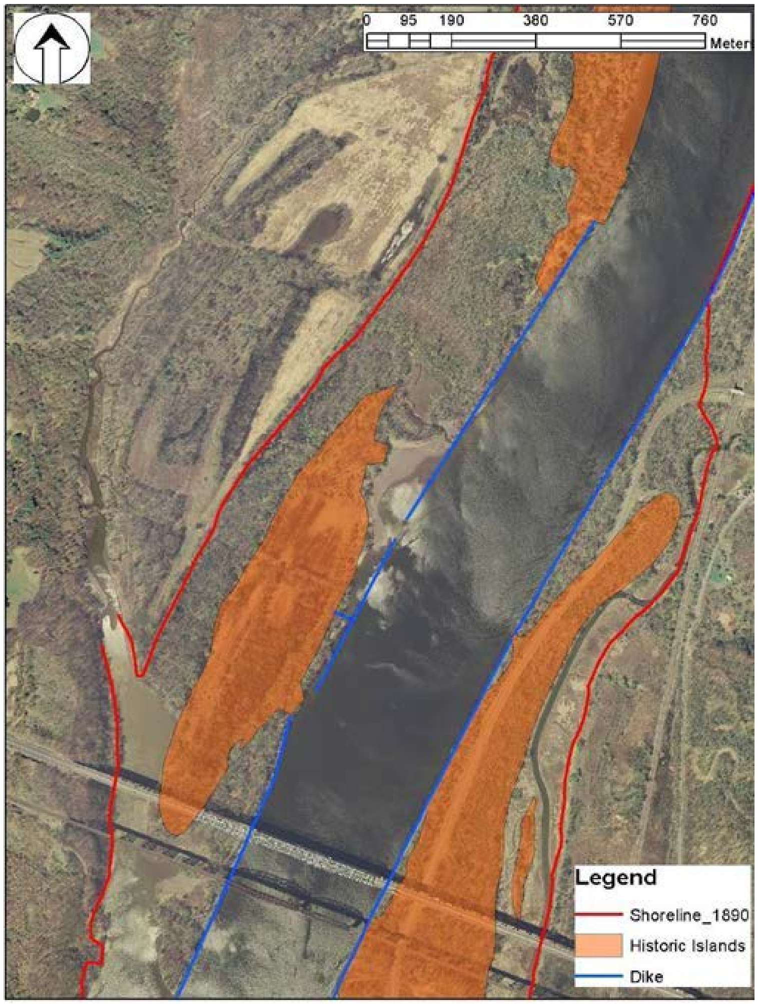


Figure 13. Historic and current shorelines of the Hudson River. Photo courtesy of New York State Department of Environmental Conservation.

