STATE OF MAINE
DEPARTMENT OF MARINE RESOURCES
21 STATE HOUSE STATION
AUGUSTA, MAINE
04333-0021

JANET T. MILLS
GOVERNOR

PATRICK C. KELIHER
COMMISSIONER

June 18, 2021

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

RE: NOTICE OF APPLICATION ACCEPTED FOR FILING, SOLICITING MOTIONS TO INTERVENE AND PROTESTS, READY FOR ENVIRONMENTAL ANALYSIS, AND SOLICITING COMMENTS, RECOMMENDATIONS, PRELIMINARY TERMS AND CONDITIONS, AND PRELIMINARY FISHWAY PRESCRIPTIONS Pejepscot Hydroelectric Project (FERC No. 4784-106)

Dear Secretary Bose:

This is the response of the Maine Department of Marine Resources (MDMR) to the Federal Energy Regulatory Commission's Notice of Application Accepted for Filing, Soliciting Motions to Intervene and Protests, Ready for Environmental Analysis and Soliciting Comments, Recommendations, Preliminary Terms and Conditions, and Preliminary Fishway Prescriptions, issued on April 19, 2021 for the Pejepscot Hydroelectric Project (FERC No. 4784-106). The Pejepscot Project ("Project") is located on the Androscoggin River in Sagadahoc, Cumberland, and Androscoggin Counties in the village of Pejepscot and the town of Topsham, Maine. The Final License Application (FLA) was filed on August 31, 2020. In response to the public notice, MDMR submits its comments, recommendations, and preliminary terms and conditions for the Project pursuant to section 10(j) of the Federal Power Act (FPA).

If you have any questions, please contact Gail Wippelhauser at gail.wippelhauser@maine.gov or Casey Clark at casey.clark@maine.gov.

Sincerely,

Patrick C. Keliher, Commissioner

cc: Sean Ledwin, Paul Christman, Michael Brown, MDMR
John Perry, James Pellerin, DIFW
Kathy Howatt, DEP
Corbin Hilling, USFWS
William McDavitt, Bjorn Lake, NMFS

1 Contents

1.0 Introduction

The MDMR is concerned with the Project's continuing direct and indirect effects on diadromous fishes in and around the Project area. Below, we provide our preliminary comments, recommendations, and terms and conditions for the protection of, mitigation of damages to, and enhancement of fish resources pursuant to Section 10(j) of the Federal Power Act. These are based, in part, on MDMR's goals and objectives for the Androscoggin River, the results of studies performed during the licensing process and filed with the Commission by Topsham Hydro Partners Limited Partnership (L.P.) or incorporated into the license application, and consultation with the state and federal resource agencies.

1.1 MDMR statutory authority

MDMR is a cabinet level agency of the State of Maine. MDMR was established to regulate, conserve, and develop marine, estuarine, and diadromous fish resources; to conduct and sponsor scientific research; to promote and develop marine coastal industries; to advise and cooperate with state, local, and federal officials concerning activities in coastal waters; and to implement, administer, and enforce the laws and regulations necessary for these purposes. MDMR is the lead state agency in the restoration and management of diadromous (anadromous and catadromous) species of fishes.

The MDMR has been an active participant throughout the licensing process. In 2017, the MDMR provided written comments on the Pre-Application Document (PAD), and submitted three study requests. In 2021, the MDMR provided written comments on the Draft License Application. In addition, we have participated in several meetings and conference calls with the Licensee to discuss study plans and study results.

2.0 Goals and objectives for the Androscoggin River

MDMR's goal is to restore Maine's native diadromous fishes to their historic habitat. Restoration of diadromous species in the Androscoggin River is guided primarily by the Draft Fisheries Management Plan for the Lower Androscoggin River, Little Androscoggin River and Sabattus River ("Fisheries Management Plan"; MDMR and MDIFW 2017). The Fisheries Management Plan incorporates the goals and objectives of various state and interstate fisheries management plans and relevant Addenda (ASMFC 1985; ASMFC 1988; ASMFC 2000).

2.1 Target species and specific management goals

All of Maine's native diadromous species are found in the Androscoggin River system, but only American Shad, Alewife, Blueback Herring, Atlantic Salmon, Sea Lamprey, and American Eel (the "target species") occur within the Pejepscot Project boundaries.

Our first management objective is to maximize the production of anadromous Alewife, Blueback Herring, American Shad, Atlantic Salmon, and Sea Lamprey by providing access to and from historical spawning and rearing habitat in the watershed through safe, timely, and effective

upstream and downstream passage at barriers. We estimate that, once accessible, habitat within the lower Androscoggin River[1] would annually produce:
817,100-1,390,800 adult Alewife (Phase 1 habitat[2] only),
1,234,000 adult Blueback herring,
204,020 adult American Shad,
11, 378 adult Atlantic Salmon, and
an unknown number of Sea Lamprey.

Our second management objective is to maximize the production of the catadromous American Eel by providing access to and from historical growth habitat in the watershed through safe, timely, and effective upstream and downstream passage at barriers. At this time we have no estimate for the potential abundance of American Eel.

2.2 Target passage numbers

The existing upstream fish passage facility at the Pejepscot Project (a fish lift) was designed to pass 85,000 American Shad and 1,000,000 river herring (Alewife and Blueback Herring combined). These population estimates were developed in the 1980s when information on the adult production per unit of spawning/rearing habitat was scarce or nonexistent and the minimum spawning escapement needed for a sustainable population was not well understood.

MDMR estimated the minimum design populations for Alewife (Phase 1), American Shad, Blueback Herring, and Atlantic Salmon in the Androscoggin River based on the amount of potential spawning and rearing habitat and an adult unit production per area of spawning habitat. The unit production is 988 adults/ha for Alewife, 203/ha for American Shad, and 1196/ha for Blueback Herring. For a harvested Alewife population, the minimum unit production is 582/ha. Atlantic Salmon estimates are based on 240 eggs/100m^2

Number to pass	Alewife at 582/ha	Alewife at 988/ha	American Shad	Blueback Herring	Atlantic Salmon
Brunswick	791,200	1,346,800	204,000	1,233,700	579
Pejepscot	791,200	1,346,800	178,300	1,082,100	
Worumbo	791,200	1,346,800	160,800	979,000	
Lower Barker	263,700	448,900	61,900	364,900	368
Upper Barker	263,700	448,900	61,200	360,700	
Hackett Mills	100,500	171,100	49,400	290,900	
Marcal	63,400	107,800	38,000	223,700	

[1] Habitat within the mainstem Androscoggin River from Brunswick Project dam to Lewiston Fall Project dam, the Little Androscoggin River to Snows Falls, the Sabattus River, and the Little River.
[2] Phase 1 Alewife habitat is currently stocked and includes four locations in the Sabattus River (Sabattus Pond, Little Sabattus Pond, Loon Pond, and No Name Pond) and three locations in the Little Androscoggin Rive (Taylor Pond, Marshall Pond, and Lower Range Pond).

Sea Lamprey do not home to their natal rivers to spawn, and juvenile American Eel are randomly distributed along the coast by ocean currents and enter river systems by chance. In order to estimate the number of Sea Lamprey and American Eel that might migrate upstream in the Androscoggin River we used the number of adult Sea Lamprey and juvenile American Eel that pass upstream in the nearby Penobscot River. In the past five years, the number of Sea Lamprey that passed upstream at the first dam (Milford Project fish lift) has ranged from 1,890 to 6,647 individuals. In 2020, the number of juvenile American Eel passed upstream at the second dam (West Enfield Project eel ramp) was more than 200,000.

2.3 Migration periods for target species

These dates are based on migration periods observed in the Saco, Androscoggin, Kennebec, and Penobscot River and may change based on new information, evaluation of new literature, and agency consultation. Target species are denoted as (A) anadromous or (C) catadromous.

Species	Upstream migration period	Downstream migration period
Atlantic Salmon (A)	May 1- November 10	April 1-June 15 smolts and kelts. October 15-December 31 kelts
Alewife and Blueback Herring (A)	May 1-July 31	June 1-November 30 adults and juveniles
American Shad (A)	May 15-July 31	June 1-July 31 adults. July 15-November 15 juveniles
Sea Lamprey (A)	May 1- June 30 (night)	
American eel (C)	June 1-September 15	August 15-November 15 (night)

3.0 Factual background

3.1 Project description

The Pejepscot Project is located at approximately river mile 14 on the Androscoggin River, about 4 miles upstream of the Brunswick Project, and 3.25 miles downstream of the Worumbo Project. The project consists of a dam, spillway, two powerhouses, and fish passage facilities. The dam extends 560-feet from the western shore and is 47.5-feet high. The spillway capacity is controlled by five 96-foot long by 3-foot high, hydraulically operated bascule gates separated by concrete piers. The gates can be adjusted to any level between 0-100%. The spillway has a discharge capacity of 95,000 cfs. Overtopping of the dam does not occur until the headpond reaches elevation 81 feet, at which point the spillway discharge is approximately 110,000 cfs. The original (eastern) powerhouse contains three horizontal Francis units (numbers 21, 22,and 23) each with a hydraulic capacity of 350 cfs. The intake trashrack has 1.5-inch clear spacing. The newer (western) powerhouse is integral to the dam and contains a low speed, adjustable-blade, Kaplan unit (number 1) with a minimum and maximum hydraulic capacities of 1,170 and 7,550 cfs respectively. The intake trashrack has 1.5-inch clear spacing in the upper 6.25 feet and 2.5-inch clear spacing in the lower 19.1 feet. The fish passage facilities are located at the new powerhouse.

3.2 Project fishways

The upstream passage facility is a fish lift (elevator) that captures fish in a hopper (20-feet long, 7-feet wide, with a capacity of about 1,000 gallons) and lifts them about 30 ft vertically from near the powerhouse tailrace to the impoundment level. The fish lift is designed to pass 85,000 American shad and 1,000,000 river herring annually. The inlet to the hopper is a V-trap about 8-in wide by 8-ft high. Four attraction pumps, positioned under a grating in front of the entry gate, create an additional flow up to 160 cfs through the entry channel to attract the fish to the lift. The pumps can be sequenced to change the volume of water passing through the entry channel, depending on the flow out of the powerhouse tailrace. The hopper discharges the fish into a metal flume about 6-ft wide and 8-ft high. The flume is approximately 110-ft long from the lift hopper to the gate at the dam. A crowding panel and viewing window in the flume allows fish to be observed as they pass through the fishway. A continuous flow of about 30 cfs from the impoundment to the hopper attracts the fish to the impoundment.

The upstream fish passage is operated annually from April 15 to November 15. The hopper is lifted every two hours beginning at 8 a.m. for a total of five lifts per day. The number of attraction water pumps operating is set by an operator and determined based on the flow coming through the turbine and out the tailrace. At river flows < 1,700 cfs, one pump is operated (total attraction flow 70 cfs); between 1,700 and 3,500 cfs, two pumps are operated (total attraction flow 110 cfs); between 3,500 and 5,200 cfs, three pumps are operated (total attraction flow 150 cfs); and at river flows >5,200 cfs, four pumps are operated (total attraction flow 190 cfs). The total of 190 cfs (attraction flow from four pumps (160 cfs) plus an additional 30 cfs provided from the impoundment via the exit trough) represents approximately 2.2% of the project maximum turbine discharge capacity (8,600 cfs). When river flows are 15,000 cfs (impoundment El. of approximately 69.5-70.0 ft) or higher, the fishway is shut down.

The downstream fish passage facilities consist of two steel entry weirs, one on either side of the Unit 1 turbine intake. Each entry weir has an invert elevation of 65.5 ft. From each weir, an outlet pipe conveys downstream migrating fish in water down to the tailwater. The weir gates are 4 ft wide and are part of an inlet box with the outlet pipe located on the side opposite the weir. The left-side (northerly) weir has a 30-inch diameter steel transport pipe that is approximately 185-ft long. The right-side (southerly) weir has a 24-inch diameter steel transport pipe that is approximately 60-ft long. Both pipes have a free discharge to the water below the dam. Each downstream bypass can pass approximately 13 cfs, 29 cfs, and 87 cfs at headpond elevations of 66.5 ft. (low), 67.2 ft. (normal), and 69.0 ft. (high), respectively. This assumes that the entrance gate at each downstream bypass is in the fully opened position. The clear spacing of the grizzly racks at the entrance to the downstream bypasses is approximately 7 inches. There is one horizontal steel member on the grizzly racks at an approximately elevation of 67.3 ft.

3.3 Project operation

The Project operates as a run-of-river facility with a continuous minimum flow of 1,710 cfs[3], or inflow, whichever is less, minus 9.3 cfs of process water and 100 cfs for pond control.

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[3] On page E11 the minimum flow appears as 1,710 cfs and as 1,170 cfs. On page E13, E-73, and E-150 the minimum flow appears as 1,270 cfs. Because the minimum flow at the upstream Worumbo Project is 1,700 cfs, MDMR has assumed the value of 1,170 is a typographical error.

3.4 Historic fisheries resources

Historically 12 species of native diadromous fishes were found in the Androscoggin River and its tributaries. The historical range of species that were harvested is fairly well known, while the range of others is less certain. Atlantic Sturgeon, Shortnose Sturgeon and Rainbow Smelt did not pass beyond Great Falls in Brunswick. On the mainstem Androscoggin River, Lewiston Falls stopped the upstream migration of Alewife, American Shad, Blueback Herring, and perhaps Sea Lamprey, while Rumford Falls was a barrier to Atlantic Salmon (Foster and Atkins 1868). On the Little Androscoggin River, the upstream migration of Atlantic Salmon was stopped at Snows Falls (Foster and Atkins 1868). Biscoe Falls, the only other natural falls on the Little Androscoggin River identified by DeRoche (1967), may have been the upstream limit of Alewife, Blueback Herring, and American Shad. The historical upstream limit of American Eel in unknown. However, MDIFW has documented the presence of this species in the last 35 years in lakes and ponds above both Rumford Falls and Snow Falls.

