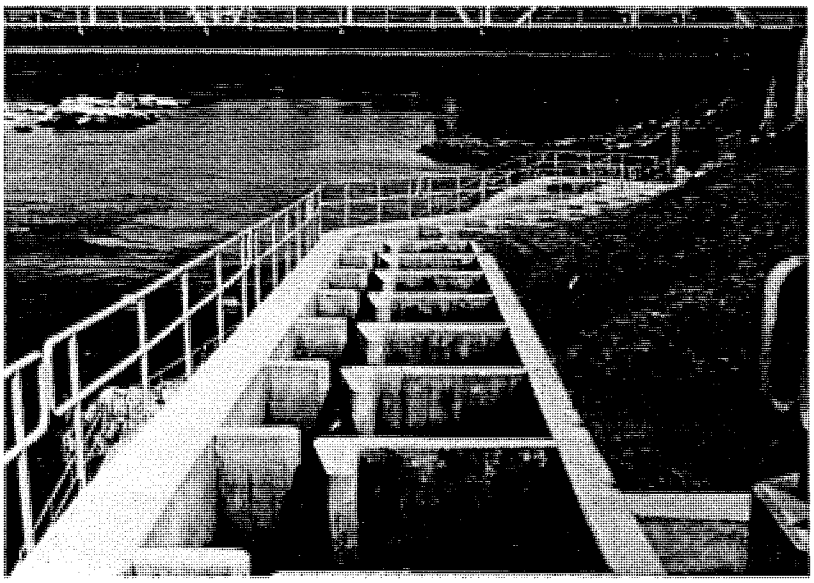
State of Maine

Department of Marine Resources

2004 Brunswick Fishway Report



Maine Department of Marine Resources
Stock Enhancement Division
#21 State House Station
Augusta, ME 04333-0021

March 2005

ANADROMOUS FISH RESTORATION IN THE ANDROSCOGGIN RIVER WATERSHED

2004 Report on the Operation of the Brunswick Fishway FERC #2284

Maine Department of Marine Resources
Stock Enhancement Division
#21 State House Station
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INTRODUCTION

The Androscoggin River, with a drainage area of approximately 3,460 square miles, is Maine's third largest watershed. Historically, the Androscoggin provided access to a large and diverse aquatic habitat and supported great numbers of diadromous and resident fish species. For most species, the natural upstream migration barrier on the main stem of the Androscoggin River was Lewiston Falls, 22 river miles above tidewater. Although Lewiston Falls was an impassable barrier for most species, sea-run Atlantic salmon and American eel were able to ascend these falls and move upstream to Rumford, 80 river miles above tidewater. Rumford Falls was an impassable barrier to migrating salmon and excluded them from the New Hampshire waters of the Androscoggin River.

River herring were known to reproduce in lake and pond habitat throughout the Androscoggin and Little Androscoggin River watersheds below Lewiston Falls, while American shad reproduced in the riverine areas below Lewiston Falls. Atlantic salmon, which could ascend the earliest built low head dams at Brunswick, were caught at Lewiston as late as 1815; however, river herring and American shad were excluded from waters above Brunswick after 1807, when the first dam was built at head-of-tide. The Little Androscoggin River, which enters the main stem Androscoggin on the west bank just below Lewiston Falls, was noted for large runs of diadromous fish. Sea-run fish ascended this major tributary to Biscoe Falls, 35 miles above the river's confluence with the main stem Androscoggin. By the early 1930s, the construction of dams that lacked fish passage capabilities, in combination with severely polluted waters, virtually eliminated all opportunity for fish to live and reproduce in the main stem Androscoggin and most of its tributaries.

Since the early 1970s, substantial improvement in water quality and the provision of fish passage at some of the dams have enhanced the potential for successful fish restoration within the lower Androscoggin River watershed. In 1982, the Brunswick vertical slot fishway and downstream fish passage were constructed at the first upstream dam on the river. In 1987, an upstream fish lift and downstream passage were provided at the Pejepscot Project, the second upstream dam on the river; in 1988, an

upstream fish lift and downstream passage were installed at the Worumbo Project, the third upstream dam on the river. Effective upstream fish passage at these three hydropower projects could potentially provide access for diadromous and resident species as far upstream as Lewiston Falls.

The restoration of native diadromous fish species to the Androscoggin River watershed has multiple benefits to the ecosystem and society. American shad and river herring provide important forage to other fish and wildlife species in both inland and coastal ecosystems. Restoring species to healthy habitat will allow individuals to utilize this valuable resource for recreational as well as commercial uses. The Androscoggin system has the potential to produce an annual sustained yield of 1,000,000 pounds of alewives and 500,000 pounds of American shad, valued at $132,000 and $206,000 respectively. The reestablishment of large runs of alewives and American shad could provide employment for a number of commercial fishermen, and large recreational fisheries for American shad could develop in the lower Androscoggin River. The 1,000,000-pound alewife harvest will increase long-term average statewide landings by 33% and provide a substantial source of bait for Maine's 6,700 licensed lobster fishermen. Efforts toward improved water quality, habitat, and fish and wildlife populations improve the overall health of the ecosystem and society.

The Maine Department of Marine Resources (DMR) provides an annual report on the operation of the Brunswick fishway to enhance its cooperative partnership with FPL Energy Maine Hydro LLC (FPLE) in the operation of the fishway and in assisting the company meet its FERC reporting requirements. DMR's report is based upon daily data, records, and logs that are maintained by DMR biologists at the fishway. This includes information regarding daily inspections, fishway cleaning and condition, fisheries data collection, and operational activities throughout the season (typically May through October). The operation of the Brunswick fishway is one tool that is utilized in the implementation of the DMR fishery restoration program for the Androscoggin River. The goals and objectives of this program, along with any additional information not specifically associated with the actual operation of the fishway, are included in this report as a courtesy to provide FERC and FPLE with a broader perspective of the

purpose, role, and usefulness of the fishway in the DMR program. Several legal authorities and state and federal plans that guide state restoration programs include:

Legal Authorities

- Fish and Wildlife Coordination Act
- Federal Power Act
- Fish and Wildlife Act of 1956
- Federal Aid in Fish Restoration Act (Dingell-Johnson Act)
- Anadromous Fish Conservation Act
- Title 12 M.R.S.A. §6021, §6022, §6051, §6052, §7701, §7702
- Title 38 M.R.S.A. §630-636

Guidance Documents

- Fishery Management Report No. 35 of the Atlantic States Marine Fisheries Commission - Amendment 1 to the Interstate Fishery Management Plan for Shad and River Herring, April 1999.
- Maine Department of Marine Resources: State of Maine Recovery Plan for American Shad (*Alosa sapidissima*) and River Herring (*Alosa pseuodoharengus* and *Alosa aestivalis*) for Amendment 1 to the Interstate Fishery Management Plan for Shad and River Herring, May 1999.
- Maine Department of Marine Resources: American Shad Management Plan.
- State of Maine Statewide River Fisheries Management Plan, 1982.

- State of Maine Anadromous Alewife Restoration Program – A Report to the Joint Standing Committee on Inland Fisheries and Wildlife. Prepared by the Maine Department of Inland Fisheries and Wildlife and Maine Department of Marine Resources. February 1998.

GOAL AND OBJECTIVES OF THE RESTORATION PROGRAM

The State of Maine's Department of Marine Resources Fishery Restoration Program goal is to increase ecosystem health in the Androscoggin River watershed by restoring native diadromous fish species and their habitats. The primary focus is to restore river herring (alewives and blueback herring) and American shad to historic habitat areas in the Androscoggin and Little Androscoggin River watersheds, while increasing the restoration potential for other native fish species.

Objective 1: Increase the abundance, survival, and natural reproduction of pre-spawning adult river herring and American shad in historic spawning and nursery habitats.

Strategies:

1. Trap upstream migrating adults at the Brunswick fishway and distribute them into upstream habitats that are inaccessible due to the obstruction of passage by dams.
2. Conduct supplemental releases of adult American shad and river herring from other tributaries when necessary.
3. Conduct American shad fry stocking to increase juvenile abundance in nursery habitats.

Objective 2: Protect and enhance the health of the native fish community structure in support of river herring and American shad restoration efforts.

Strategies to characterize and assess the fish community structure:

1. Monitor and facilitate up- and downstream movement of native diadromous and resident fish species into historic habitat by the operation of the Brunswick fishway.
2. Collect biological data on all fish species captured at the Brunswick fishway.
3. Collect fish community data during the juvenile river herring surveys conducted upstream in Sabattus Pond and the lower Androscoggin River.

Objective 3: Characterize the annual migration of adult river herring and American shad in the Androscoggin River watershed.

Strategies:

1. Assess the timing and magnitude and collect biological data from pre-spawning adult river herring and American shad captured at the Brunswick fishway.
2. Assess the timing and magnitude of the adult American shad migration upstream to the Brunswick fishway by conducting visual observations, underwater monitoring, and radio telemetry studies.

Objective 4: Assess the reproductive success of adult and productivity of juvenile alosids in the watershed.

Strategies:

1. Evaluate the juvenile river herring growth and emigration timing, habitat parameters, and fish community in Sabattus Pond, located in the upper Androscoggin River.
2. Evaluate juvenile alosid abundance and growth in the lower river by sampling at the Brunswick fishway and selected areas in the lower reaches of the Androscoggin River.

Objective 5: Increase the access to historic habitat for native diadromous and resident fish species to increase natural reproduction abundance, and survival.

Strategies:

1. Provide oversight, review, and comments on required fish passage operation and downstream effectiveness study plans at hydropower dams.
2. Identify ineffective fish passage and the potential causes by conducting studies, collecting visual observations, and utilizing underwater monitoring data.
3. Provide effective up- and downstream passage for native diadromous fish species at dams currently without passage through the FERC process and non-regulatory partnerships.

