Friends of Merrymeeting Bay

P.O. Box 233, Richmond, ME 04357 www.fomb.org

Comments on Brunswick, Maine Hydroelectric Project, Androscoggin River P-2284-0052

6/20/24

VIA E-FILING

Debbie-Ann A. Reese, Acting Secretary
Federal Energy Regulatory Commission
888 First Street, N.E., Room 1A
Washington, DC 20426

Re: COMMENTS ON THE PAD AND SCOPING DOCUMENT, AND IDENTIFICATION OF ISSUES AND ASSOCIATED STUDY REQUESTS

Dear Acting Secretary Reese,

Friends of Merrymeeting Bay (FOMB) submits the following Comment in the titled proceeding.

This dam and the project area fall entirely within the focus area of FOMB research, advocacy, education and land protection work. Our water quality monitoring in the lower Androscoggin has bracketed the project area since 1999 and has specifically included multiple sites within project area since 2010. FOMB sampling has been done under either EPA or DEP quality assurance programs. Before continuing we must point out and protest for the record, the obsolete and harmful nature of excessively long FERC licenses, industry-welcomed outdated relics of the Rural Electrification Administration days when high capital costs of large dam building led to generous times for project amortization. Long licenses are outdated, because these dams have all been paid for many times over by now and they are harmful because license terms and conditions deter spending on technological and operational updates that would further reduce environmental impacts to the public trust resources all dams use. FERC should actually be the entity to bring this before congress, proposing changes as amendments to the Federal Power Act.

Pursuant to Section 303(d) of the federal Clean Water Act. 33 U.S.C. § 1313(d) and as noted in the **2012 Maine DEP Integrated Water Quality and Assessment Report** at 82, the lower Androscoggin River mainstem segment between the Pejepscot Dam and the Brunswick Dam, is listed in non-attainment of its designated uses required in the previous Class C and current Class B water quality standards under Category 4-B for dioxin, Category 4-C-FPB for aquatic life impairment because of inadequate fish passage, and Category 5-D for impairment due to legacy polychlorinated biphenyls (PCBs) found in fish tissue. (See **Exhibit 1-Sebasticook Eel PCB's for example)**.

Information provided to the Department of Environmental Protection (DEP) from the Department of Marine Resources (DMR) indicates the segment fails to support an indigenous species of fish, the American shad, as required by statute. The dam at Brunswick and the fish passage device repeatedly fail to allow passage of a sufficient number of shad to establish a sustainable population in the river above the dam. This facility is a FERC licensed facility with a requirement for fish passage as part of a State-adopted restoration plan for this species.

Under state law, fishing and fish habitat are designated uses for Class B waters. 38 M.R.S.A § 465(3)(B). To support those uses, the Class B standards specifically provide that "waters must be of sufficient quality to support all aquatic species indigenous to those waters without detrimental changes to the resident biological community." The habitat must be characterized as unimpaired. *Id*. § 465(3)(A).

Violation of narrative water quality criteria or the absence of a designated use constitutes non-attainment of Maine's water quality standards. *See Bangor Hydro-Electric v. Bd. of Env. Prot.*, 595 A. 2d 438, 442 (Me 1991). As detailed by annual reports of the Maine DMR Androscoggin River Anadromous Fish Restoration Program, hereby incorporated by reference, they provide a definitive and conclusive more than 25- year record showing that, due to the Brunswick dam barrier, the Androscoggin River basin upstream of it no longer has an indigenous (or even artificially sustained) population of American shad and that by their absence, the resident biological community has been detrimentally affected. Neither are there upstream passage provisions for American eel currently at the Brunswick dam, and Brookfield does not propose any in their Preliminary Application Document (PAD). To meet State water quality standards and remediate what is currently and has been a Clean Water Act violation, this project must provide safe, timely, and effective passage for all diadromous species.

FOMB and Bowdoin College have both conducted multi-year underwater counts of shad in multiple areas below the Brunswick dam but mostly at a site immediately below the Frank Wood Bridge on the Brunswick shore. To illustrate the egregiousness of Brunswick's longstanding fish passage problem, we offer this recent example from 2023. On just one incoming tide using an Aris Explorer 3000 sonar video camera we counted at least 7,500 shad passing upstream toward the fishway. Yet, for the entire season, the fishway passed only 13 shad. This year we are again looking at many thousands (probably closer to 10,000) in a single half tide vs 58 shad passed into the head pond as of June 17 (**Maine DMR 2024 Trap Counts**).

The vertical slot fishway at Brunswick was designed to pass 85,000 shad and 1 million river herring (**Exhibit 2-Rizzo, USFWS 1977**). Actual passage statistics show upstream passage is an abject failure and probably downstream passage is as well. Delays and mortality causing detrimental changes to the biological community create a "take" under the ESA. The fishway pools have high velocity flows with virtually no rest areas, fish can take two days to ascend using valuable energy reserves required for spawning and the rest of their migration and the fishway entrance is in too close proximity to flows from turbine Unit 1 creating confusing bubble and flow barriers making the fishway entrance quite difficult to find. Downstream passage too is a failure with 3.5” clear spacing between trash rack bars (instead of ½” spacing or punch plate) allowing turbine intake of all but the largest fish (**Exhibit 3- Eels in turbine, Exhibit 4- Alewives Kill-FERC-filings**), trash racks perpendicular to the flow (instead of angled towards a bypass), and inadequate turbine bypass limited to narrow access between turbine units 1 and 2 leading only to an 18”round pipe.

To place limited shad passage at Brunswick in perspective (Observations by Brookfield and MDMR in 2014 at the fishway show 20 shad observed at the fishway entrance and 5 shad in the fishway, but none successfully reached the top of the fishway. This equates to a fish passage efficiency of zero, ie. 25 observed, none passed [MDMR 2015]. The entire collection of Brunswick Fishway Reports since 1982 show an identical pattern, as does **Weaver, et al 2019 Exhibit 5)**, let’s consider several other facilities.

A type example is the Cataract Dam at head of tide of the Saco River in Saco and Biddeford, Maine. In 1993, the Cataract Dam Project was fitted with a modern fish elevator/lift designed to effectively pass American shad, river herring and Atlantic salmon. In its first year of operation, the lift successfully passed more than 800 American shad; in 1999 the lift passed more than 5,000 shad and in 2012 passed more than 6,000 shad. *See:* fishway count data in State of Maine American Shad Habitat Plan, MDMR 2013, at 12. In the very first year of operation of the Cataract Dam fish lift (1993), more than twice as many shad were passed (n=800) in one season than in the entire 33-year history of the Brunswick Dam fishway from 1982-2015 (n=350). In 2012, the number of shad passed at Cataract (n=6,404) was nearly 20 times the number passed in 33 years at Brunswick (n=350). *Id.* This year’s shad count at Cataract has not been reported to DMR yet but last year’s count was 1,276 vs 13 at Brunswick.

A second comparative metric is the Penobscot River, Maine's largest. Until spring 2014, the Penobscot River was blocked near its head of tide by a large, concrete dam of similar height and design as the Brunswick Dam (the Veazie Dam). In the 1960s and 1970s it was equipped with a vertical slot fishway of very similar design to that installed at Brunswick in 1980. Fishway records indicate that from the 1970s to 2013, only 16 American shad were recorded successfully passing through the fishway (Penobscot River Restoration Trust 2014). In 2012 and 2013, the Veazie Dam and the next dam upriver (the Great Works Dam) were removed by the PRRT and its partners. In those same years the Milford Dam in Old Town, Maine (now owned by Brookfield) was equipped with a modern fish lift/elevator system. In 2014, the Milford Dam fish lift passed 800 American shad (PRRT 2014) and in 2015 the fish lift passed 1,800 American shad. *Id.* As at the Cataract Dam on the Saco River, the Milford fish lift on the Penobscot River passed in its first season twice as many shad (n=800) as the Brunswick fishway has passed in its entire 33 years of operation (n=350). As of June 10, 2024, the Milford lift has passed 9,862 shad. It seems obvious that the only possible reason the Cataract Dam fish lift and Milford fish lift have achieved these very high American shad passage numbers beginning with their first year of operation is because they **work** for American shad -- and the Brunswick dam fishway does not for American shad and, is not effective for river herring when compared to other rivers with this fishery (**Exhibit 6-Sebasticook, Damariscotta Mills, Brunswick-Lichter, et al, FOMB 2024**, **Exhibit 7-Outlet Stream-Friedman, FOMB 2024**). Note lifts are not necessarily the answer, location is important and the Lockwood lift on the Kennebec is an example of a poorly sited facility well downstream of the actual dam which in any medium flows or above, has far more attraction flow than the lift.

On January 31, 2011, Friends of Merrymeeting Bay and Environment Maine filed lawsuits in US District Court (Maine) against owners of all dams on the lower Kennebec and Androscoggin Rivers for violating take provisions of the Endangered Species Act (ESA) and in some cases for violating the Clean Water Act given non-compliance with their Water Quality Certifications (WQC) for salmon and shad passage. At the time NextEra owned Brunswick on the Androscoggin and Weston, Shawmut and Lockwood on the Kennebec while Brookfield owned HydroKennebec. Now all are owned by Brookfield.

In 2011, dam removal was not on the table for any of the dams given their outstanding terms of licensure so our claims (**Exhibits 8 & 9**) and expert opinions (**Exhibits 10 & 11** [**Bailey and Hutchings-biological impacts of dams on the GOM DPS**] and **Exhibit 12** [**Chang-economic impacts of hydropower and seasonal closures for passage]**) focused on improvements that could be made with the dams in place.

Thirteen years later, fish passage conditions remain much the same despite a plethora of studies. Any artificial fish passage requires a good deal of human intervention and management (**Merrymeeting News Spring 2008 at 1 & 4** **Exhibit 13**), hence dam removal is always the better option to maximize river restoration and one FOMB recommends especially since alternative and cleaner forms of power, particularly solar, are now more readily available.

As FERC is well aware, the Androscoggin River dams, especially Brunswick, harass, harm, and kill –and thus "take" – diadromous species including Atlantic salmon, American shad, alewives and blueback herring (collectively river herring) in a number of ways. Among these are the following (**mostly from Exhibits 8 & 9**):

a. The dams' turbines kill and injure out-migrating salmon (and other diadromous species) when the salmon and others attempt to pass through them. (**See Exhibit 4 filings re. Brunswick turbine mortality** & **Merrymeeting News, Fall 2016 at 4-Exhibit 14**)

b. The dams severely limit upstream passage of salmon and other diadromous species, preventing access to significant amounts of spawning and rearing habitat. (**Exhibit 6, Lichter, et al, FOMB, 2024 Merrymeeting News, Summer 2021at 6, Summer 2022 at 3, Spring 2024 at 4-Exhibit 15**).

c. Facilities meant to allow the salmon and other diadromous species to pass around or through the dams cause delays in passage, resulting in incremental losses of salmon smolts, pre-spawn adults, and adults. (See cites at b).

d. The dams are barriers to the migration of other fish species whose presence is optimally necessary for the salmon to complete their life cycle. (See cites at b).

e. Turbine mortality of out-migrating eels at dams releases large amounts of organochlorines and other contaminants that would otherwise be carried out of our rivers. (**Exhibit 1- Chart showing PCB levels in silver eels out-migrating through Benton Falls dam on the Sebasticook River**)

f. The dams adversely alter predator-prey assemblages, such as the ability of the salmon to detect and avoid predators.

g. The dams create slow-moving impoundments in formerly free-flowing reaches. These altered habitats are less suitable for spawning and rearing of salmon and contribute to the dams' significant impairment of essential behavior patterns of the salmon. In addition, these conditions may favor non-native competitors at the expense of the native salmon.

h. The dams result in adverse hydrological changes, adverse changes to stream and river beds, interruption of natural sediment, nutritional and debris transport (including to ocean waters-see **unnatural flows research-FOMB Cybrary**), and changes in water temperature, all of which contribute to the dams' significant impairment of essential behavior pattern for salmon and other diadromous species.

In their decision to include the Kennebec and Androscoggin River populations of Atlantic salmon on the Endangered Species List, the Services (NMFS and USFWS) found dams on those rivers play a major role in imperiling the salmon. The Services stated: "*The National Research Council stated in 2004 that the greatest impediment to self-sustaining Atlantic salmon populations in Maine is obstructed fish passage and degraded habitat caused by dams … Dams are known to typically kill or injure between 10 and 30 percent of all fish entrained at turbines [cite omitted]. With rivers containing multiple hydropower dams, these cumulative losses could compromise entire year classes of Atlantic salmon … Thus, cumulative losses at passage facilities can be significant … Dams remain a direct and significant threat to Atlantic salmon.*" 74 Fed. Reg. at 29362.

Similarly, the Services stated: "*Dams are among the leading causes of both historical declines and contemporary low abundance of the GOM DPS of Atlantic salmon [cite omitted].*" The Services also stated that the *"effects [of dams] have led to a situation where salmon abundance and distribution has been greatly reduced, and thus the species is more vulnerable to extinction … Therefore, dams represent a significant threat to the survival and recovery of the GOM DPS.*" 74 Fed. Reg. at 29366-29367.

In the Shawmut (P-2322-069) DEIS Summary section at 416 the Commission states: "*Overall, while dam removal would result in greater improvement of upstream and downstream passage survival for Atlantic salmon, alosines, American eel, and sea lamprey than relicensing the project, the upstream and downstream fish passage measures included in the Staff Alternative with mandatory conditions would nevertheless sufficiently enhance fish passage over existing conditions without the need to remove the dam.*" Everything said in the previous two paragraphs applies as well to shad, alewives, blueback herring and other species attempting to pass Brunswick and other dams or passing them with minimal success.

Despite the Commission's DEIS statement above regarding sufficiency of fish passage for Shawmut, FERC recommends neither dam removal or the Staff Alternative with Mandatory Conditions, instead opting for a straightforward Staff Alternative. The implication from these contradictory conclusions and recommendations is that FERC is not only rejecting Shawmut dam removal as recommended by various conservation groups, MDMR and NMFS but is also opting for less than sufficient improvements in fish passage by recommending the Staff Alternative rather than the Staff Alternative with Mandatory Conditions which would in theory "sufficiently enhance fish passage over existing conditions…" Hopefully FERC's inexplicable actions regarding Shawmut will be avoided when it comes to deliberations and determinations on Brunswick.

FERC in its mission to balance uses will do well to consider these words by 19th and 20th century eminent scientist and author Dr. Willard G. Van Name, associate curator of the Department of Invertebrate Zoology at the American Museum of Natural History in NY: "*The time to save a species is while it is still common. The only way to save a species is to never let it become rare*."

Largely given the problems with fish passage at Brunswick and the importance of correcting this situation, FOMB requests FERC conduct a full Environmental Impact Study (EIS) rather than Environmental Assessment (EA).

Sincerely,

Ed Friedman, Chair
207-666-3372

Attached Exhibits 1- 17

Founded in 1975, Friends of Merrymeeting Bay (FOMB) utilizes research, education, advocacy, and land conservation to preserve, protect, and improve the unique ecosystems of Merrymeeting Bay. Diadromous fish restoration in the Bay and Gulf of Maine is an important focus of the group.

FOMB Study Requests

A. Dam decommissioning and removal with site restoration

B. Passage improvements/alternatives to include fish lift (s) and nature-like passage

C. Temperature & DO profile in the project area upstream of the dam

D. Benthic Macroinvertebrate profile in the project area upstream of the dam

1. Describe the goals and objectives of each study proposal and the information to be obtained.

A. Any dam creates a host of environmental problems from fish passage to nutrient flows to water quality and production of potent greenhouse gases from impoundments. (**Exhibit 16-Hall, 2010)** Any artificial fish passage, no matter the type, requires constant human attention to maintain even minimal efficiencies. Variables requiring attention and subsequent adjustments include natural and intentional flow changes, mechanical problems, debris, storms, personnel, disease (i.e. covid shut-downs), etc. The ecosystem benefits of removing the Brunswick dam are enormous and electrical production small in the scheme of things, and easily being surpassed by alternative methods coming on line daily. Hydropower is definitely not "green." (**Exhibit 17-Merrymeeting News, 2020 at 4**) Dam removal needs to be seriously evaluated as a realistic option and alternative to modifying or replacing the existing fishway which will only be a "band-aid" approach. A comprehensive cost/benefit analysis of decommissioning/removal/restoration is necessary for a fair and reasonable evaluation and fact-based decision moving forward.

B. While still poor substitutes for a free-flowing river, fish lifts and nature-like fish passage are likely to provide more efficient and universal species passage than trying to "fix" the current vertical slot fishway. A comprehensive look at these alternatives leads to better decision making.

C. Rising temperatures-air and water, and falling dissolved oxygen (DO) levels are becoming an increasing problem which will only worsen as time goes by. Over the term of a license (unless changed by congress) a river could go from live to dead at today's rate of climate change. It's quite foreseeable that assuming the Brunswick dam remains in place, flows will need to be maintained at high levels to keep the impoundment temperature and DO levels (TDO) low and high enough respectively for fish to survive (another reason for dam removal). FOMB (currently as part of the MDEP VRMP program) monitors three sites above the dam in the project area monthly - May-October (temperature, DO, specific conductivity and bacteria)-the Mill Street park and Brunswick canoe portage (BCP), near the ledges above I-295 (BIL) and below the Pejepscot dam and Fish Park (FPD). A more comprehensive spatial and temporal temperature and DO profile using data loggers will allow for better flow management in the future assuming the dam stays in place. For an unknown reason, the DEP has requested only downstream TDO studies. Downstream, FOMB has years of water quality monitoring data and continues to monitor two sites-Brunswick Water St. boat launch (BWS) and further downstream historically at the Brunswick Bay Bridge remnant jetty (BBB) and more recently from a float on Island View Land (IVL).

D. Benthic Macroinvertebrates (BMI) provide a good indicator of water quality. As part of our Class B upgrade efforts on the lower Androscoggin, FOMB conducted BMI studies to DEP standards at five sites with one in the upstream project area for Brunswick, about midway (near our BIL water sampling site). DEP has sampled below the Pejepscot dam near the upper end of the project area. A more comprehensive spatial BMI study profile will allow for better flow management in the future assuming the dam stays in place. For an unknown reason, the DEP has requested only downstream BMI studies.

2. If applicable, explain the relevant resource management goals of the agencies or Indian tribes with jurisdiction over the resource to be studied.

A-D. Comply with state and federal (CWA) water quality standards and ESA. Maintain recreational attributes of study area waters.

3. If the requestor is not a resource agency, explain any relevant public interest considerations in regard to the proposed study.

A-D. Healthy and restored rivers improve quality of life not just for the organisms living in them (aquatic) and using them (birds mammals, reptiles/amphibians, plants) but for citizens living near or using the river. Citizen benefits include recreational, economic (real estate and river based recreation), scientific, sustenance and psychological.

4. Describe existing information concerning the subject of the study proposal, and the need for additional information

A-B. There are many studies on the harmful ecological effects of dams, for instance in the **Miscellaneous section** of the FOMB **Cybrary- unnatural flows research-FOMB Cybrary** and more in the **Biological section**.

C-D. FOMB **water quality data** from 1999 - 2023 are posted in the Chemical section of our Cybrary. Our **2021 BMI study** is posted here as well lower Androscoggin Classification Upgrade proposals. Other sources of information include DEP and Gomez & Sullivan studies for relicensing of the Pejepscot dam.

5. Explain any nexus between project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements.

A-D. This is explained in our comments and in #1 above. Aside from the obvious river obstruction and intricacies of artificial fish passage, flow regulations can directly affect water quality and thus aquatic life and habitat in the impoundment section, if not the entire upstream project area. Study results will evaluate potentially beneficial alternatives to current operations and better provide baselines in the case of water quality to set license parameters moving forward.

6. Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate filed season(s) and duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge

MDEP has established methodologies for water quality and BMI studies. Their comments provide citations. For our purposes, continuous data loggers are preferred for TDO studies. For analyses of passage alternatives and decommissioning/removal/restoration, it is important that mutually agreed upon (by the various stakeholders) third party consultants be hired rather than a typical industry consulting firm.

Comments on Brunswick, Maine Hydroelectric Project, Androscoggin River P-2284-0052

FOMB Exhibit List

1. Sebasticook Eel PCB Chart

2. Rizzo, USFWS 1977

3. Eels in turbines

4. Brunswick Alwives Kill

5. Weaver, et al. 2019 Observations of American Shad *Alosa sapidissima* Approaching and Using a Vertical Slot Fishway at the Head-of-Tide Brunswick…

6. Lichter, et al. Herring and Shad, FOMB 2024

7. Friedman, Outlet Stream-FOMB 2024

8. Next Era lawsuit

9. Brookfield Kennebec lawsuit

10. Expert Opinion-Baily

11. Expert Opinion- Hutchings

12. Expert Opinion-Chang

13. Merrymeeting News, Spring 2008

14. Merrymeeting News Fall 2016

15. Merrymeeting News-Summer 2021, Summer, 2022, Spring 2024

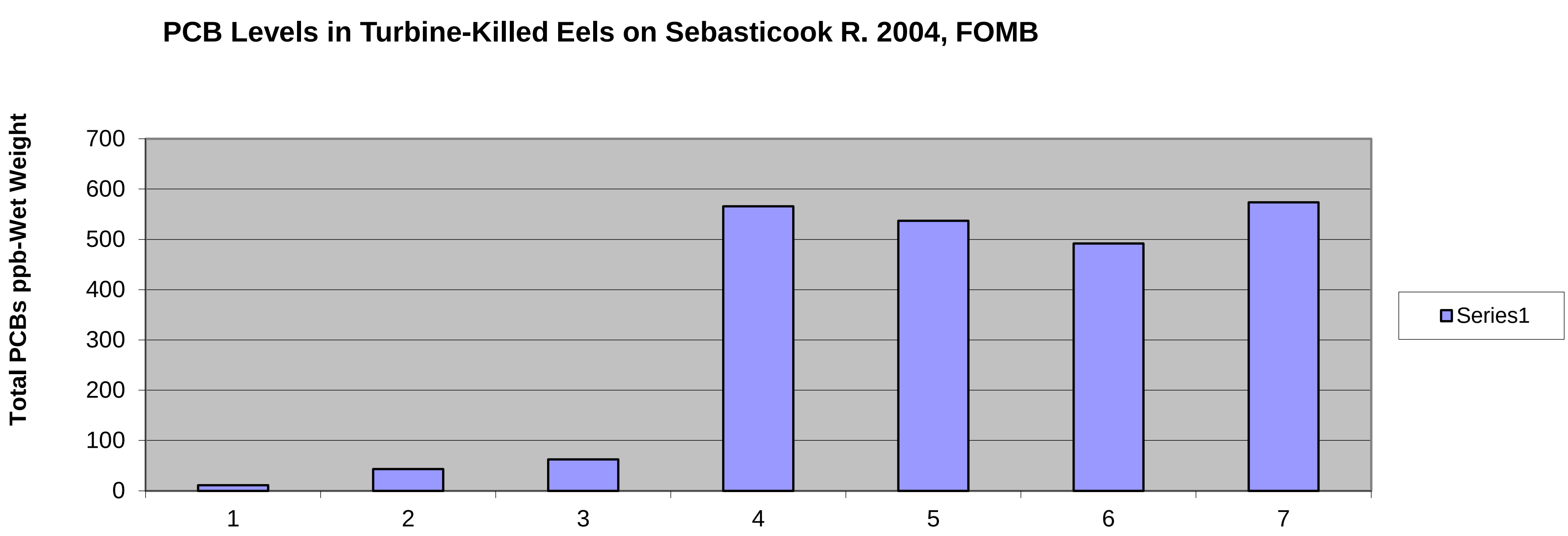
16. Hall et al, 2010 The historic influence of dams on diadromous fish habitat with a focus on river herring

17. Merrymeeting News-Winter 2020

Exhibit 1

FOMB Brunswick Exhibit 1

P-*2284-0052*



1 & 2 are PCB tissue levels [11 & 43 ppb] where Maine State Toxicologist issues Fish Consumption Advisories, 3-7 are eel samples. Eel ages 13-23

Exhibit 2

FPC 2284 Brunswick, Me. hydro

Ex. 2

Regional Engineer, Newton, Mass. 5/2 April 27, 1977

Ron Rizzo, Hydraulic Engineer
Newton, Mass.

April 7, 1977 Meeting with CMPCo and Maine Fishery Agencies regarding proposed fishway at CMPCo Brunswick Project on Androscoggin River - Brunswick, Maine

On April 7, 1977, I attended a meeting at the Central Maine Power Company (CMPCo) in Augusta, Maine, to review with State Fishery Agencies the conceptual design of fish passage facilities proposed at the CMPCo Brunswick Hydro-Power Project on the Androscoggin River, in Brunswick, Maine.

Other attendees were as follows:

CMPCo	Maine
Ralph Dean	Al Meister, Sea Run Salmon Commission
Gerald Poulin	Lynn Bond, Department of Inland Fisheries
Val Thompson	Lew Flagg, Department of Marine Resources

For the benefit of the Maine Fishery Agencies, I reviewed the pertinent features of the fish passage facilities we proposed at the subject project. (See attached conceptual plan). These facilities include:

1. A vertical-slot type fishway constructed adjacent to the proposed powerhouse. (8'-6" wide X 10' long fishway pools X 40' lift). The fishway is designed to pass a run of 85,000 American shad and 1 million alewives.

2. A side-view fish counting and trapping facility is included at the upstream end of the fishway. This facility can trap fish species selectively, or trap the entire run.

3. 70 cfs attraction water will be piped from the headpond through flow diffusion chambers into the fishway, where it combines with the 30 cfs ± flowing through the fishway to provide a total of 100 cfs ± attraction water at the fishway entrance.

4. The existing timber crib spillway under the Route 201 Bridge will be lowered approximately 4' to crest elevation 14. This structure will serve as a fish barrier dam to keep upstream migrants from entering the spillway area during periods of spillway discharge. A fish barrier wall at crest elevation 20 is also required between the main spillway and the powerhouse.

5. A floating downstream migrant fish-screen and trash boom are also provided at the powerhouse intake for future installation if turbine mortality studies deem it necessary.

6. The fishway will operate for river flows up to 30,000 cfs. When flows exceed 30,000 cfs, a sluice gate, located at the fishway exit, will automatically close. This gate will open again when river flows fall below 30,000 cfs.

The State Fishery Agencies gave their informal concurrence with the proposed fish passage facilities. They indicated formal written approval would be forwarded to CMPCo upon receipt of a written request.

Lynn Bond's main concern was the introduction of carp and other rough fish to upstream habitat-via fishways. To control the rough fish problem, the Department of Marine Fisheries agreed to trap and sort these fish at the fishway. This will involve considerable man-power and fish handling.

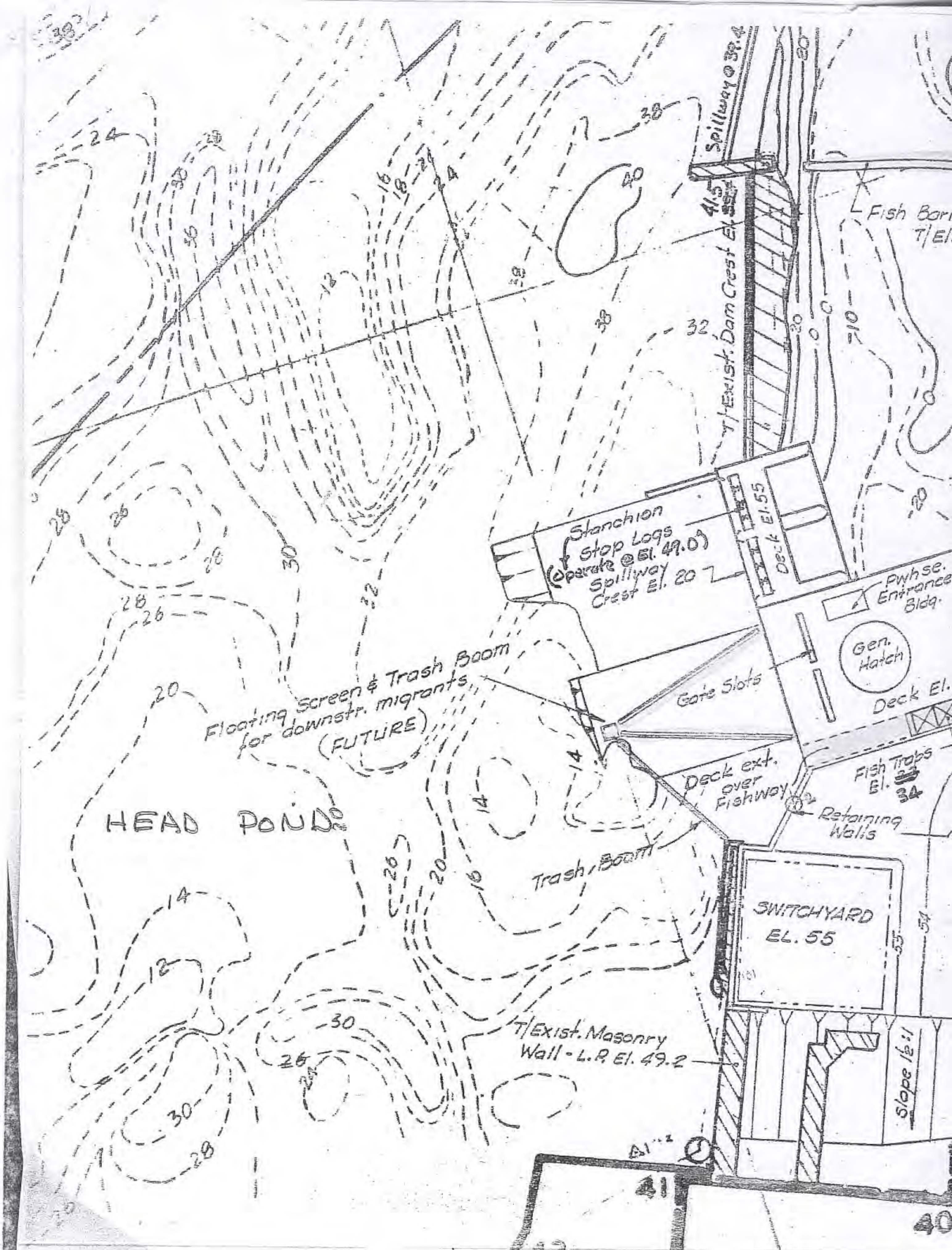
Al Meister indicated that due to the numerous upstream dams, the Androscoggin has a very low priority as far as Atlantic Salmon management; however, any salmon trapped at Brunswick will be held and utilized for artificial spawning.

CMPCo is planning a public meeting regarding the proposed project, to be held in Brunswick, sometime in May 1977.

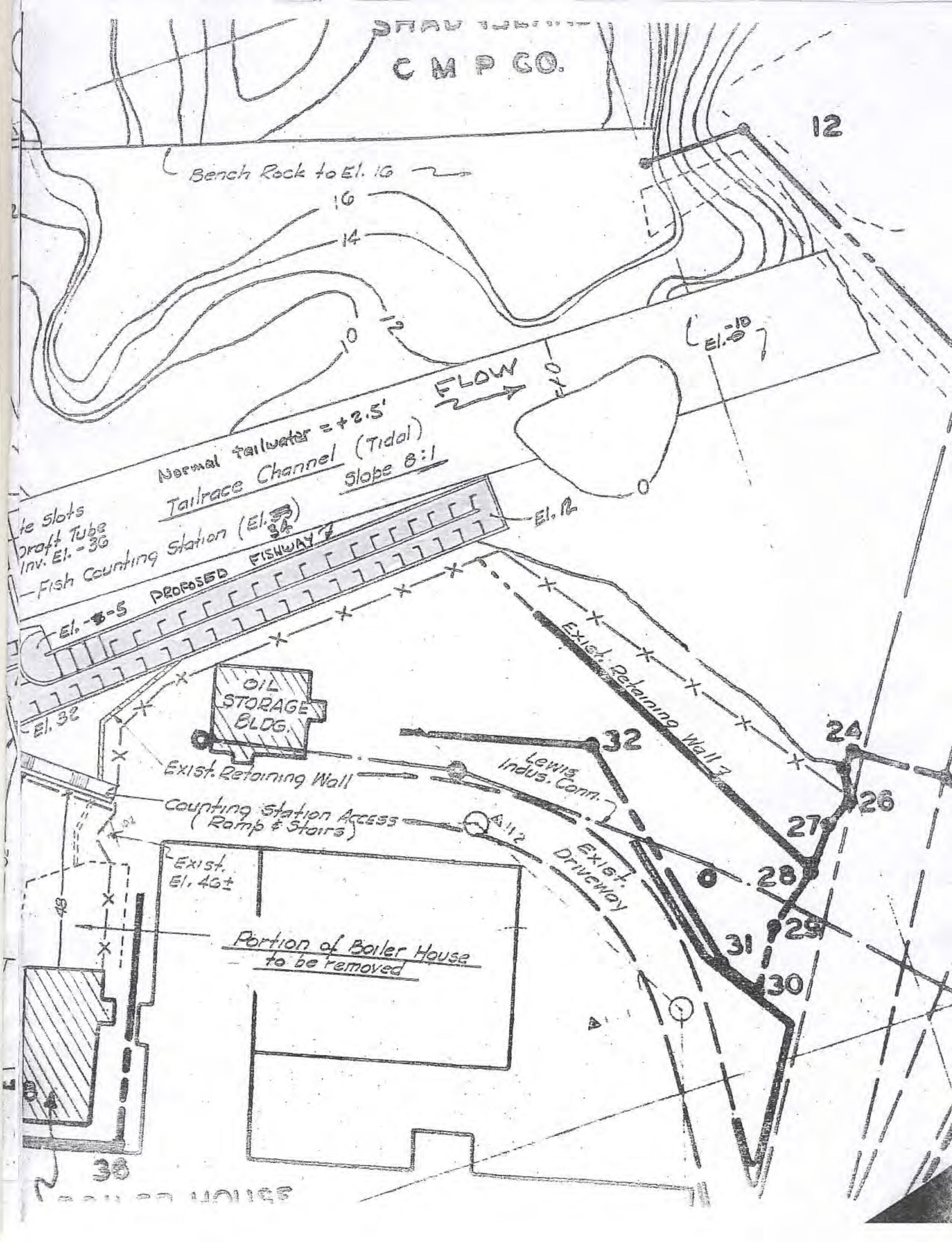
Attachment
as specified

BRizzo/sbd

CC: ABF
ABV
NEAO
WJ Patrik
B Rizzo
Charles A. Maloy - Concord, N.H.
Area Manager
Inspection & Trip Reports



Spillway @ 39.4
41.5
T/Exist. Dam Crest El.
Fish Barr
T/El
Stanchion
Stop Logs
(Operate @ El. 49.0)
Spillway
Crest El. 20
Deck El. 55
Pwhse. Entrance Bldg.
Gen. Hatch
Deck El.
Gate Slots
Floating Screen & Trash Boom
for downstr. migrants
(FUTURE)
Deck ext. over Fishway
Fish Traps El. 34
Retaining Walls
Trash Boom
HEAD POND
SWITCHYARD
EL. 55
T/Exist. Masonry
Wall - L.R. El. 49.2
Slope 1½:1
41
40



C M P CO.
12
Bench Rock to El. 16
16
14
12
10
0
(El. -10)
FLOW
Normal tailwater = +2.5'
Tailrace Channel (Tidal)
Slope 8:1
El. 12
Draft Tube
Inv. El. -36
Fish Counting Station (El. 34)
PROPOSED FISHWAY
El. -5
El. 32
OIL STORAGE BLDG.
32
Exist. Retaining Wall
Lewis Indus. Conn.
Counting Station Access (Ramp & Stairs)
Exist. El. 46±
Exist. Driveway
Exist. Retaining Wall
24
26
27
28
29
31
30
Portion of Boiler House to be removed
38

Exhibit 3

Turbine clogged with eels. Note eel skin stretched across shaft.
Photo: Alex Haro, Ph.D. , S. O. Conte Anadromous Fish Restoration Center
Presentation-**Fish Passage in the Northeast: Old Problems, New Solutions**
U.S.G.S., Biological Services

FOMB Exhibits Brunswick, Maine Hydroelectric Project, Androscoggin River FERC P-2284-0052

Exhibit 4

Ex. 4

Friends of Merrymeeting Bay

P.O. Box 233, Richmond, ME 04357 www.fomb.org

FERC Comment Ref. P-2284
Brunswick, Maine Androscoggin Dam Killing Fish

October 28, 2016 Contact: Ed Friedman, 207-666-3372 /edfomb@comcast.net

Who: Friends of Merrymeeting Bay
What: **Brookfield Energy's Brunswick Dam Turbines Kill Thousands of Fish**
When: October 15th & 16th
Where: Androscoggin River, Brunswick, Maine

Turbines at Brookfield Energy's Brunswick/Topsham dam have recently killed thousands of out-migrating young of the year (YOY) alewives and other fish. Locals first noticed the massive kill on Saturday 10/15/16, posting mortality photos from the Brunswick Water Street boat launch on Facebook.

Sunday morning, Friends of Merrymeeting Bay (FOMB) volunteers on their monthly water quality monitoring circuit, noticed the kill at Brunswick and further downstream and reported back to Ed Friedman, the organization's Chair. After documenting 500-800 dead fish just at the boat ramp and others on the rocks below the Green Bridge between Brunswick and Topsham and directly below the Brunswick turbine area, Friedman went up and downstream to rule out other sources (there was no mortality observed above Brunswick nor below and above Pejepscot dam, the next one upstream) before calling the Brookfield Emergency Phone Line later that afternoon to report their dam turbines were killing fish. It is not known what immediate action Brookfield took if any.

When next observed by FOMB Tuesday morning, previous planned dam work was underway with a diver down in the turbine vicinity and all turbines shut off. The Taintor gates were open on the Topsham side of the dam allowing fish passage there. Currently after heavy rain the entire dam is spilling.

In normal conditions, the only way for migratory fish to pass downstream at Brunswick is through an 18" pipe with grate over the upstream end and flows of 40 cubic feet per second (cfs). This downstream passage is located immediately adjacent to the Unit 1 turbine with intake extending to the surface and with a throughput of 5,075 cfs. On the other side of the fish passage pipe are Units 2 and 3 with combined 2,672 cfs and entrances about 20' below the surface. Out-migrating fish, whether alewives, salmon, shad or eels follow maximum flows leaving the designated pipe in this instance, with little chance of attraction success and ensuring passage through the turbines.

Turbine mortality occurs through decapitation, direct concussive strikes, and pressure differentials on opposite sides of turbine blades leading to exploded swim bladders and eyeballs. All of these examples were seen in the recent kills. Similar mortality has been encountered on the Union River at the dam in Ellsworth, also owned by Brookfield.

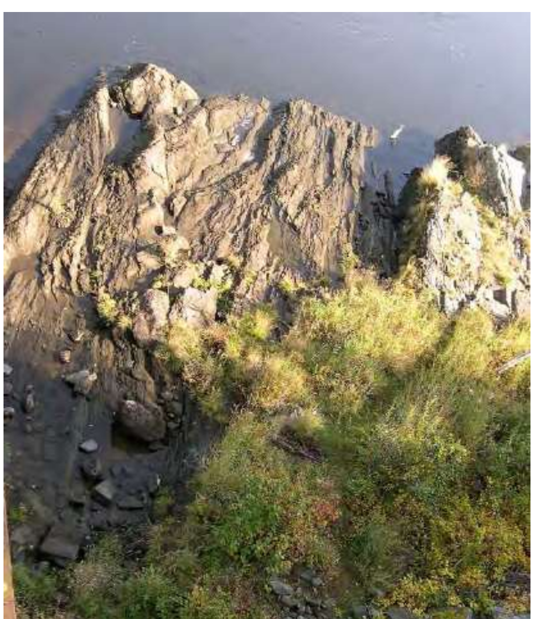
FOMB has worked for years to ensure safe passage for migratory fish on the Androscoggin and Kennebec Rivers most recently during five years of litigation under the Endangered Species and Clean Water Acts. Despite overwhelming evidence, FOMB lost these cases because in the period from start to finish of litigation, interim species protection plans (ISPP's) were developed and issued by NOAA Fisheries pursuant to a joint cooperative agreement with USFWS and the court ruled FOMB claims no longer valid (even though several years of violations had occurred for which Brookfield should have been liable).

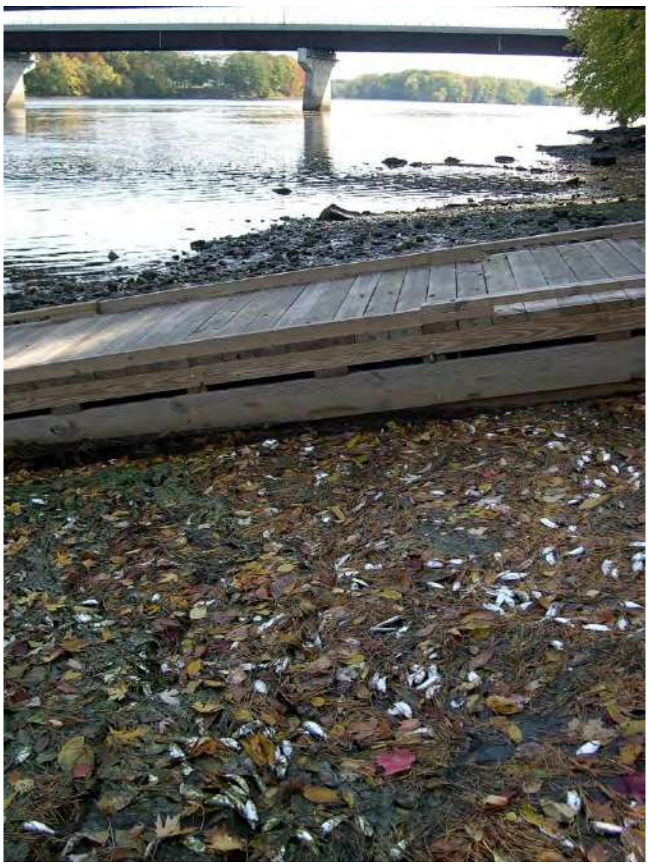
The recent kill is proof the ISPP's don't work. No fish, including endangered Atlantic salmon are adequately protected from turbine mortality at the facility as currently configured and operated. We request FERC take appropriate actions to ensure the dam owner is held liable and future mortality avoided.

An in depth report documenting detailed timelines of this event and agency correspondence will follow.







Note first photo of dam shows 18" fish passage "downspout" next to turbine bays. Dam is over 600 feet long and this is only safe passage unless water is spilling over the top. Last photo tentatively identified by DMR as a fallfish.

All photos: Ed Friedman, Friends of Merrymeeting Bay. Available on request as jpgs.

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November 7, 2016

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

RE: Project No. 2284; Brunswick Project
Brookfield White Pine Hydro LLC

Dear Secretary:

Brookfield White Pine Hydro LLC (BWPH), the licensee for the Brunswick Project, is writing to respond to an October 28, 2016 press release filed with the Commission by the Friends of Merry Meeting Bay (FOMB).

Background:

On Sunday, October 16, the Brookfield contact phone line received a report from a representative of FOMB about some juvenile river herring mortalities observed below the Brunswick Project on Saturday October 15 and Sunday, October 16. In response, a BWPH river operations crew member visited the site in the early evening of Sunday, October 16, 2016 and observed some juvenile fish mortalities at the Brunswick boat ramp below the Project and did not observe any bird feeding activity or fish mortality in the turbine discharge.

On the morning of Monday, October 17, a BWPH environmental employee arrived on site and collected approximately 1,300 juvenile river herring mortalities below the Project. No other fish species mortalities were collected and BWPH did not observe any ongoing fish mortality in the Project tailrace at the turbine discharge. That afternoon, BWPH conducted a conference call with Maine Department of Marine Resources (MDMR) and Maine Department of Environmental Protection (MDEP) personnel to inform them of the occurrence and of BWPH's intended course of action. Based on the unusually large numbers of juvenile river herring in the water during this brief period of time, that same evening (Monday, October 17), BWPH implemented turbine shutdowns targeting the dusk to dawn hours (7 p.m. - 7 a.m.), which continued for the remainder of the week, in an effort to mitigate further mortalities. It should be noted that the facility was experiencing an outage of its larger, slower unit 1 on these same dates and that only the smaller, faster units 2 and 3 were periodically online during this period.

Shoreline and turbine discharge surveys below the Project were conducted daily throughout the following week (October 18 through 23) by BWPH environmental personnel and no new shoreline or turbine discharge mortalities were observed. Periodic shoreline and turbine discharge surveys were also conducted during the following week (October 24 through 31) and no new mortalities were observed.

Normal operations were resumed at the Project on Saturday, October 29.

Unique Circumstances Identified in Discussions with MDMR and MDEP:

As noted above, on October 17, 2016, BWPH conducted a conference call with MDMR and MDEP personnel where the occurrence was discussed. From these discussions, it appeared that the juvenile river herring encountered at the Brunswick Project were fish that had out migrated from Sabattus Lake starting on October 8 when the Sabattus Lake Association released water for the annual lake drawdown.

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MDMR noted that it annually captures adult river herring from the BWPH Brunswick Project Fishway and transports these fish to Sabattus Lake, which is the largest spawning lake for river herring in the Androscoggin River basin. MDMR estimates that approximately 8 million to 10 million juvenile river herring were present in Sabattus Lake this year and that the majority of them moved out with the discharge of water associated with the annual lake drawdown. Limited rain events, associated drought conditions and low water conditions encountered this year have resulted in reduced periodic spill events at the Sabattus Lake dam that would generally occur under normal conditions. During normal spill events under normal hydrological conditions, juvenile river herring would leave the lake sporadically in smaller groups throughout the migration season starting in late summer into the fall. Instead, MDMR suspects that a very large number of juvenile river herring left the lake at the same time starting on October 8 with the Sabbatus Lake Association drawdown event and arrived at the Brunswick Project later on that week.

BWPH believes that the limited number of juvenile river herring mortalities observed on October 15th, 16th and 17th 2016 was a very unusual occurrence due to the unique circumstances described above. BWPH is not aware of any similar fish mortality occurrence reported by the public or observed by BWPH or its predecessor in the past.

Continued Approach:

BWPH took immediate action to minimize the likelihood of continued mortalities and improve downstream passage conditions at the Project and those efforts seem to have been successful as no additional mortalities have been observed at the Project for the following two week period. BWPH has and will continue to monitor the Project and downstream areas for the next two weeks and will continue to provide weekly fish passage reports to the resource agencies. BWPH believes that through the actions described above, it is taking diligent and appropriate actions to minimize fish mortalities at the Project.

If you have any questions regarding this filing, please contact Bob Richter at (207) 242-5001 or at robert.richter@brookfieldrenewable.com.

Sincerely,

Jason Seyfried

Kelly Maloney For
Manager, Licensing and Compliance

Cc: R. Richter, J.Trudell, A. Zarrella, P. McDonough, S. Michaud, J. Seyfried, K. Bernier; BWPH

J. Perry; MDIFW
K. Howatt; MDEP
M. Brown, O. Cox; MDMR
S. Shepard, A. Bentivoglio; USFWS
J. Murphy, D. Tierney, M. Buhyoff; NMFS

M. Pawlowski; FERC

BWPH File: 2284|01

FEDERAL ENERGY REGULATORY COMMISSION
Washington, D. C. 20426

OFFICE OF ENERGY PROJECTS

Project No. 2284-045 – Maine
Brunswick Project
Brookfield White Pine Hydro LLC

November 10, 2016

Ms. Kelly Maloney
Licensing Compliance Manager
Brookfield White Pine Hydro LLC
150 Main Street
Lewiston, ME 04240

Subject: October 15, 2016 Fish Kill Incident, Article 30

Dear Ms. Maloney:

On October 28, 2016, we received a report and photographs from the Friends of Merrymeeting Bay (FOMB), regarding a fish kill that had occurred at the Brunswick Project (FERC No. 2284) on or about October 15-16, 2016. The project is located on the Androscoggin River in Cumberland and Saggadahoc Counties, Maine.[1] Downstream passage at the project is provided via a surface sluice and associated 18-inch pipe that discharges fish into the project tailrace. The downstream fishways are required to be operated from April 1 to December 31 annually, as river conditions allow.

The FOMB's October report states that 500-800 dead river herring were found at the project and at locations downstream. No mortality was noted above Brunswick or at the next upstream Pejepscot Project (FERC NO. 4784). The FOMB states that it reported the incident to the Brookfield emergency phone line but received no further information whether any action was taken. The injuries to the fish included decapitation, direct strikes, and pressure injuries.

The FOMB then observed that planned project maintenance was underway on October 18, 2016 and the project was not operating although the tainter gates were opened. They also noted heavy rain and spillage across the entire dam.

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[1] Order Amending license and Issuing new Major License. 6 FERC P 61122 (F.E.R.C.), 1979 WL 19901 (issued February 9, 1979).

In order for us to review the causes and events surrounding this fish kill event, please file a report with the Commission identifying the following information: (1) the operational status of the downstream fish passage facility (i.e., whether they were clear of debris on the days in question, whether sufficient attraction flow was available, and whether they were functioning as required); (2) project operation before, during, and after the incident including any operational difficulties or abnormal river conditions; (3) any observations you have regarding the fish kill, and your conclusions regarding what caused it to occur; and (4) any action you took immediately upon learning of the incident.

Please provide this requested information within 30 days from the date of this letter. Please file the requested information using the Commission's eFiling system at http://www.ferc.gov/docs-filing/efiling.asp. For assistance, please contact FERC Online support at FERCOnlineSupport@ferc.gov, (866) 208-3676 (toll free), or (202) 502-8659 (TTY). In lieu of electronic filing, please send a paper copy to: Secretary, Federal Energy Regulatory Commission, 888 First Street NE, Washington, D.C. 20426. The first page of your filing should include docket number P-2284-045.

Thank you for your cooperation and if you have any questions regarding this letter, please contact me at (212) 273-5917 or email at *joseph.enrico@ferc.gov*.

Sincerely,

Joseph Enrico
Aquatic Resources Branch
Division of Hydropower Administration
and Compliance

Brookfield

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December 8, 2016

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

RE: **Brunswick Project; FERC Project No. 2284**
Brookfield White Pine Hydro LLC

Dear Secretary:

Brookfield White Pine Hydro LLC (BWPH), the licensee for the Brunswick Project, is writing to respond to an October 28, 2016 press release (the "Press Release") filed with the Commission by the Friends of Merry Meeting Bay (FOMB) and a FERC letter dated November 10, 2016 requesting specific information regarding the Press Release. Specifically, FERC's November 10, 2016 letter requests that BWPH provide information on:

(1) the operational status of the downstream fish passage facility (i.e., whether they were clear of debris on the days in question, whether sufficient attraction flow was available, and whether they were functioning as required);
(2) project operation before, during, and after the incident including any operational difficulties or abnormal river conditions;
(3) any observations you have regarding the fish kill, and your conclusions regarding what caused it to occur; and
(4) any action you took immediately upon learning of the incident.

BWPH previously filed a letter with FERC responding to the Press Release on November 7, 2016; however, this filing will provide some additional clarification on agency consultation and respond to the above information requests outlined in FERC's November 10, 2016 letter.

Event Description and Immediate Actions

On Sunday, October 16, the Brookfield public inquiry phone line received a report from a representative of FOMB regarding some juvenile river herring mortalities observed below the Brunswick Project on Saturday, October 15 and Sunday, October 16. In response, a BWPH river operations crew member visited the site in the early evening of Sunday, October 16, 2016 and observed some juvenile fish mortalities at the Brunswick boat ramp below the Project but did not observe any bird feeding activity or fish mortality in the turbine discharge.

On the morning of Monday, October 17, a BWPH environmental employee contacted Maine Department of Marine Resources (MDMR) personnel about the juvenile river herring mortalities observed below the Brunswick Project. At that time, MDMR indicated that it had already received the same information from a member of the public. This BWPH environmental employee then visited the site and collected approximately 1,300 juvenile river herring mortalities below the Project. No other fish species mortalities were collected and BWPH did not observe any ongoing fish mortality in the project tailrace at the turbine discharge. Based on the information collected that day, BWPH implemented unit 2 and unit 3 turbine shutdowns targeting the dusk to dawn hours (7 p.m. - 7 a.m.) that same evening (Monday, October 17). These shutdowns were implemented for the remainder of the week (through October 22), in an effort to mitigate further mortalities. As described below, unit 1 was already shut down for an annual inspection.

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On the morning of October 19[1], BWPH participated in a conference call with MDMR and Maine Department of Environmental Protection (MDEP) personnel to discuss the situation and discuss BWPH's actions to date and intended course of future action.

Shoreline and turbine discharge surveys below the Project were conducted daily throughout the week (October 18 through 23) by BWPH environmental personnel and no new shoreline or turbine discharge mortalities were observed. Periodic shoreline and turbine discharge surveys were also conducted during the following week (October 24 through 31) and no new mortalities were observed.

In its November 10, 2016 letter, FERC requested information regarding station operations before, during and after the incident and the status of the existing fishway. To that end, it should be noted that the facility was experiencing a planned annual outage and associated inspection of its larger, slower running unit 1 on these same dates. Only the smaller, faster running units (units 2 and 3) were alternately operating at 100% gate during this period passing inflow with no spill occurring until the evening of October 17. As described above, BWPH implemented unit 2 and unit 3 turbine shutdowns targeting the dusk to dawn hours (7 p.m. - 7 a.m.) starting on October 17. The shutdowns were implemented for the remainder of the week (through October 22), with Unit 2 and 3 alternately operating during the day. Normal project operations without nighttime shutdowns were resumed on October 23. Concurrently, the existing downstream fishway was clear of debris and functioning, as required during this time period.

Determination of Cause and Unique Circumstances Identified in Discussions with MDMR and MDEP

As noted above, on October 19, 2016, BWPH participated in a conference call with MDMR and MDEP personnel to discuss the situation, BWPH's actions to date, and its intended course of future action. From these discussions, it was discussed that the juvenile river herring encountered at the Brunswick Project were likely fish that had out migrated from Sabattus Lake starting on October 8 when the Sabattus Lake Association released water for the annual lake drawdown. MDMR noted that it annually captures adult river herring from the BWPH Brunswick Project Fishway and transports these fish to Sabattus Lake, which is the largest spawning lake for river herring in the Androscoggin River basin. MDMR estimates that approximately 8 million to 10 million juvenile river herring were present in Sabattus Lake this year and that the majority of them moved out with the discharge of water associated with the annual lake drawdown. Limited rain events, associated drought conditions and low water conditions encountered this year have resulted in reduced periodic spill events at the Sabattus Lake dam that would generally occur under normal conditions. During spill events occurring under normal hydrological conditions, juvenile river herring would leave the lake sporadically in smaller groups throughout the migration season starting in late summer into the fall. Instead, MDMR indicated that they suspected that a very large number of juvenile river herring left the lake at the same time starting on October 8, with the Sabbatus Lake Association drawdown event, and arrived at the Brunswick Project later on that week.

BWPH believes that the limited number of juvenile river herring mortalities observed on October 15, 16 and 17, 2016 was a very unusual occurrence due to the unique circumstances described above. BWPH is not aware of any similar fish mortality occurrence reported by the public or observed by BWPH or its predecessor in the past at this Project.

[1] The BWPH letter dated November 7, 2016 mistakenly referred to this conference call as having occurred on October 17, 2016.

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Continued Approach

BWPH took immediate action (i.e. dusk to dawn turbine shutdowns during the week of October 17) to minimize the likelihood of continued mortalities and improve downstream passage conditions at the Project and those efforts seem to have been successful as no additional mortalities were observed at the Project. BWPH will continue to provide weekly fish passage reports to the resource agencies and believes that through the actions described above, it is taking diligent and appropriate actions to minimize fish mortalities at the Project.

If you have any questions regarding this filing, please contact Bob Richter at (207) 242-5001 or at robert.richter@brookfieldrenewable.com.

Sincerely,

Jason Seyfried

Kelly Maloney for
Manager, Licensing and Compliance

Cc: R. Richter, J.Trudell, A. Zarrella, P. McDonough, S. Michaud; BWPH

J. Enrico. M. Pawlowski, FERC

M. Brown, O. Cox; MDMR
S. Shepard, A. Bentivoglio; USFWS
J. Murphy, D. Tierney, M. Buhyoff; NMFS
K. Howatt; MDEP
J. Perry; MDIFW

BWPH File: 2284|01

FEDERAL ENERGY REGULATORY COMMISSION
Washington, D. C. 20426

OFFICE OF ENERGY PROJECTS

Project No. 2284-045 – Maine
Brunswick Project
Brookfield White Pine Hydro LLC

January 3, 2017

Kelly Maloney
Licensing Compliance Manager
Brookfield White Pine Hydro LLC
150 Main Street
Lewiston, ME 04240

Subject: October 15, 2016 Fish Kill Incident, Article 30

Dear Ms. Maloney:

We received your filings of November 7 and December 8, 2016, responding to our information request regarding the fish mortality event that had occurred at the Brunswick Project (FERC No. 2284) on or about October 15-16, 2016. The project is located on the Androscoggin River in Cumberland and Sagadahoc Counties, Maine.[1] We were alerted of the fish kill by the Friends of Merrymeeting Bay (FOMB) in their letter dated October 28, 2016. Their report stated that 500-800 dead river herring were found at the project and at other locations downstream. The injuries to the fish included decapitation, direct strikes, and pressure injuries. The FOMB also observed that planned project maintenance was underway on October 18, 2016 and the project was not operating although the tainter gates were opened. They also noted heavy rain and spillage across the entire dam.

According to your filings, you received notification of the fish kill by FOMB and dispatched your staff to inspect the project on October 16, 2016. Staff observed some fish mortalities in the downstream boat ramp area but not in the tailrace discharge. On October 17, 2016 your staff collected approximately 1,300 juvenile river herring mortalities downstream of the project; however, no active mortality in the turbine discharge was noted. Following these efforts, a conference call was held with the Maine Department of Environmental Protection (Maine DEP) and Maine Department of Marine Resources (Maine DMR) later that afternoon.

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[1] Order Amending license and Issuing New Major License. 6 FERC P 61122 (F.E.R.C.), 1979 WL 19901 (issued February 9, 1979).

As a result of the unusually large numbers of juvenile river herring observed during the period, you implemented turbine shutdowns targeting the dusk to dawn hours (7 a.m. to 7 p.m.) beginning on October 17, 2016 for the remainder of the week. Shoreline and turbine discharge surveys were then conducted daily from October 18-23 and no new mortalities were observed. In addition, periodic shoreline and turbine mortality surveys were conducted during the following week with no observed mortalities and therefore, normal project operations were resumed on October 29, 2016. In your discussions with Maine DEP and Maine DMR, it was determined that the juvenile river herring encountered at Brunswick had out-migrated from Sabattus Lake starting on October 8, 2016 when the lake association began its annual lake drawdown. Maine DMR noted that there were approximately 8-10 million juvenile river herring present in Sabattus Lake this year and that a majority likely moved out during the lake drawdown. Under normal conditions, periodic rain and other spill events would move fish out of the lake sporadically; however, river conditions reduced those events this year. Maine DMR suspects that these factors resulted in a large number of juvenile river herring moving out of the lake during the drawdown. You state that no previous reports of similar mortality events have been noted at the project in the past. In summary, your report states that you took appropriate actions to minimize continued mortality once you were made aware of the events taking place. You noted that no further mortalities occurred subsequent to those actions and you continued to monitor the project and downstream areas for the following two weeks and provided weekly passage reports to Maine DEP and DMR. The resource agencies did not file specific comments on this fish mortality event.

Under normal conditions downstream passage at the project is provided via a surface sluice and associated 18-inch pipe that discharges fish into the project tailrace. The downstream fishways are required to be operated from April 1 to December 31 annually, as river conditions allow. Your report noted that the facility was clear of debris and functioning as required during the period. It is apparent that the large release of flows from Sabattus Lake was the primary factor contributing to the mortality of river herring at the Brunswick Project. Along with heavy rain and high river flows, the downstream fish passage facility was overwhelmed resulting in significant passage through the units as well as through the spillway and gates. We agree that your immediate actions were appropriate and likely minimized further mortality once you became aware of the situation. In addition, there have no similar events occurring at the project in the recent past that would suggest problems with the downstream fish passage facility at the project. However, we recommend that you discuss the event with the Sabattus Lake Association to make them aware of the impacts related to the timing of the drawdown and request that any future unusual or large flow releases/drawdowns are communicated to you in order to allow you to implement any preventative measures to minimize fish mortalities at the project.

Thank you for your cooperation and if you have any questions regarding this letter, please contact me at (212) 273-5917 or email at *joseph.enrico@ferc.gov*.

Sincerely,

Joseph Enrico
Aquatic Resources Branch
Division of Hydropower Administration
and Compliance

FOMB Exhibits Brunswick, Maine Hydroelectric Project, Androscoggin River FERC P-2284-0052

Exhibit 5

Ex. 5

North American Journal of Fisheries Management

ISSN: 0275-5947 print / 1548-8675 online
DOI: 10.1002/nafm.10330

MANAGEMENT BRIEF

Observations of American Shad *Alosa sapidissima* Approaching and Using a Vertical Slot Fishway at the Head-of-Tide Brunswick Dam on the Androscoggin River, Maine

Daniel M. Weaver*
Department of Wildlife, Fisheries and Conservation Biology, University of Maine, 5755 Nutting Hall, Orono, Maine 04469, USA

Michael Brown
Maine Department of Marine Resources, 21 State House Station, Augusta, Maine 04333, USA

Joseph D. Zydlewski
U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, 5755 Nutting Hall, Orono, Maine 04469, USA; and Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, 5755 Nutting Hall, Orono, Maine 04469, USA

Abstract
American Shad *Alosa sapidissima* have historically supported an important fishery along the Atlantic coastal waters of North America. However, the construction of dams reduced populations and restricted landings. Fishways are intended to mitigate obstacles to anadromous fish migrations, but a thorough evaluation of their efficiency is warranted. We analyzed data collected from video recordings, hydropower turbine operations, and telemetry conducted by the Maine Department of Marine Resources to evaluate American Shad behavior while approaching and using a vertical slot fishway at the head-of-tide Brunswick Dam on the Androscoggin River in Maine. American Shad passage at the dam has been poor, ranging from 0 to 1,100 fish per year, relative to passage at other facilities in the region. Additionally, our observations indicate that there are relatively high numbers of American Shad present downstream in the river (averaging 50,000) compared with the entrance of the fishway or its pools (<8,000). On average, the rates of observed American Shad on the side of the river near the fishway entrance were significantly higher (6.5–8.6 individuals/min) when the turbine closest to the entrance of the fishway was not operating compared with when it was operating (4.1 individuals/min). Most of the radio-tagged American Shad remained in the river below the dam or went undetected. Eleven of 57 tagged fish were detected at the fishway entrance and of those only five were detected in the lower fishway. Individuals that were detected were observed making multiple attempts at entering the fishway, but movements were restricted to the lower pools. Our results suggest that this fishway is not conducive to the passage of American Shad. Examining the relationship between hydropower operations and other environmental variables on the behavior and passage of migrating anadromous fish remain an area for further study.

American Shad *Alosa sapidissima* is an anadromous species requiring connectivity between marine and freshwater habitats to complete their lifecycle. Historically, populations of American Shad supported recreational, subsistence, and commercial fisheries along the Atlantic coastal waters of North America with annual landings ranging in the millions of pounds (Hightower et al. 1996; ASMFC 2007). However, overfishing, pollution, and habitat loss resulting from dams, restricted passage, and human development have reduced populations and subsequently total landings (Limburg et al. 2003; ASMFC 2007; Limburg and Waldman 2009). Many state and federal agencies have prioritized the management of American Shad by supporting research and monitoring programs aimed at conserving and restoring populations (ASMFC 2007).

Dams threaten anadromous fish populations by severing the migration of populations between marine and

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Received January 17, 2019; accepted July 5, 2019

freshwater habitats (Limburg and Waldman 2009). Additionally, dams can impose migration delays and exert negative effects on survival and fitness (Castro-Santos and Letcher 2010). The construction of fishways at dams is one approach used to mitigate obstructions to migrating fish. However, many of the fishways in rivers along the east coast of the United States have not been thoroughly evaluated for passage of American Shad and often adopted designs intended to be suitable for Pacific Salmon (Haro and Castro-Santos 2012). Quantifying fish behavior under the variability of altered environmental conditions (e.g., flows) imposed by dams may inform managers of the efficacy of fish passage structures and identify areas for modification.

Data collected by state and federal agencies are often incorporated into reports as “gray” literature and are used to inform or direct management and research. Additionally, many agencies collect data through monitoring efforts that are not strictly hypothesis-driven. Nevertheless, these data may provide insight to population dynamics, fish ecology, and fisheries management. Here, we synthesize and analyze data collected by the Maine Department of Marine Resources (MDMR) on migrating American Shad behavior approaching the head-of-tide Brunswick Dam and passage through a vertical slot fishway. The synthesis of these data presents a timely opportunity to inform managers of the efficacy of this fishway to pass migrating American Shad in preparation for the Federal Energy Regulatory Commission's (FERC) relicensing of the dam in 2024. Vertical slot fishways are a commonly employed fishway at many dams in the Northeast but their passage efficiencies for nonsalmonids are relatively poor (Noonan et al. 2012). Over the next 5–10 years, many of these dams will be up for FERC relicensing and the synthesis of research and monitoring efforts will be used to characterize and evaluate fish passage (FERC 2019). Broadly, we describe challenges facing American Shad that encounter obstacles to migration and highlight opportunities for synthesizing best available science to inform management.

Our objective was to characterize the behavior of upstream-migrating American Shad that use a vertical slot fishway when approaching the Brunswick Dam on the Androscoggin River, Maine. We hypothesize that this vertical slot fishway creates an environment that is not conducive to the migration of American Shad. Specifically, certain operational configurations of the powerhouse's turbines may alter river flows and influence the behavior of American Shad approaching the fishway. We used four sets of collected data to characterize the behavior and movement of American Shad: passage counts, video recorded counts in the river and fishway, hydropower turbine operations, and movement of tagged fish in a telemetry study.

METHODS

Study site.— This work was conducted at the head-of-tide Brunswick Dam on the Androscoggin River, Maine's third largest river, in the town of Brunswick, Maine (Figure 1). The headwaters of the Androscoggin River are in New Hampshire and the river flows through Maine before emptying into Merrymeeting Bay and eventually the Atlantic Ocean. Historically, prior to dams, diadromous fishes on the main stem of the Androscoggin River would have unrestricted upstream movement until encountering Lewiston Falls, a natural barrier located 35.2 rkm above head-of-tide (Figure 1). It was documented that a few species, notably Atlantic Salmon *Salmo salar* and American Eel *Anguilla rostrata,* could ascend these falls and continue upstream to an impassible natural barrier at Rumford Falls, 128 rkm above tide. Historical accounts describe American Shad spawning in riverine habitats throughout the watershed below Lewiston Falls (Brown et al. 2006).

The Brunswick Dam hydroelectric station and fishway were constructed in 1982 and became the lower-most dam on the Androscoggin River at head-of-tide (Figure 2). The Brunswick Dam Project consists of a 12-m-high, 184-m-long concrete gravity dam. The powerhouse contains three vertical propeller turbine generators that generate electricity at a capacity of 19,000 kW. The project normally operates as run-of-river, relying on the seasonal flows of the river to generate electricity. The Brunswick fishway has a vertical slot design providing an attraction flow of 2.8 m^3/s. Fish are routed through a 173-m-long elevated concrete raceway consisting of forty-two 2.5 × 3-m pools with 28-cm-wide openings. A switchback, located approximately halfway, requires a 180° turn and divides the “lower fishway” from the “upper fishway.” At the end of the fishway, fish are corralled into a hopper with an electric hoist that lifts them into a sorting facility where they can be captured or counted and moved upstream. The tide influences the water level in the first six pools of the lower fishway with a tidal amplitude of up to 1.8 m. The fishway was designed to pass 85,000 American Shad per year (MDMR 2014). However, anywhere from 0 to 1,100 (but usually < 12) American Shad have passed the dam annually since 2003 and monitoring by MDMR suggests that low passage rates were evident even earlier (Figure 3; Brown et al. 2006). Other diadromous fish species observed using the Brunswick fishway include Alewife *Alosa pseudoharengus*, Blueback Herring *Alosa aestivalis*, Atlantic Salmon, American Eel, Rainbow Smelt *Osmerus mordax*, and Sea Lamprey *Petromyzon marinus*.

Video-recorded counts.— Underwater video cameras were used to quantify the relative abundance of American Shad in the river and their approach and use of the vertical slot fishway during their spawning migration. Cameras were deployed from June to July during 2001–2004. One

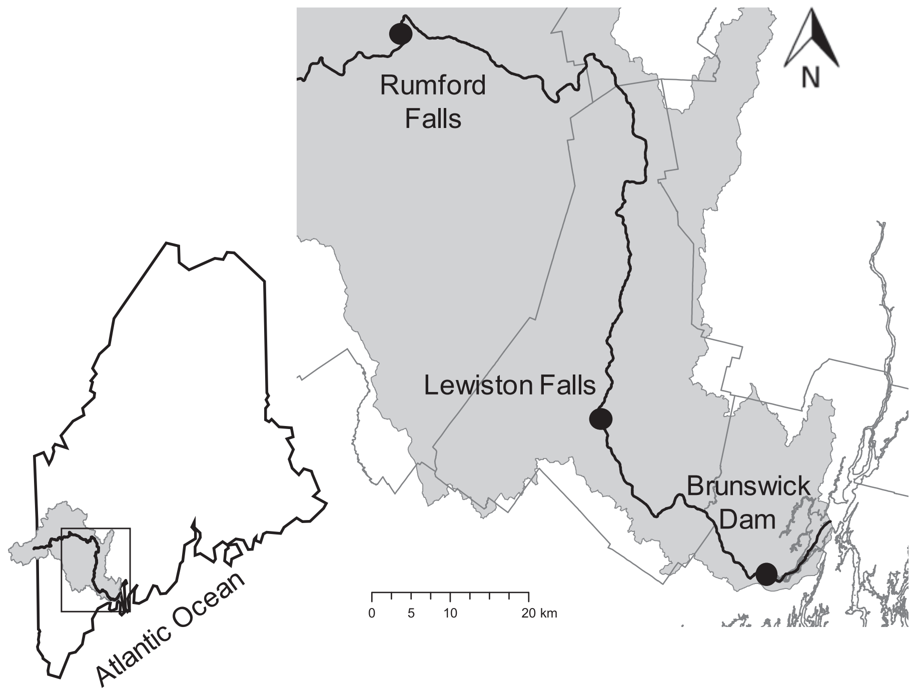


FIGURE 1. The location of the head-of-tide Brunswick Dam on the Androscoggin River, Maine, and Lewiston and Rumford falls, natural features serving as barriers to the upstream movement of American Shad and other anadromous fish. The shaded area delineates the Androscoggin River watershed boundary.

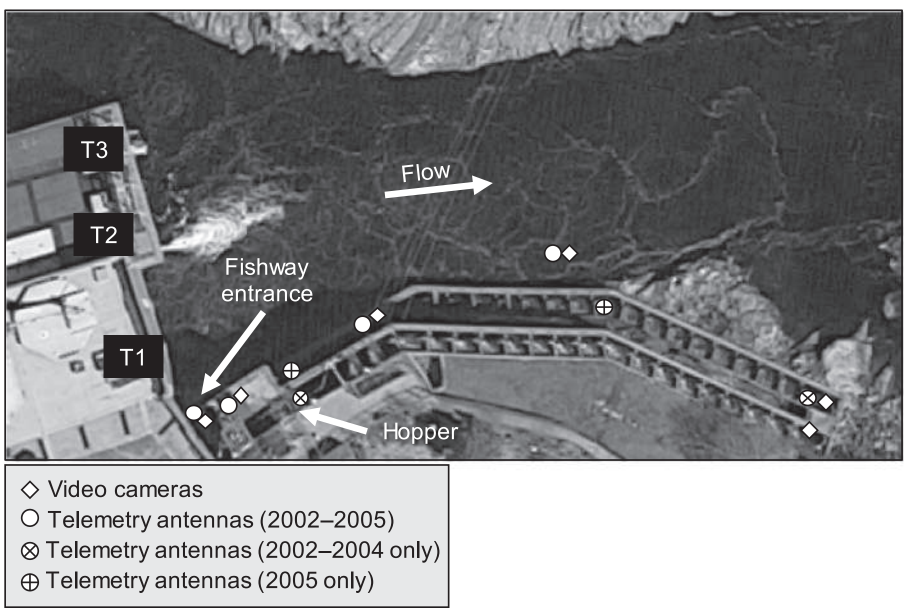


FIGURE 2. An aerial view of the Brunswick Dam (left) and fishway (bottom). T1, T2, and T3 denote the locations of the three hydropower turbine units. Areas where underwater video cameras were deployed are denoted by diamonds, and locations of telemetry receivers are represented by unique circle symbols denoted for specific years. Arrows depict the direction of flow and locations of the fishway entrance and hopper.

camera was placed in the river near the fishway. Five cameras recorded conditions in various locations in the fishway: the entrance, pool 1, pool 6, and the entrance and exit to the switchback pool. Camera depths deployed in the fishway ranged from approximately 1 to 1.8 m; the depths varied since the lower sections were influenced by the tide. Similarly, the camera placed in the river experienced tidal fluctuations and depths up to 1.2 m. Video

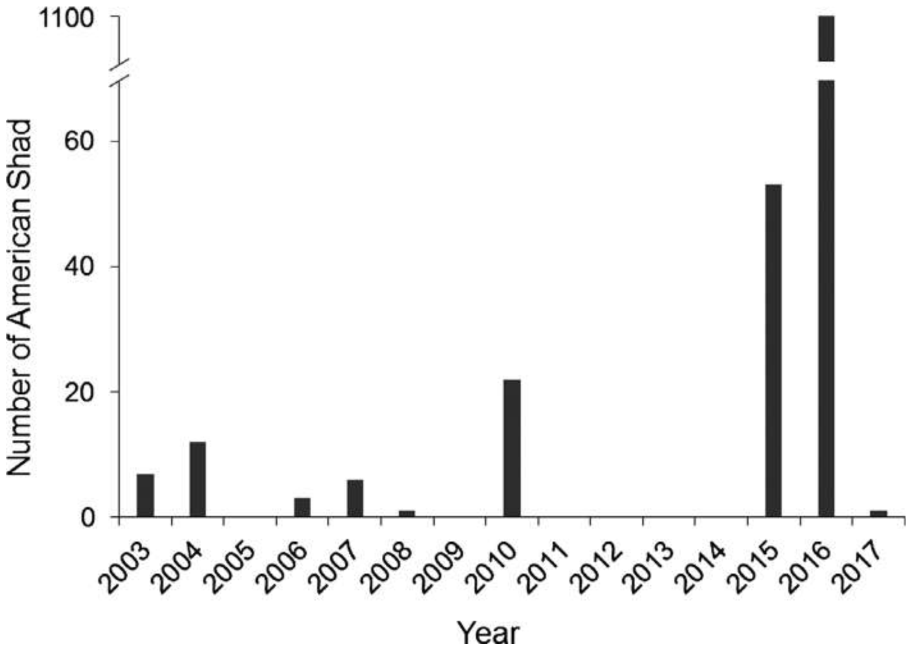


FIGURE 3. The numbers of American Shad that passed through the hopper of the vertical slot fishway at the Brunswick Dam on the Androscoggin River, Maine, from 2003 to 2017.

cameras continuously recorded their environment from 0600 to 1800 h daily. Maine Division of Marine Resources staff subsampled the video recordings by viewing the first 3 min of every 10-min period following methods adopted from Haro and Kynard (1997). Multiple observers viewed the recordings and corroborated the final counts. During these 3-min viewings, all American Shad were counted. Counts of American Shad represented only the observer counts and were not adjusted for subsampling. Fish may have been counted more than once.

Hydropower turbine operations.— We hypothesized that the operational configurations of the three turbines may influence the behavior of American Shad on their approach to the fishway (Figure 2). Utilizing turbine operational flow data and video-recorded counts from the river camera from 2004, we examined under which turbine operation combinations the majority of American Shad were counted. In 2004, cameras operated from June 8 to July 23 for a total of 45 d. We examined all operating combinations of the turbines as a 3-factorial design or 9 total combinations of the turbines either on or off (Table 1). We standardized the counts by calculating the average observation rate of American Shad (number/min) in every 3-min subsampled recording during which each of the four selected turbine configurations were operating. These reported rates were calculated from unadjusted sampled counts (i.e., not adjusted for subsampling). We found that four configurations comprised approximately 90% of all video-recorded river counts (Table 1); therefore, we only focused on those combinations in our analysis. We ran a nonparametric Kruskal–Wallis test to compare the rates of American Shad counts among the four selected turbine operating configurations. Statistical significance was gauged using a critical alpha value of 0.05. We used Dunn's post hoc test to explore pairwise differences among turbine configurations with an adjusted critical alpha value to reduce type I error rates (Benjamini and Hochberg 1995).

Telemetry study.— During May–June in 2002–2005, a telemetry study was conducted to track the movement and behavior of American Shad approaching and using the fishway. During 2002–2004, five antennas were deployed in the following locations: the river, the lower fishway consisting of the fishway entrance, the pool receiving the attraction flow, pool 6, and the upper fishway consisting of the switchback pool and the entrance to the hopper (Figure 2). In 2005, the configuration of deployed antennas was modified. The antennas located in the upper fishway were moved to pools in the lower fishway to include pool 3 and pool 14 (Figure 2). A Yagi aerial antenna was used at the fishway entrance, while dropper antennas, made from stripped coaxial cable, were used in the other locations.

American Shad were collected by angling a section of river below the dam. Fish were tagged with 11- × 42-mm microprocessor-coded internal gastric radio tags with a 29.4-cm external antenna (Lotek Wireless, Newmarket, Ontario, Canada; model MCFT-3BM). The tags had a pulse rate of 1 s and an approximate 67-d battery life. The duration of fish handling was minimized as much as possible to limit potential stress on the fish. Tagged fish were released at the same location where they were caught and

TABLE 1. Mean and SD of the number of American Shad/min observed from river camera counts and the percentage of the total counts among all turbine combinations operated during 2004 at the head-of-tide Brunswick Dam, Androscoggin River, Maine. Among turbine configurations, a "0" indicates that the turbine is off, while a "1" indicates that the turbine was on. Bolded values represent the four turbine configurations that comprised 91% of all American Shad observations used for statistical comparison (see Figure 5).

			Turbine configuration		
Mean (±SD)	Number of video segments	Percentage of total observations	Turbine 1	Turbine 2	Turbine 3
9.0 (11.1)	9	2	0	0	0
6.5 (5.6)	**105**	**21**	**0**	**0**	**1**
8.6 (6.2)	**88**	**18**	**0**	**1**	**0**
7.4 (6.7)	**182**	**37**	**0**	**1**	**1**
4.1 (3.3)	**79**	**16**	**1**	**0**	**0**
5.2 (4.5)	4	1	1	0	1
4.4 (3.2)	17	3	1	1	0
3.0 (1.9)	14	3	1	1	1

tagged below the dam. A total of 57 American Shad were tagged from 2002 to 2005 (10 in 2002 and 2003, 22 in 2004, and 15 in 2005). Each year, the angling and tagging of American Shad began in June and fish were tracked through July. In 2005, mobile tracking of radio-tagged fish was conducted on several occasions several km downstream from the study site. We used river discharge data from the U.S. Geological Survey gauging station on the Androscoggin River in Auburn, Maine, (approximately 35 rkm above the Brunswick Dam), to visually assess American Shad movement in relation to river discharge.

Radio receivers were calibrated and adjusted prior to fish tagging to define the coverage areas of the receivers to their respective pools or specific locations. However, after data collection, we observed multiple antennas picking up a single tagged fish simultaneously. This was observed during all years and we corrected for it in two ways. First, we established a minimum threshold of power output for every detection by eliminating all detections with power levels lower than the 25% quantile. Second, we eliminated any detections with < 10 events.

RESULTS

Video-Recorded Counts

Video-recorded counts served as an index of the abundance of American Shad in the river and fishway. From

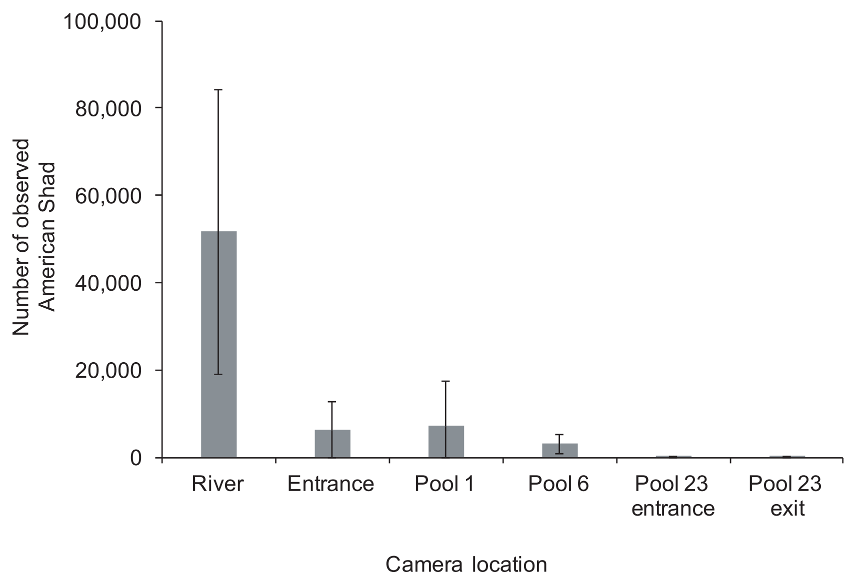
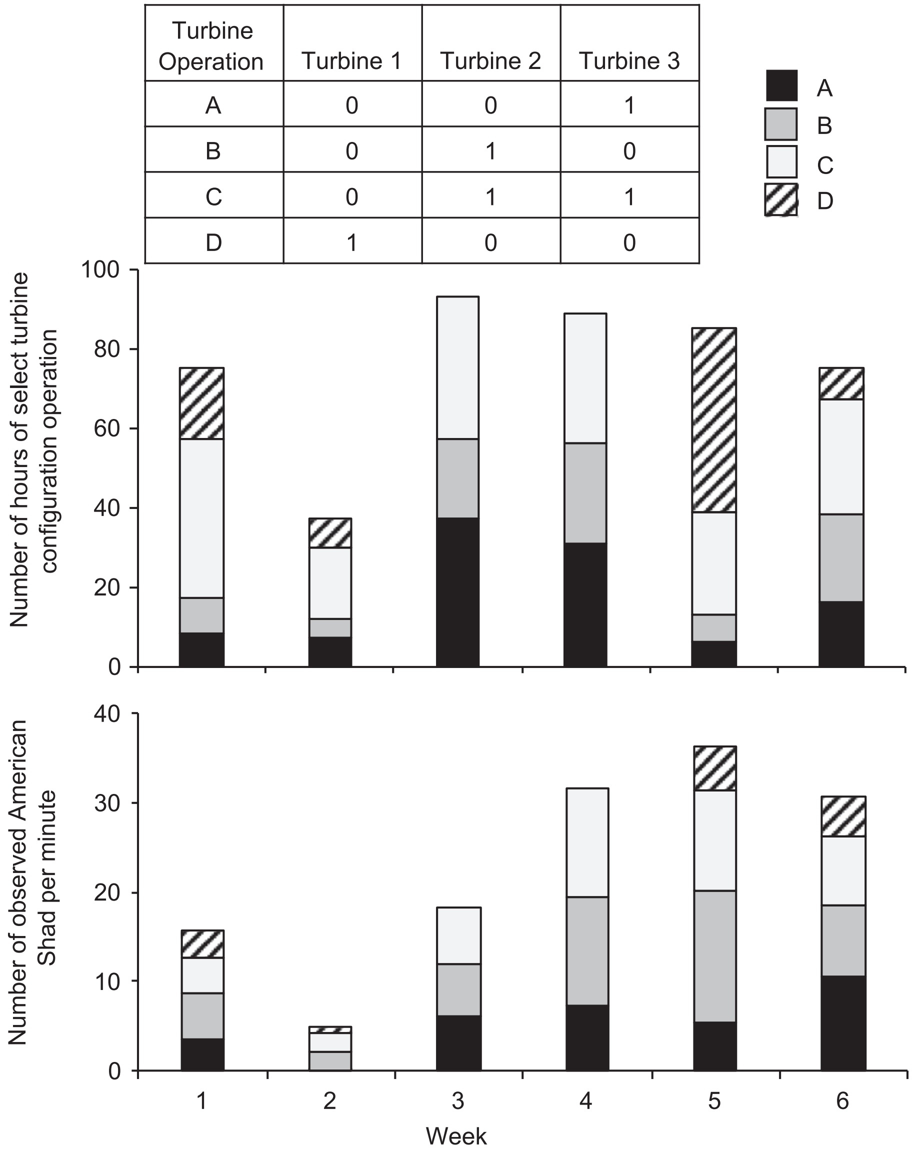


FIGURE 4. The means and SDs of counted American Shad serving as an index of abundance. Individuals were counted with the use of underwater cameras deployed during 2001–2004 at six locations in the river, fishway entrance, and select pools in the fishway. Fish may have been counted more than once. Refer to Figure 2 for locations of the cameras.



Turbine Operation	Turbine 1	Turbine 2	Turbine 3
A	0	0	1
B	0	1	0
C	0	1	1
D	1	0	0

FIGURE 5. The total number of hours of turbine operation (upper graph) and observed American Shad per minute (lower graph) among select turbine operation configurations **(A–D)** for each week during the period of American Shad migration. Rates of American Shad passage were estimated from video recordings from underwater cameras placed in the Androscoggin River, Maine. See Figure 2 for camera placement.

2001 to 2004, the unadjusted counts of American Shad in the study area were relatively high in the river, averaging approximately 51,000 and ranging from 25,000 to nearly 100,000 per year (Figure 4). This was in comparison with the number of observations in either the entrance of the fishway or the lower fishway (i.e., pools 1 and 6), which averaged <8,000. Very few fish (≤130 fish on average) were observed entering or exiting the switchback pool.

Hydropower Turbine Operations

The amount of time that each of the four selected turbine configurations operated was relatively consistent over the daily time period (0600–1800 hours) that video recordings were viewed. However, there were generally higher numbers of fish in the morning hours (0600 hours) and a decline in counts toward the evening (1800 hours; Supplementary Figure 1 available in the online version of this article). In contrast, the amount of time that each of the four turbine configurations operated over the 6-week period of American Shad migration was not equivalent and some turbine configurations operated more frequently than others (Figure 5). Furthermore, during the course of the season, we observed higher numbers of American Shad during weeks 4 and 5.

Mean rates of observed American Shad from 2004 video recordings ranged from 4.1 to 8.6 individuals/min among the four combinations (Table 1; Figure 6). We

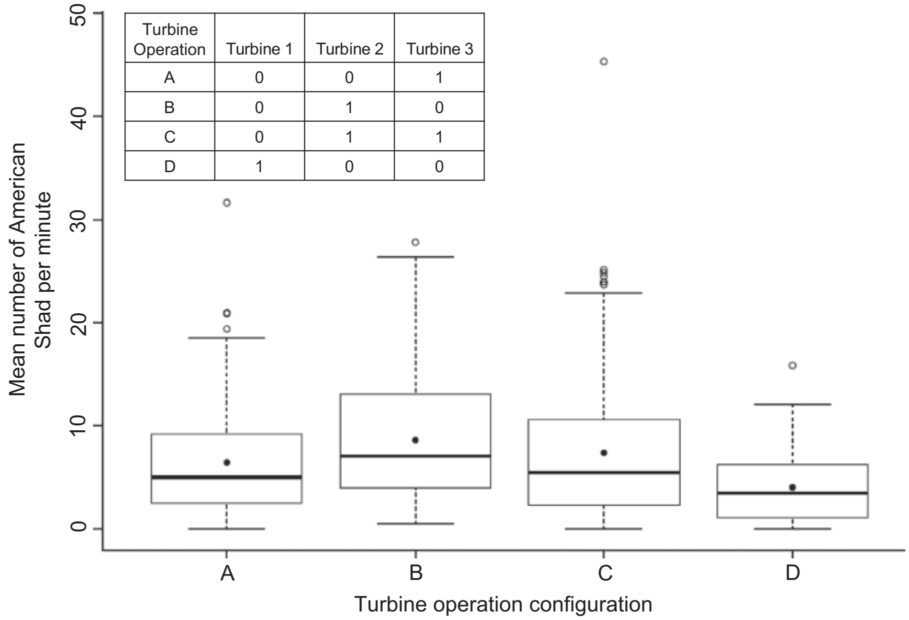


FIGURE 6. Box and whisker plots of numbers of American Shad per minute across four select hydropower turbine configurations **(A–D)**. Black lines across each box represent the median and black dots represent the mean rate for each turbine configuration. The box represents the values of the middle 50% of the calculated rates and the ends of the whiskers indicate the lowest and highest rates. The table inset indicates the operation of each turbine. A "0" indicates that the turbine was not operating while a "1" indicates that the turbine was operating. Results from a Kruskal–Wallis test found significant differences in rates of observed American Shad passage among the four combinations.