Prior to dam construction, Alewife, American Shad, Blueback Herring, Atlantic Salmon, and American Eel were very abundant in the Androscoggin River. However, in 1807 a low-head dam was constructed at the head-of-tide on the Androscoggin River that caused Alewife and American Shad runs to decline sharply. Atlantic Salmon were able to leap over the low head dam and continue upstream. Construction of higher, insurmountable dams caused their complete extinction above tidal waters in 1844. Remnant populations of Alewife and American Shad continued to reproduce in the six-mile stretch of river below Brunswick, but severe water pollution and commercial fisheries had further reduced their abundance by the 1930s.

3.5 Current fisheries resources

MDMR initiated an anadromous fish restoration program in the Androscoggin River in 1983. Water quality had improved in the river, upstream and downstream fish passage was installed at the Brunswick Project Dam, and fish passage was anticipated at the next two upstream projects. Passage was constructed at the Pejepscot Project Dam in 1987 and at the Worumbo Project Dam in 1988. Passage at all three projects resulted from recommendations made by State and federal resource agencies during the federal relicensing process. MDMR has used a combination of active (stocking) and passive (fish passage) methods to restore diadromous fishes to the Androscoggin River.

3.6 American Shad

The American Shad is a highly migratory, pelagic, schooling species that ranges along the east coast of North American from Newfoundland to Florida (Colette and Klein-MacPhee 2002; Scott and Crossman 1973). American Shad spend most of their lives in the ocean. As adults they return to their natal rivers to spawn, exhibiting low stray rates (3%) and are capable of migrating long distances upstream (CRASC 1992; MDMR and MDIFW 2008; SRAFRC 2010). Generally, in river systems with limited barriers, American Shad prefer to spawn in upstream and mid-river segments until energy reserves or water temperatures no longer facilitate spawning (Massmann 1952, Bilkovic et al. 2002). Spawning sites in Virginia were associated with hydrographic parameters (high current velocity, high dissolved oxygen, and shallow depth), physical habitat features (increasing sediment size and woody debris), and the presence of a forested shoreline (Bilkovec et al. 2002). American Shad are broadcast spawners with semi-buoyant eggs, and females will spawn multiple times throughout their annual migration (Hyle et al. 2014, McBride et al. 2016). Populations of American Shad that spawn north of Cape Hatteras are iteroparous with the repeat spawners ranging from 63-74% in the Connecticut, Saint John, and Mirimichi rivers (Colette and Klein-MacPhee 2002). Repeat spawners are especially important due to higher lifetime fecundity rates and reduced annual variability of spawning stock size (Harris and Hightower 2012). Larvae transform into juveniles 3 to 5 weeks after hatching. Juveniles disperse downstream of the spawning areas, generally staying in a lower portion of the same river for the summer (McCormick et al. 1996). Most juveniles in river systems in the northern Atlantic states will begin their seaward migration when water temperatures are between 18 and 26°C (Marcy 1976, Watson 1970). In the Connecticut, year-class strength is determined during the larval emergence stage and is significantly correlated with mean river discharge, water temperature, and total monthly precipitation (Crecco et al 1983; Crecco and Savoy 1984; Crecco and Savoy 1985).

In 1985, MDMR initiated a restoration program for American Shad in the Androscoggin River. Between 1985 and 2009, MDMR stocked 7,895 adult American Shad[4] and nearly 5.6 million American Shad fry into spawning/nursery habitat below Lewiston Falls. In addition, the 1,574 adults that have returned to the Androscoggin River and have been trapped at the Brunswick Project fishway since 1990 have been trucked upstream and released. The capture of American Shad eggs and adults between the Brunswick Project dam and the railroad bridge (located 0.8 miles downstream) in 2005 and 2006 demonstrates the presence of a spawning population. However, the population will never expand without safe, timely, and effectives access to the substantial amount of habitat located above the Pejepscot Project.

3.7 Alewife

The Alewife is an anadromous, highly migratory, euryhaline, pelagic, schooling species that historically ranged from South Carolina to Labrador, Nova Scotia, and northeastern Newfoundland (Berry 1964; Winters et al. 1973; Burgess 1978). Alewife and Blueback Herring are collectively referred to as river herring because of their similarity in size and appearance Alewife and Blueback Herring co-occur throughout much of their respective ranges, but Alewife are typically more abundant than Blueback Herring in the northern portion of their range (Schmidt et al. 2003). The Alewife spends the majority of its life at sea, returning to freshwater river systems along the Atlantic coast of the United States to spawn. Alewife spawn in lakes and ponds in coastal watersheds (Loesch 1987), in the slow-moving sections of rivers or streams (Jones et al. 1978), in shore-bank eddies or deep pools below the dams (Loesch and Lund 1977). Alewife may ascend long distances in freshwater to reach spawning habitat (O'Connell and Angermeier 1997). Spawning typically is initiated at water temperatures ranging from 5-10°C (Loesch 1987). Alewife are repeat spawners, with some individuals completing seven or eight spawning events in a lifetime (Jessop et al. 1983). The spawning habitat of Alewife can range from sand, gravel, or coarse stone substrates, to submerged vegetation or organic detritus (Edsall 1964; Mansueti and Hardy 1967; Jones et al. 1978). Adults migrate downstream soon after

[4] Adult American Shad were obtained from the Connecticut River (1985-1999) and the Merrimack River (2002-2009).

spawning. Outmigration of the juveniles is related to declining water temperature (Pardue 1983; Loesch 1987) and changes in water flow, water levels, precipitation, and light intensity (Cooper 1961; Kissil 1974; Richkus 1975; 1975b; Pardue 1983).

MDMR has stocked adult Alewife into spawning habitat in the Sabattus River and Little Androscoggin River annually since 1983, because no historic lentic habitat is accessible. As of 2021, the MDMR has stocked approximately 199,000 alewives into these ponds to maintain spawning populations. In addition, nearly 1,015,000 adult Alewife have been passed or stocked above the Brunswick, Pejepscot, and Worumbo projects in the past 37 years.

Restoring access into the Sabattus River (located above the Worumbo Project) is a current priority for MDMR, because it encompasses a substantial amount of Alewife spawning habitat that is located above the fewest barriers (three mainstem and six tributary dams). In 2019, the MDMR and the Maine Department of Environmental Protection (MDEP) collaborated to remove the lowermost dam in the Sabattus River in conjunction with contaminant remediation at the site. MDMR subsequently obtained a grant to develop designs for fish passage – either a technical fishway or dam removal – at the each of the remaining five dams. We expect the 912.6 ha (2,255 acres) of spawning habitat to be accessible within the next five years. Safe, timely, and effective upstream and downstream passage at the three mainstem dams will be necessary to achieve the goal of a self-sustaining population of Alewife in the Sabattus River watershed.

3.9 Blueback Herring

The Blueback Herring is an anadromous, highly migratory, pelagic, schooling fish found along the east coast of North America from Cape Breton, Nova Scotia and the Bay of Fundy watershed, New Brunswick, to Florida in the United States (Scott and Crossman 1973; Colette and Klein-MacPhee 2002). Blueback herring and Alewife are collectively referred to as river herring because of their similarity in size and appearance. Blueback herring spend most of their lives in the ocean and as adults they return to their coastal rivers to spawn. In the portions of their range where Blueback Herring and Alewife co-occur, Blueback Herring prefer to spawn over hard substrates in swift current (Loesch and Lund 1977; Johnston and Cheverie 1988). Blueback herring will ascend freshwater far upstream (Massmann 1953; Davis and Cheek 1966; Perlmutter et al. 1967; Crecco 1982); their distribution is a function of habitat suitability and hydrological conditions, such as swift flowing water (Loesch and Lund 1977). Spawning occurs at temperatures ranging from a minimum of 13°C (Hawkins 1979; Rulifson et al. 1982) to a maximum of 27°C (Loesch 1968). Blueback herring are repeat spawners and there appears to be an increase in repeat spawning from south to north (Rulifson et al. 1982). In Nova Scotia, 75% of adults in Nova Scotia had previously spawned (O’Neill 1980). Juvenile Blueback Herring spend three to nine months in their natal rivers before migrating to the ocean (Kosa and Mather 2001). In Maine, female and male

MDMR recently began stocking pre-spawn Blueback Herring from the Kennebec River into spawning/rearing habitat in the Androscoggin River. Since 2016, approximately 11,000 adults have been stocked above the Worumbo Project. When a population imprinted to the Androscoggin River develops, the returning adults will need safe, timely, and effectives access to the substantial amount of habitat located above the Pejepscot Project.

3.9 Atlantic Salmon

The Atlantic Salmon is a highly migratory, anadromous, iteroparous fish that historically ranged from northeastern Labrador to the Housatonic River in Connecticut (Collette and Klein-MacPhee 2002). Adults may spend several years at sea before returning to their natal rivers to spawn. Adults that return after one year at sea are called “grilse” or “1-sea-winter” fish while individuals that return after two or three years at sea are called “2-sea-winter” or “3-sea-winter” fish, respectively. Adults enter their natal rivers from spring through fall with peak upstream migration from May through mid-July in Maine (NMFS 2012). They spawn in the late fall, and will build nests (“redds”) in suitable gravel or cobble substrate (NMFS 2012). The eggs overwinter and hatch between March and April. After the fry emerge from the redd, they disperse to feed and grow, and develop into parr. The parr typically grow for 1-3 years in freshwater before undergoing a physiological transformation (smoltification) after which the smolts migrate to the ocean in the early spring (NMFS 2012).

Atlantic Salmon are a federally endangered species. The Pejepscot Project Area is within the Gulf of Maine Distinct Population Segment (GOM DPS) as part of the Merrymeeting Bay Salmon Habitat Recovery Unit. The critical habitat designation for the Androscoggin River extends from its confluence with the Kennebec River upstream to Lewiston, with the Lower Androscoggin and Little Rivers designated as sub-basins.

Efforts to restore Atlantic Salmon in the Androscoggin River has been modest compared to other GOM DPS river systems. Stocking has been limited to small numbers of fry that have been raised by school groups hand primarily released in the Little River. Since 1983, 802 adult Atlantic Salmon adults have been captured at the Brunswick Project and passed upstream. The majority of the fish have been strays of hatchery origin.

3.10 Sea Lamprey

The Sea Lamprey is an anadromous, semelparous, species that ranges in the wester Atlantic Ocean from the St. Lawrence River in Canada to the State of Florida in the United States (Scott and Crossman; Colette and Klein-MacPhee 2002). Unlike the other diadromous species native to Maine, there is no evidence that Sea Lamprey home to their natal river system (Hansen et al. 2016). They spawn in gravel-cobble substrate, and the spawning process results in streambed modification and sediment transport (Nislow and Kynard 2009; Sousa et al. 2012; Hogg et al. 2016). Lamprey spawning activities condition the habitat for other species, including Atlantic Salmon, by removing fines and reducing substrate embeddedness (Kircheis 2004). Given the high degree of embeddedness in Maine streams due to past land use practices, the role of lamprey as “ecosystem engineers” is particularly important (Kircheis 2004; Sousa et al. 2012). Sea Lamprey spawning in Maine begins in late May and extends into early summer and peaks at water temperatures of 17-19◦C (Kircheis 2004). Sea Lamprey metamorphize as juveniles and swim downstream to feed in the ocean in the late fall and spring (Kircheis 2004). General movement is thought to occur at nighttime and during high flow events (Kircheis 2004).

The number of Sea Lamprey that annually ascend the Brunswick fishway was low for many years (0-28 individuals between 1999 and 2011), but has increased recently (19-240 individuals since 2012). However, when fishways operate at night, the number of Sea Lamprey passed can be much higher. The Milford Project fish lift passed 5,483 Sea Lamprey in 2020.

3.11 American Eel

The American Eel is a highly migratory, semelparous, facultative catadromous species that spends most of its life in freshwater or estuarine environments and spawns in the ocean (Collette and Klein-MacPhee 2000; Shepard 2015). The species ranges over more than 50 degrees of latitude, being found from the southern tip of Greenland, along the entire eastern coast of North America, around the Gulf of Mexico, and through most of the West Indies (Smith 1989). Within that range, it may use the broadest types of habitat of any fish species (Helfman et al. 1987). Spawning occurs in winter and early spring only in a large region of the Sargasso Sea (Kleckner and McCleave 1985; Wippelhauser et al. 1985; McCleave et al. 1987). The eggs hatch and release a long-lived larval stage (leptocephalus) which drift and swim in the upper 300 m of the water column for several months, growing slowly to a length of 5-6 cm (Kleckner and McCleave 1985). Oceanic currents transport the leptocephali to the southwest into the Gulf Stream, which transports them northward along the east coast of the U.S. Somewhere over the continental shelf, the larvae metamorphose into a miniature transparent eels (glass eels). Glass eels actively migrate toward land and freshwater and ascend rivers during the winter and spring by drifting on flooding tides and holding position near bottom on ebb tides (McCleave and Kleckner 1982; Wippelhauser and McCleave 1987) and also by actively swimming along shore in the estuaries and above tidal influence (Sheldon and McCleave 1985). When the migrating glass eels become pigmented they are termed elvers or yellow eels. Depending on where they cease their upstream migration, some yellow eels reach the extreme upper portions of the rivers while others stay behind in the brackish areas (Hardy 1978, Fahay 1978). Eventually yellow eels undergo a final metamorphosis into a silver eel, the adult stage that will migrate to the Sargasso sea to spawn and die. The timing of the American Eel migrations in Maine is well-known from commercial harvests and MDMR monitoring. The upstream migration of glass eels is considered to occur from March 15- June 15. The upstream migration season for elvers and yellow eels is June 1-September 30. The downstream migration of silver eels occurs from August 15- October 31. Migration mostly occurs at night although glass eels may occasionally move during the day.