Objective 6: Increase public awareness of the Androscoggin River program in order to encourage participation and support in river restoration initiatives.

Strategies:

1. Conduct outreach activities such as providing presentations on the program to public and scientific audiences.
2. Participate in the development and activities of the Androscoggin River Watershed Council.

2004 BRUNSWICK FISHWAY MAINTENANCE AND OPERATION

- DMR met with the Brunswick dam owner, FPLE, in the spring of 2004 to review Brunswick Station operations, safety procedures, problems occurring with the fishway, and maintenance issues that remained from the fall 2003 season that required resolution prior to the startup of the fishway in May 2004.

- The fishway was officially opened for its 22nd consecutive season on May 7, 2004.

- Prior to the 2004 season, FPLE serviced the existing fish hoist. The foot valve was inspected and the electric motor that operates the hopper lift was recalibrated to provide the desirable lift height. In addition, FPLE supplied a 100-pound oxygen tank to provide oxygen to two overhead fish distribution tanks. This system allowed DMR personnel to increase the number of alewives held in the tanks prior to distribution. Supplemental oxygen was used to aerate water when Atlantic salmon and American shad were also held in the overhead tanks.

- Prior to opening the fishway for the season the lower section of the fishway was drained and debris was cleared from the diffusion grating and the diffusion pool. The diffusion chamber grates and baffles were in good condition and did not need to be replaced.

- Stop logs were inspected in the lower six pools of the fishway prior to fishway operation. The lower six pools of the fishway were modified by FPLE to create a pool and weir fishway to improve American shad passage in November 2001. A ten-inch stop log was removed from each of the weirs located at the entrances of pools 3 and 5. On May 25, 2004 an additional 6-inch stop log was removed from pool 5.

- Two sections of grating were replaced in the fish trap. The lower sections of the grating had corroded and rusted to the point where fish were escaping from the trap,

- As in 2001-2003, one of the four wheels of the fish crowder remained missing. In 2001, a piece of pipe was welded onto the crowder in place of the wheel assembly. This modification worked fine throughout this season, but should be checked routinely. An assessment of the reasons why this keeps occurring should be conducted before a serious malfunction preventing daily use of the crowder occurs. The fish crowder is vital to the trap and truck stocking operation being conducted from the Brunswick fishway.

- A large amount of debris was present in the river and, as a result, on the fishway exit trash racks, throughout the season. On three occasions the fishway was totally dewatered by accumulated debris. Gulf Island was contacted on four occasions to rake the fishway exit racks and restore flow to the fishway. FPLE personnel arrived within two hours and restored flow. The Fish Attraction Water Grating (FAWG) was cleaned on four occasions by FPLE personnel to provide the proper attraction flow at the fishway entrance.

- The Fish Attraction Valve (FAV) and the FAWG which are responsible for providing the appropriate amount of attraction water at the fishway entrance were not operating properly for the last six weeks the fishway operated. The valve that controls flow to the diffusion chamber was damaged in mid-September and had to be left in the open position. During this period the grating could not be cleaned and entrained air became an issue in the diffusion chamber possibly limiting the numbers of Atlantic salmon ascending the fishway in the fall.

- The Fish Passage Weir Hoist (FPWH) which controls the jet velocity at the fishway entrance malfunctioned in late August. The FPWH was inoperable from August 24, to October 27, 2004 when the fishway closed for the season. This is the third year out of four that the FPWH has failed to provide the appropriate jet velocities at the fishway entrance for extended periods of time. Maintaining appropriate attraction flows and jet velocities at the fishway entrance is important for attracting fish to the fishway entrance and eventually passing them upstream.

Recommendations:

Debris clogging the FAWG is a problem that occurs annually, and its affect on providing appropriate attraction flow to the fishway entrance could be minimized with a regular maintenance schedule. A trash boom may also help prevent the accumulation of trash on the grate especially at low headpond levels. In the past, a trash boom has been used to prevent debris from entering the fishway. The past two years the trash boom has not been deployed.

As the fishway starts to age additional attention needs to be paid to the mechanical parts of the fishway. The FPWH controls the water velocity at the fishway entrance and provides the appropriate velocity for attracting fish to the fishway entrance in relation to the amount of water in the fishway and tidal stage. The reliability of this mechanism presents is an annual problem. The brass bushing that is used while lifting and lowering the gate wears out quickly and prevents the gate from tracking properly. Three of the last four years the FPWH has not worked during extended periods during the American shad and Atlantic salmon runs. A spare bushing should be available as a replacement for the one currently being used. The FPWH is important to attracting fish to the fishway and providing the proper flow at the fishway entrance.

FPLE has agreed to address these recommendations and is currently implementing a maintenance schedule for the 2005 season.

FISH PASSAGE

River Herring:

One of the statewide goals of the Maine Department of Marine Resources is to restore self-sustaining populations of river herring to their historic range. One benefit is the restoration of native anadromous fish species to the Androscoggin River. A second benefit is that with the reestablishment of river herring populations to Maine rivers, adult broodstock become available for restoration purposes in other Maine river systems. Since 1983, DMR personnel have distributed over 925,000 adult river herring captured at the Brunswick fishway into otherwise inaccessible habitat on the Androscoggin and Little Androscoggin Rivers.

The maintenance crew of FLPE opened the Brunswick fishway on May 7, 2004; MDMR personnel staffed the fishway beginning May 7. River herring were observed at the fishway from May 9 through June 16. A total of 113,686 river herring were captured at the Brunswick fishway in 2004, establishing a new record. The run peaked May 15 through May 20 when 78,659 river herring were captured. On 17 days the number of adults captured exceeded 1,000 fish and on four days the number of fish exceeded 10,000 fish (Table 1).

Table 1. Adult river herring captured, water temperature and river flow at the Brunswick fishway, 2004

Date	Number	Water Temp. (C)	River Flow (cfs)	Cumulative Number	% Total Run
11-May	1,749	9.1	5,150	1,749	1.54%
12-May	1,885	13.1	4,170	3,634	3.20%
13-May	2,524	15.5	5,820	6,158	5.42%
15-May	17,486	14.8	4,000	23,644	20.80%
16-May	8,608	16.1	3,900	32,252	28.37%
17-May	15,256	16.2	4,450	47,508	41.79%
18-May	11,822	16.5	4,680	59,330	52.19%
19-May	17,037	16.2	4,850	76,367	67.17%
20-May	8,450	16.9	4,620	84,817	74.61%
21-May	1,850	17.3	4,770	86,667	76.23%
22-May	4,793	17.9	4,690	91,460	80.45%
23-May	3,360	16.5	4,730	94,820	83.41%
24-May	1,358	16.3	5,360	96,178	84.60%
25-May	3,310	15.4	6,140	99,488	87.51%
26-May	932	15.1	8,970	100,420	88.33%
27-May	232	14.8	9,910	100,652	88.54%
28-May	705	15.5	9,340	101,357	89.16%
31-May	275	14.3	6,720	101,632	89.40%
1-Jun	160	14.5	6,310	101,792	89.54%
2-Jun	469	13.0	4,700	102,261	89.95%
3-Jun	136	13.0	5,620	102,397	90.07%
10-Jun	250		3,050	102,647	90.29%
11-Jun	5,631	17.4	2,840	108,278	95.24%
12-Jun	3,962	18.7	1,870	112,240	98.73%
13-Jun	1,425	18.2	1,830	113,665	99.98%
14-Jun	12	17.8	2,750	113,677	99.99%
15-Jun	5	19.1	2,700	113,682	100.00%
16-Jun	4	19.2	2,680	113,686	100.00%
Total/Mean	**113,686**	**15.9**	**4,879**		

The number of river herring trapped during the 2004 season ranked the best out of the 22 seasons the fishway has been in operation (Table 2). The total number of river herring captured in 2004 exceeded the 22-year average of 42,065 (Figure1).

Table 2. Adult river herring habitat availability, number captured and distribution in Androscoggin River Watershed lakes and ponds, 1985 – 2004

Year	Habitat* (hectares)	Run Size	Total Number Stocked (Androscoggin and Kennebec)	Mean Fish / Hectare
1982	723	0	2,326	1.3
1983	1,328	601	6,305	4.2
1984	1,328	2,650	8,359	2.6
1985	3,377	23,895	37,773	11.2
1986	2,678	35,471	17,763	6.6
1987	770	63,523	11,892	15.4
1988	887	74,341	13,183	14.9
1989	887	100,895	13,814	15.6
1990	887	95,574	11,725	13.2
1991	887	77,511	13,574	15.3
1992	887	45,050	12,351	13.9
1993	722	5,202	7,448	10.3
1994	887	19,190	14,549	16.4
1995	852	32,002	10,591	12.4
1996	747	10,198	14,288	19.1
1997	612	5,540	11,524	18.8
1998	1,299	25,189	20,805	16.0
1999	1,318	8,909	8,671	6.6
2000	1,318	9,551	20,414	15.5
2001	1,846	18,196	23,459	12.7
2002	1,846	104,520	23,290	12.6
2003	1,846	53,732	20,392	11.0
2004	1,846	113,686	20,668	11.0

* Habitat area does not include the Brunswick headpond.