TABLE 2. The total number of radio-tagged American Shad (*N*) per year and the numbers associated with the location(s) of their detections. Undetected fish were never detected after tagging. Mobile tracking of fish downstream of the study site was only conducted in 2005. Individual fish could be detected at multiple locations; therefore, the sum of these locations is generally not equal to *N*.

		Location(s) of detections				
Year	*N*	Undetected	River adjacent to fishway	Fishway entrance	Lower fishway	River downstream
2002	10	10	0	0	0	N/A
2003	10	6	4	3	2	N/A
2004	22	14	8	4	2	N/A
2005	15	4	10	4	1	9
Total	57	34	22	11	5	9

found significant differences among the number of American Shad observed across the four hydropower turbine combinations ($H = 28.82$; $P < 0.05$). Mean numbers of observed American Shad were higher, ranging from 6.5 to 8.6 individuals/min when turbine 1 (the one closest to the fishway) was not operating, compared with 4.1/min when it was operating.

Telemetry Study

Among years, the time period over which tagged American Shad were detected ranged from 1 d to approximately 16 d. This detection variation was observed among all tagged fish regardless of whether they were detected in the river, fishway entrance, or fishway. The majority of tagged American Shad (34 of 57; 59%) were not detected after tagging and release. Eleven (19%) were detected approaching the entrance to the fishway and of those, 5 (8%) were detected in the lower fishway (Table 2). Of those fish that approached and used the fishway, several were generally detected making multiple attempts at entering and ascending the fishway. Periods of movement appeared to be aligned with increases in stream flow (Figure 7). In 2005, 9 individuals (15%) were detected from mobile tracking efforts downstream of the study site. None of the tagged fish were detected in the upper fishway or passed above the dam.

DISCUSSION

We synthesized a series of studies that suggest that American Shad exhibit poor passage through the

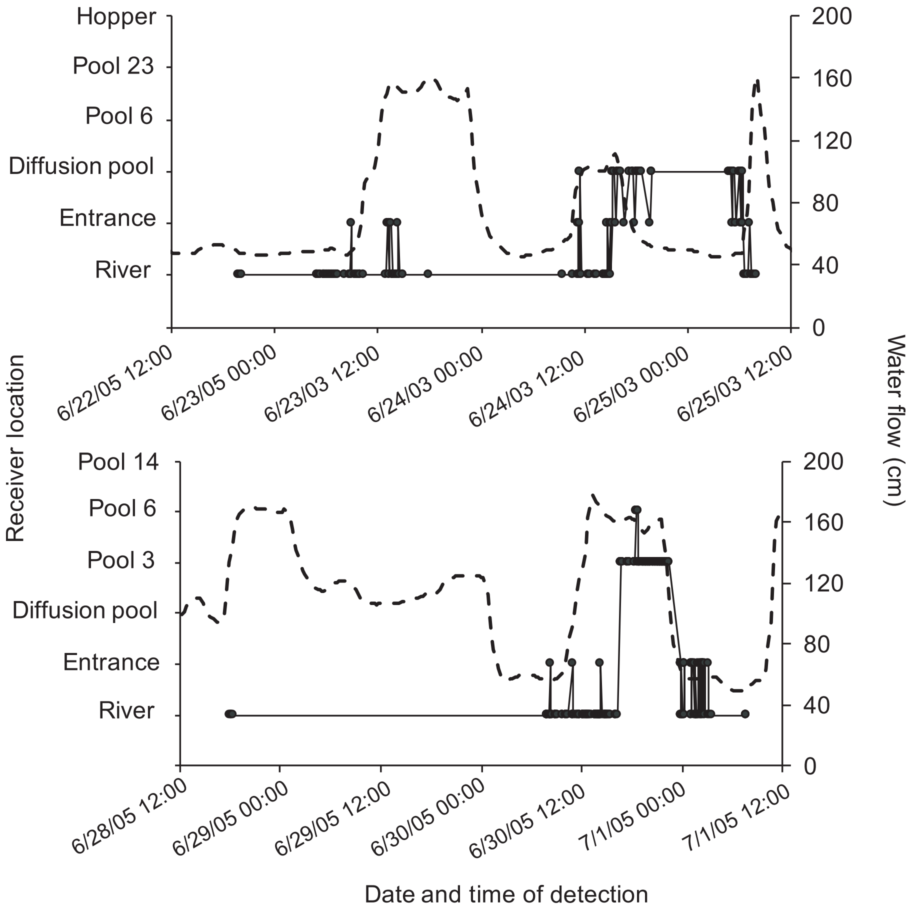


FIGURE 7. Movement of two radio-tagged American Shad from 2003 (top) and 2005 (bottom) during spawning migration in the Androscoggin River, Maine, and the Brunswick fishway. The solid line refers to locations where individuals were detected (left *y*-axis). The dashed line refers to water discharge from an upstream U.S. Geological Survey gauging station (right *y*-axis). Refer to Figure 2 for the locations of telemetry antennas.

Brunswick Dam vertical slot fishway on the Androscoggin River, Maine. American Shad were present in the river below the dam, but the operation of the turbines (particularly the one closest to the fishway) may alter flows and deter their approach to the fishway. Passage conditions at the fishway and management operations at the hydropower facility have remained largely unchanged since these studies were completed in 2005; therefore, it is likely that American Shad continue to face challenges to upstream migration. This work represents a timely step toward understanding American Shad behavior and passage that may be used to direct future research efforts, and demonstrates a case study in which the best available science, in the form of several small studies, may be used to inform management decisions.

The evaluation of fish passage through fishways typically focuses on two aspects: the attraction of the fish to the fishway entrance and the passage of the fish through the structure. Other studies examining American Shad passage align with our findings. Aunins et al. (2013) observed no radio-tagged American Shad passing through a vertical slot fishway at Bosher's Dam on the James River, Virginia, and suggested that American Shad may have difficulty locating the attraction waters of the fishway. Barry and Kynard (1986) found that the turbulence generated by the flow of water from a hydroelectric turbine may disorient American Shad, thereby imposing delays on migration. The vertical slot fishway at the Brunswick Dam was adopted from designs targeting salmonids and deployed in relatively large rivers; however, when scaled down to suit smaller Atlantic coast rivers, it may disproportionately alter hydraulics and create unsuitable passage conditions with higher turbulence and velocity (ASMFC 2010). Salmonids are generally considered relatively stronger swimmers than American Shad (Gowans et al. 1999), so certain fishway designs may create unintended physiological limitations to movement that vary by species. Thus, like previous studies, our work suggests that American Shad face obstacles including finding the attraction waters of the fishway and scaling the elevated pools of the fishway.

The Brunswick fishway was initially designed to pass 85,000 American Shad (MDMR 2014). However, the FERC did not issue a license contingent on the evaluation of efficiency studies for upstream and downstream passage of fish. The evaluation of altered flows and fishway hydraulics and the consideration of the swimming behavior of the fish intended for passage are critical components that are best identified during the fishway designing process (Weaver 1965; Castro-Santos 2005; Bunt et al. 2012; Williams et al. 2012). Furthermore, the flows encountered by migratory fish approaching the Brunswick Dam are influenced by turbine operation, river discharge, and tidal stage, creating a challenging environment to manage fish passage. The data that we synthesized suggest that significant structural changes could improve American Shad passage and could be considered by managers as this dam's FERC license expires in 2024.

Among years, 25–100% of our radio-tagged fish were not detected after release and may have succumbed to mortality or exhibited fallback behavior. Other tagging studies have reported substantial fallback behavior (i.e., downstream movement) of American Shad after tagging and release back into the river (Beasley and Hightower 2000; Aunins and Olney 2009; Grote et al. 2014). Fallback can only be identified from detections by additional downstream radio receivers, which were not present during our studies. Limited mobile tracking that took place several km downstream of the dam during 2005 detected nine fish on one or two occasions suggesting fallback behavior, but this tracking effort was not integrated as a primary component of the study and therefore any conclusions regarding this behavior are speculative.

The management of American Shad and the pattern of poor passage in the Androscoggin River has remained consistent over the last 20 years, including the years when the monitoring projects described here occurred. Relatively high passage was reported in 2016, but that was a year of historically high passage rates regionally. For example, 7,800 American Shad were passed at the Milford Dam on the Penobscot River, Maine, in 2016 (NOAA Northeast Fisheries Science Center 2016). These patterns suggest that American Shad are still present below the dam but continue to face challenges associated with passage.

Management Implications

In closing, we suggest that the vertical slot fishway at the Brunswick Dam on the Androscoggin River, Maine, provides poor passage for upstream migrating American Shad. Our work highlights the sensitivity of passage conditions to hydropower generation and the importance of characterizing the permutations of turbine operations. Experiments that systematically explore the relationship between turbine operations, river discharge, and resulting fish movement and behavior may provide additional data to characterize fishway approach and passage. Exploring the effects of river discharge, hydropower operations, and other environmental variables (e.g., tidal stage) on the behavior and passage of migrating anadromous fishes remain an important area for further study. Therefore, we demonstrate that small-scale studies, when synthesized, provide opportunities to inform the design of future studies for regulatory mandates (i.e., FERC relicensing) and for the conservation and management of fisheries.

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REFERENCES

ASMFC (Atlantic States Marine Fisheries Commission). 2007. American Shad stock assessment. ASMFC, Stock Assessment Report 07-01, Washington, D.C.

ASMFC (Atlantic States Marine Fisheries Commission). 2010. Upstream fish passage technologies for managed species. Fish Passage Working Group, Washington, D.C.

Aunins, A. W., B. L. Brown, M. Balazik, and G. C. Garman. 2013. Migratory movements of American Shad in the James River fall zone, Virginia. North American Journal of Fisheries Management 33:569–575.

Aunins, A. W., and J. E. Olney. 2009. Migration and spawning of American Shad in the James River, Virginia. Transactions of the American Fisheries Society 138:1392–1404.

Barry, T., and B. Kynard. 1986. Attraction of adult American Shad to fish lifts at Holyoke Dam, Connecticut River. North American Journal of Fisheries Management 6:233–241.

Beasley, C. A., and J. E. Hightower. 2000. Effects of a low-head dam on the distribution and characteristics of spawning habitat used by Striped Bass and American Shad. Transactions of the American Fisheries Society 129:1316–1330.

Benjamini, Y., and Y. Hochberg. 1995. Controlling the false discovery rate: a practical and powerful approach to multiple testing. Journal of the Royal Statistical Society B 57:289–300.

Brown, M. E., J. Maclaine, and L. Flagg. 2006. Anadromous alosid restoration in the Androscoggin River watershed. Maine Department of Marine Resources, Project AFC-37, Augusta.

Bunt, C. M., T. Castro-Santos, and A. Haro. 2012. Performance of fish passage structures at upstream barriers to migration. River Research and Applications 28:457–478.

Castro-Santos, T. 2005. Optimal swim speeds for traversing velocity barriers: an analysis of volitional high-speed swimming behavior of migratory fishes. Journal of Experimental Biology 208:421–432.

Castro-Santos, T., and B. H. Letcher. 2010. Modeling migratory energetics of Connecticut River American Shad (*Alosa sapidissima*):

implications for the conservation of an iteroparous anadromous fish. Canadian Journal of Fisheries and Aquatic Sciences 67:806–830.

FERC (Federal Energy Regulatory Commission). 2019. Pending licenses, relicenses and exemptions. Available: www.ferc.gov/industries/hydropower/gen-info/licensing.asp. (July 2019).

Gowans, A. R. D., J. D. Armstrong, and I. G. Priede. 1999. Movements of adult Atlantic Salmon in relation to a hydroelectric dam and fish ladder. Journal of Fish Biology 54:713–726.

Grote, A. B., M. M. Bailey, and J. D. Zydlewski. 2014. Movements and demography of spawning American Shad in the Penobscot River, Maine, prior to dam removal. Transactions of the American Fisheries Society 143:552–563.

Haro, A., and T. Castro-Santos. 2012. Passage of American Shad: paradigms and realities. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science [online serial] 4:252–261.

Haro, A., and B. Kynard. 1997. Video evaluation of passage efficiency of American Shad and Sea Lamprey in a modified Ice Harbor fishway. North American Journal of Fisheries Management 17:981–987.

Hightower, J. E., A. M. Wicker, and K. M. Endres. 1996. Historical trends in abundance of American Shad and river herring in Albemarle Sound, North Carolina. North American Journal of Fisheries Management 16:257–271.

Limburg, K. E., K. A. Hattala, and A. Kahnle. 2003. American Shad in its native range. Pages 125–140 *in* K. E. Limburg and J. R. Waldman, editors. Biodiversity, status, and conservation of the world's shads. American Fisheries Society, Symposium 35, Bethesda, Maryland.

Limburg, K. E., and J. R. Waldman. 2009. Dramatic declines in North Atlantic diadromous fishes. BioScience 59:955–965.

MDMR (Maine Department of Marine Resources). 2014. American Shad habitat plan. Atlantic States Marine Fisheries Commission, Arlington, Virginia. Available: www.asmfc.org/files/ShadHabitatPlans/AmShadHabitatPlan_ME.pdf. (July 2019).

NOAA (National Oceanic and Atmospheric Administration) Northeast Fisheries Science Center. 2016. The return of American Shad: successful spawning in Maine river a positive sign. NOAA, Northeast Fisheries Science Center, Silver Spring, Maryland. Available: www.nefsc.noaa.gov/press_release/pr2016/scispot/ss1614/. (July 2019).

Noonan, M. J., J. W. A. Grant, and C. D. Jackson. 2012. A quantitative assessment of fish passage efficiency. Fish and Fisheries 13:450–464.

Weaver, C. R. 1965. Observations on the swimming ability of adult American Shad (*Alosa sapidissima*). Transactions of the American Fisheries Society 94:382–385.

Williams, J. G., G. Armstrong, C. Katopodis, M. Larinier, and F. Travade. 2012. Thinking like a fish: a key ingredient for development of effective fish passage facilities at river obstructions. River Research and Applications 28:407–417.

SUPPORTING INFORMATION

Additional supplemental material may be found online in the Supporting Information section at the end of the article.

Exhibit 6

Exhibit 6-Lichter, et al FOMB, 2024- P-2284-0052

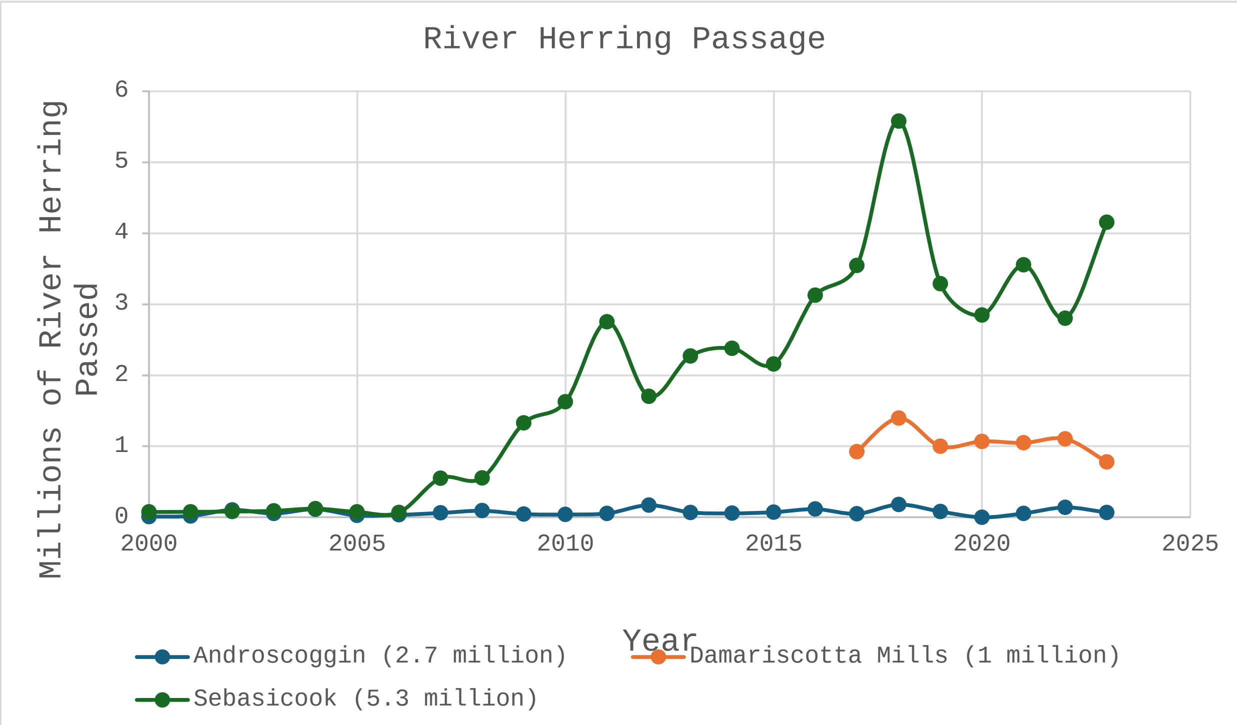


Figure 1. River herring passage at Brunswick on the Androscoggin River, Damariscotta Mills, and Benton Falls on the Sebasticook River between 2000-2023 in millions of fish passed.

Estimates of potential river herring production are 2.7 million for the Androscoggin, 1 million for Damariscota Mills, and 5.3 million for the Sebasticook. By 2009, two dams had been removed and three fish lifts installed on the remaining dams in the Sebasticook/Kennebec system allowing passage of millions of river herring. By 2017, the Damariscotta Mills fishway had been reconstructed allowing passage of ~1 million alewives each year into a single lake. The Androscoggin, however, has been left behind with inadequate fish passage. The fishway at Brunswick has only passed 71,087 river herring on average each year between 2000 and 2023, only 2.6% of its potential productivity. Also, very few American shad are able to navigate the Brunswick fishway (data not shown).

River herring include alewives and blueback herring. Both species are anadromous fish that come into the river systems to spawn between late April and June.

Shad surveys

In 2011, Professor John Lichter and Bowdoin College students worked with NextEra Energy, the owner of the Brunswick hydroelectric at that time, along with the Maine Department of Marine Resources, U. S. Fish and Wildlife Service, and the Androscoggin River Alliance to conduct an experiment to determine whether upstream passage of American shad could be improved by increasing the water flow of the attraction stream at the Brunswick Fishway. In 2013, the experiment was repeated in collaboration with Brookfield Renewable Power. The results were reported in the American Shad Habitat Plan, Maine Dept. of Marine Resources, 2020. Relatively few shad made it to the entrance of the fishway despite thousands being in the tail race. Since 2013, Professor Lichter, Bowdoin College students, and the Friends of Merrymeeting Bay have used an ARIS hydroacoustic instrument to count American shad moving upriver toward the fishway from a point just below the F. W. Wood bridge on the Brunswick side of the river. The following student report and table 1 describe these surveys along with the results. To summarize, there were usually 1000 to 7500 American shad counted moving upriver in a single tidal cycle (4-6 hours) each year, whereas only a few hundred at most were successful finding the fishway and scaling the ladder in a given year.

Relevant studies

Wippelhauser, G. S. 2012. Shad passage study at Brunswick Project. Maine Dept. of Marine Resources.

Maine Department of Marine Resources. 2020. American Shad Habitat Plan. With contributions by M. LeBlanc (Brookfield Renewable Energy), J. Stevens (NOAA), J. Lichter (Bowdoin College).

Bowdoin student work in 2017

Efficacy of fish passage over the Brunswick-Topsham hydroelectric dam by American shad (*Alosa sapidissima*) in 2017

Meera Prasad ('19), Biology Department, Bowdoin College

Faculty mentor: John Lichter, Professor of Biology and Environmental Studies

Dams at Brunswick-Topsham have obstructed passage of anadromous fish species migrating upriver to preferred spawning habitat in the Androscoggin River since the early 19th century. The American shad is a key anadromous fish species that historically migrated as far as Lewiston, Maine to spawn each year. However, dam construction, overfishing, and water pollution decimated the shad population along with several other anadromous fish species over the last three centuries. Shad is an important component of Maine's river ecosystems. Their young-of-year consume and export excess nutrients out of the riverine ecosystem and after migrating out to sea, they serve as a prey base for several piscivorous fish species in the Gulf of Maine.

In 1982, a volitional fish ladder was constructed at Brunswick-Topsham to facilitate fish passage at the dam. However, the fish ladder has not been effective for American shad. To quantify shad attempting to migrate upriver at Brunswick-Topsham, I used an ARIS Sonar instrument to count fish moving past a point below the bridge connecting Brunswick and Topsham on the Brunswick side of the river. This acoustic technology provides video-like recordings of fish passing through an approximately 8 x 20-m footprint (Figure 1). Over six sample days lasting 5-6 hours each, I recorded an average of 3495 migrating shad between June 21 and July 18 moving upriver past the sonar footprint. The peak of the migration was on July 10 in which 4791 shad were observed. At the top of the fish ladder, an employee of the Department of Marine Resources or a volunteer counts the number of fish that successfully make it to the top of the ladder. Only a single shad made it to the top of the ladder indicating that there are many more shad attempting to scale the ladder than actually succeed. Although I was able to get clear video imaging of the river ecosystem, the sonar footprint only reached halfway across the river channel below the tail race of the dam (Figure 2). Thus, my counts were at best minimal estimates of the number of shad present.

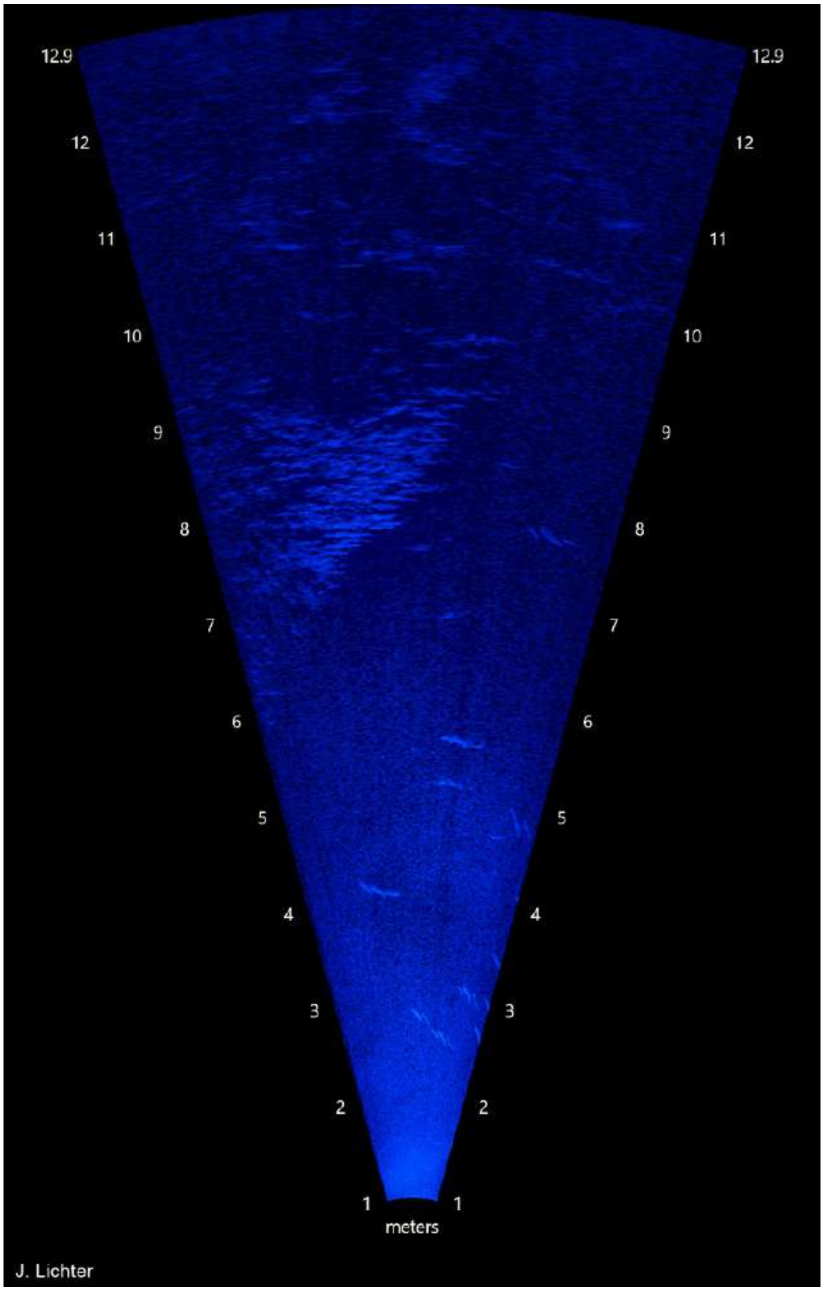


Figure 2. Underwater image from the ARIS Sonar. The light blue fish at 7 to 9 meters on the left side of the sonar footprint are river herring. A few scattered shad range from 2 to 8 meters. The rocky bottom is visible out at 9 to 12 meters.

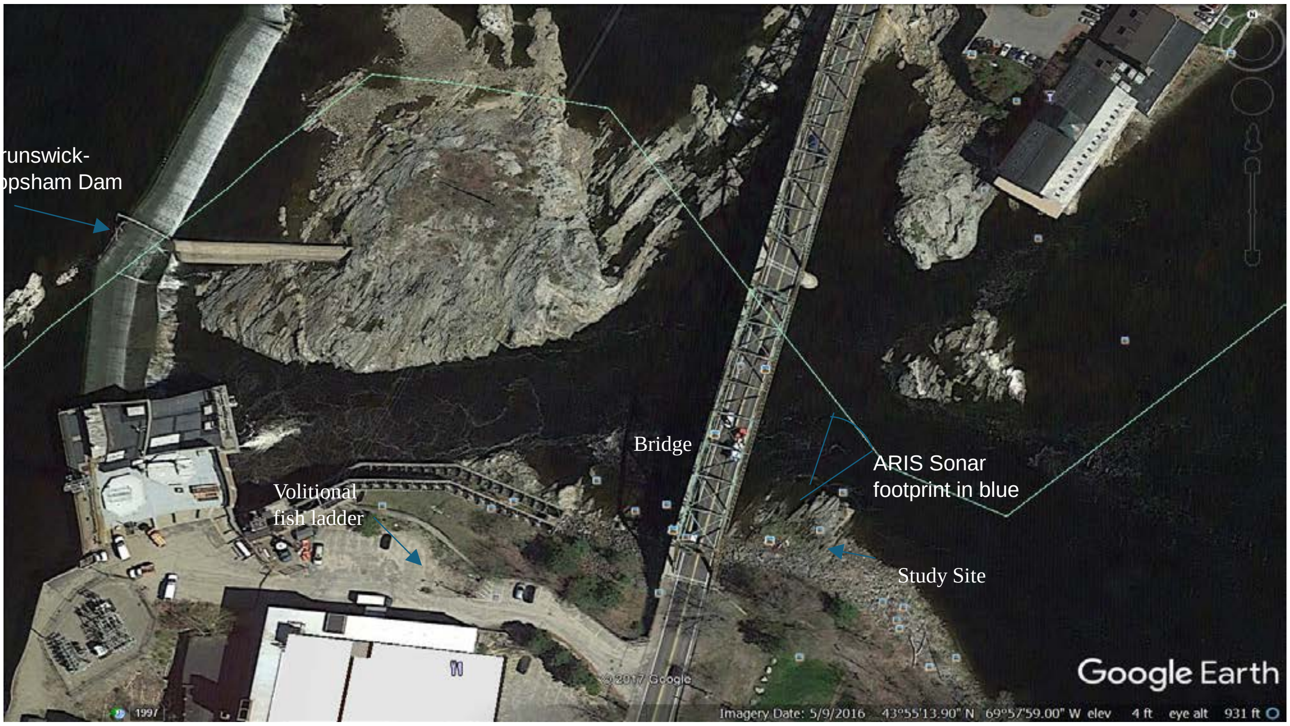


Figure 3. Aerial view of study site.

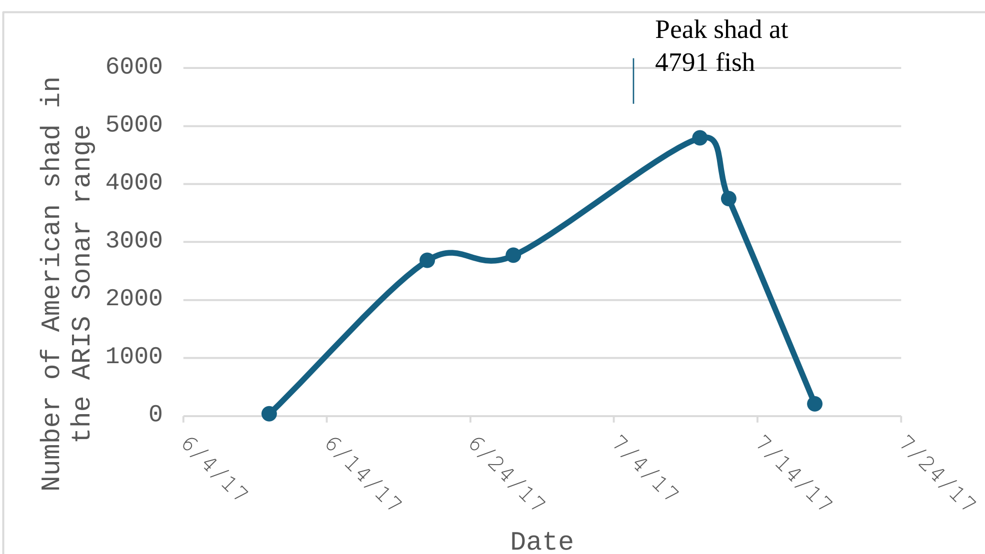


Figure 4. Number of American shad counted for 5 days over the 7-week period of the migration run.

Table 1: Minimum number of shad moving toward dam in a single tidal cycle recorded with ARIS sonar and the number of shad successfully finding and scaling the Brunswick Fishway ladder through the entire season.

	#Shad downriver	#Successful shad
7/10/2017	4791	1
7/5/2021	1459	550
6/24/2022	1382	228
5/15/2023	~7500	13
6/18/2024	*9,000-12,000	58 (5/17/24. DMR)

* Provisional quick count by June 20

References relevant to dams in Maine.

Effects of dam building on anadromous fish in Maine

Atkins, C. G. 1887. The river fisheries of Maine. Fisheries and Fishery Industries of America. U. S. Commissioner of Fisheries. *Collapsed fish populations by 1815 with concrete dam.

Atkins, C. G. and N. Foster. 1869. First report of the Commissioners of Fisheries of the State of Maine, 1868. Owen and Nash, Printers to the State, Augusta, Maine.

Atkins, C. G. and E. M. Stillwell. 1874. Obstructions to the upward movement of fishes in streams, and the remedy. In U. S. Commission of Fish and Fisheries, Part II, Report of the Commissioner for 1872 and 1873. Appendix E, Sections XXIII and XXIV. Government Printing Office, Washington, D. C., pp 589-621.

Hall, C. J., A. Jordaan, M. G. Frisk. 2011. The historic influence of dams on diadromous fish habitat with a focus on river herring and hydrologic longitudinal connectivity. *Landscape Ecology* 26:95-107. *History of dam building and loss of diadromous fish habitat.

Limburg, K.E., and J. R. Waldman. 2009. Dramatic decline in North Atlantic diadromous fishes. Bioscience 59 (11):955-965.

Poff, N. L. and D. D. Hart. 2002. How dams vary and why it matters for the emerging science of dam removal. *Bioscience* 52(8): 659-668.

Rounsefell, G. A. and L. D. Stringer. 1945. Restoration and management of New England alewife fisheries with special reference to Maine. U. S. Department of the Interior, Fish and Wildlife Service. Transactions of the American Fishery Society 73:394-424.

Saunders, R., M. A. Hachey, and C. W. Fay. 2006. Maine's diadromous fish community: past, present, and implications for Atlantic Salmon recovery. *Fisheries* 31(11)L 537-547.

Weaver, D. M., M. Brown, and J. D. Zydlewski. 2019. Observations of American Shad, Alosa sapidissima, approaching and using a vertical slot fishway at the head-of-tide Brunswick dam on the Androscoggin River, Maine. North American Journal of Fisheries Management.

Connection of alewives and anadromous fish to coastal marine food web and groundfish fisheries.

Ames, E. P. 2004. Atlantic cod structure in the Gulf of Maine. *Fisheries Research* 29:10-28.

Ames, E. P. and J. Lichter. 2013. Gadids and alewives: structure within complexity in the Gulf of Maine. *Fisheries Research* 141:70-79.

Baird, S. 1872-1873. U. S. Commissioner of Fish and Fisheries Report of 1873. Washington, D. C.

Belding, D. L. 1921. A report on the alewife fisheries of Massachusetts. Department of Conservation, Division of Fisheries and Game. Boston.

Bolster, J. 2012. The Mortal Sea: Fishing the Atlantic in the age of sail. The Belknap Press of Harvard University Press.

Fields, G. W. 1914. Alewife fishery of Massachusetts. Transactions of the American Fisheries Society 43(1): 143-161.

Hind, H. Y. 1877. The effect of the fishery clauses of the Treaty of Washington on the fisheries and fishermen of British North America.

Lichter, J. and E. P. Ames. 2012. Reaching into the past for future resilience: recovery efforts in Maine rivers and coastal waters. *Maine Policy Review* 21:96-102.

Mattocks, S. C. J. Hall, and A. Jordaan. 2017. Damming, lost connectivity, and the historic role of anadromous fish in freshwater ecosystem dynamics. Bioscience 67(8): 713-728.

Smith, H. M. 1899. Notes on the extent and condition of the alewife fisheries of the United States in 1896. In U. S. Commissioner of Fish and Fisheries Report, Part XXIV for the year ending June 30, 1898.

Walter, R. C. and D. J. Merritts. 2008. Natural streams and the legacy of water-powered mills. *Science* 319:299-304.

Department of Marine Resources, Sea-run Fisheries Division

American Shad Habitat Plan 2020. With contributions from M. LeBlanc (Brookfield), J. Stevens (NOAA), J. Lichter (Bowdoin College).

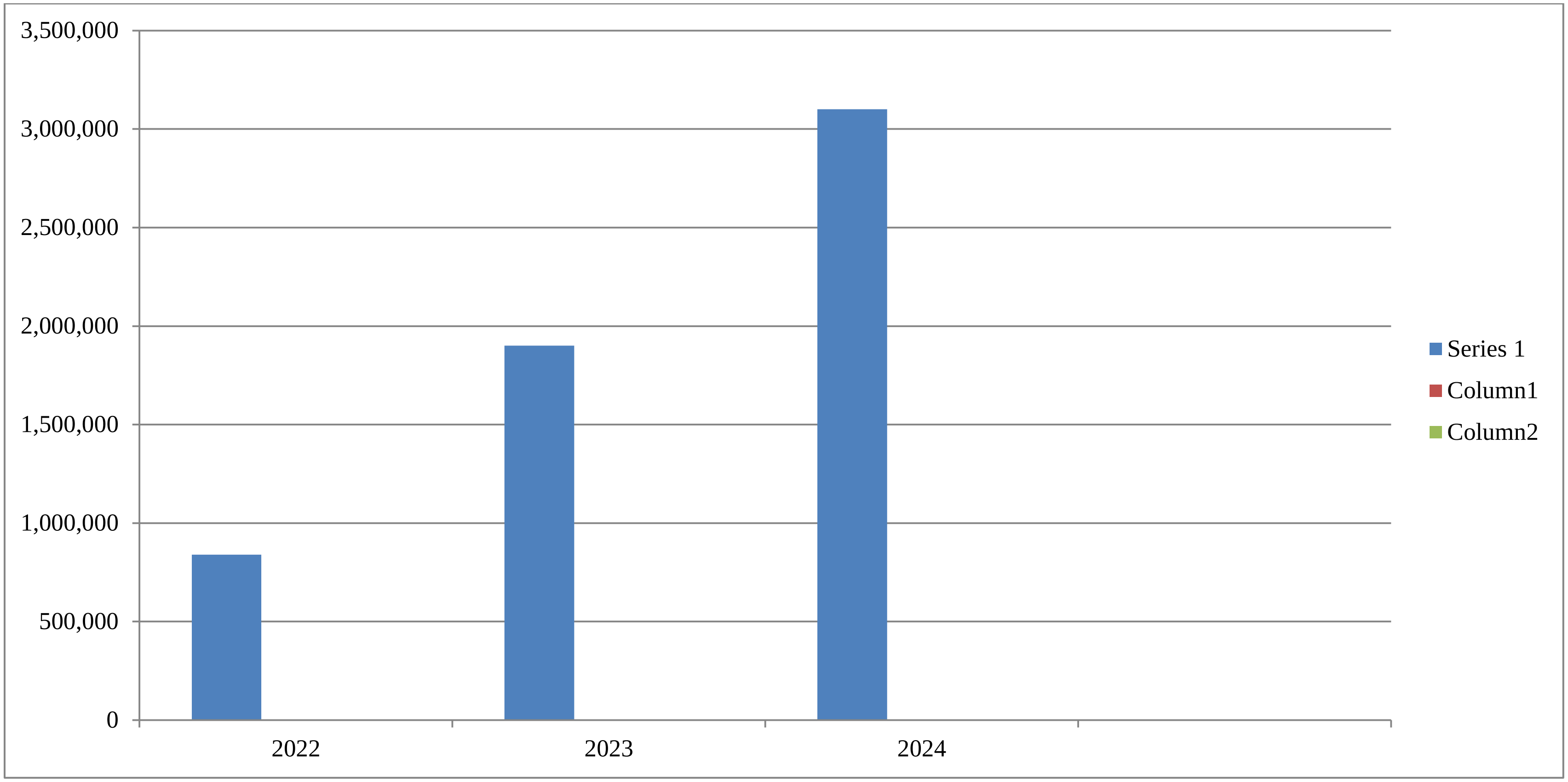
Androscoggin River Anadromous Fish Restoration Program. M. E. Brown, J. Maclaine, and L. Flagg. 2008.

Draft Fisheries Management Plan for the Lower Androscoggin River, Little Androscoggin River, and Sabattus River. 2017. Michael Brown, Paul Christman, and Gail Wippelhauser.

Exhibit 7

Exhibit 7 Friedman, FOMB 2024. P-2284-0052

**China Lake Outlet Stream-River Herring Passed into China Lake-
Through Three Dams with Fishways.**



Fish Counts: Nate Gray, MDMR, pers. comm.

China Lake-Accessible River Herring Habitat - 3,845 acres

Androscoggin River- Potential River Herring Habitat- 4,660 acres

FOMB Exhibits Brunswick, Maine Hydroelectric Project, Androscoggin River FERC P-2284-0052

Exhibit 8

Ex. 8

UNITED STATES DISTRICT COURT
DISTRICT OF MAINE

FRIENDS OF MERRYMEETING BAY and ENVIRONMENT MAINE,

Plaintiffs,

v.

NEXTERA ENERGY RESOURCES, INC.; NEXTERA ENERGY MAINE OPERATING SERVICES, LLC; and THE MERIMIL LIMITED PARTNERSHIP,

Defendants.

Civil Action No.

COMPLAINT

INTRODUCTION

1. Defendants NextEra Energy Resources, Inc., NextEra Energy Maine Operating Services, LLC, and The Merimil Limited Partnership are violating the federal Endangered Species Act ("ESA"), 16 U.S.C. § 1531 *et seq.*, by killing, harming, and harassing endangered Atlantic salmon at hydroelectric dams they own and operate on the Kennebec and Androscoggin Rivers. Defendants are, in ESA parlance, illegally "taking" this endangered species. More specifically, Defendants' dams: kill and injure salmon with their rotating turbine blades when the fish try to pass through them; impede upstream and downstream salmon passage, which prevents salmon from gaining access to significant amounts of spawning and rearing habitat; alter the natural habitat to such a degree that the essential behavior patterns of the fish are significantly impaired; and have other deleterious effects on the salmon.

2. The ESA allows the National Marine Fisheries Service ("NMFS") and United States Fish and Wildlife Service ("USFWS") (collectively, the "Services"), under certain circumstances, to authorize an otherwise prohibited taking of an endangered species "if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity." 16 U.S.C. § 1539(a)(1)(B). Defendants do not have authorization from the Services to commit an incidental take of salmon at their dams.

3. Defendants are also violating federal Clean Water Act ("CWA") water quality certifications issued for their Kennebec River dams. These certifications prohibit Defendants from allowing downstream-migrating adult salmon and adult shad to pass through the turbines of these dams unless Defendants have conducted studies proving that such passage does not result in significant injury or mortality. Although Defendants are allowing adult salmon and adult shad to pass through their turbines, they have not conducted the requisite studies. Plaintiffs believe such studies would show that turbine passage results in significant injury and mortality, as other studies have shown.

4. Neither the federal nor state government has taken enforcement action against Defendants to redress these violations. However, Congress authorized citizens to bring "citizen suits" in United States District Courts to enforce the ESA and CWA directly against violators. 16 U.S.C. § 1540(g) (ESA citizen suit provision); 33 U.S.C. § 1365 (CWA citizen suit provision).

5. Defendants' dams are a major reason the Kennebec and Androscoggin populations of salmon have declined to perilously low levels. Although they have long been aware of this fact, Defendants have not taken a number of basic, feasible steps, such as keeping fish from swimming into their spinning turbine blades, that would reduce the

detrimental effects of their dams on these endangered populations. Without a court order directing them to so, Defendants will not comply expeditiously with the ESA and their CWA water quality certifications.

PARTIES

6. Plaintiff Friends of Merrymeeting Bay ("FOMB") is a non-profit Maine corporation with over 400 members. FOMB is dedicated to preserving the ecological, aesthetic, historical, recreational, and commercial values of Maine's Merrymeeting Bay and its watershed, which includes the Kennebec and Androscoggin Rivers. FOMB accomplishes its mission through research, advocacy, land conservation, education, and litigation.

7. Plaintiff Environment Maine is a non-profit Maine corporation. It is a statewide environmental organization that advocates for clean air, clean water, and preservation of Maine's natural resources on behalf of approximately 3,460 citizen members from across the state of Maine. Among other activities, Environment Maine researches and distributes analytical reports on environmental issues, advocates before legislative and administrative bodies, engages in litigation when necessary, and conducts public education.

8. Defendant NextEra Energy Resources, Inc. ("NextEra"), either in its own name or through a subsidiary, owns Weston and Shawmut hydroelectric dams on the Kennebec River and Brunswick hydroelectric dam on the Androscoggin River. NextEra has a 50% ownership interest in Defendant The Merimil Limited Partnership ("Merimil"), which owns Lockwood dam on the Kennebec. NextEra operates, and exercises fundamental control over, Weston, Shawmut, Lockwood, and Brunswick dams.

http://www.nexteraenergyresources.com/content/where/portfolio/pdf/Maine_Kennebec.pdf (NextEra website page discussing Kennebec facilities);
http://www.nexteraenergyresources.com/content/where/portfolio/pdf/Maine_Androscoggin.pdf (NextEra website page discussing Androscoggin facilities).
NextEra is itself a subsidiary of NextEra Energy, Inc., a large energy company based in Florida that includes Florida Power & Light.

9. Defendant NextEra Energy Maine Operating Services, LLC ("NextEra Maine"), operates Weston, Shawmut, Lockwood, and Brunswick hydroelectric dams. NextEra Maine is a subsidiary of NextEra. NextEra Maine was formerly known as FPL Energy Maine Operating Services, LLC.

10. Defendant The Merimil Limited Partnership ("Merimil") owns Lockwood dam.

11. NextEra and NextEra Maine operate as the licensees of Weston, Shawmut, Lockwood, and Brunswick dams.

JURISDICTION AND VENUE

12. Subject matter jurisdiction is conferred upon this Court by 16 U.S.C. § 1540(g)(1) (ESA citizen suit provision), 33 U.S.C. § 1365(a) (CWA citizen suit provision), and 28 U.S.C. § 1331 (federal question jurisdiction). Venue lies within this District pursuant to 16 U.S.C. § 1540(g)(3)(A) (ESA venue provision), 33 U.S.C. 1365(c)(1) (CWA venue provision), and 28 U.S.C. § 1391(e) (federal venue provision).

13. Plaintiffs gave Defendants notice of the violations alleged in this Complaint more than 60 days prior to commencement of this lawsuit by a letter addressed and mailed to: the President and Chief Executive Officer of NextEra Energy Resources, F.

Mitchell Davidson; the General Manager of NextEra Energy Maine Operating Services, Kirk Toth; and Charles S. Schultz of Merimil. A copy of this letter is attached as Exhibit 1 and incorporated by reference herein. Copies of the notice letter were mailed to (a) Defendants' registered agents, (b) the Secretaries of Commerce and Interior, (c) the Administrator of the U.S. Environmental Protection Agency ("EPA") and the Regional Administrator of the EPA for New England, and (d) the Acting Commissioner of the Maine Department of Environmental Protection. The notice letters satisfy the pre-suit notice requirements of 16 U.S.C. 1540 § (g)(2)(A)(i) (ESA) and 33 U.S.C. § 1365(b)(1)(A) (CWA).

FACTUAL BACKGROUND

The Life Cycle Of Atlantic Salmon

14. Atlantic salmon are anadromous, meaning they are born in fresh water, migrate to the ocean, and then return to fresh water to spawn.

15. In late autumn, female Atlantic salmon deposit eggs in a series of nests (called "redds") in a stream or river bed. Once the eggs are fertilized by spawning adult male salmon, the female salmon uses her tail to cover those eggs with gravel. After spawning, adult salmon, called "kelts," return to the ocean in early winter or the following spring. Eggs hatch in March or April; at this point the newborn fish are referred to as "alevin" or "sac fry." Three to six weeks after hatching, alevins emerge from their redds seeking food, and are at that point called "fry." Fry quickly develop into "parr," with camouflaging vertical stripes. They feed and grow for one to three years in their native streams or rivers before becoming "smolts." Smolts are silver colored and approximately six inches long. In the spring, the body chemistry of smolts change and

they are able to enter salt water. Smolts migrate to the ocean where they develop over two to three years into mature salmon weighing 8 to 25 pounds. Mature adult salmon begin returning in the spring to their native streams to repeat the spawning cycle. Atlantic salmon are capable of spawning and completing this cycle several times.

There Are Almost No Atlantic Salmon Returning
To The Kennebec And Androscoggin Rivers

16. The Maine Atlantic Salmon Commission ("MASC") monitors the abundance and status of Atlantic salmon in many Maine rivers. On the Kennebec and Androscoggin Rivers, MASC traps and counts returning adult salmon at the lower-most dams on the rivers - Lockwood dam on Kennebec and the Brunswick dam on the Androscoggin. This trapping and counting is conducted annually, typically between May and November.

17. Historically, the Kennebec and Androscoggin Rivers, which share the same estuary, Merrymeeting Bay, had the largest Atlantic salmon runs in the United States, estimated at more than 100,000 adults each year. Now, according to the recent annual surveys done by MASC, the number of adult Atlantic salmon returning to the Kennebec and Androscoggin Rivers each year is dangerously low. In 2010, 5 adult salmon returned to the Kennebec River; in 2009, 29 returned; in 2008, 22 returned; in 2007, 16 returned; in 2006, 15 returned. In 2010, 10 adult salmon returned to the Androscoggin River; in 2009, 24 returned; in 2008, 18 returned; in 2007, 21 returned; in 2006, 7 returned.

COUNT I
DEFENDANTS ARE VIOLATING
THE ENDANGERED SPECIES ACT

18. Plaintiffs reallege and incorporate by reference paragraphs 1 through 17.

The Kennebec And Androscoggin Populations Of Atlantic Salmon Are On The Endangered Species List.

19. In enacting the Endangered Species Act, Congress expressly found that species of fish, wildlife, and plants in danger of or threatened with extinction are of "esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people." 16 U.S.C. § 1531(a)(3). Congress stated that the purposes of the ESA "are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved [and] to provide a program for the conservation of such endangered and threatened species…" 16 U.S.C. § 1531(b). By enacting the Endangered Species Act, Congress intended protection of endangered species to be afforded the highest of priorities. Under the ESA, an "endangered species" is a species of animal or plant (other than certain dangerous insect pests) which is in danger of extinction throughout all or a significant portion of its range. 16 U.S.C. § 1532(6).

20. The Secretary of Commerce (for endangered species in the ocean) and the Secretary of the Interior (for all other species) are responsible for administering and implementing the ESA, with the Services acting on their behalf. Because Atlantic salmon are anadromous, the Secretaries (and thus the Services) share responsibility for managing the protection of these fish under the ESA.

21. In 2000, the Services issued a rule listing the Gulf of Maine Distinct Population Segment ("GOM DPS") of Atlantic salmon as "endangered" because it is in

danger of becoming extinct. At that time, the Services included the salmon populations of seven rivers in Down East Maine in the description of the endangered GOM DPS, but did not include Kennebec and Androscoggin River salmon populations in this listing. In 2005, Plaintiff Friends of Merrymeeting Bay, Douglas Watts (a member of FOMB), and others filed a petition with the Services asking them to include Kennebec salmon in the GOM DPS. Although a federal "biological review team" found that the Kennebec and Androscoggin River salmon populations should be included in the GOM DPS (along with the Penobscot River salmon population) and published this finding in the "2006 Status Review for Anadromous Atlantic Salmon in the United States," by mid-2008 the Services still had not ruled on the petition. On May 12, 2008, Mr. Watts, FOMB, and other conservation groups sued the Services to obtain a ruling on the petition. On September 3, 2008, the Services did rule on the petition, proposing to include the Kennebec, Androscoggin, and Penobscot River salmon populations in the GOM DPS. 73 Fed. Reg. 51,415 (September 3, 2008). On June 19, 2009, the Services issued a final rule including the salmon populations of all three rivers in the listed GOM DPS, thereby formally designating these populations as endangered under the ESA. 74 Fed. Reg. 29,344 (June 19, 2009).

22. On that same day, NMFS issued a final rule designating "critical habitat" for the Kennebec, Androscoggin and Penobscot salmon – *i.e.*, habitat "essential to the conservation of the species" and "which may require special management considerations or protection." 16 U.S.C. § 1532(5)(A)(i). Those portions of the Kennebec and Androscoggin Rivers where the dams at issue in this case are located, and those portions

affected by the dams, are part of that critical habitat. 74 Fed. Reg. 29,300 (June 19, 2009).

"Take" Of An Endangered Species Is
<u>Prohibited By The Endangered Species Act.</u>

23. Section 9 of the ESA makes it unlawful for any person to "take" an endangered species unless authorized to do so by the federal government. 16 U.S.C. § 1538(a)(1)(b).

24. Under the ESA, the term "take" means "to harass, harm, pursue, hunt, shoot, kill, trap, or collect, or to attempt to engage in any such conduct." 16 U.S.C. § 1532(19). By USFWS regulation:

> Harass in the definition of "take" in the Act means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. [and]
>
> Harm in the definition of "take" in the Act means an act which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

50 C.F.R. § 17.3.

25. A NMFS regulation further defines "harm" as including habitat modification where a causal link is established between such modification and injury or death of a listed species. 40 C.F.R. § 222.102. In publishing that rule, NMFS listed the following among its examples of activities that may modify habitat and thus cause a take:

> 1. Constructing or maintaining barriers that eliminate or impede a listed species' access to habitat or ability to migrate;
>
> * * *
>
> 4. Removing or altering rocks, soil, gravel, vegetation or other physical structures that are essential to the integrity and function of a listed species' habitat;

* * *

> 5. Removing water or otherwise altering streamflow when it significantly impairs spawning, migration, feeding or other essential behavior patterns; [and]

* * *

> 7. Constructing or operating dams or water diversion structures with inadequate fish screens or fish passage facilities in a listed species' habitat…

64 Fed. Reg. 60,727, 60,730 (Nov. 8, 1999).

26. When a federally licensed activity – such as operating a hydroelectric dam – causes a take, the licensee may receive authorization under the ESA to continue the activity in one of two ways. One is to apply for and obtain an "incidental take permit" ("ITP") pursuant to Section 10 of the ESA, 16 U.S.C § 1539. The other is to obtain an "incidental take statement" ("ITS") pursuant to Section 7 of the ESA, 16 U.S.C. §1536; *see* 50 C.F.R. § 402.14. A take is considered "incidental" when the purpose of the activity is not to take an endangered species, but rather to conduct some otherwise lawful activity that incidentally results in a take. An ITP can require that the holder of the ITP "minimize and mitigate the impacts of" the taking "to the maximum extent practicable." 16 U.S.C. § 1539(a)(2) (B)(2); 50 C.F.R. § 402.02. Similarly, an ITS can require that "reasonable and prudent measures" be taken to "minimize" the impact of a take. 16 U.S.C. § 1536(b)(4)(ii). An ITP is not authorized unless certain specified conditions are met. Among these is that the take "will not appreciably reduce the likelihood of survival and recovery of the species in the wild." 16 U.S.C. § 1539(a)(2)(B)(4). Similarly, an ITS is not authorized if the licensed activity is "likely to jeopardize the continued existence of any endangered species…or result in the destruction or adverse modification of habitat [critical to the species]…" 16 U.S.C. § 1536(a)(2) and (b)(4)(B).

27. The citizen suit provision of the ESA grants jurisdiction to United States District Courts to issue orders enjoining violations of the Act (such as the unauthorized taking of an endangered species) and authorizes an award of costs of litigation (including reasonable attorney and expert witness fees). 16 U.S.C. § 1540(g)(1) and (4).

Defendants Are Taking Atlantic Salmon
In Violation Of Section 9 Of The ESA.

28. Defendants' Kennebec and Androscoggin River dams harass, harm, and kill – and thus "take" – Atlantic salmon in a number of ways. Among these are the following:

a. The dams' turbines kill and injure out-migrating salmon when the salmon attempt to pass through them.

b. The dams severely limit upstream passage of salmon, preventing access to significant amounts of spawning and rearing habitat.

c. Facilities meant to allow the salmon to pass around or through the dams cause delays in passage, resulting in incremental losses of salmon smolts, pre-spawn adults, and adults.

d. The dams are barriers to the migration of other fish whose presence is necessary for the salmon to complete their life cycle.

e. The dams adversely alter predator-prey assemblages, such as the ability of the salmon to detect and avoid predators.

f. The dams create slow-moving impoundments in formerly free-flowing reaches. These altered habitats are less suitable for spawning and rearing of salmon and contribute to the dams' significant impairment of essential behavior patterns of the salmon. In addition, these conditions may favor non-native competitors at the expense of the native salmon.

g. The dams result in adverse hydrological changes, adverse changes to stream and river beds, interruption of natural sediment and debris transport, and changes in water temperature, all of which contribute to the dams' significant impairment of essential behavior patterns.

29. Defendants have neither an incidental take permit nor an incidental take statement authorizing their take of Atlantic salmon at their Kennebec and Androscoggin dams. Defendants' take of Atlantic salmon therefore violates Section 9(a)(1)(B) of the ESA, 16 U.S.C. § 1538(a)(1)(B). Defendants have been violating the Section 9 take prohibition since the day Kennebec and Androscoggin salmon were included in the GOM DPS and thus designated as endangered under the ESA.

30. In their decision to include the Kennebec and Androscoggin River populations of Atlantic salmon on the Endangered Species List, the Services found dams on those rivers play a major role in imperiling the salmon. The Services stated: "The National Research Council stated in 2004 that the greatest impediment to self-sustaining Atlantic salmon populations in Maine is obstructed fish passage and degraded habitat caused by dams … Dams are known to typically kill or injure between 10 and 30 percent of all fish entrained at turbines [cite omitted]. With rivers containing multiple hydropower dams, these cumulative losses could compromise entire year classes of Atlantic salmon … Thus, cumulative losses at passage facilities can be significant … Dams remain a direct and significant threat to Atlantic salmon." 74 Fed. Reg. at 29362. Similarly, the Services stated: "Dams are among the leading causes of both historical declines and contemporary low abundance of the GOM DPS of Atlantic salmon [cite omitted]." The Services also stated that the "effects [of dams] have led to a situation

where salmon abundance and distribution has been greatly reduced, and thus the species is more vulnerable to extinction … Therefore, dams represent a significant threat to the survival and recovery of the GOM DPS." 74 Fed. Reg. at 29366-29367.

COUNT II
DEFENDANTS ARE VIOLATING
THEIR CLEAN WATER ACT WATER QUALITY CERTIFICATIONS

31. Plaintiffs reallege and incorporate by reference paragraphs 1 through 30.

Clean Water Act Water Quality Certifications Are Designed
To Maintain Compliance With Water Quality Standards.

32. Congress declared the objective of the Clean Water Act "is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." 33 U.S.C. § 1251(a).

33. Under Section 401 of the CWA, 33 U.S.C. § 1341, hydroelectric dams must obtain a state "water quality certification" before they may obtain a license to operate from the Federal Energy Regulatory Commission. This water quality certification becomes a condition of the FERC license. 33 U.S.C. § 1341(d).

34. A water quality certification must contain conditions that ensure the licensed activity will not violate or prevent attainment of state water quality standards or other state water quality requirements. 33 U.S.C. § 1341(d). Water quality standards define the minimum water quality that must be maintained within a waterbody. Water quality standards designate the uses to be sustained within the waterbody (such as habitat for fish or other aquatic life) and establish criteria to protect those uses. 33 U.S.C. § 1313; 40 C.F.R. § 131.2.

35. The citizen suit provision of the CWA authorizes citizens to enforce water quality certifications in United States District Court. 33 U.S.C. § 1365(a) and (f)(5). The

Court is authorized to award costs of litigation (including reasonable attorney and expert witness fees). 33 U.S.C. § 1365(d).

Defendants Are Violating The Water Quality Certifications
Issued For Their Dams On The Kennebec River.

36. Defendants NextEra and NextEra Maine are violating the water quality certifications issued for Lockwood, Weston, and Shawmut dams on the Kennebec River. Defendant Merimil is violating the water quality certification issued for Lockwood dam. Specifically, Defendants are violating the following provision, which is in each of these water quality certifications:

> INTERIM DOWNSTREAM FISH PASSAGE: The applicant [dam owner] shall continue and where needed improve existing operational measures to diminish entrainment, allow downstream passage, and eliminate significant injury to out-migrating anadromous fish in accordance with the terms of the KHDG [Kennebec Hydro Developers Group] Settlement Agreement.

The KHDG Settlement Agreement, in turn, provides:

> In the event that adult shad and/or adult Atlantic salmon begin to inhabit the impoundment above the [dam], and to the extent that [the dam owner] desires to achieve interim downstream passage of out-migrating adult Atlantic salmon and/or adult shad by means of passage through turbine(s), [the dam owner] must first demonstrate through site-specific quantitative studies designed and conducted in consultation with the resource agencies [which include the National Marine Fisheries Service and the U.S. Fish and Wildlife Service], that passage through turbine(s) will not result in significant injury and/or mortality (immediate or delayed).

37. In every year from 2006 forward, and in previous years, adult salmon returning from the ocean have been trapped below Lockwood dam (the most downstream dam on the Kennebec River) and transported in trucks upstream to the Sandy River, a tributary that joins the Kennebec River upstream of Defendants' three Kennebec dams. After spawning, these salmon attempt to "out-migrate" down the Kennebec toward the

sea. During this out-migration, the adult salmon inhabit the impoundments above Weston, Shawmut, and Lockwood dams.

38. Defendants have not demonstrated. through site-specific quantitative studies designed and conducted in consultation with the resource agencies, that passage through turbines at these dams will not cause "significant injury and/or mortality (immediate or delayed)" to salmon. In fact, none of the Defendants has even conducted site-specific quantitative studies on the effects of turbine passage on salmon at any of these dams.

39. However, at each of these dams, NextEra, NextEra Maine, and (with respect to Lockwood dam) Merimil have chosen to achieve (or attempt to achieve) downstream passage of adult salmon through the dams' turbines. NextEra and NextEra Maine have testified in State administrative proceedings that passage through turbines is one of the methods by which they provide downstream passage for salmon.

40. The shad population in the Kennebec River is low. Starting in 2010, adult shad have been trapped below Lockwood dam and transported in trucks to a point in the Kennebec River below the Shawmut dam. Like salmon, shad out-migrate down the Kennebec after spawning. Defendants have likewise chosen to pass (or attempt to pass) these shad through Lockwood dam turbines without first demonstrating, through site-specific quantitative studies designed and conducted in consultation with the resource agencies, that turbine passage at these dams will not cause "significant injury and/or mortality (immediate or delayed)" to adult shad. Defendants have not conducted any site-specific quantitative studies on the effects of turbine passage on adult shad at Lockwood dam.

41. Defendants have thus far refused to either (a) install devices to assure that adult salmon and adult shad will not swim through turbines or (b) shut down their turbines during salmon and shad migration seasons. Neither NextEra, NextEra Maine, nor Merimil has installed effective devices to divert salmon and shad away from its dam turbines.

PLAINTIFFS HAVE STANDING TO BRING THIS SUIT

42. Paragraphs 43 through 46 apply to both Counts I and II.

43. Plaintiffs have members who have been very active in efforts to preserve Atlantic salmon in the Kennebec and Androscoggin Rivers. For example, Plaintiffs' members have successfully petitioned and sued the Services to include the salmon population of the Kennebec in the GOM DPS, were instrumental in securing the designation of the Androscoggin salmon population as part of the GOM DPS, have for years advocated before federal and state agencies for better salmon passage at Defendants' dams, and regularly monitor the water quality of the two rivers. Plaintiffs have members who have also advocated for better shad passage at Defendants' dams.

44. Plaintiffs have members who are interested in maintaining the natural biodiversity of the Kennebec and Androscoggin Rivers and their environs. Plaintiffs have members who live near, own property near, and recreate on and near the Kennebec and Androscoggin Rivers and Merrymeeting Bay. Plaintiffs have members who, among other activities, kayak on, canoe on, fish in, walk and hike along, lead guided trips on, and enjoy observing and photographing aquatic life and wildlife in and around the Kennebec and Androscoggin Rivers and Merrymeeting Bay. Their enjoyment of these activities is impaired by the diminution of the size and health of the Atlantic salmon

populations of these rivers, and by the diminution of the size and health of the shad population.

45. Plaintiffs' members enjoy and in many ways receive great value from the presence of wild Atlantic salmon and shad and want the numbers of these fish in the Kennebec and Androscoggin Rivers to be as plentiful as possible. They also want the Kennebec and Androscoggin River populations of salmon to eventually recover to the point of no longer being endangered. The dearth of Atlantic salmon and shad in the rivers diminishes plaintiffs' members' use and enjoyment of the rivers. If Atlantic salmon were populous enough in the Kennebec and Androscoggin Rivers, Plaintiffs' members would fish for and eat that salmon. They cannot do so now because the fish are endangered. Recovery of Atlantic salmon and shad in the rivers would increase economic opportunities for Plaintiffs' members because there would be a greater demand for guided trips that they could lead, whether for paddling, fishing, fish-spotting, or photography, for example.

46. Defendants' dam operations are directly responsible for depressing Atlantic salmon populations in the Kennebec and Androscoggin Rivers. Defendants' dams are a leading cause of the near extinction of Atlantic salmon in these rivers and of the fish's presence on the Endangered Species List. If Defendants complied with the Endangered Species Act, and with the water quality certifications for their dams on the Kennebec, there would be more Atlantic salmon in the Kennebec and Androscoggin Rivers and the chance of the rivers' salmon population recovering would be improved. Moreover, preservation and restoration of the salmon's critical habitat in and along the Kennebec and Androscoggin Rivers would improve the health, biodiversity, and sustainability of

these natural areas in which Plaintiffs' members have recreational, aesthetic, and economic interests. In addition, if Defendants complied with the water quality certifications for their dams on the Kennebec, there would be more shad in the Kennebec River and the chance of the river's shad population recovering would be improved.

DEFENDANTS CAN ACHIEVE COMPLIANCE WITH THE ESA AND THEIR CWA WATER QUALITY CERTIFICATIONS IN A MANNER THAT IS CONSISTENT WITH THE TERMS OF THEIR FERC LICENSES

47. Paragraphs 48 through 51 apply to both Counts I and II.

48. Relief in this case can be fashioned in a manner that is consistent with the FERC licenses issued for the operation of Defendants' dams.

49. Since the CWA water quality certifications are part of the FERC licenses for the three Kennebec River dams, compliance with the certifications' ban on the passage of adult salmon and adult shad through the dams' turbines is *required* by the FERC licenses.

50. Moreover, there are a number of ways for Defendants to comply with their Kennebec water quality certifications and reduce their unlawful "take" of salmon in a manner consistent with the continued operation of these dams under the provisions of their FERC licenses. For example, Defendants can stop their turbines during salmon migration season to prevent the fish from swimming into the spinning turbine blades. This can be done without having to modify the FERC licenses for any of these dams. In fact, other dam owners stop their turbines in order to provide safe passage for migrating fish.

51. Defendants can also be ordered to apply for an incidental take permit under the ESA. Development of a "habitat conservation plan" ("HCP") to protect endangered species is a key component of an ITP application. Defendants have indicated they intend

to apply for an ITP, but they take the position that there is no deadline by which they must complete the HCP or apply for the ITP. Given, among other things, (a) Defendants' ongoing unlawful take of endangered Kennebec and Androscoggin River Atlantic salmon, (b) the dire condition of these Atlantic salmon populations and the risk that the fish will soon become extinct, and (c) Defendants' failure to take meaningful steps to protect salmon, despite years of warning that the ESA listing was forthcoming, Plaintiffs believe Defendants must be put on an enforceable schedule for submitting their ITP applications. Such an order would have no effect on Defendants' ability to operate in a manner consistent with their FERC licenses.

REFLIEF REQUESTED

Plaintiffs request that this Court:

a. Declare Defendants to be violating the take prohibition of the Endangered Species Act at their dams on the Kennebec and Androscoggin Rivers;

b. Declare Defendants to be violating their Clean Water Act water quality certifications for their dams on the Kennebec River;

c. For the Kennebec River dams, order Defendants to comply with the water quality certification provisions that prohibit passing adult Atlantic salmon and adult shad through turbines without first demonstrating, through site-specific quantitative studies designed and conducted in consultation with resource agencies, that turbine passage will not result in significant injury and/or mortality (immediate or delayed);

d. Order Defendants to apply for an ITP according to a specified schedule, and to (1) prevent Atlantic salmon from swimming into operating turbines at their dams on the Kennebec and Androscoggin Rivers unless authorized by an ITP or ITS and (2) implement other appropriate measures to comply with the ESA's take prohibition pending the issuance of any ITP or ITS;

e. Award costs of litigation (including reasonable attorney and expert witness fees), as provided for in 33 U.S.C. § 1365(d);

f. Order such other relief as the Court deems appropriate.

Dated: January 31, 2011

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FOMB Exhibits Brunswick, Maine Hydroelectric Project, Androscoggin River FERC P-2284-0052

Exhibit 9

Ex. 9

UNITED STATES DISTRICT COURT
DISTRICT OF MAINE

FRIENDS OF MERRYMEETING BAY and ENVIRONMENT MAINE,

Plaintiffs,

v.

BROOKFIELD RENEWABLE POWER, INC. and HYDRO KENNEBEC, LLC,

Defendants.

Civil Action No.

COMPLAINT

INTRODUCTION

1. Defendants Brookfield Renewable Power, Inc. and Hydro Kennebec LLC are violating the federal Endangered Species Act ("ESA"), 16 U.S.C. § 1531 *et seq.*, by killing, harming, and harassing endangered Atlantic salmon at their Hydro Kennebec hydroelectric dam on the Kennebec River. Defendants are, in ESA parlance, illegally "taking" this endangered species. More specifically, Defendants' dam: kills and injures salmon with its rotating turbine blades when the fish try to pass through them; impedes upstream and downstream salmon passage, which prevents salmon from gaining access to significant amounts of spawning and rearing habitat; alters the natural habitat to such a degree that the essential behavior patterns of the fish are significantly impaired; and has other deleterious effects on the salmon.

2. The ESA allows the National Marine Fisheries Service ("NMFS") and United States Fish and Wildlife Service ("USFWS") (collectively, the "Services"), under certain

circumstances, to authorize an otherwise prohibited taking of an endangered species if such taking is "incidental" to, and not the purpose of, the carrying out of an otherwise lawful activity. 16 U.S.C. § 1539(a)(1)(B). Defendants do not have authorization from the Services to commit an "incidental take" of salmon at Hydro Kennebec dam.

3. Defendants are also violating the federal Clean Water Act ("CWA") water quality certification issued for their Kennebec River dam. This certification prohibits Defendants from allowing downstream-migrating adult salmon and adult shad to pass through the turbines of the dam unless Defendants have conducted a studies proving that such passage does not result in significant injury or mortality. Although Defendants are allowing adult salmon and adult shad to pass through their turbines, they have not conducted the requisite study. Plaintiffs believe such a study would show that turbine passage results in significant injury and mortality, as other studies have shown.

4. Neither the federal nor state government has taken enforcement action against Defendants to redress these violations. However, Congress authorized citizens to bring "citizen suits" in United States District Courts to enforce the ESA and CWA directly against violators. 16 U.S.C. § 1540(g) (ESA citizen suit provision); 33 U.S.C. § 1365 (CWA citizen suit provision).

5. Defendants' dam is a major reason the Kennebec population of salmon has declined to perilously low levels. Although they have long been aware of this fact, Defendants have not taken a number of basic, feasible steps, such as keeping fish from swimming into their spinning turbine blades, that would reduce the detrimental effects of their dam on this endangered population. Without a court order directing them to so,

Defendants will not comply expeditiously with the ESA and with their CWA water quality certification.

PARTIES

6. Plaintiff Friends of Merrymeeting Bay ("FOMB") is a non-profit Maine corporation with over 400 members. FOMB is dedicated to preserving the ecological, aesthetic, historical, recreational, and commercial values of Maine's Merrymeeting Bay and its watershed, which includes the Kennebec River. FOMB accomplishes its mission through research, advocacy, land conservation, education, and litigation.

7. Plaintiff Environment Maine is a non-profit Maine corporation. It is a statewide environmental organization that advocates for clean air, clean water, and preservation of Maine's natural resources on behalf of approximately 3,460 citizen members from across the state of Maine. Among other activities, Environment Maine researches and distributes analytical reports on environmental issues, advocates before legislative and administrative bodies, engages in litigation when necessary, and conducts public education.

8. Defendant Brookfield Renewable Power, Inc. ("Brookfield"), either in its own name or through a subsidiary, owns and operates Hydro Kennebec dam on the Kennebec River. Brookfield operates, and exercises fundamental control over, this dam. www.brookfieldpower.com/_Global/5/documents/relatedlinks/1699.pdf. Brookfield is itself a wholly-owned subsidiary of Brookfield Asset Management, a Toronto-based conglomerate.

9. The Federal Energy Regulatory Commission ("FERC") license for Hydro Kennebec dam is in the name of defendant Hydro Kennebec LLC. Hydro Kennebec LLC operates Hydro Kennebec dam.

JURISDICTION AND VENUE

10. Subject matter jurisdiction is conferred upon this Court by 16 U.S.C. § 1540(g)(1) (ESA citizen suit provision), 33 U.S.C. § 1365(a) (CWA citizen suit provision), and 28 U.S.C. § 1331 (federal question jurisdiction). Venue lies within this District pursuant to 16 U.S.C. § 1540(g)(3)(A) (ESA venue provision), 33 U.S.C. 1365(c)(1) (CWA venue provision), and 28 U.S.C. § 1391(e) (federal venue provision).

11. Plaintiffs gave Defendants notice of the violations alleged in this Complaint more than 60 days prior to commencement of this lawsuit by a letter addressed and mailed to: Brookfield's Chief Operating Office for U.S. Operations, Kim Osmars, and the Managers of Brookfield New England and Hydro Kennebec LLC, Craig Laurie and Mark Brown. A copy of this letter is attached as Exhibit 1 and incorporated by reference herein. Copies of the notice letter were mailed to (a) Defendants' registered agents, (b) the Secretaries of Commerce and Interior, (c) the Administrator of the U.S. Environmental Protection Agency ("EPA") and the Regional Administrator of the EPA for New England, (d) the Acting Commissioner of the Maine Department of Environmental Protection, and (e) Brian Stetson of Brookfield. The notice letters satisfy the pre-suit notice requirements of 16 U.S.C. 1540 § (g)(2)(A)(i) (ESA) and 33 U.S.C. § 1365(b)(1)(A) (CWA).

FACTUAL BACKGROUND

The Life Cycle Of Atlantic Salmon.

12. Atlantic salmon are anadromous, meaning they are born in fresh water, migrate to the ocean, and then return to fresh water to spawn.

13. In late autumn, female Atlantic salmon deposit eggs in a series of nests (called "redds") in a stream or river bed. Once the eggs are fertilized by spawning adult male salmon, the female salmon uses her tail to cover those eggs with gravel. After spawning, adult salmon, called "kelts," return to the ocean in early winter or the following spring. Eggs hatch in March or April; at this point the newborn fish are referred to as "alevin" or "sac fry." Three to six weeks after hatching, alevins emerge from their redds seeking food, and are at that point called "fry." Fry quickly develop into "parr," with camouflaging vertical stripes. They feed and grow for one to three years in their native streams or rivers before becoming "smolts." Smolts are silver colored and approximately six inches long. In the spring, the body chemistry of smolts change and they are able to enter salt water. Smolts migrate to the ocean where they develop over two to three years into mature salmon weighing 8 to 25 pounds. Mature adult salmon begin returning in the spring to their native streams to repeat the spawning cycle. Atlantic salmon are capable of spawning and completing this cycle several times.

There Are Almost No Atlantic Salmon Returning To The Kennebec River.

14. The Maine Atlantic Salmon Commission ("MASC") monitors the abundance and status of Atlantic salmon in many Maine rivers. On the Kennebec River, MASC traps and counts returning adult salmon at the lower-most dam, Lockwood dam. This trapping and counting is conducted annually, typically between May and November.

15. Historically, the Kennebec and Androscoggin Rivers, which share a common estuary, Merrymeeting Bay, had the largest Atlantic salmon runs in the United States, estimated at more than 100,000 adults each year. Now, according to the recent annual surveys done by MASC, the number of adult Atlantic salmon returning to the Kennebec River each year is dangerously low. In 2010, 5 adult salmon returned to the Kennebec River; in 2009, 29 returned; in 2008, 22 returned; in 2007, 16 returned; in 2006, 15 returned.

COUNT I
DEFENDANTS ARE VIOLATING
THE ENDANGERED SPECIES ACT

16. Plaintiffs reallege and incorporate by reference paragraphs 1 through 15.

The Kennebec Population Of Atlantic Salmon
Is On The Endangered Species List.

17. In enacting the Endangered Species Act, Congress expressly found that species of fish, wildlife, and plants in danger of or threatened with extinction are of "esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people." 16 U.S.C. § 1531(a)(3). Congress stated that the purposes of the ESA "are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved [and] to provide a program for the conservation of such endangered and threatened species…" 16 U.S.C. § 1531(b). By enacting the Endangered Species Act, Congress intended protection of endangered species to be afforded the highest of priorities. Under the ESA, an "endangered species" is a species of animal or plant (other than certain dangerous insect pests) which is in danger of extinction throughout all or a significant portion of its range. 16 U.S.C. § 1532(6).

18. The Secretary of Commerce (for endangered species in the ocean) and the Secretary of the Interior (for all other species) are responsible for administering and implementing the ESA, with the Services acting on their behalf. Because Atlantic salmon are anadromous, the Secretaries (and thus the Services) share responsibility for managing the protection of these fish under the ESA.

19. In 2000, the Services issued a rule listing the Gulf of Maine Distinct Population Segment ("GOM DPS") of Atlantic salmon as "endangered" because it is in danger of becoming extinct. At that time, the Services included the salmon populations of seven rivers in Down East Maine in the description of the endangered GOM DPS, but did not include the Kennebec River salmon population in this listing.

20. In 2005, Plaintiff Friends of Merrymeeting Bay, Douglas Watts (a member of Plaintiff FOMB) and others filed a petition with the Services asking them to include Kennebec salmon in the GOM DPS. Although a federal "biological review team" found that the Kennebec salmon population should be included in the GOM DPS, along with the Androscoggin and Penobscot River salmon populations, and published this finding in the "2006 Status Review for Anadromous Atlantic Salmon in the United States," by mid-2008 the Services still had not ruled on the petition. On May 12, 2008, Mr. Watts, FOMB, and other conservation groups sued the Services to obtain a ruling on the petition. On September 3, 2008, the Services did rule on the petition, proposing to include the Kennebec, Androscoggin, and Penobscot River salmon populations in the GOM DPS. 73 Fed. Reg. 51,415 (September 3, 2008). On June 19, 2009, the Services issued a final rule including the salmon populations of all three rivers in the listed GOM DPS, thereby

formally designating these populations as endangered under the ESA. 74 Fed. Reg. 29,344 (June 19, 2009).

21. On that same day, NMFS issued a final rule designating "critical habitat" for the Kennebec, Androscoggin, and Penobscot salmon – *i.e.*, habitat "essential to the conservation of the species" and "which may require special management considerations or protection." 16 U.S.C. § 1532(5)(A)(i). The portion of the Kennebec River where Hydro Kennebec dam is located and those portions affected by the dam are part of that critical habitat. 74 Fed. Reg. 29,300 (June 19, 2009).

"Take" Of An Endangered Species Is Prohibited
By The Endangered Species Act.

22. Section 9 of the ESA makes it unlawful for any person to "take" an endangered species unless authorized to do so by the federal government. 16 U.S.C. § 1538(a)(1)(b).

23. Under the ESA, the term "take" means "to harass, harm, pursue, hunt, shoot, kill, trap, or collect, or to attempt to engage in any such conduct." 16 U.S.C. § 1532(19). By USFWS regulation:

> Harass in the definition of "take" in the Act means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. [and]
>
> Harm in the definition of "take" in the Act means an act which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

50 C.F.R. § 17.3.

24. A NMFS regulation further defines "harm" as including habitat modification where a causal link is established between such modification and injury or death of a

listed species. 40 C.F.R. § 222.102. In publishing that rule, NMFS listed the following among its examples of activities that may modify habitat and thus cause a take:

> 1. Constructing or maintaining barriers that eliminate or impede a listed species' access to habitat or ability to migrate;
>
> * * *
>
> 4. Removing or altering rocks, soil, gravel, vegetation or other physical structures that are essential to the integrity and function of a listed species' habitat;
>
> * * *
>
> 5. Removing water or otherwise altering streamflow when it significantly impairs spawning, migration, feeding or other essential behavior patterns; [and]
>
> * * *
>
> 7. Constructing or operating dams or water diversion structures with inadequate fish screens or fish passage facilities in a listed species' habitat…

64 Fed. Reg. 60,727, 60,730 (Nov. 8, 1999).

25. When a federally licensed activity – such as operating a hydroelectric dam – causes a take, the licensee may receive authorization under the ESA to continue the activity in one of two ways. One is to apply for and obtain an "incidental take permit" ("ITP") pursuant to Section 10 of the ESA, 16 U.S.C § 1539. The other is to obtain an "incidental take statement" ("ITS") pursuant to Section 7 of the ESA, 16 U.S.C. §1536; *see* 50 C.F.R. § 402.14. A take is considered "incidental" when the purpose of the activity is not to take an endangered species, but rather to conduct some otherwise lawful activity that incidentally results in a take. 16 U.S.C. § 1539(a)(1)(B); 50 C.F.R. § 402.02. An ITP can require that the holder of the ITP "minimize and mitigate the impacts of" the taking "to the maximum extent practicable." 16 U.S.C. § 1539(a)(2) (B)(2). Similarly, an ITS can require that "reasonable and prudent measures" be taken to "minimize" the impact of a take. 16 U.S.C. § 1536(b)(4)(ii). An ITP is not authorized unless certain

specified conditions are met. Among these is that the take "will not appreciably reduce the likelihood of survival and recovery of the species in the wild." 16 U.S.C. § 1539(a)(2)(B)(4). Similarly, an ITS is not authorized if the licensed activity is "likely to jeopardize the continued existence of any endangered species…or result in the destruction or adverse modification of habitat [critical to the species]…" 16 U.S.C. § 1536(a)(2) and (b)(4)(B).

26. The citizen suit provision of the ESA grants jurisdiction to United States District Courts to issue orders enjoining violations of the Act (such as the unauthorized taking of an endangered species) and authorizes an award of costs of litigation (including reasonable attorney and expert witness fees). 16 U.S.C. § 1540(g)(1) and (4).

Defendants Are Taking Atlantic Salmon
In Violation Of Section 9 Of The ESA.

27. Defendants' Hydro Kennebec dam harasses, harms, and kills – and thus "takes" – Atlantic salmon in a number of ways. Among these are the following:

a. The dam's turbines kill and injure out-migrating salmon when the salmon attempt to pass through them.

b. The dam severely limits upstream passage of salmon, preventing access to significant amounts of spawning and rearing habitat.

c. Facilities meant to allow the salmon to pass around or through the dam cause delays in passage, resulting in incremental losses of salmon smolts, pre-spawn adults, and adults.

d. The dam is a barrier to the migration of other fish whose presence is necessary for the salmon to complete their life cycle.

e. The dam adversely alters predator-prey assemblages, such as the ability of the salmon to detect and avoid predators.

f. The dam creates slow-moving impoundments in formerly free-flowing reaches. These altered habitats are less suitable for spawning and rearing of salmon and contribute to the dam's significant impairment of essential behavior patterns of the salmon. In addition, these conditions may favor non-native competitors at the expense of the native salmon.

g. The dam results in adverse hydrological changes, adverse changes to stream and river beds, interruption of natural sediment and debris transport, and changes in water temperature, all of which contribute to the dam's significant impairment of essential behavior patterns.

28. Defendants have neither an incidental take permit nor an incidental take statement authorizing their take of Atlantic salmon at Hydro Kennebec dam. Defendants' take of Atlantic salmon therefore violates Section 9(a)(1)(B) of the ESA, 16 U.S.C. § 1538(a)(1)(B). Defendants have been violating the Section 9 take prohibition since the day Kennebec salmon were included in the GOM DPS and thus designated as endangered under the ESA.

29. In their decision to include the Kennebec River population of Atlantic salmon on the Endangered Species List, the Services found dams on that river play a major role in imperiling the salmon. The Services stated: "The National Research Council stated in 2004 that the greatest impediment to self-sustaining Atlantic salmon populations in Maine is obstructed fish passage and degraded habitat caused by dams … Dams are known to typically kill or injure between 10 and 30 percent of all fish entrained at

turbines [cite omitted]. With rivers containing multiple hydropower dams, these cumulative losses could compromise entire year classes of Atlantic salmon … Thus, cumulative losses at passage facilities can be significant … Dams remain a direct and significant threat to Atlantic salmon." 74 Fed. Reg. at 29362. Similarly, the Services stated: "Dams are among the leading causes of both historical declines and contemporary low abundance of the GOM DPS of Atlantic salmon [cite omitted]." The Services also stated that the "effects [of dams] have led to a situation where salmon abundance and distribution has been greatly reduced, and thus the species is more vulnerable to extinction … Therefore, dams represent a significant threat to the survival and recovery of the GOM DPS." 74 Fed. Reg. at 29366-29367.

COUNT II
DEFENDANTS ARE VIOLATING
THE CLEAN WATER ACT WATER QUALITY CERTIFICATION

30. Plaintiffs reallege and incorporate by reference paragraphs 1 through 29.

Clean Water Act Water Quality Certifications Are Designed To Maintain Compliance With Water Quality Standards.

31. Congress declared the objective of the Clean Water Act "is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." 33 U.S.C. § 1251(a).

32. Under Section 401 of the CWA, 33 U.S.C. § 1341, hydroelectric dams must obtain a state "water quality certification" before they may obtain a license to operate from the Federal Energy Regulatory Commission. This water quality certification becomes a condition of the FERC license. 33 U.S.C. § 1341(d).

33. A water quality certification must contain conditions that ensure the licensed activity will not violate or prevent attainment of state water quality standards or other

state water quality requirements. 33 U.S.C. § 1341(d). Water quality standards define the minimum water quality that must be maintained within a waterbody. Water quality standards designate the uses to be sustained within the waterbody (such as habitat for fish or other aquatic life) and establish criteria to protect those uses. 33 U.S.C. § 1313; 40 C.F.R. § 131.2.

34. The citizen suit provision of the CWA authorizes citizens to enforce water quality certifications in United States District Court. 33 U.S.C. § 1365(a) and (f)(5). The Court is authorized to award costs of litigation (including reasonable attorney and expert witness fees). 33 U.S.C. § 1365(d).

Defendants Are Violating The Water Quality
Certification Issued For Hydro Kennebec Dam.

35. Defendants are violating the water quality certification issued for Hydro Kennebec dam. Specifically, Defendants are violating the following provision:

> INTERIM DOWNSTREAM FISH PASSAGE: The applicant [dam owner] shall continue and where needed improve existing operational measures to diminish entrainment, allow downstream passage, and eliminate significant injury to out-migrating anadromous fish in accordance with the terms of the KHDG [Kennebec Hydro Developers Group] Settlement Agreement.

The KHDG Settlement Agreement, in turn, provides:

> In the event that adult shad and/or adult Atlantic salmon begin to inhabit the impoundment above the [dam], and to the extent that [the dam owner] desires to achieve interim downstream passage of out-migrating adult Atlantic salmon and/or adult shad by means of passage through turbine(s), [the dam owner] must first demonstrate through site-specific quantitative studies designed and conducted in consultation with the resource agencies [which include the National Marine Fisheries Service and the U.S. Fish and Wildlife Service], that passage through turbine(s) will not result in significant injury and/or mortality (immediate or delayed).

36. In every year from 2006 forward, and in previous years, adult salmon returning from the ocean have been trapped below the Lockwood dam (the most

downstream dam on the Kennebec River) and transported in trucks upstream to the Sandy River, a tributary that joins the Kennebec River upstream of Weston dam, which is located two dams above Hydro Kennebec dam. After spawning, these salmon attempt to "out-migrate" down the Kennebec toward the sea. During this out-migration, the adult salmon inhabit the impoundments above Hydro Kennebec dam.

37. Defendants have not demonstrated, through site-specific quantitative studies designed and conducted in consultation with the resource agencies, that passage through turbines at Hydro Kennebec dam will not cause "significant injury and/or mortality (immediate or delayed)" to adult salmon. In fact, neither of the Defendants has conducted any site-specific quantitative studies on the effects of turbine passage on adult salmon at Hydro Kennebec dam.

38. However, Defendants achieve (or attempt to achieve) downstream passage of adult salmon through Hydro Kennebec dam's turbines.

39. The shad population in the Kennebec River is low. Starting in 2010, adult shad have been trapped below Lockwood dam and transported in trucks to a point in the Kennebec River below Shawmut dam, which is the dam immediately upstream of Hydro Kennebec dam. Like salmon, shad out-migrate down the Kennebec after spawning. Defendants have likewise chosen to pass (or attempt to pass) these adult shad through the Hydro Kennebec dam turbines without first demonstrating, through site-specific quantitative studies designed and conducted in consultation with the resource agencies, that turbine passage will not cause "significant injury and/or mortality (immediate or delayed)" to adult shad. Neither of the Defendants has conducted a site-specific

quantitative study on the effects of turbine passage on adult shad at Hydro Kennebec dam.