During a 2003 boat electrofishing survey of the Androscoggin River, Yoder (2009) documented American Eel in the Androscoggin River estuary and the Androscoggin River to the Deer Rips impoundment. Safe, timely, and effective fish passage in necessary for this species to migrate upstream to freshwater growth habitat, which may produce a large number of females, and migrate downstream to the sea to spawn.

4.0 Section 10(j) Recommendations

Section 10(j) of the FPA requires that each license issued for a hydropower project contain conditions to adequately and equitably protect, mitigate damages to, and enhance, fish and wildlife affected by the development, operation, and management of a project (16 U.S.C. § 803(j)). Therefore, each license issued shall include such conditions, based on recommendations of the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and state fish and wildlife agencies. The MDMR supports six of the Fisheries Environmental Measures that have been proposed by the Licensee for the Pejepscot Project. The MDMR is submitting seven 10(j) fish recommendations that are based upon our enabling legislation, the goals and objectives for the Androscoggin River contained in the Fisheries Management Plan, and information developed during the licensing proceeding and consultation with other resource agencies and the Licensee.

4.1 Proposed Fisheries Environmental Measures supported by MDMR

MDMR supports the following Fisheries Environmental Measures that have been proposed in the Final License Application for the Pejepscot Project.

1. Maintain a minimum flow of 1,710 cfs[5], or inflow, whichever is less.
2. Operate in a run-of-river mode maintaining a normal pond elevation of 67.2 ft or 0.3 ft below the top of the spill gates.
3. Develop, in consultation with stakeholders, a Stranding Plan to address potential stranding of fish in the bedrock area below bascule gate no. 5. The Plan will detail inspections of the pools by operators following spill events.
4. Implement the following measures for ESA-listed Atlantic Salmon.
    a. Continue video camera monitoring of Atlantic Salmon utilizing the Pejepscot fish lift.
5. Conduct an Atlantic Salmon radio telemetry study, to determine upstream passage effectiveness at the Pejepscot fish lift, when at least 40 adult Atlantic Salmon of Androscoggin River origin are counted at the Brunswick fishway for two consecutive years.
    a. Monitor downstream migrating Atlantic Salmon kelts as part of the adult Atlantic Salmon radio telemetry study described above.
    b. Open bascule gate No. 1 (closest to the powerhouse) 50% to provide approximately 500 cfs of spill at night (2000 – 0700 hours) during the month of May.
    c. Conduct one season of efficiency testing for Atlantic Salmon smolts once the proposed downstream fish guidance system/debris boom is installed and the modifications to bascule gate no. 1 have been completed.

[5] On page E11 the minimum flow appears as 1,710 cfs and as 1,170 cfs. On page E13, E-73, and E-150 the minimum flow appears as 1,170 cfs. Because the minimum flow at the upstream Worumbo Project is 1,700 cfs, MDMR has assumed the value of 1,170 is a typographical error.

4.2 Recommendation #1 Upstream anadromous fish passage

Within two years of license issuance, the Licensee shall replace the existing vertical entrance gate with a bottom-opening flap gate in order to pass the target species described in Section 2.1 in a safe, timely, and effective manner consistent with the performance standards described in Section 4.6. The gate shall be designed in consultation with MDMR and the resource agencies to accommodate the full 160 cfs of attraction water or more with the top of the gate positioned a minimum of 3.0 feet below the tailrace elevation under varying river flows and maintain an entrance velocity within the 4-6 ft/s range for alosines and up to 8 ft/s for Atlantic salmon and a drop at the entrance approximately 0.8 feet normally with the capability of increasing up to 1.5 to 2.0 feet. Upon license issuance, the licensee shall operate the attraction water system at full capacity, regardless of unit discharge, unless monitoring studies indicate different operations are warranted.

The Licensee shall keep the fishways in proper order and shall keep fishway areas clear of trash, logs, and material that would hinder passage. Anticipated maintenance shall be performed in sufficient time before a migratory period such that fishways can be tested and inspected and will properly operate prior to the migratory periods.

Justification

MDMR finds the Licensee's proposed environmental measures pertaining to upstream fish passage at the Project to be inadequate to meet our goals and objective for anadromous species in the Androscoggin River. The Licensee proposed to:

> Operate the existing fish lift on the following lift cycle frequency beginning in the first full passage season after the effective date of the new license:
>
> - April 15 to May 15 and following passage of the first fish at the downstream Brunswick Project, the lift will be operated once every two hours.
> - May 16 through June 15, the lift will be operated once every hour.
> - June 16 through July 1, the lift will be operated every 2 hours.
> - July 2 through November 15, the lift will be operated once a day following passage of salmon at Brunswick if not already identified passing though Pejepscot
>
> Develop a plan and schedule, in consultation with resource agencies, containing potential physical and/or operational modifications to be constructed/implemented no later than Year 3 of the new license, to address factors (i.e., internal and external attraction flow hydraulics and acoustics) that may be impacting upstream passage of migratory fish species.
>
> - Conduct one season of fish lift efficiency testing for adult river herring during the fourth full passage season after the effective date of the new license.

The results of upstream passage effectiveness studies conducted by the Licensee in 2020 on adult Alewife and adult American Shad were extremely disappointing. None of the radio-tagged adult American Shad (0%) and just 16 of 81 radio-tagged adult Alewife (19.8%; 75% CI = 14.8-24.9%) that approached within 500 feet of the downstream side of the Pejepscot Dam successfully located and used the existing fish lift for upstream passage.

According to the FLA, the upstream fish passage is operated from April 15 to November 15 and the hopper is lifted every two hours beginning at 8 a.m. for a total of five lifts per day. Despite evidence that the upstream fish passage facility is not providing safe, timely or effective fish passage, the Licensee proposes to reduce the number of lifts per day rather than increase them. Similar upstream fish passage facilities (fish lifts) on the Kennebec and Penobscot rivers lift every 20 minutes during the river herring and Atlantic Salmon passage seasons. In addition, fish lift operations are best addressed in a Fishway Operation and Maintenance Plan (Section 4.7) that can easily be updated as information becomes available.

Safe, timely, and effective upstream passage at the each of the three mainstem dams is essential for reaching our restoration goals for American Shad, Blueback Herring, Alewife, and Sea Lamprey in the watershed. Based on the best available science, we have determined that upstream passage must be 75-88% effective, depending on the species, as described in Section (Section 4.6). Clearly, the current facility does not approach this level of effectiveness.

Studies conducted by the Licensee have provided sufficient information to identify the factors, in addition to the two-hour lift cycle, that likely are causing the upstream passage facility to be ineffective.

- CFD modeling of the tailrace at flows of 1710, 4900, 7000, and 8690 cfs indicated a zone of passage on river left with an acceptable range of velocities for the target species at the three lowest flows. However, approximately 150-feet downstream of the Project an elevated shelf and spur extend into the middle of the main channel, which causes an increase in the velocity in this region relative to other nearby areas over the entire range of simulated flows. Beginning at a flow of about 4900 cfs, an area of recirculating flow develops along the river left shoreline approximately 300-feet to 500-feet downstream of the fishway. Beginning at flows of approximately 7,000 cfs there is a narrowing of the zone of passage near the area of recirculating flow as velocities increase above 5 fps in the center of the channel.
- CFD modeling of the fishway entrance with 2, 3, or 4 pumps running and 2, 3, or 4 ft of water depth over the entrance gate revealed that the entrance jet was above the 4-6 ft/sec criteria in five of the six model runs. In all runs, velocities within the entrance channel were within the range of 1.5 to 4 fps.
- Underwater sound was recorded by a hydrophone at five locations across six AWS pump and fish lift operational scenarios. There was no evidence that the AWS pumps or fish lift generated ultrasonic noise of sufficient sound pressure level (SPL) capable of deterring fish. The results did not show existence of ultrasonic noise that may deter adult alosines, specifically American Shad, from entering the fish lift at the Pejepscot upstream fish passage facility.

4.3 Recommendation #2 Upstream American Eel passage

The Licensee shall construct, operate, and maintain upstream fish passage facilities that provide safe, timely, and effective upstream passage for American Eel. During the first two full passage season after license issuance, the Licensee shall conduct visual monitoring surveys in conjunction with temporary upstream eel ramp deployments with collection traps to determine the proper location of the upstream eel passage(s). Based on the visual survey and trapping results, the Licensee shall, in consultation with the MDMR and other resource agencies, determine optimal locations for siting the permanent upstream eelway(s). Temporary upstream eel ramps shall be deployed in low flow areas that may attract migrating eels. At a minimum, the Licensee shall deploy temporary eel ramps on the bedrock outcrop located on the right bank (as proposed in the Final License Application) and near the exit of the downstream bypass. Additional locations should be decided in consultation with MDMR and the other resource agencies. Based on results of the surveys, the Licensee shall, in consultation with MDMR and other resource agencies, determine optimal locations for siting the permanent upstream eelway(s). Permanent upstream eel passage shall be operational no later than the third full passage season after license issuance.

The Licensee shall keep the fishways in proper order and shall keep fishway areas clear of trash, logs, and material that would hinder passage. Anticipated maintenance shall be performed in sufficient time before a migratory period such that fishways can be tested and inspected and will properly operate prior to the migratory periods.

Justification

The Licensee has proposed the following environmental measures for upstream passage for American Eel, which MDMR finds inadequate to meet our goals and objectives:

- Install and operate a temporary portable American Eel ramp for three passage seasons (June 1 through September 15) to identify a suitable location for a permanent upstream American Eel ramp. The temporary portable eel ramp will be installed during the first full passage season after the effective date of the new license.
- Install and operate a permanent upstream American Eel ramp (June 1 through September 15) based on the results of the temporary portable ramp evaluation. The permanent ramp will be installed when upstream eel passage facilities are constructed at the downstream Brunswick Hydroelectric Project.

The Licensee conducted 14 Eel Monitoring Surveys of the Androscoggin River immediately downstream of the Project powerhouse and dam between June 17 and August 26, 2019, but no juvenile eels were observed. The spillway was viewed at a distance from either shore and other areas were viewed from the counting room. The FLA notes that it is likely that the lack of access within the areas immediately downstream of the Project dam by boat or foot limited the ability to visually detect juvenile eels, and we concur with this assessment.

Dedicated upstream eel passage is necessary to provide access to growth habitat upstream of the Project throughout the migratory eel passage season. Observations of upstream migrating eels at the Brunswick Project and fish surveys conducted by Yoder et al. (2006) document eels are downstream of Pejepscot. The configuration of a given project may create multiple attraction points for upstream migrating eels. Therefore, more than one eel passage may be needed to provide effective passage. The most suitable locations for permanent eel passage (s) should rely on empirical data which will be collected during the temporary eel ramp deployments.

4.4 Recommendation #3 Downstream Diadromous Fish Passage

The Licensee shall construct, operate, and maintain a downstream fish passage and protection system that provides safe, timely, and effective downstream passage for the target species described in Section 2.1). Beginning in the first year following License issuance, the Licensee shall implement interim, targeted, nighttime turbine shutdowns to protect emigrating American Eel until permanent measures, as approved by the agencies, are implemented. During the downstream passage season for American Eel described in Section 2.3, turbine shutdowns shall occur from dusk to dawn for three consecutive nights following rain accumulations of 0.25 inch or more over a 24-hour period. Within three years of license issuance, the Licensee shall implement permanent downstream diadromous fish passage and protection measures for all target species. Based on currently best available information, MDMR recommends the installation of a full-depth inclined rack (with a maximum clear-spaced opening of 0.75 inch) for Unit 1 with two low-level and two surface bypasses integrated on the face of the rack; the bypasses would lead to a shared pipe that exits to the existing plunge pool with a bypass flow of 380 cfs, which is 5 percent of station capacity. MDMR also recommends full depth screening of Units 21, 22, and 23 or seasonal shutdowns to prevent turbine entrainment.

The Licensee shall keep the fishways in proper order and shall keep fishway areas clear of trash, logs, and material that would hinder passage. Anticipated maintenance shall be performed in sufficient time before a migratory period such that fishways can be tested and inspected and will properly operate prior to the migratory periods.

<u>Justification</u>

The Licensee's has proposed the following environmental measures related to downstream fish passage, which are not supported by MDMR:

- Reduce the operational setting for Unit 1 (unit turndown) to approximately 3,480 cfs (resulting in intake approach velocities of less than 1.5 fps) for eight hours during the night (8:00 pm to 4:00 am) between September 1 and October 31 annually to enhance downstream eel passage
- Discontinue the north (left bank) downstream fish bypass beginning in the second full passage season after the effective date of the new license; continue operation of south (right bank) downstream fish bypass.
- Install and operate a fish guidance system/debris boom to direct downstream migrants to a new bypass within bascule gate no. 1 beginning in the second full passage season after the effective date of the new license.
- Conduct one season of efficiency testing for juvenile alosines once the proposed downstream fish guidance system is installed and the modifications to bascule gate no. 1 have been completed.