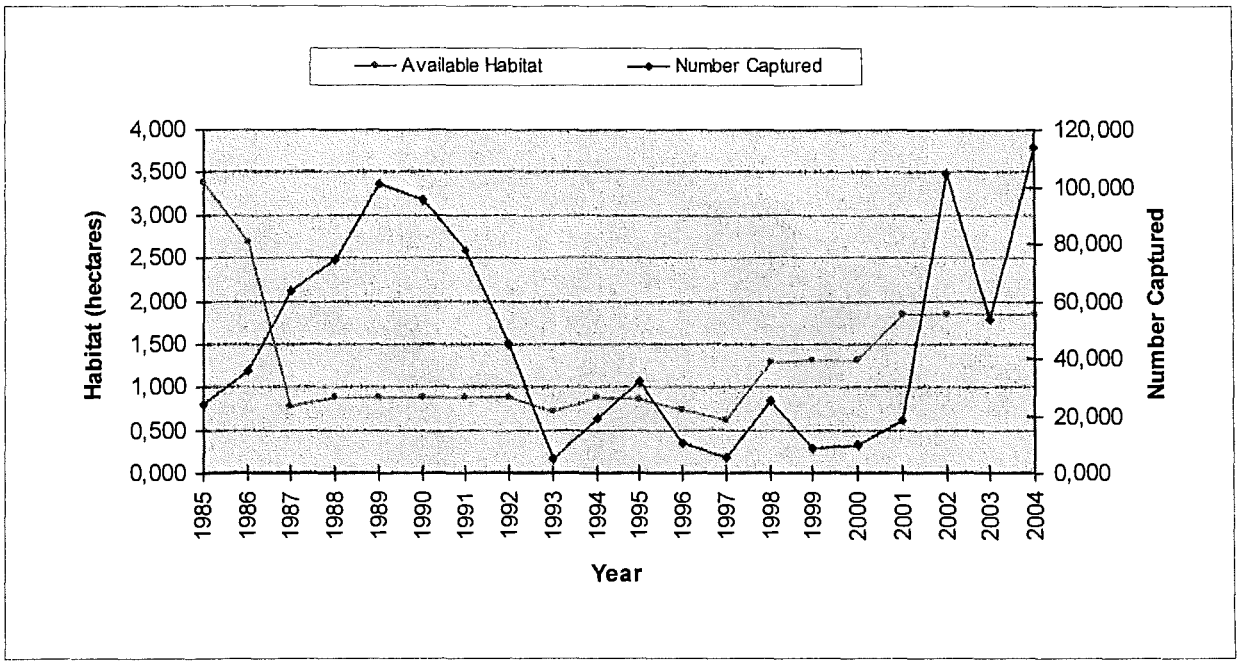


Figure 1. Adult river herring captured vs. habitat availability in the Androscoggin River Watershed, 1985-2004

The timely arrival and number of Androscoggin River adults captured for transport and release was greater than the amount of upstream spawning and nursery habitat presently available for restoration. The adult release target for the Androscoggin Watershed was 27,358 river herring into 1,846 hectares of upstream habitat available (Tables 3-4).

Table 3. Adult river herring stocking densities, 2002-2004*

Habitat	Hectares	2002 Densities (fish/hectares)	2003 Densities (fish/hectares)	2004 Densities (fish/hectares)
Sabattus Pond	723	14.8	14.8	14.0
Little Sabattus Pond	10	-	20.0	17.2
Taylor Pond	253	15.0	14.8	14.5
Taylor Brook	5	40.0	20.0	11.8
Tripp Pond	-	-	-	-
Lower Range Pond	117	15.0	14.9	14.1
Androscoggin River	-	-	-	-
Sabattus River	111	18.0	18.0	28.0
Marshall Pond	41	22.4	14.9	15.1
Bog Brook	24	16.6	28.8	28.8
Durham Boat Ramp	-	-	-	-
Loon Pond	28	-	-	-
No Name Pond	40	-	15.0	15.0
Sutherland Pond	21	24.6	-	-
Mean		**15.7**	**17.9**	**17.6**
Total	**1,373**			

Table 4. Adult river herring distribution in the Androscoggin Watershed by site, 2002-2004

Source: Androscoggin / Kennebec

Habitat	2002	2003	2004
Sabattus Pond	0 / 10,695	10,700 / 0	10,090 / 0
Little Sabattus Pond	-	200 / 0	172 / 0
Taylor Pond	1,477 / 3,018	3,750 / 0	3,672 / 0
Taylor Brook	0 / 200	100 / 0	59 / 0
Tripp Pond	-	-	-
Lower Range Pond	0 / 3,104	1,740 / 0	1,654 / 0
Androscoggin River	100,361	29,420 / 0	86,354 / 0
Sabattus River	0 / 2,000	2,000 / 0	3,112 / 0
Marshall Pond	0 / 1,881	612 / 0	619 / 0
Bog Brook	0 / 399	690 / 0	690 / 0
Durham Boat Ramp	-	-	-
Loon Pond/Curtis Stream	-	-	-
Sutherland Pond/Curtis Stream	516 / 0	-	-
No Name Pond	-	600 / 0	600 / 0
TOTAL	**102,354 / 21,297 = 123,651**	**49,812 / 0 = 49,812**	**107,022 / 0 = 107,022**
Brunswick Headpond (passed upstream)	100,361 / 0	29,420 / 0	86,354 / 0
TOTAL PASSED OR STOCKED IN THE WATERSHED	**102,354 / 21,297 = 123,651**	**49,812 / 0 = 49,812**	**107,022 / 0 = 107,022**

Of the 113,686 adults captured, 20,668 were transported upstream; 86,354 were released into the Brunswick headpond; 174 were sacrificed for biological samples; 243 were transport or fishway mortalities; and 6,247 were transported out of basin to stock additional habitats. Due to the timely run on the Androscoggin, and the certainty that there would be an adequate number of returning river herring to the Androscoggin River, the Kennebec River was not utilized as a source of pre-spawn river herring. In the past, the goal was to compensate for any Androscoggin River deficiency by releasing additional Kennebec River fish into historic spawning habitat on the Androscoggin and Little Androscoggin Rivers. As the season progressed, it became obvious that the number of river herring returning to the Androscoggin River would be sufficient and that transfers from the Kennebec would not be needed.

River herring were trapped at the Brunswick fishway beginning May 11, 2004 at a water temperature of 9.1°C and river flow of 5,150(cfs) and trapping ended on June 16, at a water temperature of 19.2°C and water flow of 2,680(cfs). The run size fluctuated widely

throughout the season, exhibiting days when large numbers of river herring would arrive at the trap. During the run, the water temperature ranged between 9.1°C and 19.2°C, averaging 15.9°C (Figure 2). The river flows ranged between 1,830(cfs) and 9,910(cfs), averaging 4,879(cfs) (Figure 3).

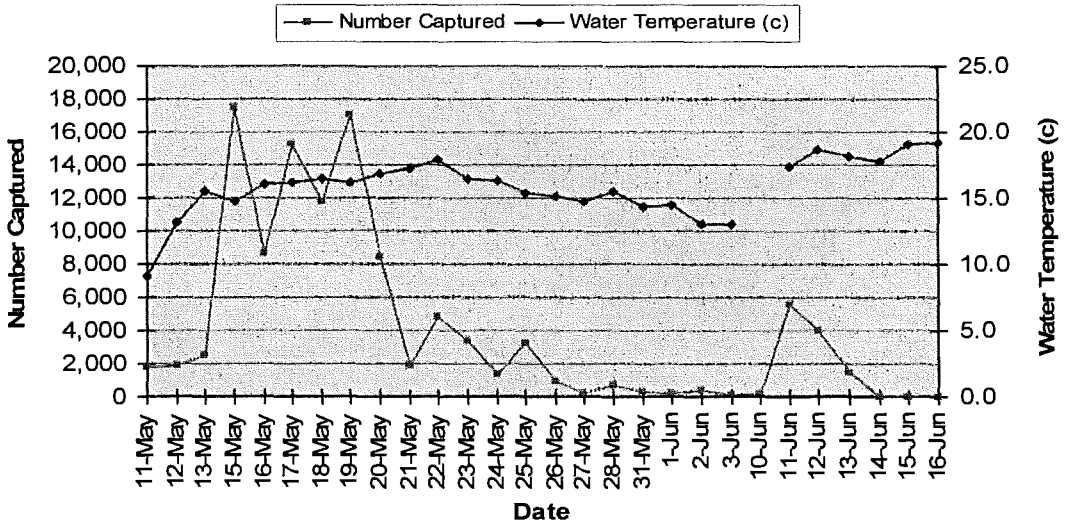


Figure 2. Number of adult river herring captured vs. water temperature at the Brunswick fishway, May - June 2004

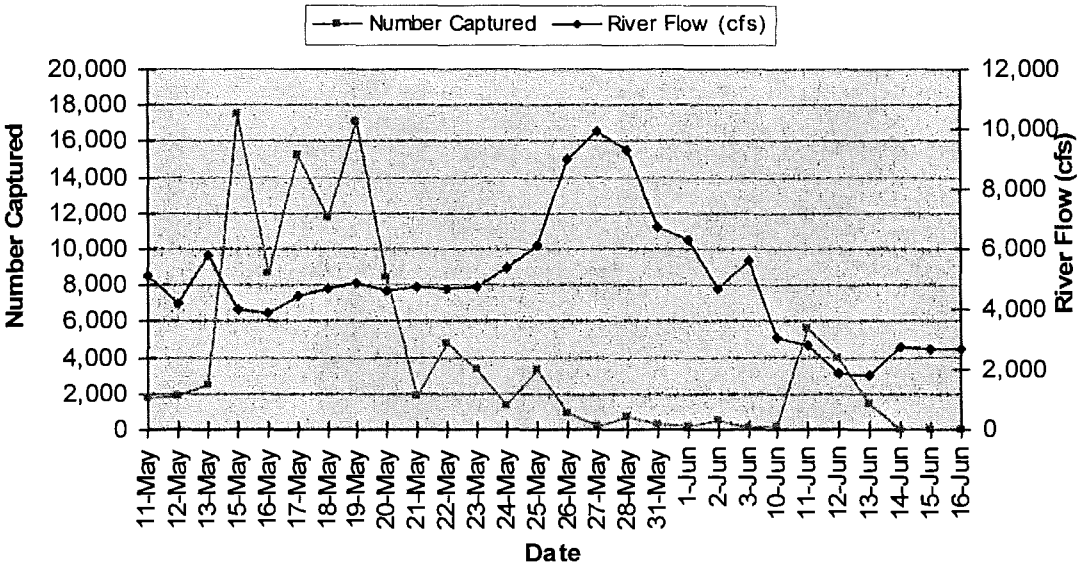


Figure 3. Number of adult river herring captured vs. river flow at the Brunswick fishway, May - June 2004

Alewives trapped at the Brunswick fishway were sampled on four different occasions. Of the individuals sampled, 40% were female, while 60% were male. Females averaged 248mm fork length and weighed on average 197g. Males averaged 240mm fork length and weighed 166g (Table 5).