40. Defendants have thus far refused to either (a) install devices to assure that adult salmon and shad will not swim through turbines or (b) shut down their turbines during salmon and shad migration seasons. Defendants have installed a diversionary device at Hydro Kennebec dam, but that device is not effective at preventing salmon and shad from swimming through turbines at that dam.

PLAINTIFFS HAVE STANDING TO BRING THIS SUIT

42. Paragraphs 43 through 46 apply to both Counts I and II.

43. Plaintiffs have members who have been very active in efforts to preserve Atlantic salmon in the Kennebec River. For example, Plaintiffs' members have successfully petitioned and sued the Services to include the salmon population of the Kennebec in the GOM DPS, have for years advocated before federal and state agencies for better salmon passage at Hydro Kennebec and other dams, and regularly monitor the water quality of the Kennebec River. Plaintiffs have members who have also advocated for better shad passage at Hydro Kennebec.

44. Plaintiffs have members who are interested in maintaining the natural biodiversity of the Kennebec River and its environs. Plaintiffs have members who live near, own property near, and recreate on and near the Kennebec River and Merrymeeting Bay. Plaintiffs have members who, among other activities, kayak on, canoe on, fish in, walk and hike along, lead guided trips on, and enjoy observing and photographing aquatic life and wildlife in and around the Kennebec River and Merrymeeting Bay. Their

enjoyment of these activities is impaired by the diminution of the size and health of the Atlantic salmon and shad population in the Kennebec River.

45. Plaintiffs' members enjoy and in many ways receive great value from the presence of wild Atlantic salmon and shad and want the numbers of wild salmon in the Kennebec River to be as plentiful as possible. They also want the Kennebec River population of salmon to eventually recover to the point of no longer being endangered. The dearth of Atlantic salmon and shad in the river diminishes Plaintiffs' members' use and enjoyment of the river. If Atlantic salmon were populous enough in the Kennebec River, Plaintiffs' members would fish for and eat that salmon. They cannot do so now because the fish are endangered. Recovery of Atlantic salmon and shad in the rivers would increase economic opportunities for Plaintiffs' members because there would be a greater demand for guided trips that they could lead for paddling, fishing, fish-spotting, or photography, and for other purposes.

46. Defendants' dam operations are directly responsible for depressing Atlantic salmon populations in the Kennebec River. Defendants' dam is a leading cause of the near extinction of Atlantic salmon in the Kennebec River and of the fish's presence on the Endangered Species List. If Defendants complied with the Endangered Species Act, and with the water quality certification for Hydro Kennebec dam, there would be more Atlantic salmon in the Kennebec River and the chance of the river's salmon population recovering would be improved. Moreover, preservation and restoration of the salmon's critical habitat in and along the Kennebec River would improve the health, biodiversity, and sustainability of these natural areas in which Plaintiffs' members have recreational, aesthetic, and economic interests. In addition, if Defendants complied with the water

quality certification for their dam, there would be more shad in the Kennebec River and the chance of the river's shad population recovering would be improved.

DEFENDANTS CAN ACHIEVE COMPLIANCE WITH THE ESA AND THEIR CWA WATER QUALITY CERTIFICATION IN A MANNER THAT IS CONSISTENT WITH THE TERMS OF THE FERC LICENSE

47. Paragraphs 48 through 53 apply to both Counts I and II.

48. Relief in this case can be fashioned in a manner that is consistent with the FERC license issued for the operation of Hydro Kennebec dam.

49. Since the CWA water quality certification is part of the FERC license for Hydro Kennebec dam, compliance with the certification's ban on the passage of adult salmon and shad through the dam's turbines is *required* by the FERC license.

50. Moreover, there are a number of ways for Defendants to comply with the water quality certification and reduce their unlawful "take" of salmon in a manner consistent with the continued operation of their dam under the provisions of the FERC license. For example, Defendants can stop the turbines during salmon migration season to prevent the fish from swimming into the spinning turbine blades. This can be done without having to modify the FERC license. In fact, other dam owners stop their turbines in order to provide safe passage for migrating fish.

51. Defendants have indicated they do not intend to apply for an incidental take permit, but, rather, intend to obtain an incidental take statement pursuant to Section 7 of the ESA, 16 U.S.C. § 1536(b)(4). The ESA directs all federal agencies to work to conserve endangered species and to use their authorities to further the purposes of the ESA. Section 7 of the ESA, entitled "Interagency Cooperation," is the mechanism

designed to ensure the actions taken by federal agencies, including those they fund or authorize, do not jeopardize the existence of any listed species.

52. Under Section 7, federal agencies must consult with the Services when any action the agency intends to carry out, fund, or authorize (such as through a federal license) may affect a listed endangered species. One of the first steps in consultation is the preparation of a "biological assessment" ("BA"). 16 U.S.C. § 1536(c). One of the purposes of a BA is to help make the determination whether a proposed activity "is likely to adversely affect" listed species or their critical habitat. Id. The federal licensee may be designated to prepare the BA, though ultimate responsibility for the BA lies with the agency issuing the license. If the agency determines through a BA that its action is likely to adversely affect a listed species, the agency is required to submit to the Services a request for consultation. 16 U.S.C. § 1536(a) and (b). This process can result in the issuance of an incidental take statement, so long as the activity to be authorized is not "likely to jeopardize the continued existence of any endangered species…or result in the destruction or adverse modification of habitat [critical to the species]…" 16 U.S.C. § 1536(a)(2) and (b)(4)(B). An ITS, if issued, "specifies those reasonable and prudent measures that the Secretary considers necessary or appropriate to minimize" the impact of an activity on endangered species, and "sets forth the terms and conditions…that must be complied with by…the applicant [for a federal license]…to implement" those measures. 16 U.S.C. § 1536(b)(4)(ii) and (iv).

53. Defendants have indicated that they will attempt to obtain an ITS by applying to amend the FERC license for Hydro Kennebec dam, which would trigger the Section 7 consultation process. Defendants have asked FERC that they be designated to prepare the

biological assessment. Given, among other things, (a) Defendants' ongoing unlawful take of endangered Kennebec River salmon, (b) the dire condition of the Atlantic salmon population and the risk that the fish will soon become extinct, and (c) Defendants' failure to take meaningful steps to protect salmon, despite years of warning that the ESA listing was forthcoming, Plaintiffs believe Defendants must be put on an enforceable schedule for preparing the BA in the event they are designated to be the parties to prepare it. Such an order would have no effect on Defendants' ability to operate in a manner consistent with their FERC license.

RELIEF REQUESTED

Plaintiffs request that this Court:

a. Declare Defendants to be violating the take prohibition of the Endangered Species Act at Hydro Kennebec dam;

b. Declare Defendants to be violating their Clean Water Act water quality certification for Hydro Kennebec dam;

c. Order Defendants to comply with the water quality certification provisions that prohibit passing adult Atlantic salmon and adult shad through turbines without first demonstrating through site-specific quantitative studies, designed and conducted in consultation with resource agencies, that turbine passage will not result in significant injury and/or mortality (immediate or delayed);

d. Order Defendants to prepare a BA according to a specified schedule, and to (1) prevent Atlantic salmon from swimming into operating turbines at Hydro Kennebec dam unless authorized by an ITP or ITS and (2) implement other appropriate measures to comply with the ESA's take prohibition pending the issuance of any ITP or ITS;

e. Award costs of litigation (including reasonable attorney and expert witness fees), as provided for in 33 U.S.C. § 1365(d);

f. Order such other relief as the Court deems appropriate.

Dated: January 31, 2011

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Exhibit 10

Opinion of Randy Bailey

1.0 Introduction

For this report, I was asked to evaluate the impacts of four dams on the Kennebec River (Lockwood, Hydro Kennebec, Shawmut, and Weston) and three dams on the Androscoggin River (Brunswick, Pejepscot, and Worumbo) on the behavior, habitat, and mortality to adult and juvenile Atlantic salmon which are listed as Endangered under the auspices of the Endangered Species Act (ESA). I was also asked to assess the impacts that these dams have on the recovery potential of the Gulf of Maine Distinct Population Segment (GOM DPS) of Atlantic salmon in general; suggest a list of interim measures that could be implemented immediately or in the very near future to mitigate the dams' impacts on salmon; and generally evaluate why it is important to the conservation of the species to begin implementation of concrete measures to avoid or reduce the mortality levels associated with the projects' infrastructure and operations. For the Kennebec River dams, I was asked to evaluate whether adult Atlantic salmon and American shad are present above the dams and whether any scientifically defensible, quantitative, site-specific studies have been conducted to assess the impacts of these dams on Atlantic salmon and American shad adults passing through turbines.

This report is divided into sections. **Section 1** is the introduction which outlines the issues addressed in this report and explains its format. **Section 2** contains a brief summary of my education, experience, and qualifications. **Section 3** contains a brief summary of my assessment of the status of the Atlantic salmon populations in the Kennebec and Androscoggin rivers. **Section 4** contains a brief background history on why the Atlantic salmon in these two rivers were listed, as well as some information on the Principal Component Elements (PCE's) of spawning and rearing habitats and migration corridors that will form the basis for developing a recovery plan for the conservation of the species. Section 4 also contains the list of factors I used to assess the impacts of each individual dam. These factors are directly related to my assessment of whether death, injury, or adverse change in habitat or fish behavior has been occurring at each dam. **Section 5** contains a brief summary of my conclusions regarding the dams' impacts on downstream migration of Atlantic salmon smolts and kelts (post spawning adults returning to the ocean), impacts on upstream migration including blockage and/or delay in passage, a brief summary of changes in habitats resulting from the project being in place, and a brief evaluation of the cumulative impacts of the two series of dams on the Atlantic salmon populations in the rivers. **Section 6** contains a review of the pertinent literature regarding mortality of fish passing through hydropower turbines and a description of the methods and flow data used to assess what percentage of time, based on historical flow records, all of the river flows could potentially pass through a project's turbines during the critical migration time periods (April – June and October – November) for Atlantic salmon. **Section 7** contains the assessment of each individual dam on the Kennebec River using the seven factors identified in Section 4. **Section 8** contains the same analysis for the three Androscoggin River dams. **Section**

9 is a brief assessment of the consequences to the Atlantic salmon populations of further delaying implementation of improvements in project operations and both upstream and downstream fish passage. **Section 10** is my evaluation comparing my experiences working with ESA listed fish species, the associated scientific studies, and restoration efforts in California and Oregon, with my impressions of what has been occurring in the Kennebec and Androscoggin watersheds. A list of references cited in the report is included at the end.

2.0 Qualifications and Experience

2.1 I am the owner and principal senior fishery scientist of my own aquatic resource consulting firm, Bailey Environmental. My office is located at 18294 S. Scotts Lane, Oregon City, OR.

2.2 I have 20 years of experience as a fishery biologist in various positions with the Federal government, including 9 years as the Chief of the Fisheries Division in the Alaska Regional Office of the U.S. Fish and Wildlife Service. In addition, I have 16 years of fishery biology consulting experience specializing in Endangered Species Act (ESA) issues, where my work has involved the evaluation of the impacts of human development on aquatic ecosystems, and the evaluation of scientific studies, reports, and environmental documents related to ESA compliance.

2.3 During my years of federal service, I was involved in numerous projects regarding ESA-listed fish species. My work with these projects included evaluating the impacts of resource development on listed species, planning and implementing habitat restoration projects for anadromous salmonids in the western United States, and designing and managing field studies on the life histories of Pacific salmon and other cold water fish species common to the west and Alaska. In my last federal position, I served as the Fish and Wildlife Program Manager for the Portland, Oregon, District of the U.S. Army Corps of Engineers. In this capacity, I was responsible for providing funding and program oversight for fish passage operations, involving numerous ESA-listed fish species, at 11 hydroelectric dams: three main-stem Columbia River dams and eight dams on four tributaries to the Willamette River in Oregon. In this position, I was responsible for the updating and modernization of four fish-trapping facilities on the four Willamette River tributaries and their associated “trap and truck” programs for ESA-listed winter steelhead and spring Chinook salmon. I also was responsible for interagency coordination regarding the development and implementation of an ESA Section 7 consultation for the operation of 8 dams in the Willamette River watershed, including provision for fish passage over the eight dams, and management of six associated genetics conservation hatchery programs.

2.4 In my consulting business, I have specialized in dealing with issues related to ESA-listed fish species for various clients. I have helped clients with a Section 7 consultation on Southern

California steelhead trout; provided technical review of various ESA documents, including biological opinions, recovery plans, and ecosystem restoration programs; provided policy recommendations on ESA issues; assisted in the development of the biological assessment for a consultation on operations of the California State Water Project (SWP) and the federal Central Valley Project (CVP); developed a portion of new water quality standards for the Sacramento/San Joaquin Delta; and provided technical review of over $500 million of habitat restoration projects for ESA-listed salmon and steelhead in Central California. I have developed or co-developed two ecosystem restoration plans aimed at protecting or improving conditions for listed species: one for two tributary watersheds to the Sacramento River, and one for the impacts of SWP and CVP operations with an estimated cost of approximately $5 billion. I believe that my experience with Pacific salmon and steelhead are directly applicable to Atlantic salmon, since these species have very similar life histories and habitat requirements.

2.5 I have a B.S. in Natural Resources Management, with an emphasis in Fish and Wildlife Management, from California Polytechnic State University, and an M.S. in Wildlife Management, with an emphasis in Fisheries Science, from Virginia Polytechnic Institute and State University. I am a Fellow Emeritus of the American Institute of Fishery Research Biologists, and am a Life Member of the American Fisheries Society, where I have held various offices and committee memberships over the past 40 years. A list of my publications is in the attached resume.

2.6 In preparing this report, I have personally reviewed the documents listed in the references section of this report, and other reports associated with the dams and individual studies and a number of the annual fish passage reports on both the Kennebec and Androscoggin rivers. Also, I was able to tour each of the dams and have my questions answered by representatives of the various owners/operators of the projects. In addition, I have had discussions with numerous representatives of federal and State of Maine resource agencies involved with Atlantic salmon and hydroelectric dams.

2.7 I have not testified as an expert witness within the last four years in any other case. I am being compensated by the plaintiffs at the rate $120.00 per hour.

3.0 Status of Gulf of Maine Atlantic Salmon Distinct Population Segment (GOM DPS)

The GOM DPS was listed in 2000 and further expanded and listed as Endangered under the authority of the ESA in 2009 (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2009). Several reasons were cited for the decision to list, including:

- The small wild population levels in all rivers containing Atlantic ,
- The dependence on a conservation hatchery program to sustain the largest individual population in the Penobscot until restoration actions can be implemented,
- The potential to create a genetic bottleneck and reduce the level of genetic diversity in the populations as a whole,
- The lack of sufficient geographic distribution and habitat diversity to create conditions that would stabilize the population's viability and allow genetic selection to continue to operate on the population.

The National Research Council, the 2006 GOM DPS Status Review Team assembled by the National Marine Fisheries Service, and the final rule on the listing decision all cite the presence of dams as the single most important factor in depressing the Atlantic salmon populations in the GOM DPS (National Research Council 2004, Fay et al. 2006, National Marine Fisheries Service and U.S. Fish and Wildlife Service 2009). All of these sources note that historically the combination of the Androscoggin, Kennebec, and Penobscot rivers support an adult run size estimated at between 300,000 and 500,000 fish annually. These sources also state that the future of the Atlantic salmon populations in Maine depends on providing access to high quality habitats and reducing or minimizing the mortality associated with passage through dams or dam complexes.

From an ecological standpoint, these same authors concluded that having only a single, currently hatchery-dependent majority population in a single river (Penobscot) was untenable. They concluded that the key to conserving the species in Maine depended on restoring robust Atlantic salmon populations to the Androscoggin and Kennebec rivers. They noted that each watershed has an abundance of high quality habitats in the upper portion of each watershed, albeit there are a number of dams currently blocking volitional access by adult Atlantic salmon. They also concluded that providing or improving adult passage at these dams was within easy reach with current technology, and that reducing mortality of downstream migrants could be accomplished by the installation of available, effective downstream bypass systems and by taking available, effective measures to keep smolts and kelts from entering project turbines.

Small, remnant populations of Atlantic salmon have persisted in the lower Androscoggin and Kennebec rivers despite all of the pollution and obstacles that existed historically. In 2010 only

14 adults were counted in both rivers combined. However, 2011's combined count was 110 adult fish. These populations have the potential to expand if access is provided to upstream areas where suitable spawning and rearing habitats exist, and if safe downstream passage for smolts and kelts is ensured.

4.0 Background Information on Development of Recovery Criteria for Habitat Requirements and Spawning Population Levels and Factors Used to Assess Dam Impacts on Atlantic Salmon Habitat and Population Levels

4.1. Listing and Recovery Criteria – In 2009, the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) (collectively the Services) listed the Atlantic salmon populations in the Androscoggin and Kennebec rivers as "Endangered" under the auspices of the Endangered Species Act (ESA) (74 FR 29344-29387). This listing includes the Atlantic salmon populations occurring in these river systems and the associated conservation hatchery populations being used to support recovery efforts in the Gulf of Maine Distinct Population Segment (GOM DPS). The ESA requires that critical habitat be designated concurrently with the listing determination. Critical habitat designations provide additional protections beyond the listing decision by avoiding the destruction or adverse modifications of the physical and biological features essential for the conservation of the species. The ESA requires that any proposed Federal actions not adversely modify or destroy designated critical habitat (NMFS 2009a). Critical habitat is generally defined as those specific areas within a broader geographic area in which are found the physical or biological features essential to the conservation of the species (NMFS 2009a).

In order to accommodate the variability in Atlantic salmon life history parameters and the diversity in aquatic habitats and watershed characteristics within the GOM DPS, three Salmon Habitat Recovery Units (SHRUs) were established for various geographic areas in the State of Maine (NMFS 2009a, NMFS 2009b): The Merrymeeting Bay SHRU; the Penobscot Bay SHRU; and the Downeast Coastal SHRU. The Androscoggin and Kennebec river watersheds contain most of the area within the Merrymeeting Bay SHRU. In addition to the designation of the SHRUs, an adult spawner population level was established for each SHRU. The level is based on the need to maintain genetic diversity within a SHRU and ensure sufficient juvenile production to maintain the population's viability within the SHRU over a substantial time period. The minimum levels to begin discussions regarding delisting are: an effective census population (assuming a 1:1 sex ratio) of 500 adult spawners; and an adult population level of 2,000 spawning adults in each SHRU to account for the complex age of spawning life history patterns in Atlantic salmon and the overall lower ocean productivity currently being experienced by pre-spawning juveniles in the open sea (NMFS 2009a, NMFS 2009b, NMFS et al. 2010).

Next, the Services completed an evaluation of the quantity and quality of habitats available within the SHRU to support 2,000 spawning adults. This evaluation considered the geographic location of habitats suitable for spawning, egg incubation, fry emergence, parr rearing, smolt migration to the ocean and abiotic factors such as water quality and water temperature. Once the 2,000 adult spawner level was determined, an evaluation was completed that determined a minimum of 30,000 units of spawning and rearing habitat (a unit of habitat is defined as 100 m^2) was necessary to support 2,000 spawning adults in each SHRU (NMFS 2009a, NMFS 2009b, NMFS et al. 2010). As part of this evaluation, a calculation of the amount of "functional equivalent" habitat was completed for the Merrymeeting Bay SHRU. The functional equivalent determination is based on the gross quantity of habitat in the geographic area adjusted downward based on the quality of the habitats to support the various life history stages of Atlantic salmon. For example, the Merrymeeting Bay SHRU was estimated to contain 372,639 habitat units based on a Geographic Information System (GIS) habitat prediction model. After the adjustment for habitat quality, the functional equivalent habitat for the SHRU was reduced to 40,001 units, which is sufficient to meet the recovery criteria for this SHRU (NMFS 2009b). The life history requirements for Atlantic salmon that were used to drive the functional equivalents determination are based on Kircheis and Liebich (2007).

4.2. Development of Primary Constituent Elements Necessary for the Conservation of the Species – The National Marine Fisheries Service (2009a) states: "Section 3(5)(A)(i) of the ESA defines critical habitat as "the specific areas within the geographical area occupied by the species at the time it is listed…on which are found those physical and biological features essential to the conservations of the species." The Departments of the Interior and of Commerce provide further regulatory guidance under 50 C.F.R. 424.12(b), stating that the Secretary shall "focus on the principal biological or physical constituent elements within the defined area that are essential to the conservation of the species … Primary Constituent Elements (PCE's) may include, but are not limited to, the following: roost site, nesting grounds, spawning sites, feeding sites, seasonal wetland or dryland, water quality or quantity, host species or plant pollinators, geological formation, vegetation types, tide, and specific soil types."

The net result of this regulatory guidance is that the Services are required to focus their recovery efforts on ensuring that a sufficient quantity and quality of habitats are available for the listed species to support all life history requirements for the population levels determined to be necessary to keep the species from becoming endangered in the future.

For the GOM DPS of Atlantic salmon, three PCE's have been established (NMFS 2009a). Listed below are the three PCE's with their subcomponents:

A. Physical and Biological Features of the *Spawning and Rearing PCE*

1. Deep, oxygenated pools and cover (e.g., boulders, woody debris, vegetation, etc.), near freshwater spawning sites, necessary to support adult migrants during the summer while they wait to spawn in the fall.

2. Freshwater spawning sites that contain clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support spawning activity, egg incubation, and larval development.

3. Freshwater spawning and rearing sites with clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support emergence, territorial development and feeding activities of Atlantic salmon fry.

4. Freshwater rearing sites with space to accommodate growth and survival of Atlantic salmon parr.

5. Freshwater rearing sites with a combination river, stream, and lake habitats that accommodate parr's ability to occupy many niches and maximize parr production.

6. Freshwater rearing sites with cool, oxygenated water to support growth and survival of Atlantic salmon parr.

7. Freshwater rearing sites with diverse food resources to support growth and survival of Atlantic salmon parr.

B. Physical and Biological Features of the *Migration PCE*

1. Freshwater and estuary migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning ground needed to support recovered populations.

2. Freshwater and estuary migration sites with pool, lake, and instream habitat that provide cool, oxygenated water and cover items (e.g., boulders, woody debris, and vegetation) to serve as temporary holding and resting areas during upstream migration of adult salmon.

3. Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.

4. Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.

5. Freshwater and estuary migration sites with sufficiently cool water temperatures and water flows that coincide with diurnal clues to stimulate migration.

6. Freshwater migration sites with water chemistry needed to support sea water adaption of smolts.

C. Physical and biological feature of marine sites and "Specific Areas" within the geographical range occupied by the species

Specific subcomponents for this PCE had not been identified at the time the NMFS (2009a) document was written.

4.3. Factors Used to Assess Impacts of the Various Dams on Atlantic Salmon Habitats and Populations – In this report, I used the physical and biological features outlined under the PCE's above to inform my evaluation of the various sources of information regarding dam-specific impacts and reach my conclusions regarding whether the Defendants' dam(s) and operations thereof are: killing, wounding or otherwise injuring Atlantic salmon directly; killing or injuring Atlantic salmon through significant habitat modification or degradation by significantly impairing normal and essential behavioral patterns (such as breeding, spawning, rearing, migrating, feeding or sheltering); or creating the likelihood of injury to Atlantic salmon by otherwise significantly disrupting these normal and essential behavioral patterns.

During my evaluation, I reviewed, for each dam:

1. The physical structure of the dam,
2. The downstream fish bypass system (if one was installed),
3. The types of turbines used to generate power,
4. The upstream fishway for adult passage (if one was installed),
5. The size and configuration of the headpond upstream of the dam,
6. The physical character of the river immediately downstream of the dam and tailrace areas as potential habitat for predators, and
7. The river flow regime during time periods critical for Atlantic salmon (April – June and October – November) in relation to the hydraulic capacity of the turbines at each project.

Each of these seven factors were reviewed to determine whether, in my opinion, direct harm results from any of these factors, or the dam or its operations significantly interferes with a fish's ability to access the type of habitats described under the PCE's, or the dam or its operations potentially alters the behavior of Atlantic salmon in biologically significant ways.

In performing this analysis, I also reviewed the results of any individual studies and all annual reports on fish passage and restoration efforts under the KHDG Settlement Agreement of 1998 for the period 2000-2010.

5.0 General Conclusions on Impacts of Hydroelectric Dams on Atlantic Salmon in the Kennebec and Androscoggin Rivers

5.1 Background Information

While there have been a number of "effectiveness" studies over the past 13 years that have assessed routes of passage through a particular dam and provided some qualitative estimates of survival for some species, the fact is that no scientifically rigorous, quantitative studies have been conducted at any of the projects to address the critical factors associated with the mortality of fish passing through dams. A quantitative study requires test fish to be released and then recaptured, to verify the fate of the fish as a result of the "treatment" imposed by, say, passing through a dam's turbines. In the absence of a downstream recapture procedure, any result can at best be labeled qualitative.

The qualitative information has been used where I believe there was sufficient data to support the conclusions stated in the various reports and if these data were consistent with other published study results that I deemed comparable.

My general conclusions regarding several aspects of fish passage through or over dams, and the cumulative effects, are provided below.

5.2 Impacts on Downstream Migrating Fish

5.2.1 Mortality Associated with Passing through Project Turbines

While a number of studies have looked at the effectiveness of various structural components of some of the dams at issue, and at routes of passage through or over some of the dams, none has addressed the fundamental question: "If fish pass through a project turbine, what percentage will be killed?" However, some of the qualitative results, from Lockwood studies in particular, fall within the range of published values in the scientific literature. Based on the review of the turbine mortality literature in Section 6.1 of this report, I conclude that the probability of an Atlantic salmon smolt passing through a project turbine has about a 15% chance of being killed within death occurring within 48 hours. For Atlantic salmon kelts, the values range from about 25-60% depending on the type of turbine, but there is essentially no literature that assesses salmon or rainbow trout of the same length as Atlantic salmon kelts in the Kennebec or Androscoggin rivers. The maximum length of comparable fish tested (from the literature) is at least about 200 mm shorter than the typical length of kelts found in the two rivers. These data suggest that the mortality rates for kelts in the Androscoggin and Kennebec rivers would be greater than the rates shown in Section 6.1 of this report.

To put this in perspective, if one assumes a "non-spill" condition (i.e., no water passing over the spillway of the dam) in the spring during the migration period for salmon smolts at the four Kennebec River dams, and if turbine mortality is 15% at each dam, then the net smolt survival rate after four dams is $(0.85)^4$, which is 52.2%. This means that 48% of the smolts migrating downstream would die from passing through four dams. This mortality rate does not include any delayed or latent mortality that would occur after injury and after 48 hours of passing through the turbine. The rate also does not include predation mortality for fish that become disoriented after passing through a turbine. With respect to kelts, if their turbine mortality is estimated at 43% at each dam (a mid-range figure based on the available literature), the net kelt survival rate after four dams is $(0.57)^4$, which is only 10.5%. Again, this rate does not include delayed or latent mortality.

A second factor to consider regarding turbine mortality is with what frequency a smolt or kelt is confronted with no choice but to pass either through a turbine or the ineffective downstream fish bypass systems currently installed at these dams (discussed in detail below). In other words, what is the probability that a fish will be forced to pass through a project's turbines because the total river flow during a critical migration period is at or below the hydraulic capacity of the project's turbines. I completed such a flow analysis for each project, which is found in Section 7 or 8 depending on the particular dam. The results of these analyses show that river flow levels are often sufficiently low to allow all river flow to pass through a project, with a probability ranging from 5-10% of the time in April to 90% of the time in October. If one's goal is to conserve these salmon populations, this situation is unacceptable and critical on both rivers. The Androscoggin is of particular concern, because all three dams have some form of adult passage which allows adults to pass upstream of the dams and spawn and a much lower overall flow regime during critical downstream migration periods. The problem is also critical on the Kennebec River, because of a combination of low flows and the fact that the State of Maine is transporting adult spawners to, and planting nearly 1,000,000 Atlantic salmon eggs per year in, the Sandy River to jump-start the restoration of Atlantic salmon. The primary problem is that even one year of low flows, forcing the salmon to run a gauntlet of multiple project turbines, can negate years of restoration efforts and adversely affect adult returns for decades into the future.

5.2.2 Passage through the Downstream Fish Bypass

Numerous studies have evaluated fish mortality associated with fish passage through bypass systems and via project spill (e.g., Stone and Webster Environmental Services 1992). Fish can be injured or killed in bypass systems due to the way the water entering the bypass system strikes hard objects in the bypass such as the walls or any associated infrastructure. Flow hydraulics in a bypass can also cause fish to be essentially trapped in the bypass or to become disoriented because of turbulent flow; such disorientation changes their behavior, and can attract predators that would not normally be attracted, resulting in death by predation.

I am unaware of any completed quantitative studies documenting the impacts of passing through the bypass facilities of the dams here. Based on my personal observations, some of the downstream bypass facilities appear to be relatively benign, while others appear as though they could be a considerable source of mortality. However, with no data, it is impossible to assess the impacts.

I conclude that one of the most important factors relating to mortality of downstream migrating Atlantic salmon is the physical location of the bypass facilities in relation to a project's turbine intakes. This situation is exacerbated because of the relatively minor flow volume passing into the bypass system at these dams when compared to the flow volume entering the turbines. Also, a number of the downstream bypass discharges drop the water and fish directly into areas that appear to be great habitat for predators. The advantages of having a bypass system may be negated simply because of the bypass's discharge location. Again, no rigorous studies have been conducted to quantitatively assess this mortality factor.

5.2.3. Downstream Passage via Spill

Fish passing via spill, either through the spillway gates or over the crest of the dam (with or without flashboards installed), can be killed, injured, or disoriented by striking project infrastructure (particularly glancing blows), striking the sill at the bottom of the dam on the downstream side, or by turbulence created by the amount of flow and the configuration of the downstream spillway (Robson et al. 2011). Several dams also have extensive bedrock outcrops on the downstream side of the dam. Fish can be killed, injured, or become disoriented by being propelled against these rocks. Fish that are disoriented can become easy prey for a variety of predators.

No project-specific, quantitative data have been collected to assess this factor in relation to fish mortality. Based on my personal observations, some projects appear to have a very low potential to kill or injure fish that pass via spill, while others appear to have a much higher potential to cause harm. I conclude that there must be some mortality or injury of fish passing via spill, but the rate will be project-specific and is not quantified at this time.

5.2.4. Disrupting Normal Behavior Patterns through Changes to Habitat

Each of the dams has an upstream impoundment that alters the behavior of juvenile fish moving downstream when they encounter the low velocity water associated with the impoundment upstream of the dam. The impacts of these impoundments are different because each impoundment is different. For example, the Worumbo Project on the Androscoggin has a relatively small impoundment because of the low height of the dam. The same situation occurs at the Lockwood Project on the Kennebec. However, the impoundment upstream of the Weston Project on the Kennebec is over 12 miles long.

Atlantic salmon smolts are adapted to moving downstream to the sea via a flowing river channel. Smolts encountering a “reservoir” can exhibit behavioral changes, such as slowing their rate of downstream movement. This is significant, as spending more time en route usually subjects them to greater predation rates (Holbrook et al. 2011). In addition, reservoirs change the location and amount of “hiding cover” in the water column, which can lead smolts to move their migratory path closer to the shore, where more hiding and escape cover is present. As a result, these smolts are at a greater risk of predation because predators such as smallmouth bass are also more likely to frequent the shoreline. Further, the interaction between the slow-moving reservoir and the dam itself provides a well-known opportunity for predators, to wait for the salmon near the dam’s spillway or fish bypass. One study conducted at the Hydro Kennebec Project videotaped large predators waiting near the entrance to the downstream bypass for juvenile fish to approach (Madison Paper Industries 2010). Some of the salmon lose their lives in this manner. Also, some smolts will feel compelled to actively swim downstream through the slow-moving reservoir water (rather than moving at their own pace), in order to meet their need to reach the estuary when growth and survival conditions are optimal. This additional physical demand can reduce their energy reserves below what would normally be expected, meaning that they reach the estuary in a less fit condition to begin the transition to salt water (Fay et al. 2006).

Again, I am aware of no quantitative studies that have been conducted to assess the mortality and behavioral changes associated with the impoundments upstream of the dams at issue here. It is reasonable to assume that fish behavior does change and that the mortality rate of passing through an impoundment is higher than it would be passing through a natural flowing water channel.

5.3 Impacts on Upstream Migrating Fish

The biggest impact of the four dams on the Kennebec River is the blockage and/or delay caused by the absence of volitional, state of the art upstream adult passage facilities. Not allowing adult Atlantic salmon to freely swim past these dams disrupts their normal migratory behavior by causing artificial delays in upstream migration, blocking passage directly during periods when the fish trap is not operational and flows are insufficient to allow passage upstream of Lockwood, or short-circuiting the normal migratory behavior and timing by trapping and trucking fish to a location not necessarily of the fish's choosing in the Sandy River. Disruption of normal migratory behavior timing can occur during the spring and/or fall migration period.

The four projects on the Kennebec River currently claim that adult fish passage is accomplished through the trap and truck program at Lockwood. However, my analysis of the physical configuration of the Lockwood Project in Section 7.1 of this report demonstrates that the program does not guarantee adult upstream passage for adult Atlantic salmon. I have managed four trap and truck programs during my time with the Army Corps of Engineers in the Willamette Valley of Oregon for listed spring Chinook salmon and winter steelhead. In my experience, relying on a trap and truck program for these low head dams in Maine is a mistake. There are a myriad of potential problems associated with a trap and truck program. For example, unless you have the entire river blocked at your trapping facility, then it is impossible to determine what fraction of the adult run that you are actually trapping. Hauling fish can be problematic because of various simple issues, such as water temperatures in the release stream being incompatible with truck water temperature, stress-related delayed mortality associated with transport, and the potential for vehicle accidents during transport. All of these issues can have major impacts on the viability of using a trap and truck system. In my opinion, the best option is to let the fish move upstream volitionally, at their own pace, over these low head dams.

On the Androscoggin, the major impact is not having enough adult passage locations available at any one dam, and the use of fish traps and lifts at the Pejepscot and Worumbo projects. While these systems technically provide upstream passage opportunities for Atlantic salmon adults, I am not aware of any evaluations as to the effectiveness of these facilities to attract and move adult fish upstream. Also, the sufficiency of attraction flows to attract salmon to the trap is a concern.

5.4 Cumulative Impacts

A successful biological ecosystem functions as a continuum. The Androscoggin and Kennebec River watersheds are part of the ecological continuum necessary to support Atlantic salmon populations required to ensure conservation of the species. These two watersheds are the second and third largest in Maine that support Atlantic salmon. Each of these watersheds can support much larger populations of Atlantic salmon than they currently do. Overall, the major impediment to increasing Atlantic salmon populations is the combination of the direct and indirect impacts that the dams in the watersheds have on the ability of the species to migrate, spawn, rear, and emigrate to the ocean.

The majority of suitable habitats necessary for salmon to complete the freshwater phases of their life history are upstream of the various dams. However, it is imperative that the sources of mortality, blockage, or delay are minimized at each individual project. If several dams upgrade by installing effective upstream and downstream fish passage facilities, much of the species gain can still be offset or negated by a single facility that does nothing to reduce its impacts on the species. Based on my experience in the Pacific Northwest, the optimum approach to restoring salmon populations is for each negative influence to be overcome in order of priority. This must be accomplished through the range of the species in each watershed in order to provide the PCE's necessary to ensure species conservation and eventual delisting.

6.0 Review of Turbine Mortality Rates and Methodology Used to Develop the River Flows Analysis

6.1 Review of Mortality and Injury Rates to Fish Passing Through Project Turbines

Each type of turbine has different characteristics (e.g., number of blades, spacing between the blades, rotation speed, etc.); these differences in characteristics result in generally different levels of mortality for fish passing through each type of turbine. Francis turbines generally have more blades (vanes), less distance between blades, and spin at higher rotations per minute (rpm), as compared with most Kaplan turbines (which include "propeller type" turbines), which have few blades, more space between blades, and spin at lower rpm. Fish passing through turbines are generally killed or injured because of three factors: 1) being struck by a spinning blade, 2) being impinged between the outside edge of the blade and the wall surrounding the turbine, and 3) experiencing rapid changes in barometric pressure that occur as water passes through the turbines. Change in barometric pressure is likely not a significant factor at these projects because the operations have a low hydraulic head. The primary direct cause of fish death or injury at the Kennebec and Androscoggin dams is blade strike. The probability that a fish will be struck by a blade is related to fish length (Robson et al. 2011). In short, the longer the fish, the shorter the distance between the blades, and the faster the turbine is spinning, the higher the probability of a fish being struck by a blade and killed or injured.

A variety of researchers have completed studies or compiled compendiums of study results for fish mortality through Kaplan and Francis type turbines. Representative results from these studies (including those for the Kennebec River) show, for Kaplan type turbines, mortality rates of:

- 5-20% -- juvenile salmonids (Robson et al. 2011).
- 24-25% -- adult eels: incomplete cites in: Normandeau Associates, Inc. and NextEra™ Energy Maine Operating Services, LLC. (2009b).
- 33% -- Immediate mortality; Atlantic salmon kelts (post-spawning adults): Lockwood Dam, ME (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008b).
- 16% -- Atlantic salmon smolts: Lockwood Dam, ME (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008d).
- 30% -- Immediate mortality; American shad: Lockwood Dam, ME (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008c).
- 16.7-21.5% -- Adult American shad (Stone and Webster Environmental Services 1992).
- Generally <10% for American shad and river herring juveniles (Stone and Webster Environmental Services 1992).
- Range of 9-16% for juvenile salmonids (Stone and Webster Environmental Services 1992).

- 11-14% -- Atlantic salmon smolts (Stone and Webster Environmental Services 1992).
- 5.7-30.5 % -- Atlantic salmon smolts (range of values from two studies of Kaplan turbines cited in the database from Winchell and Amaral 1997).

For Francis turbines, the data specific to Atlantic salmon smolt-sized fish are more limited, but it is generally agreed among fish biologists and fishery engineers that Francis turbines have higher mortality rates than Kaplan turbines for the same species and size of fish (see Stone and Webster Environmental (1992) and Robson et al. (2011) for reviews). The following references provide some indication of the mortality rates for Atlantic salmon smolts (and similar-sized fish) passing through Francis turbines:

- 0-16% -- Atlantic salmon smolts (Winchell and Amaral 1997).
- 11.8-13.7% -- Atlantic salmon smolts (Stone and Webster Environmental Services 1992).
- 28.6% -- Adult American shad (Stone and Webster Environmental Services 1992).
- 10-40% -- Juvenile American shad (Stone and Webster Environmental Services 1992).
- 22.2% -- Rainbow trout (275-360 mm) (Stone and Webster Environmental Services 1992).
- 31.4% -- Rainbow trout (280-410 mm) (Stone and Webster Environmental Services 1992).
- 38.8% -- Rainbow trout (228-401 mm) (Stone and Webster Environmental Services 1992).
- 40-60% -- Probability of blade strike for fish 500-700 mm (Robson et al. 2011).

For Francis turbines, mortality rates are directly related to the diameter of the turbine, the rotational speed, and the size of fish passing through the turbine.

6.2 Analysis of the Probability of River Flows Being Less Than or Equal to a Project's Hydraulic Capacity During Critical Migration Periods.

The objective of evaluating river flows in relation to a project's hydraulic capacity (the maximum amount of water that could flow through the project's turbines) is to obtain an understanding of how often, during critical migration periods, all of the river flow is, or could potentially be, routed thorough the turbines. *This is highly significant because at such times salmon cannot pass over the dam's spillway: they can only pass the dam by swimming through the turbines or through whatever downstream fish bypass may be available*.

I used the following project hydraulic capacities (which are drawn from the sources listed in the later sections of this report addressing these dams individually) in this evaluation:

Kennebec River Projects:

- Lockwood Project: 5,660 cfs
- Hydro Kennebec Project: 7,800 cfs
- Shawmut Project: 6,700 cfs
- Weston Project: 6,000 cfs

Androscoggin River Projects:

- Brunswick: 7,191 cfs
- Pejepscot: 8,100 cfs
- Worumbo: 9,600 cfs

I chose to evaluate mean daily flows for the time periods April through June and October through November. These time periods are generally considered to be the downstream migration periods for Atlantic salmon: smolts and kelts in the spring, and kelts in the fall (Fay et al. 2006). Although no smolt trapping occurs in the Androscoggin or Kennebec rivers, emigrating smolts are trapped in the adjacent Sheepscot River watershed. These data show that Sheepscot origin smolts began their downstream migration about the 12th of April in 2010 and median dates of capture for all smolts in 2002, 2006, and 2010 occurring near the 1st of May in those years (See Figures 5.4.5 and 5.4.6 in U.S. Atlantic Salmon Assessment Committee 2011). Atlantic salmon kelts are known to move downstream in the fall and early spring. Results from a 2008-2009 radio telemetry movement study on adult Atlantic salmon released in the Sandy River (a tributary to the Kennebec River upstream of the Weston Project) showed that fish moved downstream as expected during the fall and winter months, with several fish moving downstream to about the Lockwood Project in April of 2009 (McCaw et al. 2009).

Kennebec River flows used in this assessment are based on 25 years (1978-2011, less 1993-2000 when no flows were recorded at this site) of mean daily flow records from the USGS North Sidney, Maine, gaging station (with flows from the Sebasticook River recorded at Pittsfield, Maine subtracted). I did not adjust the flow values obtained for watershed area differences at different points along the Kennebec because of the numerous assumptions that would be required. I reasoned that adjusting flows upward, based on an additional watershed area of 374 mi.^{2} in the Sebasticook watershed that are not measured by the Pittsfield gage, were essentially offset by flow reductions achieved by reducing the watershed area upstream of the Lockwood, Hydro Kennebec, Shawmut, and Weston projects by a maximum of 283 mi.^{2}. The net effect of not adjusting for watershed area means that the flow at each of the four projects is *overestimated* by about 15-20 percent. That means the information presented in the flow analysis figures under each Kennebec River specific project assessment (Sections 7.1-7.4) will tend to *underestimate* the percentage of time when the entire flow of the river can pass through the project turbines (i.e., river flow is $\leq$ project hydraulic capacity). I used the 5th, 10th, 25th, and 50th low flow percentiles of the mean daily flows, which equate to daily probabilities of a 1 year in 20 (5%), 10 (10%), 4 (25%), or 2 (50%), respectively, chance that mean river flow on that day has historically been ≤ project hydraulic capacity. I did not use the flow records from a temporary USGS gage near Waterville because there was only a 7-year record, from 1993 to 2000.

Androscoggin River flows used in this assessment are based on 83 years (1929-2011) of mean daily flow records from the USGS Auburn, Maine, gaging station. I adjusted the flow values obtained from the gaging station upwards by a factor of 1.0806, which is the difference in watershed area at the gaging station divided by the watershed area for the Androscoggin watershed (National Marine Fisheries Service 2009b). The net effect of adjusting for watershed area means that the flow at each of the three projects may be slightly *overestimated*. This means the information presented in the flow analysis figures under each Androscoggin River specific project assessment (Sections 8.1-8.3) may tend to *underestimate* the percentage of time when the entire flow of the river can pass through the project turbines (i.e., river flow is ≤ project hydraulic capacity). I was unable to find any published estimates of the watershed area upstream of each project. I used the 5th, 10th, 25th, 50th, 75th, and 90th low flow percentiles of the mean daily flows, which equate to daily probabilities of 5%, 10%, 25%, 50%75%, or 90% chance that mean river flow on that day has historically been ≤ project hydraulic capacity.

7. 0 ANALYSIS OF KENNEBEC RIVER DAMS

7.1 Lockwood Project (NextEra)

7.1.1 Brief Project Description

The project has an 875-foot-long spillway section with 15-inch flashboards. The spillway discharges to a large exposed series of bedrock terraces, known as Ticonic Falls. The height of the top of the spillway varies from about 6-10 feet above the terraces downstream of the dam. Under high flows, the falls become submerged. A power canal is located on the west bank of the Kennebec River which leads to three surface sluices (which are considered the Project's downstream fish bypass infrastructure) and the powerhouse.

The first sluice is located just upstream of the power canal headworks structure and has a manually adjustable fixed gate with stop logs and is 7.5 feet wide by 16 inches deep. Flows through this sluice fluctuate with headpond elevation and range from 35 to 40 cfs which discharge over the face of the dam into a shallow bedrock pool connected to the river. The second sluice, located between turbine units 6 and 7 (closest to the west bank of the river), is a manually adjustable fixed gate containing five stop logs. The gate is 6 feet wide by 30 inches deep. With all stop logs removed; this gate passes flows in the range of 60 to 70 cfs. Flows from this sluice discharge directly into the tailrace of the Project, which is approximately 15 feet deep. The third sluice, installed in 2009, is located on the river side of the power canal just upstream of Unit 1 trash rack and discharges directly into the river. This facility consists of a new 10-foot-deep floating boom leading to a new 7-foot-wide by 7-foot-deep sluice and associated mechanical overflow gate. Maximum flow through the gate is 6% of station capacity or 340 cfs. The boom is 300-feet-long and is secured on the land side of the canal and angles downstream to the new sluice gate.

The powerhouse contains six vertical Francis units (#'s 1-6) and one horizontal Kaplan unit (#7) producing a total of approximately 7.5 megawatts of electricity. Total unit flow is approximately 5,660 cfs. Trash rack spacing is 2 inches for Units 1-6 and 3.5 inches for Unit 7. The project contains a fish trapping facility for upstream migrating fish located on the west bank of the river adjacent to turbine unit 7. Flow in the approximately 1,300 ft long bypassed reach (approximate distance between the spillway section of the dam and a point downstream of the powerhouse tailrace) is currently limited to leakage around and through the flashboards, including through 3 engineered slots in the boards (estimated at a total of 50 cfs) (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC, 2008d; NextEra™ Energy Maine Operating Services, LLC, 2010; Normandeau Associates, Inc., 2011b). While the published flow capacity of the turbines at the Lockwood Project is 5,660 cfs, National Marine Fisheries Service staff commented that downstream juvenile passage via spill would probably not occur if depth of flow over the spillway/flashboards was <6 inches (Normandeau Associates, Inc., 2011b). Assuming this statement is correct, that would in effect direct juvenile fish towards the power canal at flows < ~6,000 cfs, increasing the probability of fish interacting with the downstream fish bypass system or the turbines.

7.1.2 Impact of Lockwood Project on Atlantic Salmon

7.1.2.1 Impact on Individual Fish

I have analyzed seven factors (See section 4.3 for a detailed listing) related to the physical structure of the dam and adjacent river channel and operational parameters and characteristics in evaluating impacts of the project on Atlantic salmon. Below is my evaluation of these seven factors:

1. **Physical Structure of the Dam**

    A. **Evaluation –** The physical configuration and height of the dam create a barrier to upstream migrating Atlantic salmon under lower flows, but the flow volumes at which passage over the existing structure is possible are not known.

At flow levels that occur with some frequency in the Kennebec River, upstream migrating adult Atlantic salmon can in fact pass over the Lockwood Project spillway. There are places in the stream channel where water depth and flow turbulence would allow such passage. The two locations that appear to provide upstream passage opportunities are in the center of the channel adjacent to the old mid-stream fish ladder and on the east bank near and around the railroad trestle pier. In these areas the geomorphology of the channel combined with concrete structures create sufficient turbulence that could allow fish to pass upstream of the dam. Under higher flows, adults could swim right over the dam, unimpeded by the structure. (During my site visit on December 8, 2011, staff at the Lockwood Project indicated that during the 1987 flood, there was approximately 20 feet of water over the top of the dam.) If these higher flows occur during the upstream migration period, then passage is possible.

The shape and location of the spillway in relation to the powerhouse create a problem for upstream "passage" via the trap and truck program because there is about 1,300 feet of river channel to the northeast and east of the powerhouse that adult fish will occupy while migrating upstream. These fish may or may not eventually find the entrance to the fish trapping facility, which is downstream about a quarter-mile and on the extreme west bank of the river. Under flow levels that are insufficient to provide upstream passage opportunities, it is unknown what percentage of adult fish actually finds the entrance to the fish trapping facility. At lower flow levels, where the majority or all of the river flow is passing through the turbines, it is much more likely that adult fish will be attracted to that area of the river channel and eventually find the fish trapping facility. However, no studies have been completed to date which demonstrates the effectiveness of project operations to attract adult fish to the vicinity of the fish trapping facility and, if attracted, what percentage of adult fish actually enter the trap. It is possible, even under low flow conditions, that adult fish remain in the river channel near the spillway and do not find the fish trap entrance.

Atlantic salmon smolts migrating *downstream* to the ocean tend to move under low light or dark conditions (Fay et al. 2006). Given the physical shape of the spillway, it is likely that downstream migrating fish moving along the west bank of the river would move directly into the power canal towards the Project turbines. While the published flow capacity of the turbines at the Lockwood Project is 5,660 cfs, National Marine Fisheries Service staff commented that downstream juvenile passage via spill would probably not occur if depth of flow over the spillway/flashboards was <6 inches (Normandeau Associates, Inc. 2011b). Assuming this statement is correct, that would in effect direct juvenile fish towards the power canal at flows < ~6,000 cfs, increasing the probability of fish interacting with the downstream fish bypass system or the turbines.

B. Conclusions Regarding Impacts on Fish – Given the physical configuration of the spillway, its height, and the location of the power canal along the west bank of the river, I believe that the Lockwood Project is causing the following impacts to Atlantic salmon:

I. Under low flow conditions, adult Atlantic salmon are blocked from moving upstream towards spawning habitat areas that contain the characteristics outlined in the subcomponents of the "primary constituent elements" (PCE's) detailed earlier in this report.

II. Under certain flow conditions, adult Atlantic salmon are delayed from migrating upstream due to the lack of adequate fish passage facilities at the Project. This delay in their normal migration timing results from an inability to locate the entrance to the fish trapping facility in a timely fashion. Overall population productivity is likely lower because of the effect of passage blockage and/or delay on the salmon's ability to spawn at more favorable upstream locations and times.

III. The physical shape of the Project makes it much more likely that Atlantic salmon smolts and kelts migrating downstream to the ocean will enter the power canal and thus interact with one of the Project's turbines or downstream fish bypass facilities, especially when river flows are near or below the Project's turbine flow capacity. Interaction with the Project's turbines and/or downstream bypass systems causes smolt and kelt mortality and injury.

2. Downstream Fish Bypass System

A. Evaluation – The Project currently has four locations that effectively serve as a downstream fish bypass system. There are engineered slots in the flashboards on top of the spillway and the three sluices associated with the power canal. Details of each location are presented in the Brief Project Description above.

A 2007 downstream Atlantic salmon smolt passage study at the Project, conducted before the completion of the third sluiceway in the power canal in 2009, found: "For all radio-tagged Atlantic salmon smolts released into or entering the powerhouse canal, approximately 18% (8 of 45) passed via the surface sluice and the other 82% (37 of 45) passed via the turbine units."(Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC, 2008d). A companion study of Atlantic salmon kelts found: "For all radio tagged

Atlantic salmon kelts released into or entering the powerhouse canal, approximately 50% (3 of 6) passed via the surface sluice and the other 50% (3 of 6) passed via Unit 7." (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC, 2008b). These two studies clearly demonstrate that fish entering the power canal with only two sluices operating were as likely as or more likely to exit through the turbines than through the sluices (the bypass facilities). The results for the kelt study are particularly disturbing since Unit 7 has a trash rack with 3.5 inch clear spacing – which is wide enough for kelts to swim through.

In a 2011 study of Atlantic salmon smolts at the Project, downstream passage routes were determined for smolts released into the power canal (forebay canal) and upstream of the Project. This study was performed after the 2009 installation of the third fish bypass sluiceway and a fish guidance boom. For the 38 fish released directly into the forebay canal with definitive passage routes determined, only four (10.5%) were confirmed passing via the bypass sluiceways, with the remainder passing through the turbines (Table 5, Normandeau Associates, Inc. 2011c. Note, this document is under a court protective order). For the groups released upstream of the Project, 45 of 62 fish passed via spill and 17 entered the forebay canal. Of the 17 that entered the forebay canal, only five (29.4%) were confirmed using the bypasses for passage. Considering all the fish that were released into or entered the forebay canal, only 9 of 55 (16.4%) passed through the Project via the fish bypasses (Tables 5-11, Normandeau Associates, Inc. 2011c. Note, this document is under a court protective order).

In conjunction with the Lockwood Project radio telemetry smolt passage study summarized immediately above, the antennas at the Project were able to detect radio tagged Atlantic salmon smolts released upstream of the Hydro Kennebec Project, approximately 1 mile upstream of the Lockwood Project. Antennas at Lockwood detected 93 radio signals from the Hydro Kennebec releases. Of those 93, 89 signals were determined to have entered the Project area. According to Table 5 of Normandeau Associates (2011c Note, this document is under a court protective order), 74 signals passed via spill. Definitive passage routes were determined for 11 of the 15 fish detected in the forebay canal. Of these 11, only 3 (27.3%) were confirmed to have passed via the downstream fish bypass system.

These studies demonstrate clearly that Atlantic salmon smolts and/or kelts (albeit a small sample size for the kelt study) have a very high potential to not pass via the installed fish bypass system and that the guidance boom in the power canal is ineffective at guiding fish away from the turbine intakes. Atlantic salmon smolts are much more likely to pass the Project via the turbines than the fish bypass system. Under high flow conditions, some fish will pass via spill, but the critical condition occurs when river flows are just above or below the Project's turbine flow capacity of 5,660 cfs. The frequency of these lower flow conditions will be discussed in detail below. Also, I am aware of no quantitative mortality studies of fish passing via the various fish bypass routes or via spill that have been completed.

B. Conclusions Regarding Impacts on Fish – Given the 2011 combined results from studies of the smolts released at Lockwood and Hydro Kennebec, which reflect the current infrastructure configuration at the Lockwood Project, the vast majority of salmon that enter the forebay canal – more than 70%, and as many as to 85% – pass the Project via the turbines, and not via the bypass system. The initial boom installation did not function as planned, and despite modifications it is unknown if the boom will function as planned in the future. I conclude that the current downstream bypass system at the Project is ineffective, resulting in a large percentage of smolts passing through the turbines with resulting direct and indirect mortality occurring.

Further, under lower flow (non-spill) conditions, all Atlantic salmon, both smolts and kelts, are forced to pass the Project via the forebay canal and, ultimately, the ineffective fish bypass system or the Project turbines. In my opinion, the bypass system is inadequate to provide the level of protection to Atlantic salmon needed to prevent unacceptable (in terms of population recovery) levels of direct and/or indirect mortality.

3. Types of turbines used to generate power

A. Evaluation – For an overview of turbine mortality rates see Section 6.1 of this report. The Project currently contains six vertical Francis turbines (Units 1-6) and one Kaplan turbine (Unit 7).

In a 2011 draft white paper presented to the resource agencies, the NextEra Defendants reject, with no explanation, the results of their own studies, saying they are inadequate to establish passage mortality at Lockwood. The draft white paper states: "Due to the 1ack of site-specific information, estimates for passage survival of Atlantic salmon smolts through the Lockwood spillway and downstream bypass were developed based on existing empirical studies conducted at other hydroelectric projects." This report also states: "Due to the lack of site-specific information, estimates of turbine passage survival of Atlantic salmon smolts at Lockwood were developed using a combination of existing empirical studies and modeled calculations." (Normandeau Associates, Inc. 2011e. Note: this document is under a court protective order).

I agree that site-specific empirical studies have not been conducted at the Project to assess the following causes of hydroelectric dam-related mortality: predation in the headpond area as a result of changing the type of habitat upstream of the dam; spill-related mortality; mortality associated with fish using the downstream bypass system; delayed or latent mortality associated with fish passing through the turbines and not immediately killed; and mortality due to predation at locations immediately downstream of the Project infrastructure due to fish being injured or disoriented during passage through the Project.

I also agree that rigorous, scientifically reliable, quantitative studies of immediate turbine mortality have not been conducted at the Project. However, I disagree with the conclusion that *no* site-specific mortality information associated with passage through the turbines is available. Various studies conducted under the auspices of the 1998 Kennebec Hydro Developers Group ("KHDG") Settlement Agreement have, in at least a limited way, addressed survival. In fact, the NextEra Defendants have publicly represented (to the general public, to the resource agencies, and to FERC) that these studies provide survival estimates. Examples include:

- In a letter to Kimberly D. Bose, Secretary, Federal Energy Regulatory Commission, transmitting the "2007 Kennebec River Diadromous Fish Restoration Report" and FPL Energy Maine's responses to comments from the Maine Department of Marine Resources (MDMR) on the draft study reports prepared for evaluations conducted during 2007 at the Lockwood Project on Atlantic salmon smolts and kelts, FPL Energy Maine responded to the following general comment from MDMR:

  <u>MDMR</u> General Comments – Passage Through Turbines: "MDMR believes that fish passage via sluiceways and/or controlled spills is the preferred method for downstream fish passage, and that fish passage through turbines should be avoided. FPL Energy's studies have clearly shown that adult alewife, adult American shad, adult American eel, Atlantic salmon kelts, and Atlantic salmon smolts pass through the Lockwood project turbines, and sustain significant immediate mortality. However, the downstream passage studies did not quantify delayed mortality, which is usually measured by holding fish for up to 72 hours after they are passed through a turbine. Therefore, we recommend that all downstream passage survival estimates for all species be termed 'immediate survival.'"

<u>FPL Energy Response:</u> "Licensee recognizes that fish passage through turbines is not preferred by the fisheries agencies, but also recognizes that passage through turbines for certain species and life stages can be, and is on a practical basis, part of the overall passage scheme in effect at the projects. Successful passage through turbines, as well as through other routes, can be variable based upon the site characteristics, species, and life stages." The response further states: "The reports [a series of 5 studies conducted on Atlantic salmon smolts and kelts, adult river herring and American shad, and American eels at the Lockwood Project and American eels at the Shawmut Project] have been modified to include the '*immediate survival*' language." [Emphasis added].

Five additional times in this letter, FPL Energy Maine agrees with MDMR suggestions to change the wording in a final report to "immediate survival" from survival. (FPL Energy Maine 2008b).

- The 2007 diadromous fish passage report itself, which accompanied the above letter, repeatedly reports data regarding "immediate survival" of various fish species, including Atlantic salmon smolts (86% survival through turbine units; 32 of 37 fish), kelts (67% survival through Unit 7; 2 of 3 fish), and American shad (73% survival through Units 1-6; 11 of 15 fish). (FPL Energy Maine Hydro, LLC. 2008a). This report states: "Passage data indicate that *immediate survival of the smolts that passed via the units was 86% and 14% of the smolts were subject to turbine mortality. This data is similar to numerous other turbine passage studies throughout the country that indicated survival can be within that range for projects of this size (Table 3-4).*" [Emphasis added]. Table 3-4 of this report is entitled "Turbine passage survival of Atlantic Salmon Smolts at projects similar in size to the Lockwood Project". Table 3-4 represents a series of studies at other locations by Normandeau Associates, Inc. and others using balloon tags and reports survival for Kaplan and propeller turbines. Survival rates at these projects for 48 hours or less range from 88.0% to 100%. (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC, 2008d).

- Eel survival data has also been collected at NextEra dams on the Kennebec. See Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2009a , and Normandeau Associates, Inc. and NextEra^{TM} Energy Maine Operating Services, LLC. 2009b. Eel survival data can be relevant to an assessment of turbine mortality for Atlantic salmon kelts because the length of these fish is similar.

- In a response to a specific comment from MDMR on the 2007 Atlantic salmon smolt passage study at Lockwood (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008d), FPL Energy Maine responded as follows:

  MDMR Specific comments: Evaluation of Atlantic salmon smolt downstream passage at the Lockwood Project

  "Study objective was 'to determine what routes salmon smolts are using to migrate downstream through the Project and whether existing project measures, including the use of surface sluices and spillways, and other means are passing smolts successfully.' Since the study was not designed to be smolt survival study, information regarding survival through the project is, at best, guarded. Delayed mortality or injuries were not studied; little to no monitoring of smolt movements post Project passage is presented to support the survival conclusion."

  FPL Energy Response: "FPL Energy understands that the study was not designed to be a formal turbine survival study; however, the data is nonetheless valid within the limits of the study. In regards to survival, the results are similar to that of other projects on the East and West coasts." (FPL Energy Maine 2008b).

The results of the studies described above, limited as they may be, are consistent with other turbine mortality studies from Europe and the United States.

B. Conclusions Regarding Impacts on Fish– I have reached the following conclusions with respect to turbine passage at Lockwood:

I. There is a significant frequency, during critical downstream migration periods for Atlantic salmon smolts and/or kelts (April through June and October and November), when essentially the entire flow of the river passes through the Lockwood Project's turbines and bypass system. This is what is known as a "non-spill" condition. Please see the flows analysis below.

II. Given the fact that the data clearly show that the existing downstream fish bypass system is very ineffective at diverting downstream migrating Atlantic salmon away from the turbines, I conclude that during these non-spill conditions the majority of fish passing the dam do so through the Project's turbines. Even during conditions of spill (when water flows over the spillway), fish will still pass through the Project's turbines if they are operating.

III. A scientifically defensible estimate of immediate Atlantic salmon smolt mortality passing through the Francis turbines (Units 1-6) and Kaplan turbine (Unit 7) at Lockwood is approximately 15%. Immediate mortality levels for kelts will be higher, with a reasonable working value of 25-50%. It is important to note that these values do not include mortality associated with downstream predation due to injury or disorientation or latent mortality as a result of passing through the turbines.

IV. Given the preceding conclusions, the Lockwood Project is causing direct mortality to Atlantic salmon smolts and kelts by allowing fish to pass through the Project turbines. Although indirect and latent mortality have not been adequately assessed at this Project, it is reasonable to assume that some small percentage of indirect and latent mortality is also occurring as a result of turbine passage.

4. Upstream fishway for adult passage

A. Evaluation – No volitional upstream fish passage structure is part of the Project's infrastructure (that is, there is no structure allowing the fish to swim upstream past the dam on their own). The Project currently has an upstream fish trapping facility located adjacent to the west bank of the Kennebec River. The trapping facility appears to be operational from about May 1 through October 31 in most years, with some summer down periods due to high water temperature and/or annual maintenance. In addition, the trapping facility is operational generally only at flows < ~21,000 cfs (FPL Energy Maine Hydro, LLC. 2007, 2008a; NextEra™ Energy Maine Operating Services, LLC. 2009, 2010, 2011).

Since the installation of the fish trapping facility in 2006, the owners/operators of the Shawmut and Weston projects have explicitly stated that their fish passage requirement for adult Atlantic salmon is being met by the "trap and truck" program at the Lockwood Project. Although not explicitly stated, it is strongly implied that the owners/operators of the Lockwood Project believe that their upstream adult fish passage requirements are met by the trap and truck program as well (FPL Energy Maine Hydro, LLC. 2007, 2008a; NextEra™ Energy Maine Operating Services, LLC. 2009, 2010, 2011). The owner/operator of the Hydro Kennebec Project, located approximately one mile upstream from the Lockwood

Project, asserts that the Lockwood Project is a complete passage block for adult Atlantic salmon under all flow conditions and thus that there are no adult salmon that reach Hydro Kennebec. Given this conclusion, the Hydro Kennebec owners/operators conclude that no upstream passage facilities for adult Atlantic salmon are needed at their dam (Hydro Kennebec, LLC. 2011. Note: this document is under a court protective order).

A considered evaluation of the physical conditions at Lockwood does not support the conclusions reached by the various dam owners/operators. First, at some yet to be quantified flow volume, adult Atlantic salmon can pass the Lockwood Project spillway section and move upstream to the Hydro Kennebec Project simply because there will be sufficient water depth and/or flow turbulence at specific locations that will facilitate fish passage.

Second, it has not been established that all – or any known percentage of – returning adult Atlantic salmon in the immediate downstream area of Lockwood are actually captured at the fish trapping facility. The physical configuration and width of the river channel and the location of the fish trapping facility immediately adjacent to the west bank of the river strongly suggest that the probability of an adult fish actually finding the entrance to the facility varies with river flow. Given the behavior of adult Atlantic salmon to migrate upstream to the maximum extent possible, and the 1,300-foot section of channel leading up to the dam's spillway located to the east and *upstream* of the powerhouse, it is reasonable to assume that under spill or higher flow conditions adult fish will tend to stay nearer the east bank of the river, away from and upstream of the trapping facility. Only under non-spill flow conditions, or when the majority of flow entering the river channel passes through the Project's tailrace, is it more likely that fish would find the entrance to the trapping facility.

Finally, the fish trapping facility shuts down at river flows > ~ 21,000 cfs. Based on my personal observation of the Lockwood site, I do not believe that adult fish could pass the Lockwood spillway section at flow volumes in the low 20,000+ cfs range. It is therefore my opinion that Lockwood presents an impassable barrier to upstream migrating adult Atlantic salmon when river flows are > ~ 21,000 cfs but below the even higher flow volumes which would permit direct passage over the spillway section.

B. Conclusions Regarding Impacts on Fish – Given the information in the evaluation above, I have reached the following conclusions regarding upstream fish passage facilities at the Lockwood Project:

I. No volitional upstream adult passage facilities exist at the Lockwood Project. Accordingly, except when river flow is high enough to permit them to swim over the dam, upstream migrating Atlantic salmon must "find" the entrance to fish trapping facility under all flow conditions in order for them to be transported upstream via the trap and truck program.

II. It is unknown what percentage of adult Atlantic salmon that migrate from the ocean to the Lockwood Project site are actually captured and trucked to upstream summer holding and spawning areas.

III. The timing of adult Atlantic salmon upstream migration cannot be determined based on the capture data from the Lockwood fish trapping facility. The trap is operated on an apparently fixed time schedule, with no data available to me to suggest when the adults actually arrive at Lockwood.

IV. Given the physical configuration and width of the channel and the physical layout of the Lockwood Project, it is probable that upstream migrating adult fish will use the east side of the river as their initial migratory pathway and, depending on river flow volumes, may or may not move to the west side of the river channel towards the entrance to the fish trapping facility. Particularly given the dependency on favorable flow volumes, I do not believe that all adult Atlantic salmon find their way to the fish trapping facility.

V. The Lockwood Project is not a total block to upstream migrating adult Atlantic salmon under all flow conditions. At some yet to be quantified high flow volume, adult salmon can pass the Lockwood spillway section and move upstream to the Hydro Kennebec Project.

VI. At river flow volumes great enough to require the fish trapping facility to be shut down but below the higher river flow volumes sufficient to allow adult Atlantic salmon passage over the Lockwood spillway section, the Lockwood Project is an impassable barrier for upstream migrating adult Atlantic salmon.

VII. It is biologically unjustified to conclude that upstream passage requirements for adult Atlantic salmon are met by conditions and operations at the Lockwood Project.

VIII. Given these supporting conclusions, I conclude that – depending on flow conditions – the Lockwood Project blocks upstream migration of Atlantic salmon, delays their migration, or creates conditions that allow passage only under flow conditions that are different from those that existed before the Project was constructed. In addition, it is unknown what the fate of adult Atlantic salmon may be if they are unable to find a way to pass the Lockwood Project on their way upstream.

5. Size and configuration of the headpond upstream of the dam

A. Evaluation – According to published reports, the headpond area at the Lockwood Project is 81.5 acres in size (FPL Energy Maine Hydro, LLC. 2007). Although I am unable to verify this estimate, it appears reasonable, given the low height of the spillway section. However, it is not stated if this area estimate is with or without the flashboards installed. Installing the flashboards raises the effective height of the dam, thus increasing the area of the headpond. The headpond size is significant because in this area of the Lockwood Project, the habitat of the Kennebec River has been changed from a flowing river channel to a more slow-moving water habitat. The lake-like habitat is more likely to contain fish species that are predators on juvenile Atlantic salmon, and it may not contain the cover features for juvenile salmon that would normally be present in a natural river channel. I am unaware of any study or analysis that has specifically quantified the habitat characteristics of this area or quantified any predation rates on Atlantic salmon smolts.

B. Conclusions Regarding Impacts on Fish – I conclude that it is likely that levels of predation of Atlantic salmon smolts in the headpond area of the Lockwood Project are higher than what they would be in a natural river channel. But given the lack of any site-specific, quantitative studies or data, it is impossible to reach a defensible quantitative assessment of the increased predation rate or the potential impacts on the Atlantic salmon population.

6. Physical character of the river immediately downstream of the dam and tailrace areas as potential habitat for predators

A. Evaluation – Smolts can pass the Lockwood Project by going over the spillway, or passing through the turbines or downstream fish bypass system. Each of these routes may affect smolts in ways that make them more vulnerable to predation, as described in Section 5.2, above. No scientifically rigorous studies have been conducted to assess these impacts at Lockwood, although the authors of studies conducted at the Lockwood Project that focused on other passage issues conclude that some radio tagged smolts were taken by downstream predators, based on movement patterns of the tags after passage through the project ((FPL Energy

Maine Hydro, LLC. 2008a, Normandeau Associates, Inc. 2011c. Note this latter document is under a court protective order). The predation estimate in the 2011 study was 1.4%.

The configuration of the river channel and the effects of spill on juvenile Atlantic salmon passing over the spillway make these fish vulnerable to predation. Given the extensive bedrock ledges immediately downstream of the spillway section, I conclude that some yet to be quantified level of disorientation or injury increases vulnerability to predation.

Under low flow conditions, the majority of the river flow is passing through the power canal, which means fish are passing through the bypass system or turbines. In multiple reports, the published project description states that the water depth in the turbine tailrace is approximately 15 ft. This type of habitat is very conducive to harboring predators such as striped bass. Given the probability of fish being disoriented by passing through the turbines, it is likely that predation rates in this specific area of the Project are higher than other areas. However, no studies have specifically quantified the predation rate in this area.

B. Conclusions Regarding Impacts to Fish and this Factor –I conclude that the Lockwood Project's configuration and operations create conditions that result in increased predation of juvenile Atlantic salmon. There is one published estimate that would suggest a 1+% predation rate, but I do not believe that level is supported by scientifically reliable evidence. In my professional opinion, predation is occurring at some unknown level, likely in the low single digits. But given the lack of specific quantitative data, the actual level of predation below Lockwood and its impact on Atlantic salmon cannot be quantified at this time.

7. River flow regime during time periods critical for Atlantic salmon (April through June and October through November) in relation to the hydraulic capacity of the turbines

A. **Evaluation –** For a more detailed explanation of the data and procedure used to develop the figures below relating Kennebec River flow conditions and the potential for all of the river flow to pass through the Project's turbines, see Section 6.2 of this report. Results of this analysis are presented below:

Data from Figure 7.1.1 show that during the month of April there is a fairly consistent probability of 5% that river flows will be ≤ Project hydraulic capacity. This probability increases to nearly 10% during the last few days of the month.

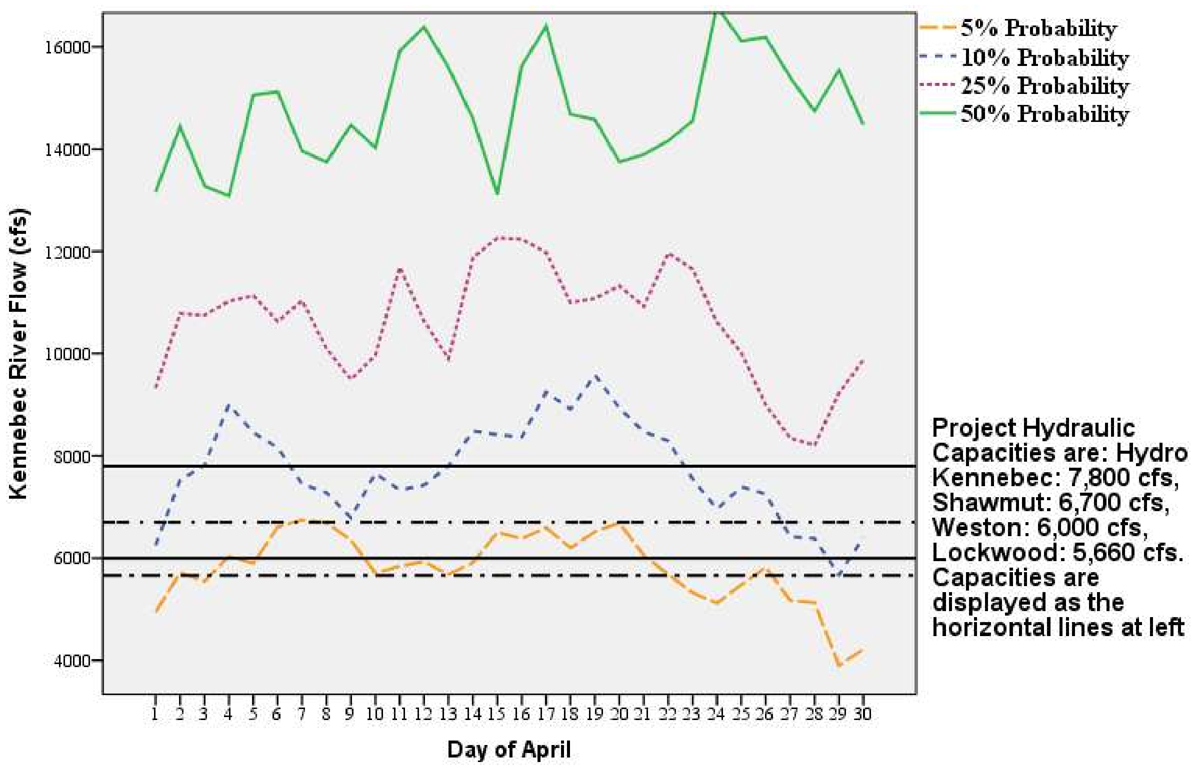


Figure 7.1.1. Relationship between Kennebec River mean daily flow in April and the hydraulic flow capacity of the Hydro Kennebec, Shawmut, Weston, and Lockwood projects. Flow curves represent the 5, 10, 25, and 50th mean daily flow percentiles. Flow volume is based on all days of record for the USGS gage at North Sidney, ME with flows from the Sebasticook River at Pittsfield, ME subtracted. No flow adjustment has been made for changes in watershed area.

Data from Figure 7.1.2 show that during the month of May there is a fairly consistent probability of 10% that river flows will be ≤ Project hydraulic capacity. This probability increases to nearly 25% during the last 10 days of the month.

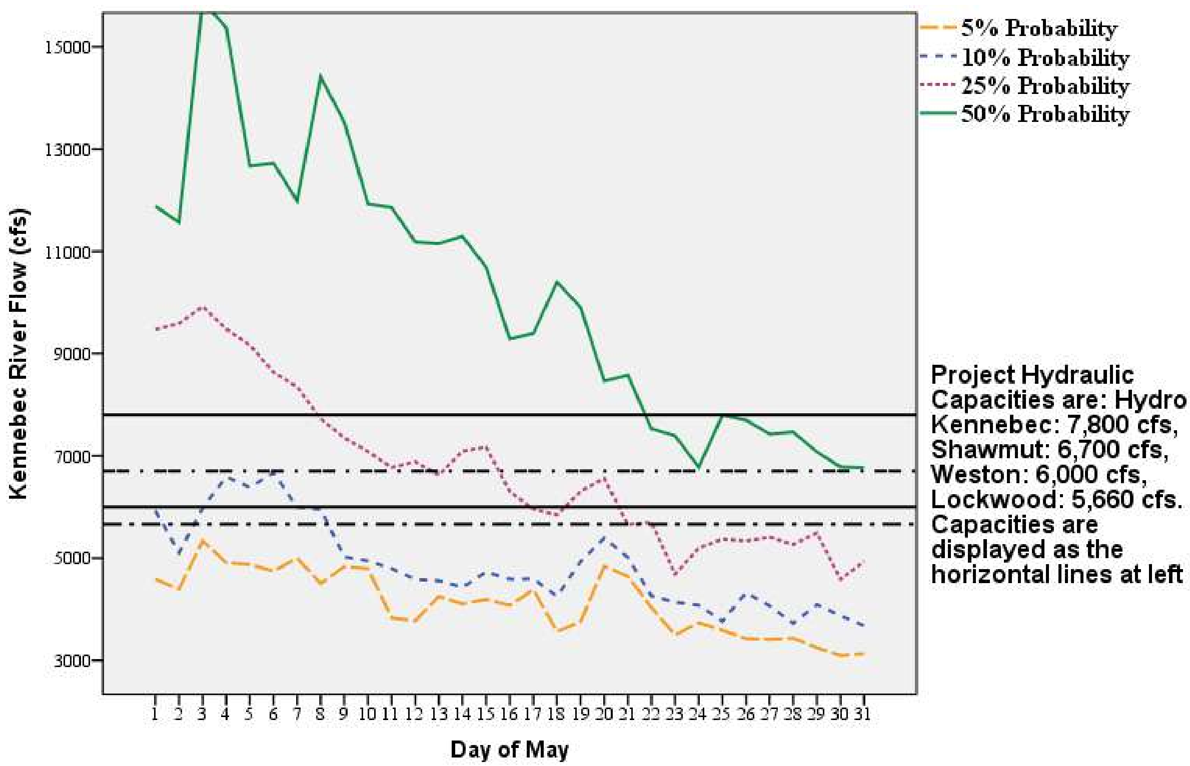


Figure 7.1.2. Relationship between Kennebec River mean daily flow in April and the hydraulic flow capacity of the Hydro Kennebec, Shawmut, Weston, and Lockwood projects. Flow curves represent the 5, 10, 25, and 50th mean daily flow percentiles. Flow volume is based on all days of record for the USGS gage at North Sidney, ME with flows from the Sebasticook River at Pittsfield, ME subtracted. No flow adjustment has been made for changes in watershed area.

Data from Figure 7.1.3 show that during the month of June there is a fairly consistent probability of 25% that river flows will be ≤ Project hydraulic capacity. This probability increases to nearly 50% during the last 10 days of the month.

Data from Figure 7.1.4 show that during the month of October there is a consistent probability of at least 50% that river flows will be ≤ Project hydraulic capacity.

Data from Figure 7.1.5 show that during the month of November there is a consistent probability of at least 25% that river flows will be ≤ Project hydraulic capacity.

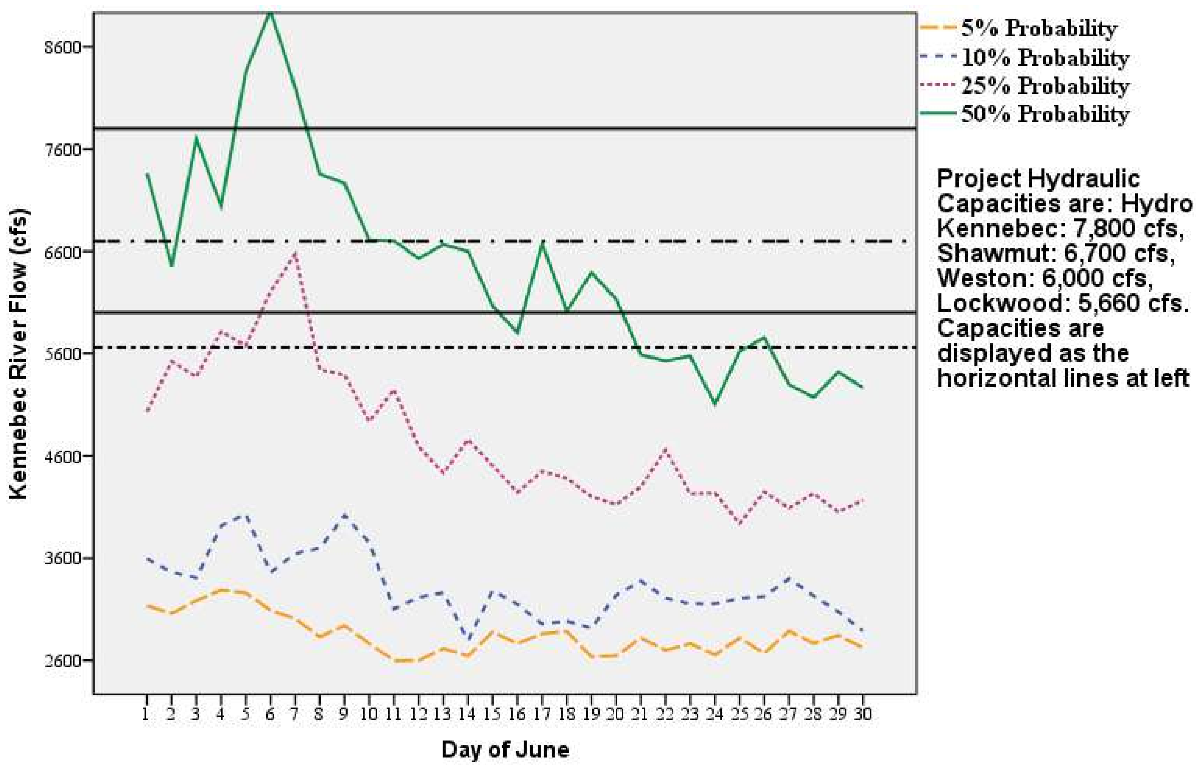


Figure 7.1.3. Relationship between Kennebec River mean daily flow in April and the hydraulic flow capacity of the Hydro Kennebec, Shawmut, Weston, and Lockwood projects. Flow curves represent the 5, 10, 25, and 50th mean daily flow percentiles. Flow volume is based on all days of record for the USGS gage at North Sidney, ME with flows from the Sebasticook River at Pittsfield, ME subtracted. No flow adjustment has been made for changes in watershed area.

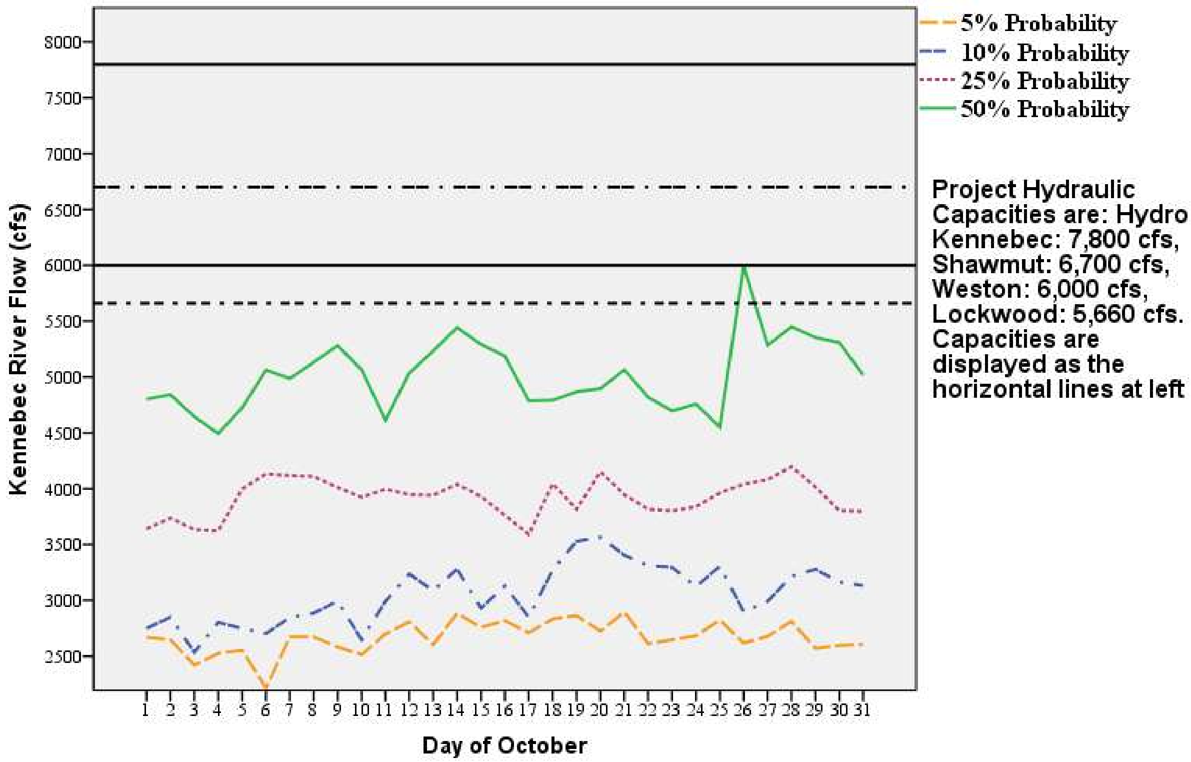


Figure 7.1.4. Relationship between Kennebec River mean daily flow in April and the hydraulic flow capacity of the Hydro Kennebec, Shawmut, Weston, and Lockwood projects. Flow curves represent the 5, 10, 25, and 50th mean daily flow percentiles. Flow volume is based on all days of record for the USGS gage at North Sidney, ME with flows from the Sebasticook River at Pittsfield, ME subtracted. No flow adjustment has been made for changes in watershed area.

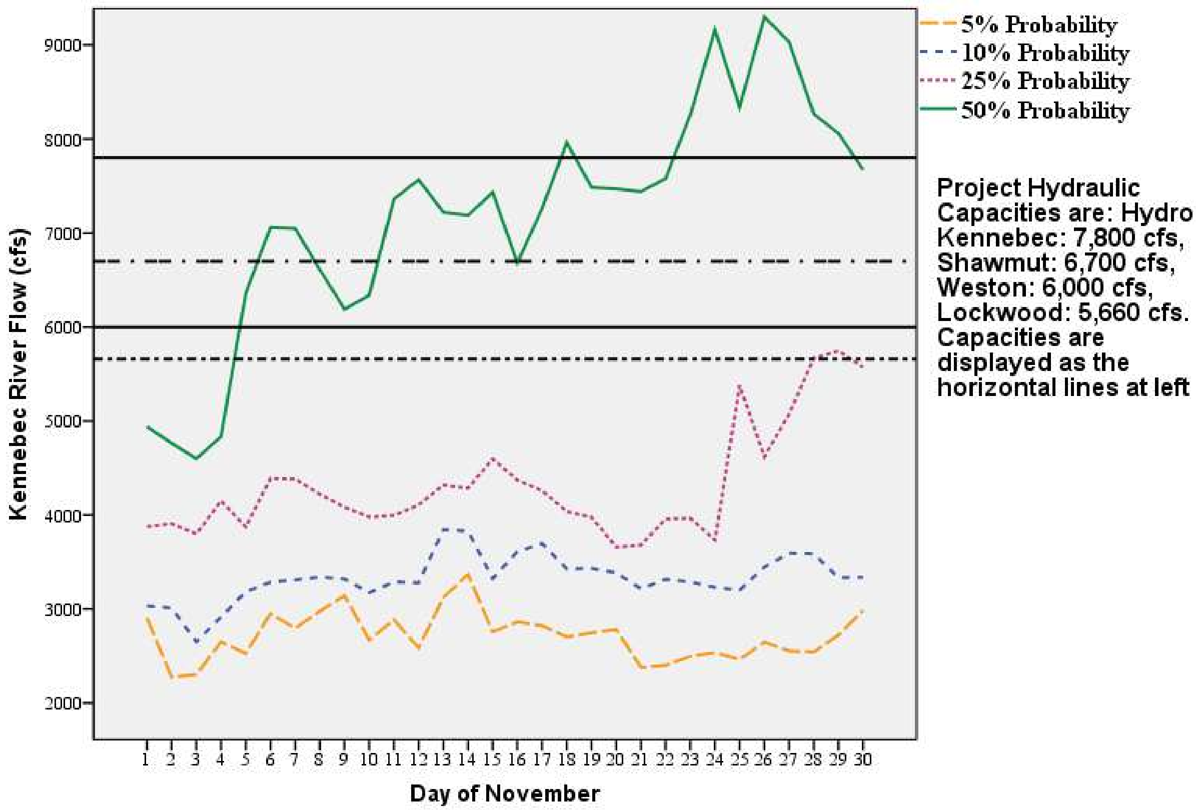


Figure 7.1.5. Relationship between Kennebec River mean daily flow in April and the hydraulic flow capacity of the Hydro Kennebec, Shawmut, Weston, and Lockwood projects. Flow curves represent the 5, 10, 25, and 50th mean daily flow percentiles. Flow volume is based on all days of record for the USGS gage at North Sidney, ME with flows from the Sebasticook River at Pittsfield, ME subtracted. No flow adjustment has been made for changes in watershed area.

B. Conclusions Regarding Impacts on Fish – The results of these analyses lead me to the following conclusions:

I. During the spring emigration period, the probabilities of river flow being ≤ the Lockwood Project's hydraulic capacity range from 5 to 50%. During the most likely time when the majority of smolts would migrate, the probabilities range from 10-25%. This level of resulting interaction with Project turbines is, in my opinion, unacceptable in terms of population survival and recovery, given the level of immediate turbine mortality at Lockwood Project and the current status of the Atlantic salmon population in the Kennebec River.