Dedicated downstream fish passage facilities are necessary to protect the target species described in Section 2.1 that emigrate past the Project. MDMR stocks Alewife and Blueback Herring upstream of the Pejepscot Project, and counts of upstream migrants at the Worumbo Project verify the presence of American Eel, American Shad, and Atlantic Salmon above the Pejepscot

Project. Without efficient downstream passage, outmigrating diadromous species will be susceptible to impingement and/or entrainment.

Downstream passage studies conducted as part of this relicensing indicated that the estimated survival of tagged fish from 650 feet upstream of the Project to the first downstream receiver (1.8 – 2.2 miles downstream) was 80.9% for adult Alewife, 54.4% for adult American Shad, and 96% for adult American Eel. For all species and life stages, the majority of fish passed through Unit 1 (51% of adult Alewife, 68.4% of juvenile Alewife, 31% of adult American Shad, and 96% of adult American Eel). Adult Alewife and adult American Shad passed via spill (27% and 26%, respectively) when it was available. However, these survival estimates are subject to biases associated with the drift of dead fish following turbine-induced mortalities. Havn et al. (2017) examined the movement of tagged dead fish and revealed that dead fish can move downstream through telemetry receiver arrays like live fish. Consequently, downstream movement does not necessarily indicate safe passage.

Safe, timely, and effective downstream passage at the each of the three mainstem dams is essential for reaching our restoration goals for American Shad, Blueback Herring, Alewife, Atlantic Salmon, Sea Lamprey, and American Eel in the watershed. Based on the best available science, we have determined that downstream passage must be at least 95% effective for juvenile alosines and 75-95% effective for adults, depending on the species, as described in Section (Section 4.6). Clearly, the current facility does not approach this level of effectiveness.

MDMR is not aware of any cases of turbine turndowns implemented as a protective measure for American Eel in the northeastern United States, and therefore there are no data to support this proposed mitigation measure. While turbine turndowns would reduce the approach velocity upstream of the Project's intake racks, the turndowns would not prevent eels from entering the units volitionally by following the flow of water due to the fact that the rack spacing does not physically exclude American eel. Furthermore, the proposed changes were not examined during studies conducted in support of this relicensing.

Units 21, 22, and 23 were not assessed as part of downstream telemetry studies but operate during the downstream migration periods of eels and other migratory fishes. The average (and maximum) amount of time these units were operating was 36% (100%) in May, 21% (52%) in June, 29% (40%) in September, and 30% (52%) in October for the years 2015-2019, excluding months when Unit 1 was offline for repairs). In 2020, the Licensee conducted a Fish Entrainment And Turbine Survival Assessment. The resulting regression-based estimates of entrainment survival for a 2-inch, 4-inch, 6-inch, 8-inch, 12-inch, and 14-inch fish were 81.8%, 65.8%, 47.3%, 36.6%, 2.2%, and 0.4%, respectively. Turbine passage might be expected to injure or kill a significant portion of the outmigrating adult Alewife, Blueback Herring, American Shad, Atlantic Salmon, and American Eel. Screening Units 21, 22, and 23 would prevent turbine passage and improve eel survival during their downstream migration.

Based on currently available information, safe, timely, and effective downstream passage for the target species can be achieved at Pejepscot via an inclined screen for Unit 1 with 0.75 inch clear spacing or less with bypasses capable of passing a minimum of 5% of station capacity in accordance with federal guidelines (USFWS 2019). Trash racks with 0.75 inch clear spacing are commonly prescribed in New England to prevent entrainment of American eels at hydropower projects (e.g., Woronoco FERC No. 2631, Scotland FERC No. 2662, Central Falls FERC No. 3063, Rollinsford FERC No. 3777). Research on inclined trash racks support that they reduce the prevalence of impingement in eels from the genus *Anguilla* (Calles et al. 2013). Downstream eel passage was studied at the Wilder (FERC No. 1892), Bellows Falls (FERC No. 1855) and Vernon Hydroelectric Projects (FERC No. 1904) and debris booms were not effective at preventing passage through the turbines[6]. Despite installation of a debris boom at the Lockwood Project (FERC No. 2574) to guide fish to a downstream bypass, only 43% of adult alewives entering the forebay canal used the downstream bypass[7]. Given that the proposed debris boom has not been proven effective at protecting American eels and has performed poorly (i.e., has not kept fish out of turbines) at other sites for other, more surface-oriented species, the proposed debris boom is not a suitable protective measure. This is especially true considering American eels spend much of their time near the bottom of rivers and are known to move vertically when encountering a barrier (Brown et al. 2009).

4.5 Recommendation #4 Diadromous Fish Passage Effectiveness testing

Beginning in the second migratory season after the new entrance gate and changes in lift timing are operational, the Licensee shall conduct three years of quantitative fish passage effectiveness testing to determine whether the existing fish lift can achieve the passage performance standards for adult American Shad, Alewife, Blueback Herring, Atlantic Salmon, and Sea Lamprey as described in Section 4.6. After the third study year for each species, the Licensee shall consult with the fishery agencies to identify potential issues causing any continued inefficiency and to develop measures to resolve them. The licensee shall conduct an additional three years of study following any modifications implemented as a result of this adaptive management.

Beginning in the second migratory season after the new downstream passage facilities are operational, the licensee shall conduct three years of quantitative fish passage effectiveness testing to determine whether the facilities can achieve the passage performance standards for adult and juvenile American Shad, Alewife, and Blueback Herring as described in Section 4.6. Effectiveness testing also shall be conducted for American Eel, although we have no performance standards at this time. The Licensee shall consult with the fishery agencies to identify potential issues causing any continued inefficiency and to develop measures to resolve them. The licensee shall conduct an additional three years of study following any modifications implemented as a result of this adaptive management.

Beginning in the first migratory season after the new upstream American Eel passage(s) are operational, the Licensee shall conduct a minimum of two years of quantitative effectiveness testing. After the second study year, the Licensee shall consult with the fishery agencies to identify potential issues causing any continued inefficiency and to develop measures to resolve them

Upstream and downstream testing of all life stages of Atlantic Salmon is contingent on agency consultation and presence of testable individuals.

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[6] Accession No. 20170228-5202
[7] Accession No. 20160331-5144

<u>Justification</u>

Fishways need to be tested to ensure they are constructed, operating and functioning as intended, and whether improvements are needed to ensure safe, timely and effective passage is provided. MDMR has provided preliminary performance standards for multiple species as a means of assessing the effectiveness testing.

4.6 Recommendation #5 Performance standards for fish passage facilities

The upstream fish passage facility (fish lift) at the Pejepscot Project shall be considered to be performing in a safe, timely, and effective manner if:

1. At least 75% of the adult American Shad that pass upstream at the next downstream dam (or approach within 200 m of the project powerhouse) pass upstream at the project within 72 hours.
2. At least 88% of the adult Blueback Herring that pass upstream at the next downstream dam (or approach within 200 m of the project powerhouse) pass upstream at the project within 72 hours.
3. At least 95% of the adult Alewife that that pass upstream at the next downstream dam (or approach within 200 m of the project powerhouse) must pass upstream at the project within 72 hours; and
4. At least 80% of the adult Sea Lamprey that pass upstream at the next downstream dam (or approach within 200 m of the project powerhouse) pass upstream at the project within 48 hours.

The downstream passage facility shall be considered to be performing in a safe, timely, and effective manner if:

1. At least 95% of the juvenile American Shad and 85% of the adult American Shad that pass downstream at the next upstream hydropower dam (or within 200 m of the project spillway) pass the project;
2. At least 95% of the juvenile Blueback Herring and 75% of the adults that pass downstream at the next upstream hydropower dam (or within 200 m of the project spillway) pass the project; and
3. At least 95% of the adult and juvenile Alewife that pass downstream at the next upstream hydropower dam (or within 200 m of the project spillway) pass the project.

<u>Justification</u>

Diadromous fish species require safe, timely, and effective access to high quality habitats at different life stages in order to successfully survive and reproduce. Hydroelectric projects often prevent or delay migrations or cause injury or mortality that contribute to population declines. These adverse impacts can be mitigated by properly designed fishways, however many fishways fail to perform as intended, including fishways developed and operated utilizing USFWS Fish Passage Design Criteria (USFWS 2019). When there are a series of fishways within a migration corridor for diadromous species, such as in the Androscoggin River, the risks increase that one or more underperforming fishways will result in significant cumulative negative impacts to these fish populations. This potential for cumulative impacts creates the need for highly effective fish passage at each of the dams that meet agency design and performance standards.

To ensure that minimum restoration goals for the Androscoggin River are met, the new fish passage facility at the Pejepscot Project and the facilities at other hydropower projects that will undergo relicensing within the next decade will need to be tested for their effectiveness in passing the target species. In a report that analyzed mitigation (fish passage) at hydropower projects, the Federal Energy Regulatory Commission (FERC 2004) acknowledged the impacts of hydropower projects on fish populations and the importance of testing the effectiveness of fish passage facilities and also recognized the use of modeling tools for assessing management actions and fish passage improvements at multiple projects.

In the Environmental Analysis of three recent relicensing proceedings[8,] the Commission did not support recommendations made by the resource agencies for effectiveness testing of all new fish passage facilities. One reason FERC did not support effectiveness testing was the lack of specific performance standards by which the effectiveness testing could be evaluated. Therefore, MDMR has developed performance standards in this plan for five species, Atlantic Salmon, American Shad, Blueback Herring, Alewife, and Sea Lamprey, which are described and justified below. Effective fish passage is also important for American Eel, which spawns just once and dies (semelparous), but performance standards have not been developed at this time.

<u>Alewife</u>

In 2020, the "Alewife population model", a web-based application[9] for understanding likely fish passage outcomes for Alewife, was developed by Betsy Barber, Alejandro Molina-Moctezuma, Jamie Gibson, Andrew O'Malley, and Joseph Zydlewski. The basic structure and inputs of the original model have been described in Barber et al. (2018), and the same information and the R code is annotated at the web site. The Alewife population model was developed to compare theoretical spawner abundance between scenarios with different dam passage rates. Spawner abundance is calculated using a deterministic population model, which defines inputs using averages applied to groups. The model is used to explore general trends and compare the results of scenarios when different average values are used as inputs. The model does not make forecasts or predictions about the exact number of spawners that will be present in the river after a certain number of years. In addition, no annual environmental variability was built into the model; inputs were averages; all spawning habitat was considered to be of the same quality; all density-dependent mortality was included in the recruitment curve; and in the absence of dams, fish were distributed throughout the system according to habitat availability.

MDMR used the Alewife population model to estimate upstream and downstream passage efficiency that would be needed to meet our restoration goals for the Sabattus River (2,255 acres of habitat would produce a minimum sustainable population of 529,925adult Alewife. The model results indicate that a passage efficiency of 95% for adults migrating upstream and juveniles and adults migrating downstream would be needed to attain the restoration goal (Appendix A). Studies conducted as part of the Pejepscot Project relicensing revealed that

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[8] American Tissue FERC No. 2809-034; Barker Mills FERC No. 2808; Ellsworth FERC No. 2727-092.
[9] https://umainezlab.shinyapps.io/Alewifepopmodel/

nearfield attraction (tailrace to fishway entrance) was fairly good (92.6%) but internal efficiency (entrance to exit) was (21.3%), resulting in an overall efficiency of 19.8%. Clearly the effectiveness of the facility needs to be improved as soon as possible..

American shad

In the past decade, computer models have been used to explore the potential impacts of dams to American Shad populations with similar results. Harris and Hightower (2012) developed a "density-dependent, deterministic, stage-based matrix model to predict the population-level results of transporting American Shad to suitable spawning habitat upstream of dams on the Roanoke River, North Carolina and Virginia". They reported that predicted population increases were highest when young-of-year survival was improved, and transport benefited the population only if high rates of effective fecundity and juvenile survival could be achieved. Castro-Santos and Letcher (2010) developed a simulation model that synthesized bioenergetics, reproductive biology, and behavior to estimate the effects of migratory distance and delays at dams on spawning success and survival of individual adult migrants that ascended the Connecticut River, spawned, and survived to return to the marine environment. They found that delays to both upstream and downstream movements had dramatic effects on spawning success and the spatial extent of spawning. Most recently, Stich et al. (2019) developed a stochastic, life-history based, simulation model for the Penobscot River and found that the probability of achieving management goals (total spawner abundance, distribution to upstream habitat, and percentage of repeat spawners) was greatest with high downstream passage efficiency, minimal migration delays at dams, and high upstream passage efficiency.

A version of the model developed by Stich (2019) was used in the Atlantic States Marine Fisheries Commission American Shad benchmark stock assessment. Each coastal river system was modeled using the potential spawning habitat available prior to the construction of dams and latitudinal-appropriate life history parameters developed for regional metapopulations (e.g., clines in size-at-age, maturity rates, and iteroparity) and used in the stock assessment. Dr. Stich has made the life history models for the Susquehanna, Mohawk-Hudson, Connecticut, Merrimack, Saco, Androscoggin, Kennebec (Stich et al. 2020), and Penobscot rivers available, and provided MDMR with the results of standard base runs for the Androscoggin River. The base runs predicted population abundance over time under varied fish passage efficiencies and distribution of spawning fish in the watershed. MDMR has used these results to develop performance standards for fish passage facilities at hydropower projects on the mainstem Kennebec River (Appendix A).