Table 5. Adult river herring sampled at the Brunswick fishway, 2004

Date	Sex	Number	Mean Total Length(mm)	Mean Fork Length(mm)	Mean Weight(g)
5/15/2004	Female	18	288	254	210
	Male	32	278	245	184
5/20/2004	Female	23	284	251	194
	Male	27	270	238	166
6/1/2004	Female	18	276	242	176
	Male	33	269	238	156
6/13/2004	Female	10	268	237	153
	Male	13	263	233	145

	Total Number	Mean Total Length(mm)	Mean Fork Length(mm)	Mean Weight (g)
Female	69	281	248	187
Male	105	272	240	166
Combined	174	276	243	174

During the past three years, average lengths and weights of pre-spawn alewives have been consistent from year to year, showing very little variation within sex. Also, the proportion of females to males caught during the 2001 - 2003 river herring run were consistent between years. In 2004 the ratio of males to females was 1.5:1, higher than the past three years. The mean lengths for both sexes also decreased compared to previous years.

All alewives sampled at the fishway are aged as part of the sampling protocol. The majority of the alewives captured at the Brunswick fishway were 4-year olds (68.0%) and are likely spawning for the first time (Table 6). A significant number of alewives also returned as 5-year olds, 28.0% of the run. The increased numbers of 5-year old fish in the 2003 and 2004 samples likely indicate a significant number of pre-spawn adult

alewives stocked in the watershed in 2002 and 2003 were able to successfully migrate downstream during high water events in June 2002 and 2003. In comparison, sample results from 2002 indicate only 9% of the 2002 alewife run were 5-year old fish. Total alewife return numbers are expected to increase in 2005 as the proportion of repeat spawners returning to the fishway increase.

Table 6. Ages of adult river herring sampled at the Brunswick fishway in 2004

	Number	Mean TL (mm)	Mean FL (mm)	Mean Wt (g)	%M	%F	%U	% of Sample
Age 3 Alewives	4	259	229	146	75%	25%	0%	2.00%
Males	3	252	222	133				
Females	1	274	234	156				
Age 4 Alewives	118	271	239	164	63%	37%	0%	67.80%
Males	74	269	237	159				
Females	44	276	243	172				
Age 5 Alewives	49	284	251	198	56%	44%	0%	28.20%
Males	27	281	248	184				
Females	22	291	256	213				
Age 6 Alewives	3	302	270	241	33%	67%	0%	2.00%
Males	1	290	265	213				
Females	2	298	268	231				
All Ages	174	276	243	174	60%	40%	0%	100.00%
Males	105	272	240	166				
Females	69	281	248	137				

There are several factors that can influence the adult river herring capture rates at the fishway. A few include environmental conditions affecting the size of any given year class of returning adults, temperature, river flows, operational activities of the hydropower facility, effectiveness of the fishway, and the number of adults released to reproduce in upstream spawning habitat four to five years earlier. Adult river herring returning to the Androscoggin River are predominantly four years old when they are captured.

American Shad:

American shad captured at the fishway are passed upstream into the headpond to continue their upstream migration. Fish lifts at the next two upstream dams provide passage that allows shad to potentially migrate to Auburn, although the effectiveness of these lifts has not been evaluated. Production potential of the habitat within the range is estimated to be 2.3 adult shad per 100 square yards of water surface area. The shad habitat area of 10,217,391 square yards in the Androscoggin could result in a return of 235,000 adult shad annually. To increase the abundance, survival, and natural reproduction of adults, Merrimack or Connecticut River pre-spawn shad are obtained through a cooperative agreement with the Connecticut River American Shad Technical Advisory Committee (CRSTAC). These fish are released into spawning and nursery areas in the Androscoggin River at Auburn.

Observed Shad:

Visual observations of adult shad at the Brunswick fishway during the spawning run have been noted periodically since the beginning of the restoration program. Detailed visual observations from the fishway walk were continued during the 2004 sample season. Selected pools (pools 0-6, 14, 23, 31, river) were monitored for 30-second intervals to standardize observations between individual pools and the river. All observations were made between 11:00 AM and 12:00 PM. Visual observations from the walkway were conducted on 61 consecutive days beginning June 1 and continuing through July 31. In 2004, a total of 412 adult shad were observed, 333 in June and 79 in July, an increase over total the number of behavioral observations recorded in 2003 (229) (Table 7).

Table 7. American shad observations at the Brunswick fishway, 2004

Year / Month	Viewing Windows	Upper Fishway	Lower Fishway	Corner Pool	Outside Fishway	Total Number	Mean Water Temp. (C)
2004 May	0	0	0	0	0	0	15.1
June	0	0	244	7	82	333	18.3
July	0	0	38	0	41	79	22.2
August	0	0	0	0	0	0	22.7

The water temperature when the shad were observed averaged 18.3°C in June (Figure 4). The river flow ranged between 1,640(cfs) and 6,540(cfs) in June (average of 3,220 cfs) (Figure 5). In July, a total of 79 shad were observed in the lower half of the fishway and the river. The water temperature when the shad were observed averaged 22.2°C in July. The river flow ranged between 1,890(cfs) and 2,913(cfs) in July (average of 4,130cfs). No shad were observed in either May or August.

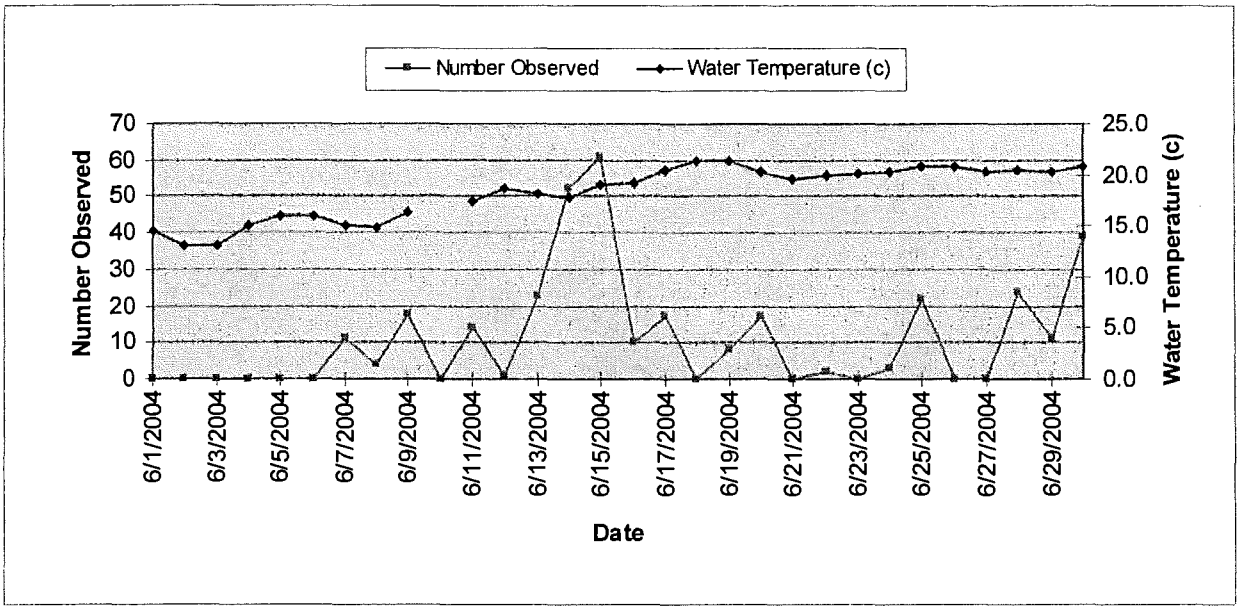


Figure 4. Number of American shad observed vs. water temperature (C) at the Brunswick fishway June 2004