II. During the fall kelt emigration period, the analysis shows probabilities of > 50% for all of October and > 25% for all of November. This level of resulting interaction with Project turbines is, in my opinion, unacceptable in terms of population survival and recovery, given the level of immediate turbine mortality at Lockwood Project and the current status of the Atlantic salmon population in the Kennebec River.

III. This analysis clearly demonstrates that the use of median monthly flow values to assess potential project impacts is not appropriate or defensible. As this analysis shows, the use of median monthly flows greatly underestimates the amount of time that river flows will be less than or equal to project hydraulic capacity, and thus underestimates the percentage of time that the only downstream passage route available for Atlantic salmon is through the project turbines and the inadequate downstream bypass system. It is my understanding, based on my review of draft white papers commissioned by the NextEra Defendants, that these Defendants plan to use median flow data to assess each Project's impacts on Atlantic salmon for purposes of obtaining Incidental Take Permits.

IV. Given the current population levels, the age structure of adults captured at the Lockwood fish trapping facility, the decades it would take to rebuild even one year's loss of smolts due to project operations, and the cumulative effects of the four projects on the Kennebec River between Waterville and the Sandy River, I believe the impacts associated with low river flows result in critical levels of mortality to Atlantic salmon on a reasonably predictable and routine basis.

7.1.3 Impacts on Atlantic salmon in the Merrymeeting Bay SHRU and, consequently, the GOM DPS as a whole

In order to evaluate impacts of dam operations on the Merrymeeting Bay SHRU and the GOM DPS as a whole, I used five parameters related to the Lockwood Project, and these same parameters and conclusions are equally applicable to the Hydro Kennebec, Shawmut, and Weston projects as well.

1) **Percentage of the total habitat in comparison to the GOM DPS –** According to the NMFS (2009b), the Merrymeeting Bay SHRU comprises approximately 46% of the land area in the GOM DPS, with the Kennebec River watershed contributing 56% of the total for the Merrymeeting Bay SHRU. Therefore, the Kennebec River watershed has the potential to be the dominant contributor to recovery in the SHRU and the GOM DPS overall because of its land area and the quality of habitats suitable for Atlantic salmon upstream of the Weston Project.

2) **Population diversity and stability –** The Kennebec River watershed is the second largest in Maine that is part of the GOM DPS and contains extensive areas

designated as critical habitat. Historically, the Androscoggin, Kennebec, and Penobscot watersheds were the largest producers of Atlantic salmon in Maine, and probably the East Coast. These large watersheds provided a variety of habitats which resulted in genetic diversity among watersheds and overall population stability because of the variety of habitats and life history strategies necessary for salmon to persist in them (National Research Council 2002, 2004; Fay et al. 2006; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2009).

3) **Location of habitats suitable to promote recovery of the species –** The overwhelming majority of habitats suitable to support Atlantic salmon spawning and juvenile rearing in the Kennebec River watershed are located upstream of the Weston Project. While the MDMR (2010) identified some habitat suitable for Atlantic salmon downstream of the Lockwood Project, a functional equivalent habitat analysis by NMFS found that all habitats downstream of the Lockwood Project received a zero rating for Atlantic salmon spawning and rearing. What this functional equivalent rating means is that the quantity and quality of downstream habitats are insufficient to adequately support the habitat and population recovery criteria for the SHRU (National Marine Fisheries Service (2009b). The NMFS analysis found that all of the habitat suitable to support the PCE requirements for spawning and rearing, and thus recovery, were upstream of the Weston Project.

4) **Blockage and/or delay to upstream migrating adult Atlantic salmon –** As demonstrated in various analyses I described earlier in this report, the Lockwood Project blocks migration of adult Atlantic salmon, delays their migration, or creates conditions that allow passage only under flow conditions that are different than those that existed before the Project was constructed. Any adults that are captured are trucked far upstream, which subjects them to the adverse impacts of trucking described in Section 5.3 and requires kelts to pass four hydroelectric dams in order to return to the sea after spawning.

5) **Mortality rate of Atlantic salmon smolts and kelts passing downstream through Lockwood Project turbines –** Smolts and kelts moving downstream through the Lockwood Project are subject to mortality associated with passage through the Project's turbines. During periods of non-spill at downstream migration time periods (see analyses of these time periods above), fish are forced to pass via the Project's power canal which contains several fish bypass sluices and the project turbines. Studies conducted on the effectiveness of the various bypass routes have shown, at best, about a 20% effectiveness of the bypass systems to successfully pass smolts through those routes (Normandeau

Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008d; Normandeau Associates, Inc. 2011c. Note: this document is under a court protective order.). Immediate mortality of smolts passing through the turbines is about 15%, while immediate mortality of kelts is about twice that rate (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008b, 2008d). Delayed turbine mortality, and additional adverse impacts on salmon going over the spillway or thru the bypass structures, are likely but have not been quantified.

Given the impacts of these five factors on individual Atlantic salmon, the effects of the Lockwood Project on the spawning and rearing and migration PCE's, and the overall negative impact on the likelihood that the recovery criteria for the Merrymeeting Bay SHRU will be met, I conclude that the Lockwood Project, as it is currently structurally configured and operated is having a significant adverse impact on the Merrymeeting Bay SHRU and the GOM DPS as a whole.

7.1.4 Interim Measures

Any or all of the following measures would either reduce the harm to Atlantic salmon currently being caused by the dams in question or contribute to efforts at restoration of the species.

7.1.4.1 Interim Measures Applicable to All Projects on the Kennebec and Androscoggin rivers

A. Ensure that when a project's turbines are operating, they are operating near peak efficiency. Running a turbine at near peak efficiency maximizes the survival of fish passing through the turbine. See Stone and Webster (1992) and Robson et al. (2011) for more detailed discussion.
B. Discontinue the use of Francis turbines during the spring migration period (April through June) and the Atlantic salmon kelt fall migration period (October and November). Francis turbines have higher mortality rates for juvenile salmonids passing through this type of turbine than do Kaplan type turbines. Temporary turbine shutdowns are specifically mentioned in the Kennebec Hydro Developers Group Settlement of 1998 (See Section IV. B.3.a (1) for example).
C. Alternatively, discontinue the use of all project turbines during the spring migration period (April through June) and the Atlantic salmon kelt fall migration period (October and November). Temporary turbine shutdowns are specifically mentioned in the Kennebec Hydro Developers Group Settlement of 1998 (See Section IV. B.3.a (1) for example).
D. Immediately fund on an annual basis, the collection and analysis of genetic samples from all returning adult Atlantic salmon entering the fish trap facilities at the Lockwood and Brunswick projects. These data are necessary to begin

monitoring the progress of restoration efforts in the Androscoggin and Kennebec river watersheds.

E. Evaluate as appropriate for an individual project, the effectiveness of an electrical guidance system to replace or supplement existing ineffective barrier or guidance booms. These systems have proven to be highly effective in providing fish guidance or barriers in situations similar to those prevailing in the Kennebec and Androscoggin (Palmisano and Burger 1988, Barrick and Miller 1990, S. P. Cramer and Associates, Inc. 1993). This technology can also be used to keep larger predators away while smaller juveniles pass. The evaluations conducted of boom guidance systems to date have demonstrated that they are ineffective at guiding fish away from project turbines and provide an inadequate level of protection to fish migrating downstream.

F. Give priority to providing alternate spill locations away from the turbine intakes to the extent practical. Many of the downstream fish bypass entrances are located in areas very close to the turbine intakes and have insufficient flow capacity to effectively attract fish from moving away from the turbine intakes and into the downstream bypass. Concentrating downstream bypass flows at one or more locations along the spillway of an individual project could improve downstream passage efficiency and potentially fish survival.

G. Increase the time period when upstream fish passage facilities are operated by beginning on April 1st.

H. Fund a series of quantitative studies to quantitatively determine fish mortality rates for the various routes of passage including through the turbines, fish bypass system(s), and spill, and to quantitatively determine mortality in the headpond upstream and tailrace downstream of the project. These studies should be conducted by an independent, unaffiliated organization such as the Maine Cooperative Fish and Wildlife Research Center at the University of Maine, Orono.

I. Complete the preliminary design of any new or additional permanent upstream and downstream fish passage facilities at each project, as needed, within 12 months. It is apparent that safe fish passage and habitat connectivity are going to be major components of any recovery plan developed for Atlantic salmon, and the impacts of project operations could be reduced much sooner if a proactive approach is taken.

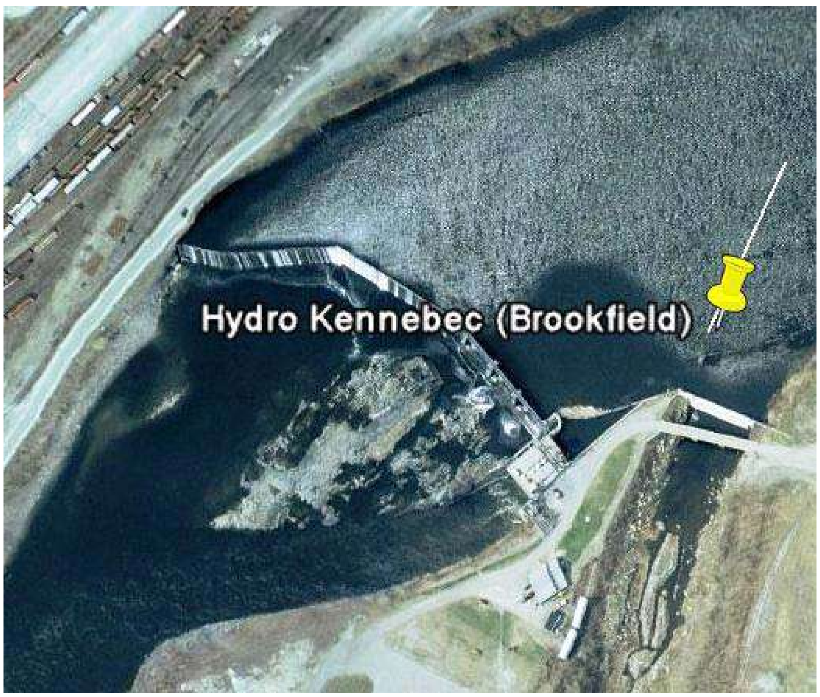
J. Fund the development and construction of a genetics conservation hatchery facility in both the Kennebec and Androscoggin River watersheds. Each facility would hatch and rear fish to approximately three inches in length for release into their respective rivers. The purpose of a conservation hatchery in each watershed would be to begin the development of a river-specific stock, as recommended by the agencies' Atlantic salmon recovery team. Each facility could be constructed for approximately $1,000,000 and be fully operational in approximately 1 year. I have been personally involved in a similar effort for winter-run Chinook salmon from concept to completed construction; that facility led to the rapid expansion of the winter-run Chinook population within 10 years.

7.1.4.2 Additional Interim Measures Specifically for the Lockwood Project

A. Install a downstream electrical guidance system to more effectively guide downstream migrating salmon and shad towards the project sluiceways. This system could be operated independently or in conjunction with the current boom system to increase the effectiveness of the boom system.

B. Extend the discharge location of the sluiceway adjacent to Unit 1 from a point immediately adjacent to the powerhouse to a point east into the thalweg (deepest section) of the main river channel.

7.2 Hydro Kennebec Project (Brookfield)



7.2.1 Brief Project Description

The Hydro Kennebec Project is the second dam upstream on the Kennebec River. The Project consists of a 555-foot-long ungated concrete gravity spillway, a 200-foot-long gated spillway, downstream fish passage facilities and a powerhouse located adjacent to the east bank of the Kennebec River. Normal operating head is 28 feet. The powerhouse contains two horizontal Kaplan type units with a combined hydraulic flow capacity of approximately 7,800 cfs. No upstream fish passage facilities exist at the project. A downstream fishway consists of a 10' deep angled fish boom in the forebay leading to a 4' wide by 8' deep slot. That slot is capable of passing 4% of turbine flow and is located in the wall between the turbine intakes and the bascule gate structures. Flow through that slot discharges to a plunge pool next to the powerhouse (Hydro Kennebec, LLC. 2011; Normandeau Associates, Inc. 2011d).

7.2.2 Impact of Hydro Kennebec Project on Atlantic Salmon

7.2.2.1 Impact on Individual Fish

I have analyzed seven factors related to the physical structure of the dam and adjacent river channel and operational parameters and characteristics in evaluating impacts of the Project on Atlantic salmon. Below is my evaluation of these seven factors:

1. **Physical Structure of the Dam**

   A. **Evaluation –** The physical configuration, lack of upstream fish passage facilities, and height of the dam create a barrier to upstream migrating Atlantic salmon under normal flows. During my site visit to the Lockwood Project on December 8, 2011, staff at the Lockwood Project indicated that during the 1987 flood, that there was approximately 20 feet of water over the top of the dam. If these higher flows occur during the upstream migration period for salmon, then passage for adult Atlantic salmon past Lockwood is possible (see discussion in Section 7.1.2.1., above). This means that migrating adult Atlantic salmon could potentially reach and then be blocked from migrating to upstream spawning habitat by the Hydro Kennebec Project. I do not know whether, under extreme flow events, adult Atlantic salmon could pass the Hydro Kennebec Project, although I consider this possibility to be highly unlikely given the height of the Project.

   Atlantic salmon smolts migrating downstream to the ocean tend to move under low light or dark conditions. Given the physical shape of the spillway, it is likely that fish moving along the east bank of the river would move directly into the power canal towards the Project turbines. While the published flow capacity of the turbines at the Hydro Kennebec Project is 7,800 cfs, National Marine Fisheries Service staff commented that downstream juvenile passage via spill would probably not occur if depth of flow over the spillway/flashboards was <6 inches (Normandeau Associates, Inc., 2011b). Assuming this statement is correct, that would in effect direct juvenile fish towards the power canal at flows < ~8,000 cfs, increasing the probability of fish interacting with the downstream fish bypass system or the turbines.

   From my personal observation, it appears that fish passing via spill at Hydro Kennebec fall approximately 30+ feet onto a sloping face, bedrock ledges, or concrete sill at the base of the spillway, which is likely to cause injury to some fish. In addition, juvenile salmon may become entrained or impinged at specific locations where water is leaking through the dam's infrastructure. Two instances of such leaking were observed during my visit to the Hydro Kennebec dam.

B. Conclusions Regarding Impacts on Fish – Given the physical configuration of the spillway, its height, and the location of the power canal along the east bank of the river, I believe that the Hydro Kennebec Project is causing the following impacts to Atlantic salmon:

I. Upstream migrating adult Atlantic salmon that reach the Hydro Kennebec Project are blocked from moving further upstream towards spawning habitat areas that contain the characteristics outlined in the subcomponents of the PCE's detailed in Section 4 of this report, except conceivably under the highest possible flow conditions. Overall population productivity is decreased as a result of any such passage blockage.

II. The physical shape of the Project causes Atlantic salmon smolts and kelts emigrating to the ocean to enter the power canal, meaning that salmon will interact with one of the Project's turbines or the downstream fish bypass facility. This is especially likely at lower river flows, when river flows are near or below the Project's turbine flow capacity. Interaction with the Project's turbines and/or downstream bypass system causes Atlantic salmon mortality and injury. See the review of turbine mortality in Section 6.1 of this report.

III. The height of the dam, the shape of the dam face, and the presence of bedrock ledges immediately downstream of the spillway section causes some yet to be quantified level of mortality or injury to Atlantic salmon passing the Project via spill.

2. Downstream Fish Bypass System

A. Evaluation – To my knowledge, no quantitative mortality studies of fish passing via the various passage routes (spill, turbines, or bypass structure) have been completed. However, fish can be injured, killed, or disoriented in passing dams via spill or via bypass systems, as described in Section 5.2, above.

The Project currently has one location that serves as a downstream fish bypass system. This bypass is a hole cut in the west wall of the turbine intake structure that passes a maximum of 320 cfs. A guidance boom is intended to "lead" fish to the bypass entrance. The initial boom installation did not function as planned, and despite modifications it is unknown if the boom will function as planned in the future.

A 2008 downstream Atlantic salmon smolt passage study at the Project documented that 46% of the smolts in the study used the bypass (Madison Paper

Industries 2009). In a 2011 study of Atlantic salmon smolts released upstream of the Project, downstream passage routes were determined. Under high flow, spill conditions, 30 fish were confirmed passing via the bypass or through the turbines. Of these 30 fish, 14 (~54%) passed through the turbines (Table 4, Normandeau Associates, Inc. 2011d).

These studies demonstrate clearly that more than 50% of the Atlantic salmon smolts that do not (or cannot, because of low flow conditions) pass over the dam's spillway will pass via the Project's turbines, and that the guidance boom in the power canal is relatively ineffective at guiding fish away from the turbine intakes. Under high flow conditions, some fish will pass via spill (subject to the mortality described above), but the critical condition occurs when river flows are at or below the Project's turbine flow capacity of 7,800 cfs. The frequency of lower flow conditions will be discussed in detail below.

From my personal observations of Hydro Kennebec's fish bypass, I noted at least three points at which physical impacts or disorientation could occur: (a) where a highly turbulent discharge flows from the bypass opening against a concrete wall in the bypass spill chamber; (b) at a rock ledge alongside the fast-flowing narrow channel at the end of the bypass system; and (c) upon metal posts and hardware standing in the flow stream from the fish bypass.

B. **Conclusions Regarding Impacts on Fish –** Given the results of the 2008 and 2011 studies of smolts released upstream of Hydro Kennebec, which reflect the current infrastructure configuration at the Hydro Kennebec Project, along with my personal observations, I believe that the Hydro Kennebec Project is causing the following impacts to Atlantic salmon:

I. Approximately 54% of the smolts released at Hydro Kennebec that entered the forebay canal, and for which definitive passage routes were determined, passed the Project via the turbines and not the bypass system. It is clear that the current downstream bypass system at the Project is ineffective, resulting in a large percentage of smolts passing through the turbines with direct and indirect mortality occurring.

II. Under lower flow (non-spill) conditions, Atlantic salmon, both smolts and kelts, are forced to pass the Project via the fish bypass system or Project turbines. The bypass system is ineffective in diverting salmon from the turbines and therefore is inadequate to provide the level of protection to Atlantic salmon needed to prevent unacceptable (in terms of population recovery) levels of direct and/or indirect mortality.

III. Smolt and kelts passing Hydro Kennebec via the downstream fish bypass suffer death, injury, and disorientation as a result of that passage, at a rate yet to be quantified.

3. Types of turbines used to generate power

A. Evaluation – For an overview of turbine mortality rates see Section 6.1 of this report. The Project currently contains two horizontal Kaplan turbines. Change in barometric pressure is not a significant factor at the Project because the operation has a low hydraulic head. The primary direct cause of fish death or injury at Hydro Kennebec is blade strike.

A 2011 draft biological assessment for the Hydro Kennebec Project, commissioned by the project owner/operator, states: "Because of the few salmon returns and limited amount of juvenile stocking efforts, smolt survival has not been studied in the Kennebec River. Therefore, the licensee analyzed immediate turbine survival rates of Atlantic salmon smolts … estimated to potentially be entrained at the Hydro Kennebec Project under existing conditions based on the results of field trials compiled in the EPRI turbine passage survival database…"

I agree that site-specific empirical studies have not been conducted at the Project to asses: predation in the headpond area as a result of changing the type of habitat upstream of the dam; spill-related mortality; mortality associated with fish using the downstream bypass system; delayed or latent mortality associated with fish passing through the turbines and not immediately killed; and mortality due to predation at locations immediately downstream of the Project infrastructure due to fish being injured or disoriented during passage through the Project.

However, I disagree with the conclusion that *no* Kennebec River-specific information is available regarding mortality associated with Atlantic salmon smolts and kelts passing through Kaplan type turbines. For a more detailed evaluation of the studies on the Kennebec River at the Lockwood and Hydro Kennebec projects, please see the companion evaluation for the Lockwood Project above (Section 7.1). In short, these studies and associated annual restoration program reports to FERC and an associated transmittal letter continually assert that the results of the studies are consistent and comparable with other turbine mortality studies from Europe and the United States, which are discussed in Section 6.1 above.

B. Conclusions Regarding Impacts on Fish – Given the information in the references cited above in Sections 6.1 and 7.1, and the study results completed on a nearby project with similar turbine types, I have the following conclusions with respect to the impacts of turbine passage on Atlantic salmon:

I. There is a significant frequency, during critical downstream migration periods for Atlantic salmon smolts (April through June) and/or kelts (April through June and October and November), when the river flows are low enough that essentially the entire flow of the river passes through the Project's turbines and bypass system. Please see the flows analysis below.

II. Site-specific data clearly show that the existing downstream fish bypass system is less than 50% effective at diverting downstream migrating Atlantic salmon away from the turbines. In non-spill conditions the de facto majority route of passage is through the Project's turbines. Even during conditions of spill, fish will still pass through the Project's turbines if they are operating.

III. A scientifically defensible estimate of immediate mortality for Atlantic salmon smolts passing through the Kaplan turbines at Hydro Kennebec is approximately 15%. Immediate mortality levels for kelts will be higher, with a reasonable working value of 25-50%. It is important to note that these values do not include mortality associated with downstream predation due to injury or disorientation or latent mortality as a result of passing through the turbines.

IV. Given the preceding conclusions, I conclude that the Hydro Kennebec Project is causing direct mortality to Atlantic salmon smolts and kelts by allowing them to pass through the Project turbines. Although indirect and latent mortality have not been adequately assessed at this Project, it is reasonable to assume that some small percentage of indirect and latent mortality is also occurring as a result of turbine passage.

4. Upstream fishway for adult passage

A. Evaluation – No volitional upstream fish passage structure is part of the Project's infrastructure. The owner/operator of the Hydro Kennebec Project, which is located approximately one mile upstream from the Lockwood Project, asserts that the Lockwood Project is a complete passage block for adult Atlantic salmon under all flow conditions and that there are no adult salmon that reach Hydro Kennebec. The Hydro Kennebec owner/operator therefore concludes that no upstream passage facilities for adult Atlantic salmon are needed (Hydro Kennebec, LLC. 2011. Note: this document is under a court protective order).

As described more fully in Section 7.1.2.1(4) above, a considered evaluation of the physical conditions at Lockwood does not support the conclusions reached by the Hydro Kennebec Project. First, at some yet to be quantified flow volume, adult Atlantic salmon can pass the Lockwood Project spillway section and move upstream to the Hydro Kennebec Project simply because there will be sufficient water depth and/or flow turbulence at specific locations that will facilitate fish passage. Second, upstream migrating salmon that are trapped at Lockwood could be placed back in the river immediately above Lockwood and allowed to continue their migration if there were an effective volitional upstream passage structure at Hydro Kennebec.

B. **Conclusions Regarding Impacts on Fish –** Given the information in the evaluation above, I have reached the following conclusions regarding the impacts of upstream fish passage facilities at the Hydro Kennebec Project:

I. No volitional upstream adult passage facilities exist at the Hydro Kennebec Project. As a result, adult salmon that swim upstream over the Lockwood Project at high flows are blocked from swimming further upstream when they reach Hydro Kennebec. Similarly, adult salmon trapped at the Lockwood Project cannot be placed back into the river immediately above Lockwood, but must instead be trucked further upriver. Impacts of the trucking program on Atlantic salmon are discussed in Section 5.3 above.

II. The Lockwood Project is not a total block to adult Atlantic salmon under all flow conditions. At some yet to be quantified high flow volume, adult salmon can pass the Lockwood spillway section and move upstream to the Hydro Kennebec Project.

III. As described in Section 7.1.2.1(4), the Lockwood Project blocks migration of adult Atlantic salmon, delays their migration, or creates conditions that allow passage only under flow conditions that are different from those that existed before the Project was constructed. It is biologically unjustified to conclude that upstream passage requirements for adult Atlantic salmon are met by conditions and operations at the Lockwood Project. If the Hydro Kennebec Project is relying on the Lockwood Project fish trapping operations to meet its adult salmon passage requirements, then I conclude that that assumption is not justified by the current operational scenario at the Lockwood Project. The Hydro Kennebec Project therefore harms adult Atlantic salmon by blocking or delaying their migration.

5. **Size and configuration of the headpond upstream of the dam**

   A. **Evaluation –** According to published reports, the Hydro Kennebec Project's headpond has a gross impoundment of ~ 3,900 acre-ft. (Hydro Kennebec, LLC. 2011). Although I am unable to verify this estimate, it appears reasonable, given the height of the spillway section. However, it is not stated whether this estimate is with or without the flashboards installed. If it is without flashboards, then the headpond area will be larger when the flashboards are installed. In the headpond area of the Hydro Kennebec Project, the habitat of the Kennebec River has been changed from a flowing river channel to a more slow-moving water habitat. The lake-like habitat is more likely to contain fish species that are predators on juvenile Atlantic salmon and may not contain the cover features for juvenile salmon that would normally be present in a natural river channel. Results from the 2008 smolt study at Hydro Kennebec clearly show predatory fish stationary in the vicinity of the entrance to the downstream fish bypass and turbines, and predatory fish were observed chasing smolts; however, no quantitative evaluation of predation was completed (Madison Paper Industries 2009). I am unaware of any data that has specifically quantified the habitat characteristics of this area or quantified any predation rates on Atlantic salmon smolts.

   B. **Conclusions Regarding Impacts on Fish –** I conclude that, given the documented presence and behavior of predatory fish in the vicinity of the entrance to the downstream bypass and turbines, and the characteristics typical of such impoundments, levels of predation of Atlantic salmon smolts in the headpond area of the Hydro Kennebec Project are higher than what they would be in a natural river channel. But given the lack of any site-specific, quantitative studies or data, it is impossible to reach a defensible quantitative assessment of the increased predation rate or the potential impacts on the Atlantic salmon population.

6. **Physical character of the river immediately downstream of the dam and tailrace areas as potential habitat for predators**

   A. **Evaluation –** The configuration of the river channel and the effects caused by passing over the spillway section make juvenile Atlantic salmon passing the Hydro Kennebec Project more vulnerable to predation, as discussed in Section 5.2. No site-specific studies have been conducted to assess this condition.

   Given the extensive bedrock ledges immediately downstream of the spillway section, I conclude there is some yet to be quantified level of disorientation or injury that causes increased vulnerability to predation for salmon passing the Project via spill.

In addition, under low flow conditions, all or a majority of the river flow is passing through the power canal, which means fish must pass through the bypass system or turbines. Given the fact that fish become disoriented by passing through the turbines, I conclude that predation rates in this specific area of the Project are higher than other areas.

B. Conclusions Regarding Impacts on Fish – Although there is an absence of site-specific quantitative data, I am able to conclude, based on my observations of the site and my professional experience that the Project configuration and operations create conditions that result in increased predation on juvenile Atlantic salmon. In my professional opinion, predation is occurring at some yet to be quantified level, which is most likely in the low single digits. Given the lack of site-specific quantitative data, the level of predation below the Hydro Kennebec Project and its impact on the species cannot be quantified at this time.

7. River flow regime during time periods critical for Atlantic salmon (April through June and October through November) in relation to the hydraulic capacity of the turbines

A. Evaluation – For a more detailed explanation of the data and procedure used to develop the figures below relating Kennebec River flow conditions and the potential for all of the river flow to pass through the Project's turbines, see Section 6.2 of this report. Results of this analysis are presented below:

Figures referenced in this section of this report are located in Section 7.1.2.1(7) of the Lockwood Project evaluation (Section 7.1). Data from Figure 7.1.1 for the Hydro Kennebec Project show that during the month of April there is a consistent probability of 5% that river flows will be $\leq$ Project hydraulic capacity. This probability increases to nearly 10% during the last 10 to 15 days of the month.

Data from Figure 7.1.2 for the Hydro Kennebec Project show that during the month of May there is a consistent probability of 10% that river flows will be $\leq$ Project hydraulic capacity. This probability increases to nearly 25% during the last 20 days of the month.

Data from Figure 7.1.3 for the Hydro Kennebec Project show that during the month of June there is a consistent probability of 25% that river flows will be $\leq$ Project hydraulic capacity. This probability increases to 50% during the last 20 days of the month.

Data from Figure 7.1.4 for the Hydro Kennebec Project show that during the month of October there is a consistent probability of at least 50% that river flows will be ≤ Project hydraulic capacity.

Data from Figure 7.1.5 for the Hydro Kennebec Project show that during the month of November there is a consistent probability of at least 50% that river flows will be ≤ Project hydraulic capacity for the first 21 days of the month. During the last week of the month, the probability that river flows will be ≤ Project hydraulic capacity decreases to about 25%.

B. Conclusions Regarding Impacts on Fish – The results of these analyses lead me to the following conclusions:

I. During the spring emigration period, the probabilities of river flow being ≤ the Hydro Kennebec Project's hydraulic capacity range from about 10 to 50%. During the most likely time when the majority of smolts would migrate, the probabilities range from 10 to 25%. This level of interaction with Project turbines is, in my opinion, unacceptable in terms of population survival and recovery, given the level of immediate turbine mortality at Hydro Kennebec Project, the ineffectiveness of the fish bypass structure, and the current status of the Atlantic salmon population in the Kennebec River.

II. During the fall kelt emigration period, the analysis shows probabilities of > 50% for all of October and > 50% for most of November. This level of potential interaction with Project turbines is, in my opinion, unacceptable in terms of population survival and recovery, given the level of immediate turbine mortality at Hydro Kennebec Project, the ineffectiveness of the fish bypass structure, and the current status of the Atlantic salmon population in the Kennebec River.

III. This analysis clearly demonstrates that the use of median monthly flow values to assess potential project impacts is not appropriate or defensible. As this analysis shows, the use of median monthly flows greatly underestimates the amount of time that river flows can be ≤ Project hydraulic capacity and thus underestimates the percentage of time that the only downstream passage route available for Atlantic salmon is through the Project turbines and the inadequate downstream bypass system. And yet it is my understanding, based on my review of the draft biological assessment commissioned by Brookfield, that this Defendant plans to use median flow data to assess the Project's impacts on Atlantic salmon for purposes of obtaining an Incidental Take Statement.

IV. Given the current population levels, the age structure of adults captured at the Lockwood fish trapping facility, the decades it would take to rebuild even one year's loss of smolts due to Hydro Kennebec Project operations, and the cumulative effects of the four projects on the Kennebec River between Waterville and the Sandy River, I believe the impacts associated with low river flows result in critical levels of injury and mortality to Atlantic salmon on a reasonably predictable and routine basis.

7.2.3 Impacts on Atlantic salmon in the Merrymeeting Bay SHRU and, consequently, the GOM DPS as a whole

In order to evaluate impacts of dam operations on the Merrymeeting Bay SHRU and the GOM DPS as a whole, I used five parameters related to the Hydro Kennebec Project, and these same parameters and conclusions are equally applicable to the Lockwood, Shawmut, and Weston projects as well.

1) **Percentage of the total habitat in comparison to the GOM DPS –** According to the NMFS (2009b), the Merrymeeting Bay SHRU comprises approximately 46% of the land area in the GOM DPS, with the Kennebec River watershed contributing 56% of the total for the Merrymeeting Bay SHRU. Therefore, the Kennebec River watershed has the potential to be the dominant contributor to recovery in the SHRU and the GOM DPS overall because of its land area and the quality of habitats suitable for Atlantic salmon upstream of the Weston Project.

2) **Population diversity and stability –** The Kennebec River watershed is the second largest in Maine that is part of the GOM DPS and contains extensive areas designated as critical habitat. Historically, the Androscoggin, Kennebec, and Penobscot watersheds were the largest producers of Atlantic salmon in Maine, and probably the East Coast. These large watersheds provided a variety of habitats that have resulted in genetic diversity among watersheds and overall population stability because of the variety of habitats and life history strategies necessary for salmon to persist in them (National Research Council 2002, 2004; Fay et al. 2006; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2009).

3) **Location of habitats suitable to promote recovery of the species –** The overwhelming majority of habitats suitable to support Atlantic salmon spawning and juvenile rearing in the Kennebec River watershed are located upstream of the Weston Project. While the MDMR (2010) identified some habitat suitable for

Atlantic salmon downstream of the Lockwood Project, a functional equivalent habitat analysis by NMFS found that all habitats downstream of the Lockwood Project received a zero rating for Atlantic salmon spawning and rearing. What this functional equivalent rating means is that the quantity and quality of downstream habitats are insufficient to adequately support the habitat and population recovery criteria for the SHRU (National Marine Fisheries Service (2009b). The NMFS analysis found that all of the habitat suitable for meeting the PCE requirements for spawning and rearing, and thus recovery, were upstream of the Weston Project.

4) **Blockage and/or delay to upstream migrating adult Atlantic salmon –** Hydro Kennebec has no provision for upstream fish passage; it relies on the operation of the trapping facility at Lockwood to achieve upstream passage. As demonstrated in various analyses described earlier in this report (see Section 7.1.2.1(4), the Lockwood Project blocks migration of adult Atlantic salmon, delays their migration, or creates conditions that allow passage only under flow conditions that are different than those that existed before the Project was constructed. Any adults that are captured are trucked far upstream, which subjects them to the adverse impacts of trucking described in Section 5.3 and requires kelts to pass four hydroelectric dams in order to return to the sea after spawning.

5) **Mortality rate of Atlantic salmon smolts and kelts passing downstream through Hydro Kennebec Project turbines –** Smolts and kelts moving downstream through the Hydro Kennebec Project are subject to mortality associated with passage through the Project's turbines. During periods of non-spill at downstream migration time periods (see analyses of these time periods above), all fish are forced to pass via the Project's power canal, which contains an ineffective guidance boom and fish bypass structure along with the Project turbines. Studies conducted on the effectiveness of the bypass system have shown that less than 50% of smolts entering the power canal are diverted from the turbines (Madison Paper Industries 2009, Hydro Kennebec, LLC. 2011). Immediate mortality of smolts passing through the turbines is about 15%, while the immediate mortality of kelts is about twice that rate (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008b, 2008d). Delayed turbine mortality and additional adverse impacts on salmon going over the spillway or thru the bypass structure, are likely but have not been quantified.

Given the impacts of these five factors on individual Atlantic salmon, the effects of the Hydro Kennebec Project combined with the Lockwood Project's inability to consistently provide adult upstream passage or to achieve the spawning and rearing and migration PCE's, and the overall negative impact on the likelihood that the recovery criteria for the

Merrymeeting Bay SHRU will be met, I conclude that the Hydro Kennebec Project, as it is currently structurally configured and operated, is having a significant adverse impact on the Merrymeeting Bay SHRU and the GOM DPS as a whole.

7.2.4 Interim Measures

Any or all of the following measures would either reduce the harm to Atlantic salmon currently being caused by the dams in question or contribute to efforts at restoration of the species.

7.2.4.1 Interim Measures Applicable to All Projects on the Kennebec and Androscoggin rivers

A complete list of the interim measures applicable to all projects can be found in Section 7.1.4.1 of the Lockwood Project evaluation.

7.2.4.2 Additional Interim Measures Specifically for the Hydro Kennebec Project

A. Install a downstream electrical guidance system to more effectively guide downstream migrating salmon and shad towards the project fish bypass. This system could be operated independently or in conjunction with the current boom system to increase the effectiveness of the boom system. Documented evidence of predators adjacent to the existing downstream bypass entrance indicates a predation problem. Correct installation and operation of an electrical guidance system could also disperse these predators.
B. Provide a downstream passage route on the west side of the spillway during the downstream migration period of April through June. Consider closing the existing downstream bypass system and replacing it with a minimum one-foot-deep notch in the flashboards west of the project's gates.
C. Increase the water surface elevation in the downstream plunge pool of the existing fish bypass. Increase the water height by increasing the height of the weir between the concrete wall and the bedrock outcrop downstream of the pool. Step the flow down from the plunge pool to the project turbine tailrace.

7.3 Shawmut Project (NextEra)

7.3.1 Brief Project Description

The Project includes two powerhouses. The first powerhouse contains six horizontal Francis units (Units 1-6). The second powerhouse contains two horizontal fixed propeller units (Units 7 and 8). Propeller turbines are a type of Kaplan turbine. Total unit flow is approximately 6,700 cfs. Trash racks are located in front of the intake sections to limit debris from passing through the turbines. Trash rack “clear” spacing is 1.5 inches for Units 1-6 and 3.5 inches for Units 7 and 8. The spillway section of the dam is approximately 1,135 ft. long with an average height of about 24 ft., and consists of a hinged flashboard section, a 25 ft wide by 8 ft deep log sluice equipped with a timber and steel gate, and a four-foot high plywood flashboard section. The Project includes a 1,310-acre impoundment upstream of the spillway section. The Project has one surface sluice gate located in the forebay between the two powerhouses. The sluice gate is a manually adjustable gate containing three stop logs. The gate is 4 feet wide by 22 inches deep. With all stop logs removed; this gate passes flows in the range of 30 to 35 cfs. Flows from this sluice discharge over the downstream slope of the dam and drain into a pool connected to the river. The vertical distance from the gate discharge to the pool is approximately 20 feet. The project's tailrace channels are excavated riverbed located downstream of the powerhouses. The project boundary extends upstream about 12 miles (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC, 2008e; Normandeau Associates, Inc., 2011f Note: this document is under a court protective order).

7.3.2 Impact of Shawmut Project on Atlantic Salmon

7.3.2.1 Impact on Individual Fish

I have analyzed seven factors related to the physical structure of the dam and adjacent river channel and operational parameters and characteristics in evaluating impacts of the project on Atlantic salmon. Below is my evaluation of these seven factors:

1. **Physical Structure of the Dam**

    A. **Evaluation –** The physical configuration and 24-foot height of the dam create a barrier to upstream migrating Atlantic salmon. Adult Atlantic salmon cannot pass this Project under normal flow conditions. It is unknown if extremely high flow events would allow upstream migrating salmon to reach this facility given the height of the Hydro Kennebec Project downstream.

       Atlantic salmon smolts migrating downstream to the ocean tend to move under low light or dark conditions. Given the location of the two powerhouses along the west bank of the river, it is likely that fish moving along the west bank of the river would move directly into the power canal towards the Project turbines. While the published flow capacity of the turbines at the Shawmut Project is 6,700 cfs, National Marine Fisheries Service staff commented that downstream juvenile passage via spill would probably not occur if depth of flow over the spillway/flashboards was <6 inches (Normandeau Associates, Inc.,2011b). Assuming this statement is correct, that would in effect direct juvenile fish towards the power canal at flows < ~7,000 cfs, increasing the probability of fish interacting with the downstream fish bypass system or the turbines.

    B. **Conclusions Regarding Impacts on Fish –** Given the physical configuration of the spillway, its height, and the location of the power canal along the west bank of the river, I believe that the Shawmut Project is causing the following impacts to Atlantic salmon:

I. Adult Atlantic salmon are blocked from moving upstream towards spawning habitat areas that contain the characteristics outlined in the subcomponents of the PCE's detailed in Section 4 of this report.

II. The physical shape of the Project makes it likely that Atlantic salmon smolts and kelts migrating downstream to the ocean will enter the power canal and, interact with one of the Project's turbines or with the downstream fish bypass facilities, especially when river flows are near or below the Project's turbine flow capacity. Interaction with the Project's turbines and/or downstream bypass systems causes mortality and injury.

2. Downstream Fish Bypass System

A. Evaluation – The Project currently has several locations that may serve as a downstream fish bypass system. There are inflatable dam spillway sections, the log/debris sluice, and a bypass sluice located between the two powerhouses that can pass a maximum of 30-35 cfs. However, no studies have been conducted to evaluate any of the potential downstream passage routes as to their effectiveness in attracting Atlantic salmon smolts or kelts emigrating to the ocean, or the mortality associated with any of the particular routes of passage.

B. Conclusions Regarding Impacts on Fish – I conclude that the Shawmut Project is causing the following impacts to Atlantic salmon:

I. In the absence of any contrary empirical data, and given the height of the dam and the configuration of the face of the spillway section, I believe that there is some mortality associated with the fish passing over the spillway section.

II. Under lower flow (non-spill) conditions, Atlantic salmon, both smolts and kelts, are forced to pass the Project via the fish bypass system or Project turbines. Given that the flow of water passing through the bypass system is only a maximum of about 35 cfs, in comparison to 6,700 cfs passing through the Project turbines, I conclude that the majority of smolts or kelts must be passing through the Project turbines, with the resultant mortality rate associated with each type of turbine installed. In my opinion, the design of the current downstream bypass system is ineffective and the system is inadequate under lower flow conditions to provide the level of protection to Atlantic salmon needed to prevent unacceptable (in terms of population recovery) levels of direct and/or indirect mortality.

3. Types of turbines used to generate power

A. Evaluation – For an overview of turbine mortality rates see Section 6.1 of this report. The Project currently contains six horizontal Francis turbines (Units 1-6) and two fixed propeller turbines (Units 7 & 8). The Francis turbines at this Project have 10-13 blades, a smaller space between blades than the propeller turbines, and spin at about 200 rotations per minute (rpm). The fixed propeller turbines have three blades, more space between blades, and spin at about 900 rpm (Normandeau Associates, Inc. 2011h).

In a 2011 draft white paper presented to the resource agencies, the NextEra Defendants reject the results of their own passage studies, saying they are inadequate to establish passage mortality at Shawmut. While I agree that site-specific empirical studies have not been conducted at the Shawmut Project to assess a variety of passage mortality factors (predation in the headpond area as a result of changing the type of habitat upstream of the dam; spill-related mortality; mortality associated with fish using the downstream bypass system; delayed or latent mortality associated with fish passing through the turbines and not immediately killed; and mortality due to predation at locations immediately downstream of the Project infrastructure due to fish being injured or disoriented during passage through the Project), I reject these Defendants' conclusion that *no* site-specific (or at least Kennebec River-specific) information is available regarding mortality associated with Atlantic salmon smolts and kelts passing through Francis and Kaplan type turbines. For a more detailed evaluation of the studies on the Kennebec River at the Lockwood and Hydro Kennebec projects, please see the companion evaluation for the Lockwood Project (Section 7.1).

B. Conclusions Regarding Impacts on Fish – Given the information in the references cited above and in Sections 6.1 and 7.1, and the study results completed on a nearby project with similar turbine types, I have the following conclusions with respect to the impacts of turbine passage on Atlantic salmon:

I. During critical downstream migration periods for Atlantic salmon smolts and/or kelts (April through June and October through November), when the river flows are low enough that essentially the entire flow of the river passes through the Project's turbines and bypass system. Please see the flows analysis below.

II. I conclude that in non-spill conditions the de facto majority route of passage is through the Project's turbines. Even during conditions of spill, fish will still pass through the Project's turbines if they are operating.

III. A scientifically defensible estimate of immediate Atlantic salmon smolt mortality passing through the Francis turbines (Units 1-6) and the fixed propeller turbines (Units 7 & 8) at Shawmut is approximately 15%. Mortality levels for kelts will be higher, with a reasonable working value of 25-50%. It is important to note that these values do not include mortality associated with downstream predation due to injury or disorientation or latent mortality as a result of passing through the turbines.

IV. Given the preceding conclusions, I conclude that the Shawmut Project is causing direct mortality to Atlantic salmon smolts and kelts by allowing fish to pass through the Project turbines. Although indirect and latent mortality have not been adequately assessed at this Project, it is reasonable to assume that some small percentage of indirect and latent mortality is also occurring as a result of turbine passage.

4. Upstream fishway for adult passage

A. Evaluation – No volitional upstream fish passage structure is part of the Project's infrastructure. Since the installation of the Lockwood Project's fish trapping facility in 2006, the owners/operators of the Shawmut Project have explicitly stated that their fish passage requirement for adult Atlantic salmon is being met by the "trap and truck" program at the Lockwood Project (FPL Energy Maine Hydro, LLC. 2007, 2008a; NextEra™ Energy Maine Operating Services, LLC. 2009, 2010, 2011). For the reasons described in Sections 5.3 and 7.1.2.1(4) above, any reliance on the Lockwood fish trapping facility and the subsequent trucking program to provide adequate upstream passage for Atlantic salmon is misplaced.

B. Conclusions Regarding Impacts on Fish – Given the information in the evaluation above, I have reached the following conclusions regarding the impacts of upstream fish passage facilities at the Shawmut Project:

I. No volitional upstream adult passage facilities exist at the Shawmut Project. As a result, adult salmon trapped at the Lockwood Project must be trucked further upriver. Impacts of the trucking program on Atlantic salmon are discussed in Section 5.3 above.

II. As described in Section 7.1.2.1(4), the Lockwood Project blocks migration of adult Atlantic salmon, delays their migration, or creates conditions that allow passage only under flow conditions that are different than those that existed before the Project was constructed. It is biologically unjustified to conclude that upstream passage requirements for adult Atlantic salmon are met by conditions and operations at the Lockwood Project. Therefore, I conclude that the claim of the Shawmut Project owners/operators that the Lockwood trap and truck program "provides" their requirement to provide upstream adult passage for Atlantic salmon is simply not justified by the facts. The Shawmut Project therefore harms adult Atlantic salmon by blocking or delaying their migration.

5. **Size and configuration of the headpond upstream of the dam**

   A. **Evaluation –** The Shawmut Project includes a 1,310-acre impoundment upstream of the spillway section. The creation of this impoundment has changed the habitat of the Kennebec River from a flowing river channel to a more slow-moving water habitat. The lake-like habitat is more likely to contain fish species that are predators on juvenile Atlantic salmon and may not contain the cover features for juvenile salmon that would normally be present in a natural river channel. I am unaware of any data that have specifically quantified the habitat characteristics of this area or quantified any predation rates on Atlantic salmon smolts.

   B. **Conclusions Regarding Impacts on Fish –** I conclude that it is likely that levels of predation of Atlantic salmon smolts in the headpond area of the Shawmut Project are higher than what they would be in a natural river channel. But given the lack of any site-specific, quantitative studies or data, it is impossible to reach a defensible quantitative assessment of the increased predation rate or the potential impacts on the Atlantic salmon population.

6. **Physical character of the river immediately downstream of the dam and tailrace areas as potential habitat for predators**

   A. **Evaluation –** The configuration of the river channel and the effects caused by passing over the spillway section may make juvenile Atlantic salmon passing the Shawmut Project more vulnerable to predation, as discussed in Section 5.2. No site-specific studies have been conducted to assess this condition. However, given the height of the dam and the shape of the spillway section on the downstream face, I conclude there is some yet to be quantified level of disorientation or injury that causes increased vulnerability to predation. In addition, under low flow conditions, the majority of the river flow is passing through the power canal, which means fish are passing through the bypass system or turbines. In this situation, the flows are concentrated in two locations which allow predators to focus on specific locations. Predator concentration is highly likely in the excavated channel that serves as the tailrace for turbine Units 7 & 8.

This channel is highly confined and provides excellent predator habitat. Given the probability of fish being disoriented by passing through the turbines, I conclude that predation rates in these specific areas of the Project are higher than other areas. However, no studies have specifically quantified the predation rate in this area.

B. **Conclusions Regarding Impacts on Fish –** Although there is an absence of site-specific quantitative data, I am able to conclude, based on my observations of the site, the scientific literature, and my professional experience, that the project configuration and operations create conditions that result in increased predation on juvenile Atlantic salmon. In my professional opinion, predation is occurring at some yet to be quantified level, which is most likely in the low single digits. Given the absence of sire-specific quantitative data, the level of predation below the Shawmut Project and its impact on listed species cannot be quantified at this time.

7. **River flow regime during time periods critical for Atlantic salmon (April through June and October through November) in relation to the hydraulic capacity of the turbines**

A. **Evaluation –** For a more detailed explanation of the data and procedure used to develop the figures below relating Kennebec River flow conditions and the potential for all of the river flow to pass through the Project's turbines, see Section 6.2 of this report. I used a project hydraulic capacity of 6,700 cfs in evaluating the Shawmut Project. Results of this analysis are presented below:

Figures referenced in this section of this report are located in Section 7.1.2.1(7) of the Lockwood Project evaluation (Section 7.1).

Data from Figure 7.1.1 for the Shawmut Project show that during the month of April there is a consistent probability of 5% that river flows will be ≤ Project hydraulic capacity. This probability increases to approximately10% during the last few days of the month.

Data from Figure 7.1.2 for the Shawmut Project show that during the month of May there is a consistent probability of 10% that river flows will be ≤ Project hydraulic capacity. This probability increases to nearly 25% during the last 15 days of the month.

Data from Figure 7.1.3 for the Shawmut Project show that during the month of June there is a consistent probability of 25% that river flows will be ≤ Project hydraulic capacity. This probability increases to 50% during the last 20 days of the month.

Data from Figure 7.1.4 for the Shawmut Project show that during the month of October there is a consistent probability of at least 50% that river flows will be ≤ Project hydraulic capacity.

Data from Figure 7.1.5 for the Shawmut Project show that during the month of November there is a consistent probability of at least 25% that river flows will be ≤ Project hydraulic capacity.

B. Conclusions Regarding Impacts on Fish – The results of this analysis lead me to the following conclusions:

I. During the spring emigration period, the probabilities of river flow being ≤ the Shawmut Project's hydraulic capacity range from 5 to 50%. During the most likely time when the majority of smolts would migrate, the probabilities range from 10-25%. This level of interaction with Project turbines is, in my opinion, unacceptable in terms of population survival and recovery, given the level of immediate turbine mortality at Shawmut Project, the ineffectiveness of the fish bypass structure, and the current status of the Atlantic salmon population in the Kennebec River.

II. During the fall kelt emigration period, the analysis shows probabilities of > 50% for all of October and > 25% for all of November. This level of interaction with Project turbines is, in my opinion, unacceptable in terms of population survival and recovery, given the level of immediate turbine mortality at Shawmut Project, the ineffectiveness of the fish bypass structure, and the current status of the Atlantic salmon population in the Kennebec River.

III. This analysis clearly demonstrates that the use of median monthly flow values to assess potential project impacts is not appropriate or defensible. As this analysis shows, the use of median monthly flows greatly underestimates the amount of time that river flows can be ≤ to Project hydraulic capacity and thus underestimates the percentage of time that the only downstream passage route available for Atlantic salmon is through the Project turbines and the inadequate downstream bypass system. And yet it is my understanding, based on my review of draft white papers commissioned by the NextEra Defendants, that these Defendants plan to use median flow data to assess each Project's impacts on Atlantic salmon for purposes of obtaining Incidental Take Permits.

IV. Given the current population levels, the age structure of adults captured at the Lockwood fish trapping facility, the decades it would take to rebuild even one year's loss of smolts due to Shawmut Project operations, and the cumulative effects of the four projects on the Kennebec River between Waterville and the Sandy River, I believe the impacts associated with low river flows result in critical levels of mortality to Atlantic salmon on a reasonably predictable and routine basis.

7.3.3 Impacts on Atlantic salmon in the Merrymeeting Bay SHRU and, consequently, the GOM DPS as a whole

In order to evaluate impacts of dam operations on the Merrymeeting Bay SHRU and the GOM DPS as a whole, I used five parameters related to the Shawmut Project, and these same parameters and conclusions are equally applicable to the Lockwood, Hydro Kennebec, and Weston projects as well.

1) **Percentage of the total habitat in comparison to the GOM DPS –** According to the NMFS (2009b), the Merrymeeting Bay SHRU comprises approximately 46% of the land area in the GOM DPS, with the Kennebec River watershed contributing 56% of the total for the Merrymeeting Bay SHRU. Therefore, the Kennebec River watershed has the potential to be the dominant contributor to recovery in the SHRU and the GOM DPS overall because of its land area and the quality of habitats suitable for Atlantic salmon upstream of the Weston Project.

2) **Population diversity and stability –** The Kennebec River watershed is the second largest in Maine that is part of the GOM DPS and contains extensive areas designated as critical habitat. Historically, the Androscoggin, Kennebec, and Penobscot watersheds were the largest producers of Atlantic salmon in Maine, and probably the East Coast. These large watersheds provided a variety of habitats that have resulted in genetic diversity among watersheds and overall population stability because of the variety of habitats and life history strategies necessary for salmon to persist in them (National Research Council 2002, 2004; Fay et al. 2006; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2009).

3) **Location of habitats suitable to promote recovery of the species –** The overwhelming majority of habitats suitable to support Atlantic salmon spawning and juvenile rearing in the Kennebec River watershed are located upstream of the Weston Project. While the MDMR (2010) identified some habitat suitable for Atlantic salmon downstream of the Lockwood Project, a functional equivalent habitat analysis by NMFS found that all habitats downstream of the Lockwood

Project received a zero rating for Atlantic salmon spawning and rearing. What this functional equivalent rating means is that the quantity and quality of downstream habitats are insufficient to adequately support the habitat and population recovery criteria for the SHRU (National Marine Fisheries Service (2009b). The NMFS analysis found that all of the habitat suitable to support the PCE requirements for spawning and rearing, and thus recovery, were upstream of the Weston Project.

4) **Blockage and/or delay to upstream migrating adult Atlantic salmon –** Shawmut has no provision at all for upstream fish passage; it relies on the operation of the trapping facility at Lockwood to achieve upstream passage. As demonstrated in various analyses described earlier in this report, the Lockwood Project blocks migration of adult Atlantic salmon, delays their migration, or creates conditions that allow passage only under flow conditions that are different than those that existed before the Project was constructed. Any adults that are captured are trucked far upstream, which subjects them to the adverse impacts of trucking described in Section 5.3 and requires kelts to pass four hydroelectric dams in order to return to the sea after spawning.

5) **Mortality rate of Atlantic salmon smolts and kelts passing downstream through Lockwood Project turbines –** Smolts and kelts moving downstream through the Shawmut Project are subject to mortality associated with passage through the Project's turbines. During periods of non-spill at downstream migration time periods (see analyses of these time periods above), fish are forced to pass via the Project's power canal, which contains an ineffective fish bypass sluice and the Project turbines. Immediate mortality of smolts passing through the turbines is about 15%, while immediate mortality of kelts is about twice that rate (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008b, 2008d). Delayed turbine mortality and additional adverse impacts on salmon going over the spillway or thru the bypass structures, are likely but have not been quantified.

Given the impacts of these five factors on individual Atlantic salmon, the effects of the Shawmut Project combined with the Lockwood Project's inability to consistently provide adult upstream passage or to achieve the spawning and rearing and migration PCE's, and the overall negative impact on the likelihood that the recovery criteria for the Merrymeeting Bay SHRU will be met, I conclude that the Shawmut Project, as it is currently structurally configured and operated, is having a significant adverse impact on the Merrymeeting Bay SHRU and the GOM DPS as a whole.

7.3.4 Interim Measures

Any or all of the following measures would either reduce the harm to Atlantic salmon currently being caused by the dams in question or contribute to efforts at restoration of the species.

7.3.4.1 Interim Measures Applicable to All Projects on the Kennebec and Androscoggin rivers

A complete list of the interim measures applicable to all projects can be found in Section 7.1.4.1 of the Lockwood Project evaluation.

7.3.4.2 Additional Interim Measures Specifically for the Shawmut Project

A. Provide a downstream passage route on the west side of the spillway during the downstream migration period of April through June. This location should be east of the powerhouse and upstream and east of the entrance to the power canal and turbine forebays.
B. Increase the flow through the existing downstream bypass between the powerhouses and provide a more effective downstream plunge pool area in terms of size and configuration to prevent injury and predation.
C. Install a new fish guidance system, either electrical or a boom/electrical combination, to guide fish away from the west powerhouse turbine intakes.

7.4 Weston Project (NextEra)

7.4.1 Brief Project Description

The Weston Project includes a 930-acre impoundment, two dams, and one powerhouse. The Project impoundment extends 12.5 miles upstream. The two dams are constructed on the north and south channels of the Kennebec River where the river is divided by Weston Island.
The North Channel dam is a concrete gravity and buttress dam approximately 38 feet high and extends about 529 ft. from the north bank of the Kennebec River to Weston Island. The South Channel dam consists of the powerhouse, a log sluice and a stanchion gate section. A floating boom and metal plate curtain extending down about 10 ft. was installed in the South Channel and extends from the stream bank out to the edge of the log sluice. This structure is intended to act as a "fish guidance boom" to encourage fish to move away from the flow net associated with the turbines and use the sluice as a bypass. No evaluation of its effectiveness has been published to date. The log

sluice is located near the Unit 4 intake. It is 18-feet-wide by 14-feet-high with a resultant flow discharge into a deep plunge pool. Maximum flow through the gate at full pond is 2,250 cfs.

The powerhouse contains four vertical Francis units with a total unit flow of approximately 6,000 cfs. Trash racks are located in front of the intake sections to limit debris from passing through the turbines. Trash rack "clear" spacing is 4 inches for Units 1–4 (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC, 2008g; Normandeau Associates, Inc., 2011g Note: this document is under a court protective order).

7.4.2 Impact of Weston Project on Atlantic Salmon

7.4.2.1 Impact on Individual Fish

I have analyzed seven factors related to the physical structure of the dam and adjacent river channel and operational parameters and characteristics in evaluating impacts of the Project on Atlantic salmon. Below is my evaluation of these seven factors:

1. **Physical Structure of the Dam**

    A. **Evaluation –** The physical configuration and height of the dam create a barrier to upstream migrating Atlantic salmon. At a height of 38 ft., adult Atlantic salmon cannot pass this Project under normal flow conditions. It is unknown if extremely high flow events would allow salmon to reach this facility given the heights of the Hydro Kennebec and Shawmut projects downstream.

       Atlantic salmon smolts migrating downstream to the ocean tend to move under low light or dark conditions. Given the location of the powerhouse along the north bank of the South Channel, it is likely that fish moving along the north bank of the river would follow the north and east shoreline of Weston Island towards the Project turbines. Under non-spill conditions, the majority of the river flow is towards the South Channel where the powerhouse is located. While the published flow capacity of the turbines at the Weston Project is 6,000 cfs, National Marine Fisheries Service staff commented that downstream juvenile passage via spill would probably not occur if depth of flow over the spillway/flashboards was <6 inches (Normandeau Associates, Inc. 2011b). Assuming this statement is correct, that would in effect direct juvenile fish towards the power canal at flows < ~6,200 cfs, increasing the probability of fish interacting with the downstream fish bypass system or the turbines.

    B. **Conclusions Regarding Impacts on Fish –** Given the physical configuration of the spillway, its height, and the location of the powerhouse, I believe that the Shawmut Project is causing the following impacts to Atlantic salmon:

I. Adult Atlantic salmon are blocked from moving upstream towards spawning habitat areas that contain the characteristics outlined in the subcomponents of the PCE's detailed in Section 4 of this report;

II. The physical shape of the Project makes it likely that Atlantic salmon smolts and kelts emigrating to the ocean will enter the power canal and interact with one of the Project's turbines or the downstream fish bypass facility, especially when river flows are near or below the Project's turbine flow capacity. Interaction with the Project's turbines and/or downstream bypass system causes mortality and injury.

2. Downstream Fish Bypass System

A. Evaluation – The Project currently uses only the log sluice on the South Channel dam as a downstream fish bypass system; there is no fish bypass system at the North Channel dam. The sluice is operated between April 1 and June 15 with a bypass flow of 120 cfs (Normandeau Associates, Inc., 2011g . Note: this document is under a court protective order). However, no studies have been conducted to evaluate any of the potential downstream passage routes as to their effectiveness in attracting Atlantic salmon smolts or kelts emigrating to the ocean, or the mortality associated with any of the particular routes of passage.

B. Conclusions Regarding Impacts on Fish – I conclude that the Weston Project is causing the following impacts to Atlantic salmon:

I. Given the height of the dam and the configuration of the face of the spillway section, it is unlikely that mortality rates associated with passing over the spillway sections are zero.

II. Under lower flow (non-spill) conditions, Atlantic salmon, both smolts and kelts, are forced to pass the Project via the fish bypass system (the log sluice) or Project turbines. Given that the bypass system routinely passes only a maximum of about 120 cfs, in comparison to 6,000 cfs passing through the Project turbines, I conclude that the majority of smolts or kelts pass through the Project turbines, with the resultant mortality rate associated with each turbine installed. Although no formal evaluation of the fish guidance boom has been conducted at the Project, evaluations of very similar systems at the Hydro Kennebec and Lockwood projects have demonstrated that guidance effectiveness ranges from < 50% at Hydro Kennebec to about 18% at Lockwood (Hydro Kennebec, LLC. 2011, Normandeau Associates, Inc. 2011e. Note: both of these documents are under a court protective order). In my opinion, the current downstream bypass system – which, like the guidance booms at Hydro Kennebec and Lockwood, extends only 10 feet below the surface while depths in the pool are as much as 20 feet, according to Project personnel – is ineffective in design and inadequate under lower flow conditions to provide the level of protection to Atlantic salmon needed to prevent unacceptable (in terms of population recovery) levels of direct and/or indirect mortality.

3. Types of turbines used to generate power

A. Evaluation – For an overview of turbine mortality rates see Section 6.1 of this report. The Project currently contains four vertical Francis turbines (Units 1-4). The Francis turbines at this Project have 13-16 blades, less distance between blades than do Kaplan turbines, and spin at about 200 rotations per minute (rpm) (Normandeau Associates, Inc. 2011h). Change in barometric pressure is not a significant factor at the Project because the operation has a low hydraulic head. The primary direct cause of fish death or injury for fish passing through turbines at Weston is blade strike.

In a 2011 draft white paper presented to the resource agencies, the NextEra Defendants reject the results of their own passage studies, saying they are inadequate to establish passage mortality at Weston. (Normandeau Associates, Inc. 2011g. Note: this document is under a court protective order). While I agree that site-specific empirical studies have not been conducted at the Weston Project to assess a variety of passage mortality factors (predation in the headpond area as a result of changing the type of habitat upstream of the dam; spill-related mortality; mortality associated with fish using the downstream bypass system; delayed or latent mortality associated with fish passing through the turbines and not immediately killed; and mortality due to predation at locations immediately downstream of the Project infrastructure due to fish being injured or disoriented during passage through the Project), I reject these Defendants' conclusion that *no* site-specific (or at least Kennebec River-specific) information is available regarding mortality associated with Atlantic salmon smolts and kelts passing through Francis and Kaplan type turbines. For a more detailed evaluation of the studies on the Kennebec River at the Lockwood and Hydro Kennebec projects, please see the companion evaluation for the Lockwood Project (Section 7.1).

B. Conclusions Regarding Impacts on Fish – Given the information in the references cited above in Sections 6.1 and 7.1, and the study results completed on a nearby project with similar turbine types, I have the following conclusions with respect to the impacts of turbine passage on Atlantic salmon:

I. There is a significant frequency, during critical downstream migration periods for Atlantic salmon smolts and/or kelts (April through June and October through November), when the river flows are low enough that essentially the entire flow of the river passes through the Project's turbines and bypass system. Please see the flows analysis below.

II. I conclude that in non-spill conditions the de facto majority route of fish passage is through the Project's turbines. Even during conditions of spill, fish will still pass through the Project's turbines if they are operating.

III. A scientifically defensible estimate of immediate mortality for Atlantic salmon smolts passing through the Francis turbines (Units 1 – 4) at Weston is approximately 15%. Immediate mortality levels for kelts will be higher, with a reasonable working value of 25-50%. It is important to note that these values do not include mortality associated with downstream predation due to injury or disorientation or latent mortality as a result of passing through the turbines.

IV. Given the preceding conclusions, I conclude that the Weston Project is causing direct mortality to Atlantic salmon smolts and kelts by allowing them to pass through the Project turbines. Although indirect and latent mortality have not been adequately assessed at this Project, it is reasonable to assume that some small percentage of indirect and latent mortality is also occurring as a result of turbine passage.

4. Upstream fishway for adult passage

A. Evaluation – No volitional upstream fish passage structure is part of the Project's infrastructure. Since the installation of the Lockwood Project's fish trapping facility in 2006, the owners/operators of the Weston Project have explicitly stated that their fish passage requirement for adult Atlantic salmon is being met by the "trap and truck" program at the Lockwood Project (FPL Energy Maine Hydro, LLC. 2007, 2008a; NextEra™ Energy Maine Operating Services, LLC. 2009, 2010, 2011). For the reasons described in Sections 5.3 and 7.1.2.1(4) above, any reliance on the Lockwood fish trapping facility and the subsequent trucking program to provide adequate upstream passage for Atlantic salmon is misplaced.

B. Conclusions Regarding Impacts on Fish – Given the information in the evaluation above, I have reached the following conclusions regarding the impacts of upstream fish passage facilities at the Weston Project:

I. No volitional upstream adult passage facilities exist at the Weston Project. As a result, adult salmon trapped at the Lockwood Project must be trucked further upriver. Impacts of the trucking program on Atlantic salmon are discussed in Section 5.3 above.

II. As described in Section 7.1.2.1 (4), the Lockwood Project blocks migration of adult Atlantic salmon, delays their migration, or creates conditions that allow passage only under flow conditions that are different than those that existed before the Project was constructed. It is biologically unjustified to conclude that upstream passage requirements for adult Atlantic salmon are met by conditions and operations at the Lockwood Project. Therefore, I conclude that the claim of the Weston Project owners/operators that the Lockwood trap and truck program "provides" their requirement to provide upstream adult passage for Atlantic salmon is simply not justified by the facts. The Weston Project therefore harms adult Atlantic salmon by blocking or delaying their migration.

5. Size and configuration of the headpond upstream of the dam

A. Evaluation – The Weston Project includes a 930-acre impoundment extending 12.5 miles upstream. The creation of this impoundment has changed the habitat of the Kennebec River from a flowing river channel to a more slow-moving water habitat. The lake-like habitat is more likely to contain fish species that are predators on juvenile Atlantic salmon and may not contain the cover features for juvenile salmon that would normally be present in a natural river channel. I am unaware of any data that has specifically quantified the habitat characteristics of this area or quantified any predation rates on Atlantic salmon smolts.

B. Conclusions Regarding Impacts on Fish – I conclude that it is likely that levels of predation of Atlantic salmon smolts in the headpond area of the Weston Project are higher than what they would be in a natural river channel. But given the lack of any site-specific, quantitative studies or data, it is impossible to reach a defensible quantitative assessment of the increased predation rate or the potential impacts on the Atlantic salmon population.

6. Physical character of the river immediately downstream of the dam and tailrace areas as potential habitat for predators

A. Evaluation – The configuration of the river channel and the effects caused by passing over the spillway section make juvenile Atlantic salmon passing the Weston Project more vulnerable to predation, as discussed in Section 5.2. No site-specific studies have been conducted to assess this condition. However, given the height of the dam and the shape of the spillway section on the downstream face, I conclude there is some yet to be quantified level of disorientation or injury that could cause increased vulnerability to predation. In addition, under low flow conditions the majority of the river flow is passing through the South Channel, which means fish are passing through the bypass system or turbines. In this situation, the flows are concentrated in two locations which allow predators to focus on specific locations. Given the probability of fish being disoriented by passing through the turbines, it is likely that predation rates in these specific areas of the Project are higher than other areas. However, no studies have specifically quantified the predation rate in this area.

B. Conclusions Regarding Impacts on Fish – Although there is an absence of site-specific quantitative data, I conclude, based on my observations of the site, the scientific literature, and my professional experience, that the Project configuration and operations do create conditions that result in increased predation on juvenile Atlantic salmon. In my professional opinion, predation is occurring at some yet to be quantified level, which is most likely in the low single digits. Given the absence of sire-specific quantitative data, the level of predation below the Weston Project and its impact on the species cannot be quantified at this time.

7. River flow regime during time periods critical for Atlantic salmon (April through June and October through November) in relation to the hydraulic capacity of the turbines

A. **Evaluation –** For a more detailed explanation of the data and procedure used to develop the figures below relating Kennebec River flow conditions and the potential for all of the river flow to pass through the Project's turbines, see Section 6.2 of this report. Results of this analysis are presented below:

Figures referenced in this section of this report are located in Section 7.1.2.1(7) of the Lockwood Project evaluation (Section 6.1).

Data from Figure 7.1.1 for the Weston Project show that during the month of April there is a fairly consistent probability of 5% that river flows will be $\leq$ Project hydraulic capacity. This probability increases to nearly 10% during the last few days of the month.

Data from Figure 7.1.2 for the Weston Project show that during the month of May there is a consistent probability of 10% that river flows will be $\leq$ Project hydraulic capacity. This probability increases to > 25% during the last 10 days of the month.

Data from Figure 7.1.3 for the Weston Project show that during the month of June there is a consistent probability of 25% that river flows will be ≤ Project hydraulic capacity. This probability increases to 50% during the last 10 days of the month.

Data from Figure 7.1.4 for the Weston Project show that during the month of October there is a consistent probability of at least 50% that river flows will be ≤ Project hydraulic capacity.

Data from Figure 7.1.5 for the Weston Project show that during the month of November there is a consistent probability of at least 25% that river flows will be ≤ Project hydraulic capacity.

B. Conclusions Regarding Impacts on Fish – The results of these analyses lead me to the following conclusions:

I. During the spring emigration period, the probabilities of river flow being ≤ the Weston Project's hydraulic capacity range from 5 to 50%. During the most likely time when the majority of smolts would migrate, the probabilities range from 10-25%. This level of interaction with Project turbines is, in my opinion, unacceptable in terms of population survival and recovery, given the level of immediate turbine mortality at Weston Project, the ineffectiveness of the fish bypass structure, and the current status of the Atlantic salmon population in the Kennebec River.

II. During the fall kelt emigration period, the analysis shows probabilities of > 50% for all of October and > 25% for all of November. This level of interaction with Project turbines is, in my opinion, unacceptable in terms of population survival and recovery, given the level of immediate turbine mortality at Weston Project, the ineffectiveness of the fish bypass structure, and the current status of the Atlantic salmon population in the Kennebec River.

III. This analysis clearly demonstrates that the use of median monthly flow values to assess potential project impacts is not appropriate or defensible. As this analysis shows, the use of median monthly flows greatly underestimates the amount of time that river flows can be ≤ to Project hydraulic capacity and thus underestimates the percentage of time that the only downstream passage route available for Atlantic salmon is through the Project turbines and the inadequate downstream bypass system. And yet it is my understanding, based on my review of draft white papers commissioned by the NextEra Defendants, that these Defendants plan to use median flow data to assess each Project's impacts on Atlantic salmon for purposes of obtaining Incidental Take Permits.

IV. Given the current population levels, the age structure of adults captured at the Lockwood fish trapping facility, the decades it would take to rebuild even one year's loss of smolts due to Weston Project operations, and the cumulative effects of the four projects on the Kennebec River between Waterville and the Sandy River, I believe the impacts associated with low river flows result in critical levels of mortality to Atlantic salmon on a reasonably predictable and routine basis.

7.4.3 Impacts on Atlantic salmon in the Merrymeeting Bay SHRU and, consequently, the GOM DPS as a whole

In order to evaluate impacts of dam operations on the Merrymeeting Bay SHRU and the GOM DPS as a whole, I used five parameters related to the Weston Project, but these same parameters and conclusions are equally applicable to the Lockwood, Hydro Kennebec, and Shawmut Projects as well.

1) **Percentage of the total habitat in comparison to the GOM DPS –** According to the NMFS (2009b), the Merrymeeting Bay SHRU comprises approximately 46% of the land area in the GOM DPS, with the Kennebec River watershed contributing 56% of the total for the Merrymeeting Bay SHRU. Therefore, the Kennebec River watershed has the potential to be the dominant contributor to recovery in the SHRU and the GOM DPS overall because of its land area and the quality of habitats suitable for Atlantic salmon upstream of the Weston Project.

2) **Population diversity and stability –** The Kennebec River watershed is the second largest in Maine that is part of the GOM DPS and contains extensive areas designated as critical habitat. . Historically, the Androscoggin, Kennebec, and Penobscot watersheds were the largest producers of Atlantic salmon in Maine, and probably the East Coast. These large watersheds provided a variety of habitats that have resulted in genetic diversity among watersheds and overall population stability because of the variety of habitats and life history strategies necessary for salmon to persist in them (National Research Council 2002, 2004; Fay et al. 2006; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2009).

3) **Location of habitats suitable to promote recovery of the species –** The overwhelming majority of habitats suitable to support Atlantic salmon spawning and juvenile rearing in the Kennebec River watershed are located upstream of the Weston Project. While the MDMR (2010) identified some habitat suitable for

Atlantic salmon downstream of the Lockwood Project, a functional equivalent habitat analysis by NMFS found that all habitats downstream of the Lockwood Project received a zero rating for Atlantic salmon spawning and rearing. What this functional equivalent rating means is that the quantity and quality of downstream habitats are insufficient to adequately support the habitat and population recovery criteria for the SHRU (National Marine Fisheries Service (2009b). The NMFS analysis found that all of the habitat suitable to support the PCE requirements for spawning and rearing, and thus recovery, were upstream of the Weston Project.

4) **Blockage and/or delay to upstream migrating adult Atlantic salmon –** Weston has no provision for upstream fish passage; it relies on the operation of the trapping facility at Lockwood to achieve upstream passage. As demonstrated in various analyses described earlier in this report, the Lockwood Project blocks migration of adult Atlantic salmon, delays their migration, or creates conditions that allow passage only under flow conditions that are different than those that existed before the Project was constructed. Any adults that are captured are trucked far upstream, which subjects them to the adverse impacts of trucking described in Section 5.3 and requires kelts to pass four hydroelectric dams in order to return to the sea after spawning.

5) **Mortality rate of Atlantic salmon smolts and kelts passing downstream through Weston Project turbines –** Smolts and kelts moving downstream through the Weston Project are subject to mortality associated with passage through the Project's turbines. During periods of non-spill at downstream migration time periods (see analyses of these time periods above), all fish are forced to pass via the Project's power canal, which contains an ineffective fish bypass sluice and the Project turbines. Immediate mortality of smolts passing through the turbines is about 15%, while the immediate mortality of kelts is about twice that rate (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008b, 2008d). Delayed turbine mortality and additional adverse impacts on salmon going over the spillway or through the bypass structure are likely but have not been quantified.

Given the impacts of these five factors on individual Atlantic salmon, the effects of the Weston Project combined with the Lockwood Project's inability to consistently provide adult upstream passage or to achieve the spawning and rearing and migration PCE's, and the overall negative impact on the likelihood that the recovery criteria for the Merrymeeting Bay SHRU will be met, I conclude that the Weston Project, as it is currently structurally configured and operated, is having a significant adverse impact on the Merrymeeting Bay SHRU and the GOM DPS as a whole.

7.4 Interim Measures

Any or all of the following measures would either reduce the harm to Atlantic salmon currently being caused by the dams in question or contribute to efforts at restoration of the species.

7.4.4.1 Interim Measures Applicable to All Projects on the Kennebec and Androscoggin rivers

A complete list of the interim measures applicable to all projects can be found in Section 7.1.4.1 of the Lockwood Project evaluation.

7.4.4.2 Additional Interim Measures Specifically for the Weston Project

A. Provide a downstream passage route on the north side of the spillway during the downstream migration period of April through June. This location should be in the North Channel.

7.5 Presence of Adult Atlantic Salmon and American Shad at Kennebec River Dams

I was asked to evaluate and provide responses to three questions relating to the Clean Water Act certifications for the four dams on the Kennebec River. My responses to these questions are included below:

7.5.1 Do adult salmon or shad currently inhabit the impoundments above the four Kennebec River dams (Weston, Shawmut, Hydro Kennebec, and Lockwood)?

Yes. Adult American shad have been transported from the fish trapping facility at Lockwood and released into the headpond upstream of Hydro Kennebec since 2006 (Maine Department of Marine Resources 2011b). An American shad stocking program was in place from 1991 through 2008. During this period, millions of juvenile shad fry were stocked in the Kennebec River upstream of the Hydro Kennebec Project (Maine Department of Marine Resources 2009). The MDMR completed an assessment of American shad habitat in the Kennebec River watershed, which shows roughly 70% of the shad production potential is upstream of the Lockwood Dam (Maine Department of Marine Resources 2009).

Since 2003, eggs or fry of Atlantic salmon have been planted or released into the Sandy River, which is a tributary to the Kennebec River upstream of the Weston Project (Maine Department of Marine Resources 2011b). Since 2006, adult Atlantic salmon captured at the Lockwood fish trapping facility have been transported to the Sandy River and released into the wild to spawn naturally (Maine Department of Marine Resources 2011b). The eggs planted and adults released are all part of the GOM DPS and the suitable habitats upstream and downstream of the Weston Project are all considered “occupied” by NMFS (National Marine Fisheries Service 2009b).

7.5.2 Given the current design of the dams and their related structures, are adult salmon or shad currently able to access the turbines at the four Kennebec River dams (Weston, Shawmut, Hydro Kennebec, and Lockwood)?

Adult American shad currently have access to the turbines at Hydro Kennebec and Lockwood projects. The only reason that adults do not have access to the turbines at Weston and Shawmut is that the adult runs have been so small that efforts have not been made to truck adult American shad upstream of the Weston Project. Plus, the MDMR estimates a 10% mortality factor for American shad at each project (Maine Department of Marine Resources 2009). Adult Atlantic salmon have access to the turbines at the four Kennebec River dams. At none of the dams is the trash rack bar spacing sufficiently narrow to prevent adult Atlantic salmon or shad from entering the turbines. No studies have been conducted on the impingement potential of the existing trash rack spacing to my knowledge. One study, completed at the Lockwood Project, found that 33% of Atlantic salmon kelts (post-spawning adults) passing through the Project’s turbines suffered “immediate mortality” (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC 2008b). Studies of downstream bypass effectiveness indicated that they divert only 50% of Atlantic salmon adults away from the turbines with smolts only about 18% effective (Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC 2008b; Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008d; Normandeau Associates, Inc. 2011c. Note: this document is under a court protective order).

The NextEra Defendants have acknowledged, in a 2008 letter to FERC, that turbine passage for adult salmon and shad is part of normal operations at the Kennebec dams. In response to a comment by the Maine Department of Marine Resources that “FPL Energy’s studies have clearly shown that adult alewife, adult American shad, adult American eel, Atlantic salmon kelts, and Atlantic salmon smolts pass through the Lockwood project turbines, and sustain significant immediate mortality,” FPL Energy responded as follows: “Licensee recognizes that fish passage through turbines is not preferred by the fisheries agencies, but *also recognizes that passage through turbines for certain species and life stages can be, and is on a practical basis, part of the overall passage scheme in effect at the projects.* Successful passage through turbines, as well as through other routes, can be variable based upon the site characteristics, species, and life stages.” [Emphasis added]. (FPL Energy Maine 2008b).

7.5.3 Are there any site-specific, quantitative studies of any of the four Kennebec River dams (Weston, Shawmut, Hydro Kennebec, and Lockwood) that demonstrate that passage of adult salmon and shad through the turbines at such dams will not result in significant injury or mortality, immediate or delayed?

No. The owners/operators all state in their existing documents that no site-specific studies have been completed at any of the projects that address Atlantic salmon kelt mortality related to passage through project turbines (Hydro Kennebec, LLC. 2011; Normandeau Associates, Inc. 2011e,f, g.). Further, none of the studies that I have evaluated regarding any of the four dams is a site-specific, quantitative study demonstrating that turbine passage of adult salmon or shad will not result in significant injury or mortality, and to my knowledge no such study exists. The studies that have been done demonstrate that passage through turbines at these dams causes significant injury and mortality to adult salmon and shad. The site-specific data are consistent with the published literature cited in Section 6.1.

8.0 ANALYSIS OF ANDROSCOGGIN RIVER DAMS

8.1 Brunswick Project (NextEra)

8.1.1 Brief Project Description

The Brunswick Project includes a 300 acre impoundment, a 605 ft. concrete gravity dam approximately 40 ft. high, a gate section containing two Taintor gates and an emergency spillway, a powerhouse and intake, a fishway, a 21 ft. high fish barrier wall between the dam and Shad Island. The concrete gravity dam consists of two ogee overflow spillway sections separated by a pier and barrier wall. The right spillway section, about 128 ft. long, is topped wooden flashboards that are 2.6 ft. high. The left section does not have flashboards. The two Taintor gates each measuring 32.5 ft. wide by 22 ft. high and an emergency spillway are located at the left abutment on the Topsham shoreline. The intake structure and powerhouse are integral with the dam and located adjacent to the Brunswick shoreline. The powerhouse contains three turbines. Unit 1 is a vertical propeller turbine with a maximum flow capacity of 5,075 cfs, with peak efficiency at 4,519 cfs and runs at 90 rpm. Units 2 and 3 are horizontal propeller turbines that have a flow capacity of 1,336 cfs each and spin at 211.8 rpm. In the flows analysis, I used a figure of 7,191 cfs as the Project's hydraulic capacity, even though Unit 1 can pass an additional 566 cfs at maximum flow for the unit ((Normandeau Associates, Inc. 2011h, i).

Upstream passage for fish species is provided with a vertical slot fishway and associated trap and sort facility installed in 1983 along the west shore of the river. The fishway is 570 ft. long and consists of 42 individual pools, with a one-foot drop between each. The fishway is designed to pass American shad, river herring, and Atlantic salmon. Atlantic salmon are passed upstream of the Project. At the intake to the turbines and downstream fishway, a combination trash boom and fish screen direct downstream migrating fish to the downstream fishway which is located between the turbine intakes for the powerhouse.

The draft white paper prepared by NextEra, indicates that the Project operates in a near run-of-the-river mode. Unit 1 is generally operating at maximum efficiency at flows less than about 4,400 cfs. At flows between 4,400 to 5,000 cfs, the unit will run in an on-off mode with unit discharge approximating river flows. Unit 2 and 3 will then normally come on line for river flows at 6-7,000 cfs or greater. (Normandeau Associates, Inc. 2011i). Since the Project has a nominal hydraulic flow capacity of 7,191 cfs, I used this value in the flows analysis because the operational criteria mentioned above did not indicate any fixed rule on when Units 2 and 3 could come on line.

8.1.2 Impact of Brunswick Project on Atlantic Salmon

8.1.2.1 Impact on Individual Fish

I have analyzed seven factors (See section 4.3 for a detailed listing) related to the physical structure of the dam and adjacent river channel and operational parameters and characteristics in evaluating impacts of the project on Atlantic salmon. Below is my evaluation of these seven factors:

1. **Physical Structure of the Dam**

    A. **Evaluation –** The physical configuration and height of the dam creates a barrier to upstream migrating Atlantic salmon under most flows, in the absence of an effective upstream fishway. The Project installed a vertical slot fishway in 1983 and has been passing some adult Atlantic salmon since then. This upstream fishway appears to function acceptably under some circumstances. At river flow levels at or below the hydraulic capacity of the Project's turbines, most of the flow is exiting via the turbine tailraces, which are located adjacent to the entrance to the upstream fish entrance. This situation is acceptable for upstream passage. However, at flows above the Project's hydraulic capacity, flow is spilled on the north side of the Project, which could attract adult fish resulting in a delay or inability of adults to find the entrance to the upstream fishway. I am unaware of any studies that provide data on what percentage of the adults that approach the

Project from downstream actually use each channel. The "fish barrier wall" located between the dam and Shad Island prevents lateral movement along the downstream margin of the dam except at extreme flows.

The downstream fishway entrance is located between the powerhouses of Unit 1 and Units 2 and 3. The fishway entrance is a grate covering the upstream end of a pipe that I believe is approximately 18" in diameter and passes approximately 40 cfs directly through the dam and discharges into the tailraces below. The entrance is poorly located for use by salmon; it is immediately adjacent to the Unit 1 intake, which extends up to the water surface. The intakes for Units 2 and 3 are located approximately 20 ft. beneath the water surface to the immediate south of the downstream fishway entrance.

While I calculated the hydraulic flow capacity of the turbines at the Brunswick Project at 7,191 cfs, National Marine Fisheries Service staff commented that downstream juvenile passage via spill would probably not occur if depth of flow over the spillway/flashboards was <6 inches (Normandeau Associates, Inc. 2011b). Assuming this statement is correct, that would in effect direct juvenile fish towards the turbine intakes at flows < ~7,500 cfs, increasing the probability of fish interacting with the downstream fish bypass system or the turbines.

B. Conclusions Regarding Impacts on Fish – Given the physical location of the Taintor gates and spillway, the dam's height, and the fact that there is a "defacto" north channel that is for all practical purposes separated from the low flow channel along the south bank of the river by the fish barrier wall and Shad Island, I believe that the Brunswick Project is causing the following impacts to Atlantic salmon:

I. Under low flow conditions, upstream migrating adult Atlantic salmon follow the low flow (south) channel, because of the flow coming from the powerhouse tailrace and find the entrance to the upstream fishway;

II. Under certain flow conditions, adult Atlantic salmon may be delayed from migrating upstream because of an inability to locate the entrance to the upstream fishway in a timely fashion. It is also possible, under the right flow conditions that adult fish do not find the entrance to the upstream fishway and are thus blocked from passing upstream. I am unaware of any data or studies that address these issues, and thus I cannot assess the impacts to overall population productivity caused by any passage blockage and/or delay.

2. **Downstream Fish Bypass System**

   A. **Evaluation –** As noted, the downstream fishway entrance is located between the powerhouses of Unit 1 and Units 2 and 3. The fishway entrance is a grate covering the upstream end of a pipe that I believe is approximately 18” in diameter. The pipe passes approximately 40 cfs of water directly through the dam and discharges into the tailraces below. The entrance is poorly located; it is immediately adjacent to the Unit 1 intake, which extends up to the water surface. The intakes for Units 2 and 3 are located approximately 20 ft. beneath the water surface to the immediate south of the downstream fishway entrance. In my professional opinion, a downstream fishway that has a flow capacity of approximately 40 cfs cannot effectively compete with a turbine intake of 5,075 cfs maximum capacity on one side and the intakes for Units 2 and 3 with a combined capacity of 2,672 cfs on the other side. I am unaware of any studies that have been conducted to look at the effectiveness of the trash boom/fish guidance device at diverting fish away from the turbine intakes and into the downstream fishway.

   B. Conclusions Regarding Impacts on Fish – Given the poor location of the downstream fishway (between the turbine intakes) and the lack of sufficient flow to effectively “compete” with the flows passing into the turbines, I conclude that the downstream fishway is ineffective and does not adequately protect downstream migrating Atlantic salmon from passing through the Project’s turbines. Mortality rates of various fish species and sizes passing through different turbines are reviewed in Section 6.1 of this report.

3. **Types of turbines used to generate power**

   A. Evaluation – For an overview of turbine mortality rates see Section 6.1 of this report. The powerhouse contains three turbines. Unit 1 is a vertical propeller turbine with a maximum flow capacity of 5,075 cfs, with peak efficiency at 4,519 cfs and runs at 90 rpm. Units 2 and 3 are horizontal propeller turbines that have a flow capacity of 1,336 cfs each and spin at 211.8 rpm. Propeller turbines are a type of Kaplan turbine.

   In a 2011 draft white paper presented to the resource agencies, the NextEra Defendants state there are no site-specific data regarding turbine passage survival at the Brunswick Project. The draft white paper states: “Due to the lack of site-specific information, estimates of turbine passage survival of Atlantic salmon smolts at Lockwood were developed using a combination of existing empirical studies and modeled calculations.” (Normandeau Associates, Inc. 2011i).

I agree that site-specific empirical studies have not been conducted at the Project to assess the following causes of hydroelectric dam-related mortality: predation in the headpond area as a result of changing the type of habitat upstream of the dam, spill-related mortality, mortality associated with fish using the downstream bypass system, delayed or latent mortality associated with fish passing through the turbines and not immediately killed, and mortality due to predation at locations immediately downstream of the Project infrastructure due to fish being injured or disoriented during passage through the Project.

However, there are data from studies conducted at dams on the nearby Kennebec River which do offer some indication of the mortality rates associated with the types of turbines found at the Brunswick Project. Section 6.1 of this report summarizes some of the literature reporting turbine mortality rates for juvenile and adult Atlantic salmon-sized fish. For a more comprehensive review see Stone and Webster (1992) and Winchell and Amaral (1997).

B. Conclusions Regarding Impacts on Fish – I have reached the following conclusions with respect to turbine passage at Brunswick:

I. There is a significant frequency, during critical downstream migration periods for Atlantic salmon smolts and/or kelts (April through June and October and November), when the river flows are low enough that essentially the entire flow of the river passes through the Project's turbines and bypass system. Please see the flows analysis below.