Blueback herring

Dr. Daniel Stich has recently developed a stochastic, life-history based, simulation model for Blueback Herring for the Mohawk River, Kennebec River, and Androscoggin River; these models are conceptually similar to the American Shad model. Dr. Stich ran 48 scenarios to explore the effects of downstream passage survival (1.00, 0.95, and 0.90) in combination with varying upstream passage efficiency (0.70-1.00) and time-to-pass (1, 3, 7, and 20 days per dams) on Blueback Herring distribution and abundance (Appendix A). The upstream and downstream passage facilities should be operated daily (24 hours/day) to accommodate the migratory movements of river herring (Grote et al. 2014).

4.7 Recommendation #6 Fishway Operation and Maintenance Plan

Within 12 months of license issuance, the Licensee will prepare in consultation with MDMR and the other resource agencies (MDIFW, USFWS, and NMFS) a Fishway Operation and Maintenance Plan (FOMP) covering all operations and maintenance of the upstream and downstream fish passage facilities in operation at the time. The FOMP shall include 1) a schedule for routine fishway maintenance to ensure the fishways are ready for operation at the start of the migration season; 2) procedures for routine upstream and downstream fishway operations including fish lift cycle time; and 3) procedures for monitoring and reporting on the operation and maintenance of the facilities as they affect fish passage.

The FOMP shall be submitted to the MDMR and other resource agencies for review and approval prior to submitting the FOMP to the Commission for its approval. Thereafter, the Licensee update the FOMP to reflect any changes in fishway operation and maintenance planned for the year. If the MDMR requests a modification of the FOMP, the Licensee shall amend the FOMP within 30 days of the request and send a copy of the revised FOMP to the MDMR. Any modifications to the FOMP by the Licensee will require the approval of the Service prior to implementation and prior to submitting the revised FOMP to the Commission for its approval.

The Licensee shall provide information on fish passage operations and project generating operations that may affect fish passage, upon written request from the Service or other resource agencies. Such information shall be provided within 10 calendar days of the request, or upon a mutually agreed upon schedule.

4.8 Recommendation # 7 Fishway Effectiveness Monitoring Plan

The Licensee shall develop a Fishway Effectiveness Monitoring Plan (FEMP) in consultation with, and requiring approval by, MDMR. The FEMP will contain plans for ensuring (1) the effectiveness of the upstream and downstream passage measures required pursuant to Sections 4.2, 4.4, 4.4, and 4.6; and (2) that the proposed minimum flow requirement of 1,710 cfs provides safe, timely, and effective downstream passage to emigrating diadromous fish. The FEMP shall be submitted to FERC for approval 6 months prior to the implementation dates for installing fish passage systems.

The Licensee shall begin implementing effectiveness testing measures at the start of the first migratory season after the fishway(s) are operational and shall conduct quantitative fish passage effectiveness testing and evaluation for a minimum of three years. If MDMR requests a modification of the FEMP, the Licensee shall amend the FEMP within 30 days of the request and send a copy of the revised FEMP to MDMR and resource agencies. Any modifications to the FEMP by the Licensee will require approval by MDMR prior to implementation.

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Appendix A

American shad dam passage performance standard model results 06/18/2021

Summary

Existing dam passage performance standard models that were developed for American shad (Stich et al. 2019) and that have since been implemented in 7 other watersheds for American shad and blueback herring (Stich et al. 2021) were extended to the Androscoggin River in Maine, USA. Most software routines and ecological inputs are generalized across catchments and species. A brief overview is provided below regarding species- or catchment-specific habitat definitions, environmental data, and biological data.

Model scenarios were run to explore effects of varying upstream passage efficiencies in combination with varying downstream survival through dams on American shad populations using the `androscogginRiverModel()` function in the *shadia* package for R (v2.0). The model runs considered variable upstream and downstream passage rates applied to all dams in the catchment. All model runs assumed an upstream passage time of 3 days (72 hours) and included separate downstream survival rates through dams for adult and juvenile fish. Probability of using the Sabattus River for spawning was assumed to be 0.05 (default) in all models based on proportional distribution of habitat in the Sabattus River and mainstem Androscoggin River (including Little Androscoggin). Both upstream and downstream passage rates at Littlefield Dam (breached) were set to 1.00 for all simulations. For each set of scenarios, outputs included total number of spawners returning to the river after 40 years as well as the number of spawners reaching habitat upstream of Worumbo Dam.

A model overview is provided below and is available on the [*shadia* project website]. The code is open-source and publicly available and can be installed from the [*shadia* project GitHub repository] following instructions at the bottom of the readme file. Results of the three sets of scenarios are presented in two sections following the overview to facilitate comparisons.

1 Model Overview

1. 1 Habitat definitions

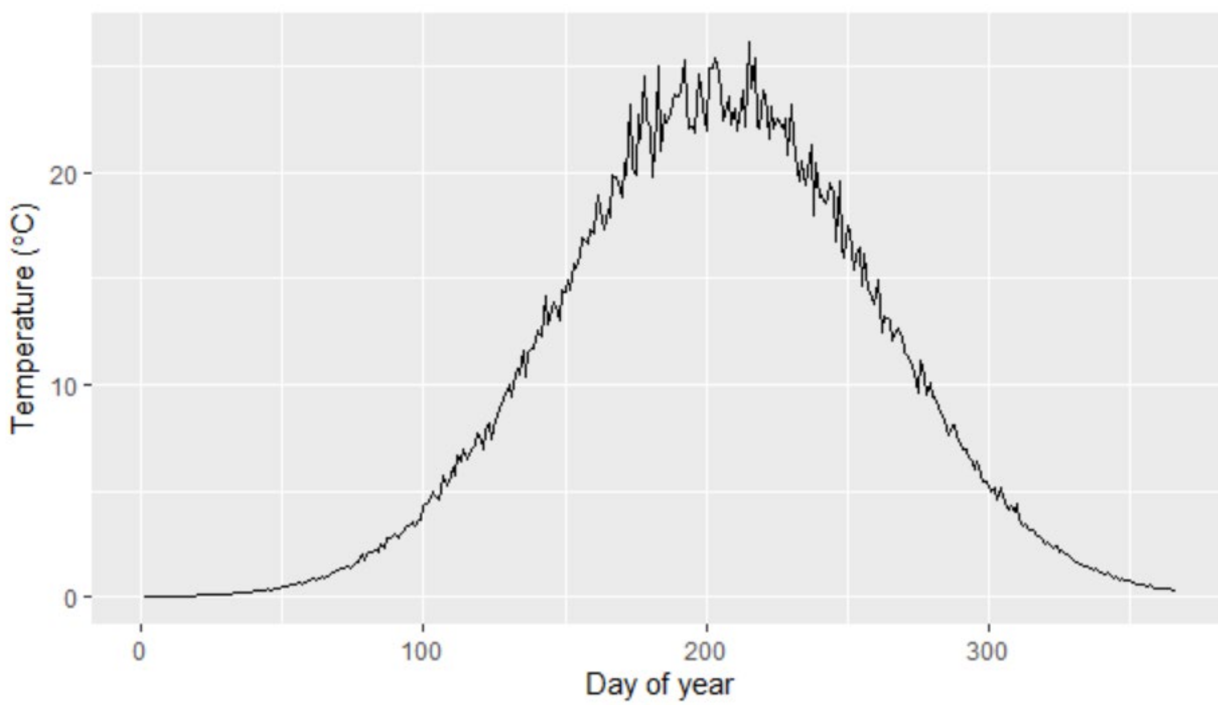
The Androscoggin River Model includes American shad and blueback herring habitat from Brunswick Dam at head of tide to Bisco Falls in the Little Androscoggin and Sabattus Pond in the Sabattus River. Projects that can be assessed in the Androscoggin and Little Androscoggin Rivers include Brunswick, Pejepscot, Worumbo, Lower Baker, Upper Baker, Littlefield (breached), Hackett's Mills, Mechanics Falls (Marcal), Welchville, and South Paris. Farwell and Fortier dams can each be assessed within the Sabattus River. The probability that fish use the mainstem or the Sabattus River can be specified by the user, and default value is based on proportion of habitat in each of the migration routes.

The river is split into two migratory routes at the confluence of the Androscoggin River and the Sabattus River. A total of 12 production units (PUs) are delineated based on dam locations in each route. The mainstem route includes PUs 1A through 10A. The Sabattus River route includes PUs 1A - 3A, and 4B-5B. Abundances and carrying capacities are evaluated collectively in any shared PUs after the upstream migration model runs each year.

Carrying capacity in the Androscoggin River is based on number of adult spawners per unit surface area of habitat, an approach that is widely used for New England Rivers, but that is also highly uncertain. As in other applications, we assume a carrying capacity of about 100 fish per acre (or 200 fish per ha) for American shad, and 484 fish per acre for blueback herring (based on counts in the Sebasticook River, ME, USA). Because of the uncertainty associated with these values here and elsewhere, this value is drawn from a distribution of values so sensitivity to assumptions can be assessed by users.

1. 2 Environmental data

Historical temperature data are compiled from various locations in the Androscoggin River watershed 2009-2018 by the Maine Department of Marine Resources, Pennsylvania State University and others who provided public data through the SHEDS Stream Temperature Database. Briefly, these sources include a total of 28 monitoring sites throughout the watershed. These data are used to simulate new daily temperatures using the `simTemperature()` function in *shadia*. The figure below shows an example of simulated daily temperatures in the Androscoggin River using these data.



1. 3 Biological data for American shad

Most biological data and behavioral processes in *shadia* are conserved between systems to standardize the approach. Others are seeded initially and are derived from model observations as emergent patterns thereafter. However, each river system requires some river-specific biological data including maximum age, starting population sizes, and membership in life-history based regions used to parameterize size at age and marine survival rates from coastal stock assessments.

The maximum age used for simulation in the Androscoggin River is age 13 based on observed fish ages in other New England Rivers (ASMFC 2020). Growth and marine survival inputs are parameterized using estimates for "Northern iteroparous" populations from Atlantic States Marine Fisheries Commission (ASMFC) 2020 American shad stock assessment. Growth and mortality are both projected from parameters of a von Bertalanffy growth function (VBGF) that includes effects of sea surface temperature on parameters L_∞ and K. Marine survival and growth parameters are projected under RCP8.5 for this system using SST from the Northeast Continental Shelf Large Marine Ecosystem (Gilligan et al. 2021).

2 Model Scenarios

2. 1 Catchment-wide passage scenarios

These scenarios explored catchment-wide abundance of spawning American shad under variable 72-hour upstream passage efficiencies (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.00), with variable adult downstream passage (0.5, 0.6, 0.7, 0.8, 0.9, 1.00) and juvenile downstream passage (0.80, 0.90, or 1.00). The same upstream, downstream, and downstream juvenile passage rates were assigned to all dams in the watershed. A total of 15,000 simulations were run for this scenario set to characterize uncertainty.

3 Results

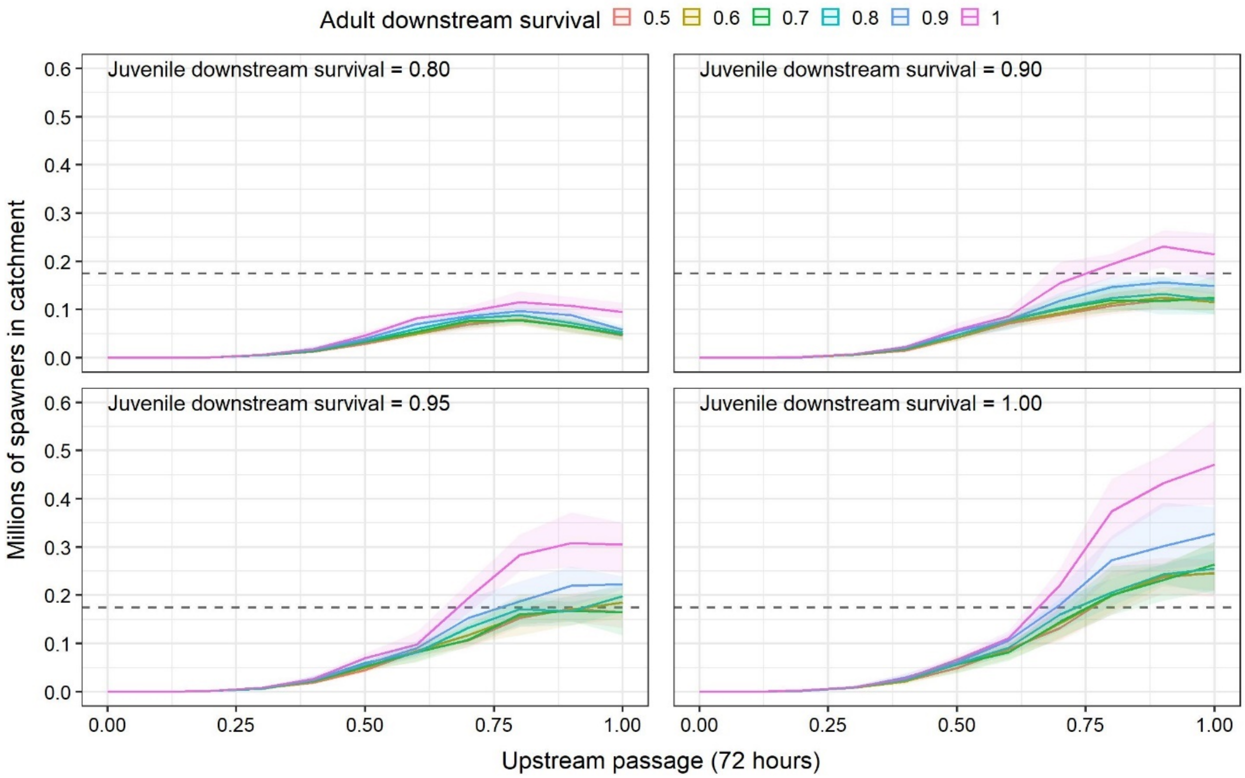
3. 1 Catchment-wide passage scenarios

These scenarios explored catchment-wide abundance of spawning American shad under variable upstream passage efficiencies (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.00) with variable adult downstream passage (0.5, 0.6, 0.7, 0.8, 0.9, 1.00) and juvenile downstream passage (0.80, 0.90, or 1.00). Each scenario assumes the same upstream efficiency, upstream passage time (72 h), and downstream survival at all dams in the watershed. Catchment-wide abundance is reported in 3. 1. 1 and abundance of adults upstream of Worumbo Dam is shown in 3. 1. 2.