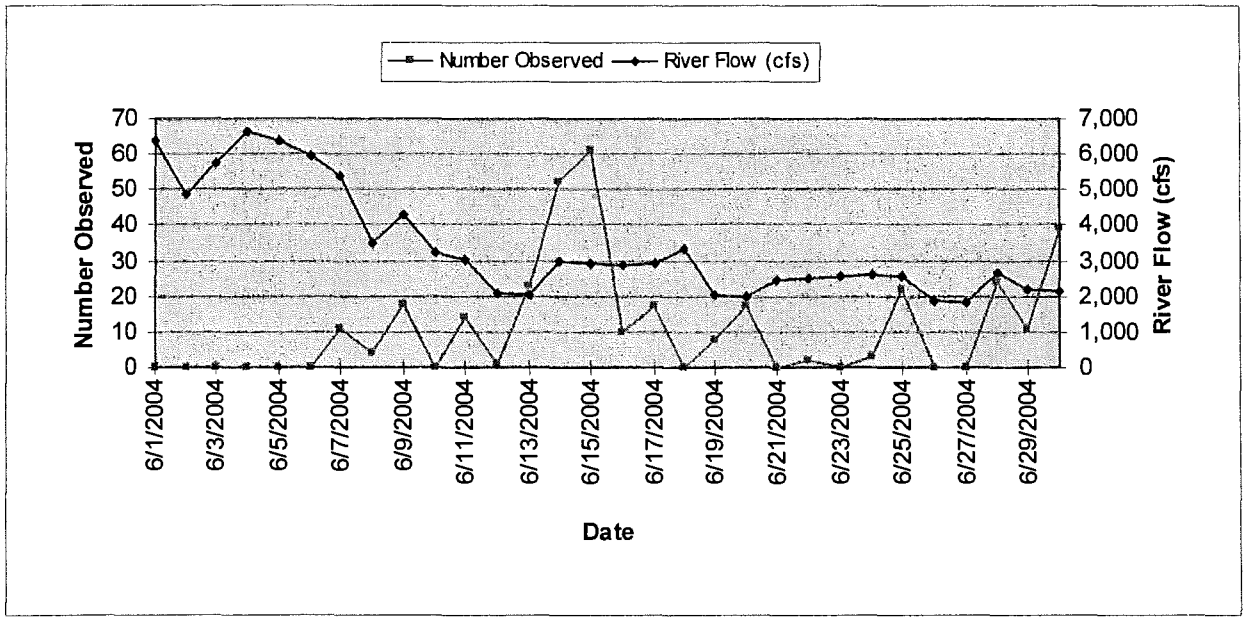


Figure 5. Number of American shad observed vs. river flow (cfs) at the Brunswick fishway June 2004

Shad outside the fishway entrance were usually swimming up- and downstream along the concrete wall in a school. In the corner pool, they were usually holding a single position in a school or circling, but not moving up- or downstream. Shad were rarely observed in the upper fishway. During the second week of June, shad were observed attempting to pass upstream and downstream over the weirs in the lower section of the fishway. These observations were independent of the daily shad observations made throughout the shad run. Shad appeared to have difficulty passing over these weirs, either upstream or downstream, during periods of low fishway flows throughout the migration. In the past during periods of high to moderate flow shad were observed passing over these weirs, although none were observed in 2004.

Captured Shad:

In 2004, the number of American shad captured at the Brunswick fishway declined from highs of 87 and 88 captured during 1999 and 2000 respectively. A total of twelve adults were captured between June 13 and July 23 (Table 8). The decrease in the number of trapped adults was expected based upon the number of pre-spawn adults passed upstream in 1999 (Table 9).

Table 8. American Shad captured at the Brunswick fishway, 2004

Date	Number	Water Temperature (c)	River Flow (cfs)
6/13/2004	2	18.2	1830
6/14/2004	1	17.8	2750
6/15/2004	5	19.1	2700
6/20/2004	1	20.3	1810
6/26/2004	1	20.9	1700
7/6/2004	1	21.8	2180
7/23/2004	1	23.6	3540
Total Number	**12**		
Mean		**20**	**2,359**
Min / Max	**1 / 5**	**17.9 / 23.5**	**1,890 / 3,720**

Table 9. Adult American shad distribution in main stem Androscoggin River at Auburn, 1985-2004

Year	Number Distributed	Source			Mortality During Transport
		Androscoggin	Connecticut	Merrimack	
2004	929	12	-	917	1.3%
2003	421	7	-	418	11.0%
2002	278	11	-	267	2.8%
2001	26	26	-	-	N/A
2000	88	88	-	-	N/A
1999	357	88	270	-	10.6%
1998	5	5	-	-	N/A
1997	221	2	219	-	13.0%
1996	312	2	310	-	37.8%
1995	1,090	3	1,087	-	9.8%
1994	707	1	706	-	38.0%
1993	580	1	579	-	20.0%
1992	566	-	566	-	15.0%
1991	357	-	357	-	31.0%
1990	354	1	353	-	21.0%
1989	414	-	414	-	25.5%
1988	513	-	513	-	1.2%
1987	92	-	-	92	11.0%
1986	224	-	-	224	17.00%
1985	115	-	-	115	35.80%
Total	**7,649**	**247**	**5,374**	**2,033**	**17.8%**

Biological data were collected on all shad captured in 2004, including length and sex (Table 10). Scales were also collected for age determination and fin clips were collected for genetic analysis when additional funding becomes available for this study.

Table 10. Age, length and sex of American shad sampled at the Brunswick fishway in 2004.

	Number	Mean TL (mm)	Mean FL (mm)	Mean Wt (kg)	%M	%F	%U	% of Sample
Age 3 Shad	*	*	*	*	*	*	*	*
Age 4 Shad	4	457	414	*	75	25	0	34.0%
Age 5 Shad	7	467	422	*	71	29	0	58.0%
Age 6 Shad	1	560	495	*	0	100	0	8.0%
Age 7 Shad	*	*	*	*	*	*	*	*
Age 8 Shad	*	*	*	*	*	*	*	*
Age 9 Shad	*	*	*	*	*	*	*	*
Age 10 Shad	*	*	*	*	*	*	*	*
Undermined	*	*	*	*	*	*	*	*

In 2004, all adult shad trapped at the Brunswick fishway were released into the main stem river between Brunswick and Auburn. The largest number of shad captured at the Brunswick fishway occurred June 15, with a mean water temperature of 19.1°C and a mean daily flow of 2,700(cfs) (Figures 6-7).

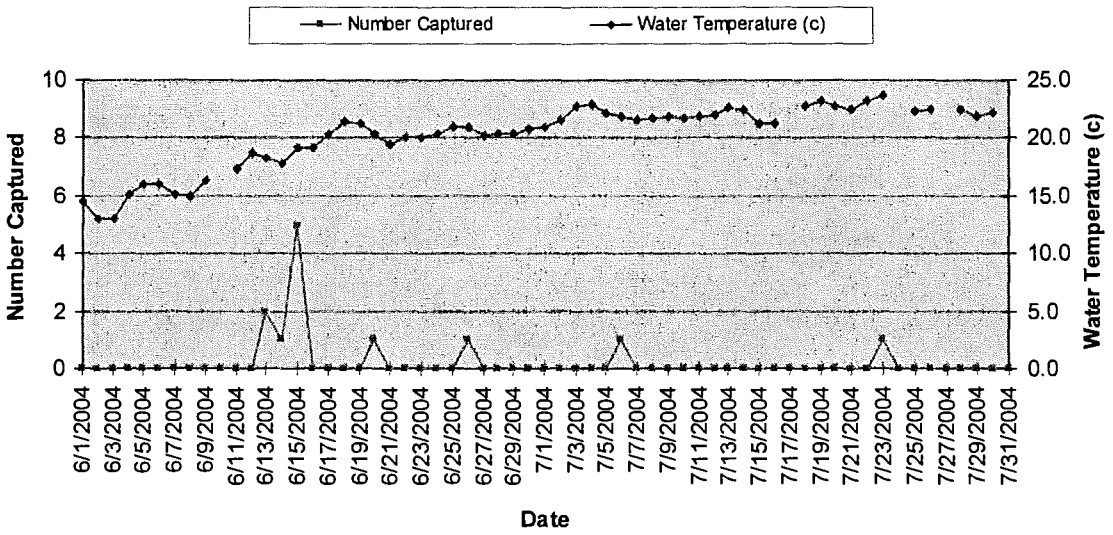


Figure 6. Adult American shad captured at the Brunswick fishway vs. water temperature June - July 2004

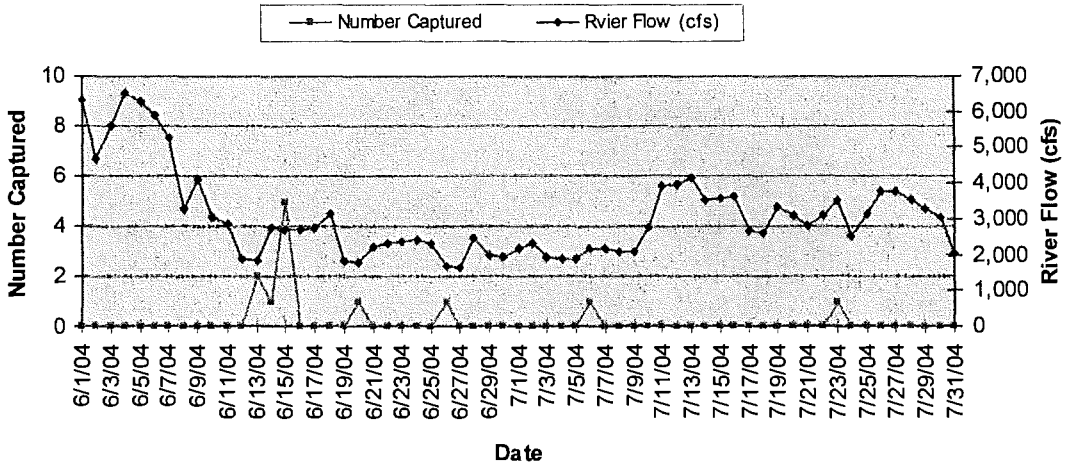


Figure 7. Adult American shad captured at the Brunswick fishway vs. river flow June - July 2004

Shad passed above the Brunswick dam into the headpond have the ability to migrate as far upstream as Lewiston-Auburn. The fish lift at Pejepscot, the next hydropower dam upstream, was monitored during the shad run to determine if shad were using the lift to migrate upstream. The fish lifts at both Pejepscot and Worumbo are automated, lifting once every two hours from 8:00 A.M. through 4:00 P.M. daily. No American shad were observed passing into the Pejepscot headpond during the 2004 season. Worumbo hydropower personnel monitor upstream passage at the Worumbo site daily while the fish lift is in operation. Similar to Pejepscot, a control gate is used to trap fish in the upstream passage canal until personnel open the upstream gate. All fish passing upstream are identified by species and counted. An annual report of fish passage activities recorded at Worumbo will be prepared and presented at an annual meeting of Miller Hydro and MDMR in March 2005.