II. Given the fact that the flows into the existing downstream fish bypass system cannot adequately compete with the flows entering the turbines, and thus cannot effectively divert downstream migrating Atlantic salmon away from the turbines, I conclude that in non-spill conditions most downstream migrating salmon will pass the Project through the Project's turbines. Even during conditions of spill, fish will still pass through the Project's turbines if they are operating.

III. A scientifically defensible estimate of immediate Atlantic salmon smolt mortality passing through Kaplan type turbines at Brunswick is approximately 15%. Mortality levels for kelts will be higher, with a reasonable working value of 25-50%. It is important to note that these values do not include mortality associated with downstream predation due to injury or disorientation or latent mortality as a result of passing through the turbines.

IV. Given the preceding conclusions, the Brunswick Project is causing direct mortality to Atlantic salmon smolts and kelts by allowing fish to pass through the Project turbines. Although indirect and latent mortality have not been adequately assessed at this Project, it is reasonable to assume that some smaller percentage of indirect and latent mortality is also occurring as a result of turbine passage.

4. Upstream fishway for adult passage

A. Evaluation – The Project installed a vertical slot fishway (fish "ladder") in 1983 and has been passing adult Atlantic salmon since then. Between 1983 and 2010 at total of 742 adult Atlantic salmon have been counted at the upstream fishway. In 2011, 47 adults were counted. The 2011 count of 47 fish is the third largest number in the history of the fishway. Although there are records of 4,000 Penobscot origin Atlantic salmon fry being stocked in the Androscoggin River in 2001 and 2003, a run of adult fish has been present in the river since the ladder was installed. Analysis of the hatchery versus wild components of the run shows 13.6% of the fish are of wild origin (Fay et al. 2006; Maine Department of Marine Resources. 2011a).

At river flow levels at or below the hydraulic capacity of the Project's turbines, most of the flow is exiting via the turbine tailraces which are located adjacent to the entrance to the upstream fish entrance. This situation is acceptable for upstream passage. However, at flows above the Project's hydraulic capacity, flow is spilled on the north side of the Project, which could attract adult fish resulting in a delay or inability of adults to find the entrance to the upstream fishway. I am unaware of any studies that provide data on what percentage of the adults that approach the Project from downstream actually use each channel. The "fish barrier wall" located between the dam and Shad Island prevents lateral movement along the downstream margin of the dam except at extreme flows.

B. Conclusions Regarding Impacts on Fish – Given the information in the evaluation above, I have reached the following conclusions regarding upstream fish passage facilities at the Brunswick Project:

I. Adult Atlantic salmon were captured in the very first year the Brunswick Project's fishway was installed, in 1983 – approximately 100 years since the last documented stocking of Atlantic salmon in the Androscoggin River (Fay et al. 2006). In addition, some percentage of returning fish have consistently been classified as wild origin since 1983. Given these facts, I conclude that there must have been a low level persistent run of

Atlantic salmon into the Androscoggin River. This run has continued to the present, although I do not know precisely where adult Atlantic salmon are spawning and rearing upstream of the Brunswick Project.

II. Under low flow conditions, adult Atlantic salmon follow the low flow (south) channel, because of the flow coming from the powerhouse tailrace and find the entrance to the upstream fishway.

III. Under certain flow conditions, adult Atlantic salmon may be delayed from migrating upstream because of an inability to locate the entrance to the upstream fishway in a timely fashion. It is also possible, under certain flow conditions, that adult fish do not find the entrance to the upstream fishway and are thus blocked from passing upstream. I am unaware of any data or studies that address these issues, and thus I cannot assess the impacts to overall population productivity because of any passage blockage and/or delay.

5. Size and configuration of the headpond upstream of the dam

A. Evaluation – According to published reports, the Brunswick Project headpond area is 300 acres (Normandeau Associates, Inc. 2011i). Although I am unable to verify this estimate, it appears reasonable, given the height of the spillway section. The headpond size is significant because in this area of the Brunswick Project, the habitat of the Androscoggin River has been changed from a flowing river channel to a more slow-moving water habitat. The lake-like habitat is more likely to contain fish species that are predators on juvenile Atlantic salmon and may not contain the cover features for juvenile salmon that would normally be present in a natural river channel. Species composition data from the upstream fishway captures document the presence of several predatory species of fish such as smallmouth and largemouth bass. I am unaware of any data that has specifically quantified the habitat characteristics of this area or quantified predation rates on Atlantic salmon smolts.

B. Conclusions Regarding Impacts on Fish – I conclude that levels of predation of Atlantic salmon smolts in the headpond area of the Brunswick Project are higher than what they would be in a natural river channel. But given the lack of any site-specific, quantitative studies or data, it is impossible to reach a defensible quantitative assessment of the increased predation rate or the potential impacts on the Atlantic salmon population.

6. **Physical character of the river immediately downstream of the dam and tailrace areas as potential habitat for predators**

   A. **Evaluation –** Smolts can pass the Brunswick Project by going over the spillway, or passing through the turbines or downstream fish bypass system. Each of these routes may affect smolts in ways that make them more vulnerable to predation, as described in Section 5.2, above. No scientifically rigorous studies have been conducted to assess these impacts at Brunswick, although the authors of studies conducted at the Lockwood Project that focused on other passage issues conclude that some radio tagged smolts were taken by downstream predators, based on movement patterns of the tags after passage through the project ((FPL Energy Maine Hydro, LLC. 2008a, Normandeau Associates, Inc. 2011c. Note this latter document is under a court protective order). The predation estimate in the 2011 study was 1.4%.

      The configuration of the river channel and the effects of spill on juvenile Atlantic salmon passing over the spillway section may make these fish vulnerable to predation. Given the extensive bedrock ledges immediately downstream of the spillway section and the presence of a concrete sill along the downstream base of the spillway section that can provide low velocity habitat for potential predators, I conclude that some yet to be quantified level of disorientation or injury to the salmon increases their vulnerability to predation.

      Under low flow conditions, the majority of the river flow is passing through the bypass system or turbines. The river channel immediately downstream of the powerhouse tailrace appears deep and highly confined. This type of habitat is very conducive to harboring predators such as striped bass. Given the probability of fish being disoriented by passing through the turbines, it is my opinion that predation rates in this specific area of the Project are higher than other areas. However, no studies have specifically quantified the predation rate in this area.

   B. **Conclusions Regarding Impacts to Fish and this Factor –**I conclude that the Brunswick Project's configuration and operations create conditions that are likely to result in increased predation of juvenile Atlantic salmon. There is one published estimate that would suggest a 1+% predation rate, but I do not believe that level is supported by scientifically reliable evidence. In my professional opinion, predation is occurring at some unknown level, likely in the low single digits. But given the lack of specific quantitative data, the actual level of predation below Brunswick and its impact on Atlantic salmon cannot be quantified at this time.

7. **River flow regime during time periods critical for Atlantic salmon (April through June and October through November) in relation to the hydraulic capacity of the turbines**

   A. **Evaluation –** For a more detailed explanation of the data and procedure used to develop the figures below relating Androscoggin River flow conditions and the potential for all of the river flow to pass through the Project's turbines, see Section 6.2 of this report. Results of this analysis are presented below:

   Data from Figure 8.1.1 show that during the month of April there is a fairly consistent probability of 5% that river flows will be ≤ Project hydraulic capacity. This probability increases to nearly 10% during the last few days of the month.

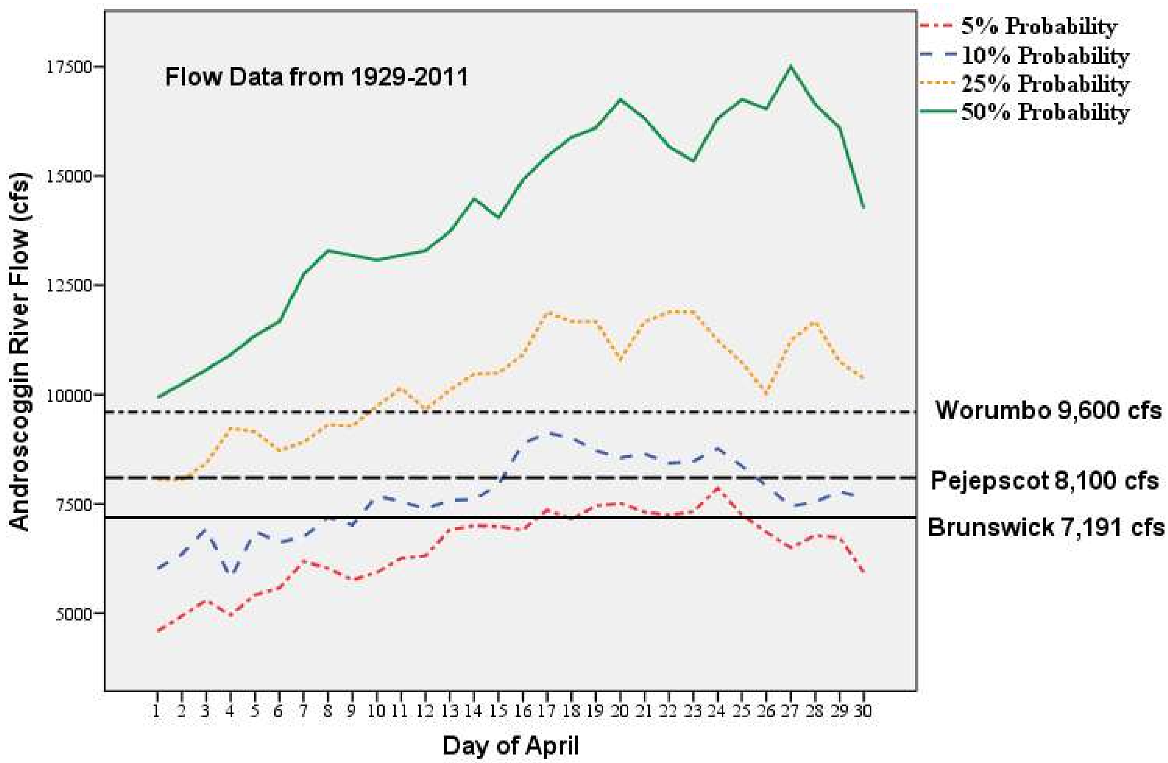


Figure 8.1.1 Relationship between Androscoggin River mean daily flow in April and the hydraulic flow capacity of the Brunswick, Pejepscot, and Worumbo projects. Flow curves represent the 5, 10, 25, 50, 75, and 90th mean daily flow percentiles. Flow volume is based on all days of record for the USGS gage at Auburn, ME for the period 1929-2011. Flows were adjusted upward by a factor of 1.0806 because of the difference in watershed area between the gaging station and the beginning of the watershed near Brunswick.

   Data from Figure 8.1.2 show that during the month of May there is a fairly consistent probability of 10% that river flows will be ≤ Project hydraulic capacity.

This probability increases to 25% during the middle of the month and to 50% at the end of the month.

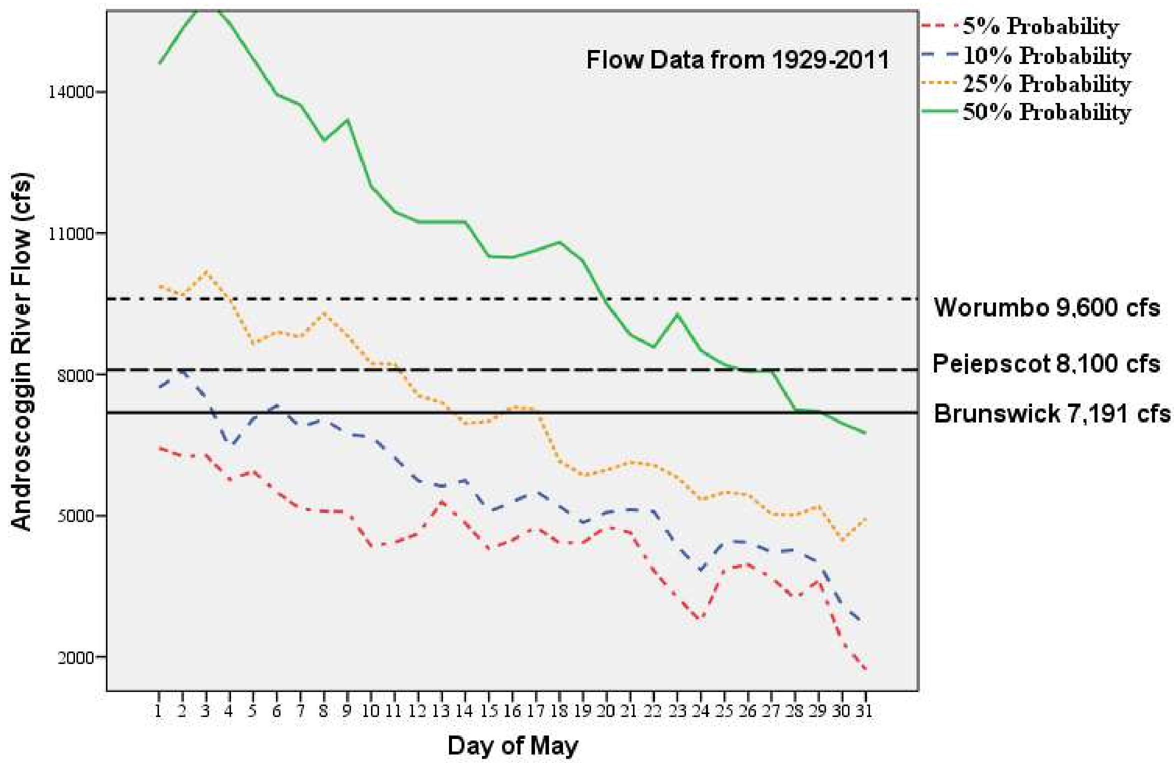


Figure 8.1.2 Relationship between Androscoggin River mean daily flow in May and the hydraulic flow capacity of the Brunswick, Pejepscot, and Worumbo projects. Flow curves represent the 5, 10, 25, 50, 75, and 90th mean daily flow percentiles. Flow volume is based on all days of record for the USGS gage at Auburn, ME for the period 1929-2011. Flows were adjusted upward by a factor of 1.0806 because of the difference in watershed area between the gaging station and the beginning of the watershed near Brunswick.

Data from Figure 8.1.3 show that during the month of June there is a consistent probability of more than 50% that river flows will be ≤ Project hydraulic capacity. This probability increases to about 75% during the last 10 days of the month.

Data from Figure 8.1.4 show that during the month of October there is a consistent probability of at least 75% that river flows will be ≤ Project hydraulic capacity. The probability is near 90% during the first 10 days of the month.

Data from Figure 8.1.5 show that during the month of November there is a consistent probability > 50% that river flows will be ≤ Project hydraulic capacity. The real probability is closer to 75% than it is to 50%.

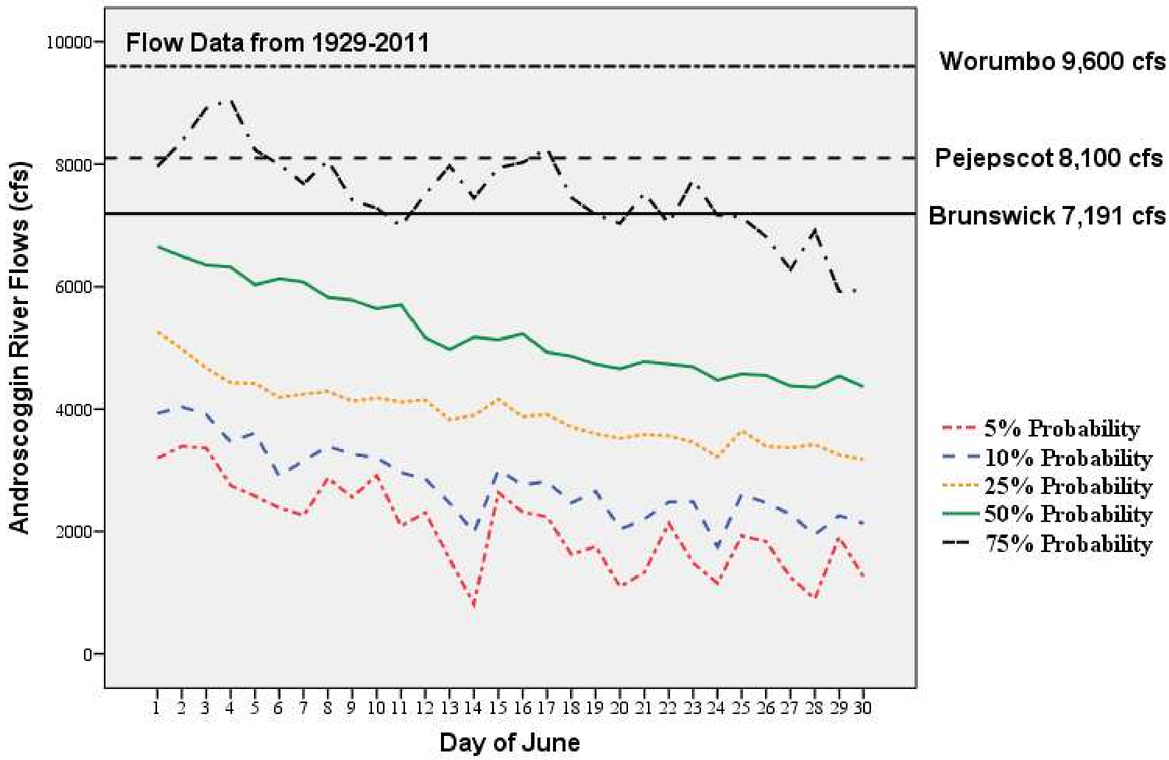


Figure 8.1.3 Relationship between Androscoggin River mean daily flow in June and the hydraulic flow capacity of the Brunswick, Pejepscot, and Worumbo projects. Flow curves represent the 5, 10, 25, 50, 75, and 90th mean daily flow percentiles. Flow volume is based on all days of record for the USGS gage at Auburn, ME for the period 1929-2011. Flows were adjusted upward by a factor of 1.0806 because of the difference in watershed area between the gaging station and the beginning of the watershed near Brunswick.

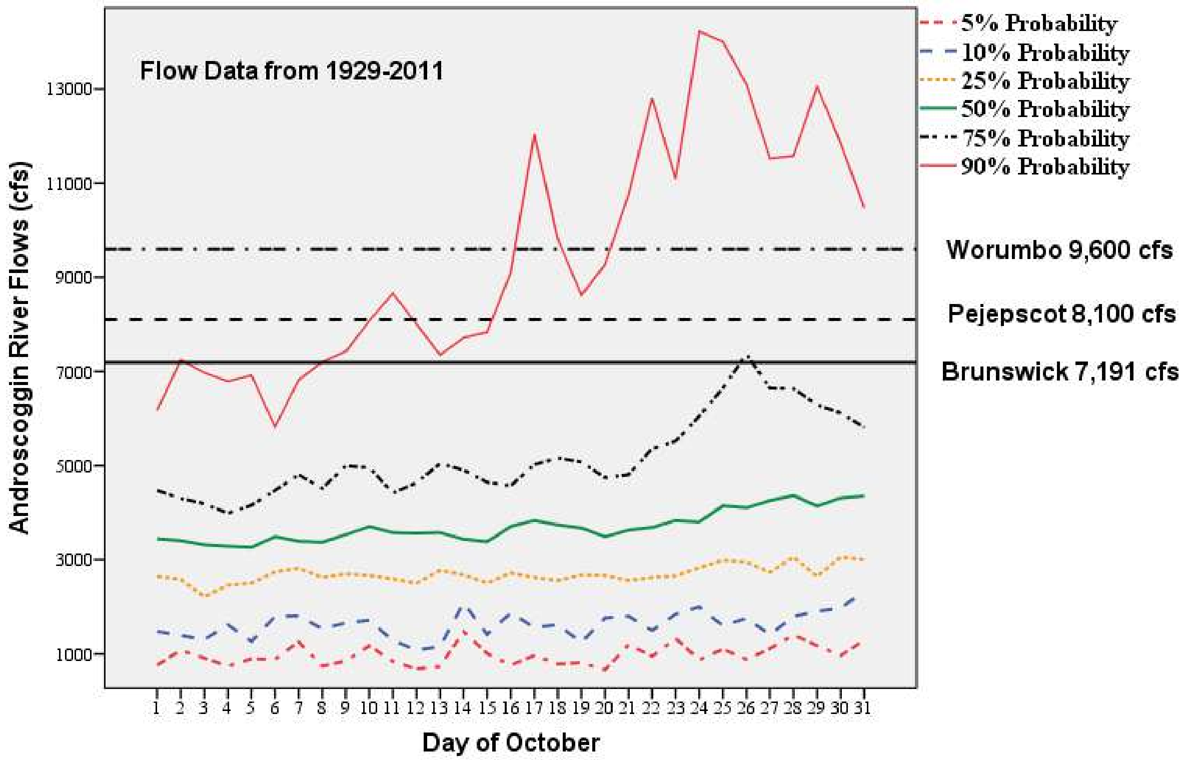


Figure 8.1.4 Relationship between Androscoggin River mean daily flow in October and the hydraulic flow capacity of the Brunswick, Pejepscot, and Worumbo projects. Flow curves represent the 5, 10, 25, 50, 75, and 90th mean daily flow percentiles. Flow volume is based on all days of record for the USGS gage at Auburn, ME for the period 1929-2011. Flows were adjusted upward by a factor of 1.0806 because of the difference in watershed area between the gaging station and the beginning of the watershed near Brunswick.

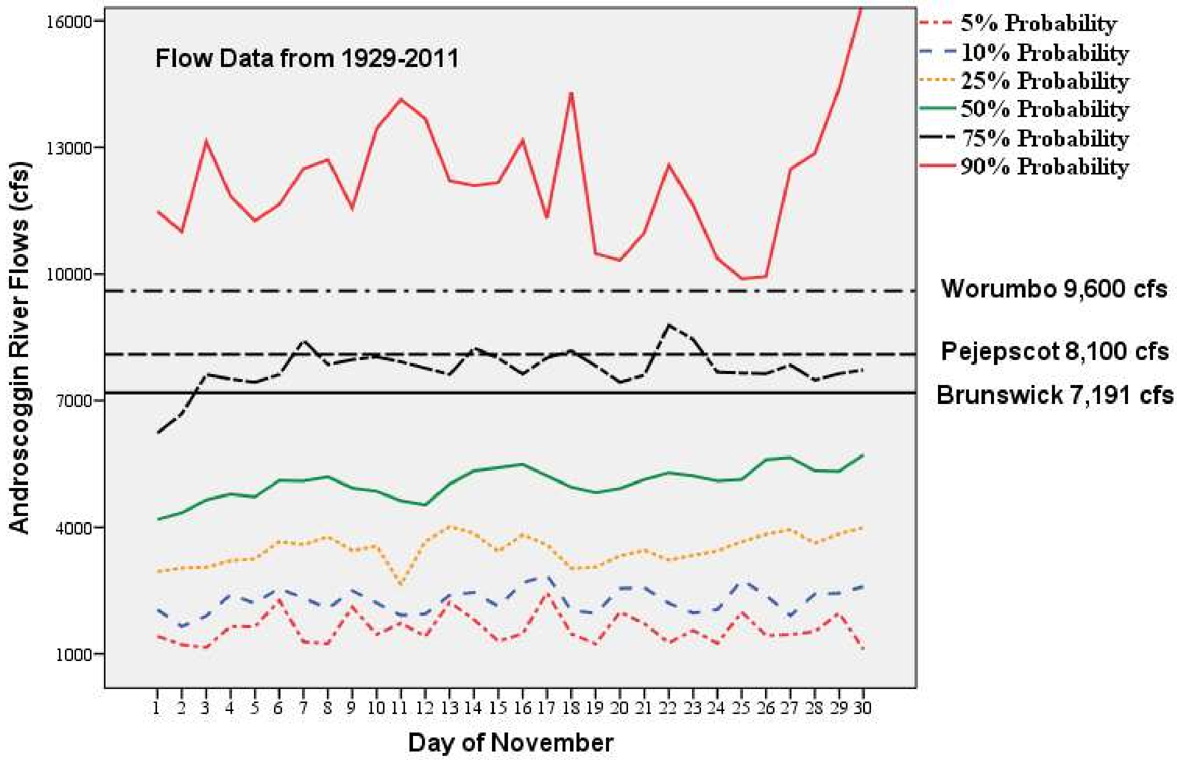


Figure 8.1.5 Relationship between Androscoggin River mean daily flow in November and the hydraulic flow capacity of the Brunswick, Pejepscot, and Worumbo projects. Flow curves represent the 5, 10, 25, 50, 75, and 90th mean daily flow percentiles. Flow volume is based on all days of record for the USGS gage at Auburn, ME for the period 1929-2011. Flows were adjusted upward by a factor of 1.0806 because of the difference in watershed area between the gaging station and the beginning of the watershed near Brunswick.

B. Conclusions Regarding Impacts on Fish – The results of these analyses lead me to the following conclusions:

I. During the spring emigration period, the probabilities of river flow being ≤ the Brunswick Project's hydraulic capacity range from 5 to 75%. During the most likely time when the majority of smolts would migrate, the probabilities range from 10-50%. This level of interaction with Project turbines is, in my opinion, unacceptable for population survival or restoration, given the level of immediate turbine mortality at Brunswick Project and the current status of the Atlantic salmon population in the Androscoggin River.

II. During the fall kelt emigration period, the analysis shows probabilities of > 75% for all of October and > 50% for all of November. This level of interaction with Project turbines is, in my opinion, unacceptable in terms of population survival and recovery, given the level of immediate turbine mortality at Brunswick Project and the current status of the Atlantic salmon population in the Androscoggin River.

III. This analysis clearly demonstrates that the use of median monthly flow values to assess potential project impacts is not appropriate or defensible. As this analysis shows, the use of median monthly flows greatly underestimate the amount of time that river flows can be ≤ to project hydraulic capacity and thus the percentage of time that the only downstream passage route available for Atlantic salmon is through the project turbines and the inadequate downstream bypass system. It is my understanding, based on my review of draft white papers commissioned by the NextEra Defendants, that these Defendants plan to use median flow data to assess each Project's impacts on Atlantic salmon for purposes of obtaining Incidental Take Permits.

Given the current population levels, the age structure of adults captured at the Brunswick fish trapping facility, the decades it would take to rebuild even one year's loss of smolts due to project operations, and the cumulative effects of the three projects on the Androscoggin River that are the subject of this litigation, I believe the impacts associated with low river flows result in critical levels of mortality to Atlantic salmon on a reasonably predictable and routine basis.

8.1.3 Impacts on Atlantic salmon in the Merrymeeting Bay SHRU and, consequently, the GOM DPS as a whole

In order to evaluate impacts of dam operations on the Merrymeeting Bay SHRU and the GOM DPS as a whole, I used five parameters related to the Brunswick Project, and these same parameters and conclusions are equally applicable to the Pejepscot and Worumbo projects as well.

1) **Percentage of the total habitat in comparison to the GOM DPS –** According to the NMFS (2009b), the Merrymeeting Bay SHRU comprises approximately 46% of the land area in the GOM DPS, with the Androscoggin River watershed contributing 33% of the total for the Merrymeeting Bay SHRU. Therefore, the Androscoggin River watershed has the potential to be a dominant contributor to recovery in the SHRU and the GOM DPS overall because of its land area and the quality of habitats suitable for Atlantic salmon upstream of the Lisbon Falls.

2) **Population diversity and stability –** The Androscoggin River watershed is the third largest in Maine that is part of the GOM DPS and contains a significant quantity of designated critical habitat. Historically, the Androscoggin, Kennebec, and Penobscot watersheds were the largest producers of Atlantic salmon in

Maine, and probably the East Coast. These large watersheds provided a variety of habitats that have resulted in genetic diversity among watersheds and overall population stability because of the variety of habitats and life history strategies necessary for salmon to persist in them (National Research Council 2002, 2004; Fay et al. 2006; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2009).

3) **Location of habitats suitable to promote recovery of the species –** The majority of habitats suitable to support Atlantic salmon spawning and juvenile rearing in the Androscoggin River watershed are located upstream of Lisbon Falls. Analysis of the biological value of habitats in the Androscoggin watershed shows the highest and second highest value habitats in the Androscoggin basin. (National Marine Fisheries Service (2009b). The NMFS analysis found that a majority of the habitat suitable to support the PCE requirements for spawning and rearing, and thus recovery, were upstream of the Brunswick Project.

4) **Blockage and/or delay to upstream migrating adult Atlantic salmon –** As demonstrated in various analyses I described earlier in this report, the Brunswick Project may directly block or delay adult upstream migrants because of the presence of its spillway section and the potential for adult fish to use the river channel north of Shad Island. Under flow levels where spill is occurring on the north portion of the dam, adult fish may move towards this flow source. No fish passage facilities exist in this area of the Project. No studies have documented whether adults are blocked or delayed because of their transit into this area of the Project. The fate of any fish that does not find the upstream fishway is unknown.

5) **Mortality rate of Atlantic salmon smolts and kelts passing downstream through Brunswick Project turbines –** Smolts and kelts moving downstream through the Brunswick Project are subject to mortality associated with passage through the Project's turbines. During periods of non-spill at downstream migration time periods (see analyses of these time periods above), fish are forced to pass either via the Project's small and in my opinion ineffective downstream fishway or through the project turbines. Immediate mortality of smolts passing through Kaplan type turbines is about 15%, while immediate mortality of kelts is about twice that rate (See Section 6.1 of this report for a review of turbine mortality studies). It is likely that additional salmon die as a result of delayed turbine mortality, and that other salmon suffer adverse impacts as a result of going over the spillway or through the bypass structures, but these percentages have not been quantified.

Given the impacts of these five factors on individual Atlantic salmon, the effects of the Brunswick Project on the spawning and rearing and migration PCE's, and the overall negative impact on the likelihood that the recovery criteria for the Merrymeeting Bay SHRU will be met, I conclude that the Brunswick Project, as it is currently structurally configured and operated, is having a significant adverse impact on the Merrymeeting Bay SHRU and the GOM DPS as a whole.

8.1.4 Interim Measures

Any or all of the following measures would either reduce the harm to Atlantic salmon currently being caused by the dams in question or contribute to efforts at restoration of the species.

8.1.4.1 Interim Measures Applicable to All Projects on the Kennebec and Androscoggin rivers

A complete list of the interim measures applicable to all projects can be found in Section 7.1.4.1 of the Lockwood Project evaluation.

8.1.4.2 Additional Interim Measures Specifically for the Brunswick Project

A. Provide a downstream passage route on the north side of the spillway section adjacent to the spillway gates. Flow through this bypass should be provided during the downstream migration period of April through June and October through November.

8.2 Pejepscot Project (Topsham Hydro Partners)

8.2.1 Brief Project Description

The Project consists of a 560 ft. long overflow dam with five 3-foot-high crest gates, two powerhouses, and upstream and downstream fish passage facilities. Powerhouse A contains a vertical Kaplan turbine with a flow capacity of about 7,100 cfs which operates fairly consistently because of a minimum flow requirement in the Androscoggin River upstream of the Project. Powerhouse B consists of three horizontal Francis turbines with a combined capacity of about 1,000 cfs. Total hydraulic capacity of the Project is 8,100 cfs operating at a gross head of 25 ft.

The downstream fish bypass facilities consists of two separate entrances and conveyance pipes through the dam. One entrance is a 4-foot wide opening on the south wall of Powerhouse B (north side of the Powerhouse A intake) immediately adjacent to the trash racks and intake for the larger Kaplan unit. The second entrance is the same size and is immediately adjacent to the Kaplan intake on the south side. Each conveyance pipe has a capacity of approximately 40 cfs and flows directly through the dam, discharging about 4 ft. above the water surface below. Upstream adult passage is provided via a downstream trap, a fish lift, and a metal canal that allows fish from the lift to swim upstream of the dam.

8.2.2 Impact of Pejepscot Project on Atlantic Salmon

8.2.2.1 Impact on Individual Fish

I have analyzed seven factors (See section 4.3 for a detailed listing) related to the physical structure of the dam and adjacent river channel and operational parameters and characteristics in evaluating impacts of the project on Atlantic salmon. Below is my evaluation of these seven factors:

1. **Physical Structure of the Dam**

    A. **Evaluation –** The physical configuration and height of the dam create a barrier to upstream migrating Atlantic salmon under most flows, in the absence of an effective upstream fishway. The Project installed the trap and lift passage system in 1987 and has been passing some adult Atlantic salmon since then. At river flow levels at or below the hydraulic capacity of the Project's turbines, most of the flow is exiting via the turbine tailraces which are located adjacent to the entrance to the fish trap entrance.

    The spillway section of the dam consists of a concrete face on the downstream side, which is sloped at an angle of about 30 degrees. A concrete sill runs along the base of the spillway section, causing falling water to change direction from vertical to horizontal. No evidence of bedrock ledges was present during my site visit, except on the southwest corner of the spillway.

    B. **Conclusions Regarding Impacts on Fish –** Given the physical configuration of the sloping spillway section of the dam, I believe that the Pejepscot Project is causing the following impacts to Atlantic salmon:

    I. Under spill conditions, fish passing over the spillway can be killed or injured by striking the sloping concrete surface of the spillway or the concrete apron across the bottom of the spillway.

    II. Under certain flow conditions, adult Atlantic salmon may be delayed from migrating upstream because of an inability to locate the entrance to the upstream fishway in a timely fashion. It is also possible, under the right flow conditions that adult fish do not find the entrance to the upstream fishway and are thus blocked from passing upstream. I am unaware of any data or studies that address these issues, and thus I cannot assess the impacts to overall population productivity caused by any passage blockage and/or delay.

2. **Downstream Fish Bypass System**

A. **Evaluation –** The two downstream fishway entrances are located on each side of the intake to Powerhouse A, which houses a Kaplan turbine that has a hydraulic capacity of 7,100 cfs. Each downstream fishway has a flow capacity of only 40 cfs. There is no effective bypass provided to "compete" with the flows entering the three Francis turbines, since the easternmost bypass entrance is "around the corner" and downstream from the Francis unit's intake. The second downstream fishway entrance is immediately adjacent to the Kaplan turbine intake on the opposite side of the forebay. Neither of the two downstream fishway bypass entrances is located where it might provide sufficient attraction flow to effectively compete with flows that pass through the Kaplan turbine, which runs almost continuously.

B. Conclusions Regarding Impacts on Fish – Given the poor locations of the downstream fishway (immediately adjacent to the Kaplan turbine intake) and the lack of sufficient flow into the fishways to effectively "compete" with the flows passing into the turbines, I conclude that the downstream fishway is ineffective and does not adequately protect downstream migrating Atlantic salmon from passing through the Project's turbines. Mortality rates of various fish species and sizes passing through different turbines are reviewed in Section 6.1 of this report.

3. **Types of turbines used to generate power**

A. Evaluation – For an overview of turbine mortality rates see Section 6.1 of this report. Powerhouse A contains a single Kaplan turbine that operates almost continuously and has a hydraulic capacity of about 7,100 cfs. Three Francis turbines are located in Powerhouse B and have a combined capacity of about 1,000 cfs, bringing the total project hydraulic capacity to 8,100 cfs.

I am unaware of any site-specific empirical studies conducted at the Project to assess the following causes of hydroelectric dam-related mortality: predation in the headpond area as a result of changing the type of habitat upstream of the dam, spill-related mortality, mortality associated with fish using the downstream bypass system, delayed or latent mortality associated with fish passing through the turbines and not immediately killed, and mortality due to predation at locations immediately downstream of the Project infrastructure due to fish being injured or disoriented during passage through the Project.

However, there are data from studies conducted at dams on the nearby Kennebec River which do offer some indication of the mortality rates associated with the types of turbines found at the Pejepscot Project. Section 6.1 of this report summarizes some of the literature reporting turbine mortality rates for juvenile and adult Atlantic salmon-sized fish. For a more comprehensive review see Stone and Webster (1992) and Winchell and Amaral (1997).

B. **Conclusions Regarding Impacts on Fish –** I have reached the following conclusions with respect to turbine passage at Pejepscot:

I. There is a significant frequency, during critical downstream migration periods for Atlantic salmon smolts and/or kelts (April through June and October and November), when the river flows are low enough that essentially the entire flow of the river passes through the Project's turbines and bypass system. Please see the flows analysis below.

II. Given the fact that the flows into the existing downstream fish bypass system cannot adequately compete with the flows entering the turbines and effectively divert downstream migrating Atlantic salmon away from the turbines, I conclude that in these non-spill conditions the majority of the fish passing through the dam do so through the Project's turbines. Even during conditions of spill, fish will still pass through the Project's turbines if they are operating.

III. A scientifically defensible estimate of immediate Atlantic salmon smolt mortality passing through Kaplan type turbines at Pejepscot is approximately 15%. Mortality levels for kelts will be higher, with a reasonable working value of 25-50%. It is important to note that these values do not include mortality associated with downstream predation due to injury or disorientation or latent mortality as a result of passing through the turbines.

IV. Given the preceding conclusions, the Pejepscot Project is causing direct mortality to Atlantic salmon smolts and kelts by allowing fish to pass through the Project turbines. Although indirect and latent mortality have not been adequately assessed at this Project, it is reasonable to assume that some smaller percentage of indirect and latent mortality is also occurring as a result of turbine passage.

4. Upstream fishway for adult passage

A. **Evaluation –** The Project installed an adult fish trap, fish lift, and upstream conveyance canal in 1987 and has been providing passage opportunity for adult Atlantic salmon since then. However, I am unaware of any documentation of fish passing the dam. But, between 1983 and 2010, a total of 742 adult Atlantic salmon have been counted at the upstream fishway at the Brunswick Project. In 2011, 47 adults were counted. The 2011 count of 47 fish is the third largest number in the history of the fishway. Analysis of the hatchery versus wild components of the run shows 13.6% of the fish are of wild origin (Fay et al. 2006; Maine Department of Marine Resources. 2011a). I am not aware of any data documenting where adult Atlantic salmon are spawning or rearing in the Androscoggin River watershed at this time. I understand that a radio telemetry study of some type was conducted in 2011, but I have not seen any report on the results of any study that may have been conducted.

At river flow levels at or below the hydraulic capacity of the Project's turbines, most of the flow is exiting via the turbine tailraces, which are located adjacent to the entrance to the upstream fish entrance. This situation is acceptable for upstream passage. However, at flows above the Project's hydraulic capacity, flow is spilled away from the entrance to the fish trap and it is unknown what the effectiveness of the flow attraction is to get fish to enter the trap. While the spill gates are adjacent to the fish trap, spill over the non-gate spillway section may result in a delay or inability of adults to find the entrance to the upstream fishway.

B. **Conclusions Regarding Impacts on Fish –** Given the information in the evaluation above, I have reached the following conclusions regarding upstream fish passage facilities at the Pejepscot Project:

I. Adult Atlantic salmon were captured in the very first year the Brunswick Project's fishway was installed in 1983 – approximately 100 years since the last documented stocking of Atlantic salmon in the Androscoggin River (Fay et al. 2006). In addition, some percentage of returning fish has consistently been classified as wild origin since 1983. Given these facts, I conclude that there must have been a low level persistent run of Atlantic salmon into the Androscoggin River. This run has continued but I do not know where adult Atlantic salmon are spawning and rearing and whether or not those areas are upstream of the Pejepscot Project.

II. Under low flow conditions, adult Atlantic salmon follow the low flow (south) channel, because of the flow coming from the powerhouse tailrace, and find the entrance to the upstream fishway.

III. Under certain flow conditions, adult Atlantic salmon may be delayed from migrating upstream because of an inability to locate the entrance to the upstream fishway in a timely fashion. It is also possible that under certain flow conditions adult fish do not find the entrance to the upstream fishway and are thus blocked from passing upstream. I am unaware of any data or studies that address these issues, and thus I cannot assess the impacts to overall population productivity caused by any passage blockage and/or delay.

5. **Size and configuration of the headpond upstream of the dam**

   A. **Evaluation –** Based on my personal observations, a review of Google Earth photos of the Pejepscot Project-to-Worumbo Project section of the Androscoggin River, and comments made by Worumbo staff during my site visit, I estimate the headpond area at about 100+ acres. Although I am unable to verify this estimate, it appears reasonable, given the height of the spillway section. The headpond size is significant because in this area of the Pejepscot Project the habitat of the Androscoggin River has been changed from a flowing river channel to a more slow-moving water habitat. This lake-like habitat is more likely to contain fish species that are predators on juvenile Atlantic salmon and may not contain the cover features for juvenile salmon that would normally be present in a natural river channel. I am unaware of any data that would allow specific quantification of the habitat characteristics of this area or the predation rates on Atlantic salmon smolts.

   B. **Conclusions Regarding Impacts on Fish –** I conclude that levels of predation on Atlantic salmon smolts in the headpond area of the Pejepscot Project are higher than what they would be in a natural river channel. Given the lack of any site-specific, quantitative studies or data, it is impossible to reach a defensible quantitative assessment of the increased predation rate or the potential impacts on the Atlantic salmon population.

6. **Physical character of the river immediately downstream of the dam and tailrace areas as potential habitat for predators**

   A. **Evaluation –** Smolts can pass the Pejepscot Project by going over the spillway or passing through the turbines or downstream fish bypass system. Each of these routes may affect smolts in ways that make them more vulnerable to predation, as described in Section 5.2, above. No scientifically rigorous studies have been conducted to assess these impacts at Pejepscot, although the authors of studies conducted at the Lockwood Project that focused on other passage issues conclude that some radio tagged smolts were taken by downstream predators, based on movement patterns of the tags after passage through the project ((FPL Energy Maine Hydro, LLC. 2008a, Normandeau Associates, Inc. 2011c. Note this latter document is under a court protective order). The predation estimate in the 2011 study was 1.4%.

The configuration of the river channel and the effects of spill on juvenile Atlantic salmon passing over the spillway section make these fish vulnerable to predation. Given the presence of a concrete sill along the downstream base of the spillway section that can provide low velocity habitat for potential predators, I conclude that some yet to be quantified level of disorientation or injury increases vulnerability to predation.

Under low flow conditions, the majority of the river flow is passing through the bypass system or turbines. The river channel immediately downstream of the powerhouse tailrace appears deep. This type of habitat is very conducive to harboring predators. Given the probability of fish being disoriented by passing through the turbines, it is my opinion that predation rates in this specific area of the Project are higher than in other areas. However, no studies have specifically quantified the predation rate in this area.

B. Conclusions Regarding Impacts to Fish – I conclude that the Pejepscot Project's configuration and operations create conditions that result in increased predation of juvenile Atlantic salmon. There is one published estimate that would suggest a 1+% predation rate, but I do not believe that level is supported by scientifically reliable evidence. In my professional opinion, predation is occurring at some unknown level, likely in the low single digits. But given the lack of specific quantitative data, the actual level of predation below Pejepscot and the resultant impact on Atlantic salmon cannot be quantified at this time.

7. River flow regime during time periods critical for Atlantic salmon (April through June and October through November) in relation to the hydraulic capacity of the turbines

A. **Evaluation –** For a more detailed explanation of the data and procedure used to develop the figures below relating Androscoggin River flow conditions and the potential for all of the river flow to pass through the Project's turbines, see Section 6.2 of this report. Results of this analysis are presented below:

Figures referenced in this section are found in Section 8.1.2.1(7) above.

Data from Figure 8.1.1 for the Pejepscot Project show that during the month of April there is a consistent probability of over 5% that river flows will be ≤ Project hydraulic capacity. The probability varies close to 10% during most of the entire month.

Data from Figure 8.1.2 for the Pejepscot Project show that during the month of May there is a consistent probability of more than 10% that river flows will be ≤ Project hydraulic capacity. This probability increases to 25% during the last 20 days of the month and to 50% at the end of the month.

Data from Figure 8.1.3 for the Pejepscot Project show that during the month of June there is a consistent probability of 75% that river flows will be ≤ Project hydraulic capacity.

Data from Figure 8.1.4 for the Pejepscot Project show that during the month of October there is a probability of about 90% that river flows will be ≤ Project hydraulic capacity during the first 15 days of the month. The probability decreases to between 75% and 90% during the last 15 days of the month.

Data from Figure 8.1.5 for the Pejepscot Project show that during the month of November there is a consistent probability of approximately 75% that river flows will be ≤ Project hydraulic capacity.

B. Conclusions Regarding Impacts on Fish – The results of these analyses lead me to the following conclusions:

I. During the spring emigration period, the probabilities of river flow being ≤ the Pejepscot Project's hydraulic capacity range from 5 to 75%. During the most likely time when the majority of smolts would migrate, the probabilities range from 10-50%. This level of interaction with Project turbines is, in my opinion, unacceptable in terms of population survival and recovery, given the level of immediate turbine mortality at Pejepscot Project and the current status of the Atlantic salmon population in the Androscoggin River.

II. During the fall kelt emigration period, the analysis shows probabilities of > 75% for all of October and > 50% for all of November. This level of interaction with Project turbines is, in my opinion, unacceptable in terms of population survival and recovery, given the level of immediate turbine mortality at Pejepscot Project and the current status of the Atlantic salmon population in the Androscoggin River.

III. This analysis clearly demonstrates that the use of median monthly flow values to assess potential project impacts is not appropriate or defensible. As this analysis shows, the use of median monthly flows greatly underestimates the amount of time that river flows can be ≤ to project hydraulic capacity and thus the percentage of time that the only downstream passage route available for Atlantic salmon is through the project turbines and the inadequate downstream bypass system.

Given the current population levels, the age structure of adults captured at the Brunswick fish trapping facility, the decades it would take to rebuild even one year's loss of smolts due to project operations, and the cumulative effects of the three projects on the Androscoggin River that are the subject of this litigation, I believe the impacts associated with low river flows result in critical levels of mortality to Atlantic salmon on a reasonably predictable and routine basis.

8.2.3 Impacts on Atlantic salmon in the Merrymeeting Bay SHRU and, consequently, the GOM DPS as a whole

In order to evaluate impacts of dam operations on the Merrymeeting Bay SHRU and the GOM DPS as a whole, I used five parameters related to the Pejepscot Project, and these same parameters and conclusions are equally applicable to the Brunswick and Worumbo projects as well.

1) **Percentage of the total habitat in comparison to the GOM DPS –** According to the NMFS (2009b), the Merrymeeting Bay SHRU comprises approximately 46% of the land area in the GOM DPS, with the Androscoggin River watershed contributing 33% of the total for the Merrymeeting Bay SHRU. Therefore, the Androscoggin River watershed has the potential to be a dominant contributor to recovery in the SHRU and the GOM DPS overall because of its land area and the quality of habitats suitable for Atlantic salmon upstream of the Lisbon Falls.

2) **Population diversity and stability –** The Androscoggin River watershed is the third largest in Maine that is part of the GOM DPS and contains a significant quantity of designated critical habitat. Historically, the Androscoggin, Kennebec, and Penobscot watersheds were the largest producers of Atlantic salmon in Maine, and probably the East Coast. These large watersheds provided a variety of habitats that have resulted in genetic diversity among watersheds and overall population stability because of the variety of habitats and life history strategies necessary for salmon to persist in them (National Research Council 2002, 2004; Fay et al. 2006; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2009).

3) **Location of habitats suitable to promote recovery of the species –** The majority of habitats suitable to support Atlantic salmon spawning and juvenile rearing in the Androscoggin River watershed are located upstream of Lisbon Falls. Analysis of the biological value of habitats in the Androscoggin watershed

shows the highest and second highest value habitats in the Androscoggin basin. (National Marine Fisheries Service (2009b). The NMFS analysis found that a majority of the habitat suitable to support the PCE requirements for spawning and rearing, and thus recovery, were upstream of the Brunswick Project.

4) **Blockage and/or delay to upstream migrating adult Atlantic salmon –** As demonstrated in various analyses I described earlier in this report, the Brunswick Project may directly block or delay adult upstream migrants because of the presence of its spillway section and the potential for adult fish to use the river channel north of Shad Island. Under flow levels where spill is occurring on the north portion of the dam, adult fish may move towards this flow source. No fish passage facilities exist in this area of the Brunswick Project. No studies have documented whether adults are blocked or delayed because of their transit into this area of that Project. The fate of any fish that does not find the upstream fishway is unknown. I also conclude, given the configuration of the Pejepscot Project, that there is a low (non-zero) level of probability that some fish will be unable to find the fish trap entrance at Pejepscot.

5) **Mortality rate of Atlantic salmon smolts and kelts passing downstream through Pejepscot Project turbines –** Smolts and kelts moving downstream through the Pejepscot Project are subject to mortality associated with passage through the Project's turbines. During periods of non-spill at downstream migration time periods (see analyses of these time periods above), fish are forced to pass either via the Project's small and in my opinion ineffective downstream fishway or through the project turbines. Immediate mortality of smolts passing through Kaplan type turbines is about 15%, while immediate mortality of kelts is about twice that rate (See Section 6.1 of this report for a review of turbine mortality studies). It is likely that additional salmon die as a result of delayed turbine mortality, and that other salmon suffer adverse impacts as a result of going over the spillway or through the bypass structures, but these percentages have not been quantified.

Given the impacts of these five factors on individual Atlantic salmon, the effects of the Pejepscot Project on the spawning and rearing and migration PCE's, and the overall negative impact on the likelihood that the recovery criteria for the Merrymeeting Bay SHRU will be met, I conclude that the Pejepscot Project, as it is currently structurally configured and operated is having a significant adverse impact on the Merrymeeting Bay SHRU and the GOM DPS as a whole.

8.2.4 Interim Measures

Any or all of the following measures would either reduce the harm to Atlantic salmon currently being caused by the dams in question or contribute to efforts at restoration of the species.

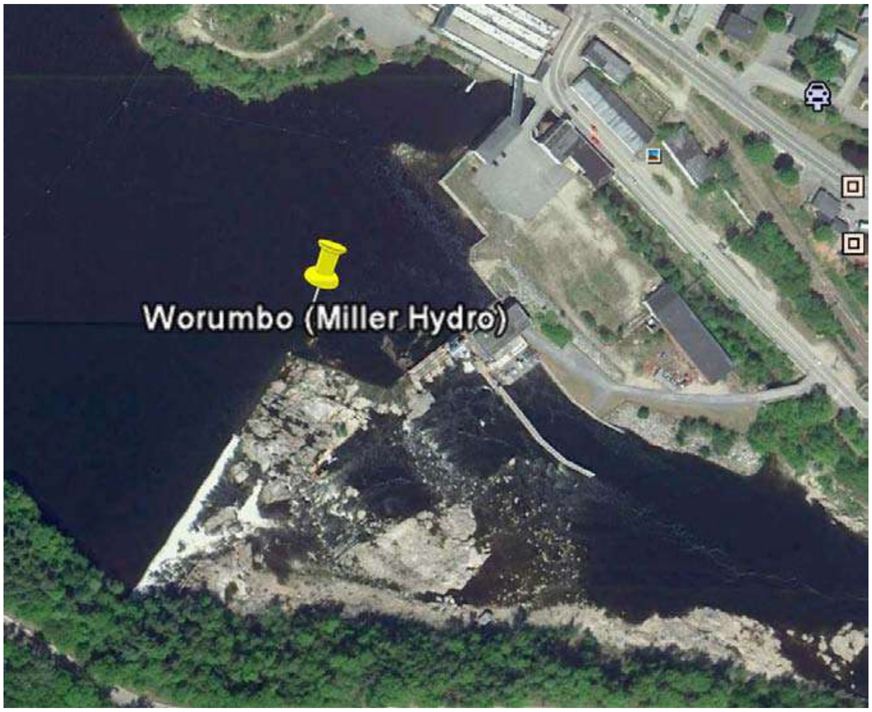
8.2.4.1 Interim Measures Applicable to All Projects on the Kennebec and Androscoggin rivers

A complete list of the interim measures applicable to all projects can be found in Section 7.1.4.1 of the Lockwood Project evaluation.

8.2.4.2 Additional Interim Measures Specifically for the Pejepscot Project

A. Increase the water velocity in the upstream conveyance channel for adult salmon to a minimum of 1.5 ft/sec.
B. Provide a downstream passage route on the southwest side of the spillway during the downstream migration period. Flow through this bypass should be provided during the downstream migration period of April through June and October through November.

8.3 Worumbo Project (Miller Hydro)



8.3.1 Brief Project Description

The Project consists of an approximately 850 ft. long overflow dam plus three gates, which are located adjacent to the downstream fish bypass and powerhouse on the northeast bank of the river. The height of the spillway section appears to be about 10 ft., but this section was being reconstructed during my site visit and I have no published height data. An upstream adult trapping facility is located inside the turbine tailrace, which is contained by a rock wall on one side and a concrete retaining wall on the southwest side. The adult trap lifts fish into an upstream conveyance channel, which allows fish to pass upstream of the dam. The downstream fish bypass located between the easternmost gate and the turbine intakes passes an unknown volume of water, but it appears to be in the 100-125 cfs range. I have been unable to find a published value for this discharge. The powerhouse contains two Kaplan turbines with a flow capacity of about 4,800 cfs each. Total hydraulic capacity of the Project is 9,600 cfs.

8.3.2 Impact of Worumbo Project on Atlantic Salmon

8.3.2.1 Impact on Individual Fish

I have analyzed seven factors (See section 4.3 for a detailed listing) related to the physical structure of the dam and adjacent river channel and operational parameters and characteristics in evaluating impacts of the project on Atlantic salmon. Below is my evaluation of these seven factors:

1. **Physical Structure of the Dam**

   A. **Evaluation –** The physical configuration and height of the dam creates a barrier to upstream migrating Atlantic salmon under most flows, in the absence of an effective upstream fishway. The Project installed the trap and lift passage system in 1988 and has providing passage opportunities for adult Atlantic salmon since then. At river flow levels at or below the hydraulic capacity of the Project's turbines, most of the flow is exiting via the turbine tailraces which are located adjacent to the fish trap entrance.

      The spillway section of the dam contains extensive bedrock ledges, except immediately downstream of the three gates and powerhouse tailrace.

   B. **Conclusions Regarding Impacts on Fish –** Given the physical configuration of the sloping spillway section of the dam, I believe that the Worumbo Project is causing the following impacts to Atlantic salmon:

      I. Under spill conditions, fish passing over the spillway are subject to death or injury caused by striking the bedrock ledges immediately downstream of the dam.

      II. Under certain flow conditions, adult Atlantic salmon may be delayed from migrating upstream because of an inability to locate the entrance to the upstream fishway in a timely fashion since considerable flow will be concentrated in the southwest corner of the spillway section. It is also possible, under certain flow conditions, adult fish do not find the entrance to the upstream fishway and are thus blocked from passing upstream. I am unaware of any data or studies that address these issues, and thus I cannot assess the impacts to overall population productivity caused by any passage blockage and/or delay.

2. **Downstream Fish Bypass System**

   A. **Evaluation –** The downstream fishway entrance is located adjacent to the turbine intakes. I do not have any published values for the flow through the bypass; it appears from photos to be in the range of 100-125 cfs. The outfall of the bypass discharges into the pool area below the spillway gates.

   B. **Conclusions Regarding Impacts on Fish –** Given the poor location of the downstream fishway (immediately adjacent to the Kaplan turbines intakes) and the lack of sufficient flow into the fishway to effectively "compete" with the flows passing into the turbines, I conclude that the downstream fishway is ineffective and does not adequately protect downstream migrating Atlantic salmon from passing through the Project's turbines. Mortality rates of various fish species and sizes passing through different turbines are reviewed in Section 6.1 of this report.

3. Types of turbines used to generate power

A. Evaluation – For an overview of turbine mortality rates see Section 6.1 of this report. The powerhouse contains two Kaplan turbines with a flow capacity of about 4,800 cfs each. Total hydraulic capacity of the Project is 9,600 cfs.

I am unaware of any site-specific empirical studies conducted at the Project to assess the following causes of hydroelectric dam-related mortality: predation in the headpond area as a result of changing the type of habitat upstream of the dam, spill-related mortality, mortality associated with fish using the downstream bypass system, delayed or latent mortality associated with fish passing through the turbines and not immediately killed, and mortality due to predation at locations immediately downstream of the Project infrastructure due to fish being injured or disoriented during passage through the Project.

However, there are data from studies conducted at dams on the nearby Kennebec River which do offer some indication of the mortality rates associated with the types of turbines found at the Worumbo Project. Section 6.1 of this report summarizes some of the literature reporting turbine mortality rates for juvenile and adult Atlantic salmon-sized fish. For a more comprehensive review see Stone and Webster (1992) and Winchell and Amaral (1997).

B. Conclusions Regarding Impacts on Fish – I have reached the following conclusions with respect to turbine passage at Worumbo:

I. There is a significant frequency, during critical downstream migration periods for Atlantic salmon smolts and/or kelts (April through June and October and November), when the river flows are low enough that essentially the entire flow of the river passes through the Project's turbines and bypass system. Please see the flows analysis below.

II. Given the fact that the flows into the existing downstream fish bypass system in all likelihood cannot adequately compete with the flows entering the turbines and effectively divert downstream migrating Atlantic salmon away from the turbines, I conclude that in these non-spill conditions the majority of the salmon passing through the Project do so through the Project's turbines. Even during conditions of spill, fish will still pass through the Project's turbines if they are operating.

III. A scientifically defensible estimate of immediate Atlantic salmon smolt mortality passing through Kaplan type turbines at Worumbo is approximately 15%. Mortality levels for kelts will be higher, with a reasonable working value of 25-50%. It is important to note that these values do not include mortality associated with downstream predation due to injury or disorientation or latent mortality as a result of passing through the turbines.

IV. Given the preceding conclusions, the Worumbo Project is causing direct mortality to Atlantic salmon smolts and kelts by allowing fish to pass through the Project turbines. Although indirect and latent mortality have not been adequately assessed at this Project, it is reasonable to assume that some smaller percentage of indirect and latent mortality is also occurring as a result of turbine passage.

4. Upstream fishway for adult passage

A. Evaluation – The Project installed an adult fish trap, fish lift, and upstream conveyance canal in 1988 and has been providing passage opportunity for adult Atlantic salmon since then. However, I am unaware of any documentation of fish passing the dam. But between 1983 and 2010 at total of 742 adult Atlantic salmon have been counted at the upstream fishway at the Brunswick Project. In 2011, 47 adults were counted. The 2011 count of 47 fish is the third largest number in the history of the fishway. Analysis of the hatchery versus wild components of the run shows 13.6% of the fish are of wild origin (Fay et al. 2006; Maine Department of Marine Resources 2011a). I am not aware of any data documenting where adult Atlantic salmon are spawning or rearing in the Androscoggin River watershed at this time. I understand that a radio telemetry study of some type was conducted in 2011, but I have not seen any report on the results of any study that may have been conducted.

At river flow levels at or below the hydraulic capacity of the Project's turbines, most of the flow is exiting via the turbine tailraces which are located adjacent to the entrance to the upstream fish entrance. This situation is acceptable for upstream passage. However, at flows above the Project's hydraulic capacity, flow is spilled away from the entrance to the fish trap and it is unknown what the effectiveness of the flow attraction is to get fish to enter the trap. While the spill gates are adjacent to the fish trap, spill over the non-gate spillway section, particularly in the southwest portion of the spillway, may result in a delay or inability of adults to find the entrance to the upstream fishway.

B. Conclusions Regarding Impacts on Fish – Given the information in the evaluation above, I have reached the following conclusions regarding upstream fish passage facilities at the Worumbo Project:

I. Adult Atlantic salmon were captured the first year the Brunswick Project's fishway was installed in 1983. This is approximately 100 years since the last documented stocking of Atlantic salmon in the Androscoggin River (Fay et al. 2006). However, with fish to appearing in the first year of the fishway operation, I conclude that there must have been a low level persistent run of Atlantic salmon into the Androscoggin River given the lack of previous stocking and the percentage of the fish classified as wild origin since 1983. This run has continued but I do not know where adult Atlantic salmon are spawning and rearing and whether or not those areas are upstream of the Worumbo Project.

II. Under low flow conditions, adult Atlantic salmon follow the northeast channel, because of the flow coming from the powerhouse tailrace and find the entrance to the upstream fishway;

III. Under certain flow conditions, adult Atlantic salmon may be delayed from migrating upstream because of an inability to locate the entrance to the upstream fishway in a timely fashion. It is also possible that under certain conditions adult fish do not find the entrance to the upstream fishway and are thus blocked from passing upstream. I am unaware of any data or studies that address these issues, and thus cannot assess the impacts to overall population productivity caused by any passage blockage and/or delay.

5. Size and configuration of the headpond upstream of the dam

A. Evaluation – Based on my personal observations and review of Google Earth photos of the Worumbo project section of the Androscoggin River, I estimate the headpond area at about 10+ acres. Although I am unable to verify this estimate, it appears reasonable, given the height of the spillway section. The headpond can provide habitat for predators, because in this area of the Worumbo Project, the habitat of the Androscoggin River has been changed from a flowing river channel to a more slow-moving water habitat. This lake-like habitat is more likely to contain fish species that are predators on juvenile Atlantic salmon and may not contain the cover features for juvenile salmon that would normally be present in a natural river channel. I am unaware of any data that has specifically quantified the habitat characteristics of this area or quantified predation rates on Atlantic salmon smolts.

B. **Conclusions Regarding Impacts on Fish –** I conclude that it is likely that levels of predation of Atlantic salmon smolts in the headpond area of the Worumbo Project are higher than what they would be in a natural river channel. But given the lack of any site-specific, quantitative studies or data, it is impossible to reach a defensible quantitative assessment of the increased predation rate or the potential impacts on the Atlantic salmon population.

6. Physical character of the river immediately downstream of the dam and tailrace areas as potential habitat for predators

A. **Evaluation –** Smolts can pass the Worumbo Project by going over the spillway, or passing through the turbines or downstream fish bypass system. Each of these routes may affect smolts in ways that make them more vulnerable to predation, as described in Section 5.2, above. No scientifically rigorous studies have been conducted to assess these impacts at Worumbo, although the authors of studies conducted at the Lockwood Project that focused on other passage issues conclude that some radio tagged smolts were taken by downstream predators, based on movement patterns of the tags after passage through the project ((FPL Energy Maine Hydro, LLC. 2008a, Normandeau Associates, Inc. 2011c. Note this latter document is under a court protective order). The predation estimate in the 2011 study was 1.4%.

The configuration of the river channel and the effects of spill on juvenile Atlantic salmon passing over the spillway section may make these fish vulnerable to predation. Given the presence of a concrete sill along the downstream base of the spillway section that can provide low velocity habitat for potential predators, I conclude that some yet to be quantified level of disorientation or injury increases vulnerability to predation. Also, the extensive bedrock ledges greatly increase the risk of death or injury to fish passing over the spillway during higher flows. The “pond-like” area downstream of the spillway in the southwest corner of the Project also provides an area suitable for predators to congregate.

Under low flow conditions, the majority of the river flow is passing through the bypass system or turbines. The river channel immediately downstream of the powerhouse tailrace is relatively deep. This type of habitat is very conducive to harboring predators. Given the probability of fish being disoriented by passing through the turbines, it is my opinion that predation rates in this specific area of the Project are higher than other areas. However, no studies have specifically quantified the predation rate in this area.

B. **Conclusions Regarding Impacts to Fish and this Factor –**I conclude that the Worumbo Project's configuration and operations create conditions that are likely to result in increased predation of juvenile Atlantic salmon. There is one published estimate that would suggest a 1+% predation rate, but I do not believe that level is supported by scientifically reliable evidence. In my professional opinion, predation is occurring at some unknown level, likely in the low single digits. But given the lack of specific quantitative data, the actual level of predation below Worumbo, and the resultant impact on Atlantic salmon, cannot be quantified at this time.

7. **River flow regime during time periods critical for Atlantic salmon (April through June and October through November) in relation to the hydraulic capacity of the turbines**

A. **Evaluation –** For a more detailed explanation of the data and procedure used to develop the figures below relating Androscoggin River flow conditions and the potential for all of the river flow to pass through the Project's turbines, see Section 6.2 of this report. Results of this analysis are presented below:

Figures referenced in this section are found in Section 8.1.2.1(7) above.

Data from Figure 8.1.1 for the Worumbo Project show that during the month of April there is a consistent probability of between 10% and 25% that river flows will be ≤ Project hydraulic capacity.

Data from Figure 8.1.2 for the Worumbo Project show that during the month of May there is a consistent probability of more than 25% that river flows will be ≤ Project hydraulic capacity. This probability increases to more than 50% during the last 10 days of the month.

Data from Figure 8.1.3 for the Worumbo Project show that during the month of June there is a consistent probability of >75% that river flows will be ≤ Project hydraulic capacity.

Data from Figure 8.1.4 for the Worumbo Project show that during the month of October there is a probability of about 90% that river flows will be ≤ Project hydraulic capacity during the first 15 days of the month. The probability decreases to between 75% and 90% during the last 15 days of the month.

Data from Figure 8.1.5 for the Worumbo Project show that during the month of November there is a consistent probability of > 75% that river flows will be ≤ Project hydraulic capacity.

B. Conclusions Regarding Impacts on Fish – The results of these analyses lead me to the following conclusions:

I. During the spring emigration period, the probabilities of river flow being ≤ the Worumbo Project's hydraulic capacity range from 10% to 75%. During the most likely time when the majority of smolts would migrate, the probabilities range from 10-50%. This level of interaction with Project turbines is, in my opinion, unacceptable in terms of population survival and recovery, given the level of immediate turbine mortality at Worumbo Project and the current status of the Atlantic salmon population in the Androscoggin River.

II. During the fall kelt emigration period, the analysis shows probabilities of > 90% for the first half of October and > 75% for all of November. This level of interaction with Project turbines is, in my opinion, unacceptable in terms of population survival and recovery, given the level of immediate turbine mortality at Worumbo Project and the current status of the Atlantic salmon population in the Androscoggin River.

III. This analysis clearly demonstrates that the use of median monthly flow values to assess potential project impacts is not appropriate or defensible. As this analysis shows, the use of median monthly flows greatly underestimate the amount of time that river flows can be ≤ to project hydraulic capacity and thus the percentage of time that the only downstream passage route available for Atlantic salmon is through the project turbines and the inadequate downstream bypass system.

Given the current population levels, the age structure of adults captured at the Brunswick fish trapping facility, the decades it would take to rebuild even one year's loss of smolts due to project operations, and the cumulative effects of the three projects on the Androscoggin River that are the subject of this litigation, I believe the impacts associated with low river flows result in critical levels of mortality to Atlantic salmon on a reasonably predictable and routine basis.

8.3.3 Impacts on Atlantic salmon in the Merrymeeting Bay SHRU and, consequently, the GOM DPS as a whole

In order to evaluate impacts of dam operations on the Merrymeeting Bay SHRU and the GOM DPS as a whole, I used five parameters related to the Worumbo Project, and these same parameters and conclusions are equally applicable to the Brunswick and Pejepscot projects as well.

1) **Percentage of the total habitat in comparison to the GOM DPS –** According to the NMFS (2009b), the Merrymeeting Bay SHRU comprises approximately 46% of the land area in the GOM DPS, with the Androscoggin River watershed contributing 33% of the total for the Merrymeeting Bay SHRU. Therefore, the Androscoggin River watershed has the potential to be a dominant contributor to recovery in the SHRU and the GOM DPS overall because of its land area and the quality of habitats suitable for Atlantic salmon upstream of the Lisbon Falls.

2) **Population diversity and stability –** The Androscoggin River watershed is the third largest in Maine that is part of the GOM DPS and contains a significant quantity of designated critical habitat. Historically, the Androscoggin, Kennebec, and Penobscot watersheds were the largest producers of Atlantic salmon in Maine, and probably the East Coast. These large watersheds provided a variety of habitats that have resulted in genetic diversity among watersheds and overall population stability because of the variety of habitats and life history strategies necessary for salmon to persist in them (National Research Council 2002, 2004; Fay et al. 2006; National Marine Fisheries Service and U.S. Fish and Wildlife Service 2009).

3) **Location of habitats suitable to promote recovery of the species –** The majority of habitats suitable to support Atlantic salmon spawning and juvenile rearing in the Androscoggin River watershed are located upstream of Lisbon Falls. Analysis of the biological value of habitats in the Androscoggin watershed shows the highest and second highest value habitats in the Androscoggin basin. (National Marine Fisheries Service (2009b). The NMFS analysis found that a majority of the habitat suitable to support the PCE requirements for spawning and rearing, and thus recovery, were upstream of the Brunswick Project.

4) **Blockage and/or delay to upstream migrating adult Atlantic salmon –** As demonstrated in various analyses I described earlier in this report, the Brunswick Project may directly block or delay adult upstream migrants because of the presence of its spillway section and the potential for adult fish to use the river channel north of Shad Island. Under flow levels where spill is occurring on the

north portion of the dam, adult fish may move towards this flow source. No fish passage facilities exist in this area of the Brunswick Project. No studies have documented whether or not adults are blocked or delayed because of their transit into this area of the Project. The fate of any fish that does not find the upstream fishway is unknown. I also conclude, given the configuration of the Pejepscot Project, that there is a low level of probability that some fish are unable to find the fish trap entrance at Pejepscot, but that probability is not zero. The probability of Atlantic salmon being blocked at the Worumbo Project is higher than at Pejepscot because of the configuration of the dam and the presence of essentially a second channel on the southwest portion of the Worumbo Project. This makes it more likely that fish may be attracted to this area and will not find the entrance to the Worumbo fish trap.

5) **Mortality rate of Atlantic salmon smolts and kelts passing downstream through Worumbo Project turbines –** Smolts and kelts moving downstream through the Worumbo Project are subject to mortality associated with passage through the Project's turbines. During periods of non-spill at downstream migration time periods (see analyses of these time periods above), fish are forced to pass via the Project's small and in my opinion ineffective downstream fishway or the project turbines. Immediate mortality of smolts passing through Kaplan type turbines is about 15%, while immediate mortality of kelts is about twice that rate (See Section 6.1 of this report for a review of turbine mortality studies). It is likely that additional salmon die as a result of delayed turbine mortality, and that other salmon suffer adverse impacts as a result of going over the spillway or through the bypass structures, but these percentages have not been quantified.

Given the impacts of these five factors on individual Atlantic salmon, the effects of the Worumbo Project on the spawning and rearing and migration PCE's, and the overall negative impact on the likelihood that the recovery criteria for the Merrymeeting Bay SHRU will be met, I conclude that the Worumbo Project, as it is currently structurally configured and operated is having a significant adverse impact on the Merrymeeting Bay SHRU and the GOM DPS as a whole.

8.3.4 Interim Measures

Any or all of the following measures would either reduce the harm to Atlantic salmon currently being caused by the dams in question or contribute to efforts at restoration of the species.

8.3.4.1 Interim Measures Applicable to All Projects on the Kennebec and Androscoggin rivers

A complete list of the interim measures applicable to all projects can be found in Section 7.1.4.1 of the Lockwood Project evaluation.

8.3.4.2 Additional Interim Measures Specifically for the Worumbo Project

A. Create an opening in the west turbine tailrace training wall to allow upstream migrating adult salmon swimming up the west side of the wall to cross over to the actual tailrace and find the upstream trapping facility.

9.0 Consequences of Delay in Requiring Improvements to Fish Passage

The Maine Department of Marine Resources (MDMR) has embarked on an aggressive egg planting program in the Sandy River, upstream of the four Hydro Kennebec Development Group dams, in order to "jump-start" restoration of Atlantic salmon in the Kennebec River watershed. From 2004 to 2007, an average of ~22,000 eggs was planted in the Sandy River. Beginning in 2008, the egg planting program has expanded by factors of 10-40X, with 245,000, 166,000, 567,000, and 900,000 eggs being planted in 2008-2011, respectively (Maine Department of Marine Resources 2011; Paul Christman, MDMR, pers. comm.). In addition, in 2011 over 60 adult Atlantic salmon were trapped at the Lockwood fish trapping facility and transported to the Sandy River. Assuming that approximately 25% of the 60 fish were females, based on the sex composition at the Lockwood trap, this equates to an additional 100,000 eggs being deposited in the Sandy River.

The consequence of increased egg plantings and the number of adults being released in the Sandy River is that more listed Atlantic salmon smolts and kelts will be moving downstream through the dams on the lower Kennebec River. In addition, given the age at maturity, adult fish from the 2008 increased egg planting could begin returning to Lockwood as early as spring 2012. Given the lack of adult upstream passage facilities and the poor location of the adult trap at Lockwood, it is my opinion that the full benefits of the egg planting and adult release programs will not be realized. Also, given the lack of effective barriers to keep smolts and kelts from entering project turbines and the general ineffectiveness of the currently installed downstream bypass systems, it is my opinion that there will be significant losses of Atlantic salmon at all four of the Kennebec dams. This situation will be particularly acute during low flow years when all of the river flow essentially passes through the project turbines or ineffective downstream fish bypass systems. In my opinion, any delay in immediately implementing improved upstream adult fish passage facilities and in greatly reducing the ability of smolts and kelts to enter the projects' turbines will only result in increased mortality or harm to listed species, and will effectively negate the current efforts to restore Atlantic salmon to the Kennebec River.

While the three dams in question on the Androscoggin River have all installed upstream adult passage facilities, only the Brunswick Project has a formal fishway constructed. The others have a trap, lift, and upstream conveyance channel. The trapping facilities all need to be evaluated in terms of their ability to handle ESA listed fish more effectively and with less harm. However, the critical issue with all three Androscoggin River projects is that it is currently unknown how effective these facilities are at passing adult Atlantic salmon upstream. There are potential problems with delay or blockage of migrating adults that have not been assessed. Given the physical configurations of all three dams, additional upstream passage facilities at other locations on each dam are warranted.

Generally the downstream bypass facilities at the Androscoggin dams are poorly located and inadequate to protect fish from entering the project turbines, resulting in higher mortality rates than is acceptable in terms of population recovery.

10.0 Comparison of Efforts Undertaken by, or Proposed for, Maine Dam Owners with Efforts Taken by Government Agencies and Dam Owners Elsewhere in the U.S.

I have been personally involved in watershed scale Pacific salmon and steelhead restoration efforts in the Columbia River, Klamath River, and Central Valley of California. My involvement has included: 1) development and implementation of site specific habitat restoration projects, 2) development of both small and large scale watershed restoration plans, 3) development and review of project effectiveness monitoring programs, and 4) evaluation of the effectiveness of hundreds of millions of dollars in project expenditures for restoration of habitats and populations of listed species.

Based on my experiences in the Western U.S., restoration of the various salmon populations began even before the fish were listed under ESA. Sport and commercial fishing groups, Native American tribes, resource agency staffs, and environmental groups all pushed to develop programs aimed specifically at restoring salmon habitats and populations along the West Coast. The Bonneville Power Administration in the Columbia River watershed has had a $700 million/yr. program for the past 30+ years. California passed a multi-billion dollar bond issue to fund restoration activities in the Central Valley. In addition, federal agencies such as the U.S. Bureau of Reclamation have been forced to acknowledge their responsibilities for salmon restoration through proactive agency response and court order. In the West, the question is not longer whether to restore anadromous fish populations, but rather how can it be done in the most efficient and cost effective manner. The public takes great pride in the restoration successes of the Redfish Lake sockeye salmon and winter-run Chinook salmon populations.

Comparing what I have seen in the documentation from the various studies and reports I reviewed from the Kennebec and Androscoggin rivers to what has happened in the West provides a “night and day” contrast. In Maine, I see a process that appears designed to delay the acquisition of the appropriate data, and studies designed with insufficient rigor and/or scope to answer the critical questions necessary to form the foundation of a real restoration program. Despite all of the positive words regarding restoration in the KHDG annual reports and all of the pronouncements in the results of the various studies conducted, the KHDG Settlement Agreement studies program comes down to the various dam owners asserting – in the white papers and biological assessment developed for the ESA incidental take permitting process – that no site-specific quantitative data exist at the various projects, and therefore data from other hydroelectric projects must be used to assess the projects’ impacts. My conclusion, based on my experience and review of the documentation, is that there has been a concerted effort to *not* collect the appropriate data, despite numerous suggestions by resource agencies to the contrary, and it appears that the agency staff are not able to compel the scientifically rigorous studies needed to provide data to support a truly science-based restoration program.

Further, some of the obvious solutions to problems do not need study results to support an implementation program. The best example of this is the obvious need to provide effective upstream adult Atlantic salmon passage at the Weston, Shawmut, Hydro Kennebec, and Lockwood Projects. To assert that the current trap and truck program is adequate to provide upstream passage, or that the Lockwood Dam presents a total barrier to upstream adult Atlantic salmon passage under all flow conditions, borders on the absurd. In my opinion, the restoration program at the dams that are the subject of this litigation has been underfunded, plagued by poor quality scientific studies, and has accomplished much less than should have been achieved since 1998 on the Kennebec River.

______________________________ January 16, 2012

Randy Bailey

References

Barrick, D. H. and L. E. Miller. 1990. Effectiveness of an electrical barrier in blocking fish movements. Research Report PES/90-07. Production Environmental Services, Duke Power Company, Huntersville, NC

Fay C., M. Bartron, S. Craig, A. Hecht, J. Pruden, R. Saunders, T. Sheehan, and J. Trial. 2006. Status review for anadromous Atlantic salmon (S*almo salar*) in the United States. Report to the National Marine Fisheries Service and U.S. Fish and Wildlife Service.

FPL Energy Maine Hydro, LLC. 2007. Diadromous fish passage report for the lower Kennebec River watershed during the 2006 migration season. FPL Energy Maine Hydro, LLC.

FPL Energy Maine Hydro, LLC. 2008a. Diadromous fish passage efforts for the lower Kennebec River watershed during the 2007 migration season. FPL Energy Maine Hydro, LLC.

FPL Energy Maine Hydro, LLC. 2008b. Transmittal letter and response to agency comments on the 2007 Kennebec River Diadromous Fish Restoration Annual Reports to Kimberly D. Bose, Secretary, Federal Energy Regulatory Commission, dated June 4, 2008.

Holbrook, C. M., M. T. Kinnison, and J. Zydlewski. 2011. Survival of migrating Atlantic salmon smolts through the Penobscot River, Maine: a prerestoration assessment. Transactions of the American Fisheries Society 140: 1255-1268.

Hydro Kennebec, LLC. 2011. Hydro Kennebec Project, FERC No. 2611 draft biological assessment for Gulf of Maine Distinct Population Segment of Atlantic salmon. Hydro Kennebec, LLC, Winslow, ME. (Note: this document is under a court protective order).

Kircheis, D. and T. Liebich. 2007. Draft report on: Habitat requirements and management considerations for Atlantic salmon (*Salmo salar*) in the Gulf of Maine Distinct Population Segment (DPS). NOAA-Fisheries, Northeast Region Protected Resources Division. Gloucester, MA

Madison Paper Industries. 2009. Hydro Kennebec Project, FERC NO. 2611 2008 study evaluating interim downstream fish passage effectiveness final report. Package includes the final report and the initial study plan (Appendix A), plus transmittal correspondence. Madison Paper Industries, Madison, Maine

Madison Paper Industries. 2010. Hydro Kennebec Project (FERC NO. 2611) 2009 Downstream Atlantic salmon smolt passage study. Draft report. Madison Paper Industries, Madison, Maine.

Maine Department of Marine Resources. 2009. Kennebec River anadromous fish restoration: annual progress report – 2008. Bureau of Sea-Run Fisheries and Habitat. Augusta, Maine.

Maine Department of Marine Resources. 2010. Kennebec River anadromous fish restoration: annual progress report – 2009. Bureau of Sea-Run Fisheries and Habitat. Augusta, Maine.

Maine Department of Marine Resources. 2011a. 2010 Brunswick Fishway Report. Bureau of Sea-Run Fisheries and Habitat. Augusta, Maine.

Maine Department of Marine Resources. 2011b. Kennebec River anadromous fish restoration: annual progress report – 2010. Bureau of Sea-Run Fisheries and Habitat. Augusta, Maine.

McCaw, D. E., P. M. Christman, C. A. King, and J. E. Overlock. 2009. 2008-2009 Kennebec River radio telemetry study. Included as part of Appendix E in the Kennebec River anadromous fish restoration annual report. Bureau of Sea-Run Fisheries and Habitat, Maine Department of Marine Resources. Hallowell, Maine.

National Marine Fisheries Service. 2009a. Designation of critical habitat for Atlantic salmon (*Salmo salar*) in the Gulf of Maine Distinct Population Segment: Final ESA Section 4(b)(2) report. Northeast Region, National Marine Fisheries Service. Gloucester, MA.

National Marine Fisheries Service. 2009b. Biological valuation of Atlantic salmon habitat within the Gulf of Maine Distinct Population Segment. Northeast Region, National Marine Fisheries Service. Gloucester, MA.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2009. Endangered and threatened species; determination of endangered status for the Gulf of Maine Distinct Population Segment of Atlantic salmon; Final Rule. June 19, 2009. 74 Federal Register: 29344-29387.

National Marine Fisheries Service, Maine Department of Marine Resources, U.S. Fish and Wildlife Service, and Penobscot Indian Nation. 2010. Atlantic salmon recovery framework: August 2010 draft.

National Research Council. 2002. Genetic status of Atlantic salmon in Maine: Interim Report from the Committee on Atlantic Salmon in Maine. Committee on Atlantic Salmon in Maine, Board on Environmental Studies and Toxicology, Ocean Studies Board. National Research Council, National Academy of Sciences.

National Research Council. 2004. Atlantic salmon in Maine. Committee on Atlantic Salmon in Maine, Board on Environmental Studies and Toxicology, Ocean Studies Board, Division on Earth and Life Sciences. National Research Council, National Academy of Sciences.

NextEra™ Energy Maine Operating Services, LLC. 2009. NextEra diadromous fish passage report for the lower Kennebec River watershed during the 2008 migration season. NextEra™ Energy Maine Operating Services, LLC. Hallowell, Maine.

NextEra™ Energy Maine Operating Services, LLC. 2010. NextEra diadromous fish passage report for the lower Kennebec River watershed during the 2009 migration season. NextEra™ Energy Maine Operating Services, LLC. Hallowell, Maine.

NextEra™ Energy Maine Operating Services, LLC. 2011. NextEra diadromous fish passage report for the lower Kennebec River watershed during the 2010 migration season. Includes: transmittal correspondence and agency comments. NextEra™ Energy Maine Operating Services, LLC. Hallowell, Maine.

Normandeau Associates, Inc. 2011b. A review of the effects of the Lockwood Project on the Kennebec River, Maine on Atlantic salmon (Salmo salar) smolt and kelt downstream passage and adult upstream passage. August 2011 Draft White Paper prepared for The Merimil Limited Partnership, Hallowell, Maine.

Normandeau Associates, Inc. 2011c. Downstream bypass effectiveness for the passage of Atlantic salmon smolts at the Lockwood Project (FERC Project No. 2574, Kennebec River, Maine. Report prepared for The Merimil Limited Partnership, Hallowell, Maine. NOTE: Contains Lockwood portion of the data for the concurrent Hydro Kennebec study and is under a court protective order.

Normandeau Associates, Inc. 2011d. Downstream bypass effectiveness for the passage of Atlantic salmon smolts at the Hydro-Kennebec Project, Kennebec River, Maine. Report prepared for Great Lakes Hydro America, LLC. Millinocket, Maine.

Normandeau Associates, Inc. 2011e. A review of the effects of the Lockwood Project on the Kennebec River, Maine on Atlantic salmon (Salmo salar) smolt and kelt downstream passage and adult upstream passage. December 2011 Draft White Paper prepared for The Merimil Limited Partnership, Hallowell, Maine. Note: this document is under a court protective order.

Normandeau Associates, Inc. 2011f. A review of the effects of the Shawmut Project on the Kennebec River, Maine on Atlantic salmon (Salmo salar) smolt and kelt downstream passage and adult upstream passage. December 2011 Draft White Paper prepared for FPL Energy Maine Hydro, LLC., Hallowell, Maine. Note: this document is under a court protective order.

Normandeau Associates, Inc. 2011g. A review of the effects of the Weston Project on the Kennebec River, Maine on Atlantic salmon (Salmo salar) smolt and kelt downstream passage and adult upstream passage. December 2011 Draft White Paper prepared for FPL Energy Maine Hydro, LLC., Hallowell, Maine. Note: this document is under a court protective order.

Normandeau Associates, Inc. 2011h. Submission 00003964 from Normandeau Associates, Inc. which is an Excel spreadsheet containing characteristics of the turbines found at the Lockwood, Shawmut, Weston, and Brunswick projects.

Normandeau Associates, Inc. 2011i. A review of the Brunswick Project on the Androscoggin River, Maine on Atlantic salmon (Salmo salar) smolt and kelt downstream passage and adult upstream passage. August 2011 Draft White Paper prepared for FPL Energy Maine Hydro, LLC., Hallowell, Maine.

Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008b. Evaluation of Atlantic salmon kelt downstream passage at the Lockwood Project Kennebec River, Maine. Report to FPL Energy Maine Hydro, LLC. Lewiston, Maine.

Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008c. Evaluation of adult river herring and American shad downstream passage at the Lockwood Project Kennebec River, Maine. Report to FPL Energy Maine Hydro, LLC. Lewiston, Maine.

Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008d. Evaluation of Atlantic salmon smolt downstream passage at the Lockwood Project Kennebec River, Maine. Report to FPL Energy Maine Hydro, LLC. Lewiston, Maine.

Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008e. Evaluation of silver American eel downstream passage at the Shawmut Project, Kennebec River, Maine. Report to FPL Energy Maine Hydro, LLC. Lewiston, Maine.

Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2008g. Upstream passage evaluation of the Weston Project eelway (FERC No. 2325). Report to FPL Energy Maine Hydro, LLC. Lewiston, Maine.

Normandeau Associates, Inc. and FPL Energy Maine Hydro, LLC. 2009a. Evaluation of silver American eel downstream passage at the Shawmut Project, Kennebec River, Maine. Report to FPL Energy Maine Hydro, LLC. Lewiston, Maine.

Normandeau Associates, Inc. and NextEra™ Energy Maine Operating Services, LLC. 2009b. Evaluation of silver American eel downstream passage at the Weston Project, Kennebec River, Maine. Report to NextEra™ Energy Maine Operating Services, LLC. Augusta, Maine.

Palmisano, A. D. and C. V. Burger. 1988. Use of a portable electric barrier to estimate Chinook salmon escapement in a turbid Alaskan river. North American Journal of Fisheries Management 8:475-480.

Robson, A., I. G. Cowx, and J. PL. Harvey. 2011. Impact of run-of river hydro-schemes upon fish populations: Phase I literature review. Report prepared for the Scotland & Northern Ireland Forum for Environmental Research. Edinburgh, Scotland, UK.

S. P. Cramer and Associates, Inc. 1993. Biological assessment for evaluation of sound and electrical guidance systems at the Wilkins Slough Diversion operated by Reclamation District 108. Report prepared for Reclamation District 108, Grimes, CA

Stone & Webster Environmental Services. 1992. Fish entrainment and turbine mortality review and guidelines. EPRI Research Project No. 2694-01. EPRI Product ID: TR-101231. Palo Alto CA.

Winchell, F. C. and S. V. Amaral. 1997. Turbine entrainment and survival database - field tests. Report and database prepared by Alden Research Laboratories, Inc. for the Electric Power Research Institute, Palo Alto, CA. EPRI Report: TR-108630.

U.S. Atlantic Salmon Assessment Committee. 2011. Annual report of the U.S. Atlantic Salmon Assessment Committee. Report 23-2010 Activities. U.S. Atlantic Salmon Assessment Committee.

Exhibit 11

Opinion of Dr. Jeffrey A. Hutchings

Killam Professor of Biology (2012-2017)
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Qualifications

After receiving my doctorate in Evolutionary Ecology from Memorial University of Newfoundland (Canada) in 1991, I undertook postdoctoral research at the University of Edinburgh (Scotland) and at the Department of Fisheries and Oceans, St. John's, Newfoundland. As Killam Professor of Biology at Dalhousie University in Canada and as Adjunct Professor at the University of Oslo in Norway, my research focuses on life history evolution, population ecology, genetics, and conservation biology of fishes. I have published more than 150 research papers in the peer-reviewed, primary scientific literature. Since 1999, I have served on the editorial boards of 6 national and international peer-reviewed scientific journals. From 2006-2010, I chaired Canada's national science advisory body responsible, by federal statute, for assessing the risk of extinction of Canadian species and population (www.cosewic.gc.ca). I am President of the 900-member Canadian Society for Ecology and Evolution (2012-2013). And, since 2009, I have chaired a Royal Society of Canada expert panel studying the effects of climate change, fisheries, and aquaculture on Canadian marine biodiversity, including Atlantic salmon.