3. 1. 1 Catchment-wide abundance

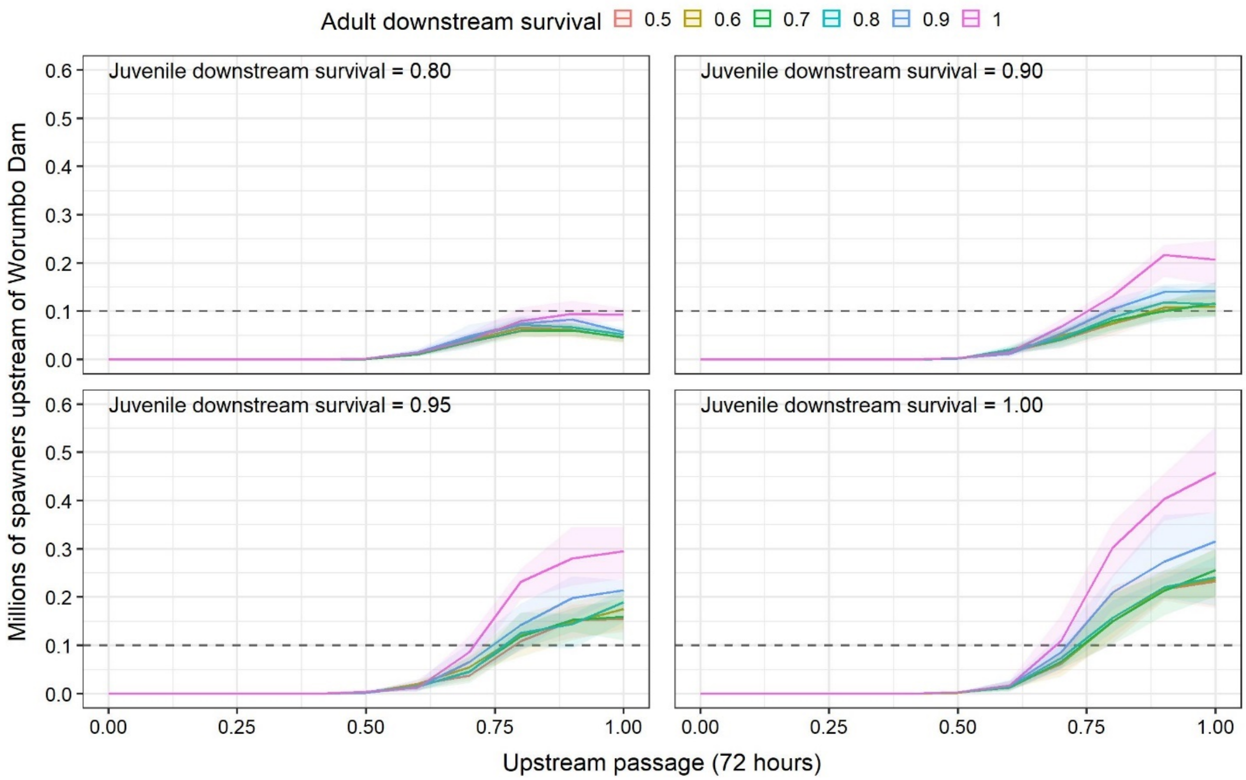
The figure below shows predicted population responses of American shad to varying 72-hour upstream passage, and downstream survival of adults and juveniles through dams. The horizontal, dashed line shows a reference population size of 175,000 spawners. Solid lines show mean predicted abundance, and transparent ribbons show 95% confidence intervals around estimated mean abundances.

American shad dam passage performance standard model results 06/18/2021



3. 1. 2 Number of spawners upstream of Worumbo Dam

The figure below shows predicted number of spawners upstream of Worumbo Dam with varying 72-hour upstream passage, and downstream survival of adults and juveniles through dams. The horizontal, dashed line represents a reference point of 100,000 fish. All other symbols are defined as in the previous figure.



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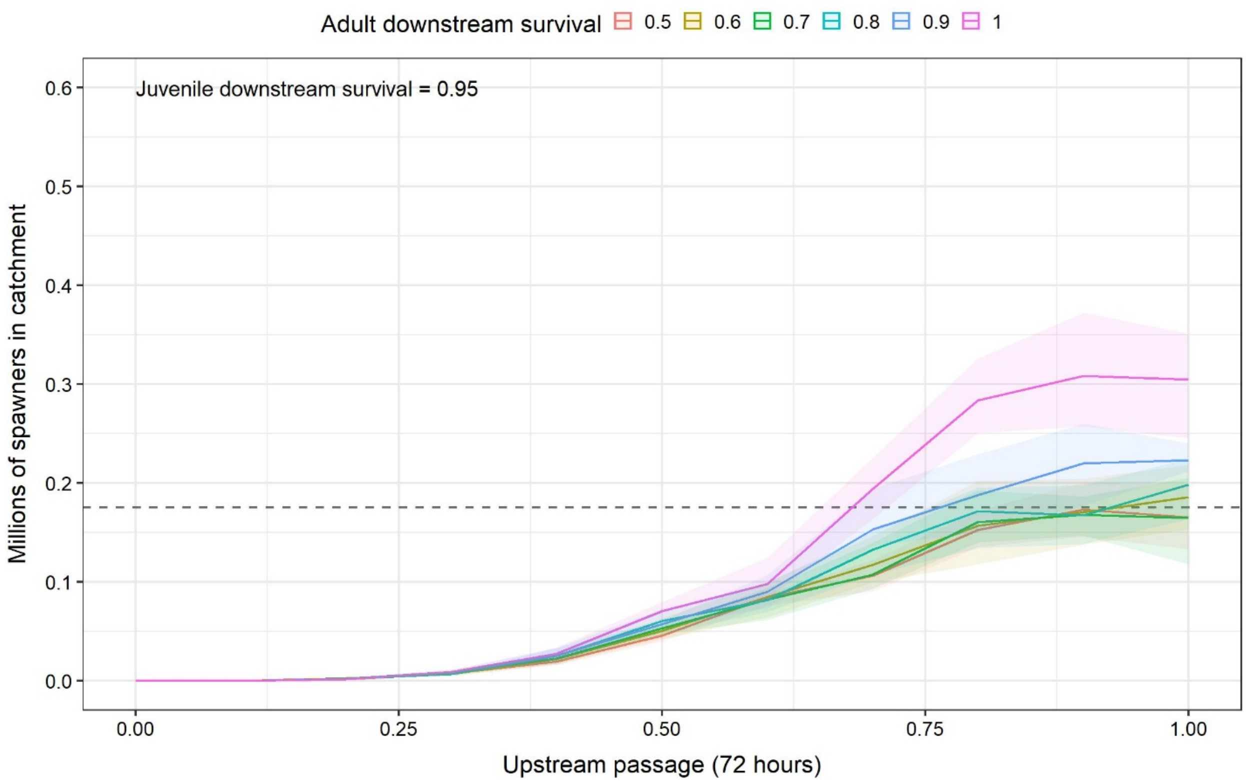
American shad dam passage performance standard model results 06/18/2021

Expanded figures from scenario set 1

A. 1 Catchment-wide abundance

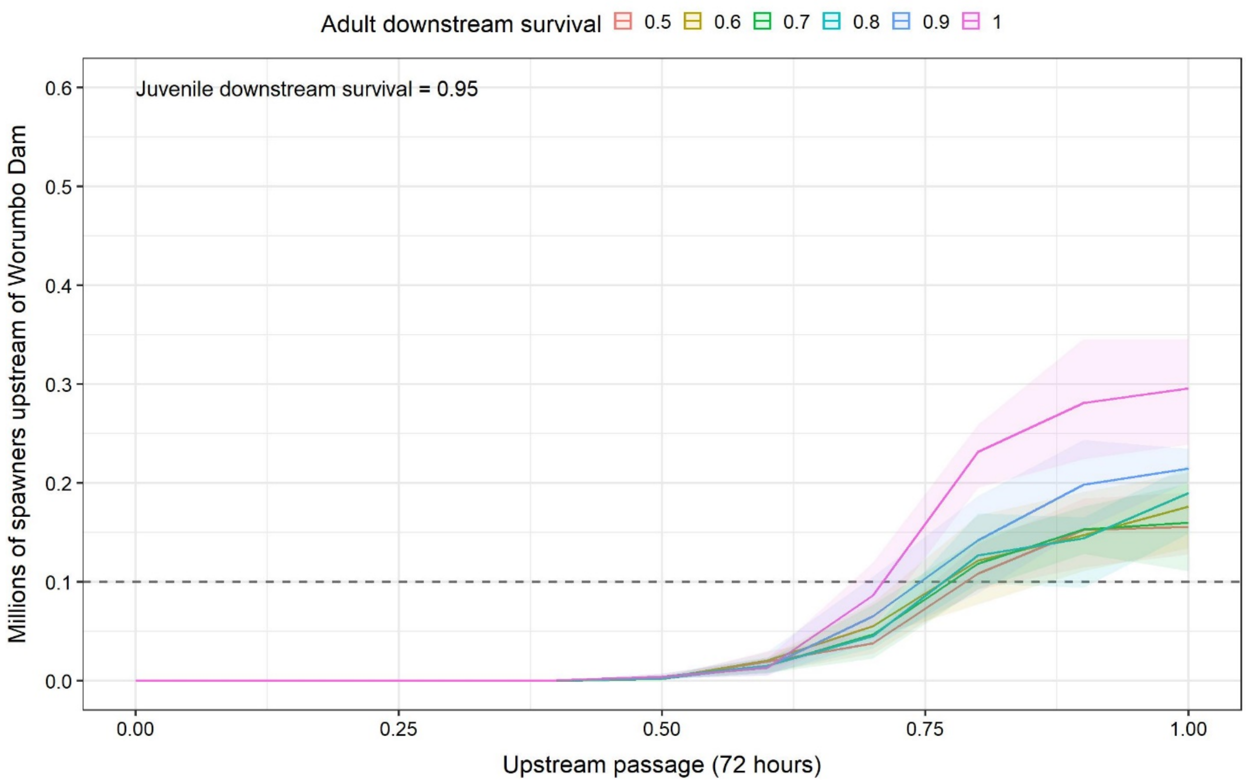
The figure below shows predicted catchment-wide abundance of American shad with varying 72-hour upstream passage, and downstream survival of adults when juvenile downstream survival through dams = 0.95. The horizontal, dashed line shows a reference population size of 175,000 spawners. Solid lines show mean predicted abundance, and transparent ribbons show 95% confidence intervals around estimated mean abundances.



American shad dam passage performance standard model results 06/18/2021

A. 2 Abundance upstream of Worumbo Dam

The figure below shows predicted abundance of American shad upstream of Worumbo Dam with varying 72-hour upstream passage, and downstream survival of adults when juvenile downstream survival through dams = 0.95. The horizontal, dashed line shows a reference population size of 175,000 spawners. Solid lines show mean predicted abundance, and transparent ribbons show 95% confidence intervals around estimated mean abundances.



Blueback herring dam passage performance standard model results 06/18/2021

Summary

Existing dam passage performance standard models that were developed for American shad (Stich et al. 2019) and that have since been implemented in 7 other watersheds for American shad and blueback herring (Stich et al. 2021) were extended to the Androscoggin River in Maine, USA. Most software routines and ecological inputs are generalized across catchments and species. A brief overview is provided below regarding species- or catchment-specific habitat definitions, environmental data, and biological data.

Model scenarios were run to explore effects of varying upstream passage efficiencies in combination with varying downstream survival through dams on blueback herring populations using the `androscogginRiverModel()` function in the *shadia* package for R (v2.0). The model runs considered variable upstream and downstream passage rates applied to all dams in the catchment. All model runs assumed an upstream passage time of 3 days (72 hours) and included separate downstream survival rates through dams for adult and juvenile fish. Probability of using the Sabattus River for spawning was assumed to be 0.05 (default) in all models based on proportional distribution of habitat in the Sabattus River and mainstem Androscoggin River (including Little Androscoggin). Both upstream and downstream passage rates at Littlefield Dam (breached) were set to 1.00 for all simulations. For each set of scenarios, outputs included total number of spawners returning to the river after 40 years as well as the number of spawners reaching habitat upstream of Worumbo Dam.

A model overview is provided below and is available on the *shadia* project website. The code is open-source and publicly available and can be installed from the *shadia* project GitHub repository following instructions at the bottom of the readme file. Results of the three sets of scenarios are presented in two sections following the overview to facilitate comparisons.