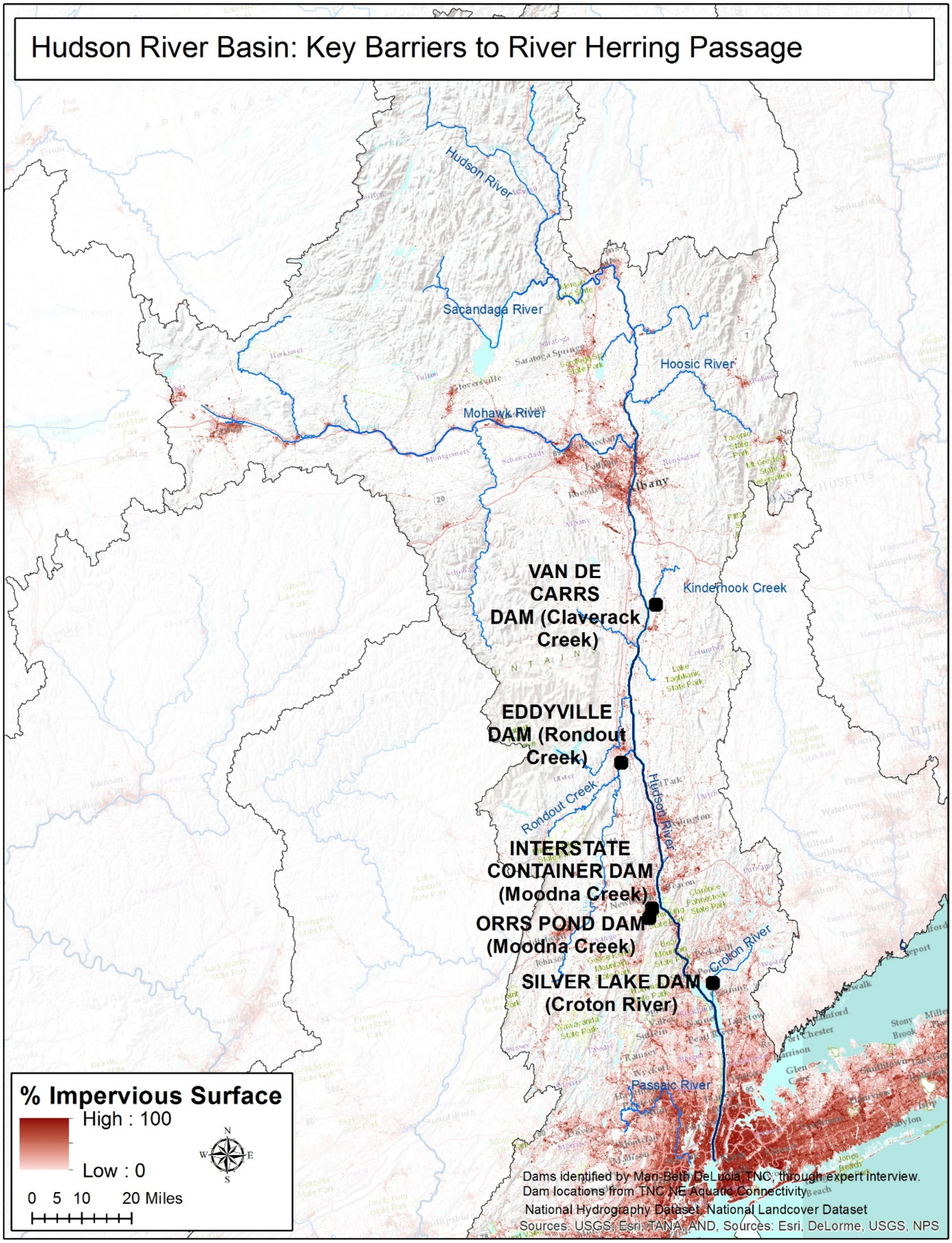


Figure 14. Key barriers to river herring passage on the Hudson River.