Among others, I have had the following experience on scientific issues pertaining to the conservation biology of Atlantic salmon, a species that I started researching thirty years ago, in Newfoundland, in 1982. I was an invited speaker at the inaugural *International Conference on Interactions Between Wild and Cultured Atlantic Salmon* held in Loen, Norway, in April, 1990. Since 1995, I have been regularly invited by the Canadian Department of Fisheries & Oceans (DFO) to serve as a reviewer of stock assessments for Atlantic salmon in the Maritimes and Newfoundland. In 1996, I was a Canadian member of the Canada/U.S. Genetics Subgroup of the *Scientific Working Group on Salmonid Introductions and Transfers*, NASCO (North Atlantic Salmon Conservation Organization). In 1998, I served as a member of two DFO-sponsored, international review panels responsible for assessing the consequences of interactions between wild and cultured Atlantic salmon and striped bass in Atlantic Canada. In 1998 and 2000, I served on 2 separate review panels responsible for evaluating the reasons for the decline of Atlantic salmon returning to North American rivers in the 1990s. Throughout the 2000s, I served on the arms-length-from-government committee (www.cosewic.gc.ca) responsible for assessing the risk of extinction of hundreds of at-risk Canadian species, including Canada's 16 Designatable Units of Atlantic salmon (these are directly analogous to the Distinct Population Segments identified under the U.S. *Endangered Species Act*). Since 2009, I am have co-chaired an international working group at UC Santa Barbara's National Center for Ecological Analysis and

Synthesis on ‘red flags’ of species endangerment (www.nceas.ucsb.edu/projects/12559).

I am being compensated by the Plaintiffs at the rate of US$200 per hour. I have not testified as an expert in any legal matter within the past four years.

1 Introduction

The Gulf of Maine Distinct Population Segment (hereafter, GOM DPS) of Atlantic salmon comprises all sea-run Atlantic salmon whose freshwater range occurs in the watersheds of the Androscoggin River northward along coastal Maine to the Dennys River (including these fish wherever they occur in the estuarine and marine environments, and excluding sections of rivers above impassable falls in some rivers within the DPS) (Fay et al. 2006). The decision by the Biological Review Team to include the Androscoggin and Kennebec Rivers in the DPS (their consideration for inclusion in the DPS in a 2000 final-rule listing decision had been deferred) was based on genetic, life-history, and zoogeographic information (Fay et al. 2006). The GOM DPS is recognized as comprising three Salmon Habitat Recovery Units, or SHRUs. ‘Recovery units’ are deemed necessary to both the survival and recovery of the DPS, according to the National Marine Fisheries Service Interim Recovery Plan Guidance documents. One of these SHRU’s — the Merrymeeting Bay SHRU — comprises salmon in the Androscoggin and Kennebec Rivers.

I have rendered several opinions in this document, which can be summarized as follows. It is my opinion that:

- Restoration of Atlantic salmon populations in both the Androscoggin and Kennebec Rivers of the Merrymeeting Bay SHRU is fundamentally important to the recovery of the GOM DPS of Atlantic salmon;
- Hatchery fish are necessary — but far from sufficient — for the recovery of the Atlantic salmon populations of the Androscoggin and Kennebec Rivers, Merrymeeting Bay SHRU, and, thus, the recovery of the GOM DPS;
- Partitioning of the GOM DPS into three SHRU’s is scientifically reasonable and representative of a responsible management strategy consistent with a precautionary approach to the conservation of biodiversity;
- An Atlantic salmon population that experienced the current levels of smolt-adult survival experienced by hatchery-origin smolts that pass by dams during their downstream migration in the GOM DPS would not increase in abundance and would never recover;
- The mortality experienced by downstream migrating smolts and kelts and by upstream migrating returning adults attributable to dam facilities in the Merrymeeting Bay SHRU will have an adverse impact on the survival and the prospects for recovery of the SHRU and, thus, of the GOM DPS as a whole;
- Given the exceedingly low numbers of returning adults to the SHRU, most notably of fish of wild origin, the loss of a single smolt, or of a single adult, to human-induced causes is significant.

2 Gulf of Maine Distinct Population Segment of Atlantic Salmon

2.1 Importance of the Androscoggin and Kennebec Rivers to the recovery and persistence of the DPS

For recovery purposes, the GOM DPS is partitioned into three Salmon Habitat Recovery Units, or SHRU's. In my opinion, the restoration of Atlantic salmon populations in the Androscoggin and Kennebec Rivers, which comprise the Merrymeeting Bay SHRU, are fundamentally important to the recovery of the Gulf of Maine DPS of Atlantic salmon.

The Androscoggin (266 km long) and Kennebec (373 km) Rivers are among the largest in the GOM DPS. The lengths of these rivers dwarf the lengths of the Downeast Maine rivers (16-107 km long) that are part of the GOM DPS. As a consequence, they are vital to the recovery and persistence of the DPS. It is well-established that large, complex river systems – such as the Androscoggin and Kennebec Rivers – are capable of supporting large salmon populations (Aas et al. 2011). It is also well established that, all else being equal, large populations are less vulnerable than small populations to extinction (*e.g.,* Shaffer 1981; Caughley 1994; Allendorf and Luikart 2007). The greater the number of individuals in a population, the less likely it is that the population will decrease (and the greater the chance that the population will persist) because of: (i) unpredictable environmental changes that similarly affect all individuals (termed 'environmental stochasticity'); (ii) unpredictable environmental changes that affect some but not all individuals (termed 'demographic stochasticity'); and (iii) unpredictable changes in genes and/or gene frequencies, which can lead to inbreeding and the fixation of harmful genes (termed 'genetic stochasticity') (Lande 1988, 1993).

Large populations are also less likely to experience a situation manifested by what is termed an 'Allee effect', which can lead to population decline. It is normally assumed that as populations decrease in abundance, their *rate of population growth* steadily increases (Gotelli 2010). Population growth rate is assumed to increase because as a population declines, conditions favorable to survival, growth, and reproduction should improve; lower population abundance is assumed to translate into reduced competition, meaning that each individual has better access to necessary resources, such as food, at low population abundance than at high population abundance. An Allee effect exists when population growth rate begins to decline, rather than increase, at a certain 'threshold' level of abundance (Courchamp et al. 2008). All else being equal, large populations are less likely than small populations to decline to this threshold level of abundance, at which the Allee effect is expressed.

Large populations are also of fundamental importance to the recovery of the GOM DPS because of the contributions that large populations make to the persistence of small populations, such as those that exist in the northern coastal part of the DPS. This is because of the 'straying' characteristic of salmon populations. (Based on historical documents, such as those written by Atkins and Foster (1867, 1868), it is highly probable that the Androscoggin, Kennebec, and Penobscot Rivers each once supported adult salmon populations comprising at least 100,000 spawning adults.)

That is, when adults return from the ocean to their natal rivers to spawn, errors in migration can occur, and some adults (albeit a small percentage, estimated to be 1% for the GOM DPS; Baum 1997) end up spawning in rivers in which they were not born. This straying can be extremely important to the persistence of small salmon populations (that are at greater risk of decline because of the three forms of stochasticity, or unpredictability, identified above) because of the additional spawners that large populations, produced by large rivers, can provide (Fraser et al. 2007). Put another way, the large salmon populations that can be produced by large rivers, such as the Androscoggin, Kennebec, and Penobscot Rivers of the GOM DPS, can provide a ‘rescue effect’ to small populations, thus increasing the chance that population groups, such as the GOM DPS, will persist through time.

In addition to their potential for producing large populations of salmon, the inclusion of the Androscoggin and Kennebec Rivers in the GOM DPS provides far greater potential for the ability of the DPS to adapt to future environmental change. This is because of the *increased diversity* that recovered salmon populations in the Merrymeeting Bay SHRU would provide to the DPS as a whole.

Diversity is directly related to persistence. The more variable systems are, the more likely they will persist over time. Stock market portfolios typically reflect breadth to reduce the overall risk to one’s investment capital. Farmers typically grow a variety of crops to reduce the chance of failure of any one particular crop. From a biological perspective, high genetic diversity increases the likelihood of having or producing individuals with genes that will allow adaptation to environmental change, including alterations to habitat or biological community brought about by natural variation and human actions.

The greater the genetic variation and the phenotypic differentiation (*i.e.,* variation in observable characteristics such as body size, behavior, and growth) within and among salmon populations, the greater the likelihood that some salmon populations within the DPS will be better able to respond favorably to environmental change than others. Extremely strong evidence of the vital importance of population differentiation and diversity to the persistence of salmon meta-populations, or DPS’s, has recently been provided in a study of sockeye salmon in the Gulf of Alaska (Schindler et al. 2010).

2.2 Importance of hatchery fish to the recovery of the Merrymeeting Bay SHRU

It is my opinion that hatchery fish are necessary — but far from sufficient — for the recovery of the Merrymeeting Bay SHRU of Atlantic salmon and, thus, the recovery of the GOM DPS. Hatchery fish are likely to be of greatest importance to recovery efforts during the initial years of the recovery program, when population numbers are very low, as they are now. At present, as Table 1 below indicates, fewer than 10 adult fish of wild origin have been returning to the SHRU annually in each of the past five years for which data are available (2006-2010). This is an exceedingly low number of returning adults and places the SHRU at heightened risk of extinction because of the SHRU's increased susceptibility to stochastic, unpredictable events — anything from droughts to disease to chemical spills — that increase the chance of extinction. *Any measure that increases the chances of survival to the returning-adult stage will reduce the SHRU's probability of extinction.*

Even though hatchery-origin fish have lower survival rates than wild-origin fish in the GOM DPS (Table 2), they are capable of increasing the number of spawning adults in the short term, providing a potentially important 'kick start' to the recovery process (Waples et al. 2007; Berejikian et al. 2008). The period of time that constitutes the 'short term' depends on many factors and cannot be articulated precisely for any given situation. Nonetheless, it has been noted that fitness losses in salmonids can potentially arise after only 1 or 2 generations of captive-breeding/rearing (Fraser 2008; Christie et al. 2011). And there is considerable evidence, both theoretical and empirical in nature, to suggest that the magnitude of fitness loss increases as the duration of hatchery populations in captivity increases. As concluded by Fraser (2008) in his exhaustive review of the ability of hatchery and captive breeding programs to conserve salmonid biodiversity, "No matter how good the intentions, it would appear that as yet, humans have not generated a group of captive-bred/reared fish that on average will perform equally to wild fish once they are released into the wild".

Notwithstanding their importance in the early stages of the recovery program, the use of hatchery fish does not present a medium- or long-term solution. One reason for this can be attributed to the genetic and phenotypic differences that exist between hatchery-spawned and/or reared fish and those that are spawned and reared in the wild (Fraser 2008; Christie et al. 2011). Such differences can exist even in the offspring of hatchery broodstock obtained directly from the wild because of inherited maladaptive phenotypic characteristics. A second reason, as discussed in greater detail below (section 3.2), is the observation that smolts of hatchery origin (documented for Penobscot River smolts that must pass dams during their downstream migration) within the GOM DPS are estimated to have less than 25% the rate of survival to the adult stage as smolts of wild origin (documented for Narraguagus River smolts that do not pass dams during their downstream migration) (USASAC 2011). It is my opinion that some part of the elevated mortality experienced by hatchery-origin smolts in the Penobscot River is caused by their hatchery origin and some part is caused by their passage by dams. A third reason, also discussed below (Section 3.3), is that an Atlantic salmon population that experiences the smolt-adult survival rates that have been documented for hatchery-origin smolts in the GOM DPS (and that pass by dams in the Penobscot River) will experience negative population growth, meaning that it will decline with time.

In short, while hatchery-bred fish and eggs can provide an essential supplement to wild salmon populations at the brink of extinction, such as those in the Merrymeeting Bay SHRU, they cannot by themselves bring such populations back to sustainable levels. That is, hatchery fish are necessary — but far from sufficient — for the recovery of the Atlantic salmon populations of the Androscoggin and Kennebec Rivers, Merrymeeting Bay SHRU, and, thus, the recovery of the GOM DPS.

2.3 Recovery of Salmon Habitat Recovery Units (SHRU's)

In my opinion, the partitioning of the GOM DPS of Atlantic salmon into three Salmon Habitat Recovery units, or SHRU's, is scientifically sound, theoretically and empirically defensible, and representative of a responsible management strategy consistent with a precautionary approach to resource management and the conservation of biodiversity.

As noted by the 2009 draft of the Gulf of Maine Distinct Population Segment Management Guidance for Recovery (NOAA 2009), "maintaining a population in all three SHRU's is necessary in order to preserve the genetic variability of the DPS, which in turn is necessary in ensuring that the population is capable of adapting to and surviving natural environmental and demographic variation that all populations are subjected to over time".

The responsible authorities have proposed a minimum census abundance of 500 spawners of non-hatchery origin for each SHRU to serve as a "benchmark to evaluate the population as either recovered or one that requires protection under the ESA [Endangered Species Act]" (NOAA 2009). That is, the census abundance of 500 spawners per SHRU is meant to provide a 'starting point' for establishing delisting criteria (NOAA 2009). As noted by NOAA (2009), this benchmark of 500 spawners is consistent with viability criteria established for endangered and threatened salmonid populations elsewhere in the U.S, such as those in the Interior Columbia Basin (Cooney et al. 2007) and in the Central Valley region of California for endangered winter-run Chinook salmon, threatened spring-run Chinook salmon, and threatened steelhead (NMFS 2009). It is worth noting, however, that this benchmark of 500 is less than 1% of the presumed historical spawning population sizes of at least 100,000 for *each* river within the SHRU.

It is also important that the benchmark of 500 spawners be distributed between the Androscoggin and Kennebec Rivers to ensure that the breadth of ecological and environmental conditions that each river's watershed contributes to the process of natural selection in salmon is maintained. It is necessary to maintain this breadth in order to generate the genetic and phenotypic variability within and among salmon populations that is necessary for the Merrymeeting Bay SHRU to contribute positively to the persistence of the GOM DPS.

3 Merrymeeting Bay SHRU

3.1 Current status: numbers of returning adults

Remnant populations of Atlantic salmon exist in the Merrymeeting Bay SHRU. As noted above and elsewhere (*e.g.,* Baum 1997), historical records indicate that several hundred thousand adults returned annually to the largest rivers in the GOM DPS. Atkins and Foster (1867) estimated that between 68,000 and 216,000 adults were harvested in Kennebec River in 1820, and that the average annual yield of salmon in Penobscot River, before the construction of dams in the river, could not have been less than 150,000 adult salmon (Atkins and Foster 1868).

The historical numbers of salmon returning annually to the largest rivers in the GOM DPS were more than ten thousand times greater than the annual counts of adults of wild origin in the Androscoggin and Kennebec Rivers in the past 3 to 4 decades (Table 1; USASAC 2011). Several observations can be drawn from these census count data:

- Since 2006, fewer than 50 adults have returned annually to the Androscoggin River; in 4 of the past 6 years, the numbers of returning adults have numbered 20 or less;
- Since 2006, fewer than 65 adults have returned annually to the Kennebec River; in 4 of the past 6 years, the numbers of returning adults have numbered 21 or less;
- Since 2006, the number of adults returning to the Merrymeeting Bay SHRU has fluctuated considerably, reaching a low of 14 adults in 2010 and a high of 110 adults in 2011;
- Based on the most recent 5 years for which data are available (2006-2010), 77% of adults returning to the Merrymeeting Bay SHRU have been of hatchery origin;
- Based on the most recent 5 years for which data are available (2006-2010), 71% of adults returning to the Merrymeeting Bay SHRU that were spawning for the first time were two-sea-winter (2SW) fish (meaning they spent 2 winters at sea before returning to the river to spawn);
- Based on the most recent 5 years for which data are available (2006-2010), 4% of adults returning to the Merrymeeting Bay SHRU have been 3SW fish or Previous Spawners (PS) (*i.e.*, adults who spawned, returned to the sea, and are back to spawn again).

The proportion of 1SW, 2SW, 3SW, and PS salmon varies considerably among Atlantic salmon populations throughout the species' range. In the GOM DPS, the incidence of 2SW adults is quite high; much higher than the incidence in many rivers in Nova Scotia and New Brunswick and far greater than those in Newfoundland (where most salmon spawn as 1SW adults) (Hutchings and Jones 1998). These differences in sea-age at maturity are adaptive, meaning that, in the GOM DPS, adults that return to spawn as 2SW fish have greater reproductive success (are better 'adapted' to local environments) than salmon returning to spawn at other ages. However, it is certainly possible that the recent predominance of 2SW adults represents an adaptive response to recent (*e.g.,* past century) human-induced changes to the environment, meaning that 2SW adults might not have been as dominant historically when 3SW (and possibly 4SW) adults might have been more common. It is also reasonable to hypothesize that PS fish, which migrate downstream to the sea as 'kelts', represent genotypes that are well-adapted to current local conditions, given that they survived to potentially spawn more than once – further emphasizing the importance of safe downstream passage for kelts.

3.2 Survival rates

In general, the life cycle of Atlantic salmon can be thought of as comprising three stages: (i) egg-to-smolt stage; (ii) smolt-to-spawning-adult stage; (iii) post-spawning stage. The first stage represents the period from the time at which the eggs are released by the female until the time at which the salmon begin their downstream migration to the ocean as smolts. The second stage represents the period from the beginning of the smolt migration until the time at which the returning adults are spawning. The third stage represents the 'kelt' or 'previous spawner' stage and extends from the time of initial spawning until the time at which the same individual spawns again.

Table 1. *Atlantic salmon of wild and hatchery origin returning to Androscoggin and Kennebec Rivers (USASAC 2011). Abbreviations: 1SW, 2SW, 3SW refer to salmon that spent 1, 2, and 3 winters at sea, respectively, before returning to a river to spawn for their first time; PS refers to Previously Spawned adult; NA= data not yet available.*

		Hatchery Origin				**Wild Origin**				**Total**
River	**Years(s)**	**1SW**	**2SW**	**3SW**	**PS**	**1SW**	**2SW**	**3SW**	**PS**	
Androscoggin	1983-2000	26	507	6	2	6	83	0	1	631
	2001	1	4	0	0	0	0	0	0	5
	2002	0	2	0	0	0	0	0	0	2
	2003	0	3	0	0	0	0	0	0	3
	2004	3	7	0	0	0	1	0	0	11
	2005	2	8	0	0	0	0	0	0	10
	2006	5	1	0	0	0	0	0	0	6
	2007	6	11	0	0	1	2	0	0	20
	2008	8	5	0	0	2	1	0	0	16
	2009	2	19	0	0	0	3	0	0	24
	2010	2	5	0	0	0	2	0	0	9
	2011									47
Annual average	**2006-2010**	**4.6**	**8.2**	**0**	**0**	**0.6**	**1.6**	**0**	**0**	**15**
Annual average	**2007-2011**	NA	NA	NA	NA	NA	NA	NA	NA	**23.2**
Kennebec	1975-	12	189	5	1	0	9	0	0	216

	2000									
	2006	4	6	0	0	3	2	0	0	15
	2007	2	5	1	0	2	6	0	0	16
	2008	6	15	0	0	0	0	0	0	21
	2009	0	16	0	6	1	10	0	0	33
	2010	0	2	0	0	1	2	0	0	5
	2011									63
Annual average	**2006-2010**	**2.4**	**8.8**	**0.2**	**1.2**	**1.4**	**4.0**	**0**	**0**	**18**
Annual average	**2007-2011**	NA	NA	NA	NA	NA	NA	NA	NA	**27.6**

Estimates of survival between the egg and smolt stages are rare for populations within the GOM DPS, based on the reviews undertaken by Bley and Moring (1988) and by Hutchings and Jones (1998). The only study cited by either review for GOM DPS Atlantic salmon is the work of Meister (1962) who provided an estimate of 1.1% for salmon in Cove Brook, Maine (part of the GOM DPS). Based on egg-smolt survival data compiled for 12 rivers worldwide, Hutchings and Jones (1998) reported a median probability of surviving between the egg and smolt stages of 0.0137 (*i.e.,* 1.37%). Restricting the smolt-adult survival data to those populations (located in New Brunswick and Québec) nearest to the GOM DPS (Big Salmon River: 0.0017; Miramichi: 0.0047; Pollett: 0.0198; Bec-Scie: 0.0156; Saint-Jean: 0.303; and Trinité: 0.0324), the median egg-smolt survival is 0.0177. For the model simulations used here, the value of 0.0177 was used. (Note that this value of almost 1.8% exceeds the value estimated by Meister (1962) for a GOM DPS salmon population.)

Estimates of survival between the smolt and returning-adult stages are not available for the Merrymeeting Bay SHRU populations. However, there are smolt-adult survival estimates available for salmon in two other rivers in the GOM DPS (USASAC 2011). These survival data distinguish Penobscot River smolts of hatchery origin that pass by one or more dams during their downstream migration and Narraguagus River smolts of wild origin for which their downstream passage is unimpeded by dams. Smolt-adult survival data are available from: (i) 1969 to 2009 for hatchery-origin smolts returning as 1SW adults to Penobscot River; (ii) 1969 to 2008 for hatchery-origin smolts returning as 2SW adults to Penobscot River; and (iii) 1997 to 2008 for wild-origin smolts returning as 2SW adults to Narraguagus River (Table 2).

Estimates of survival during the kelt stage in the scientific literature are rare. In a Newfoundland population where all of the fish spawn as 1SW adults, Chadwick et al. (1978) estimated a mean overwinter survival of post-spawning 1SW fish to the kelt stage to be 63%. Given the absence of data for other rivers, that is the estimate used here. (Although there are reports that 20% of kelts migrate downstream before winter in the Merrymeeting Bay SHRU (NextEra 2011), it is assumed here that all kelts spend the winter in the river before returning to the ocean the following spring. This assumption has little effect on the final model results.) During their downstream migration, kelts are assumed to experience a survival rate of 82% as they pass each dam (based on the average of 4 whole-station kelt survival estimates for dams in the Kennebec and Androscoggin Rivers; NextEra 2011). Once kelts have entered the ocean, they are assumed to experience an 80% survival rate prior to their return to the river in the same year to spawn.

3.3. Population growth rate

It is my opinion that an Atlantic salmon population that experienced the current levels of smolt-adult survival realized by hatchery-origin smolts that pass by dams during their downstream migration in the GOM DPS (Table 2) would not increase in abundance and would never recover.

A standard measure of density-independent population growth is provided by *r*, a parameter often referred to as the intrinsic rate of population growth (*e.g.,* Gotelli 2010). Using life-history data (*i.e.,* information on a survival rates and estimates of the number of eggs a female produces), population growth rate (*r*) can be estimated from what is commonly known as the Euler-Lotka equation (Roff 2002; Gotelli 2010):

$$1 = l_x \, m_x \exp(-rx)$$

where l_x is the probability of surviving from birth until age *x* and m_x is the number of eggs produced by an individual breeding at age *x* (Roff 2002). In estimating *r* for the Merrymeeting Bay SHRU, the number of eggs per female was assumed to be 8,500 eggs for each adult spawning for the first time and 10,000 eggs for each Previously Spawned adult (or kelt), based on eggs-per-female data provided by USASAC (2011). By estimating population growth rate, one can then determine whether a population is likely to increase or decrease under a range of potential survival conditions. When a population is increasing, the population growth rate (*r*) is positive and it is greater than zero; when a population is declining, *r* is negative and it is less than zero.

Table 2. *Estimates of the survival of fish, expressed as a proportion, between the smolt and returning-adult stage over the most recent ten-year period for which data are available (USASAC 2011). If survival is sufficient to result in population growth (meaning that the number of returning adults would increase over time), a positive sign is indicated in parentheses. If survival is not sufficient to produce population growth (meaning that the number of returning adults would decline over time), a negative sign is indicated. 'Year of Smolt Cohort' is the year in which smolts migrated downstream to the ocean. Abbreviations: SW=sea winter; H=hatchery-origin smolts that pass dams in Penobscot River; W=wild-origin smolts that pass no dams in Narraguagus River.*

Year of Smolt Cohort	**2SW (W)**	**2SW (H)**	**1SW (H)**
2009	--------	--------	0.0009 (−)
2008	0.0063 (+)	0.0020 (−)	0.0006 (−)
2007	0.0200 (+)	0.0036 (−)	0.0018 (−)
2006	0.0076 (+)	0.0030 (−)	0.0006 (−)
2005	0.0073 (+)	0.0014 (−)	0.0008 (−)
2004	0.0097 (+)	0.0015 (−)	0.0007 (−)
2003	0.0104 (+)	0.0016 (−)	0.0007 (−)
2002	0.0060 (+)	0.0021 (−)	0.0006 (−)
2001	0.0084 (+)	0.0019 (−)	0.0008 (−)
2000	0.0017 (−)	0.0010 (−)	0.0006 (−)
1999	0.0052 (+)	0.0011 (−)	--------

10-year average	**0.0083 (+)**	**0.0019 (−)**	**0.0008 (−)**

Three important conclusions can be drawn from the data in Table 2, which represent prevailing smolt-adult survival rates for two rivers in the GOM DPS:

- During the past ten years, the survival to the 2SW adult stage has, on average, been *4 times greater* for smolts of wild origin that pass *no* dams during downstream migration (0.83%) than it has been for smolts of hatchery origin that *do* pass dams during downstream migration (0.19%);
- An Atlantic salmon population that experienced the smolt-adult survival rates reported for wild-origin 2SW adults that do not migrate past dams would increase with time ($r > 0$ in 9 of the past 10 years);
- An Atlantic salmon population that experienced the smolt-adult survival rates reported for hatchery-origin 2SW adults that must migrate past dams would decrease with time ($r < 0$ every year in the past 10 years).

Another, and perhaps more intuitive, way to think of the survival data in Table 2 is to determine the number of smolts required to produce a single returning adult. (This is simply 1 divided by the survival proportions given in Table 2.) These estimates are given in Table 3. They show that, on average, and over the past ten years:

- In the absence of dams, 120 wild-origin smolts are required to produce a single returning 2SW adult;
- In the presence of dams, 526 hatchery-origin smolts are required to produce a single returning 2SW adult;
- In the presence of dams,1250 hatchery-origin smolts are required to produce a single returning 1SW adult.

Table 3. *Smolt-to-adult survival data from Table 2 expressed as the number of smolts required to produce a single returning adult. For example, if smolt-adult survival was 0.001, the number of smolts required to produce 1 returning adult is 1/0.001 = 1,000. Abbreviations are the same as those in the caption for Table 2.*

Year of Smolt Cohort	**2SW (W)**	**2SW (H)**	**1SW (H)**
2009	--------	--------	1111
2008	159	500	1667
2007	50	278	556
2006	132	333	1667
2005	137	714	1250
2004	103	667	1429
2003	96	625	1429
2002	167	476	1667
2001	119	526	1250
2000	588	1000	1667
1999	192	909	--------
10-year average	**120**	**526**	**1250**

4 Effect of Dams on the Merrymeeting Bay SHRU

4.1 Effect of dams on survival

For the Merrymeeting Bay SHRU of Atlantic salmon, there are potentially several periods of life during which survival is negatively affected by the presence of dams. One occurs during the smolt migration; a second occurs during the upstream migration of returning adults to the spawning grounds. Additional periods would include the downstream and subsequent upstream migrations of post-spawning kelts. And the prevention of upstream migration by spawning adults to suitable spawning habitat would represent another example of how the presence of dams can affect population viability and persistence.

There are estimates of smolt survival as they pass by dam facilities. Based on the four estimates of whole-station smolt survival available for the Kennebec and Androscoggin Rivers (NextEra 2011), the average whole-station survival rate per dam, using the initial injury rate model estimates (the most defensible estimates among those available), is 87%. (These ‘initial’ injuries include scale loss, gill damage, severed body/backbone, and bruised head or body (NextEra 2011), all of which can be expected to result in significantly increased likelihood of death. However, the injury-rate mortality estimates do not account for delayed mortality, *i.e*., the mortality that occurs after a smolt has passed a dam but that can be attributed to dam passage.) Although estimates of the survival probabilities for upstream migrating adults could be estimated from available data (potentially between 67 and 76%; Bailey 2011), these estimates will not be considered further in this opinion for the purpose of predicting recovery times and population growth rate. In other words, the assumption here is that *all* returning adults survive the upstream migration to the spawning grounds. This assumption will have the effect of *under*-estimating recovery times and *over*-estimating population growth in the forecasts presented below. The forecasts presented here are thus conservative estimates that understate the effects that dams have on Atlantic salmon mortality. Put another way, the forecasts demonstrate that even if existing dams were modified to provide 100% effective upstream passage, the downstream impacts alone will have significant effects.

As mentioned previously, survival data are not available for salmon in the Merrymeeting Bay SHRU, necessitating the use of survival data for the only two rivers in the GOM DPS for which such data are available: the Penobscot and Narraguagus Rivers. Given that there are dams on the Penobscot River, it is not unreasonable to consider the prevailing smolt-adult survival rates experienced by hatchery-origin smolts, recorded from the Penobscot River (Table 2), to be representative of prevailing smolt-adult survival in the presence of dams for salmon in the Androscoggin and Kennebec Rivers. Similarly, it is not unreasonable to consider the prevailing smolt-adult survival rates experienced by wild-origin smolts, recorded from the Narraguagus River (Table 2), to be representative of prevailing smolt-adult survival in the absence of dams for salmon in the Androscoggin and Kennebec Rivers.

The smolt-adult survival data in Table 2 allow for two different analyses to be undertaken to explore the effects of dams on salmon population growth rate and recovery. The first method involves *removing* the effects of dam-related mortality on kelt survival and from the smolt-adult survival rates reported for hatchery-origin smolts in the Penobscot River. The second method involves *including* the effects of dam-related mortality on kelt survival and on the smolt-adult survival rates reported for wild-origin smolts in the Narraguagus River. The use of *both* approaches should yield an empirically defensible range of estimates of the consequences of dams to the population growth rate and recovery of the Merrymeeting Bay SHRU.

To *remove* the influence that each dam has on smolt-adult survival (using the Penobscot River data), one simply needs to *divide* the prevailing survival rate (*i.e.*, those for *hatchery*-origin smolts presented in Table 2, which factor in mortality related to passing multiple dams) by 0.87^n, where *n* represents the number of dams through which smolts must pass during their downstream migration and for which one is now assuming 100% safe downstream passage. To *include* the influence that each dam has on smolt-adult survival (using the Narraguagus River data), one *multiplies* the prevailing survival rate (*i.e.*, those for *wild*-origin smolts that do not pass dams; Table 2) by 0.87^x, where *x* represents the number of dams through which smolts must pass during their downstream migration.

Based on hatchery-origin smolt survival rate data from the Penobscot River, even if smolt and kelt survival were to be improved when passing 3 dams now presumed 100% safe or 4 dams now presumed 100% safe, the population growth rate (*r*) would be negative (Table 4).

Based on wild-origin smolt survival rate data from the Narraguagus River (in which dams do not affect salmon passage), if smolt and kelt survival declined when passing 3 or 4 dams, the population growth rate (*r*) would be negative for 6 of the past 10 years in the presence of 3 dams and negative for 7 of the past 10 years in the presence of 4 dams (Table 4).

4.2 Effects of dams on recovery time

The population growth rate (*r*) can be used to predict the times required for the Merrymeeting Bay SHRU to reach 500 returning adults of wild origin. The estimates provided here represent scenarios for which there is no future input of hatchery-origin fish into the SHRU, *i.e.*, all of the production will be assumed to originate from fish spawning in the wild. Of course, additional inputs of hatchery-origin fish into the Kennebec River are anticipated. What this means for the forecasts presented here is that the predicted recovery times may be over-estimated. However, the *qualitative* differences in recovery times under different survival-rate scenarios will not be affected. For example, if the time to achieve 500 adults is estimated to be 60 years if smolts and kelts experience 100% survival through each of 3 dams, as opposed to 120 years under survival rates of smolt and kelt involving passage through dams, the 60- and 120-year time frames might represent over-estimates, but the predicted *doubling* of recovery time is a robust estimate of the effects of dams on recovery time.

Table 4. *Estimates of the survival of fish, expressed as a proportion, between the smolt and returning-adult stage over the most recent ten-year period for which data are available (a) if the smolt survival consequences of migrating past 3 and 4 dams are included in the smolt-adult survival rates of 2SW wild-origin smolts (see* '2SW (W)' *in the table) or (b) if the smolt survival consequences of migrating past 3 and 4 dams are excluded from the smolt-adult survival rates of 2SW and 1SW hatchery-origin smolts (see* '2SW (H) and 1SW (H)' *in the table.*

Year of Smolt Cohort	**2SW (W)**		**2SW (H)**		**1SW (H)**	
	3 dams' impacts included	4 dams' impacts included	3 dams' impacts removed	4 dams' impacts removed	3 dams' impacts removed	4 dams' impacts removed
2009	--------	--------	--------	--------	0.0014 (−)	0.0016 (−)
2008	0.0042 (−)	0.0036 (−)	0.0030 (−)	0.0035 (−)	0.0009 (−)	0.0010 (−)
2007	0.0132 (+)	0.0115 (+)	0.0055 (−)	0.0063 (+)	0.0027 (−)	0.0031 (−)
2006	0.0050 (−)	0.0044 (−)	0.0046 (−)	0.0052 (−)	0.0009 (−)	0.0010 (−)
2005	0.0048 (−)	0.0042 (−)	0.0021 (−)	0.0024 (−)	0.0012 (−)	0.0014 (−)
2004	0.0064 (+)	0.0056 (+)	0.0023 (−)	0.0026 (−)	0.0011 (−)	0.0012 (−)
2003	0.0068 (+)	0.0060 (+)	0.0024 (−)	0.0028 (−)	0.0011 (−)	0.0012 (−)
2002	0.0040 (−)	0.0034 (−)	0.0032 (−)	0.0037 (−)	0.0009 (−)	0.0010 (−)
2001	0.0055 (+)	0.0048 (−)	0.0029 (−)	0.0033 (−)	0.0012 (−)	0.0014 (−)
2000	0.0011 (−)	0.0010 (−)	0.0015 (−)	0.0017 (−)	0.0009 (−)	0.0010 (−)
1999	0.0034 (−)	0.0030 (−)	0.0017 (−)	0.0019 (−)	--------	--------
10-year average	**0.0054 (+)**	**0.0047** (−)	**0.0029 (−)**	**0.0034 (−)**	**0.0012 (−)**	**0.0014 (−)**

To estimate recovery times for the Merrymeeting Bay SHRU under different smolt-adult survival scenarios, one can use the following equation (Gotelli 2010) to estimate how the abundance of returning adults (*N*) will change with generation time (*t*) for different rates of population growth (*r*) for any particular starting population size (N_0):

$$N_t = N_0 (\exp(rt)) \quad .$$

For the present purposes, the starting population size (N_0) was set to two numbers. The first (N_0 = 50) represents the average number of adults returning to the Merrymeeting Bay SHRU in the past 5 years (2007-2011; Table 1). The second (N_0 = 110) represents the maximum number of adults returning to the SHRU in the past 5 years (in 2011; Table 1). The time required to achieve 500 2SW adults is equal to the number of generations (*t*) multiplied by 5 years (Table 5).

The results of this analysis indicate that the presence of dams very significantly increases the time required to achieve the benchmark of 500 wild spawners in the Merrymeeting Bay SHRU.

The first analysis uses the smolt-adult survival data for wild-origin 2SW

Narraguagus River salmon as the baseline and incorporates the survival consequences of dam passage for smolts and kelts. The results indicate that the presence of 3 dams, when compared to the no-dam scenario, reduces population growth rate to such a large extent (*r* declines from 0.130 to 0.015) that the recovery time is increased by a factor almost ten. The same analysis indicates that population growth rate (*r*) would be negative (−0.02) in the presence of 4 dams, meaning that the population would never recover.

The risk of such greatly extended recovery times — and the reason one would want to reduce recovery time — is that the longer a population exists near the brink of extinction, the more likely it is that one or more stochastic, unpredictable events will occur which might significantly increase the chance of extinction of the SHRU.

The second analysis uses the smolt-adult survival data for hatchery-origin 2SW and 1SW Penobscot River salmon as the baseline and removes the survival consequences of dam passage for smolts and kelts. The results suggest that 100% safe passage by both smolts and kelts by either 3 or 4 dams would not be sufficient to result in positive population growth, meaning that the population would never recover.

Table 5. *Estimated effects of dams on smolt-adult survival, population growth rate (r), and the estimated time, in years, for a population size of 500 adults to be attained, under two different starting population sizes (N_0 = 50 and 110). For 2SW wild-origin smolts* ('2SW (W)')*, the current conditions reflect survival in the absence of dams; by including the effects of dams on survival, the smolt-adult survival rates are reduced. For 2SW and 1SW hatchery-origin smolts* ('2SW (H)' *and* '1SW (H)')*, the current conditions reflect survival in the presence of dams; by excluding the effects of dams on survival, the smolt-adult survival rates are increased.*

	2SW (W)			**2SW (H)**			**1SW (H)**		
	Current smolt survival	Lowered smolt and kelt survival through 3 dams	Lowered smolt and kelt survival through 4 dams	Current smolt survival	100% smolt and kelt survival through 3 dams	100% smolt and kelt survival through 4 dams	Current smolt survival	100% smolt and kelt survival through 3 dams	100% smolt and kelt survival through 4 dams
10-year average smolt-adult survival	0.0083	0.0054	0.0047	0.0019	0.0029	0.0034	0.0008	0.0012	0.0014
Population growth rate (*r*)	0.130	0.015	-0.02	−0.16	−0.07	−0.04	−0.39	−0.28	−0.25
Time (yr) to achieve 500 2SW adults when N_0=50	90	770	never	never	never	never	never	never	never

Time (yr) to achieve 500 2SW adults when N_0=110	60	505	never	never	never	never	never	never	never

5 Summary

Atlantic salmon in the Merrymeeting Bay SHRU are at historically low levels of abundance. The very low abundance of returning adults (Table 1) renders the SHRU extremely vulnerable to *any* anthropogenic or natural factor that threatens the survival of Atlantic salmon, particularly those of wild origin. The total number of adult salmon of wild origin returning annually to Androscoggin and Kennebec Rivers in the past 5 years (2006-2010) for which the smolt origin (wild vs hatchery) is known has been less than 10. The 2011 count of all fish returning to the Merrymeeting Bay SHRU, irrespective of smolt origin, was 110. By comparison, most salmon populations in Canada number in the hundreds, thousands, and tens of thousands of spawning Atlantic salmon (COSEWIC 2011).

Measured against the number of returning adults of wild origin, the Merrymeeting Bay SHRU is on the brink of extinction. As a consequence of this fragility, it is my opinion that the mortality experienced by downstream migrating smolts and kelts, and by upstream migrating returning adults, attributable to dam facilities in the SHRU will have an adverse impact on the survival and the prospects for recovery of the Merrymeeting Bay SHRU and, thus, of the GOM DPS as a whole. Given the exceedingly low numbers of returning adults, most notably of fish of wild origin, the loss of a single smolt, or of a single adult, is significant.

6 References

Aas, O., Klemetsen, A., Einum, S., and J. Skurdal. 2011. *Atlantic Salmon Ecology*. Wiley-Blackwell, London.

Allendorf, F.A., and G. Luikart. 2007. *Conservation and the Genetics of Populations*. Blackwell, Malden, MA.

Atkins, C.G., and N.W. Foster. 1867. Report of Commission on Fisheries. *In:* Twelfth Annual Report of the Secretary of the Maine Board of Agruiculture 1867. Stevens and Sayward Printers, Augusta, ME, pp 70-194.

Atkins, C.G., and N.W. Foster. 1868. *In:* Second Report of the Commissioner of Fisheries of the State of Maine. Owen and Nash, Augusta, ME.

Bailey, R. 2011. Declaration of Randy E. Bailey. *Friends of Merrymeeting Bay and Environment Maine vs. Brookfield Power US Asset Management, LLC, and Hydro Kennebec, LLC.* United States District Court, Court of Maine, 30 November 2011.

Baum, E.T. 1997. *Maine Atlantic Salmon: A National Treasure*. Atlantic Salmon Unlimited, Hermon, ME.

Berejikian, B.A., Johnson, T., Endicott, R., and J. Lee. 2008. Increases in steelhead red abundance resulting from two conservation hatchery strategies in the Hamma

Hamma River, WA. Canadian Journal of Fisheries and Aquatic Sciences 65: 754–764.

Bley, P.W., and J.R. Moring. 1988. Freshwater and ocean survival of Atlantic salmon and steelhead: a synopsis. U.S. Fish and Wildlife Service, Biological Report 88, 22 p.

Caughley, G. 1994. Directions in conservation biology. Journal of Animal Ecology 63: 215-244.

Chadwick, E.M.P., Porter, T.R., and P. Downton. 1978. Analysis of growth of Atlantic salmon (*Salmo salar*) in a small Newfoundland river. Journal of the Fisheries Research Board of Canada 35: 60-68.

Christie, M.R., Marine, M.L., French, R.A., and M.S. Blouin. 2011. Genetic adaptation to captivity can occur in a single generation *Proceedings of the National Academy of Sciences*, www.pnas.org/cgi/doi/10.1073/pnas.1111073109.

Cooney, T., McClure, M., Baldwin, C., Carmichael, R., Hassemer, P., Howell, P., McCullough, D., Schaller, H., Spruell, P., Petrosky, C., and F. Utter. 2007. Viability criteria for application to Interior Columbia Basin salmonid ESUs. Review Draft. Interior Columbia Basin Technical Recovery Team. March, 2007.

Courchamp, F., Berec, L., and J. Gascoigne. 2008. *Allee Effects in Ecology and Conservation.* Oxford University Press, Oxford.

Fay, C., Bartron, M., Craig, S., Hecht, A., Pruden, J., Saunders, R., Sheehan, T., and J. Trial. 2006. Status review for anadromous Atlantic salmon (*Salmo salar*) in the United States. Report to the National Marine Fisheries Service and U.S. Fish and Wildlife Service. 294 pages.

Fraser, D.J., Jones, M.W., McParland, T.L., and J.A. Hutchings. 2007. Loss of historical immigration and the unsuccessful rehabilitation of extirpated salmon populations. Conservation Genetics 8: 527-546.

Fraser, D.J. 2008. How well can captive breeding programs conserve biodiversity? A review of salmonids. Evolutionary Applications 1: 535-586.

Hutchings, J.A., and M.E.B. Jones. 1988. Life history variation and growth rate thresholds for maturity in Atlantic salmon, *Salmo salar*. Canadian Journal of Fisheries and Aquatic Sciences 55 (Suppl. 1): 22-47.

Lande, R. 1988. Genetics and demography in biological conservation. Science 241: 1455-1460.

Lande, R. 1993. Risks of population extinction from demographic and environmental stochasticity and random catastrophes. American Naturalist 142: 911-927.

Meister, A.J. 1962. Atlantic salmon production in Cove Brook, Maine. Transactions of the American Fisheries Society 91: 208-212.

NextEra. 2011. Review of the revised-draft Atlantic salmon white papers. Technical Advisory Committee Meeting, September 7, 2011.

NOAA. 2009. Gulf of Maine Distinct Population Segment management guidance for recovery. Draft 2009. (http://www.nero.noaa.gov/prot_res/altsalmon/Appendix%20A%20-%20Recovery%20Criteria%20Final.pdf; accessed 22-12-11)

NMFS. 2009. Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead. Sacramento Protected Resource Division, National Marine Fisheries Service.

Roff, D.A. 2002. *Life History Evolution*. Sinauer Associates, Sunderland, MA.

Shaffer, M.L. 1981. Minimum viable population sizes for species conservation. BioScience 31: 131-134.

Schindler, D.E., Hilborn, R., Chasco, B., Boatright, C.P., Quinn, T.P., Rogers, L.A., and M.S. Webster. 2010. Population diversity and the portfolio effect in an exploited species. Nature 465: 609–612.

USASAC. 2011. Annual report of the U.S. Atlantic Salmon Assessment Committee. Report no. 23 – Activities. Prepared for U.S. Section to NASCO (North Atlantic Salmon Conservation Organization).

Waples, R.S., Ford, M.J., and D. Schmitt. 2007. Empirical results of salmon supplementation in the Northeast Pacific: A preliminary assessment. *In:* Bert, T.M. (ed.), *Ecological and Genetic Implications of Aquaculture Activities*. Kluwer Academic Publishers, Dordrecht, Netherlands, pp 383–403.

11 January 2012

Jeffrey A. Hutchings Date

FOMB Exhibits Brunswick, Maine Hydroelectric Project, Androscoggin River FERC P-2284-0052

Exhibit 12

Ex. 12

Synapse
Energy Economics, Inc.

Analysis of selected Maine hydro plants on the Androscoggin and Kennebec Rivers and their importance to the New England electricity system

Opinion of Maximilian Chang

January 12, 2012

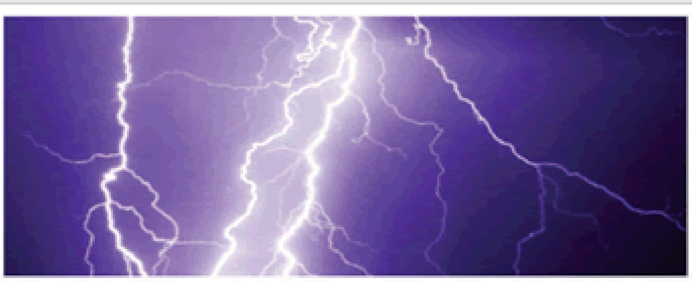

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Table of Contents

1. Introduction

I have been asked by the Plaintiffs to evaluate the contribution of seven Maine dams to the New England electric grid. Four of the dams are located on the Kennebec River: Lockwood (owned by NextEra and Merimil Limited Partnership), Shawmut, Weston, and Hydro-Kennebec (owned by Brookfield Power US Asset Management). The other three dams are located on the Androscoggin River: Brunswick (owned by NextEra), Pejepscot (owned by Topsham Hydro Partners), and Worumbo (owned by Miller Hydro Group). Maine has classified these seven dams as “run-of-the-river,” meaning that they have limited or no storage reservoirs that would regulate water flow across the turbines (Maine 2010).

My opinion, expressed herein, is based on my professional experience and is informed by (a) a review of documents and statistics prepared by the Department of Energy’s Energy Information Agency and the New England Independent System Operator, (b) relevant industry analyses, and (c) information provided by the Defendants through interrogatories. Where appropriate to support my opinion, I have cited these documents, and they are listed in the Bibliography at the end of this opinion.

My analysis evaluates the impact on the New England electric grid if the seven dams individually or collectively were to shut down seasonally to accommodate migrating anadromous fish.

In preparing my opinion, I have been asked by the Plaintiffs to consider the following questions:

1. What is the energy and capacity contribution of the seven dams to the New England electric grid?
2. What would be the impact upon the New England electric grid if the seven dams shut down seasonally?
3. What would be the impact upon the dam owners of seasonally shutting down the seven dams?

To answer these questions, I have organized my opinion in the following manner. First, I provide a brief overview of the New England electric grid, including historical supply and demand for the six New England states and Maine alone; the markets for electric energy and capacity that operate in the region; and the role that run-of-the-river hydropower plays in the regional market. Next, I look specifically at the seven dams in question to identify the percentage of energy and capacity they provide in New England and within Maine, alone. I then evaluate whether these contributions are necessary in order to meet average and peak demand in New England or within Maine, alone. Finally, I discuss possible impacts on dam owners’ revenues if these dams were to shut down seasonally to accommodate migrating anadromous fish.

In summary, it is my opinion that neither the New England’s electric power grid nor the local electric system within Maine would be adversely impacted by a seasonal shut-down of the dams. The seven hydro dams contribute to the electric grid; however, the seasonal shut-down of these units would not result in a significant impact on the region or the state. Both Maine and New England have adequate supply capacity to offset the loss of these dams.

Based on historical energy prices, lost revenue to dam owners would be in the range of roughly $1.5 – $2 million in aggregate for the seven dams for each month that turbines are fully shut down from April through June, and roughly $1.5 – $1.75 million in aggregate for each month that turbines of the seven dams are fully shut down from October to November. Monthly energy revenue losses for each dam would range roughly from $100,000 to $360,000 depending on the individual dam and time of year.

Based on regional capacity prices, the lost capacity revenue to dam owners would be in the range of roughly $130,000 in aggregate for the seven dams for each month that turbines are fully shut down from April through June, and roughly $210,000 in aggregate for each month that turbines of the seven dams are fully shut down from October to November. Monthly capacity revenue losses for each dam would range roughly from $7,000 to $43,000 depending on the individual dam and time of year.

2. Qualifications and Experience

I hold a Bachelor of Arts degree in Biology and Classical Civilization from Cornell University, and a Master of Science degree in Environmental Health from the Harvard School of Public Health. In my current position at Synapse Energy Economics, I conduct analyses on issues relating to electricity markets, avoided costs, energy efficiency, capacity markets, and the economics of energy supply resources. Synapse works for a wide range of clients throughout the United States, including environmental groups, public utility commissions and their staff, governmental associations, public interest groups, attorneys general, offices of consumer advocates, foundations, and federal governmental organizations such as the Environmental Protection Agency and the Department of Energy.

As part of my work at Synapse, I co-authored the two most recent *Avoided Energy Supply Costs in New England* reports (2009 and 2011), which are used by the New England energy efficiency program administrators to quantify the value of energy efficiency programs. I have also co-authored a recent report investigating the economics of proposed nuclear power plants and alternatives in the Southeast United States. Additionally, I have testified in front of the Massachusetts Department of Public Utilities on behalf of the Cape Light Compact in support of its three-year energy efficiency programs.

The Plaintiffs are compensating me for my work on this case at a rate of $140 per hour. I have been engaged in this case on their behalf since December 2011.

In preparing this report, I supervised the work of a Senior Consultant who assisted me in preforming the analysis consistent with Synapse Energy Economics' in carrying out such practices.

A copy of my resume is included as Attachment One.

3. General Explanation the New England Electric Grid

A. Brief Overview of New England's Electric Power System

The New England electrical power system spans the six states of New England, and serves the 14 million people living therein. This system includes: more than 300 generating units, representing approximately 32,000 megawatts (MW) of generating capacity; more than 5,000 demand assets, representing 2,500 MW of demand resources; and more than 8,000 miles of high-voltage transmission lines. These resources work together to meet the New England regional load, regardless of state boundaries (ISO-NE 2011c).[1]

The New England Independent System Operator (ISO-NE) is the non-profit entity that manages and coordinates the generation and transmission of power across New England to meet demand. ISO-NE has operational, market, and planning responsibilities to balance supply (capacity) and demand (load) of electricity across New England (Giaimo 2011). ISO-NE's operational responsibilities include ensuring minute-to-minute reliable operation of the New England power grid, ensuring the dispatch of lowest-priced resources, and coordinating operations with neighboring power systems. ISO-NE's market responsibilities include the administration and monitoring of wholesale electricity markets, which include energy and capacity. ISO-NE's planning responsibilities include administering requests to interconnect generation and transmission resources, and conducting transmission needs assessments to meet current and future power needs in New England.

Measuring Electrical Output

All electric generating units measure their electrical output in two different but related ways. Amounts of electric energy used or produced (e.g., in a year) are measured in megawatt-hours (MWh). When discussing an amount of electric energy produced (e.g., the number of MWh produced in a given year), the terms "generation," "generated," or "electric output" will be used. The amount of electric power produced or consumed at a given moment will be referred to as "load" or "demand," respectively, while the amount that *can be* produced at a given moment will be referred to as "capacity." Capacity is measured in kilowatts (kW) or megawatts (MW). The amount of energy that *is* produced by a generator in a given period is often compared to the amount it *could* have produced if running at full capacity 100 percent of the time. That ratio, expressed as a percent or as a number between zero and one, is called the plant's capacity factor (CF) (Steinhurst 2008).

B. Overview of New England Supply and Demand

The approximately 32,000 MW of generating capacity in New England can be broken out by fuel type, as shown in Exhibit 1 (ISO-NE 2011a).

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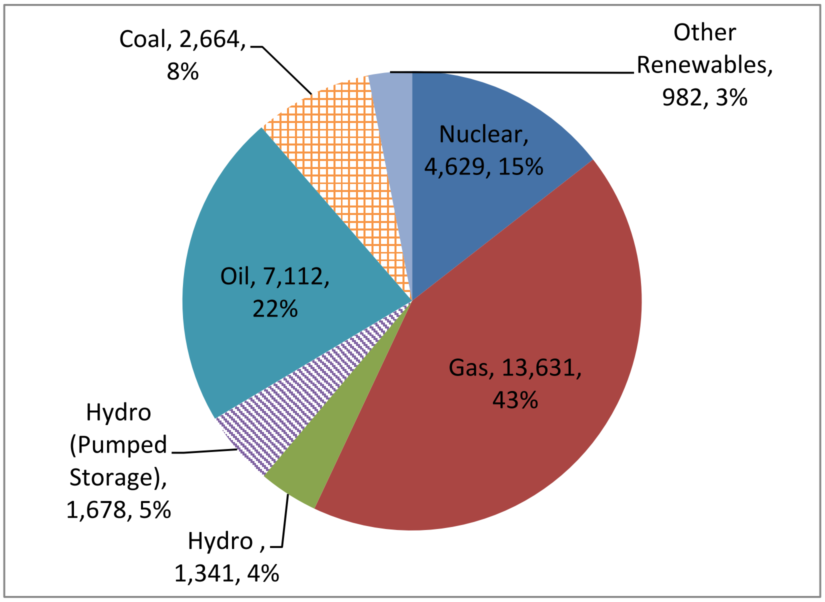
[1] One megawatt is the equivalent of one million watts.

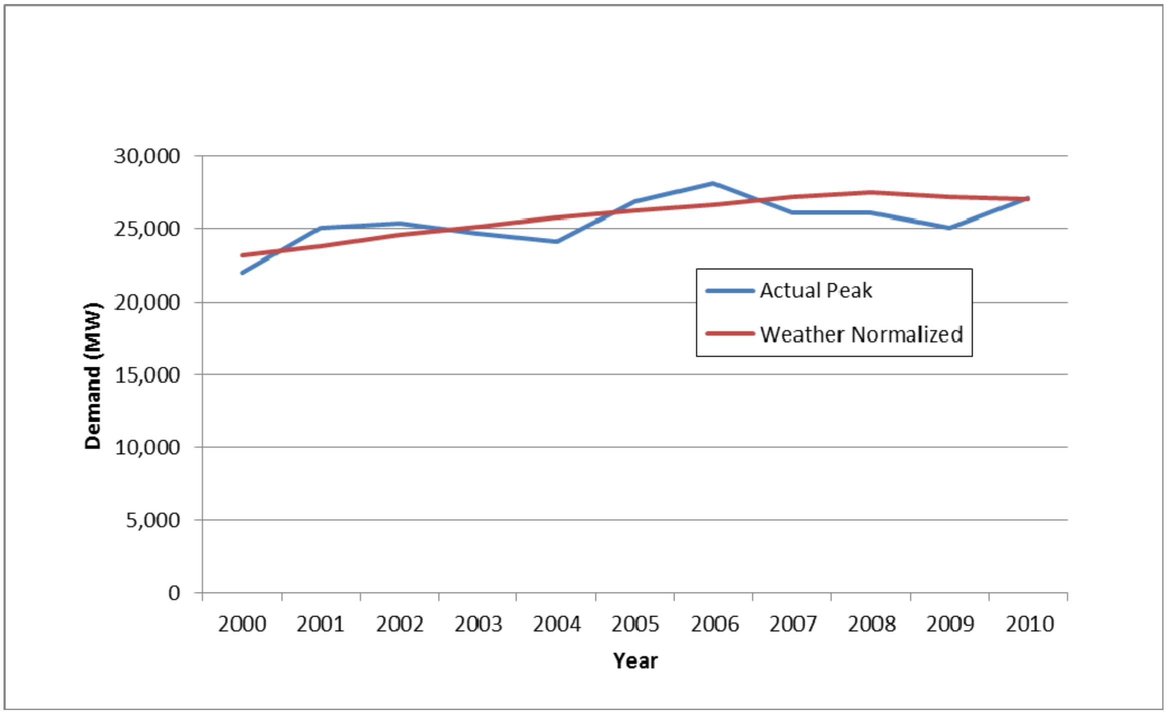
Exhibit 1. 2011 Expected Summer New England Capacity by Energy Source (MW)



By far the most dominant form of generating capacity in New England is natural gas combustion units, which represent 43 percent (13,631 MW) of New England's total generating capacity. Oil combustion generating capacity follows at 22 percent (7,112 MW), nuclear units provide 15 percent (4,629 MW), and hydro resources represent 4 percent (1,341 MW) (ISO NE 2011a). Pumped storage facilities (which represent 5 percent, or 1,678 MW, of New England's capacity in Exhibit 1) pump water into storage ponds during periods of low demand and then pass the water through turbines to generate electricity during periods of high demand.

The New England region is a summer-peaking region, meaning that the demand for power is greatest in the summer. According to ISO-NE, actual peak load in 2010 was 27,102 MW. The historical trend in peak load is shown in the following exhibit for both actual and weather-normalized peaks.

Exhibit 2. 2000-2010 New England Actual and Weather-Normalized Summer Peaks (MW)



The 2010 peak load of 27,102 MW was balanced against a resource capacity of 32,431 MW, which included non-generation demand resources (e.g. energy efficiency and demand response) and imports from outside New England. The excess capacity of 5,329 MW represents a reserve margin of approximately 20 percent (ISO-NE 2011a). Each year, ISO-NE projects the future installed capacity requirement (ICR) for the New England region (ISO-NE 2011b). The ICR represents the capacity plus reserves needed to meet New England's future capacity needs. ISO-NE projects reserve margins in future years through 2020 at a range of 12.6 to 14.6 percent (ISO-NE 2011c).

Data for 2003-2010 indicate that New England has added 4,382 MW of new capacity, as shown in the following exhibit.

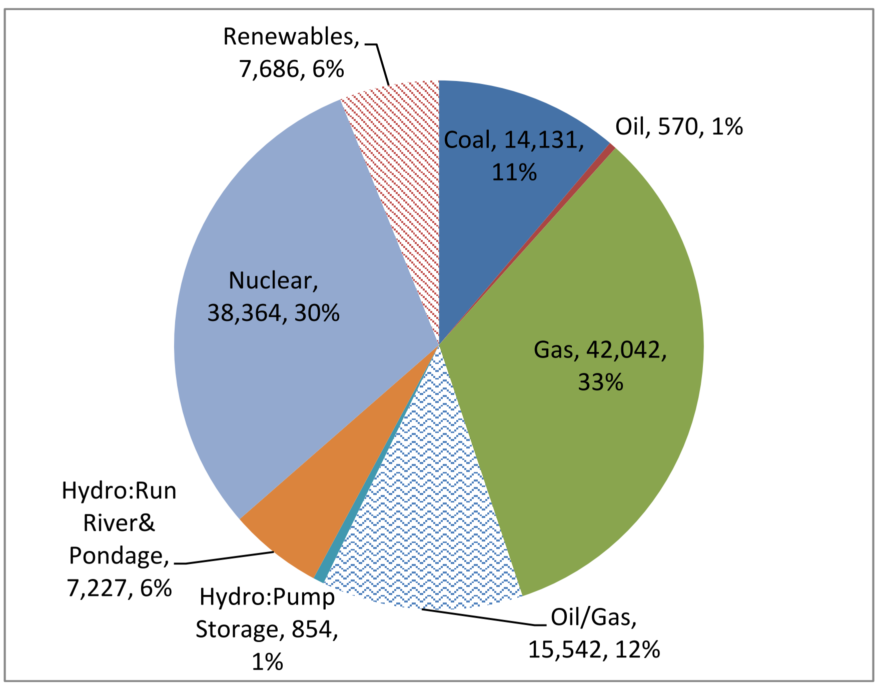
Exhibit 3. New England New Capacity Additions (Summer Capacity in MW)

Year	Summer Capacity (MW)
2003	2,757
2004	578
2005	6
2006	31
2007	142
2008	142
2009	367
2010	359
Total	4,382
Notes	
Data from EIA Form 860	

These data show that New England continues to add additional capacity to meet future load. According to ISO-NE, an additional 11,816 MW of new capacity is currently in the interconnection queue (ISO-NE 2011c). However, it is important to note that not all of the projects in the interconnection queue will actually be built. The ISO-NE historical attrition rate is 69% (ISO-NE 2011c). Using this attrition rate suggests that 3,663 MW of the 11,816 MW of new capacity in queue may actually be added.

Total annual energy requirements in 2010, the most recent full year of available data, were 130,771 gigawatt-hours (GWh) (ISO-NE 2010). The following exhibit shows the distribution of energy production by generating source for New England.

Exhibit 4. 2010 New England Generation by Energy Source (GWh)



On an energy basis (i.e., the amount of electric output of New England generation for 2010), 33 percent (42,042 GWh) of New England's electricity generation was from natural gas combustion units. Nuclear units provided 30 percent (38,364 GWh) of electricity generation in New England, and hydro resources represented 5.5 percent (7,227 GWh).

C. Overview of Maine Supply and Demand

Although New England's electric grid operates at a regional level, it is useful to view the electric system through the context of Maine. Maine represents approximately 9 percent of population and 8.9 percent of electricity consumption in New England (ISO-NE 2011d). In terms of capacity for the 2011 – 2012 period, Maine has 3,244 MW of in-state generation and 287 MW of in-state non-generation resources, for a total capacity of 3,531 MW. According to ISO-NE, Maine's 2011 actual peak demand was 1,964 MW. Maine currently exports electricity to other New England states, since Maine's capacity exceeds demand.

ISO-NE reports that, within Maine, 1,300 MW of new supply capacity are in the process of connecting to the regional transmission grid. While it is likely that not all of these projects will be completed, the number suggests proposed projects are in place that could meet the shortfall of generation resulting from the seasonal shut-down of the dams (see Section 4 for quantification of the dams' contributions to the grid).

While the grid operates on a regional basis, there are situations where local generation is required to meet specific reliability needs of the transmission system. In western Maine, ISO-NE had identified the need to maintain local generation in order to maintain voltages across transmission lines (ISO-NE 2011c). However, the dams in question have not been specifically identified by ISO-NE to maintain voltages in western Maine, as other local generation options are adequate to fulfill this requirement.

Additionally, ISO-NE has indicated that two current transmission projects (the Maine Power Reliability Project and the Rumford-Woodstock-Kimball Road) will alleviate this reliability constraint in western Maine once they are operational (ISO-NE 2011c).

D. Energy and Capacity Markets

Energy Markets

ISO-NE manages and coordinates the wholesale energy markets through two primary markets: (1) the Day-Ahead Market, where the majority of the transactions occur; and (2) the Real-Time Market, where the remaining energy supplies and demands are balanced. These two markets represent the bulk of electricity transactions, and their prices on average are very close to each other. However, there is greater volatility in the Real-Time Market, since it reflects real-time requirements.

The Forward Capacity Market

ISO-New England's Forward Capacity Market (FCM) is a market-driven approach designed to ensure that there is enough generation on the electrical grid to meet the peak demands each summer and winter. Under the FCM, ISO-NE acquires sufficient capacity to satisfy the installed capacity requirement (ICR) that it has set for a given power-year; this is accomplished by way of a forward-capacity auction (FCA) for that power-year, which sets the price for capacity. The FCA for each power-year is conducted roughly three calendar years in advance of the start of that power-year. ISO-NE has held five FCAs to date; FCA 1 was held in 2008 for the power-year starting June 2010, and, most recently, FCA 5 was held in 2011 for the power year starting June 2014.

At the most basic level, there are four steps to the forward capacity market:

1) The ISO-NE forecasts the peak demand that will need to be met three years ahead of time, hence a forward market.
2) ISO-NE then asks for a show of interest from owners of new or existing generation units, energy efficiency programs, or distributed generation projects who may be interested in providing capacity during this future year.
3) Next, ISO-NE puts those potential market participants through a qualification process to ensure each is a viable source of providing energy or reducing demand during peak load hours.
4) Finally, ISO-NE runs a descending clock auction for all qualified participants. Those who own the most cost-effective resources are given a capacity obligation, and are guaranteed revenue for the capacity they provide.

E. Role of Hydro in New England Energy and Capacity Markets

Like wind and solar energy resources, run-of-the-river hydropower is to some extent dependent on uncontrollable conditions, in this case river flow. As a result, ISO-NE categorizes wind, solar, and run-of-the-river hydro as “intermittent” resources. This affects the role that run-of-the-river hydropower plays in both the energy and capacity markets.

As noted earlier, ISO-NE works to ensure that capacity is available to meet New England’s peak demand, which occurs during the summer months. ISO-NE rates the summer and winter capacities for intermittent resources based on historical output (ISO-NE). For the summer rating of an existing run-of-the-river hydro resource, ISO-NE uses a formula based on the resource’s median output from 1 p.m. to 6 p.m., from June through September, for the last five years. The winter rating is the median output from 5 p.m. to 7 p.m., from October through May, for the last five years. Thus, ISO-NE’s summer and winter ratings for a hydro resource may differ, depending on historical river flow conditions. This means that the hydro resource’s value in the capacity market may also differ from season to season.

4. Power Produced from the Identified Dams

Exhibit 5, below, summarizes the energy and capacity characteristics of the seven hydro plants analyzed in this study. The generating capacity is represented both by nameplate values (the technical rating) from Energy Information Administration (EIA) and by the seasonal load-carrying capacity as determined by ISO-NE. Note that the summer capacity is much less than both the nameplate and winter capacities, due to summer river flow conditions that impact each dam’s summer rating for capacity revenues. These are all run-of-river facilities with minimal reservoir storage. Exhibit 5 also presents the 2010 generation for each facility as reported to the EIA, and an equivalent capacity factor (representing how much the plant runs) based on the nameplate capacity.

Exhibit 5. Hydro Plant Capacity and Generation Summary

Facility	Owner	Nameplate Capacity (MW)	Summer Capacity (MW)	Winter Capacity (MW)	2010 Electric Generation (MWh)	Capacity Factor
		1	2	3	4	5=4÷(1*8760)
Hydro Kennebec Project	Brookfield	15.0	3.8	7.9	50,337	38%
Worumbo Hydro Station	Miller Hydro	19.4	4.7	10.2	90,947	54%
Brunswick	NextEra	20.0	5.9	14.7	98,844	56%
Lockwood Hydroelectric Facility	NextEra, Mermil	7.2	2.5	4.8	32,371	51%
Shawmut	NextEra	9.2	9.5	9.5	52,001	65%
Weston	NextEra	13.2	13.2	13.2	65,685	57%
Pejepscot Hydroelectric Project	Topsham	13.7	4.3	10.7	74,823	62%
Total		97.7	44.0	71.0	465,008	54%

Notes

1 Nameplate capacity based on EIA Form-860 data for 2010

2,3 Summer and winter capacity based on ISO-NE 2011 CELT data

4 2010 electric generation based on EIA Form-923 data for 2010

A. The Seven Dams as a Percent of 2010 New England Energy and Capacity

As reported by ISO-NE, the 2010 total net energy requirement for New England was 130,767,000 MWh (ISO-NE 2011a). The electric generation at the seven Maine dams, presented in Exhibit 5, represents 0.36 percent or a small fraction of one percent of that total. The New England summer claimed capability for generators in 2010 was 31,435 MW, of which the above generators, at 44 MW, represent 0.14 percent or a small fraction of one percent of New England's summer claimed capability.

Based on EIA data for 2010, the seven dams generated approximately 465,000 MWh of electricity (EIA 860 Data). I have been asked to evaluate the effects of seasonal shutdowns of the dams' turbines during the spring Atlantic salmon smolt and kelt downstream migration period (which I have been told to assume lasts from April through June) and the fall kelt downstream migration period (which I have been told to assume lasts from October through November).

One simple approach to examine how New England could make up the shortfall of generation resulting from a seasonal shut down of the dams in the spring and/or fall months is to identify other, existing units that could be operated more often. While this analysis ignores specific generating unit limitations or transmission limitations, it provides a high-level indication of whether or not there is existing under-utilized electric generation capability. Using an EPA database generation sources in Maine, we analyzes generation from Rumford Power Associates, a 270 MW gas combined cycle plant located in Rumford, Maine (EPA). In 2010, this plant generated approximately 520,000 MWh, which translates into a capacity factor of 22 percent. Increasing the capacity factor of the plant to 40 percent would result in an increase in electricity generation of 425,000 MWh, nearly the equivalent electricity generation of the seven dams for the entire year.

Another approach of viewing the dam's role in the New England capacity market is to compare the nameplate capacity of the seven dams, which is 97.7 MW as shown in Exhibit 5, against ISO-NE's excess capacity, which for 2010 was 5,239 MW. The nameplate capacity of the seven dams that would be replaced represents less than 2 percent of the 2010 excess capacity. The summer capacity of the seven dams, which would be a more appropriate comparison to the summer excess capacity, are less than one percent of the 2010 excess capacity.

B. The Seven Dams as a Percent of Maine Energy and Capacity

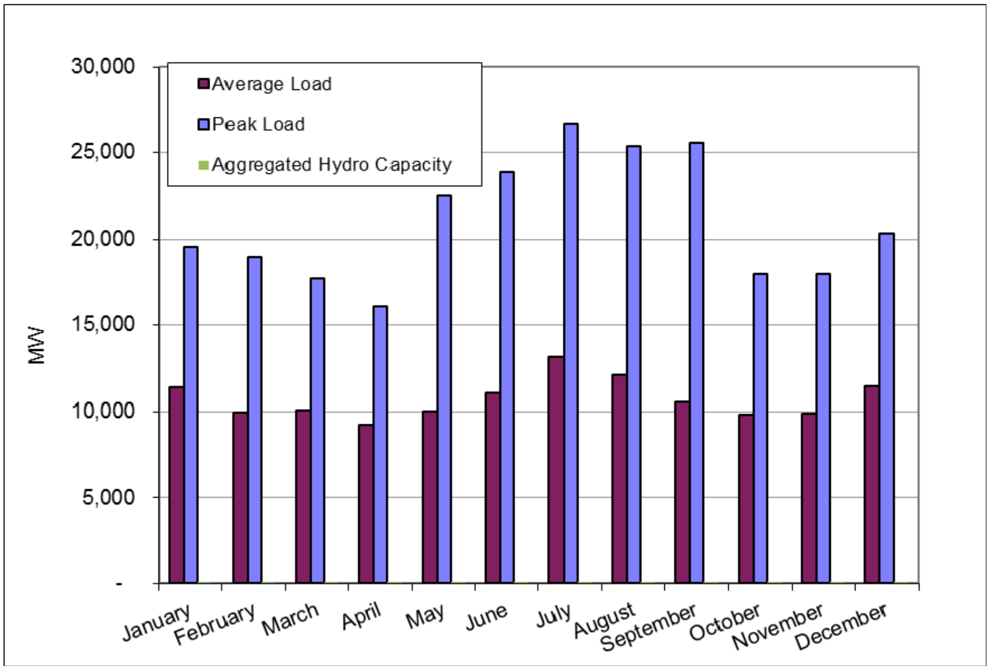
Although ISO-NE does not report a specific net energy requirement for Maine, electricity consumption in Maine in 2010 represented 8.9 percent of the New England total. Thus, electric generation of these hydro plants represented approximately 5.5 percent of Maine's total generation in 2010 based on ISO-NE and EIA data. Similarly, these hydro plants represented 2.3 percent of Maine's 2010 summer generating capability, which totaled 3,071 MW (ISO-NE 2011d).

5. New England and Maine Monthly Loads

A. Overview of New England Loads

Exhibit 6, below, shows the monthly average and peak loads in 2010, with the summer capacity (44 MW) and winter capacity (71 MW) associated with the seven dams. The highest loads in New England occur during the summer period. However, as noted above, ISO-NE rates the summer capacity of the seven dams as 44 MW, based on historical output during peak summer periods. The capacity of the seven dams is barely visible on the graph below.

Exhibit 6. New England 2010 Average and Peak Load by Month with Summer and Winter Capacity of the Seven Dams (MW)

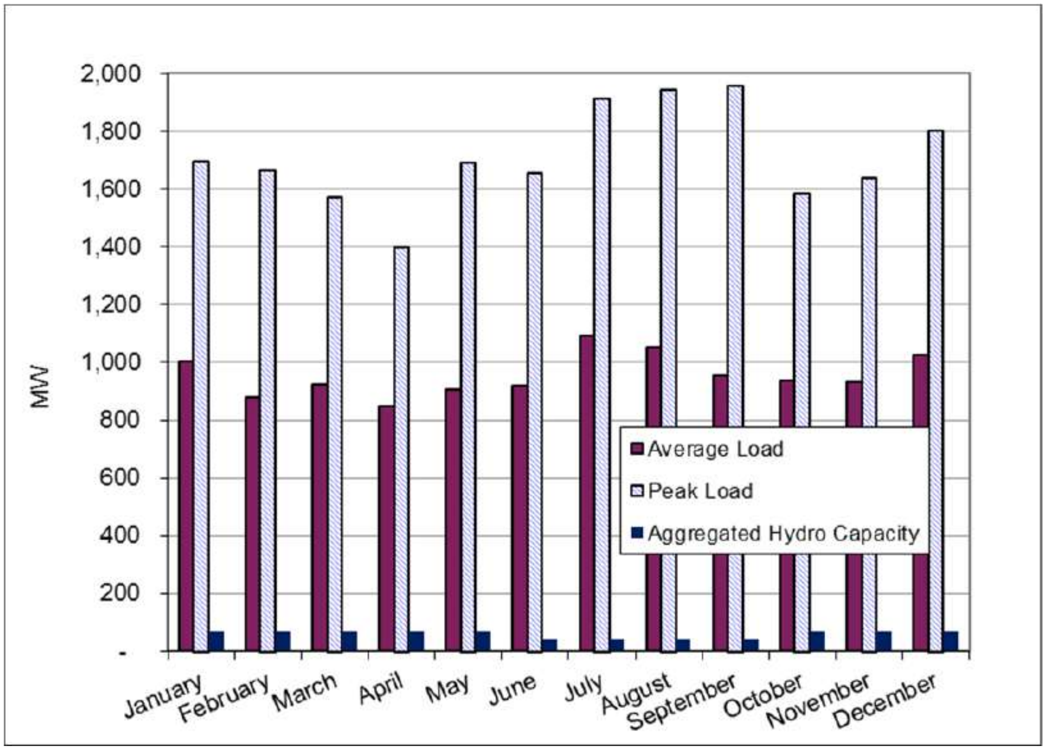


This exhibit shows that the seven dams meet an imperceptibly small fraction of New England's total load.

B. Overview of Maine Loads

Even though the New England electric system operates on a regional basis, looking at Maine's load provides a useful examination. As indicated earlier, Maine represents about 8.9 percent of total New England loads. Exhibit 7, below, shows the monthly average and peak loads in 2010 for Maine from ISO-NE data. Like the rest of New England, the highest loads in Maine occurred during the summer period. The aggregated summer and winter capacities of the seven dams are also included, in order to show their contribution to meeting Maine's load throughout the year.

Exhibit 7. 2010 Monthly Loads in Maine (MW)



This exhibit shows that the seven dams meet only a small fraction of Maine's load.

C. Monthly Hydro Generation

Exhibit 8, below, shows the monthly generation from the studied hydro plants, as well as Maine's monthly and total electricity demand in 2010. Hydro generation is greatest in April, both in absolute terms and as a percentage of load, but this is also one of the lowest load months, as shown in Exhibit 7. For the five-month period of April through June plus October and November, these hydro plants represent an average of 6.1 percent of Maine's electricity demand. As noted earlier, other available resources are more than sufficient both in New England and within Maine to make up this generation if the dam turbines do not operate in April, May, June, October, and November.

Exhibit 8. 2010 Monthly Hydro Generation from Seven Dams and Maine Electricity Consumption

Month	Hydro Generation (MWh)	Maine Electricity Consumption (MWh)	Hydro Percentage of Maine Electricity Consumption
	1	2	3=1÷2
January	45,375	748,464	6.1%
February	40,607	590,688	6.9%
March	46,451	686,712	6.8%
April	51,002	610,560	8.4%
May	40,087	675,552	5.9%
June	32,366	663,840	4.9%
July	31,055	813,936	3.8%
August	29,196	784,920	3.7%
September	29,112	688,320	4.2%
October	39,727	698,616	5.7%
November	40,087	672,480	6.0%
December	39,941	764,832	5.2%
Year	465,008	8,398,920	5.5%

Notes
1 Hydro generation from EIA-923 data
2 Maine load from ISO-NE data

D. Impact of the Loss of Capacity and Generation

In aggregate, the capacity from these hydro plants represents 1.43 percent of Maine's summer capacity and 2.12 percent of its winter capacity. Available capacity in Maine exceeds the state's peak load by a significantly larger amount than these dams' aggregate capacity.

These dams represent a larger fraction of the total capacity in the April to June period, when their generation is greatest and the loads are the lowest. However, partial or full loss of their output could easily be covered by other available resources at all times of the year.

Maine currently has a renewable portfolio standard (RPS) that requires 30 percent of electricity sales to come from eligible renewable resources, and hydropower is one of the eligible resources to help meet this goal. While electricity generation from hydropower will vary year-by-year, 2010 data from EIA indicates that Maine hydropower plants generated 45.4 percent of Maine's electricity demand. Reducing the generation from the seven dams even by the **full** year would reduce the Maine's hydro generation percentage to 39.9 percent, still well above the 30 percent threshold, even before the inclusion of other eligible resources in Maine. Reducing the generation from the seven dams for only April through June and October through November, would only reduce Maine's hydro generation from 45.4 to 42.9 percent.

6. Possible Impacts on Dam Owners

A. Loss of Revenues

Although I do not have access to actual revenue or operating cost data from the dam operators, it is possible to estimate a reasonable range of annual gross revenues based on publically available data. This data includes the monthly generation for each plant from the U.S. Energy Information Administration (EIA), monthly energy prices by period from ISO-NE (ISO-NE 2012), and capacity prices from ISO-NE.

Energy Revenues

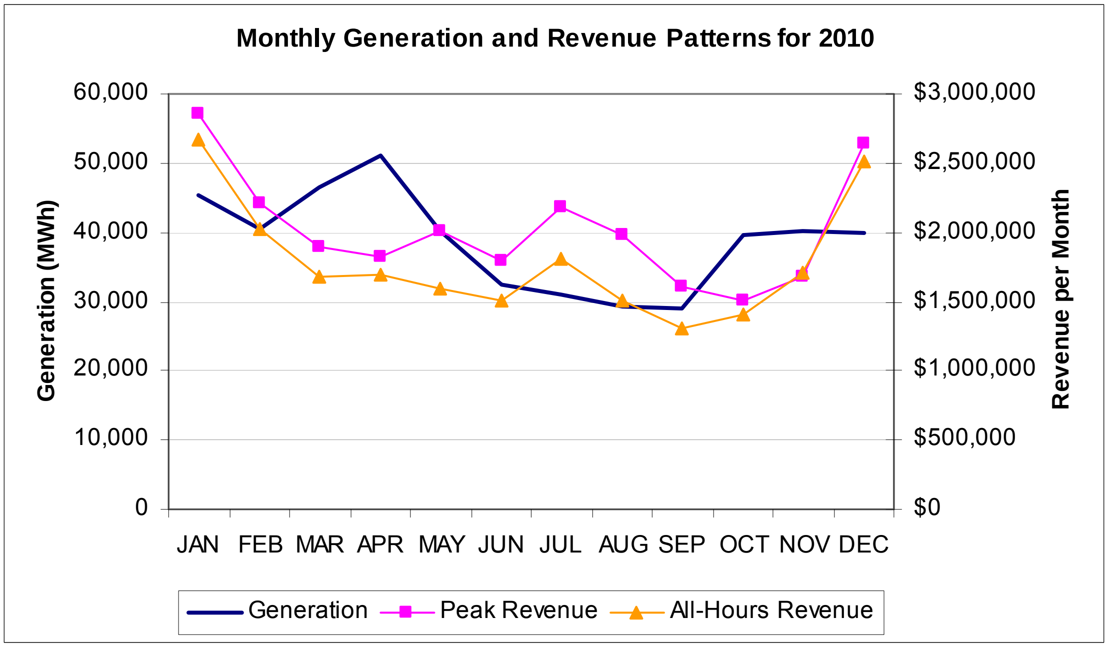
For energy revenues, I estimate a range of possible revenues based on the peak period prices for the upper bound, and the all-hours prices for the lower bound. Although these plants are run-of-the-river, they are identified by ISO-NE as "daily cycling," given that there is likely some flexibility in scheduling generation to match daily peak hours.

The following exhibit summarizes the 2010 generation and my estimates of gross energy revenues based on wholesale market prices. The energy revenues for the seven dams aggregated together run a little below $2 million per month, and are greatest in the winter. Summer revenues are a little above the average, even though generation is lower in those months, because energy prices are higher.

Partial or full shutdown of these hydro units would have energy revenue impacts proportional to the monthly loss of generation. Monthly revenues for all seven dams together in 2010 were in the $1.5 to $2 million range from April through June, and in the $1.5 to $1.75 million range for October and November. For each individual dam, the revenues from April through June range from approximately $100,000 to $350,000 and from October and November range from approximately $97,000 to $360,000, depending on the individual dam and month.

Electric energy wholesale prices (and revenues) may be a little higher in future years. But the primary determinant of electric wholesale prices in New England is natural gas prices, which are forecast to be relatively stable (Hornby 2011).

Exhibit 9. Monthly Generation and Energy Revenues for all Seven Dams



Capacity Revenues

ISO-NE provides and pays for capacity through the Forward Capacity Market (FCM) and annual auctions for capacity three years in the future. As mentioned earlier, five Forward Capacity Auctions (FCA) have been held to date to provide capacity up through May 31, 2015. In recent FCAs, there has been a capacity surplus and the auctions have cleared at their floor prices.

There are big differences between winter and summer capacities for these hydro plants. New England's peak load period is summer. Capacity prices have dropped considerably in New England and stopped at the floor level because of capacity surpluses. Capacity payments for these hydro plants will be at their winter capacity values for eight months (October through May) and at summer capacity values for four months (June through September). Total capacity revenue for the seven dams for the next several years may be over $2 million per year. If they do not run or have their capacity reduced in a given month, their monthly payments will be proportionally reduced. For example, if all of the studied hydro plants were totally shut down during the month of June in 2013, the capacity revenue loss would be about $130,000 in aggregate for the seven dams. For each individual dam, the loss of capacity revenue will vary by the capacity obligation of each dam. For the June 2013 example, this range is approximately $7,300 for the Lockwood dam to $39,000 for the Weston dam. Exhibit 10, below, shows the total expected capacity revenue for the seven dams based on each of the five Forward Capacity Auctions.

Exhibit 10. Expected Capacity Revenues for All Seven Dams

Capacity Auction	Period (June 1 start)	Capacity Price ($/kW-month)	Summer Capacity (MW)	Winter Capacity (MW)	Summer Capacity Revenue	Winter Capacity Revenue	Annual Capacity Revenue
		1	2	3	4=1*2*(4)*(1,000)	5=1*3*(8)*(1,000)	6=4+5
FCA-1	2010-2011	$4.500			$792,000	$2,557,000	$3,349,000
FCA-2	2011-2012	$3.600			$633,000	$2,046,000	$2,679,000
FCA-3	2012-2013	$2.951	43.99	71.30	$519,000	$1,677,000	$2,196,000
FCA-4	2013-2014	$2.951			$519,000	$1,677,000	$2,196,000
FCA-5	2014-2015	$3.209			$565,000	$1,823,000	$2,388,000

Notes
Values may not sum due to rounding
Summer: June through September
Winter: October through May
Capacity prices based on ISO-NE data for Forward Capacity Auction (FCA)
Capacity values based on CELT 2011

7. Summary

Based on the analysis provided above, it is my opinion that neither the New England electric power grid nor the local electric system within Maine would be adversely impacted by a seasonal shut-down of the seven dams. The seven hydro dams contribute to the electric grid; however, the seasonal shut-down of these units would not result in a significant impact on the region or the state. Both Maine and New England have more than adequate supply capacity to offset the seasonal loss of these dams.

I estimate that the lost energy revenues to the dam owners would be in the range of roughly $1.5 – $2 million in aggregate for the seven dams for each month that turbines are fully shut down from April through June, and roughly $1.5 – $1.75 million in aggregate for each month that turbines of the seven dams are fully shut down from October to November. I estimate that the lost capacity revenues to the dam owners would be roughly $130,000 in aggregate for the seven dams for the month of June, and roughly $210,000 in aggregate for each month that turbines of the seven dams are fully shut down during the months of April, May, October, and November.

Maximilian Chang
January 12, 2012

8. Bibliography

Energy Information Administration. *2010: Form EIA-860 Annual Electric Generator Report*. Available at http://www.eia.gov/cneaf/electricity/page/eia860.htm

Energy Information Administration. 2010: EIA-923 January – December Final, Nonutility Energy Balance and Annual Environmental Information Data. Available at http://www.eia.gov/cneaf/electricity/page/eia906_920.html

Environmental Protection Agency. *Clean Air Markets Division 2010 Data.* Available at ftp://ftp.epa.gov/dmdnload/emissions/hourly/monthly/2010/

Giaimo, M. Ferdinand, W. *ISO New England Overview*. Presentation January 20, 2011. Available at http://www.iso-ne.com/pubs/pubcomm/pres_spchs/2011/final_maine_jan20_11_post.pdf

Hornby, R., Chernick, P., Swanson, C., White, D., Chang, M., Gifford, J., Hughes, N., Wilson, R., Wittenstein, M., and Biewald, B. *Avoided Energy Supply Costs in New England: 2011 Report*. August 11, 2011. Available at http://www.synapse-energy.com/Downloads/SynapseReport.2011-07.AESC.AESC-Study-2011.11-014.pdf.

ISO-New England. *Energy Sources in New England 2010.* (n.d.) Available at http://www.iso-ne.com/nwsiss/grid_mkts/enrgy_srcs/index.html

ISO-New England. *2011-2020 Forecast Report of Capacity, Energy, Loads, and Transmission*. April 2011. Available at http://www.iso-ne.com/trans/celt/report/2011/2011_celt_rprt.pdf.

ISO-New England. *ISO New England Installed Capacity Requirement, Local Sourcing Requirements, and Maximum Capacity Limit for the 2014/15 Capability Year*. April 2011 Available at http://www.iso-ne.com/genrtion_resrcs/reports/nepool_oc_review/index.html

ISO-New England. *2011 Regional System Plan*. October 21, 2011. Available at www.iso-ne.com/trans/rsp/2011/rsp11_final_102111.doc

ISO-New England. *Maine 2011-12 State Profile.* Updated December 2011. Available at http://www.iso-ne.com/nwsiss/grid_mkts/key_facts/me_12-2011_profile.pdf

ISO-New England. *Monthly Summary of Hourly Data.* Updated January 10, 2012. Available at http://www.iso-ne.com/markets/hstdata/znl_info/monthly/index.html

ISO-New England. *Section III Market Rule 1 Standard Market Design.* Available at http://www.iso-ne.com/regulatory/tariff/sect_3/mr1_sec_13-14.pdf

State of Maine Department of Environmental Protection. *Hydroprojects in Maine.* April 1, 2010.

State of Maine Statutes. Title 35-A, Ch 32. §3210. Available at http://www.mainelegislature.org/legis/statutes/35-a/title35-asec3210.html

Steinhurst, W. 2008. *The Electric Industry at a Glance*. National Regulatory Research Inst. Available at http://www.synapse-energy.com/Downloads/SynapseReport.2011-01.0.Elec-Industry-Overview.10-076.pdf

Exhibit 13

Ex. 13

Merrymeeting News

Spring 2008 VOLUME XVIII, No. 2

The Newsletter of Friends of Merrymeeting Bay • Box 233 • Richmond Maine 04357 • www.friendsofmerrymeetingbay.org

Friends of Merrymeeting Bay

Friends of Merrymeeting Bay is a 501(c)(3) non-profit organization. Our mission is to preserve, protect and improve the unique ecosystems of the Bay through:

Education

Conservation & Stewardship

Research & Advocacy

Member Events

Support comes from members' tax-deductible donations and gifts.

Merrymeeting News is published seasonally by Friends of Merrymeeting Bay (FOMB), and is sent to FOMB members and other friends of the Bay.