The condition of the shad varied, but all had at least some scale loss on the sides of the body. In general, the condition of these shad reverted to those observed in previous years. Hemorrhaging around the mouth and head, common during the 1999 - 2001 seasons, were again observed in 2003-2004. This may be a result of the amount of time shad are spending in the fishway. The vertical slots in the lower six pools were

increased in width from 11 inches to 26 inches to improve upstream passage (Figures 8-9).

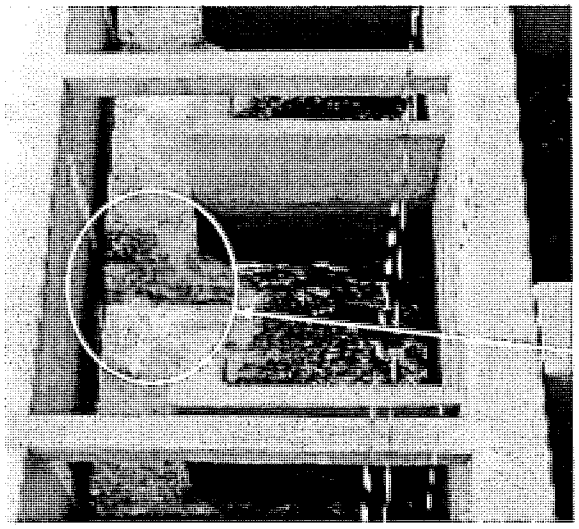


Figure 8. Modifications made by FPLE to increase the slot width and modify flow in the lower section (pools 1-6) of the Brunswick fishway to improve upstream shad passage.

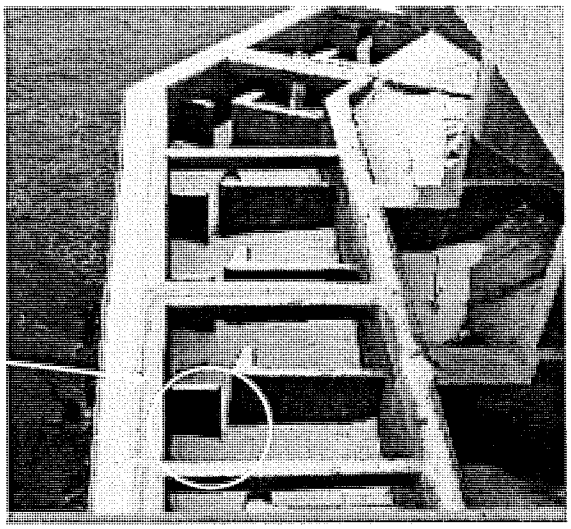


Figure 9. Existing fishway slot widths prior to modification by FPLE in November 2001.

In 2004, 58 juvenile shad were sampled from the fish trap at the Brunswick fishway (Table 11). Only a limited number of juvenile shad captured at the fishway in 2004 were retained for otolith analysis. An additional 77 shad were identified and passed downstream while project personnel collected juvenile river herring samples. Capturing juvenile shad and river herring at the fishway is difficult due to the 1.5-nch bar spacing in the grating that make-up the trap. A large proportion of all juvenile fish passing downstream pass undetected through the trap, downstream bypass, or the turbines. The shad samples will be analyzed later this winter to determine the number of hatchery raised fish vs. the number of wild shad emigrating from the system. An additional 22 shad were collected from the fishway when the fishway was closed for the season. These fish were used to train project personnel in otolith extraction and analysis. Six of the nine study fish sampled (67%) were hatchery origin shad. The remaining twelve shad still need to be examined.

Table 11. Juvenile American shad sampled at Brunswick fishway - 2004

Date	Number	Mean Total Length(mm)	Mean Fork Length (mm)	Mean Weight(g)	Water Temp (c)	River Flow (cfs)
24-Aug	1	79	67	3.1	21.4	4,530
25-Aug	2	93	83	5.8	21.4	4,130
26-Aug	1	73	65	3.0	21.2	3,210
1-Sep	31	86	76	5.0	22.0	4,160
2-Sep	23	88	79	5.5	21.5	5,310

The DMR considers collection of this data essential for the effective management of this species and participates as a member of the Atlantic States Marine Fisheries Commission, in which specific fishery independent monitoring programs for American shad are conducted.

Transported & Released Shad:

A statewide objective of the DMR is to restore self-sustaining populations of American shad to their historic range. A primary benefit of restoring shad to several rivers in Maine is that adult broodstock are available from several nearby Gulf of Maine sources and can be utilized for restoration purposes in other Maine rivers.

The number of pre-spawn adult shad currently captured in the trap at Brunswick is inadequate for a successful restoration program. To increase the abundance, survival, and natural reproduction of adults, Connecticut River or Merrimack River pre-spawn shad are obtained through a cooperative agreement with the Connecticut River American Shad Technical Advisory Committee (CRSTAC) and the State of New Hampshire. Previously, these fish were released into spawning and nursery areas in the Androscoggin River at Auburn. After a two-year absence, the adult pre-spawn stocking program was resumed in 2002. A total of 267 adult American shad were transported from the Merrimack River and stocked into the Androscoggin River at Durham. Adult transfers from the Merrimack River increased to 917 in 2004, up from 418 in 2003. In addition, pre-spawn adults were transported to the Waldoboro Hatchery where the shad were spawned in specialized tanks. The eggs were collected from the spawning tanks

and the fry were reared on site prior to release. Once the shad fry were treated with oxytetracycline (OTC) to mark their otoliths and differentiate them from naturally reproduced shad, they were released into the Androscoggin below Lewiston Falls.

In 1999, the first American shad fry were released into the Androscoggin River. These were reared at the Waldoboro Hatchery and released on June 30 into the main stem at the Auburn boat launch. The 280,000 fry were 10 - 17 days old and consisted of Connecticut River and Connecticut River/Saco River stock in origin. In 2000, American shad fry stocking occurred for the second time in as many years. The 529,000 fry raised at the Waldoboro Hatchery for release into the Androscoggin River originated from Connecticut/Kennebec River stock. Fry were stocked July 10 and were 7-10 days old at the time of release. Fry stocking continued on the Androscoggin from 2001 through 2004. In 2004, 538,613 fry 7-10 days old were released at the Durham boat launch. The fry were of Merrimack River origin and released as a group on July 7, 2004 (Table 12).

Table 12. American shad fry released into the main stem Androscoggin River at Auburn, 1999-2004

Date	Source	Number Released	Age	% Mortality	Loading Site Temp.(C)	Receiving Site Temp. (C)	Marking Method
07/07/04	Merrimack	538,613	7 to10 days old	~0.0%	20.9	22.0	Tetra-cycline*
6/30/2003	Merrimack	748,586	6 - 8 days old	~0.0%	20.0	22.0	Tetra-cycline*
7/1/2003	Merrimack	521,256	6 - 8 days old	~0.0%	19.6	23.0	Tetra-cycline*
7/2/2003	Merrimack	806,527	6 - 8 days old	~0.5%	19.3	25.0	Tetra-cycline*
7/17/2002	Merrimack	295,725	10 - 17 days old	~1%	18.5	23.2	Tetra-cycline*

In 2003 record production at the Waldoboro Shad Hatchery produced excess fry that allowed increased stocking rates for the Androscoggin River. In 2004, the number of fry produced was approximately 6-million compared to 11-million the previous year. The number of fry allocated to the Androscoggin was reduced in relation to hatchery production. All fry received a tetracycline mark prior to release to distinguish them from wild origin adult returns. In the fall, juvenile shad migrating downstream were collected while sampling at the Brunswick fishway to determine if they originated from the fry

stocking or the natural reproduction of the 917 pre-spawn adults transported from the Merrimack River, in addition to the 12 Androscoggin River shad passed above the Brunswick dam. The results of this study, and a similar study being conducted on the Kennebec, will be used to analyze the success of fry stocking in these rivers.

2004 American Shad Study:

In 2004, six underwater video cameras were installed to observe American shad behavior, movement and numbers in the fishway. One camera was placed in the river to record shad behavior outside the fishway. The other five cameras were placed in the fishway entrance, Pool 1, Pool 6, Pool 23 entrance and Pool 23 exit. A time-lapse video recorder began recording at 6A.M. and stopped recording at 6P.M. each day, beginning June 6 and ending July 25. In 2004, approximately 3,456 hours of video were recorded using the six cameras. Project personnel have not reviewed all the videotape collected in the fishway and the river adjacent to the fishway. Video data from 2003 and 2004 are currently being reviewed and hoped to be finished by April 2004. Based on preliminary data the number of behaviors observed in 2004 will likely be higher than 2003. Unfortunately, the types of behaviors displayed by shad remain the same despite several modifications to the lower six pools of the fishway. Shad continue to enter the fishway but are unwilling to ascend further than pool six in appreciable numbers. While turbine unit 1, the turbine closest to the fishway, is operating we observe upstream behavior toward the fishway entrance while shad swim downstream, away from the fishway entrance when unit 1 is off. As the shad enter the fishway, holding and circling behaviors become predominant. Final analysis may or may not indicate slight improvements or lead to further modifications that may improve upstream passage.

Clearly, as with any study, visual observations of shad made from the fishway wall and through the use of video equipment have certain limitations that are considered when analyzing the data, such as the potential for overestimating (same fish counted more than once) or underestimating (limited visibility when looking down into the fishway/water) the number of fish actually present. The purpose of collecting this preliminary data was to first determine if there is a need to conduct more quantifiable studies that would require substantially more funds, staff, and equipment. Preliminary

data clearly indicates the need for a quantitative study to focus on the numbers of fish in the river and the effectiveness of the Brunswick fishway in relation to American shad passage on the Androscoggin River.