1 Model Overview

1. 1 Habitat definitions

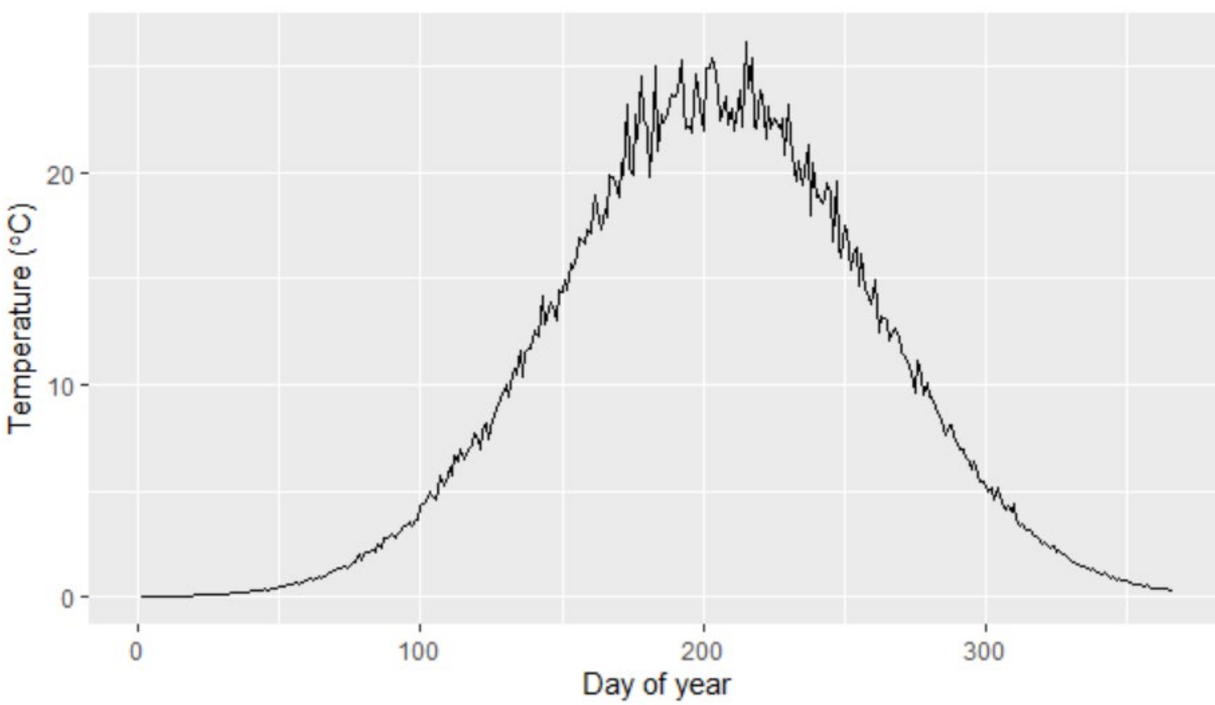
The Androscoggin River Model includes American shad and blueback herring habitat from Brunswick Dam at head of tide to Bisco Falls in the Little Androscoggin and Sabattus Pond in the Sabattus River. Projects that can be assessed in the Androscoggin and Little Androscoggin Rivers include Brunswick, Pejepscot, Worumbo, Lower Baker, Upper Baker, Littlefield (breached), Hackett's Mills, Mechanics Falls (Marcal), Welchville, and South Paris. Farwell and Fortier dams can each be assessed within the Sabattus River. The probability that fish use the mainstem or the Sabattus River can be specified by the user, and default value is based on proportion of habitat in each of the migration routes.

The river is split into two migratory routes at the confluence of the Androscoggin River and the Sabattus River. A total of 12 production units (PUs) are delineated based on dam locations in each route. The mainstem route includes PUs 1A through 10A. The Sabattus River route includes PUs 1A - 3A, and 4B-5B. Abundances and carrying capacities are evaluated collectively in any shared PUs after the upstream migration model runs each year.

Carrying capacity in the Androscoggin River is based on number of adult spawners per unit surface area of habitat, an approach that is widely used for New England Rivers, but that is also highly uncertain. As in other applications, we assume a carrying capacity of about 100 fish per acre (or 200 fish per ha) for American shad, and 484 fish per acre for blueback herring (based on counts in the Sebasticook River, ME, USA). Because of the uncertainty associated with these values here and elsewhere, this value is drawn from a distribution of values so sensitivity to assumptions can be assessed by users.

1. 2 Environmental data

Historical temperature data are compiled from various locations in the Androscoggin River watershed 2009-2018 by the Maine Department of Marine Resources, Pennsylvania State University and others who provided public data through the SHEDS Stream Temperature Database. Briefly, these sources include a total of 28 monitoring sites throughout the watershed. These data are used to simulate new daily temperatures using the `simTemperature()` function in *shadia*. The figure below shows an example of simulated daily temperatures in the Androscoggin River using these data.



1. 3 Biological data for blueback herring

Most biological data and behavioral processes in *shadia* are conserved between systems to standardize the approach. Others are seeded initially and are derived from model observations as emergent patterns thereafter. However, each river system requires some local or regional biological data including maximum age, probability of recruitment to spawn at each age, and growth used to parameterize size at age and marine survival rates from.

Some species-specific data were used in parameterizing blueback herring models, although the majority of movement dynamics are the same as for American shad because 1) previously implemented dynamics were based on body lengths per second, and 2) similar data for blueback herring are currently lacking.

Species-specific life-history inputs from blueback herring from the Kennebec River, co-located within the Merrymeeting Bay watershed, are used for this model. These inputs include maximum age, cumulative probability of recruitment to first spawn, probability of repeat spawning, length-at-age and von Bertalanffy growth parameter estimates, and natural mortality estimates.

- **Maximum age** reported by Maine Department of Marine Resources (MEDMR, unpublished data) was 7 years.
- **Cumulative probability of recruitment to first spawn** from the same data set were 0, 0.01, 0.48, 0.90, 1, 1, 1 for ages 1 - 7.
- **Probability of repeat spawning at age** was initialized for ages 1-7 as: 0, 0, 0.004, 0.28, 0.83, 1, 1, and derived thereafter from simulated spawning populations.
- **Parameters of the von Bertalanffy growth function (VBGF)** were estimated from `age` and `length` data provided by MEDMR. Three VBGFs were fit using Bayesian hierarchical models in Stan software using Rstan. These included sex-aggregate, male-only, and female-only models. The full posteriors for log-scale parameters `Linf`, `K`, and `t0` are stored in `vbgf_kennebec_bbh_agg`, `vbgf_kennebec_bbh_m`, and `vbgf_kennebec_bbh_f`. A description of the estimates can be accessed in R by typing `?vbgf_kennebec_bbh_...` in the console and running, where `...` should be replaced by `agg, m,` or `f`. Sex-specific lengths of simulated fish are drawn for each fish in each year by sampling one set of correlated VBGF parameters from the appropriate posterior to incorporate these correlations and avoid nonsensical pairing of simulated VBGF parameters.
- **Natural mortality (*M*)** is estimated on a per-simulation basis (not per-year) from the sex-aggregated VBGF parameters using the modification of Pauly (1980) recommended by Then et al. (2015) when virgin maximum age of a stock is unknown.

2 Model Scenarios

2. 1 Catchment-wide passage scenarios

These scenarios explored catchment-wide abundance of spawning blueback herring under variable 72-hour upstream passage efficiencies (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.00), with variable adult downstream passage (0.5, 0.6, 0.7, 0.8, 0.9, 1.00) and juvenile downstream passage (0.80, 0.90, or 1.00). The same upstream, downstream, and downstream juvenile passage rates were assigned to all dams in the watershed. A total of 15,000 simulations were run for this scenario set to characterize uncertainty.

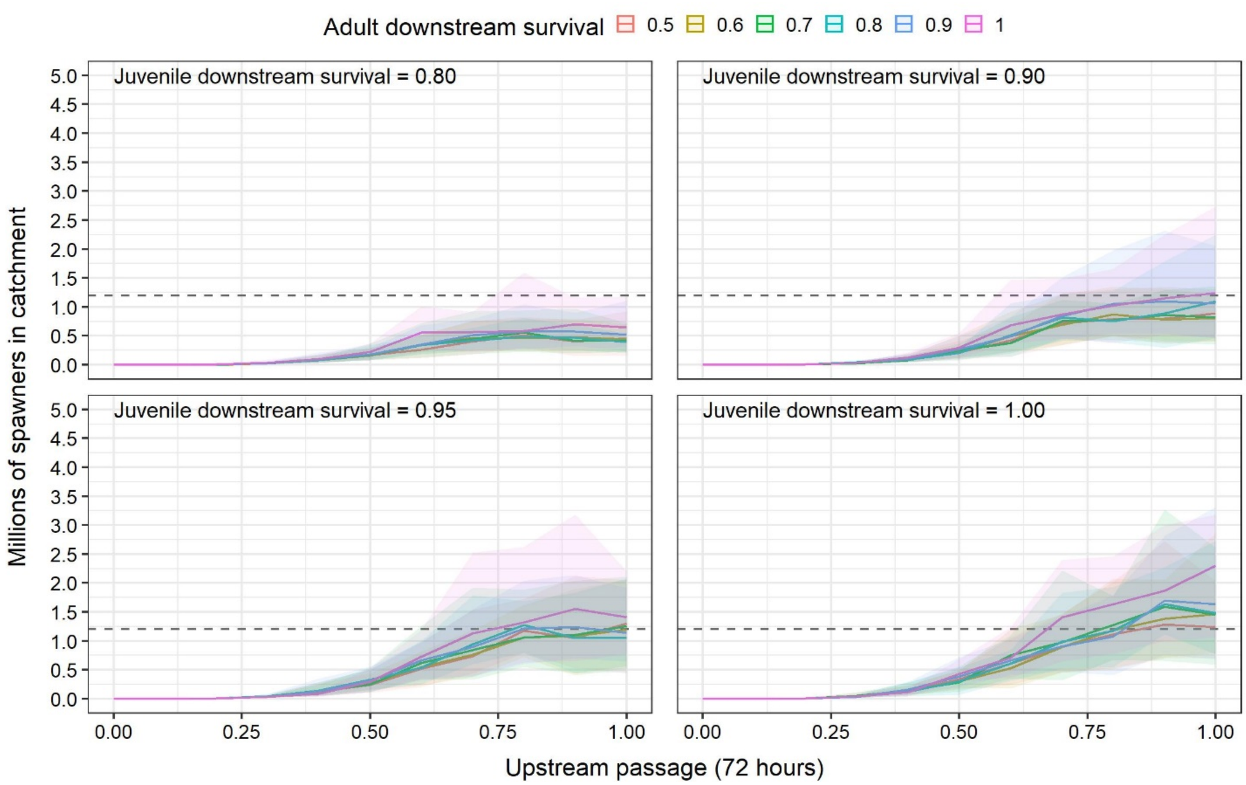
3 Results

3. 1 Catchment-wide passage scenarios

These scenarios explored catchment-wide abundance of spawning blueback herring under variable upstream passage efficiencies (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.00) with variable adult downstream passage (0.5, 0.6, 0.7, 0.8, 0.9, 1.00) and juvenile downstream passage (0.80, 0.90, or 1.00). Each scenario assumes the same upstream efficiency, upstream passage time (72 h), and downstream survival at all dams in the watershed. Catchment-wide abundance is reported in 3. 1. 1 and abundance of adults upstream of Worumbo Dam is shown in 3. 1. 2.

3. 1. 1 Catchment-wide abundance

The figure below shows predicted population responses of blueback herring to varying 72-hour upstream passage, and downstream survival of adults and juveniles through dams. The horizontal, dashed line shows a reference population size of 1.20 million spawners. Solid lines show mean predicted abundance, and transparent ribbons show 95% confidence intervals around estimated mean abundances.