For more information call:
Ed Friedman
Chair of Steering Committee
666-3372

Read more about our Safe Passage! Campaign on Page 6

Moving Fish!

This spring was a banner season for alewives in mid coast rivers. These important forage fish are blocked from most of their spawning habitat [fairly shallow inland ponds] by our many dams. At the Florida Power & Light Energy [FPLE] Ft. Halifax dam located where the Sebasticook River meets the Kennebec in Waterville/Winslow and at the FPLE Brunswick-Topsham dam on the Androscoggin, Maine Department of Marine Resources restoration biologists Nate Gray and Mike Brown respectively, go into 14 hours/day, 7 days/week overdrive with their teams to move as many fish as possible.

Fish are moved first to certain stocking ponds within the watersheds and then trapped and trucked to various locations around Maine. Forage species like the alewives and other river herring, are key to the health of the Gulf of Maine fishery and though artificial passage moves only a fraction of the fish and not without mortality, these dedicated crews do their very best. This year about 500,000 fish were passed through at Ft. Halifax and about 70,000 in Brunswick.

Ed Friedman

Some of the 70,000 Brunswick alewives headed for the trap.

In Russian roulette, only one chamber has a bullet. At FPLE's Brunswick dam, downstream fish passage [small pipe at waterline] is sandwiched between multiple turbines. Just the opposite of the hand gun-gamble. Turbines here, of course, remain unscreened.

The Brunswick fish ladder.

Moving Fish Photo Essay Continued on Page 4

Our experts are finally admitting it: human activities have become the dominant influence on the shape of the earth.

Some insights from the late Bruce Trigger are recalled:

A fascinating story that caught my eye on the front pages this week was about a group of British geologists who have suggested that the Holocene — covering the last 11,700 years of the planet's natural history — should be modified to account for the recent predominance of human activities in shaping our Earth.

An Introduction to the Anthropocene Era

Several years ago I mentioned in one of my columns the recent book by friend and former glaciology professor Paul Mayewski on increasing rapid climate change events. Paul having worked extensively on ice cores from Antarctica to Greenland is an expert on the subject and is seeing first-hand, historical evidence of dramatic climate changes. Kicking off our 2007-2008 Speaker Series was mountaineer, physicist and author Mark Bowen who spoke of Lonnie Thompson, a well respected climatologist specializing in tropical ice cores.

The evidence has become overwhelming, even though we first became aware of the problem in the 1800s. We are changing the planet's climate, probably not for the better, and extremely rapidly.

While the 12,000 or so year period since the last continental glaciation has historically been known to geologists as the Holecene Era, there is now a growing movement to mark recent centuries as the Anthropocene Epoch [see Boyce Richardson article on this page] referring to the era of dominant technology and its attendant problems, when the activities of the human race first began to have a significant global impact on the Earth's climate and ecosystems. The term was coined in 2000 by the Nobel Prize winning scientist Paul Crutzen, who regards the influence of human behavior on the Earth in recent centuries as so significant as to constitute a new geological era. While most scientists tend to think of this period as beginning in the 19th century, some feel it began as early as 8,000 years ago with mankind's first efforts at large scale farming.

Ed Friedman

They say that our current era of dominant technology and its attendant problems should be renamed the Anthropcene in recognition of the changes that human-driven technology has wrought in the shape of the Earth.

As readers of this site will probably know, I was friendly with the remarkable, recently deceased McGill University professor Bruce Trigger, who, from his differing viewpoint as an anthropologist and archaeologist produced some fascinating insights into this very question, particularly in a lecture he gave in November 1986, on *Archaeology and the Future.*

Trigger --- who at his death was widely considered to be the world's leading expert in the history of archaeology --- in his lecture divided human history into three stages. The first was the one in which nature was dominant. It was characterized by small-scale, egalitarian societies based either on hunting or gathering. People had a short life-span, population densities remained low allowing for considerable leisure time and flexible work schedules, although long-term planning became more important as reliance on stored foods increased.

In Trigger's view, the archaeological record reveals that co-operation rather than conflict was the dominant theme in these societies in which people survived, not as ruthless predators (as depicted in modern right-wing mythology), but as "effective co-operators." Decisions were normally reached through consensus, and the prestige derived from generosity "was a major stimulus for aspiring leaders to work hard and keep little for themselves." Finally, at that time, nature was believed to be "animated by spirits that resembled, but in many cases were more powerful than human beings, and hence were able to influence human destiny in important ways."

Trigger's second stage of human development he called the "pre-industrial civilizations." These began in the Near East 5,000 years ago and ended in Europe "only in the last (meaning 19th) century." These were characterized by coercive political structures by which rulers dominated and exploited the vast majority of their subjects. Great temples, tombs and palaces were constructed. Individual political units embraced tens of thousands to millions of people, at higher population densities, with a complex division of labour and a class structure that "concentrated wealth and powers in the hands of a small, privileged and archeologically highly visible elite."

These structures led to a hierarchical society dominated by rulers who relied on force to suppress opposition. "Poverty, exploitation and outright slavery became the lot of vast numbers of people," wrote Trigger, and concepts of dominance and obedience, authority and submission pervaded the whole of society. "Rewards and punishments were believed to be sanctioned by heavenly rulers and contrasted sharply with the social values of egalitarian societies."

Technology, however, was rudimentary, and conspicuous consumption of wealth was what marked the behaviour of elites in this period.

The third period— through which we are now living— Trigger called, "modern industrial civilizations a stage of human history when technology is dominant."

The number of food producers has declined rapidly, as farming has become "more efficient than nineteenth-century economists ever imagined possible." And the exploitation of an "ever-expanding range of natural resources" has caused industrial economies to spread into every part of the world, "terminating the independence of all the surviving band and tribal societies." Education has led to societies with wide diversities of skills, and medical advances have allowed "a vast world-wide increase in population. Although there has been a significant increase in the quality of life for most people, Trigger said technological and medical advances "have generated a vast number of new problems." He named over-population and depletion of non-renewable resources as the greatest of these, leading to "growing concern" that the higher populations, combined with higher levels of personal consumption, will outstrip the available resources of the planet.

Higher populations, combined with higher levels of personal consumption, will outstrip the available resources of the planet.

Trigger listed pollution— unsafe disposal of industrial waste, misuse of chemicals, acid rain, nuclear accidents, and the greenhouse effect (only then emerging) as growing dangers— with growing concern over the effects of genetic engineering and mind-controlling devices "that can be used by governments to manipulate human behaviour." In short, these problems could become so severe on the health and prosperity of populations that they "could result in the destruction of civilization."

On the possibility of controlling this technology, Trigger did not mince words: the nation state "is unable to provide regulation on a scale adequate to control the harmful use of modern technology." Internationally, we lack effective instruments of control; while even within nation states, planning and control is inadequate to the task.

"The survival of humanity now depends on its ability to predict the long-term environmental and social impacts of technology, and to eliminate or modify technologies that in the long run threaten human welfare."

Trigger ran through a number of possible solutions, for example, slowing down, or even eliminating technological growth, but rejected them as likely to lead to repressive controls and regimentation. His more favored solution he posited as "wide-scale and detailed planning", which would necessitate "the fullest possible utilization of humanity's potential as well as realized intellectual resources."

It follows that "control of the world ecosystem necessitates a much greater degree of social, economic and political equality within countries and throughout the world, than exists at present. Such conditions may have to be achieved at the cost of some material sacrifice by the more affluent." From this he concluded that the "now largely abandoned concept of the accelerated promotion of social and political equality is not merely a utopian ideal but a precondition for survival in an environment dominated by an advanced industrial technology."

He comes to an ironic conclusion: the qualities that we most need to survive today— foresight, personal restraint and co-operation— were essential for Paleolithic hunter-gatherer life. The difference is that these qualities must be applied on an ever-widening scale and with rapidity that precludes further significant inputs from natural selection."

In other words, we have to learn how to govern ourselves in new ways that will make planning, freedom and equality synonymous for the first time in human history.

Boyce Richardson
Reprinted with permission of the author.
From the Blog of Boyce Richardson January 25, 2008

Boyce Richardson, born 1928 in New Zealand and a Canadian resident for many years is a former journalist, writer and documentary filmmaker. Richardson's book on the battle of the Cree Indians against Hydro-Quebec, *Strangers Devour the Land*, (first published in 1974) is being re-published this year by Chelsea Green Publishing, of Vermont, with a new introduction. His Blog, *Boyce's Paper* has been described as "the world's oldest Blog, got up by the world's oldest Blogger." In 2002, Richardson was invested a Member of the Order of Canada, his country's highest honor. Look for him on the web: brich@magma.ca.

Moving Fish! [*continued from front page*]

A stream full of alewives.

This year about 500,000 fish were passed through Ft. Halifax and about 70,000 in Brunswick.

At the north corner of Ft. Halifax dam, a powerful pump sucks up fish attracted by the flow coming out of the open pipe. Alewives are pulled up to a large holding tank in the parking lot by the powerhouse where they can be discharged to the headpond or transferred to a tank truck for transfer to a spawning pond.

At Brunswick, certain fish species come up the ladder and into a trapping area made from steel grate where they are raised up the vertical shaft (seen in the center rear of this picture) to the raised sorting and counting facility and then released into a center tank full of water.

If they are being passed above the dam they are netted and counted and transferred to the left tank where they than are released through a pipe, falling down to the head pond.

If the alewives are to be trucked, they are counted as moved to the right tank, where they then come out the suspended hose into an aerated tank truck for their journey.

The Wolf is Back

The wolf is back in the northeast, if in fact it was ever gone. The killing of an 85 pound wolf by a western Massachusetts sheep farmer in October 2007 is likely evidence that wolves now range throughout much of the region, from the Adirondacks to northern Maine. The animal was killed just eighty miles from where a wolf was killed in New York in 2001.

A spokesperson for the U.S. Fish and Wildlife Service (USFWS) wrongly claimed that the Massachusetts animal was the first gray wolf found in the northeast since a wolf was killed near Moosehead Lake in 1993. In fact, the Massachusetts animal was at least the eighth DNA confirmed wolf killed south of the St. Lawrence River since 1993.

It is widely believed that wolves were extirpated south of the St. Lawrence River by around the turn of the 20th century as they, their prey and their habitats were destroyed by humans. Although breeding populations may have been eliminated, occasional wolves continued to appear in the northeast U.S., possible dispersers from north of the St. Lawrence.

A wolf was killed in western Massachusetts in 1902 and another wolf was seen in that state in 1918. A pack of wolves was reported to have roamed northwest New York in the 1930's. An animal reported to be a wolf was killed near Cherryfield, Maine in November, 1953. Several other reported wolves were killed in New York in the 1950's and 1960's the skull of one of which is in the Smithsonian.

The closest acknowledged wolf populations to the northeast U.S. are in southern Quebec, some sixty miles from New York and fifty miles from Maine. The Frontenac Axis in southeast Ontario may serve as a wolf dispersal corridor from Canada into the U.S. The Axis extends south from established wolf range, to the north shore of the St. Lawrence River. Moose, fisher, and lynx have been documented crossing the St. Lawrence from New York into Ontario. Wolves are very capable of making the same journey from north to south.

The 2007 Massachusetts wolf was identified by USFWS as an "eastern gray wolf." The wolf was likely a hybrid gray wolf/eastern wolf with a very small percentage of coyote. As a gray wolf hybrid, however, it was protected under the Endangered Species Act. Recent DNA analyses of Maine's 1993 and 1996 wolves indicate that they were primarily gray wolf with smaller percentages of eastern wolf and coyote. They were most genetically similar to gray/eastern wolf hybrids that live in a zone that stretches across Ontario and Quebec.

Gray wolves live across much of Canada from Labrador to the Yukon. Eastern wolves are closely related to red wolves and live in southern portions of Ontario and Quebec, most notably in and around Algonquin Park. Eastern wolves are smaller than gray wolves with adult males in Algonquin Park averaging only 65 lbs. The male wolves documented killed in the northeast in recent years have averaged 85-90 lbs.

It is not known how many eastern wolves and female gray wolves have been killed in the northeast, that were simply considered "coyotes" due to their smaller size. The so-called "coyotes" of the northeast U.S. are actually coyote/eastern wolf/gray wolf hybrids with varying percentages of each.

The U.S. and Canadian governments provide virtually no protection for wolves that may be attempting to re-colonize the northeast U.S. from Canada. All of the northeast states allow virtually unlimited killing of "coyotes" and this has resulted in the illegal killing of wolves. There is growing evidence that wolves are attempting to recolonize the northeast U.S. including DNA evidence of a possible breeding population.

As ungulate populations in the northeast grow and expand, the need for natural population checks continues to grow as well. The gray wolf is filling an ecological void. If simply allowed to survive, it will do just that.

John Glowa
Chair, Policy and Government Relations Committee
Maine Wolf Coalition
"Know Wolves"
Website: http://home.acadia.net/mainewolf/

When the animals come to us,
asking for our help,
will we know what they are saying?
When the plants speak to us
in their delicate, beautiful language,
will we be able to answer them?
When the planet herself
sings to us in her dreams,
will we be able to wake ourselves, and act?

Gary Lawless

Program Updates: How We're Making a Difference

Kathleen McGee recovers a drifter tracked by air to a location one mile up Spinney Mills Creek from Fiddler's Reach.

Intern Simon Beirne, and volunteer Jim Gillies with his dog Joy, set off from the Chops to radio track and retrieve, our current study drifters.

Students get their hands dirty during the watershed modeling project at Bay Day.

Current Study

With a protracted period of snow melt followed by several inches of rain, we had a good season for gathering our high flow field data. This is the final scheduled segment of the study. A few quick snippets since all of our data are not yet analyzed: drifters moved from Augusta to the Bay in a day, some drifters moved to the mouth of the Kennebec from the Chops in a couple of tides, one drifter ended up beneath the South Bath boat ramp [whose sides extend well below water level] and several weeks after our deployments were done, one of our four un-recovered drifters [and we searched the area from the Bay to Monhegan to western Casco Bay] drifted on to a Wellfleet beach in Cape Cod Bay.

Legal

Final briefs in our safe passage appeal to the Maine Supreme Court were submitted on schedule. The Court is scheduled to deliberate on the case in June. In our ESA Salmon case, the feds did not respond with any kind of settlement offer to our 60 day notice of intent to sue, so along with Doug Watts and the Center for Biological Diversity, we filed suit in Portland's Federal Court.

The government has until July 21 to respond to our complaint that they are 2 years past the statutory deadline for making a listing decision on the Kennebec salmon. All legal documents are posted in that section of the "cybrary" on our web site. While receiving lots of print media attention on this subject, we were also interviewed by CBC Radio from maritime Canada.

Land Conservation

Things are moving along well on a number of conservation deals around the Bay, both in fee and easements. **It's official! As of May 22, the conservation tax incentive has been extended through the end of 2009, and retroactive to January 1.** Congress overrode a Presidential veto to pass the Food, Conservation and Energy Act of 2008. In addition to renewing the easement incentive, this bill:

- Provides a total of $733 million over 5 years for the Farmland Protection Program.
- Re-establishes the Grassland Reserve Program with a goal of 1.22 million acres, funded with an estimated $300 million.

Education

May 20 we had another great Bay Day with perfect weather at beautiful Chop Pt. School in Woolwich. About 200 students from West Bath, Woolwich, Chop Pt. and Fisher Mitchell schools attended, got dirty, had fun and learned some great information about the Bay. We had to turn away nearly another 100 students from Jordan Acres for lack of room [but made it up to them a little bit with an in-school visit]. During this school year we have worked with over 900 students from pre-school through sixth grade attending 12 schools.

Friends of Merrymeeting Bay · Box 233 · Richmond, Maine 04357

Membership Levels

❑ $1,000+ Sturgen ❑ $750 American Eel ❑ $500 Wild Salmon ❑ $250 Striped Bass
❑ $100 Shad ❑ $50 Alewive ❑ $20 Smelt ❑ Other

Name

RR# or Street Address

Town/State/Zip

Phone Email

❍ $7 Enclosed for a copy of *Conservation Options: A Guide for Maine Land Owners* [$5 for book, $2 for postage].

❍ Renewal ❍ New Member ❍ Send me information about volunteer opportunities.

Friends of Merrymeeting Bay

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Executive Coordinator

Misty Gorski 582-5608 email: fomb@gwi.net

Thanks to Will Everitt for design and layout of this newsletter edition.

FOMB Welcomes New Executive Coordinator!

After much consideration and review of approximately thirty applicants, the FOMB Steering Committee is excited to have hired Misty Gorski as our new Executive Coordinator. With good memories of the Bay from childhood, Misty is excited to return here and is passionate about the work we do. She will be living in Richmond when beginning work in mid June. A brief introduction from Misty follows:

I grew up an avid reader of Dr. Seuss' work. His creative, fun, easy to read books were always plentiful in my childhood home. It wasn't until years later, rereading the *The Lorax*, that I realized how important this particular story was. The Lorax was the voice of the flora and the fauna and fought to point out the destruction of greed. It reminded me a lot of what I had seen growing up; forests were clear cut, water sources polluted, and biodiversity decreased. This enlightening story made me realize that I too needed to be a voice for the trees.

Feeling inspired, I was easily drawn towards studying environmental studies and pursuing work in the conservation field.

I received a Bachelor of Science in Environmental Studies from the University of Maine at Machias. Living in Downeast Maine allowed me to experience the struggles between resource use and strengthening their economy. Realizing the need for balance between economic growth and sustainable resource use I went on to pursue a Masters degree at Antioch University New England in Resource Management and Conservation. Through my studies I learned not only hard science but also how to be an agent of change.

Upon finishing my degree this past spring, I found myself searching for the right position that will allow me to be that agent for change. This is what led me to Friends of Merrymeeting Bay.

We need to be more like the Lorax. We are the voices of the trees, the Bay, and all the species that make their homes here. Merrymeeting Bay is a special place that we have been blessed with and it is our responsibility to be good stewards. It is important to conserve what is close to our hearts and allow these ecosystems to sustain themselves so that they will be available for future generations.

I am ecstatic to start working for FOMB as the new Executive Coordinator and look forward to working collaboratively with members and non-members to protect the Bay.

It's like Dr. Seuss wrote: "Unless someone like you, cares a whole awful lot, nothing's going to get better.
It's not".

Misty Gorski

Friends of Merrymeeting Bay
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It has been an incredibly busy and productive spring for FOMB. So THANKS!

To Bay Day Guides:
Tom Weddle, Nate Gray, Margaret Chabot, Ann Speers, Jamie Silvestri, Alison Baird, Jay Robbins, Steve Eagles, Kent Cooper, Nancy Murphy, Paul Dumdey, Judy Chute, John McPhedran, Ed Friedman, Kerry Hardy, Sarah Cowperthwaite, Kathleen McGee, and Grace Cooney;

And Bay Day Chaperones:
Pippa Stanley, Milo Stanley, Becca Hamilton, Carla Rensenbrink, Margy Miller, Ruth Gabey, Petey Ambrose, John Ambrose, Bill Briggs, Dick Nickerson, Bev Nickerson, Patty Olds , Fritz Kempner, Steve Musica, Dana Pratt, Tom Walling, Bethany Laursen, Robin Brooks, to Wild Oats Bakery, and to our hosts at Chop Pt. School!;

To In-School Visit Volunteers:
Joan Llorente, Dana Pratt, Tom Walling, Andy Cutko, Wayne Robbins, Kathie Duncan, Kathleen McGee and Ed Friedman;

For help with the Current Study to:
Steve Dexter, Tom Walling, Simon Beirne, Peter & Noreen Ryan, Jim Gillies, Kathleen McGee, Ed Friedman, Scott Allen, Ben Magro, Peter Milholland and Steve Pelletier; Laura Flight, Charlie Culbertson and Greg Stewart from USGS, Curt Fish, Dick Lemont, Mary Earle Rogers and Chop Pt. School;

To Kermit Smyth, Bill Milam, Ruth Innes, John Lichter and our very large band of water quality monitors off to another good start;

To Kent Cooper providing refreshments for most of our 2007-2008 Speaker Series and to Eric Herter and Martha Spiess for their efforts at filming the Series;

And to Steve Musica, David Whittlesey, Pippa Stanley and Kathleen McGee for help with mailings as well as to Stan Moody and Martin McDonough for their continued website work.

FOMB Receives Award!

On April 26, FOMB was honored at the annual Peace Action Maine Awards Dinner.

Peace Action Maine (PAM) has a new initiative called ***Reclaim Maine*** that hopes to better integrate actions taken towards and groups working towards, improving life in Maine. We received PAM's Peacemaker Award as an organization working holistically to do just this.

In giving us the award, PAM noted that they have been inspired by our work and that they aspire to the high level of work we are doing.

THANK YOU!

FOMB Exhibits Brunswick, Maine Hydroelectric Project, Androscoggin River FERC P-2284-0052

Exhibit 14

Ex. 14

Merrymeeting News

Fall 2016 Vol. XXV, No. 4

The Newsletter of Friends of Merrymeeting Bay • PO Box 233 • Richmond Maine 04357 • 207-666-1118 • www.fomb.org

Friends of Merrymeeting Bay (FOMB) is a 501(c)(3) non-profit organization. Our mission is to preserve, protect, and improve the unique ecosystems of the Bay through:

Education

Conservation & Stewardship

Research & Advocacy

Member Events

Support comes from members' tax-deductible donations and gifts.

Merrymeeting News is published seasonally and is sent to FOMB members and other friends of the Bay.

For more information, contact:

Kathleen McGee
Coordinator/Organizer
207-666-1118
fomb@comcast.net

Dodging Natural Law

This spring of 2016 began like none I recall. No snowpack to speak of. Early warming and ice out on the lakes and ponds some of the earliest on record. The ice was out on China Lake in late March. Some lakes and ponds experienced fish kills caused by rapidly warming water. Temperatures continued to rise. April came and went and the showers so often predicted failed to materialize. The May flowers came up anyway. And the river herring that typically show up in May did show up with a vengeance. Fish passage operations began throughout the state. Numbers seemed to be up for the remaining runs in extant on the eastern seaboard. At Benton Falls, the numbers which are staggering to begin with became downright epic. In all, this facility passed three point five million river herring. This is a minimal count. The technology we use to count the fish can only count so many at once. It's not as if the fish know to get in line, remain orderly and pass the counter single file. Nope, they're on a mission to procreate, their sexual maturity driving them on. The Sebasticook system is open to the ocean now and many thousands of acres of historical spawning habitat are accessible. What we predicted would happen…happened in a huge way. So huge, in fact, there can be no doubt as to the veracity of the early colonists' observations: "You could cross the river on their backs!" they said. Those who came later on passed that statement off as so much hyperbole. Seeing the alewives this spring I know the truth. I didn't test the "walking on water" hypothesis but I remain curious. The river ran black with them.

May came and went with alarming speed. So did flows on all the rivers. Any promise of a steady rain repeatedly quashed. Meanwhile the fish continued to pour on. American shad, the largest herring species in the world, and one we've worked hard restoring returned in good numbers. While the numbers of shad were not staggering, they were very encouraging. At Benton Falls the numbers of shad passed were not that high and there is a reason for that. The river simply ran out of water. At 900 square miles the Sebasticook basin is pretty big. But it will only hold so much water. When the rains failed to come, the river dried up. The downstream bypass at Benton Falls dam were opened in late May to allow the post spawn adult river herring egress from the system above. This dedicated fish bypass consumes 30 cubic feet per second (CFS). The fish lift consumes up to 90 CFS. The turbines can consume many times that amount. But the water resource just wasn't there. In order to maximize the downstream potential for the 3.5 million fish above us we decided to suspend active lifting upstream in mid-June. The turbines fell silent shortly after and remained silent the entire summer.

Photo: Ed Friedman, Shad Tombstone; Monica Chau

(continued page 2)

Dodging Natural Law (continued)

On June 19th I paddled the Sebasticook River from Benton Falls downstream to its confluence with the Kennebec at Fort Halifax in Winslow. I was acting as fisheries interpreter for a group of fine folks with the Sebastiook Regional Land Trust. Most folks were in kayaks. The one canoe carried Kerry Hardy who was the naturalist/native American interpreter. This stretch of river is littered with remains of an occupation of peoples spanning thousands of years. Carried by the swirling currents of the river, it doesn't take much imagination to understand why this was so. The Sebasticook still teemed with fish in late June. I saw one shoal of shad numbering at least a thousand strong. A school of white suckers blackened the bottom gravel as they darted in mass from beneath my kayak for a minute solid. Individual schools of blueback herring flitted in the shallows. Sea lamprey nests were scattered on gravel shoals. And most stunningly, the shore was littered with the carcasses of river herring by the thousands. Their tiny bodies lay in all stages of decay, many showing signs of active scavenging. We saw songbirds galore, eagles, osprey, a beaver, great blue herons, gulls and the list goes on. All of these species are beneficiaries of the river herring in one way or another. Either directly or indirectly, the decomposition of these fish feed the river nutrients. These in turn feed bacteria, plant growth, insects, in short a stunningly rich and functional ecosystem. By the end of the paddle I was nearly speechless. I'd just covered a six mile stretch of river and seen more fish than most will in a lifetime.

"Catch the fish, sort the fish, load the fish, count the fish, drive the fish, dump the fish, and repeat until you run out of fish."

I was asked many times about the number of dead fish scattered on the shoreline. I got the idea that most folks seemed uncomfortable with the thought of these fish dying on their spawning run. Why so many? Isn't this a bad thing? Why'd they die? Innocent enough questions, and ones most find disturbing in a reflective sort of way. The answer I find is somewhat miraculous. Having come to the job early on in the restoration, slaving for eight or nine weeks each spring to move one hundred thousand river herring by truck, past the dams to historical habitat, is something I can look back upon now with nostalgia. At the time it was a major grind. Seven days a week, ten, twelve, fourteen hours per day. Catch the fish, sort the fish, load the fish, count the fish, drive the fish, dump the fish, and repeat until you run out of fish.

That was the reality from 1983 to 2008 on the Sebasticook. If we had significant mortalities in the trucks we wracked our meager brains for a solution. We got better at trucking fish. But we were no surrogate for Mother Nature. Mother Nature demands all run the gauntlet. She cares not for the individual. Some make a wrong turn at the right time for the osprey or heron. Others may be on their second or third spawning run and are the human equivalent of an octogenarian. Many succumb to exhaustion in the oxygen depleted warm water. Whole shoals of herring might be driven ashore by hungry stripers, flipping desperately on dry gravel. Some flip the wrong way, back to waiting stripers or, further up the bank to eager herons. And man has certainly done his share to harvest them. It's tough hoeing being an alewife.

For the alewife it is a numbers game. The "You can't eat us all" strategy. Given a decent playing field, the alewife will produce numbers of young that are staggering. Females carry up to and beyond 100,000 eggs. A runs composition is close to 50% female. So, the 2016 run going into the Sebasticook could potentially produce up to 175,000,000,000. That's 175 billion eggs. If we look at the average adult returns on the Sebasticook of 2.7 million, then from egg to adult (4 years avg.) the alewive's odds of making it to maturity are 1:64,815. I've learned that alewives love long odds.

Nate Gray

Editor's Note:
2016 brought a relatively unique set of circumstances: low river flows, and high temperatures. These factors caused the dam owners to husband their precious impoundments for fear there would not be a rainy day to raise levels. Add recovering migratory fish biomass into this mix, dissolved oxygen (DO) levels fall, fish suffocate and die. With climate changing, this may become the new norm or, may never happen again. Regardless, we suggest a Department of Marine Resources/Department of Environmental Protection initiative to monitor temperatures and DO , taking action if temperatures get too high and DO too low. Call it a SWAT team for Surface Water Ambient Temperatures. When conditions get dire, dam owners must be required to release water. Higher flows equal greater DO and less chance of fish kills.

Fall Bay Day-September 27, 2016

Early morning showers stopped right on schedule giving about 130 students from Pittston, Bowdoin and Bowdoinham as well as 30 volunteer guides and chaperones a perfect Bay Day at the Merrymeeting Bay Wildlife Management Area in Bowdoinham next to the Cathance River mouth. Fabulous hands-on sessions included watershed modeling, anadromous fish printing, primitive skills, macroinvertebrates, conservation canines, field ecology and art in nature. How could you not have a blast??

Thanks to Guides:
Steve Eagles, Kent Cooper, Kathleen McGee, Leslie Anderson, Tom Hoerth, Betsy Steen, Nate Bears, Mark Gershman, Bethany Brown, Roy Morejon, Fred Koerber, Jay Robbins, Nate Gray, Toby Bonney, Megan McCuller, Hannah Goodman and Grant Connors.

And to Chaperones:
Tom Hughes, Tom Walling, Richard and Rachel Evans, Carole Sargent, Bob Goldman, Heather Cox, Phil Brzozowski, Tina Goodman, David Hammond, Martin McDonough, David Whittlesey.

Special thanks to: Kathleen McGee and Ed Friedman for organizing, scheduling and photos. Wild Oats Bakery for the delicious lunch wraps, Keel Kemper, IF&W Regional Biologist for use of the area and the weather gods for the usual rarified atmosphere of Bay Day!

Archaeology

Fish Printing

Watership Modeling

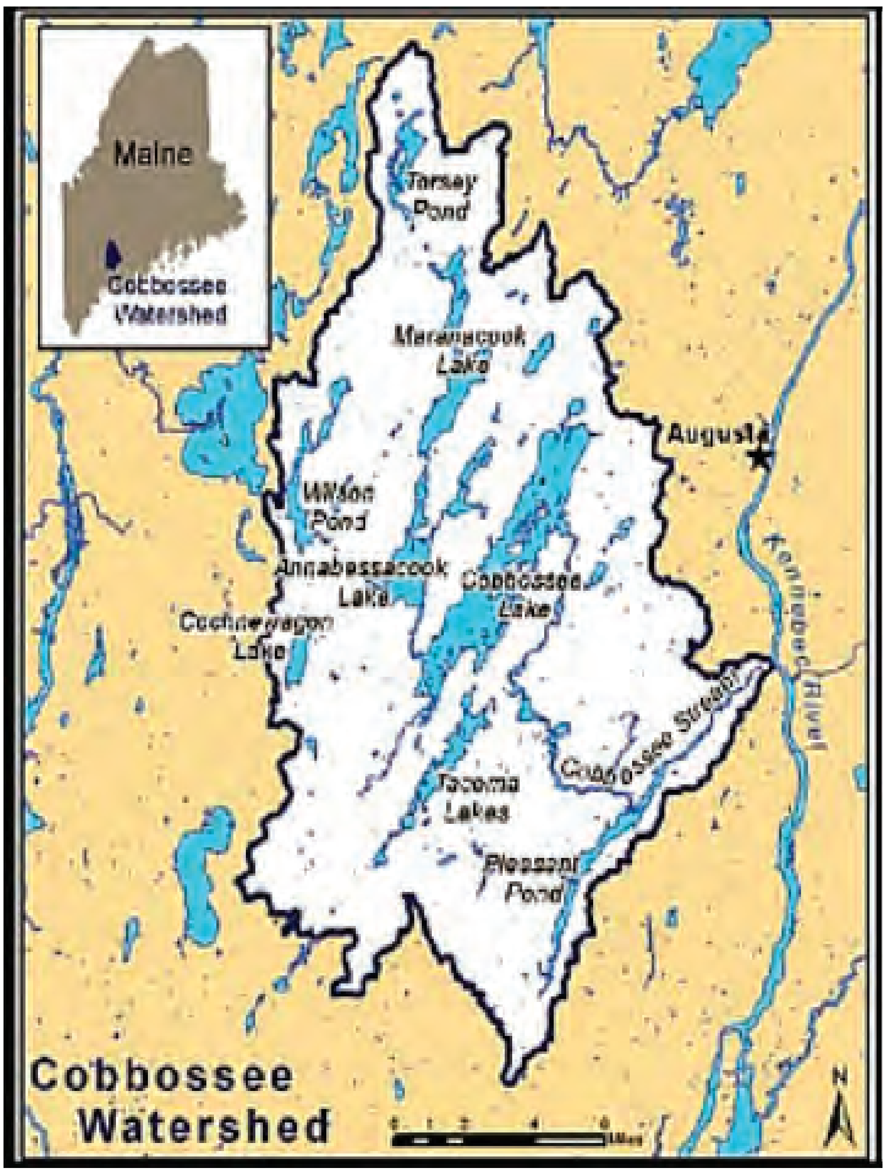
Primitive Skills-Wild Rice Foraging

Brookfield Energy Kills Fish

This Fish Kill ocurred at Brookfield's Brunswick Dam on 10/15 & 10/16. While these thousands of fish were mostly river herring, they could easily be endangered salmon smolt. The only regular non-turbine passage through this dam is an 18" pipe seen spewing from the power house between multiple turbines. One of our water quality monitors called this in and we reported the kill to the Federal Energy Regulatory Commision (FERC) who licenses the dam, DEP, USFWS and NOAA Fisheries. Dispicable on so many levels. Brookfield, a multi-national, kills fish at many Maine dams.

Water from Afar

Maybe we're a little spoiled. Merrymeeting Bay is a beautiful place and the water quality these days at least, not half bad. Built into their culture, the Wabanakis were true stewards of land and water in this area. Since our intrusion into their domain 400 plus years ago, there's been a slow deterioration. By the 1960's scum flowed freely throughout the majority of U.S.rivers. In our neighborhood Androscoggin, fume-filled river fog peeled house paint and Kennebec foam at the Chops was several feet deep. Whether it was carelessness, ignorance, bad science, or the "profits over people and environment" mantra of capitalistic policy....fresh water was filthy and change was needed.



Maine's Senators Muskie and Mitchell were very instrumental in implementing legislation to improve our nation's (and Merrymeeting Bay's) water quality. Muskie with his work on the Clean Water Act of 1972....regulating discharge of pollutants into navigable and certain service waters and putting enforcement teeth into same.....and Mitchell in the 1980's with his dedication in securing Federal funding for upgrading waste water treatment facilities and dealing with non-point pollution.

Six rivers drain into our Bay. They in turn gain their volumes from hundreds of streams, outlets, and land-shed waters along the way. Over 6,000 square miles of water-shed drains through. Upwards of 38% of all Maine waters rushes out of Chop Point in route to the Gulf of Maine. So while Friends of Merrymeeting Bay has been near the stirring (yes, pun intended) wheel over the last 40 plus years improving and monitoring our Bay's water quality, there are more players in the equation. Besides individuals and families who serve as advocates for water quality, lake associations and their brethren spawned from the environmental movement.

A prime example within our watershed is the Cobbossee Watershed District (CWD). It was authorized by the State Legislature in 1971 and, although many lake associations exist (Belgrade, China, 30 Mile River, etc.) CWD is Maine's only "Watershed District".
Partially located within Gardiner, West Gardiner, Richmond, Litchfield, Readfield, Manchester, Monmouth, Mt.Vernon, Wayne, and Winthrop....member towns (plus Winthrop Utilities District and minus West Gardiner) appoint trustees to set policy, establish a budget, and oversee staff projects and activities. They contribute the vast majority of the annual budget ($306 K in 2015-16) which is approved annually by the nine members.

CWD regularly monitors 26 lakes, ponds and streams of the Cobbossee Watershed, a 217 square mile drainage basin, to protect and maintain water quality conditions. Special emphasis is given to restoration of lakes with impaired water quality. They also manage and monitor water levels, advise and cooperate with dam operators, and work with farmers and camp owners to identify and reduce non-point pollution. Much of this work is funded by federal grants awarded to the District.

(continued page 6)

Water from Afar (continued)

Millions of gallons of water annually leaves the District through Cobbossee Stream into the Kennebec River and on to the Bay. Water improved to benefit users all along the way. Users that include many more forms of life than we visiting humans. Our Native American "forefathers," made up of people with the foresight to see water as perhaps our greatest natural resource, might be proud of the groups discussed above.

Steve Musica
(*Note: The author serves as the Town of Richmond's representative on the Boards of FOMB and CWD*)

Editor's Note:
Connectivity between water bodies in a watershed is critical to the health of and even presence of native migratory fish. Cobbosee watershed, dammed at head of tide in 1761remains the largest coastal watershed in Maine impassable to native migratory fish. Some alewives are trapped and trucked here but only a few eels can ascend the watershed on their own. Unfortunately while the CWD regulates water levels behind dams in the highly blocked watershed, the District has no criteria for minimum stream flows. (Watts, 2012) So, in terms of diadromous fish access and habitat, the watershed gets a failing grade. In terms of potential however, it gets an A+.

Reference:
Watts, D. 2012 Cobbosseecontee Watershed, Maine. Fish History, Water Quality, Hydrology and Aquatic Restoration Overview

Anne Hammond Donors-Thank You!!

Thanks so much to the following people for their FOMB donations in memory of Anne Hammond:

Hannah Trowbridge, Robert & Avis Meade, Maria & Richard McElman, Shirley & Donald Kenney, Sally Joy, Scott Shaffer (Makita USA), Sarah Redfield, Lorraine Norton, Kathie Weibal, Peter Fessenden, E. Ahlquist Chadbourne, Dot & Dan Erickson, Judith & Robert Mansfield, Ed Friedman &, Kathleen McGee.

Get Wired (not Wireless)!

We have discussed the growing issue of radiofrequency radiation (RFR) or electromagnetic frequency (EMF) pollution in several articles over the years but what we can we do to decrease our RFR footprint and minimize harmful exposure to ourselves and others?

After Reducing Your Use of Unnecessary Electronics, Get Wired! - Use corded phones [portable phones are very high RFR emitters since their base stations are constantly on]; use direct cable connection and modems without wireless for computers; if your modem or router have wireless functions, you may be able to have them disconnected by your provider; turn off the default wireless search on your computer; opt out of smart meters, if and when using a cell phone, use speaker function or air tubes to your ears and, disconnect wireless baby monitors, put them on timers or hard wire them. Consider exposure to others when out and about with the urge to use your wireless device. For many, including some wildlife, the RFR from your device is debilitating. Meters to measure RFR are readily available as are various shielding materials for those acutely sensitive. Using the internet, learn a lot more from organizations **on page 7 graphic**, that took part in a New York City Forum this past spring or call Ed with questions at 666-3372.

We Need You! Please Support Our Important Work

FOMB Leadership

Our accomplishments are due to the hard work of dedicated volunteers, especially those who serve on our committees. If you want to get involved and serve, please contact the committee chair or Kathleen McGee. We always welcome member input and we'd love for you to join us!

Steering Committee
Ed Friedman, Chair (Bowdoinham)
Nate Gray, Treasurer (Freeport)
Tom Walling, Secretary (Bowdoinham)
Steve Musica (Richmond)

Education Committee
Betsy Steen, Co-Chair, 666-3468
Tom Walling, Co-Chair, 666-5837

Conservation and Stewardship Committee
Chair Vacancy

Membership and Fundraising Committee
Nate Gray, Chair, 446-8870

Research and Advocacy Committee
Ed Friedman, Chair, 666-3372

Coordinator/Organizer
Kathleen McGee, 666-1118

Friends of Merrymeeting Bay · PO Box 233 · Richmond, Maine 04357

Membership Levels

- ☐ $1,000+ Sturgeon
- ☐ $750 American Eel
- ☐ $500 Wild Salmon
- ☐ $250 Striped Bass
- ☐ $100 Shad
- ☐ $50 Alewife
- ☐ $20 Smelt
- ☐ Other

Name ______________________

Address ______________________

Town/State/Zip ______________________

Phone ______________ Email ______________

☐ $7 Enclosed (optional) for a copy of *Conservation Options: A Guide for Maine Land Owners* [$5 for book, $2 for postage].

- ☐ Renewal
- ☐ New Member
- ☐ Send information about volunteer opportunities
- ☐ I would like a sticker

Thanks to Will Zell and Zellous.org for newsletter layout.

Friends of Merrymeeting Bay
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2016-2017 Winter Speaker Series!

All talks 7:00pm at Curtis Memorial Library,
Brunswick, unless noted. Details at www.fomb.org

OCTOBER 12 **Ranked Choice Voting**
Finn Melanson, League of Women Voters

NOVEMBER 09 **Electronic Silent Spring**
Katie Singer, Medical Journalist & EMF Activist •
Unitarian Universalist Church, Brunswick

DECEMBER 14 **Twisted Genes, Distorted Narratives**, *CR Lawn, Founder, Fedco Seeds*

JANUARY 11 **Bateaux to Quebec: Life & Times of Ruben Colburn**, *Tom Desjardin, Author, Historian & Director, Bureau of Public Lands*
FOMB Annual Meeting & Potluck: 6:00pm, Public Welcome, Cram Alumni House, Bowdoin College• 83 Federal St., Brunswick

FEBRUARY 08 **Talking Fish-Heads**
Nate Gray, DMR Fishery Biologist, Doug Watts, River Activist & Author, & Ed Friedman, FOMB, Moderator

MARCH 08 **The King's Broad Arrow: Maine's Mast Trade,** *Harper Batsford, Assistant, Tate House Museum*

APRIL 12 **Cougar Recovery in Eastern North Americam,** *Chris Spatz, President, Cougar Rewilding Foundation*

MAY 10 **Dragonflies & Damselflies in Maine**
Ron Butler, Biologist, U. Maine Farmington

Exhibit 15

Ex. 15

Merrymeeting News

Summer 2021 Vol. XXXI No. 3

The Newsletter of Friends of Merrymeeting Bay • PO Box 233 • Richmond Maine 04357 • 207-666-1118 • www.fomb.org

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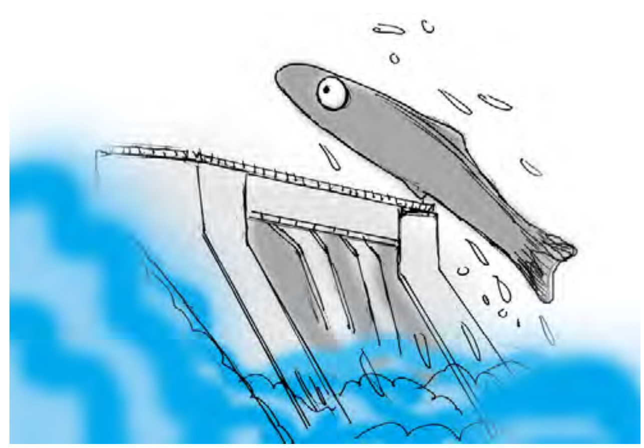
For more information, contact:

Ed Friedman
Chair
207-666-3372
edfomb@comcast.net

Hydroelectric dams are destroying the Gulf of Maine fishery

In a June 10, 2012, Bangor Daily News (BDN) article, "Study finds potentially disastrous threat to single-celled plants that support all life on Earth," the late BDN reporter Christopher Cousins asked if the reader is interested in the rapid disintegration of the marine ecosystem. Yes, Chris, and although over 6 years late you have my full attention.

Since he wrote this compelling article, we now are aware that the essential nutrient of the most important single-celled plants is dissolved silicate, and reservoir hydroelectric dams work to extinguish the annual free transport of this nutrient via the rivers into the ocean currents feeding the Gulf of Maine.



Credit: George Danby-BDN

If we could magically engineer a tree that produces 10 times the oxygen of any existing equally sized tree on Earth, we would worship it. If we could engineer a tree that removes 40 percent of the carbon dioxide from the air and water and permanently buried its absorbed carbon in the depths of the soil, we would welcome it. With this special tree, we might have a fighting chance against accelerating global warming.

Here on Earth, there is a plant that is only 2 percent of the Earth's biomass but provides us with 20 percent of the oxygen we breathe. This plant removes a significant percentage of the carbon dioxide from the ocean and miraculously permanently sequesters the carbon it contains in the deep ocean sediments. This plant is the diatom, a phytoplankton, and it is a miracle "tree."

Tragically, we are destroying the diatom populations. Worldwide, diatoms, like other beneficial phytoplankton, are disappearing by about 1 percent per year. In the Gulf of Maine, phytoplankton, including diatoms, have decreased by a factor of five in just 17 years. Diatoms require adequate dissolved silicate to grow their heavy thick shells. Worldwide, the proliferation of tens of thousands of mega dams over the last 70 years is preventing silica and other important nutrients from reaching the oceans.

Ground zero for the impacts of dams is the relatively enclosed Gulf of Maine. This area of the earth was the finest fishery because of its huge watershed delivering copious amounts of dissolved silicate annually to the gulf. The rivers of New England, the Canadian Maritime Provinces, Quebec, and Ontario all delivered nutrients like no other place on Earth. The St. Lawrence River, by discharge volume, is the second largest river in North America. Nothing is more important to estuaries and coastal water ecosystems than the seasonal timing and volumes of freshwater flow.

Now, the regulation of river flow in the US and Canada has moved to follow a highly

Continued on next page

Hydro electric dams, continued from page 1

unnatural policy of diminishing, if not eliminating, the nutrient-delivering spring freshet, and maintaining low flows from spring through the fall, while reservoir storage dams release high flows in the winter when flows were naturally at their lowest. In Canada, the size and numbers of dams and reservoirs are staggering.

Around the world and in Canada more hydro dam projects are planned. Not only do these dams change nutrient delivery in northern seas but they release vast quantities of warm reservoir water in the winter and eliminate the natural cold spring freshet waters. It is not surprising the Gulf of Maine is warming faster than any other ocean body. The numbers and sizes of the diatoms have been reduced as more and more reservoir dams have been discharging silica-depleted water into the ocean currents that feed it. Unnatural freshwater flow regulation is a climate and marine ecological train wreck for the microscopic diatom to the noble right whale. Dams have weakened the natural function of diatoms to feed bountiful fisheries and reduce carbon dioxide levels.

We will not forget Chris Cousins' 2012 article, and we will continue to sound this alarm.

Roger Wheeler, president, Friends of Sebago Lake

This op-ed was originally published in the Bangor Daily News on January 8, 2019.

Gateway - Merrymeeting Bay 2021
Notes from the Field

River herring (alewives and blueback herring) showed up early this year. They entered the mouth of the Kennebec River, cycling back and forth on the tide until the light grew long and waters warmed. Then they ratcheted their way upstream. With each successive tide, climbing higher in the system as spring advanced, through the Chops into Merrymeeting Bay, up the Androscoggin, the Eastern, and the main stem. As the spring freshet flows ebbed, the waters warmed more rapidly, and fish pushed harder to make it to their spawning grounds in time. Rivers, ponds, lakes, and streams are all connected, critical to a healthy run of our native diadromous species.

On April 13, river herring were detected below Box Mill fishway on Outlet Stream, draining China Lake in Vassalboro, Maine. The previous week, they were detected in Dresden on the Eastern River. Water temps were high and flows were abnormally low throughout the basin. Things were happening fast. The run at Benton Falls (seven miles upstream from Winslow) on the Sebasticook roared to life in late April. We scrambled to keep up with all the studies and field work: A fish count at the new Togus Pond fishway, fish counts at Benton Falls, fish counts at Brunswick, stocking trucks readied, river herring stocking out of both Brunswick and Lockwood, fish counts at Webber Pond and counts at Three Mile Pond. Atlantic Salmon smolt traps were installed on the lower Sandy River in Farmington. In short, we could barely keep up, and I know I've missed a few things. Clearly there is no good substitute for a river unimpaired by dams but we try our best with what we have.

Sebasticook River
Photo: Point of View Helicopter Services

We began to hear reports from south of Maine that those river herring runs were poor in 2021. From the Carolinas on up through Connecticut, Rhode Island, Massachusetts, and New Hampshire river herring numbers were down. There is a lot of speculation as to why runs south of us were down. Theories ran the usual gamut from over fishing and habitat loss to drought conditions throughout the mid-Atlantic states. We just don't know, but we're watching closely. Most of us think it is a combination, with habitat loss being the biggest contributor.

Even before this spring, river herring numbers were at a mere 5 percent of their historical highs. Ninety-five percent of the species were extirpated across their historical range. In Maine we've come a long way in our restoration efforts.

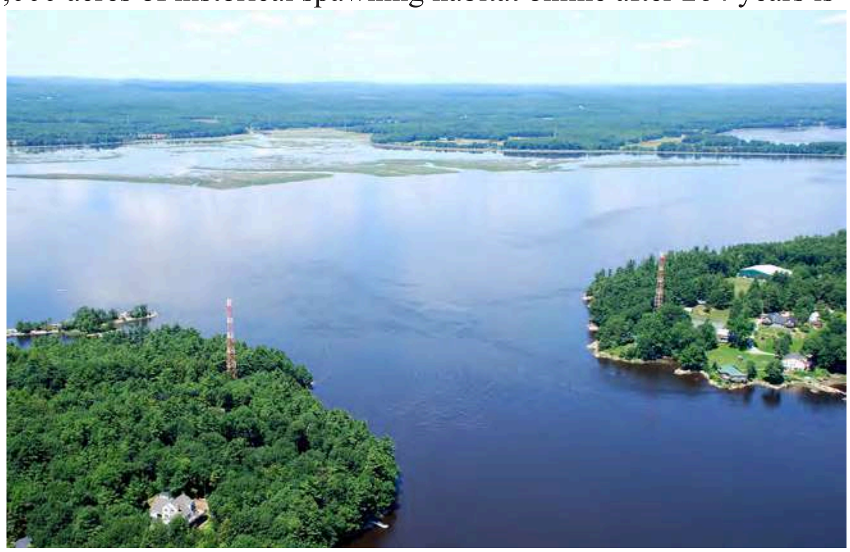
Continued on next page

Gateway - Merrymeeting Bay, continued from page 2

Although we have the largest extant runs remaining, there is still much to do. But we know what to do and how to do it. In theory, restoration is a simple act. In practice, river and fish restoration is very complex. Most projects take years to accomplish. Many partners are required: Federal agencies, state agencies, non-governmental organizations, corporations, communities, municipalities, biologists, engineers, grant writers, lake or pond associations, businesses, surveyors, citizens, and volunteers.

The run on Outlet Stream in Vassalboro is still under restoration. Each spring we stock China Lake with up to 25,000 adult prespawn river herring. The restoration on Outlet Stream is nearing completion with three technical fish passages installed (at Box Mill dam, Ladd dam, Outlet dam [underway]) and three dam removals. We removed Masse dam, Lombard dam, and lastly Morneau (underway). A total of six projects implemented over seven years. China Lake is big. At 4,000 acres we anticipate an annual run somewhere around the million mark. Marine Resources partnered with Maine Rivers, U.S. Fish and Wildlife Service (USFWS), Kennebec Water District, United States Department of Agriculture Natural Resources Conservation Service (USDA/NRCS), Patagonia, China Regional Lakes Alliance (CRLA), the Sebasticook Regional Land Trust (SRLT), the China Lake Association, the towns of Vassalboro and China, multiple private foundations, and multiple private individual land owners. As the lowest tributary to the Sebasticook River, Outlet Stream will add upwards of 30 percent to the total run on the Sebasticook. This year the minimum herring escapement at Benton Falls was 3.5 million. Getting 4,000 acres of historical spawning habitat online after 264 years is a rare bird.

All these fish pass through Merrymeeting Bay. Millions in the spring, millions in the summer, and in the fall a hundred million juvenile river herring cycle into and out of Merrymeeting Bay. On the way, the millions upon millions of herring will feed cormorants, heron, osprey, eagle, king fisher, merganser, seals, mink, stripers, and eels. Between Benton Falls and Outlet dam in mid-May I saw an oak tree filled with 38 bald eagles. All sated. All sleepy. None eager to leave. Beneath the eagles, Outlet Stream thronged with river herring. Best guess: 180,000 river herring. Those eagles would not leave until the river herring were gone.



Chops passage, gateway to the middle Bay
Photo: Jesse Miller, Point of View Helicopter Services

On June 2, a FOMB helicopter flush count of aggregated eagles on the lower Sebasticook and Outlet Stream counted 328 birds. When a healthy and plentiful sea-run supper is served, the bush telegraph lights up, and hungry customers come from miles and miles. This is what river restoration looks like.

A final (and fun) field observation. I have my hand dangling in a bucket of young American eels, all between 5 and 10 inches long, 3- to 5-year-olds. Just kids, really, in the lifespan of eels. There are 60 of them. I'm watching them recover from anesthesia. I hate doing it to them, but measuring them otherwise is about impossible. Once we measure them all to the nearest millimeter, they go into the recovery bucket. A small battery-powered bubbler keeps the few gallons of water well oxygenated. Recovery takes about half an hour. Once all the eels are measured, we get a weight for the batch and then an average weight. From that we can extrapolate how many eels we had in total. I relax my fingers an inch below the surface. An eel approaches and swims through my fingers, then another and another. Within a minute most of the eels are on my hand. Dozens of them. I slowly remove my hand and the eels drop off one by one. Placing my hand back in the bucket, the eels come back. I repeat the exercise a dozen times. Each time the eels seek out my hand and climb on. It's hard not to anthropomorphize the eels. What are they thinking? Their behavior is remarkable. Why do the eels climb onto my hand? I just messed with them pretty hard. I'm going to experiment with eels preanesthesia to see if those eels climb on my hand. My guess is they do. Eels, like humans, are curious.

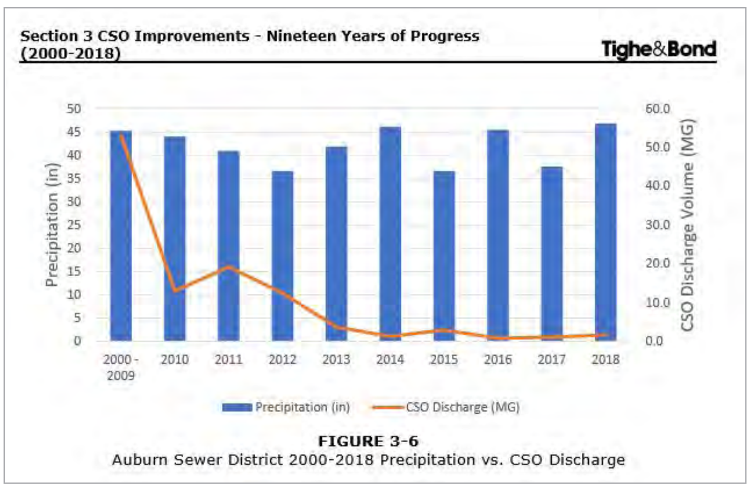
Nate Gray
(Nate, a long-time FOMB Board member, is a fisheries biologist with the Maine Department of Marine Resources)

Bugs!

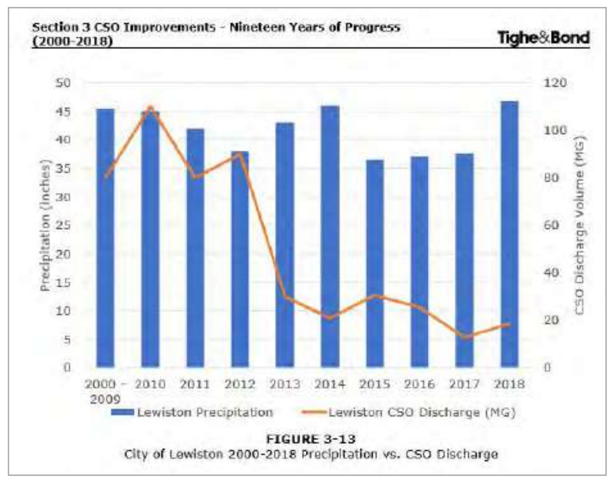
For many years FOMB has been attempting to upgrade the water quality classification of the lower Androscoggin River. Our efforts are based on over 20 years of volunteer monitoring data collected under EPA and or DEP quality assurance plans. We upgrade to codify improved ambient river conditions because the Clean Water Act and state statute contain antidegradation language prohibiting backsliding without a major analysis and approval from EPA. In the case of the lower Androscoggin, actual conditions based on dissolved oxygen (DO) and *E. coli* bacteria have for years met Class B standards, but the river is still classified as Class C by the legislature, based on recommendations from the Maine Department of Environmental Protection (DEP).

The DO minimum for Class B is 7 parts per million (ppm) and for Class C, 5 ppm. What this means is that although the ambient DO conditions are 7 ppm or above, because the classification is lower, conditions could degrade substantially to 5 ppm and still meet the current classification. A similar situation exists for bacteria. Besides the numeric standards mentioned, DEP also considers aquatic life standards as indicated by benthic invertebrates, commonly referred to as "bugs." Different invertebrates are typical of different water quality conditions, Class AA, A, B, or the lowest, C.

On this section of the Androscoggin, DEP last sampled for bugs in 2010, and since then Lewiston and Auburn have dramatically improved how they deal with Combined Sewage Overflows (CSO) or the extra untreated runoff occurring following rain events.



Auburn CSO summary



Lewsiton CSO summary

In an effort to bolster our current upgrade proposal (third plus sign down on Cybrary Chemical page), submitted in conjunction with Grow L+A and with broad support, FOMB has hired aquatic biologist Paul Leeper of Moody Mountain Environmental Services to conduct widespread invertebrate sampling over a more representative stretch of the river. Bug sampling is done by setting out replicate baskets—bags or cones filled with standardized amounts of stones—for 30-60 days depending on the site and then seeing which species of bugs colonize them.

Rock bags and baskets
Photo: Ed Friedman

In 2010, DEP deployed rock containers in the Brunswick and Pejepscot dam silty impoundments yielding Class C bugs and a sample below Pejepscot dam yielding Class B bugs. In 2018, Gomez & Sullivan Engineering sampled below Pejepscot as part of the upcoming dam relicensing and recovered Class A bugs from this site. Despite our request to DEP to retest its three sites this year in conjunction with the upgrade proposal, they initially refused and, only after repeated pressure, partially relented, agreeing to sample above and below Pejepscot dam.

Continued on next page

Bugs! Continued from page 4

FOMB did a site reconnaissance by helicopter on June 17 with Paul and ultimately decided to sample at six locations from not far below the I-95 crossing to halfway down the Brunswick impoundment, near our water quality site not far above I-295. Three of the sites are shallow and rock bags could be deployed by wading, and three were deeper sites that required SCUBA diving to properly align rock baskets and ascertain substrates. As usual, FOMB research is informing our advocacy. We deployed on August 4 and 5, and will retrieve bags and baskets in early September.

Helicopter site reconnaissance.
Photo: Point of View Helicopter Services

In theory, every three years the DEP solicits river classification proposals. They review these and make recommendations to their governing body, the Board of Environmental Protection (BEP). The BEP holds a public hearing and, in turn, makes recommendations (which nearly always echo those of the DEP) to the legislature, the only body that can classify water bodies. The BEP is holding their public hearing on October 7. The BEP has a nondiscretionary duty to recommend an upgrade based on ambient water quality conditions. So far, they never have. We will consider a legal challenge should this occur again. Comments should be addressed to Board Chair Mark Draper and can be submitted electronically to the DEP linked here. We will send out an electronic alert with talking points.

Fifty years ago Maine Senator Ed Muskie introduced the Clean Water Act in large part because of the horribly polluted Androscoggin River. It is long past time to recognize how the river has improved and lock in those improvements.

Above and right: Deploying and marking rock bags at shallow and deep sites
Photos: Ed Friedman

Common stonefly (*Paragnetina immarginata*)
Photo: Bob Henricks

Left: Deeper sites required SCUBA diving.
Photos: Ed Friedman

Androscoggin Shad Passage

The Androscoggin River contains 100.5 river kilometers of potential American shad habitat. Of this, 48.3 river kilometers are accessible (though accessibility to habitat above dams with fish passage is limited), while the remaining habitat is inaccessible due to obstructed fish passage.

Brookfield's 18" downstream fish passage pipe adjacent to several turbines.
Photo: Ed Friedman

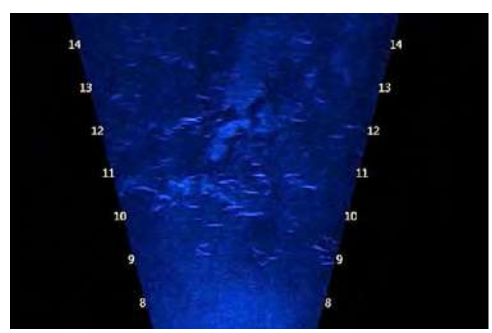
While passage above the Brunswick Dam is considered possible because the vertical-slot fishway allows some shad passage, actual passage by American shad has been documented to be very low, and the majority of habitat use has been documented in the small portion of river below the dam.

American shad historically spawned in the Androscoggin River from Merrymeeting Bay to Lewiston Falls, and in the Little Androscoggin River from its confluence with the Androscoggin to Biscoe Falls. However, construction in 1807 of a low-head dam at the head-of-tide on the Androscoggin River caused the abundant American shad run to decline sharply.

In 1980 the U.S. Fish and Wildlife Service developed conceptual drawings for a vertical slot fishway for the Brunswick Project, which is located at the head-of-tide on the river. The fishway was designed to pass 85,000 American shad and 1,000,000 alewives annually.

Above: Shad computer in anti-glare box
Below: Sonar video of shad moving by

Photo: Ed Friedman



The upstream passage facility was one of the first vertical slot fishways designed to pass American shad on the east coast, and was a scaled-down version of a fishway located on the Columbia River. Redevelopment of the Brunswick Project and construction of the fishway was completed in 1983.

The completed fishway was 570 feet long, and consisted of 42 individual pools with a one-foot drop between each.

Downstream passage consisted of a 12-inch (now 18-inch) pipe located between two turbine intakes. When the Federal Energy Regulatory Commission issued a license for the Brunswick Project in 1979, it did not require efficiency studies for the upstream and downstream passage facilities. (From: Maine Department of Marine Resources American Shad Habitat Plan, 1983.) Unfortunately, after USFWS approval of Brunswick's upstream fishway design, Central Maine Power, dam owner at the time, shifted positioning of the turbines so turbines #1 and #2 bracket the fishway entrance. There were no subsequent design revisions and a major problem with the site is that attraction flows for the fishway entrance are obscured by flows from Turbine #1 confusing the already skittish shad.

With Brunswick due for relicensing in 2029 our goal is to document the thousands of shad below the dam unable to go further in any significant numbers and to use this information in the relicensing proceeding to support improved passage or dam removal. This year's effort (tentatively counting over 3,000 fish) builds on earlier work by John Lichter and his Bowdoin students who pioneered use of the Arris sonar video unit for counting and identifying fish at this site.

Thanks to Dave Mention for use of his skiff!

Education Update

You may have noticed FOMB did not run our usual Summer Outside Series this year. We did not want to put anyone in harm's way with COVID. Fortunately, our members have many recreational land- and water-based opportunities easily available in the area. On our website's home page in the right column under Education you can find A Self-Guided Nature Tour of Merrymeeting Bay by member Terry Porter, completed as part of her Maine Master Naturalist program, and in the Education section you can view and download Fifty Environmental Activities Kids Can Do at Home.

FOMB was awarded a grant from the New England Foundation for the Arts to host several showings (in person and virtual) of the Theater's production To Bee or Not To Bee this fall in area schools and as a Speaker Series event. Our Speaker Series will continue into its 25th year on October 13th with a presentation by Roger Wheeler on the widespread, deeply important effects of megadams. Watch your mailbox for a postcard with the entire Speaker Series, which again will be presented via Zoom.

CMP Tower Lawsuit Update

Maine Business Court Justice Murphy ruled in favor of CMP's motion to dismiss our nuisance suit based on federal preemption. We don't believe an FAA lighting recommendation can preempt state law and so appealed the decision to the Maine Supreme Judicial Court. In fact the FAA used the excuse that these guidelines were only recommendations to avoid any environmental review! The case has been fully briefed and oral arguments will be heard in early October.

We Need You! Please Support Our Important Work

FOMB Leadership

Our accomplishments are due to the hard work of dedicated volunteers, especially those who serve on our committees. If you want to get involved and serve, please contact the committee chair or Ed Friedman. We always welcome member input and we'd love for you to join us!

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Vance Stephenson, Treasurer (Kettering, OH)
Tom Walling, Secretary (Bowdoinham)
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Becky Bowes (Brunswick)
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Friends of Merrymeeting Bay · PO Box 233 · Richmond, Maine 04357

Membership Levels

☐ $1,000+ Sturgeon
☐ $750 American Eel
☐ $500 Wild Salmon
☐ $250 Striped Bass
☐ $100 Shad
☐ $50 Alewife
☐ $20 Smelt
☐ Other

☐ $7 Enclosed (optional) for a copy of Conservation Options: A Guide for Maine Land Owners [$5 for book, $2 for postage].

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☐ Renewal
☐ New Member
☐ Send information about volunteer opportunities
☐ I would like a sticker

Thanks to Rebecca Bowes for newsletter layout.

Friends of Merrymeeting Bay
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Counting Shad

Left: Looking for shad at the base of the Brunswick dam
Photo: John Lichter

Above: John Lichter monitors shad
Photo: Ed Friedman

Merrymeeting News

Summer 2022 Vol. XXXII No. 3

The Newsletter of Friends of Merrymeeting Bay • PO Box 233 • Richmond Maine 04357 • 207-666-1118 • www.fomb.org

Friends of Merrymeeting Bay (FOMB) is a 501(c)(3) non-profit organization. Our mission is to preserve, protect, and improve the unique ecosystems of the Bay through:

Education

Conservation & Stewardship

Research & Advocacy

Member Events

Support comes from members' tax-deductible donations and gifts.

Merrymeeting News is published seasonally and is sent to FOMB members and other friends of the Bay. Article hyperlinks and color images are available in our online edition at www.fomb.org

For more information, contact:

Ed Friedman
Chair
207-666-3372
edfomb@comcast.net

Androscoggin Upgrade: The Saga Continues

The Law

On March 31, Governor Mills signed into law LD 1964, the surface waters reclassification bill which included upgrading the lower Androscoggin River (Pleasant Pt. to Worumbo dam) from Class C to Class B, a goal as many of you know, FOMB has worked towards for years. The upgrade was unanimously recommended by the Board of Environmental Protection (BEP) despite continued objections by the Department of Environmental Protection (DEP). BEP's recommendation was incorporated into LD 1964 which was unanimously passed by the legislative Joint Committee on the Environment and Natural Resources (where the DEP now spoke in favor of the Androscoggin upgrade) and then also unanimously by the full House and Senate before being signed by the Governor.

FERC

Virtually all of the Androscoggin watershed hydroelectric dams come up this decade for relicensing by the Federal Energy Regulatory Commission (FERC). FERC is the only place where an entity receives a license for 30-50 years, a holdover from the Roosevelt years of the Rural Electrification Administration (and 1936 Act) when builders of large dams were given years to amortize their project costs. These dams are all long since paid for but the extraordinary privilege of an exceptionally long license period still exists. Generally, only at relicensing are there opportunities to make changes or upgrades to dam operations for such things as fish passage, but extinction doesn't wait.

CWA

Under Section 401 of the Clean Water Act, states can issue Water Quality Certificates (WQC), also known as 401 Certificates, which can stipulate an almost infinite variety of state concerns the dam owner must comply with. The WQC gets incorporated into the new FERC license and runs for the full license period unless amended, which can only be done if the applicant (dam owner), state agencies and FERC agree. In Maine, the DEP issues the WQC.

> ***As the old popular ABC radio show host Paul Harvey used to say "and now for the rest of the story…"***

Classification Changes

On June 3, FOMB found out the name of DEP's new hydropower coordinator and emailed him to be sure he was aware of the upgrade to Class B since Brunswick, Pejepscot and Worumbo dams would all be affected and in their relicensing would need to be compliant with the new classification which probably for the most part will be ensuring enough flows through the project areas to maintain the higher levels of dissolved oxygen Class B requires (minimum 7 parts per million vs. 5 ppm for Class C).

Continued on next page

Androscoggin Upgrade: And Now for the Rest of the Story, continued from page 1

DEP

The DEP coordinator replied he was aware of the upgrade but was still issuing the Pejepscot WQC, due the following week, to be compliant with Class C. As it happens, Maine laws do not technically go into effect until 90 days after the end of session (May 9), which made the effective date August 8. So, we find ourselves in a very unusual position of having a WQC issued during the transition period between a pertinent law's passage and its effective date.

Because the DEP has unlimited discretion in WQC content, FOMB and others immediately urged them to amend the Certificate language, the draft of which was only issued a few days before the hard final federal deadline. The DEP refused. They could have changed all Class C references in the WQC to Class B or at the very least they could have added a paragraph requiring Class B compliance as of August 8. The DEP refused, instead creating a 40-year Class C carve-out in the middle of a Class B section, despite public opinion, the BEP, the legislature, and the Governor. Their action preserves the "room to pollute" condition existing when actual water quality is higher than the classification (the water quality can degrade while still meeting its classification).

Pejepscot dam,
Photo: Point of View Helicopter Services

Under the Clean Water Act section 401, Congress provides states, territories, and Tribes with a tool to protect their waters from adverse impacts that federally licensed or permitted projects may cause. Under section 401, a project proponent for a federal license or permit that may result in a discharge into waters of the United States must obtain a water quality certification from the certifying authority.

Federal licenses and permits that may require section 401 water quality certification include: CWA section 404 dredge and fill permits from the Army Corps of Engineers (Corps), hydroelectric licenses from the Federal Energy Regulatory Commission (FERC), and CWA section 402 pollutant discharge permits from EPA. A broad range of individuals and entities including corporations and other businesses, federal and state agencies, contractors, and individual citizens seek 401 certification for a wide range of projects. Thousands of water quality certifications are granted each year.

EPA first promulgated implementing regulations for water quality certification in 1971, which remained in effect until the 2020 CWA Section 401 Certification Rule (2020 Rule). After reviewing the 2020 Rule pursuant to Executive Order 13990, the Agency announced its intention to revise the 2020 Rule to better uphold the role of states, territories, and Tribes under section 401 as an essential component of the Act's system of cooperative federalism. The Agency's actions will be grounded in robust stakeholder input (code for major industry influence).

The Appeal

FOMB, needless to say is outraged at this abuse of discretion on the part of DEP and has had no choice but to appeal the WQC to the BEP. The appeal stops most of the FERC process. Of course the effective date of August 8 will have long since come and gone by the time the BEP holds a public hearing and deliberates on the matter. At our request, we have been joined in the appeal by now co-appellants: Grow L+A, Downeast Salmon Federation, Native Fish Coalition-Maine Chapter, Friends of Sebago Lake, and Maine Council, Trout Unlimited. We are so grateful for their support! FOMB and co-appellants are represented by Portland attorney Scott Sells.

Ed Friedman

Shad Say No to Brunswick Dam

On May 30th we began another spring season of recording frustrated shad below the Brunswick dam. Using an Aris side scan underwater sonar/video camera we record shad counts at several points spanning the length of run. It is well known shad are very skittish and it is problematic getting them into even a well-designed fishway which the Brunswick ladder is not.

As we wrote in our Summer, 2021 newsletter:

> In 1980 the U.S. Fish and Wildlife Service developed conceptual drawings for a vertical slot fishway for the Brunswick Project, which is located at the head-of-tide on the Androscoggin River. The fishway was designed to pass 85,000 American shad and 1,000,000 alewives annually. The upstream passage facility was one of the first vertical slot fishways designed to pass American shad on the east coast, and was a scaled-down version of a fishway located on the Columbia River. Redevelopment of the Brunswick Project and construction of the fishway was completed in 1983. The completed fishway was 570 feet long, and consisted of 42 individual pools with a one-foot drop between each. Downstream passage consisted of a 12-inch pipe located between two turbine intakes. When the Federal Energy Regulatory Commission issued a license for the Brunswick Project in 1979, it did not require efficiency studies for the upstream and downstream passage facilities. (From: Maine Department of Marine Resources American Shad Habitat Plan, 1983)

Not a shad!
Photo: John Lichter

John Lichter adjusts Aris depth
Photo: Ed Friedman

Unfortunately, after USFWS approval of Brunswick's upstream fishway design, Central Maine Power, dam owner at the time, shifted positioning of the turbines so they became close to the fishway entrance. There were no subsequent design revisions and a major problem with the site is that attraction flows for the fishway entrance are obscured by flows from Turbine #1 confusing the already skittish shad.

This year we recorded a total of about 7550 shad on four successful monitoring dates-5/20, 6/24, 6/30 and 7/11. Only about 240 (3.2%) made it up through the vertical slot fishway confirming its inefficiency. We believe multiple years of data like these will support major fish passage changes when the Brunswick Topsham dam comes up for relicensing in 2029.

Of special note this season was the 5/30 recording session when we counted about 80 sturgeon leaping (this is a known spawning area for shortnose sturgeon) during our 5 hours or so on site and the almost solid mass of spawning and finning blueback herring in the area that filled the Aris scope screen nearly the entire time.

Special thanks to John Lichter, Bowdoin College summer intern Renske Kerhofs and Dave Mention for continued use of his skiff.

Ed Friedman

China Lake Syndrome

Every spring is different. The spring of 2021 was early and dry. Streams and rivers were experiencing August flows as spring fish migrations began. The alewives returned up Outlet Stream to China Lake in early April. Previously I might have expected the alewives to show up in May on Outlet Stream. After all, the alewives show up at Webber Pond in early May. Webber Pond is connected to the Kennebec via Seven Mile Stream. Outlet Stream is another 17 miles upriver. Why did the alewives show up so much earlier on Outlet Stream in 2021? Not just earlier but three weeks earlier and they had to swim another 17 miles. I spent a fair bit of time in 2021 watching the alewives linger below Outlet dam to China Lake. We had already hand-bailed 25,000 fish into China Lake, but there had to be between 150 and 250,000 alewives below the dam waiting to get in. The final fishway was yet to be installed. The alewives finally got tired of hanging below the dam and returned down stream to try and spawn again in 2022. Our stocking permit only allowed for 25,000 fish to be stocked.

In October of 2021 the final fish passage was installed in Outlet dam to China Lake. This marked the culmination of seven years of hard work. Marine Resources partnered with Maine Rivers to see this complex project complete. The project consisted of three dam removals and three fish passage installations to connect 4,000 acres of prime historical habitat in the Kennebec-Sebasticook lower river complex. The Sebasticook already had a huge run of river herring (alewives and bluebacks), and China Lake access increased the habitat in the Sebasticook River system by 38%!

Masse dam removed below China Lake.
Photo: Point of View Helicopter Services

An estimate of annual returns for alewives to China Lake are one million fish per year. It has been 238 years since a run of this magnitude has come to China Lake—since 1783, the last known run of alewives before Outlet Stream succumbed to the damming that occurred along its seven meandering miles. Outlet Stream went from hundreds of thousand of alewives per year for millennia to thirteen dams and no fish in 30 years. Which brings us to 2022.

The spring of 2022 was a lot wetter and a lot cooler than 2021. I was in the process of reconfiguring an electronic fish counter to fit in the new fishway at China Lake's Outlet dam. The objective is to count the returning alewives. For the first time in 238 years, free swimming herring from the Gulf of Maine could enter China Lake.

Continued on next page

China Lake Syndrome, continued from page 4

Alewives exit Benton Falls fish counter
Photo: Ed Friedman

The fish counter consists of twelve 20-in. schedule 40 PVC pipes, each with a 4 in. inside diameter. Each tube has three stainless steel bands on the inside spaced 5 inches apart. Each band has a wire that leads to a Smith-Root model 1601 digital fish counter. Fish swim through the tube, break the invisible electric field between stainless bands, and get counted. Simple as that. Building the array takes time. I had a sneaking suspicion in March those fish just might show up earlier than expected. Better get cracking on this counting tube array. Only a few weeks left to build this thing out.

I was really close to completing the array in April's early days. River and stream flows were high and water temps were cool. Surely the alewives would behave "normally," showing up in early May as they do at Webber and even further up the Sebasticook River where we monitor them at Benton Falls.

Nope. They showed up at Outlet Stream's first obstruction, Box Mill dam fishway (built in 2020), on April 10— even earlier than they had in 2021. The fish rapidly ascended through Box Mill and made it to the Ladd dam fishway (built in 2019) where I kept them below until I could get the counting tube array properly fitted at Outlet dam. We opened Ladd dam fishway on April 25th. Alewives ascended the stream past Lombard dam site (removed 2018), the Morneau dam site (removed 2021) and the Masse dam site (removed 2017) to reach the Outlet dam Denil fishway into China Lake.

A May 31 helicopter flush count of eagles counted 132 on the 7 miles of Outlet Stream. The dinner bell rang and fresh fish was served!

Here is where it gets real interesting. Based on stocking rates, we calculated a return of up to 250,000 fish. By the end of the 2022 alewife run I had counted over 835,000 fish. The run was enormous. I didn't expect those numbers until 2026. Was the counter wrong? Nope. I proofed it at least a dozen times with timed visual counts. The counter was doing great. At the peak of the run 100,000 fish passed through the counting array in 24 hours.

So why did so many fish show up? We have a theory and I think it's a good one. Alewives on the spawning run will stray to novel waters. This is a well-documented behavior. It's Mother Nature's way of not putting all her eggs in one basket. All of the river herring swimming past Outlet Stream to Benton Falls could smell those fish up Outlet Stream. And it smelled good. So they took a right hand turn into Outlet Stream, where waters were also warmer than on the main stem.

Nate Gray counts eagles
Photo: Ed Friedman

At Benton Falls the fish lift there passed only 2.8 million river herring in 2022. Was that because the Sebasticook didn't smell as much like a spawning event waiting to happen after Outlet Stream got a two week jump start? Would the Benton Falls fish lift pass an additional 600,000 fish had Outlet Stream not been restored? (In 2017 Benton passed 3.5 million herring, in 2018, 5.6 million). I just love a good mystery.

We will be counting again in 2023 at Outlet Stream. You should come see it in May. Old habits die hard. Maybe come in April. You should definitely come and see.

Nate Gray

The Wild West of PFAS Testing

Last summer/fall, FOMB in cooperation with Military Poisons and the Women's International League for Peace and Freedom (WILPF) conducted preliminary area sampling for PFAS chemicals. These are often referred to as "forever chemicals" because of their persistence in the environment.

PFAS are widely used, long lasting per- and polyfluoroalkyl synthetic organofluorine chemical compounds that have multiple fluorine atoms attached to an alkyl chain. They break down very slowly over time and many of them have been linked to harmful health effects in humans and animals. There are thousands of PFAS chemicals, and they are found in many different consumer, commercial, and industrial products. Because of their widespread use and their persistence in the environment, many PFAS compounds are found in the blood of people and animals all over the world and are present at low levels in a variety of food products and in the environment. Due to their prevalence, PFAS chemicals might also be termed "everywhere" chemicals.

Martha and Ed processing samples.
Photo: Jason Prout

Virtually all PFAS sampling through EPA-certified labs is done by sending an actual water sample, on ice, back to the lab via overnight delivery. For each sample taken, a field blank is also collected. This is a supplied sample of PFAS-free water poured on site from its original container into another container to ensure contamination has not occurred in the sampling process.

PFAS tests are generally very expensive, ranging from about $400 to $700. The same fee applies to a field blank as it does to the actual sample, since both are analyzed. If high levels of PFAS are found in home drinking water, the Maine Department of Environmental Protection (DEP) will reimburse the homeowner up to a certain amount, providing the sample was sent to a DEP-approved lab.

Enter Cyclopure. This Illinois-based company is in the primary business of making a PFAS-filtering media they call DEXSORB®. The DEXSORB product (a corn-based medium) is used by the Department of Defense and other agencies and entities to clean up PFAS-polluted waters. As sort of a sideline, Cyclopure also makes water test kits consisting of a plastic container with a DEXSORB filter in it. The suspect water is poured into the container and allowed to drain through the filter and then the empty container with filter is returned to Cyclopure for analysis. No ice or overnight delivery is needed, further reducing shipping weight and cost. The Cyclopure test costs about $80 and screens for more PFAS compounds (about 55) than many of the certified labs. *The high cost of certified lab testing surely acts as a testing deterrent for the average homeowner.* Cyclopure kits are not certified, although they use the highest quality equipment and follow EPA protocols.

FOMB, Military Poisons, and WILPF used Cyclopure kits last year in our initial probe. Results compared favorably to past contaminant levels detected by DEP and Brunswick Naval Air Station (BNAS) testing. Last fall our Research & Advocacy Committee recommended a Bay-wide screening for PFAS, using the affordable Cyclopure kits, if we could formally validate them in a side-by-side comparison with certified labs using split samples all coming from the same source.

We asked the DEP to cooperate with us on this, and they would not, since Cyclopure was not certified, even though there could be a great deal of taxpayer savings using Cyclopure as a screening test and participation would likely be far greater.

Instead we partnered with the Brunswick Sewage District (BSD), who understood the value of what we were doing and could appreciate the potential cost saving for screening, even if not able to use the results for regulatory purposes.

Continued on next page

The Wild West of PFAS Testing, continued from page 6

On April 22, 2022, BSD hosted and assisted us in gathering sewage water samples for each lab, all from the same stainless steel bucket. Samples went to Cyclopure and certified labs Alpha Analytical, Eurofins (the leader in PFAS testing), and Battelle (a lab often used by the military, industry, and universities). Replicate samples were included for Cyclopure and Alpha Analytical.

Results were telling: with Cyclopure, Alpha Analytical, and Eurofins all being similar in compounds and concentrations found. Reports on findings were delivered in 1–2 weeks by these labs. Battelle, on the other hand, promised delivery in 28 days and took twice that. More importantly, they only detected one PFAS compound, whereas the other three companies found 10–12 each.

Since this test validated Cyclopure testing, FOMB purchased 30 test kits and is currently in the process of sampling all the Bay tributaries and the Bay itself. The results of our comparison testing are or will be posted in the Chemical section of our web Cybrary by the time you read this. When our spatial screening of Bay waters is complete, those results will also be posted and released to the press.Thanks to Jason Prout, Jennifer Nicholson, and Rob Pontau of BSD, Katie and Frank Casssou of Cyclopure, and FOMB volunteer Martha Spiess.

Ed Friedman

Jason readies another sample pour for Ed.
Photo: Martha Spiess

We Need You! Please Support Our Important Work

FOMB Leadership

Our accomplishments are due to the hard work of dedicated volunteers, especially those who serve on our committees. If you want to get involved and serve, please contact the committee chair or Ed Friedman. We always welcome member input and we'd love for you to join us!

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- ☐ $1,000+ Sturgeon
- ☐ $750 American Eel
- ☐ $500 Wild Salmon
- ☐ $250 Striped Bass
- ☐ $100 Shad
- ☐ $50 Alewife
- ☐ $20 Smelt
- ☐ Other

☐ $7 Enclosed (optional) for a copy of Conservation Options: A Guide for Maine Land Owners [$5 for book, $2 for postage].

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- ☐ Renewal
- ☐ New Member
- ☐ Send information about volunteer opportunities
- ☐ I would like a sticker

Thanks to Rebecca Bowes for newsletter layout.

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Own a Unique Piece of Maine's Environmental History!

This beautiful table made from a live-edge redwood slab has been donated to FOMB to support our research, advocacy, education, and land-protection work. It was bequeathed to our donor in 2016 by one of Maine's premier environmental writers, Phyllis Austin.

At this table Phyllis wrote a wide array of articles and her landmark books, *Wilderness Partners: Buzz Caverly and Baxter State Park* and *Queen Bee: Roxanne Quimby, Burt's Bees and Her Quest for a New National Park*, as well as her coedited volume of essays, *On Wilderness: Voices from Maine*.

The table has been valued at $8,000–$12,000 just to re-create. We are open to offers beginning at $5,000. Dimensions: 76"L x 29-32.5"W x 29"H x 3" thick. The table is on view in the Harraseeket Inn lobby. Stop by for a look and a meal at their Broad Arrow Tavern.

Please contact Ed Friedman at 207-666-3372 or edfomb@comcast.net to make an offer. Find details on our home page at friendsofmerrymeetingbay.org.

Photo: Harraseeket Inn

Merrymeeting News

Spring 2024 Vol. XXXIV No. 2

The Newsletter of Friends of Merrymeeting Bay • PO Box 233 • Richmond Maine 04357 • 207-666-1118 • www.fomb.org

Friends of Merrymeeting Bay (FOMB) is a 501(c)(3) nonprofit organization. Our mission is to preserve, protect, and improve the unique ecosystems of the Bay through:

Education

Conservation & Stewardship

Research & Advocacy

Member Events

Support comes from members' tax-deductible donations and gifts.

Merrymeeting News is published seasonally and is sent to FOMB members and other friends of the Bay. Article hyperlinks and color images are available in our online edition at www.fomb.org

For more information, contact:

Ed Friedman
Chair
207-666-3372
edfomb@comcast.net

It's Spring!

It's spring and FOMB is busy! Not only with Bay Day and in-school theatre, but out in the field our volunteers continue monitoring eagle populations, PFAS levels, and shad attempting in vain to pass the Brunswick dam. Details inside.

A proud angler preserves his big fish.

Moving ice from the canal to the conveyor

Alex Poliakoff counts eagles in our aerial survey.

Chris Gutscher samples for PFAS leaking from BNAS into the Androscoggin.

John Lichter recording upstream fish migrants on sonar

Shad counting site below the Frank Wood Bridge

Our Town

During the school week of May 20, thirty 4th graders from Richmond's Marcia Buker elementary school travelled back to the 1800s as they co-wrote and acted in a theatre/film production brought to them by FOMB in another collaboration with the **Piti Theatre Company**.

Jay with TJ and Jane Southard

Drifting back to the past

Young future filmmakers?

After brainstorming on different aspects of Richmond life in the 19th century, the students elected to focus on ship building, dairy farming, ice harvesting, and spinning mills. Each of the two classes took two of the subjects to develop, in large part from actual historical accounts. They then scripted various scenarios which became the basis for their acting efforts.

This week-long theatre residency was filmed. It follows an "Our Town" theme the troupe developed to highlight special aspects of each community they work in. In 2022 Piti and FOMB collaborated with the Bowdoin Central School in a similar effort, the product of which **premiered** at our May 11, 2023 Winter Speaker Series. We also brought Piti's production "**To Bee or Not to Bee**" to Bowdoin Central and Bowdoinham Community Schools in the fall of 2021. This award-winning performance calls attention to the global threats critical pollinators face.

Post-production of "Our Town" involves substantial editing, scoring, and sound and graphic work. Expect the final product sometime in late fall or early winter.

Left: A cowbell from the time capsule trunk recalls dairy farming

Right: The fence is broken and cows about to escape

Left: About to launch

Right: Waiting for the train

Photos: Ed Friedman

Our Town, continued from page 2

Leading a horse team scoring ice for block sawing

Moving blocks inside the ice house

Conveyor load of ice into the ice house

A good harvest

I don't want to share a room with my little brother while we board the ice workers

Above: The bobbins spin round and round
Left: A loom in the mill

All photos: Ed Friedman

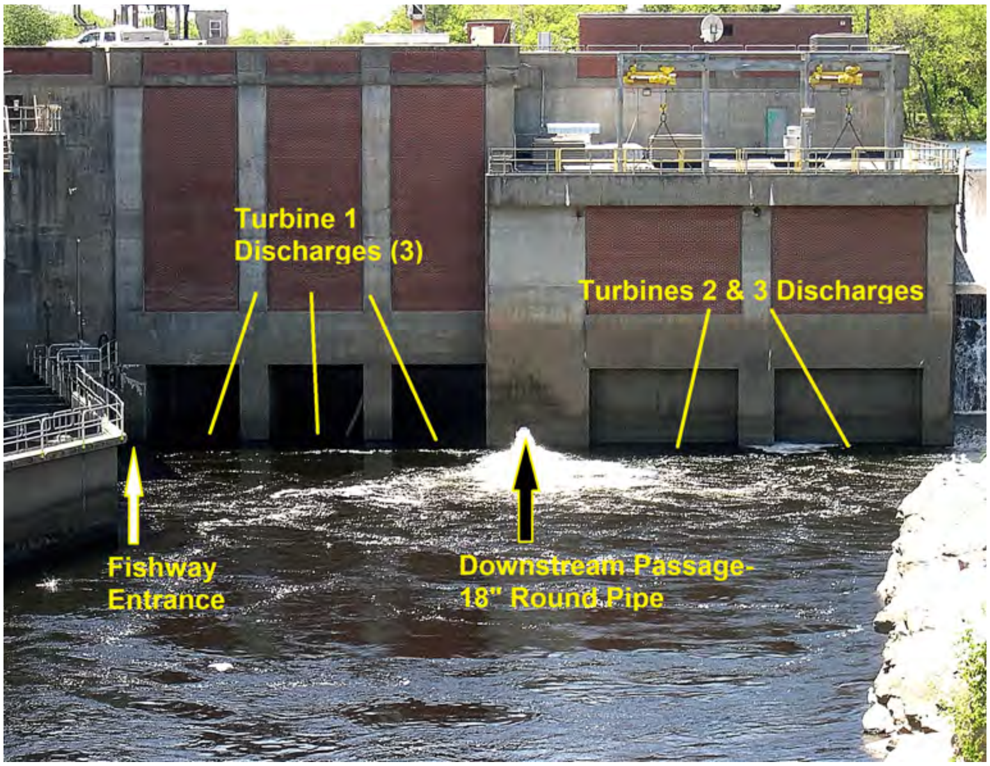
This work is partially funded by the New England Foundation for the Arts, but we are still $10,000 shy of our needed $15,000 goal. If you particularly appreciate this sort of effort, for a minimum tax deductible donation of $1,000 we will list you in the film credits as an associate producer and for a minimum $5,000 donation as an executive producer.