Radio Tagging Study:

During the past three years, FPLE, DMR, and the NMFS have conducted a limited radio telemetry study to better understand the behaviors American shad display at the Brunswick fishway. This study was designed to complement visual observations and the underwater video camera study currently being conducted at the fishway and ultimately be used to improve upstream passage for American shad. Due to the high cost of radio telemetry studies, predominately the cost of tags, only a small number of shad were tagged and tracked during the last three years, ten each in 2002 & 2003 and 20 tags in 2004. FPLE contributed eight radio receivers and an aerial antenna, and provided technical support in setting up the equipment. DMR and NMFS provided the tags, tagged the shad, and monitored project progress.

Lotek radio receivers and radio tags were used for this study. The tags were internal MCFT-3BM microprocessor coded transmitter tags with a 12-inch external antenna. The tags had a pulse rate of one second and a battery life of approximately 67 days. The dimensions of the tag body were 11mm x 42mm. Two types of antennas were used for this project. A Yagi aerial antenna was placed at the entrance to the fishway and monitored shad movements into and out of the fishway entrance. Dropper antennas, made from shielded copper wire, were used in individual pools to monitor passage through the fishway pools and in the river adjacent to the fishway. The antenna configuration and receiver setup were similar for all three years of the study.

Radio telemetry equipment used during the 2004 American shad study was deployed June 1 and calibrated and tested on June 3. The gain settings on the radio receivers were calibrated to avoid more than one receiver logging data from the same tag during the same time. By adjusting the receiver gains, we were able to define the coverage areas easily. Coverage outside the fishway was limited to an area 6m from the location of the river camera location and coverage at the fishway entrance was restricted to

4.5m in front of the fishway entrance (Figures 10 - 11). Antennas located in the fishway pools were calibrated to pick up radio signals only in their respective pools.

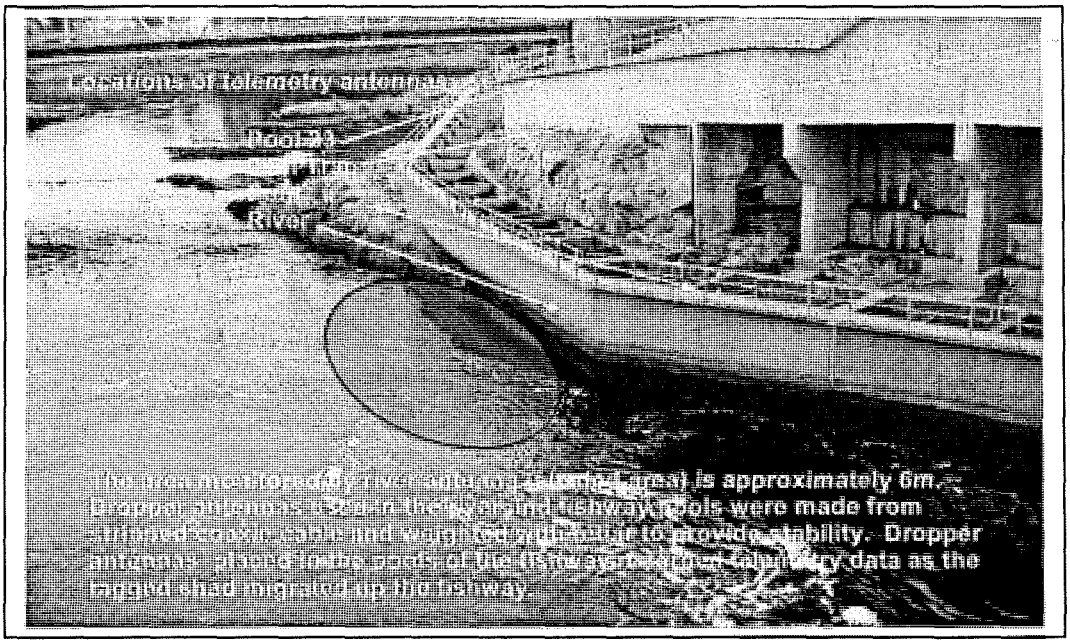


Figure 10. Antenna and reception layout of the telemetry equipment deployed at the Brunswick fishway during the 2004 American shad study.

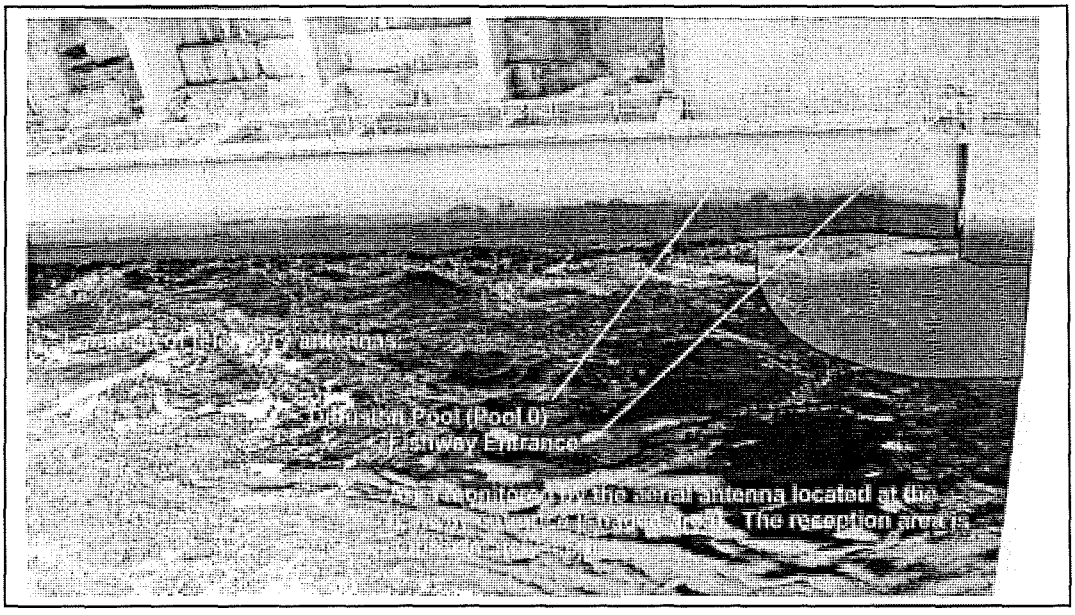


Figure 11. Location of antennas in the lower section of the Brunswick fishway, 2004

Beginning June 24, the first three American shad were captured, tagged, and released into the Brunswick tailrace. The internal tags were inserted into the stomach using a plastic tube inserted into the mouth and down the esophagus. On June 25, one additional shad was tagged and released. Eleven shad were released June 28 and five on June 30 in the same manner described above. A total of 20 shad were tagged and released over a seven day period. Biological data were not collected from any of the study fish in order to reduce the amount of time the shad were out of water and minimize handling stress. Immediately after a shad was tagged and released, tag data transmitted from the tag was received and recorded by the nearest antenna/radio receiver combination. Tagging was conducted in the area immediately adjacent to the antenna located in the river. Each tag was coded so that individual fish could be tracked and differentiated from one another during the study. Tag numbers for this study ranged from 104-123 and were recorded as such by the radio receivers.

Table 13. Summary of radio telemetry data collected during the 2004 Brunswick fishway passage study

Date	Number Tagged	Tag Number	Number of days data were recorded	Number of attempts into Pool 0	Number of attempts into Pool 6	Number of attempts into Pool 23
6/24/2004	3	105	1	0	0	0
		106	1	0	0	0
		107	1	0	0	0
6/25/2004	1	104	1	0	0	0
6/28/2004	11	108	8	29	1	0
		109	1	0	0	0
		110	7	31	2	1
		111	1	0	0	0
		112	3	0	0	0
		113	10	0	0	0
		119	1	0	0	0
		120	1	0	0	0
		121	1	0	0	0
		122	1	0	0	0
		123	1	0	0	0
6/30/2004	5	114	5	58	5	0
		115	1	0	0	0
		116	1	0	0	0
		117	1	0	0	0
		118	2	0	0	0
	Total		**49**	**118**	**8**	**1**

Fifteen of the 20 tagged shad spent little time in the study area, less than three days. The majority of these shad dropped out of the study area within an hour of being tagged. Five of the study fish spent large blocks of time in the study area (Table 13). Shad #113, spent ten days in the study area. Shad #108, spent eight days in the study area. The duration of time spent in the study area by the remaining shad ranged from three to seven days.

In general, three of the tagged shad that spent significant time in the study area made several attempts to enter and progress through the fishway. All shad that spent more than one day in the study area routinely passed within 4.5m of the fishway entrance as they circled in the tailrace, being picked up by both the river antenna and the fishway entrance antenna. The shad were often absent from the study area at night, leaving between 6 and 8P.M. and returning to the study area between 4 and 6A.M. This was consistent with the radio telemetry data collected in 2003. One shad, #110 spent a significant amount of time in the tailrace during the night and the early morning hours. Shad #114 attempted to climb the fishway at least 58 times during the five days it was in the study area. This fish reached pool 6 on five occasions but never progressed to pool 23, halfway up the fishway. Similar data were collected for shad #108 and #110, which ascended to pool six on 1 and 2 occasions respectively. During the study, it was common for them to disappear for 1 - 2 hours at a time before being picked up again by a receiving unit and on a few occasions the shad would leave the study area for days before returning. None of the tagged shad were observed visually or caught at the top of the fishway in the fish trap.