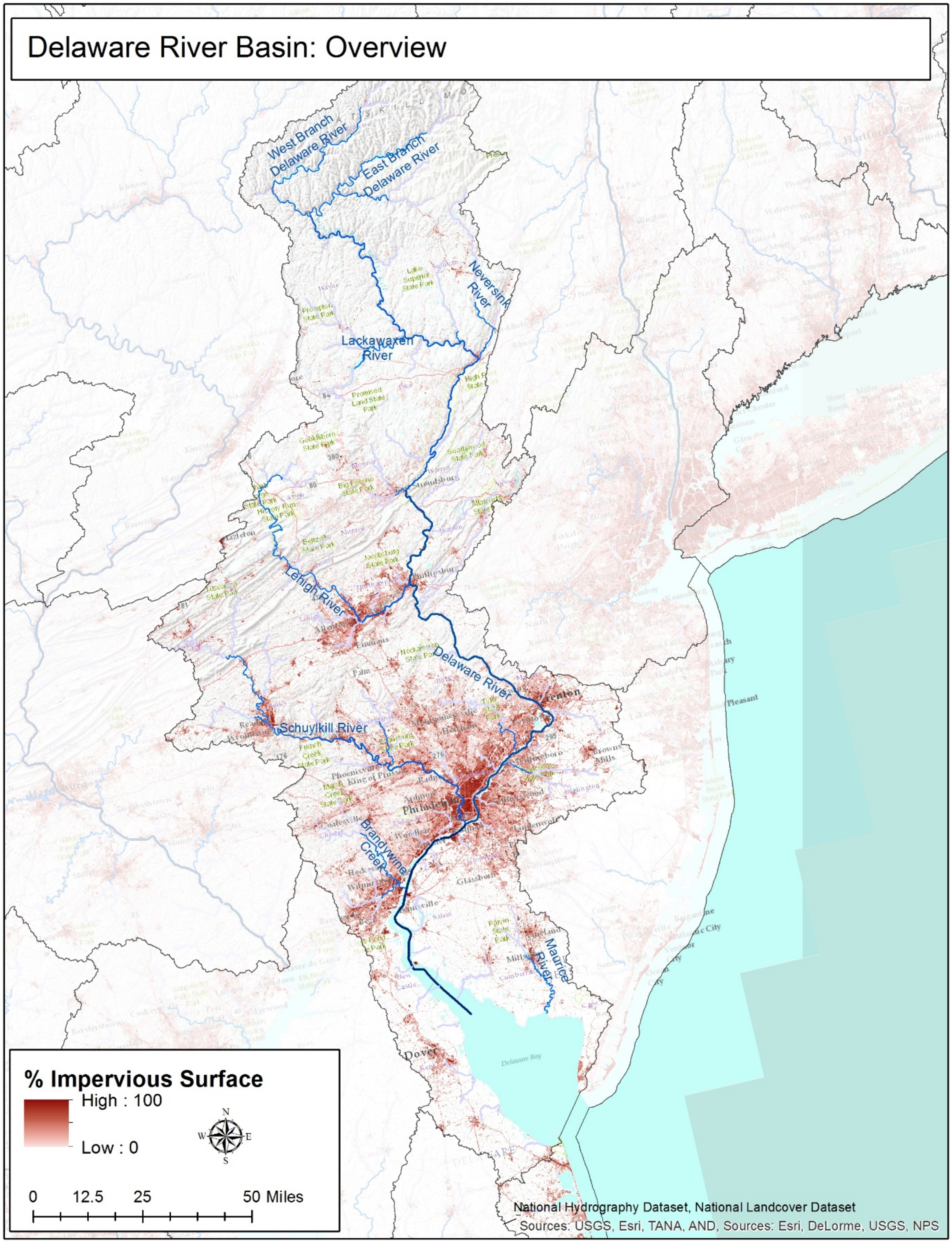


Figure 15. Overview of the Delaware River Basin, with impervious surface cover.

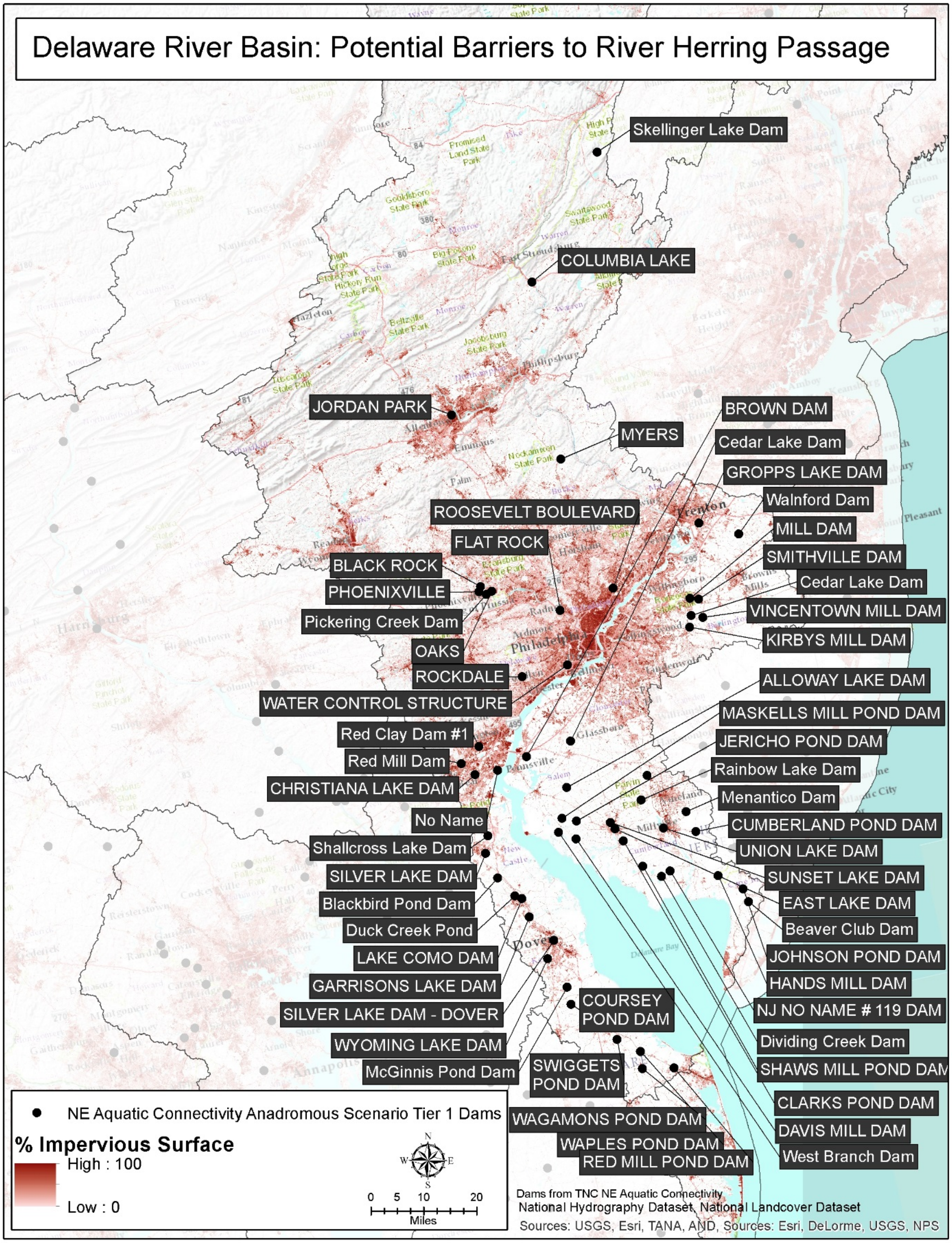


Figure 16. Potential barriers to river herring passage in the Delaware River basin, with impervious surface cover.