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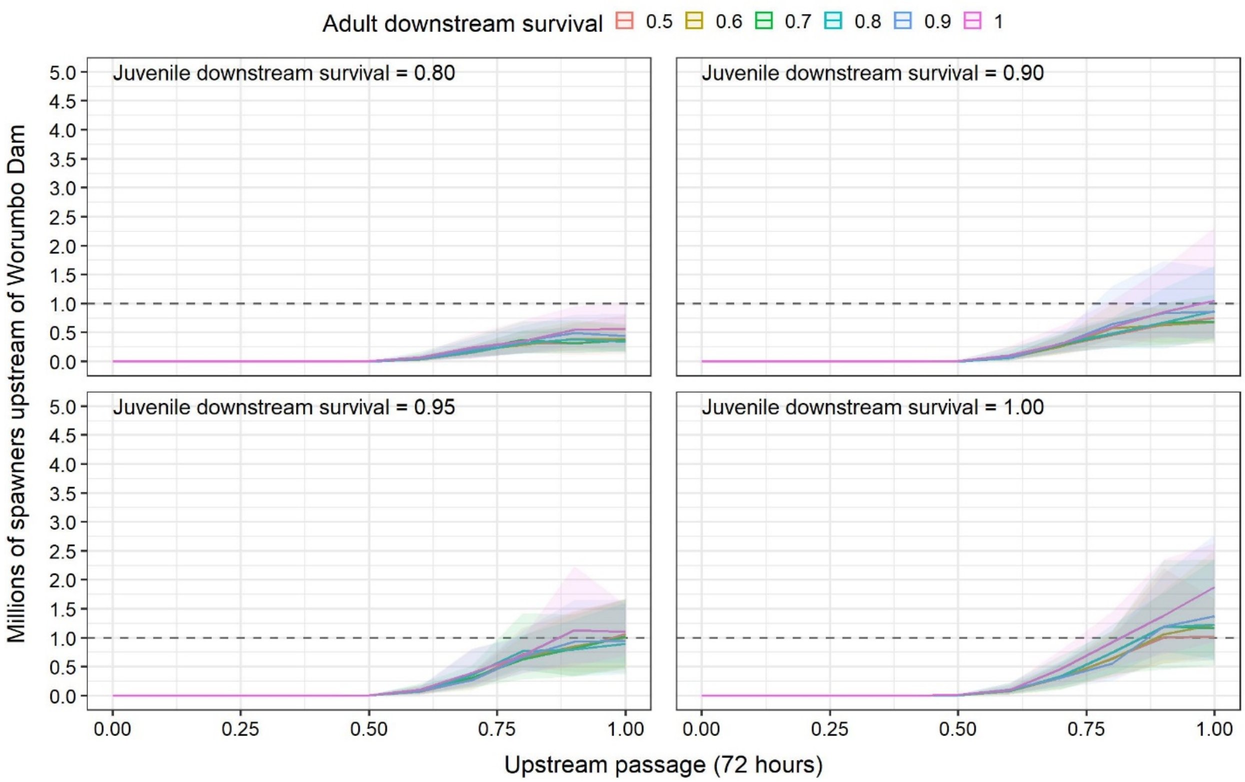
3. 1. 2 Number of spawners upstream of Worumbo Dam

The figure below shows predicted number of spawners upstream of Worumbo Dam with varying 72-hour upstream passage, and downstream survival of adults and juveniles through dams. The horizontal, dashed line represents a reference point of 1 million spawners. All other symbols are defined as in the previous figure.



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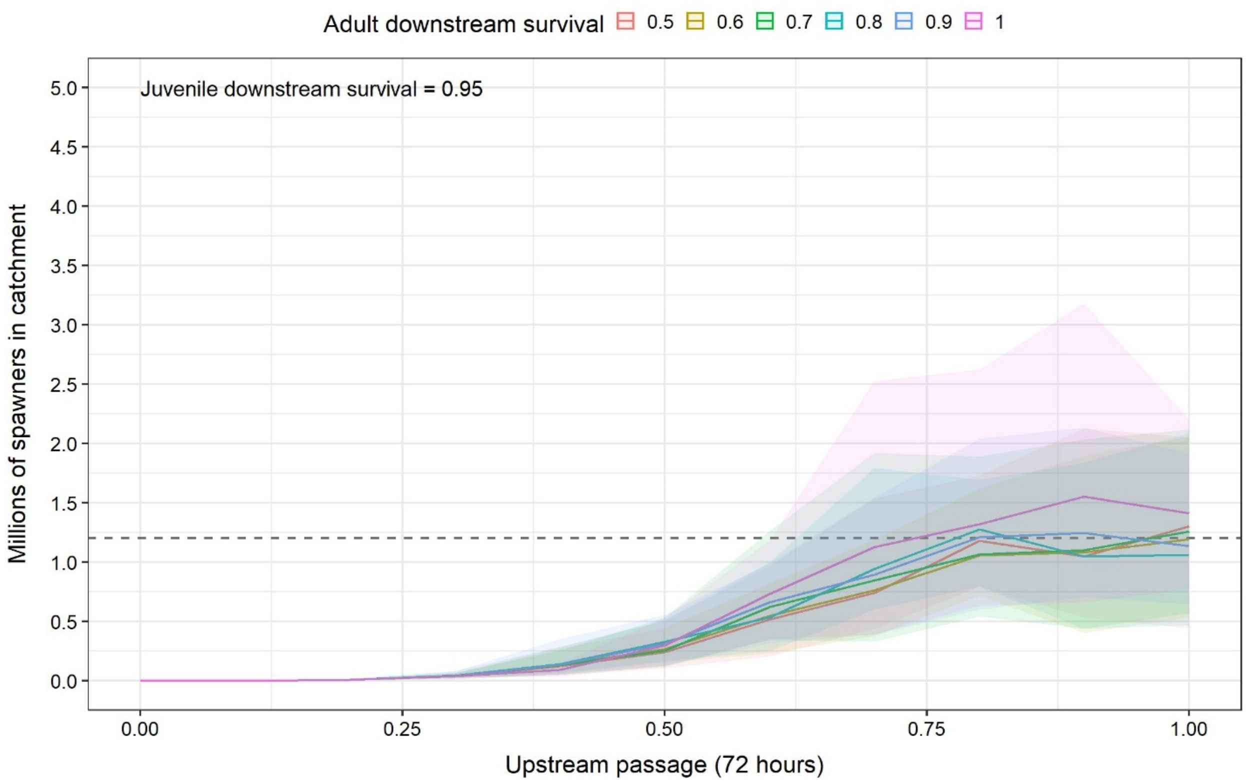
Expanded figures from scenario set 1

A. 1 Catchment-wide abundance

The figure below shows predicted catchment-wide abundance of blueback herring with varying 72-hour upstream passage, and downstream survival of adults when juvenile downstream survival through dams = 0.95. The horizontal, dashed line shows a reference population size of 1.2 million spawners. Solid lines show mean predicted abundance, and transparent ribbons show 95% confidence intervals around estimated mean abundances.



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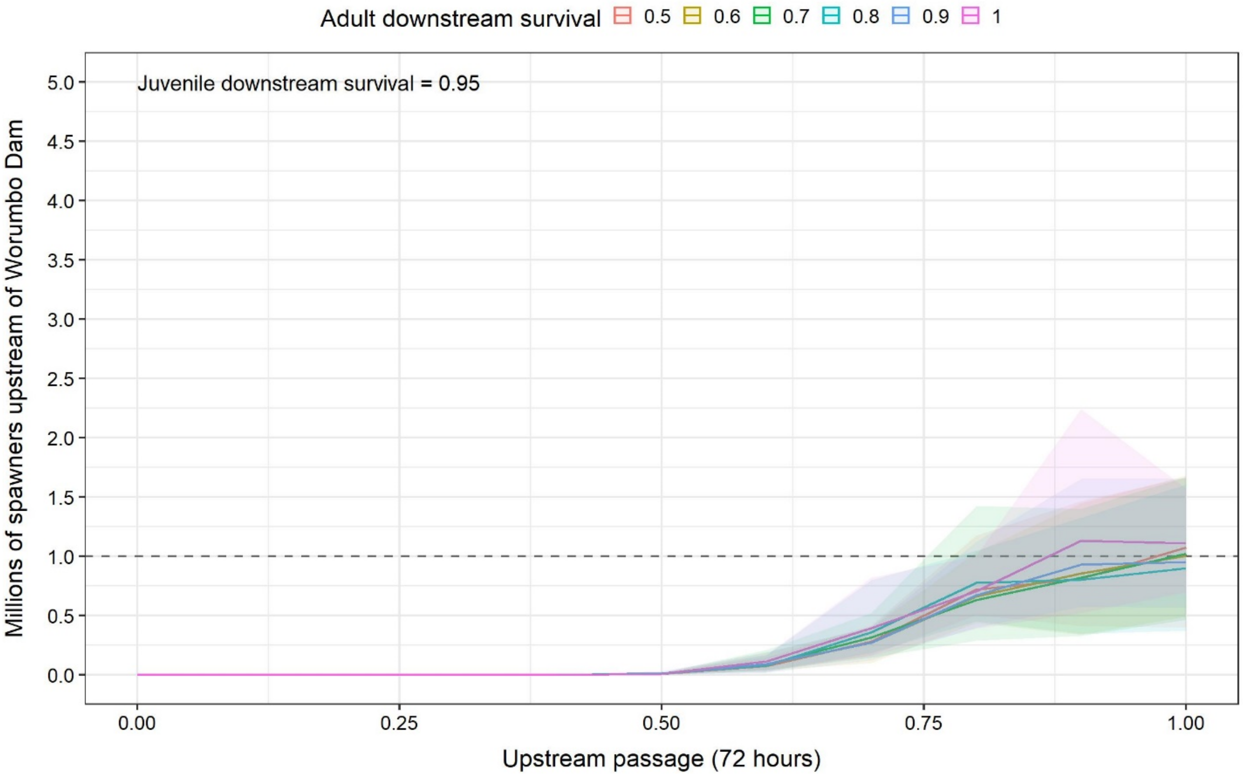
A. 2 Abundance upstream of Worumbo Dam

The figure below shows predicted abundance of blueback herring upstream of Worumbo Dam with varying 72-hour upstream passage, and downstream survival of adults when juvenile downstream survival through dams = 0.95. The horizontal, dashed line shows a reference population size of 1 million spawners. Solid lines show mean predicted abundance, and transparent ribbons show 95% confidence intervals around estimated mean abundances.

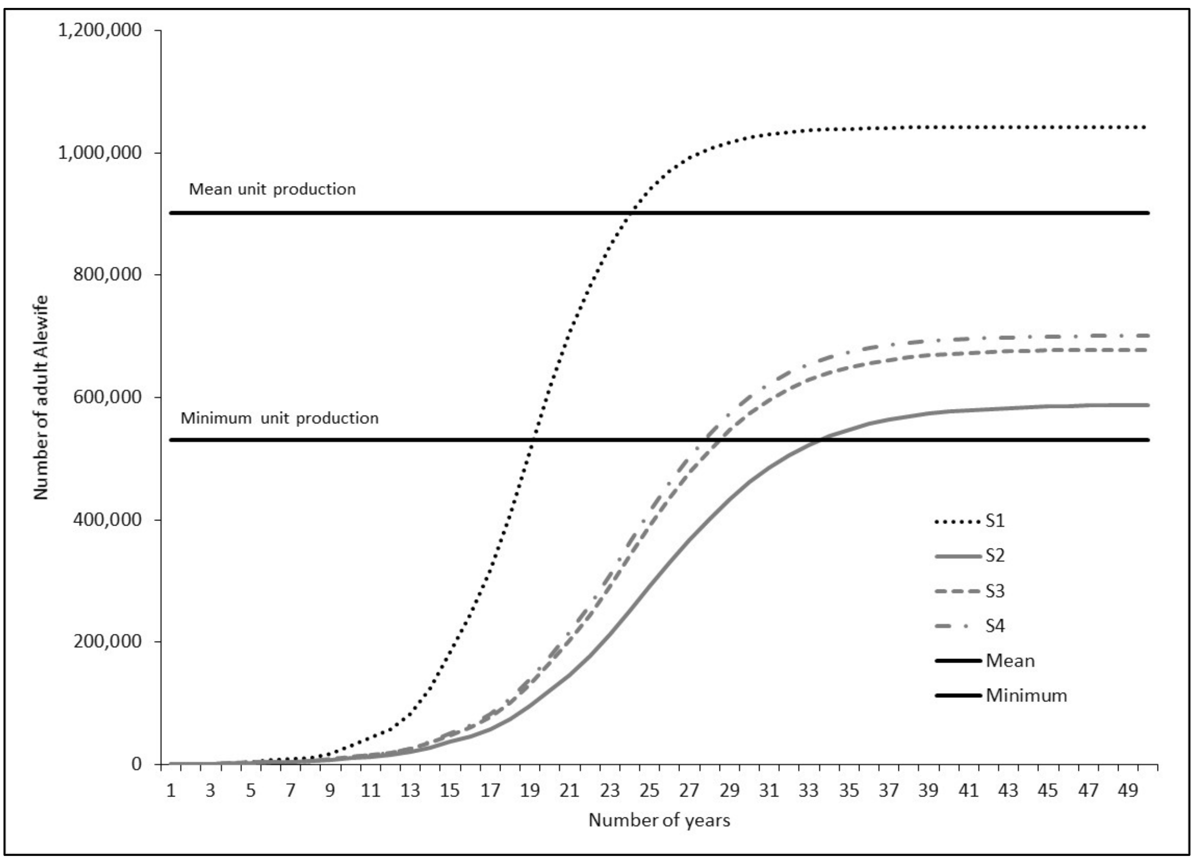


Alewife Population Model results 6/18/2021

In 2020, the "Alewife population model", a web-based application1 for understanding likely fish passage outcomes for Alewife, was developed by Betsy Barber, Alejandro Molina-Moctezuma, Jamie Gibson, Andrew O'Malley, and Joseph Zydlewski. The basic structure and inputs of the original model have been described in Barber et al. (2018), and the same information and the R code is annotated at the web site.

MDMR used the Alewife population model to estimate upstream and downstream passage efficiency that would be needed to meet our restoration goals for the Sabattus River (2,245 acres of habitat would produce a minimum sustainable population of 527,481 adult Alewife.

The figure show modeled adult Alewife abundance in the Sabattus River under four scenarios (S1-S4) of upstream and downstream passage efficiency at three mainstem hydropower dams (Brunswick, Pejepscot, and Worumbo) and three nonhydropower dams on the Sabattus River (Farwell, Fortier, and Sleeper). In the baseline scenario (S1), upstream passage of adults and downstream passage for adults and juveniles at all dams was 100% efficient (the equivalent of all dams removed). In S2, upstream and downstream passage for all life stages at all dams was 95% efficient. In S3, downstream passage efficiency at the nonhydropower dams was increased to 98% efficiency. In S4, all passage at one of the nonhydropower dams was increased to 100% (removed).



[1] https://umainezlab.shinyapps.io/Alewifepopmodel/