Many thanks to Jon Mirin, Laura Josephs, and Godeliève Richard of Piti Theatre; Mary Paine, Taylor Burke, John Libby, support staff, and the 4th graders of Marcia Buker School; Jay Robbins, Paul Berry, and Terri Blen Parker of the Richmond Historical Society; Richmond Public Works; the Ames Mill, K&G Hardware, and Main St. Dairy Treat.

Ed Friedman

Brunswick Dam Relicensing

The Brunswick-Topsham dam across the Androscoggin River is licensed by the Federal Energy Regulatory Commission (FERC or Commission) and this 50-year license expires in 2029. The approximately 5-year relicensing process has begun with FERC currently reviewing a Pre-Application Document (PAD), filed on February 21, 2024, by Brookfield White Pine Hydro LLC (Brookfield) for relicensing the Brunswick Hydroelectric Project No. 2284 (Brunswick Project or project).



Brunswick dam turbines downstream
Photo: Ed Friedman

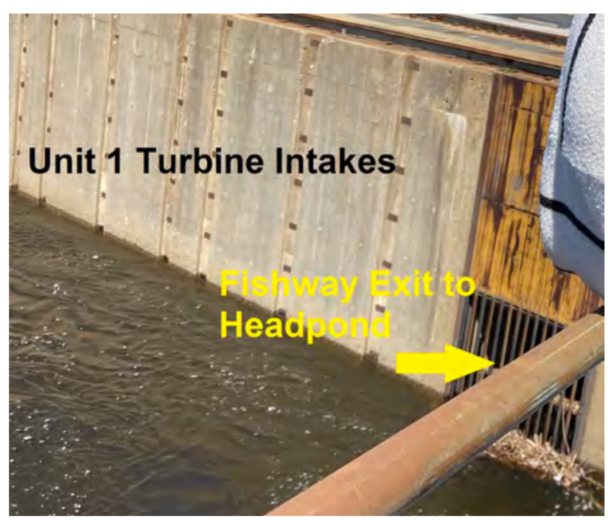
Pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended, FERC staff will prepare either an environmental assessment (EA) or a more detailed environmental impact statement (EIS) (collectively referred to as the "NEPA document"), which will be used by the Commission to determine whether, and under what conditions, to issue a new license for the project.

To support and assist FERC's environmental review, the Commission is beginning the public scoping process with goals to identify and analyze all pertinent issues, and assure that the NEPA document is thorough and balanced. The Commission's scoping process will satisfy the NEPA scoping requirements, irrespective of whether the Commission issues an EA or an EIS. FERC held a scoping meeting on May 7 in Brunswick, followed by a tour of the dam facility.

Several FOMB members attended one or both. We submitted oral and written comments at the meeting and will file more complete comments with FERC.

This dam and the project area (a few hundred yards below the dam and upstream to just below Pejepscot dam) fall entirely within the Friends of Merrymeeting Bay (FOMB) focus area of our research, advocacy, education, and land protection work. Our water quality monitoring in the lower Androscoggin completed under EPA or MDEP quality assurance programs has bracketed the project area since 1999 and has specifically included multiple sites within the project area since 2010. Our sampling has been done under either EPA or DEP quality assurance programs. FOMB's work led to an upgrade in water classification from Class C to Class B for the project area, locking in improved water quality, in particular higher minimum levels of dissolved oxygen.

This article does not detail the entirety of our concerns, which, among other issues, also include fish passage alternatives (dam removal, fish lift, nature-like fish passage), the inadequacy of current downstream fish passage, and the obsolete and harmful nature of excessively long FERC licenses in general.



Fishway exit into head pond on upstream dam face
Photo: Phil Brzozowski

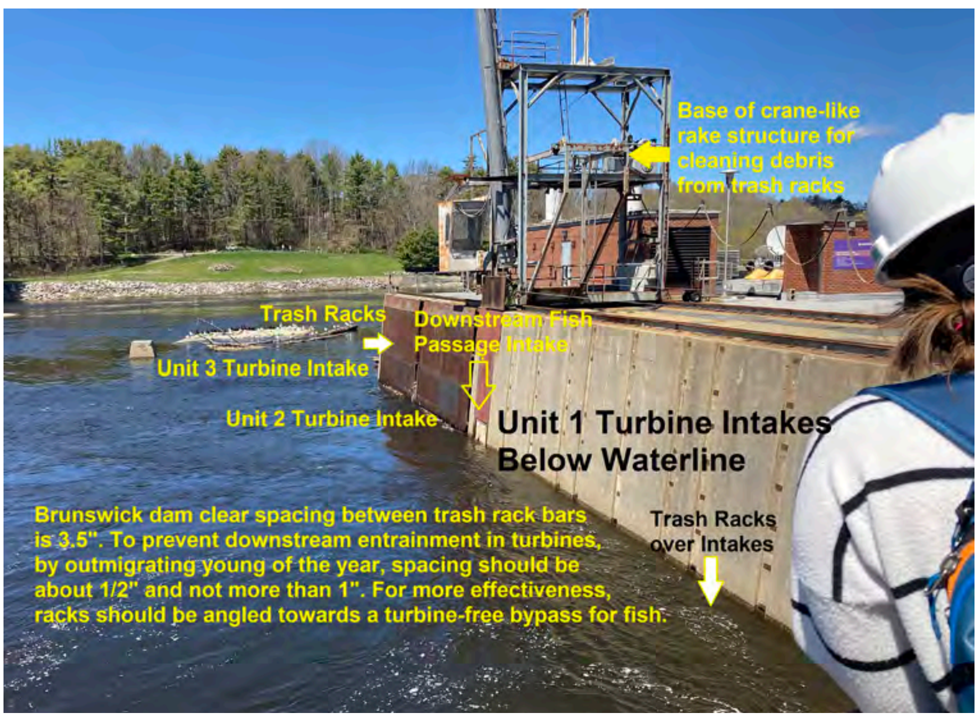
Continued on next page

Brunswick Dam Relicensing, continued from page 4

Pursuant to Section 303(d) of the federal Clean Water Act. 33 U.S.C. § 1313(d) and as noted in the 2012 Maine DEP Integrated Water Quality and Assessment Report, the lower Androscoggin River mainstem segment between the Pejepscot dam and the Brunswick dam, is listed in Category 4C (Impaired by non-pollutant), in non-attainment of the designated uses required by both its previous Class C and current Class B water quality standards. Information provided to the DEP from the Department of Marine Resources indicates the segment fails to support an indigenous species of fish, the American shad, as required by statute. The dam at Brunswick and the fish passage device repeatedly fail to allow passage of a sufficient number of shad to establish a sustainable population in the river above the dam. This facility is a FERC-licensed facility with a requirement for fish passage as part of a state-adopted restoration plan for this species.

American shad
Photo: Ed Friedman

Under state law, fishing and fish habitat are designated uses for Class B waters [38 M.R.S.A § 465(3)(B)]. To support those uses, the Class B standards specifically provide that "waters must be of sufficient quality to support all aquatic species indigenous to those waters without detrimental changes to the resident biological community." The habitat must be characterized as unimpaired [Id. § 465(3)(A)].



Dam face upstream
Photo: Phil Brzozowski

Violation of narrative water-quality criteria or the absence of a designated use constitutes non-attainment of Maine's water quality standards. See Bangor Hydro-Electric v. Bd. of Env. Prot., 595 A. 2d 438, 442 (Me 1991). Annual reports of the Maine Department of Marine Resources' (DMR) Androscoggin River Anadromous Fish Restoration Program provide a definitive and conclusive record of more than 25 years showing that, due to the Brunswick dam barrier, the Androscoggin River basin upstream no longer has an indigenous (or even artificially sustained) population of American shad and that, by their absence, the resident biological community has been detrimentally affected.

FOMB and Bowdoin College have both conducted multi-year underwater counts of shad in multiple areas but mostly at a site immediately below the Frank Wood bridge. To illustrate the egregiousness of Brunswick's longstanding fish passage problem, on just one incoming tide in 2023 we counted over 7,000 shad passing upstream toward the fishway. Yet, for the entire season, the fishway passed only 13 shad. FOMB has requested that FERC conduct a full EIS in relicensing and will remain an active participant in the process.

Ed Friedman and Steve Hinchman

Spring Bay Day Blooms Again

On the morning of May 14, sandwiched between several days of rain, a few early morning drops gave way to sunshine as the good folks at Chop Pt. School welcomed us back for the first spring Bay Day since Covid began. Over one hundred 4th graders from Fisher Mitchell, Phippsburg, Woolwich, and Chop Pt. schools enjoyed a great day in a fabulous location as they studied macroinvertebrates, ran around as predators and prey, built nests, got dirty, and learned about what makes Merrymeeting Bay special.

Each student attended three of these workshops: Watershed Modeling, Wildlife, Marine Mammal Rescue, Beach Seining, Trees, Anadromous Fish Printing, Macroinvertebrates, Fish Migration, Nests, Where are We?, and Where's the Poop Go?

Great lunch view

Cool macroinvertebrates

Beach seining practice
Photo: Becky Bowes

Wildlife

Watershed modeling
Photo: Adele Morgan

Where does our poop go?

Using a fishway takes a lot of energy.

Herring predators: seal and big fish

Where are we?

Photos: Ed Friedman except where noted.

Continued on next page

Spring Bay Day Blooms Again, continued from page 6

Many thanks to:

Guides: Eric Ham, Kent Cooper, Bert Singer, Steve Pelletier, Jason Bartlett, Shannon Nelligan, Nate Gray Nathan Abbott, Lucy Poole, Elizabeth Walker, Leslie Anderson, Will Blocher, Betsy Steen, Bryan Chonko, Ernie Bergeron, Riley Palazzo and Madison Leibowitz

Chaperones: Adele Morgan, Steve Musica, Becky Bowes, Carole Sargent, Mike Curran, Bill Good, Tina Phillips, Dan Smith, Phil Brzozowski, Elise Straus-Bowers, Jane Frost, and Brian Bowers

Bus wrangler and back-up chaperone: Jim Rea

Chief cook and bottle washer: Susan Chase

Special thanks to: Chop Pt. School for their hospitality and Wild Oats Bakery & Café for our lunch wraps!!

Beach seining haul
Photo: Becky Bowes

We Need You! Please Support Our Important Work

FOMB Leadership

Our accomplishments are due to the hard work of dedicated volunteers, especially those who serve on our committees. If you want to get involved and serve, please contact the committee chair or Ed Friedman. We always welcome member input and we'd love for you to join us!

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Tom Walling, Secretary (Bowdoinham)
Simon Beirne (Gardiner)
Becky Bowes (Brunswick)
Phil Brzozowski (Brunswick)
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☐ $100 Shad
☐ $50 Alewife
☐ $20 Smelt
☐ Other

☐ $7 Enclosed (optional) for a copy of Conservation Options: A Guide for Maine Land Owners [$5 for book, $2 for postage].

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Town/State/Zip

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☐ Renewal
☐ New Member
☐ Send information about volunteer opportunities
☐ I would like a sticker

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Native fish need healthy rivers and a healthy bay

Alewives
Photo: John Lichter

Blueback herring

Leaping sturgeon
Photo: John Lichter

Sea lamprey

Striper

Photos: Ed Friedman except where noted.

Exhibit 16

Landscape Ecol
DOI 10.1007/s10980-010-9539-1

RESEARCH ARTICLE

The historic influence of dams on diadromous fish habitat with a focus on river herring and hydrologic longitudinal connectivity

Carolyn J. Hall · Adrian Jordaan · Michael G. Frisk

Received: 23 February 2010 / Accepted: 1 October 2010

Abstract The erection of dams alters habitat and longitudinal stream connectivity for migratory diadromous and potamodromous fish species and interrupts much of organismal exchange between freshwater and marine ecosystems. In the US, this disruption began with colonial settlement in the seventeenth century but little quantitative assessment of historical impact on accessible habitat and population size has been conducted. We used published surveys, GIS layers and historical documents to create a database of 1356 dams, which was then analyzed to determine the historical timeline of construction, use and resultant fragmentation of watersheds in Maine, US. Historical information on the anadromous river herring was used to determine natural upstream boundaries to migration and establish total potential alewife spawning habitat in nine watersheds with historic populations. Dams in Maine were constructed beginning in 1634 and by 1850 had reduced accessible lake area to less than 5% of the virgin 892 km^2 habitat and 20% of virgin stream habitat. There is a near total loss of accessible habitat by 1860 that followed a west-east pattern of European migration and settlement. Understanding historic trends allows current restoration targets to be assessed and prioritized within an ecosystem-based perspective and may inform expectations for future management of oceanic and freshwater living resources.

Electronic supplementary material The online version of this article (doi:10.1007/s10980-010-9539-1) contains supplementary material, which is available to authorized users.

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Keywords Historical Ecology · Gulf of Maine · Habitat fragmentation · Alewife · Blueback herring · Forage fish · Ecosystem · Energy flux · Restoration targets

Introduction

Widespread species loss and large-scale environmental change over the past 400 years has been well documented (Foster et al. 2002; Lotze et al. 2006; Jackson 2008). One prominent environmental change has been the fracturing of coastal watersheds by man-made obstructions (Dynesius and Nilsson 1994; Humphries and Winemiller 2009). Damming of waterways alters the aquatic environment and surrounding landscape through sedimentation, channelization, flooding and temperature changes (Poff et al. 1997; Poff and Hart 2002; Walter and Merritts 2008). Passage of aquatic migratory species between feeding and spawning sites is interrupted, as is the exchange of nutrients among ecosystems (Kline et al. 1990; Bilby et al. 1996; Walters et al. 2009). Subsequent habitat and population loss leads to alteration of foodwebs, loss of biodiversity, species decline and extirpation

Published online: 04 November 2010

(Pringle et al. 2000; Jackson et al. 2001; Pess et al. 2008; Morita et al. 2009). An understanding of the historical condition of ecosystems before significant anthropogenic impact is required to assess restoration targets, yet landscape studies and ecological baselines are often lacking historical perspective or use incomplete data (Wu et al. 2003). Historical data is needed to empirically evaluate the loss of habitat connectivity in relation to species presence and ecosystem function over centuries to effectively apply conservation and restoration methods (Haila 2002).

In the northeastern U.S., concentrated commercial fishing, forestry, agriculture and damming of riverways began altering the condition of river ecosystems with the arrival of European colonists in the seventeenth century. Unfortunately, reliable records of watershed conditions and fish harvests were not kept until the formation of Federal and State Fish Commissions in the 1860s (Atkins and Foster 1868; Judd 1997). Previous to these records were numerous mentions of colonial mill dams obstructing the migration of spawning fishes including river herring [collectively alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*)], shad (*Alosa sapidissima*), Atlantic salmon (*Salmo salar*) and Atlantic sturgeon (*Acipenser oxyrinchus*) (Anonymous 3/26/1798; Moody 1933, pp 445–446). After the construction of the first saw mill dam in Maine in 1634 (Pope 1965, p. 219), hundreds of small dams appeared statewide wherever natural waterfalls and topography provided an area of impoundment and the vertical height required to generate mechanical energy (Moody 1933, p. 332; Clark 1970, p. 336). In 1829 it was estimated that 1,686 principal manufacturing establishments, primarily mills, depended upon water-power (Greenleaf 1829, p. 451). Forty years later, over 3,100 sites in use or potentially suitable for harnessing water-power were documented in Maine (Wells 1869).

The species listed above are diadromous, crossing the ocean-freshwater boundary to complete spawning, and provided abundant resources to historical local diets and commercial fisheries along the Gulf of Maine's coastal and inland ecosystems (Atkins and Foster 1868; Mullen et al. 1986). They also provided a rich forage base for valuable coastal predators and game fish including Atlantic cod (*Gadus morhua*) (Baird 1872; Graham et al. 2002). Decline of coastal cod populations has been linked to the loss of the nutritious and predictable food source these species provided (Baird 1883; Ames 2004). By 1870, State Fish Commissioners concluded that dam construction was the principal cause of migratory fish extinction from Maine's waterways (Atkins and Foster 1868) and 20 years later estimated that only 10% of original habitat remained available for spawning (Atkins 1887). Current diadromous species' populations are at historic lows with some at less than 1% of early nineteenth century estimations (Lotze and Milewski 2004; Saunders et al. 2006). Presently, river herring and Atlantic sturgeon are listed as species of concern and Atlantic salmon as an endangered species (Federal Register 2006). Thus, efforts to provide long-term solutions through population and watershed restoration are of immediate importance, yet no comprehensive attempts have been made to assess virgin habitat baselines or thoroughly document the long-term scale of habitat destruction these species have endured.

Historical records of dam construction can present a timeline of stream and landscape alteration and physical impediment of spawning diadromous species. Here we estimate the loss of accessible freshwater habitat within Maine from 1600 to 1900 due to dam obstruction. First, we present a spatial and temporal analysis of dam construction from the seventeenth through the nineteenth century. Second, we quantitatively present an analysis of accessible migratory and spawning area, both stream and lake habitat, impacted by the erection of dams over time with river herring as our example "species." Current river herring habitat status and coastal watersheds will be evaluated in light of the historical baseline determined for the state of Maine and related to restoration of stream networks and ecosystem connectivity.

Materials and methods

River herring life history

River herring are a mid-trophic level species that prey primarily on zooplankton (Bigelow and Schroeder 1953). River herring reach reproductive maturity in 3–5 years and are iteroparous, or capable of spawning for multiple years, returning to spawn in natal Maine streams between late April and early July (MDMR 1982). Alewives historically migrated over 300 km to spawning areas in quiet freshwaters of Maine, primarily lakes and ponds but also slow sections of streams;

bluebacks prefer riverine habitat up to or near head of tide with moving water. Both species will spawn below head of tide provided that appropriate habitat is available (Bigelow and Schroeder 1953; MDMR 1982). For the purpose of this study, measured stream habitat is defined broadly as accessible habitat for both species but is not included in measurable alewife spawning habitat which is limited to lakes and ponds, and thus an underestimate of total potential area.

Study area

Dams throughout Maine were documented, but analysis was limited to nine historical river herring watersheds, approximately 60% of our estimated historical range, that were divided amongst three categories: (1) primary river watersheds with extensive tributaries totaling a stream distance of 1000 km or greater; (2) secondary watersheds with few tributaries totaling less than 1000 km; (3) bay watersheds composed of multiple small rivers and coastal waterways (Fig. 1). Primary (category 1) watersheds are the Androscoggin, Kennebec and Penobscot Rivers. Secondary (category 2) watersheds are the Mousam, Sheepscot, St. George, Union and Dennys Rivers. The Casco Bay watershed with the Presumpscot River was used as the example for tertiary (category 3) watersheds. Watershed analysis

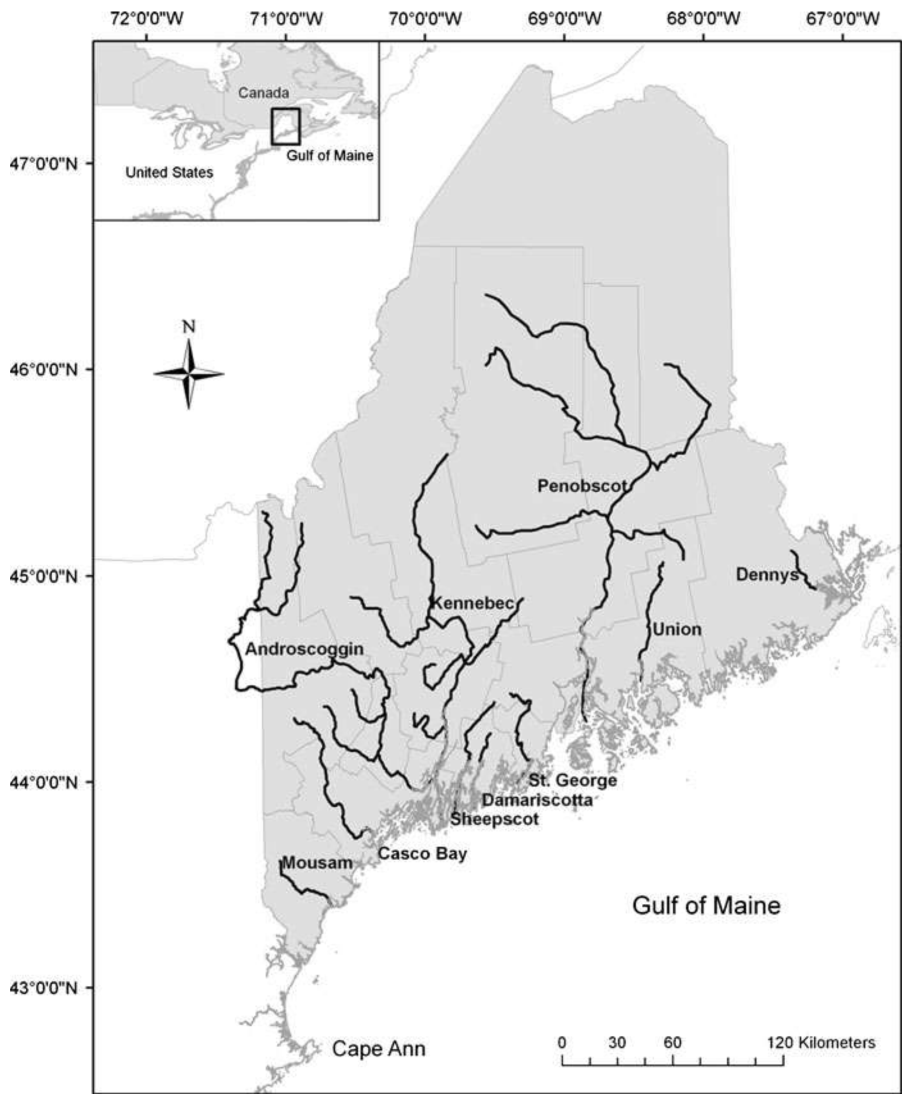

Fig. 1 State of Maine highlighted with historical river herring watersheds assessed in this study for temporal spawning habitat changes from 1600 to 1900

was constrained to within the State of Maine. The Damariscotta River watershed is also referenced in this study.

Methodology

We followed a 6-step procedure to document and map locations of dams, natural boundaries and upstream limits of diadromous fish migration, and determine the historical timeline of use and main stem blockage by dams.

1. Determination of current dam locations

The Maine Geographic Information Systems (MEGIS) Impound database completed in 2006 by the US Fish and Wildlife Service Gulf of Maine Coastal Program (MEGIS 2006) served as our initial database and includes full demographics of still functional dams including waterway, latitude and longitude, ownership, year of completion of the most recent dam at the location (not the original configuration), structural height, and limited information about recent breaches or removals. The database was developed from data collected in the U.S. Army Corp of Engineers (USACE) 1987 Dam Survey, Maine Department of Environmental Protection (MDEP), Bureau of Land and Water Quality (BLandWQ) staff for use with BLandWQ projects. The Maine Emergency Management Agency (MEMA) reviewed all point locations against existing orthophotography or digital raster graphic base layers. Point locations of dams, levees, and impoundments in Maine are at 1:24000 scale. Inventories of removed dams, potentially removable dams and currently active dams listed by MDEP (2009) were an additional source.

2. Determination of historic dams and timeline of use

The most comprehensive reference for historic dams was *The Water-power of Maine*, a hydrographic survey with water resource demographics from the 1860s (Wells 1869). Not all dams reported in Wells (1869) were included in this study. Omitted dams were: (1) not located due to an historic name or no precise location mentioned; (2) upstream of alewife migrations; (3) on tributaries above head of tide with no pond area for alewife spawning; or (4) one of many already surveyed dams on a short stretch of waterway (under 3 miles).

Nineteenth and twentieth century governmental reports were also used to identify and date original construction of dams. These included Maine Commissioner of Fisheries (COF) reports spanning from 1868 to 1899 (Atkins and Foster 1868, 1869; Atkins and Stillwell 1874; Atkins 1887; Smith 1899), and alewife fisheries reports and collections of Atlantic Sea-Run Salmon Commission river surveys and management reports through the 1980s (Rounsefell and Stringer 1945; Supplementary Materials I).

Dates and locations of dams constructed prior to Wells (1869) were found in wills, historical magazines and journals, town histories, eighteenth and early nineteenth century newspaper articles and records of early nineteenth century Maine Legislative Records containing legislative acts and petitions held at the Maine State Archives (Supplementary Materials I). Hand drawn maps labeled with early settlements included in historical publications gave clear references to location of mills and date of existence. For a full list of references used to date and locate mills and dams see Supplementary Materials I. In historical literature, mills are documented more consistently than dams, therefore it was assumed the presence of a mill indicated the presence of a dam.

3. Determination of main stem blockage

Main stem blockage, particularly dams at head of tide, was determined from historical reports by Atkins (1887) and other publications that stated the year of full obstruction and were only considered migration obstacles beginning on sourced dates.

4. Determination of natural barriers and limits to upstream alewife migration

Natural barriers and limits of anadromous species upstream passage, particularly alewives, were determined using Maine COF reports, alewife fishery and Atlantic Sea-Run Salmon Commission river survey and management reports (Atkins and Foster 1868, 1869; Atkins and Stillwell 1874; Atkins 1887; Smith 1899; Rounsefell and Stringer 1945; Supplementary Materials I). Because of historical omnipresence of alewives in Maine ponds with connection to the ocean (Atkins 1887; Mullen et al. 1986), all water bodies below natural barriers within known migration distances were considered potential spawning sites. Thus, we assumed presence of fish unless we found evidence to the contrary. Town histories were instrumental in further determining presence or absence of alewives. For example, in *The History of Sanford Maine 1661–1900* (Emery 1901, pp. 169–170) litigation regarding fish passage for salmon, alewives and shad at mills within the town of Sanford on the Mousam River is discussed. This indicates alewives surmounted the considerable falls downstream of Sanford. Our approach possibly overestimates alewife lake and pond spawning habitat and requires further water body sediment and artifact research to empirically determine historical presence.

5. GIS mapping

All dams, natural obstructions and migratory limits were mapped using ESRI® ArcGIS™ v.9.3. Map base layers in 1:24000 scale of watersheds, counties and coastline were obtained from the MEGIS database (MEGIS 2004). Latitude and longitude in decimal degrees were geo-referenced using the Geographic Coordinate System North America 1983.

6. Error checking

Latitude and longitude in decimal degrees for existing and historical dam sites were confirmed or determined using the 26th (2003) and 30th (2007) editions of the DeLorme Maine Atlas and Gazetteer™ and Google Earth 5.0 during the period of January to July 2009. Additionally, personal site visits were conducted throughout the state of Maine in 2008 and 2009 to ground-truth over 90 dams with GPS and obtain information, photographs and meet with current owners and local residents.

Analysis

Virgin spawning habitat was dated in year 1600, pre European colonization. Historical river herring migratory and spawning habitat was estimated using stream and lake demographics from MEGIS (2004). Streams categorized as perennial on the MEGIS database that led to ponds within the estimated range of alewife migration were used to calculate potential stream migration distance whereas streams categorized as intermittent or not connected to water bodies above head of tide were not included. Perennial streams below or to head of tide but without connection to water bodies were included for potential blueback migratory and spawning habitat.

Let m be the river mouth and n_v the historical natural limit of migration; virgin habitat for alewife spawning (V_A), and blueback and alewife migration ($V_{BB,A}$), is the sum of all suitable lake (L, in km^2) and stream (S, in km) habitat, respectively, such that:

$$V_A = \sum_m^{n_v} L; \quad V_{BB,A} = \sum_m^{n_v} S,$$

Accessible habitat (h_A, $h_{BB,A}$) was then calculated chronologically from 1600 to 1900 each year a new obstruction occurred within the defined virgin habitat area, where n_x is the year specific upstream migration boundary:

$$h_A = \sum_m^{n_x} L; \quad h_{BB,A} = \sum_m^{n_x} S$$

Changes in accessible habitat (H_A, $H_{BB,A}$) resulting from dam construction was calculated using:

$$H_A = V_A - h_A; \quad H_{BB,A} = V_{BB,A} - h_{BB,A}$$

Then change from virgin conditions in percent (R_A, $R_{BB,A}$) since 1600 was calculated:

$$R_A = \frac{H_A}{V_A}100; \quad R_{BB,A} = \frac{H_{BB,A}}{V_{BB,A}}100$$

Results

Dam timeline

A total of 1356 historical and current dams were documented in the state of Maine from the Piscataqua/Salmon Falls River in the west to the St. Croix River in the east and all inlets and islands along the coast (Table 1). A comprehensive database with the history of each dam including use, dates of construction and reconstruction, owners, fish passage capability, hydrology, etc. can be viewed at the Gulf of Maine Historical Ecology Research website: www.GOMHER.org. Dams were grouped according to watershed access to coastal regions divided into western, central and eastern. Earliest construction of dams in the three regions was 1634, 1640 and 1763 for western, central and eastern, respectively. Of the

Table 1 Summary of historical and current dams in Maine by region and watershed[a]

Coastal region	Watershed	Total dams constructed 1600-present	Year of earliest documented dam construction	Number of dams still on watershed as of 2006[b]
Western	Piscataqua/Salmon Falls River	29	1634	12
	York River	12	1634	6
	Mousam River	24	1672	12
	Kennebunk River	10	1749	1
	Saco River	72	1648	42
	Fore River	6	1674	2
	Presumpscot River	68	1732	30
	Royal River	10	1722	4
Central	Kennebec River	226	1754	128
	Androscoggin River	145	1716	79
	Sheepscot River	47	1664	15
	Damariscotta River	8	1726	2
	Pemaquid River	6	1640	3
	Medomak River	12	1797	5
	St. George River	35	1647	18
	Penobscot River	283	1768	116
Eastern	Union River	36	1766	11
	Narraguagus River	15	1773	4
	Pleasant River	9	1765	2
	Machias River	13	1763	6
	East Machias River	12	1765	4
	Orange River	6	1828	4
	Dennys River	19	1787	8
	Pennamaquan River	18	1823	7
	St. John River	77	1811	48
	St. Croix River	48	1780	20
General	Coastal Waterways	110	1651	45
	Total	1356		634

[a] Includes dams that could not be assigned latitude and longitude

[b] Dams still present in 2006 at completion of the MEGIS impoundment database. Includes dams with fish passage and those more recently removed or breached

1356 dams documented in this study, 47% (634 dams) were still present on the waterways as of 2006. Not all of the locations of dams were identified clearly enough in the literature for exact, or estimated, latitude and longitude; therefore a total of 1333 dams were assigned coordinates and are presented in Fig. 2a.

Accumulation of dams across the state on all watersheds is mapped in four time periods: 1630–1750 (Fig. 2b), 1630–1800 (Fig. 2c), 1630–1850 (Fig. 2d) and 1630–1900 (Fig. 2e). A total of 43, 164, 187 and 521 dams were completed in each of the four time periods, respectively, for a total of 915 dams. Between 1750 and 1800, dam completion more than tripled and by 1900, increased 20-fold.

Dam development remained localized in the southwest of the state until northeast expansion in the mid 1700s (Fig. 2b, c). The rate of expansion to the east was more rapid than northern, or inland, but by 1850 the maximum range was reached in both directions while the density of dams continued to increase through the present (Fig. 2).

Historical habitat analysis

The Penobscot watershed had the most virgin habitat with 5332 km of streams and 327.7 km^2 of lake area whereas the Mousam watershed was the smallest with 183.5 km of streams and 10.7 km^2 of lake area (Table 2). From 1720 to 1846, impassable dams were

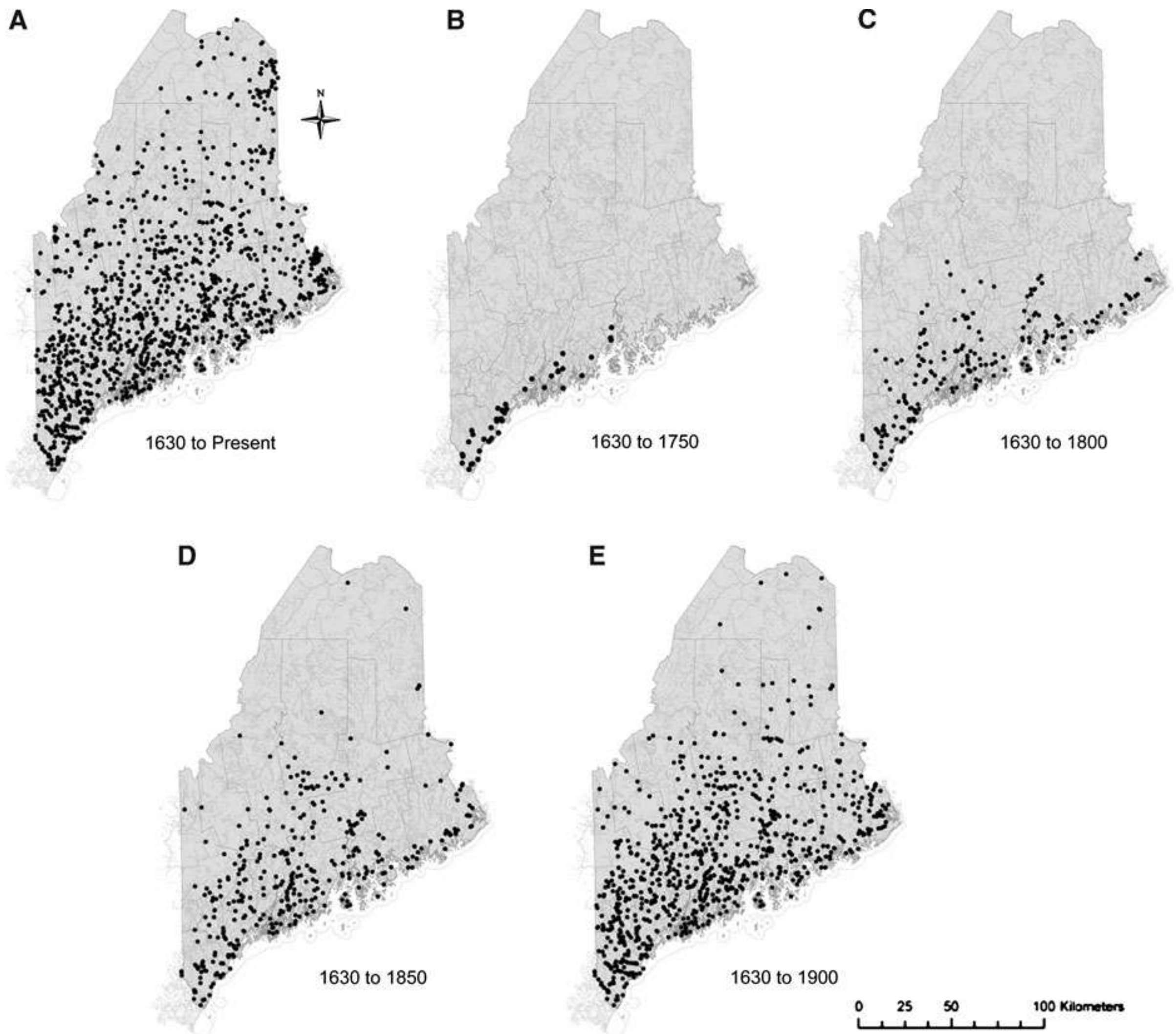

Fig. 2 Temporal and spatial accumulation of dams in Maine for which latitude and longitude were determined. Each dot represents a dam. **a** comprehensive of all dams completed through 2008. **b** all dams constructed by 1750. **c–e** the cumulative increase of completed dams in 50-year increments from 1750 to 1900

constructed at or near head of tide on the main stem of our nine historical river herring watersheds (Table 2). Head of tide dams alone reduced accessible stream distance and lake area to between 7–59% and 0–33%, respectively, having the greatest impact on the Kennebec, Mousam and Casco Bay watersheds with less than 1% of virgin lake surface area remaining after construction.

A representative watershed for each category is used to illustrate chronological changes in available spawning habitat. The Kennebec, St. George and Casco Bay represent primary, secondary and bay watersheds. See Supplementary Material II for remaining watersheds. On the Kennebec watershed, considerable reductions in stream and lake habitat first occurred in 1754. Stream habitat declined to 65.4% and lake area to 53.6% (Fig. 3a). Dam construction in 1760 reduced lake area to 25.6% of virgin habitat and in 1792 further reduced habitat to 14.8% of streams and 4.8% of lake area. In 1837 the Edwards Dam was built at head of tide which reduced stream habitat to 6.9%. The last dams to have a measurable impact on the Kennebec watershed were completed in 1867 and left 4.9% and 0.4% of stream and lake area available, respectively.

Table 2 Nine focus watersheds with total virgin stream distance (SD) and lake surface area (LSA) in year 1600 for potential accessible river herring habitat, year of head of tide dam construction and percent remaining stream and lake habitat after full obstruction at head of tide[a]

Category	Watershed	Virgin SD (km)	Virgin LSA (km^2)	Year	% SD	% LSA
1	Androscoggin	906.2	45.9	1807	14.9	4.4
1	Kennebec	2392.3	197	1837	7.3	0.5
1	Penobscot	5332	327.7	1835	18.6	8.2
2	Mousam	183.5	10.7	1720	8.1	0
2	Sheepscot	558	19.4	1762	58.2	32.4
2	St. George	549.2	31.7	1840s	20.5	6.8
2	Union	480.9	93.2	1800	21.5	5.2
2	Dennys	230.1	30.1	1846	31.9	1.9
3	Casco Bay	862.1	136.1	1819	20.9	0.1

[a] Percent calculated based on presence of head of tide dam only. Habitat loss from other dams built on watersheds previous to above years or below head of tide not considered for this estimate

On the St. George watershed, the first notable reductions in available habitat occurred in 1777 resulting in 82.7% of stream and 72.2% of lake area remaining (Fig. 3b). Obstructed at head of tide in 1785, habitat was reduced to 18.9% stream and 4.9% lake area. The last dam to have a measurable impact on accessible spawning habitat was completed in 1867 leaving 13% stream and 0% lake habitat available.

Changes in available spawning habitat in Casco Bay were quite different between streams and lakes. Stream distance decreased 9.5% in fairly regular intervals until 1762 while lake area remained above 99% (Fig. 3c). Construction of a main stem dam on the Presumpscot River in 1762 reduced lake habitat to 3% and stream habitat to 57.8%. The Presumpscot River provides access to 116.4 km^2 Sebago Lake, the principal lake of the Casco Bay watershed. By blocking access to Sebago Lake, the dam obstructed nearly 97% of the watershed lake habitat but only about a third of the accessible stream habitat.

For an overall picture of Maine, the nine analyzed watersheds were combined (Fig. 3d). Remaining stream and lake habitat both decreased to below 50% by 1800 and were further reduced to 16.22% and 2.42% by 1900, respectively.

Discussion

This study provides the first comprehensive temporal and spatial analysis of dam construction as it relates to historical watersheds in Maine and determination of virgin baselines for diadromous river herring habitat. We illustrate the early history of anthropogenic fracturing of northeastern U.S. coastal ecosystems and consequent statewide loss of longitudinal connectivity and diadromous spawning habitat accessibility. From 1634 to 1850 mill dam construction on tributaries and small watersheds reduced Maine's river herring lake habitat by more than 95%. Large dams on primary rivers at head of tide led to a near total loss of accessible habitat by the 1860s. Legacy land use has diminished hydrologic connectivity within and among coastal ecosystems resulting in shifts to ecological form and function that must be recognized and incorporated explicitly into restoration.

Implications for restoration and management

While restoration and trending towards pre-colonial habitat have occurred since the American Civil War (Foster 2002), obstruction of waterways, especially at head of tide, has meant that waterways and diadromous fish are not experiencing the same trend. In light of our results, Atkins' (1887) underestimated lost habitat by an order of magnitude, and even the dire estimate of 1% remaining at present (Lotze and Milewski 2004) fails to identify that this baseline was reached 150 years ago, before industrial pollution and human-induced climate change had become widespread concerns. Historically, alewife migrated 193 km and 322 km inland on the Kennebec and Penobscot Rivers, respectively (Atkins and Foster 1868), but completion of head of tide dams restricted

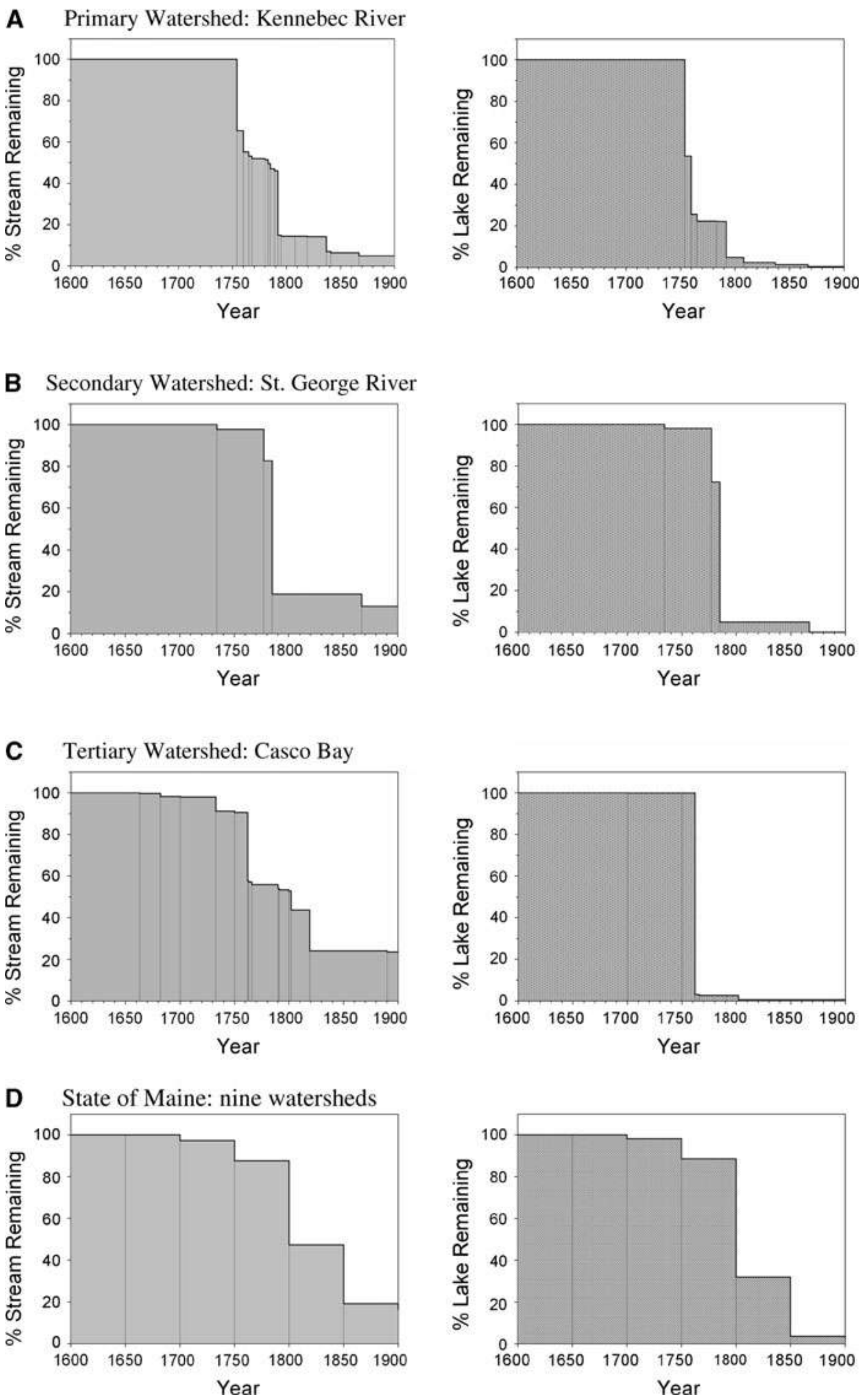

Fig. 3 Percent virgin habitat. Percent stream distance remaining (*on left*) and percent lake surface area remaining (*on right*) for representative watersheds of three categories and all nine assessed watersheds combined to represent the state: **a** primary rivers represented by the Kennebec River, **b** secondary rivers represented by the St. George River, **c** tertiary bay systems represented by Casco Bay and **d** state of Maine. Vertical drop down lines in each graph indicate year of dam construction that resulted in a measurable loss of potential spawning habitat

migration to less than 8% and 19% virgin habitat. Penobscot historical alewife catch declined from 1 million individuals in 1867 (Atkins 1887) to 230,283 in 1943 (Maine Department of Marine Resources unpublished data), documenting species decline due to habitat fragmentation and other factors. The extent of habitat loss during the 1800s left little spawning habitat accessible to wild populations along the Maine coast with the Damariscotta River serving as the only consistent documented refuge for river herring (Maine Secretary of State 1804–1893). As a result, Damariscotta fish were likely responsible for repopulating other watersheds through straying and restocking efforts as habitat re-opened during the 1900s (Rounsefell and Stringer 1945). Increased population biocomplexity, where population structure includes access to a greater variety of spawning sites, improves species resilience in the face of environmental changes (Hilborn et al. 2003). Genetic and spatial variability of spawning populations would have been reduced from numerous discrete groups to as few as one, potentially endangering the resiliency of the species and possibly contributing to its current depleted status.

Over 100 years before recognition of the dramatic impacts of species loss, and advent of the Endangered Species Act, river herring were already at critically low population levels experiencing habitat conditions linked to genetic bottlenecks. The current IUCN Red List criteria for listing a species as "vulnerable" includes a 30% or greater loss of historic Area of Occupancy or Extent of Occurrence (IUCN Standards and Petitions Working Group 2008). Our study is far from global and does not conform to regional Red List guidelines' definition of a state or province (IUCN 2003). Yet, if our analysis can be assumed to represent the entire State, continued presence of migration barring dams contributing to 70% or greater loss of accessible habitat per watershed would merit a listing of "regionally endangered". Disruption of habitat-use and spawning migrations occurred during colonial development along the entire U.S. Atlantic coast (ASMFC 2009). An IUCN evaluation of river herring in watersheds throughout the greater Gulf of Maine, from Bay of Fundy in the north to Cape Cod in the south, would include numerous extirpated historical runs where the species is "regionally extinct" (IUCN 2003, p. 10). Subpopulation watershed loss could be the most important conservation parameter on a regional scale. Incorporation of assessments at watershed and subpopulation levels into regional river herring management efforts is critical and should be required.

Fortunately, alewives are ideal candidates for restoration because they rapidly populate reopened spawning habitat within 3–5 years, roughly equivalent to the species age of maturity (Atkins and Foster 1868; Pardue 1983; Lichter et al. 2006). Some progressive state management plans have implemented individual watershed restoration programs (Brown et al. 2008; MDMR 2008; Brady 2009) and currently there are numerous efforts in Maine to restore stream connectivity and diadromous fish habitat access through fish passage construction, dam removal and stocking with varying success. Fish passage over the head of tide Brunswick Dam in 1981 provided access to 53.8% of historical lake habitat for the Androscoggin watershed (Brown et al. 2008). Removal of the head of tide Edwards Dam in 1999, without unblocking additional upstream dams, allowed access to only 1% of potential lake habitat within the Kennebec watershed (MDMR 2008). Yet, removal of Fort Halifax Dam in 2008 at the mouth of the Sebasticook River provided access to 45% of the original lake habitat. Opening of these two dams potentially provided access to 46% of the Kennebec watershed's virgin lake habitat. Finally, planned removal of the main stem Great Works and Veazie Dams on the Penobscot would restore 37% of the Penobscot watershed's historical lake habitat (MBSRFH 2007; MDEP 2009), which with the already accessible Orland River would make 42% of historic lake habitat available. We propose that habitat is the best indicator of restoration success and efforts to reopen historical spawning habitat and apply management per watershed, in addition to larger coastal regions, is an important step towards restoring Gulf of Maine river herring.

Landscape and ecosystem impacts

Understanding the consequences of diadromous species' loss of access to spawning habitat is relatively straightforward compared to assessing their contribution to Gulf of Maine ecosystems, including as a nutrient vector between freshwater and marine environments. Extensive research on anadromous and semelparous (death after single spawning) Pacific salmon (*Oncorhynchus* spp.) has shown significant transport of marine derived nutrients to freshwater spawning sites and incorporation into aquatic and terrestrial food webs (Kline et al. 1990; Bilby et al. 1996; Schindler et al. 2003). River herring along the Atlantic coast could be equally important but differ from Pacific salmon by not providing as substantial an influx of nutrients through mortality. However, by returning to the marine environment multiple times, iteroparous river herring provide repeated exchange between fresh and marine aquatic systems. Short-term research on small watersheds shows evidence of marine derived nutrient incorporation into freshwater ecosystems (MacAvoy et al. 2000; Walters et al. 2009). Long-term studies of river herring reintroduction and nutrient transport are needed to understand greater ecosystem impacts (Schindler et al. 2003).

Small-scale natural and human induced change to watershed morphology was not accounted for in our four-century analysis. To assess large-scale obstruction, we assumed stream distance and lake area remained consistent with values obtained from MEGIS (2004). As mentioned in the introduction, long-term presence of dams seriously affects water body characteristics and biological habitat availability (Poff and Hart 2002; Wu et al. 2004; Walter and Merritts 2008). Accurate estimates of these changes are difficult to obtain (Petts 1989; Poff et al. 1997) and require quantitative analyses of historical maps and sediment profiles to determine river width, depth and lake surface area over time. Also, small-scale natural (i.e: beaver dams) and human induced (i.e: road culverts) fragmentation was not assessed here. Inclusion of this work is necessary to improve understanding and management of localized landscape changes.

We have focused on the long-term destruction of river herring habitat. Substantial impacts on other diadromous species, including salmon, American eel (*Anguilla rostrata*) and shad, and their contributions to freshwater and coastal ecosystems were not considered. Consideration of all species implies a devastating loss of diadromous biomass from coastal food webs, as suggested for over 100 years (Baird 1872; Ames 2004). While trophically important river herring also potentially provide prey buffering for juvenile salmon from fish and bird predators (Fay 2003), restoration efforts have suffered because of perceived competition with sport fisheries (Willis 2006). Further, river herring as bycatch in marine fisheries such as Atlantic herring (*Clupea harengus*) is increasingly considered an impediment to successful restoration (Kritzer and Black 2007). Thus, recovery of one species does not occur in a vacuum.

While diadromous fish are impacted by obstructions to a greater degree than potamodromous species (Cote et al. 2009), fragmentation of rivers, isolation of lake and stream habitat, rapid increase of impoundments combined with deforestation and other land-use changes that accompanied dams, have altered landscape ecology and affected all species (Foster et al. 2003). Fragmentation, land clearance and conversion to pasture land co-occurred with mill development. Thus, the documentation of damming is an indicator of regional changes to the landscape, including loss of foundation species (Ellison et al. 2005), shifts in species and habitats, nutrient composition, soil and sediment structure, presence of woody debris and overall flora and fauna (Foster et al. 2003). When the scale of alteration is considered (Walter and Merritts 2008) in relation to hydrologic connectivity and the relative strengths and directionality of hierarchal processes (Poole 2002), a dramatic shift from habitat continuum to discontinuum, not only within stream networks, but across the freshwater-oceanic boundary, has occurred. Further, punctuated discontinuities across the landscape together with homogenization of forests at the regional scale (Foster et al. 1998) have shifted the biotic structure and nutrient flux of Maine's ecosystems. Today, the terrestrial, riverine and marine landscape of Maine favors shorter-lived rapid growing species compared to pre-colonial ecosystems (Foster et al. 2002). A systematic and comprehensive plan is required to determine minimum habitat connectivity and species restoration targets, with multi-level involvement from individual watersheds to coast-wide management. Finally, by comparing current watershed restoration results to baseline habitat and productivity estimates we can determine the effectiveness of proposed actions towards regaining ecological connectivity after centuries of watershed obstruction.

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References

Ames EP (2004) Atlantic Cod stock structure in the Gulf of Maine. Fisheries 29:10–28
Anonymous (1798) Legislature of Massachusetts. The Eastern Herald and Gazette of Maine [Portland] 26 March, 1798

ASMFC (2009) Amendment 2 to the Interstate Fishery Plan for shad and river herring (river herring management). Atlantic States Marine Fisheries Commission

Atkins CG (1887) The river fisheries of Maine. In: Goode BG (ed) The fisheries and fishery industries of the United States, Section V, vol. 1, pp 673–728

Atkins CG, Foster N (1868) First Report of the Commissioners of Fisheries of the State of Maine, 1867. Owen and Nash, Printers to the State, Augusta, ME

Atkins CG, Foster N (1869) Second Report of the Commissioners of Fisheries of the State of Maine, 1868. Owen and Nash, Printers to the State, Augusta, ME

Atkins CG, Stillwell EM (1874) Obstructions to the upward movement of fishes in streams, and the remedy In: US Commission of Fish and Fisheries, Part II, Report of the Commissioner for 1872 and 1873. Appendix E; Sections XXIII and XXIV. Government Printing Office, Washington, DC, pp 589–621

Baird ST (1872) Letter to Maine Commissioner of Fisheries on the diminution of the supply of food-fishes. In: Atkins CG (ed) 1872 Sixth Report of the Commissioners of Fisheries of the State of Maine, 1872. Owen and Nash, Augusta, ME, pp 7–10

Baird ST (1883) US Commission of Fish and Fisheries Report of the Commissioner for 1883. Government Printing Office, Washington, DC

Bigelow HB, Schroeder WC (1953) Fishes of the Gulf of Maine. US Fish and Wildlife Service Fishery Bulletin #74, vol 53. US Government Printing Office, Washington, DC, 577 pp

Bilby RE, Fransen BR, Bisson PA (1996) Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Can J Fish Aquat Sci 53:164–173

Brady PD (2009) Marine fisheries to work with local river herring officials on sustainable management of Massachusetts River Herring. DMF News 30: 9. Massachusetts Department of Marine Fisheries, Boston, MA

Brown ME, Maclaine JE, Flagg L (2008) Anadromous fish restoration in the Androscoggin River Watershed. 2007 report on the operation of the Brunswick fishway. FERC #2284, Maine Dept of Marine Resources. PL 89-304, 28 pp

Clark CE (1970) The Eastern Frontier: the settlement of Northern New England 1610–1713. Alfred A Knopf, New York, 419 pp

Cote D, Kehler DG, Bourne C, Wiersma YF (2009) A new measure of longitudinal connectivity for stream networks. Landscape Ecol 24:101–113

Dynesius M, Nilsson C (1994) Fragmentation and flow regulation of river systems in the Northern third of the World. Science 266(5186):753–762

Ellison AM, Bank MS, Clinton BD, Colburn EA, Elliott K, Ford CR, Foster DR, Kloeppel BD, Knoepp JD, Lovett GM, Mohan J, Orwig DA, Rodenhouse NL, Sobczak WV, Stinson KA, Stone JK, Swan CM, Thompson J, Von Holle B, Webster JR (2005) Loss of foundation species: consequences for the structure and dynamics of forested ecosystems. Front Ecol Environ 3(9):479–486

Emery E (1901) In: Emery WM (ed) The history of Sanford Maine 1661–1900. Fall River, ME, 537 pp

Fay C (2003) Biological and ecological role of alewives. Maine Rivers annual conference 2003, September 27–28, 2003 Indian Island, ME

Federal Register (2006) Vol 71, No 200/Tuesday, October 17, 2006/Notices, pp 61022–61025

Foster DR (2002) Thoreau's country: a historical-ecological perspective to conservation in the New England landscape. J Biogeogr 29:1537–1555

Foster DR, Motzkin G, Slater B (1998) Land-use history as long-term broad-scale disturbance: regional forest dynamics in central New England. Ecosystems 1:96–119

Foster DR, Motzkin G, Bernardos D, Cardoza J (2002) Wildlife dynamics in the changing New England landscape. J Biogeogr 29:1337–1357

Foster DR, Swanson FJ, Aber JD, Burke I, Brokaw N, Tilman D, Knapp A (2003) The importance of land-use legacies to ecology and conservation. Bioscience 53:77–88

Graham J, Engle S, Recchia M (2002) Local knowledge and local stocks: an atlas of groundfish spawning in the Bay of Fundy. The Centre for Community-based Management, Extension Dept., St. Francis Xavier University, Antigonish, NS, Canada

Greenleaf M (1829) A survey of the State of Maine: In: Reference to its geographical features, statistics and political economy. Shirley and Hyde, 460 pp

Haila Y (2002) A conceptual genealogy of fragmentation research: from island biogeography to landscape ecology. Ecol Appl 12(2):321–334

Hilborn R, Quinn TP, Schindler DE, Rogers DE (2003) Biocomplexity and fisheries sustainability. Proc Natl Acad Sci 100:6564–6568

Humphries P, Winemiller KO (2009) Historical impacts on river fauna, shifting baselines, and challenges for restoration. Bioscience 59(8):673–684

IUCN (2003) Guidelines for application of IUCN Red List criteria at regional levels: version 3.0. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK, ii + 26 pp

IUCN Standards and Petitions Working Group (2008) Guidelines for using the IUCN Red List categories and criteria. Version 7.0. Prepared by the Standards and Petitions Working Group of the IUCN SSC Biodiversity Assessments Sub-Committee in August 2008. Downloadable from http://intranet.iucn.org/webfiles/doc/SSC/RedList/RedListGuidelines.pdf

Jackson JBC (2008) Ecological extinction and evolution in the brave new ocean. Proc Natl Acad Sci 105(Suppl 1): 11458–11465

Jackson JBC, Kirby M, Berger W, Bjorndal KA, Botsford L, Bourque BJ, Bradbury RH, Cooke RG, Erlandson J, Estes JA, Hughes TP, Kidwell S, Lange C, Lenihan H, Pandolfi JM, Peterson C, Steneck R, Tegner MJ, Warner RR (2001) Historical overfishing and the collapse of coastal ecosystems. Science 293:629–638

Judd RW (1997) Common lands, common people. Harvard University Press, Cambridge, MA, 335 pp

Kline TC, Goering JJ, Mathisen OA, Poe PH, Parker PL (1990) Recycling of elements transported upstream by runs of Pacific salmon I $\partial^{15}N$ and $\partial^{13}C$ evidence in Sashin Creek, southeastern Alaska. Can J Fish Aquat Sci 47:136–144

Kritzer J, Black P (2007) Oceanic distribution and bycatch of river herring. An analysis of federal fishery-independent and fishery-dependent data. Progress report. October 2007. Environmental Defense

Lichter J, Caron H, Pasakarnis TS, Ridgers SL, Squiers TS Jr, Todd CS (2006) The ecological collapse and partial recovery of a freshwater tidal ecosystem. Northeastern Nat 13(2):153–178

Lotze HK, Milewski I (2004) Two centuries of multiple human impacts and successive changes in a North Atlantic food web. Ecol Appl 14(5):1428–1447

Lotze HK, Lenihan HS, Bourque BJ, Bradbury RH, Cooke RG, Kay MC, Kidwell SM, Kirby MX, Peterson CH, Jackson JBC (2006) Depletion, degradation, and recovery potential of estuaries and coastal seas. Science 312(5781): 1806–1809

MacAvoy SE, Macko SA, McIninch SP, Garman GC (2000) Marine nutrient contributions to freshwater apex predators. Oecologia 122:568–573

Maine Secretary of State. Fish Inspector Records (1804–1893) Boxes 1–9. Maine State Archives. Augusta, ME

MBSRFH (2007) Draft strategic plan for the restoration of diadromous and resident fishes to the Penobscot River. Maine Bureau of Sea-Run Fisheries and Habitat, Department of Marine Resources, Augusta, ME

MDEP (2009) January 1, 2009 status reports: hydropower projects in Maine, DEPLW0363-H2009, and Dam Removals in Maine and Dams Subject to Regulated Minimum Flow Releases. Maine Department of Environmental Protection

MDMR (1982) Statewide river fisheries management plan. Maine Department of Marine Resources, Maine Department of Inland Fisheries and Wildlife, and Atlantic Sea Run Salmon Commission. State of Maine Augusta, ME

MDMR (2008) Kennebec River anadromous fish restoration Annual progress report—2007. Maine Department of Marine Resources, Bureau of Sea-Run Fisheries and Habitat, 131 pp

MEGIS (2004) Watershed, county line and coast base layers. Maine Geographic Information Systems (comp, ed), United States Geological Survey. Last accessed April 2009 at http://megismainegov/catalog/

MEGIS (Maine Geographic Information Systems) (comp, ed), Army Corp of Engineers (USACE), Maine Emergency Management Agency (MEMA), Maine Department of Environmental Protection (MEDEP)(comp, ed) (2006) Impound database. Last accessed August 2008 at http://megismainegov/catalog/catalogasp?state=2andextent=cover

Moody RE (1933) The Maine Frontier 1607–1763. Yale University, New Haven, CT, 462 pp

Morita K, Morita SH, Yamamoto S (2009) Effects of habitat fragmentation by damming on salmonid fishes: lessons from white-spotted charr in Japan. Ecol Res 24(4):711–722

Mullen DM, Fay CW, Moring JR (1986) Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic)—alewife/blueback herring U S Fish Wildl Serv Biol Rep 82(1156) U S Army Corps of Engineers, TR EL-82-4, 21 pp

Pardue GB (1983) Habitat suitability index models: alewife and blueback herring. USFWS, FWS/OBS-82/10.58, 22 pp

Pess GR, McHenry ML, Beechie TJ, Davies J (2008) Biological impacts of the Elwha River dams and potential salmonid reasons to dam removal. Northwest Sci 82(Sp Iss SI):72–90

Petts GE (1989) Perspectives for ecological management of regulated rivers. In: Alternatives in regulated river management by JA Gore and GE Petts. CRC Press, pp 3–24

Poff NL, Hart DD (2002) How dams vary and why it matters for the emerging science of dam removal. Bioscience 52(8):659–668

Poff NL, Allan JD, Bain MB, Karr JR, Prestegaard KL, Richter BD, Sparks RE, Stromberg JC (1997) The natural flow regime: a paradigm for river conservation and restoration. Bioscience 47(11):769–784

Poole G (2002) Fluvial landscape ecology: addressing uniqueness within the river discontinuum. Freshw Biol 47:641–660

Pope CH (1965) The pioneers of Maine and New Hampshire 1623 to 1660. Originally published Boston, 1908. Genealogical Pub Co, Baltimore, MD, 252 pp

Pringle CM, Freeman MC, Freeman BJ (2000) Regional effects of hydrologic alterations on riverine macrobiota in the New World: tropical-temperate comparisons. Bioscience 50:807–823

Rounsefell GA, Stringer LD (1945) Restoration and management of the New England alewife fisheries with special reference to Maine. US Department of the Interior, Fish and Wildlife Service. Trans Am Fish Soc 73:394–424

Saunders R, Hachey MA, Fay CW (2006) Maine's diadromous fish community: past, present, and implications for Atlantic salmon recovery. Fisheries 31(11):537–547

Schindler DE, Scheuerell MD, Moore JW, Gende SM, Francis TB, Palen WJ (2003) Pacific salmon and the ecology of coastal ecosystems. Front Ecol Environ 1(1):31–37

Smith HM (1899) Notes on the extent and condition of the alewife fisheries of the United States in 1896. In: US Commissioner of Fish and Fisheries Report part XXIV for the year ending June 30, 1898. Government Printing Office, Washington, DC, pp 31–43

Walter RC, Merritts DJ (2008) Natural streams and the legacy of water-powered mills. Science 319:299–304

Walters AW, Barnes RT, Post DM (2009) Anadromous alewives (*Alosa pseudoharengus*) contribute marine-derived nutrients to coastal stream food webs. Can J Fish Aquat Sci 66:439–448

Wells W (1869) The Waterpower of Maine Hydrographic Survey of Maine Sprague. Owen and Nash, Printers to the State, Augusta, ME, 526 pp

Willis TV (2006) St. Croix River alewife—smallmouth bass interaction study. Final Report to Maine Rivers, Hallowell, Maine

Wu J, Huang J, Han X, Zongqiang X, Gao X (2003) Three Gorges Dam—experiment in habitat fragmentation? Science 300:1239–1240

Wu J, Huang J, Han X, Gao X, He F, Jiang M, Jiang Z, Primack RB, Shen Z (2004) The Three Gorges Dam: an ecological perspective. Front Ecol Environ 2(5):241–248

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Exhibit 17

Ex. 17

Merrymeeting News

Winter-2020 Vol. XXX No. 1

The Newsletter of Friends of Merrymeeting Bay • PO Box 233 • Richmond Maine 04357 • 207-666-1118 • www.fomb.org

Friends of Merrymeeting Bay (FOMB) is a 501(c)(3) non-profit organization. Our mission is to preserve, protect, and improve the unique ecosystems of the Bay through:

Education

Conservation & Stewardship

Research & Advocacy

Member Events

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Merrymeeting News is published seasonally and is sent to FOMB members and other friends of the Bay. Article hyperlinks and color images are available online at: www.fomb.org

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Let There Be Dark

The FOMB Annual Meeting on January 8, 2020 featured an in-depth discussion of light pollution, a growing problem worldwide, in Maine and here on the Bay. The evening's presenter, Robert Burgess of Brunswick, is President of Southern Maine Astronomers, a NASA Solar System Ambassador, and a member of the Brunswick Planning Board, providing him with several vantage points from which to see and analyze this problem.

Burgess addressed the audience of about 30 saying "In a world full of problems this is not the biggest." However, he said "But unlike so many of the larger societal problems we face, this one can be addressed at the local level where we live and is one where each of us can have a positive impact on the natural world around us."

Light pollution is typically the result of "misdirected or misused light" generally caused by the improper use of outdoor lighting products and practices involving buildings, parking lots and streets.

Burgess identified many of the impacts light pollution is having on our world including effects on animal habitats and behaviors, disturbing predator/prey conditions and reproductive cycles. Sixty percent of animal life on Earth is nocturnal and this adaptation can be significantly disrupted: everything from migratory bird patterns (deaths from collisions with lit buildings and towers at night), to insects, amphibians, spawning fish and other mammals. Even the blooming of trees and plants can be affected when bombarded by light. We are at risk of destroying night ecosystems with obvious and sometimes not so obvious repercussions to the daylight half.

Continued on page 2.

Effects on human health have only recently been recognized in the disruption of our circadian rhythms, reducing the amount of melatonin produced in the brain at night that is essential for our immune system and exacerbated by the increase in "blue-rich" light consequent to the widespread adoption of LED (light emitting diode) lighting. Late night screen time plays a common role in this.

Glare attendant to the improper use of lights can be hazardous to drivers and pedestrians alike, and particularly affects older individuals because of conditions in the eye that develop with aging.

Another major consequence of light pollution is sky glow robbing us of our ability to see the night sky. Burgess noted that 80% of the world's population live under some impact of sky glow, and that a vast majority of Americans can no longer see the Milky Way, only a few handful of stars and the occasional planet. Burgess said the loss of awe we used to experience under a dark sky extinguishes a cultural and spiritual connection humans have had with their environment for hundreds of thousands of years. He said the loss of this experience denies "the human soul the opportunity to recalibrate." It is also affecting astronomical research as more and more sky glow creeps into previously dark locations of major observatories. So really, light pollution is psychologically, scientifically, physiologically and of course spatially, one of the world's biggest problems.

Finally, Burgess reviewed our level of energy consumption. Following estimates of the International Dark Sky Association (IDA) that about 6% of national electricity consumption is for lighting, and 30% of that wasted through poorly aimed lights and over-use, IDA determined that we waste about $3.3 billion dollars per year on electricity and unnecessarily inject an additional 21 million tons of CO_2 into the atmosphere, contributing to global warming. Burgess says such use affects us as taxpayers, causing higher municipal street lighting costs, and as consumers, in higher business operating costs affecting pricing of goods and services.

According to the International Dark-Sky Association, only 2 of every 10 people on earth can now see the Milky Way and 99% of the U.S .and Europe are considered light polluted. The much treasured plain old delight, inspiration and wondrous awe from star gazing are becoming things of the past.

Burgess discussed the recent introduction of LED lights that had (and still has) the potential to reduce our energy use in lighting but cautioned about the "correlated color temperature" (CCT) of the lamps. He noted that lamps with too much blue in their spectrum, having CCTs in excess of 3,000 degrees Kelvin, are not recommended because of glare and light scattering effects, yet many businesses and municipalities are unwittingly installing these lamps with CCTs of 4,000 and 5,000 degree Kelvin ratings. Because LEDs are so efficient and durable, the bad decisions being made today will be with us for a generation (20 years) before the lamps will need to be replaced unless proper regulations are in place. It's important to note many LEDs can be electrically polluting with radiofrequencies causing health or electrical interference issues and have different light distribution characteristics than other lighting. LEDs, can have flicker problems, different lumen outputs and color quality than incandescent bulbs so researching LED models is important when replacing older inefficient lighting

Movements are increasing in Maine and around the country to adopt dark sky-friendly lighting ordinances and to put limits on the correlated color temperature of LED installations. Brunswick is one municipality where the Planning Board is reviewing new standards. Challenges in the adoption of new ordinances include dealing with preexisting installations, and the question of how far we want to go in residential lighting regulation. Burgess noted sometimes this discussion can seem as academic "until it's your neighbor's light shining all night into your bedroom window." The same applies to tower or other industrial lighting destroying local neighborhoods or viewsheds. No matter what local standards are adopted, Burgess stated a robust public education program will need to accompany it. He encouraged the audience to educate themselves about their communities' lighting ordinances and become involved in changing them if deficient.

There are five simple principals that should guide each of us in our individual use of outdoor lighting: 1) light only what needs to be lit; 2) only when it's needed; 3) no brighter than necessary; 4) with a lamp CCT of 3,000 degrees Kelvin or less; and with a fully-shielded cut off fixture that directs the light downward.

For more information please feel free to contact the author and speaker at: rburgess250@comcast.net.

2019 Accomplishments and Preliminary Financials

Media
- Print: (Over 12), Archaeology, Presumpscot River CWA, BIW, Habitat Assessment Project, Education, Speaker Series, the Bay, Outings, etc.

Volunteers
- Approximately 3073 volunteer hours (384 days)
- 85 volunteers

Membership
- 450 households
- Speaker Series – (308 people)
- Outside 2019 (Paddle Series, Walks, etc.) – 130 people.
- Newsletters – 3

Grants
- $5,000- Education
- $3,000-Water Quality Monitoring
- $25,000-Vegetation Mapping & Habitat Assessment

Outreach Presentations
- Maine Maritime Museum Cruises (80 participants)

Education
- One Bay Day (160 students, 3 different schools) (Spring Bay day weathered out)
- School Visits (312 students)
- Non-School Visits (450 people): library, summer series and science night
- Web site updates

Conservation and Stewardship
- Additional easements in progress
- Continuous landowner outreach
- Ongoing stewardship activities
- Control one phragmites stand in Bowdoinham
- Monitor all easement & fee properties
- Initiate Centers Pt. protection/acquisition efforts

Research
- Water Quality Monitoring – 17 sites
- Dresden Falls Archaeology Radiocarbon Dating
- 10-year Vegetation and Land Use Update Completed
- Compile Historic Altered River Flow Research

Advocacy (postings, letters, testimony, etc.)
- Submit/ testify Lower Androscoggin Upgrade
- Lawsuit-GMO Atlantic salmon ongoing
- Healthy Rivers/Healthy Gulf promoting safe fish passage
- Smart Meters-On request: submit amicus brief for PA ratepayers with no opt outs
- Climate Change-Green New Deal
- Various National Efforts-National Environmental Policy Act, Ocean Plastics, ESA, etc.
- Posting Fish Consumption Advisories
- Presumpscot R. CWA-FERC & DEP Comments & Legal
- CMP Chops Tower Lighting
- Union River fish passage

Primary Partners:

The Archaeological Conservancy
Kennebec Reborn
Avian Haven
Maine Coalition to Stop Smart Meters
Quebec Labrador Foundation
Maine Historic Preservation Commission
Bowdoin College Environmental Studies
Department of Inland Fisheries and Wildlife
Maine Maritime Museum
Department of Marine Resources
Bowdoinham Public Library
Maine Land Trust Network
Friends of Sebago Lake
Department of Environmental Protection
Patagonia Outlet, Freeport
Chop Point School
Curtis Memorial Library
Green Justice Legal
Downeast Salmon Federation
Earthjustice
Center for Food Safety

Abbreviated Financials

As usual, FOMB members get a huge bang for your financial support. Thanks in large part to active volunteer participation, cautious spending and excellence in leveraging external support, our administrative expenses remain low and accomplishments high. Technically, while we await year-end reporting from the Calvert Social Investment Fund where we have some assets invested, this report remains “preliminary” but we expect no substantive changes to our bottom line when that reporting is received. Thank you all for your continued support!

Respectfully submitted,

Vance Stephenson - Treasurer

Income $98,600	Expenses $69,300
Grants 33%	Programs 90%
Membership 21%	Administration 7%
Annual Appeal 15%	Membership & Fundraising 3%
Other 31%	

Released Back into the Environment: On the Road to a Blue Future

Travelling to the Canadian Maritimes and to the nation's capital, interviewing directors of research institutes and retired scientists alike, or plunging into decades-old library archive records, these are just some of the many tasks I carried out in searching for a cohesive picture on the effects of hydropower damming…

But before we delve into this wonderful journey of an experience, a little about me: I graduated with a B.Sc. in Biology from McGill University in the summer of 2018 with a focus on ecology. It was during those years my curiosity to understand the interlinkage between different strata of the natural world blossomed. Throughout my degree and afterwards, as a research assistant, I studied how streams, rivers, and wetlands of Uganda were being affected by climate change. The numerous facets exhibited in these ecosystems that are responding to or will soon respond negatively to global changes are often cascading in nature and truly worrisome, to say the least. In the end, I needed more experience and I wanted that experience to come from a different world, one that I knew. I began perusing my online network looking for opportunities in Montreal that lined up with my interests: the changing landscape of water, climate change, and assessing environmental impacts. This led me to an internship hosted by the Quebec-Labrador Foundation that partnered with Friends of Merrymeeting Bay and Friends of Sebago Lake to research and compile information on the effects of unnatural freshwater flows.

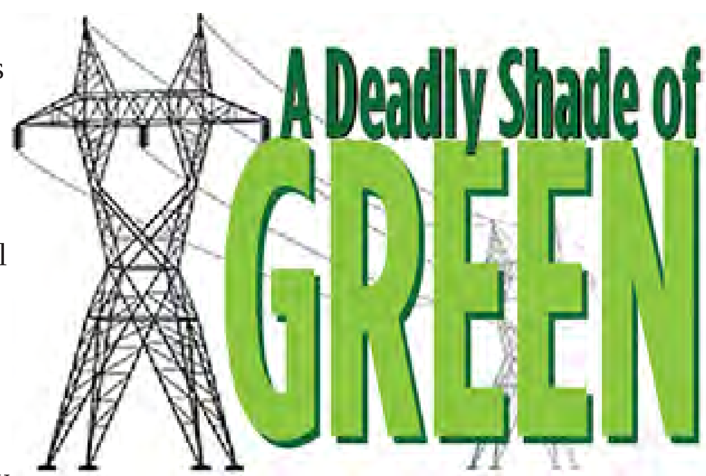
Photo: Hydro Quebec

I began the internship going through records, documents, and files sent to me as background information. Two names were oft mentioned: Hans Neu and Michael A. Rozengurt. Both men were senior scientists who rallied against a blind eye often turned by government regulators and other scientists, to the negative effects of large hydropower reservoirs including the selective releasing of stored, stagnant water back into the environment. In the case of the former, Neu worked in Canadian federally funded research institutions since emigrating from Germany after World War II due to the rising political divide at home. Hans Neu, an oceanographer proved to be the more prolific of the two (Rozengurt emigrated from the U.S.S.R. to the U.S. as an expatriate fisheries biologist), and the more outspoken. He would speak to the press, sometimes much to his detriment, and often felt muzzled by higher-ups. His story fascinated me; a man inside the highest-level research organizations who couldn't be less like the bureaucratic dogma perpetuated by these organizations—speaking out for the good of our environmental future. My way through to understanding hydropower became through Dr. Hans Neu, but both distinguished scientists were remarkably prescient on hydro's widespread ecological effects .

Both long since deceased, I tracked down former colleagues of Neu who reside in Nova Scotia and who might be able to speak to his character and work. Nova Scotia also hosts some of the most cutting-edge marine biology and oceanographic research in the world. I took advantage of this fact to interview anyone willing to speak with me in these fields. It would be in Nova Scotia I would learn about historical obstructions, such as how the oil and gas industry would fund environmental research, or now, having experiences relayed to me about what the cost of government administrations cutting critical scientific research does to generational morale (in part because of the research funding source shift from public to private). It was also there that I gathered a sentiment among researchers, industry professionals, and professors alike, (often funded by oil, gas and electrical interests) that hydropower operations are not significantly thought of to be detrimental to the environment. Even after visiting one of the largest historical research libraries in Ottawa, the NRC National Science Library, and reading about hydropower project research there, the sentiment persists.

Quite often, hydropower and other large corporations attempt to mask the detrimental side of their operations through prolific philanthropy. Big hydro is expert at integrating itself into communities and regional subconscious by providing resources beyond that of just energy. Last year alone, Hydro-Quebec contributed many millions of dollars to institutions considered pillars of society. Even though corporate philanthropy need not have ulterior motives, one needs to be acutely aware of funding sources and whether explicit or implicit expectations, quid pro quo or research bias are a result.

As with most complex subject matter of this scale, one can find yourself threading a biased narrative because convincing material is present on both sides; therefore, the only solution is a careful and critical education: you can find the historical displacement of indigenous people from their land angering; the diminishing of groundwater tables and land erosion frightening; increasing fragmentation and reduction of fisheries threatening; the disruption of natural nutrient cycling and greenhouse gas emissions from reservoirs dangerous and industry funding of science influencing research outcomes. However, we cannot forget hydropower is sometimes the only energy source powering entire communities, and until truly green alternatives are developed and utilized, may remain the only viable option.



What is the solution, you may ask? In the end, after all the research, the interviews, the internal processing, the solutions are the same as they always have been for environmental issues: meaningful policy, regulation, enforcemental awareness, conservation and innovation. Hydropower is a monolithic institution, not going anywhere quickly, but some adverse effects can be mitigated; for instance more ecological flow regimes, minimal cultural and wildlife displacement, mandatory fish passage and limits to the number of dams on rivers. In the course of my internship I spoke with a UNESCO chair on the matter who recently helped pass a global methodology and policy through the International Panel on Climate Change (IPCC) requiring that every country must report how much greenhouse gases are emitted from their reservoirs. What gives me hope, are the scientists like him, Dr. Neu, Dr. Rozengurt and others around the world who fight for our future.

You can read more about the material I have found by visiting FOMB's website Cybrary and looking up Unnatural Freshwater Flow Project in the Miscellaneous section.

Kiran Yendamuri

From the Chair

CMP's new 240' towers at the Chops Kennebec crossing dramatically violate the Merrymeeting Bay night sky viewshed with their excessive and as it turns out, unneeded lighting. TRC, CMP's project consultant, picked an off the shelf "solution" to a problem that doesn't exist, and was initiated and completed with wanton disregard for locals and the environment. Not surprisingly, there is tremendous financial incentive for CMP to "build big", and with as much "gold plate" as possible. This emblematic local project represents in many ways, the recent wholesale dismantling of our national environmental laws whether National Environmental Policy, Clean Water, Clean Air, or Endangered Species Acts.

In recent decades, increasingly severe ecological, astronomical and aesthetic problems from night sky light pollution have spawned an international movement to restore and protect our dark skies (see cover story and https://www.darksky.org/). Surface lights and internet satellite lighting and radiofrequencies are hampering worldwide astronomical observations. See an excellent animation of the expected 57,000 new orbiting satellites planned for the next nine years at www.mainecoalitiontostopsmartmeters.org.

An aircraft detection lighting system able to activate tower lights only when an aircraft approaches within range is being considered as an alternative for the Chops and while essentially eliminating the light issues, could substantially worsen human and wildlife health effects. Using active and powerful Doppler radar (CMP is proposing the Harrier system made by DeTect), likely in the 175 watt range (smart meters and cell phones are 1-2 watts) and able to detect aircraft 24 miles away, these systems blanket the area with microwave radiofrequency radiation, often harmful to people and causing adverse behavioral changes to birds, bats, insects and other wildlife. In fact, radar is sometimes used to deter birds from wind turbines that could kill them or from high use aircraft areas where they might cause an accident. Maybe Merrymeeting Bay needs fewer insects and birds?

A common suite of adverse health conditions including tinnitus, fatigue, loss of cognitive ability, headache and cardiac arrhythmia became known as "microwave sickness" (often now referred to as electromagnetic sensitivity) because of their association with workers involved in the early development of radar and exposed to non-ionizing radiofrequency radiation (RFR). These biological responses became the basis for eastern European exposure guidelines far more (100X) protective than those of western countries, based only on tissue heating. Many current precautionary guidelines suggest limits 1,000 times less than obsolete and irrelevant U.S. FCC guidelines. Just a week before press time, two lawsuits were filed against the FCC for their arbitrary and capricious actions in disregarding thousands of peer reviewed studies to the contrary, when deciding current RFR exposure guidelines promulgated in 1996, based on post WWII data, were still sufficient to provide safety. Filings are posted at www.maincoalitiontostopsmartmeters.org .

Radiofrequency radiation was classified as a possible human carcinogen by the World Health Organization in 2011. The NIH National Toxicology Program in a 10 year 30 million dollar study recently found *clear evidence* (their most definitive category) of heart tumors from whole body exposure to low level RFR, *some evidence* (next category down) of brain and adrenal gland tumors and DNA damage in multiple organs. For a densely populated area also rich in wildlife, 24/7 radar pollution is a particularly ludicrous idea, particularly when unneeded.

There has been a misperception that structures over 200' above ground level (AGL) require lighting to deter aircraft. Our multiple legal analyses show this is wrong. According to federal regulation (14 CFR § 77.17 a. 2.), structures 200' or more within 3 miles of the center of an airport with runway at least 3,200' are obstructions to air navigation. Obstruction height thresholds increase 100' for each mile further from the airport up to 499' above which every structure is considered an obstacle. Wiscasset at 5 miles being the closest qualifying airport, the Chops towers would need to be 400' AGL to be considered obstacles and subject to FAA lighting and marking recommendations. Contrary to popular opinion, these towers, even unlit, are not obstructions to air navigation.

Fortunately, the simplest and easiest solution, just turning tower lights off, provides the most satisfactory outcome at the least cost and with the most rapid relief. We have requested CMP extinguish the lights and issue a Notice to Airmen (NOTAM) of unlit towers and wire crossing at these coordinates, at least pending resolution of a FAA Marking and Lighting Study which is probably required to back out of their current situation. Understand the old towers were unlit for 80 years of higher volumne air traffic and the wires were unmarked. Now, the larger towers are easier to see and wires marked with FAA approved large colored spheres.

Unfortunately, because utilities receive a guaranteed rate of return (annualized 10-14%) on investment, CMP has an incentive rather than disincentive, for costly solutions. High costs of lighting and radar are recovered with interest, through rate hikes and paid by us all. Follow the money. This alone is probably an excellent reason to support Representative Berry's idea of state owned transmission (and I'd add, considering river health, generation) facilities.

Far more detailed citations and exhibits on this issue can be found in a CMP section near the top of our web home page at www.fomb.org and later probably migrating to our Advocacy section of the Cybrary.

In 2019 we continued our outstanding education efforts with children and adults, received radiocarbon dates of 6-8,000 years before present from pine and oak charcoal recovered in our Dresden Falls archaeology work, built more partnerships towards our goal to lock in as minimum, current water quality on the Lower Androscoggin through reclassification and initiated efforts to protect the single largest parcel of unprotected and undeveloped land on the Bay, Centers Pt. in Bowdoinham.

Just as CMP's actions at the Chops (and many would add statewide) are a metaphor for national environmental assaults, so too is FOMB's advocacy on this issue; saving our night sky, protecting our health and wildlife and saving ratepayer money; representative of essential work thousands of local, regional and national groups of concerned citizens are actively engaged in. More often than not, we are standing up as in this case, and speaking out against false choices. Without a great Steering Committee and fantastic membership, we would be nothing. Thank you all so much.

Respectfully submitted, Ed Friedman, Chair

We Need You! Please Support Our Important Work

FOMB Leadership

Our accomplishments are due to the hard work of dedicated volunteers, especially those who serve on our committees. If you want to get involved and serve, please contact the committee chair or Ed Friedman. We always welcome member input and we'd love for you to join us!

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Membership Levels

☐ $1,000+ Sturgeon
☐ $750 American Eel
☐ $500 Wild Salmon
☐ $250 Striped Bass
☐ $100 Shad
☐ $50 Alewife
☐ $20 Smelt
☐ Other

Name

Address

Town/State/Zip

Phone

Email

☐ $7 Enclosed (optional) for a copy of *Conservation Options: A Guide for Maine Land Owners* [$5 for book, $2 for postage].

☐ Renewal
☐ New Member
☐ Send information about volunteer opportunities
☐ I would like a sticker

Thanks to Rebecca Bowes for newsletter layout.

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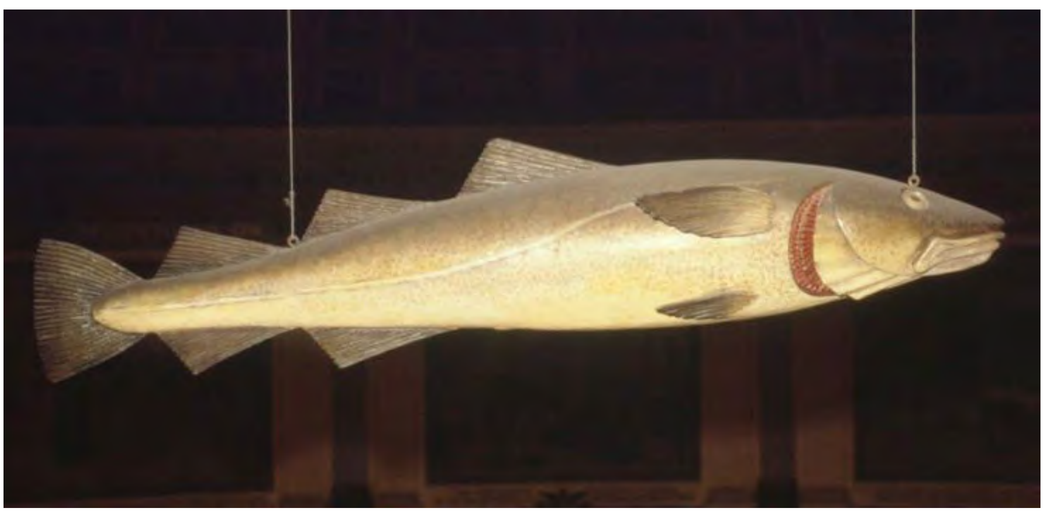
The "Sacred" Cod Moves to the New State House



On January 11, 1798, the Massachusetts (including, until 1820, today's Maine) legislature paraded solemnly from the Old State House to its quarters in a new building at the top of Beacon Hill. Designed by Boston-born architect Charles Bulfinch, the elegant new State House was tangible evidence of the Commonwealth's growing prosperity. The men who governed Massachusetts were thinking of the state's promising future, but they brought with them a symbol of the past. They carried a four-foot, eleven-inch wooden fish wrapped in an American flag. This "Sacred" Cod had hung in the Old State House, and it hangs in the new one to this very day. There is no better symbol of how much Massachusetts owes both its survival and its success to the humble cod fish.

The Massachusetts Senate has a "Holy" mackerel incorporated in its chandelier to compete with the "Sacred" Cod in the House of Representatives. (masshumanities.org).