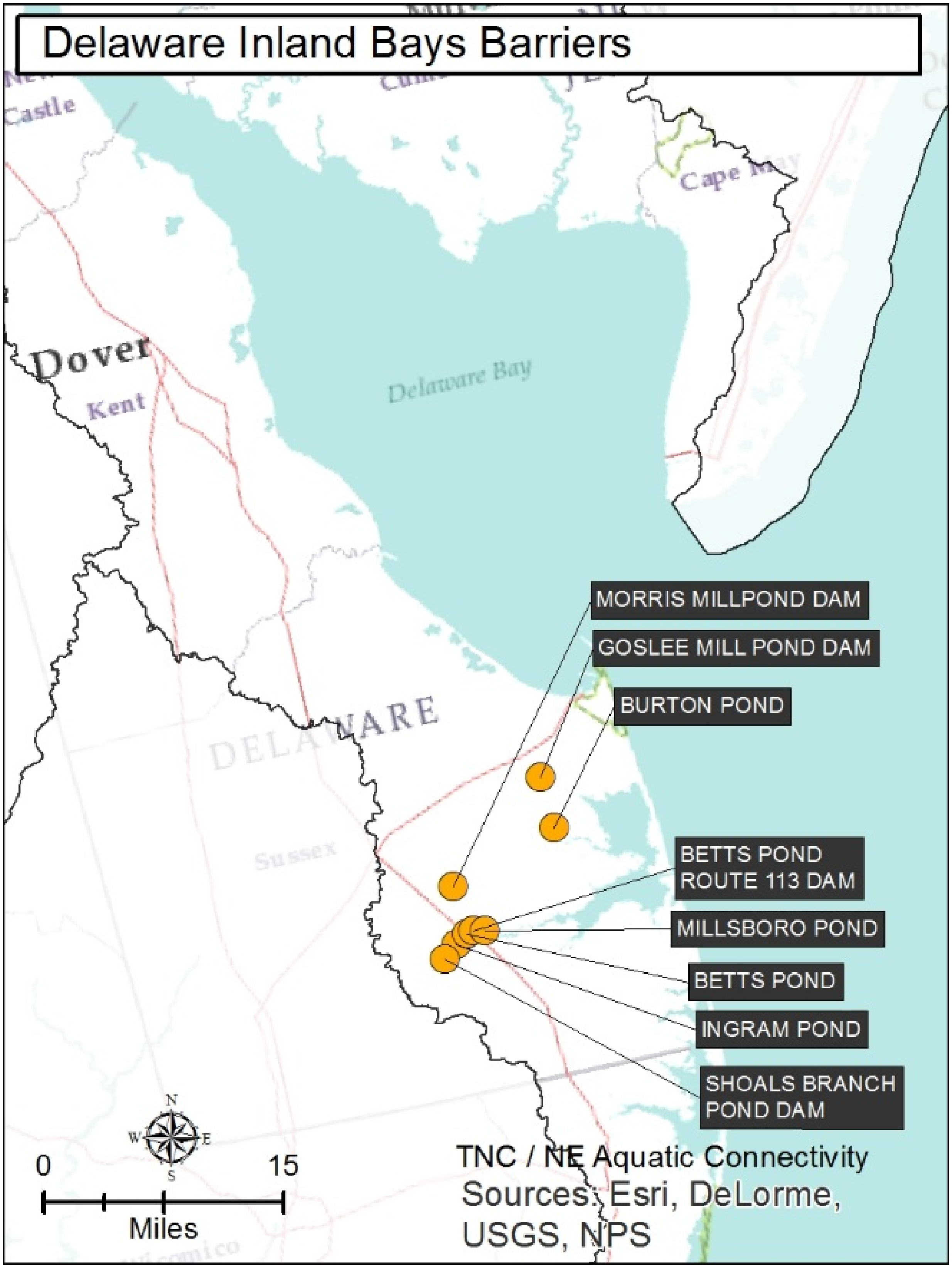


Figure 17. Inland Bay barriers for the Delaware River watershed.