Each of the tagged shad spending more than two days in the study area displayed unique types of behavior during the relatively short time we were able to track them (Figures 12 - 15). Shad #108, would enter the study area early in the day and progress through the fishway, reaching pool 6 in the early afternoon. During the late afternoon and early evening the shad would return to the river but spend less time within range of the river antenna. Shad #113 was rarely in the study area during mid-day. This fish would arrive early in the morning, disappear, and then return to the study area in the late evening. It is unclear where any of the shad went when they were not in the tailrace

of the hydropower station. Compared to the majority of the tagged shad, shad #114 spent little time in the tailrace. This fish spent a larger proportion of its time in the fishway, especially pool six. This was the most persistent fish we observed in terms of the number of attempts to progress through the fishway, at least 58 times during the five days it was in the study area. This total may be higher, but we were unable to split out behavior recorded within the one-minute continuous time-out parameters we used during this study. The time spent in the study area and the number of attempts to progress through the fishway may be a trait linked to the gender of the shad. Gender was not determined prior to releasing study fish.

Figure 12. Total number of events recorded by location and hour of day for shad number 108 tagged during the 2004 Brunswick fishway radio telemetry study

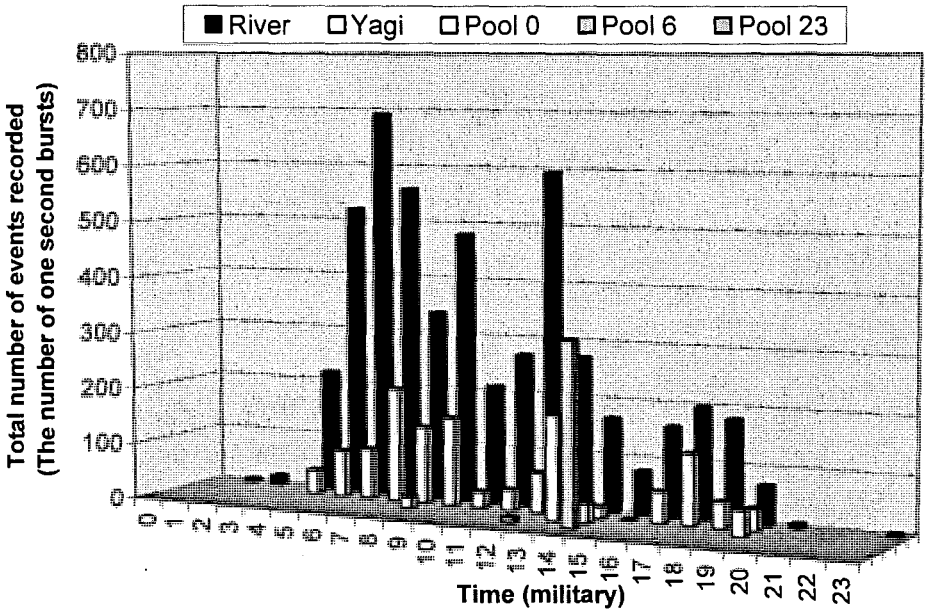


Figure 13. Total number of events recorded by location and hour of day for shad number 110 tagged during the 2004 Brunswick fishway radio telemetry study

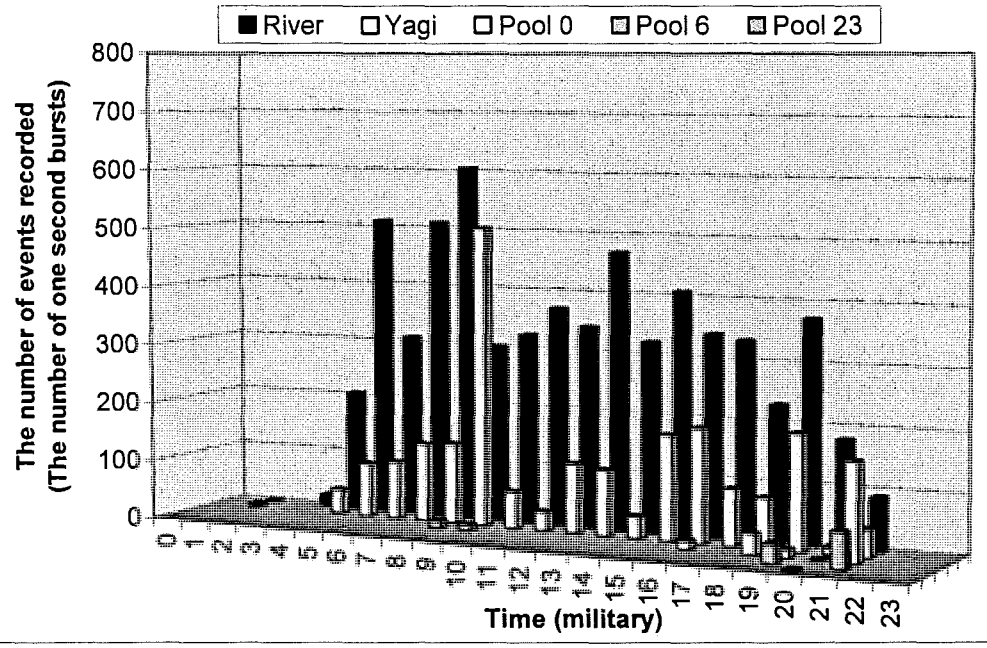


Figure 14. Total number of events recorded by location and hour of day for shad number 113 tagged during the 2004 Brunswick fishway radio telemetry study

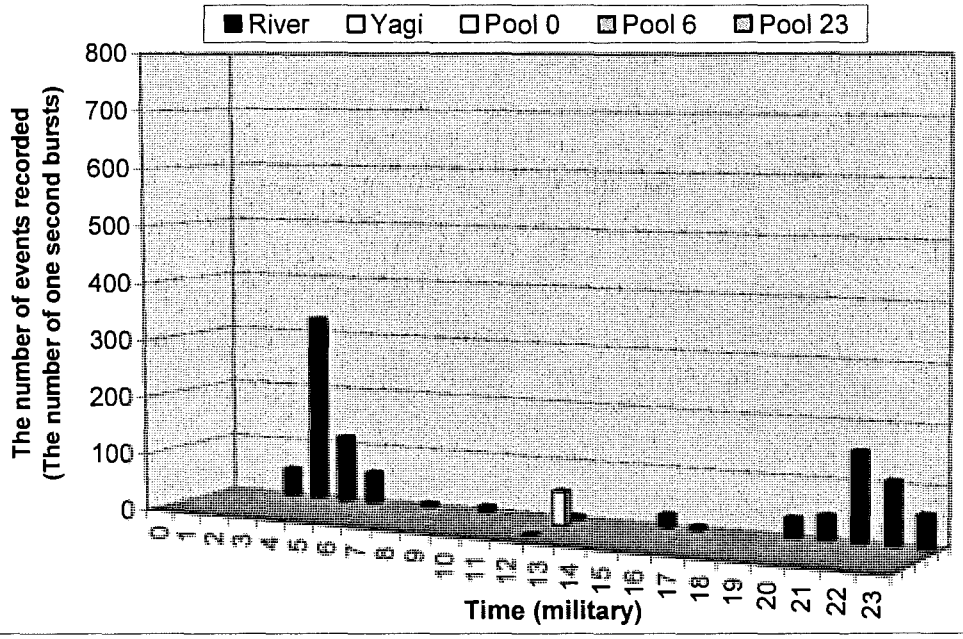
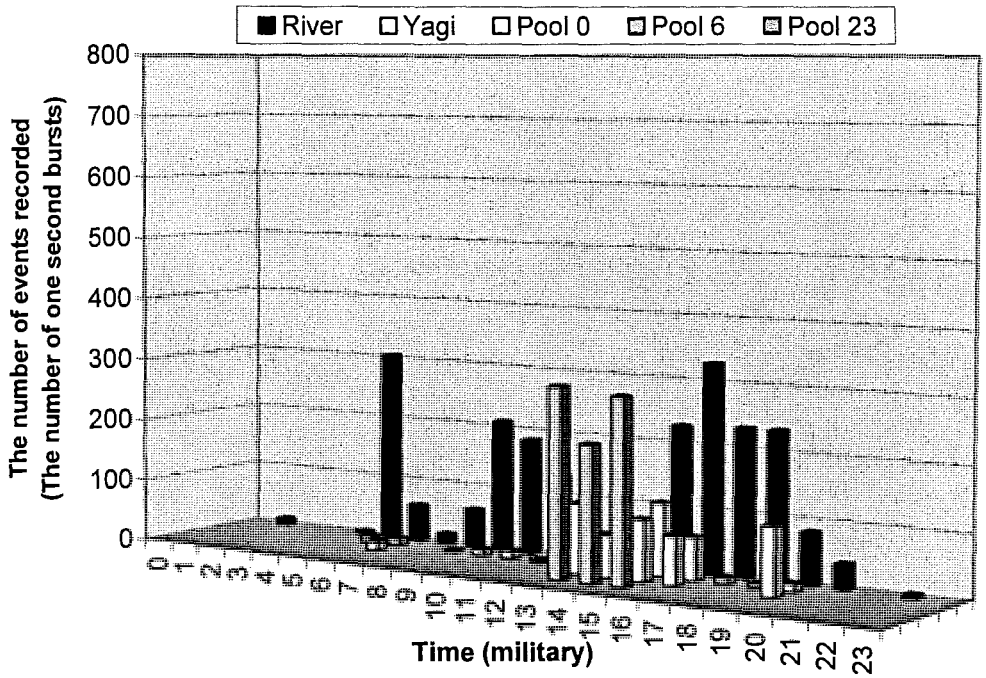


Figure 15. Total number of events recorded by location and hour of day for shad number 114 tagged during the 2004 Brunswick fishway radio telemetry study



Daily differences in fish behavior among all locations were also observed during the study (Figures 16 – 18). Data from all tagged fish were analyzed by hour and locations combined. These data show differences in movement within the tailrace and the fishway by day. Three distinct hourly patterns were observed; unimodal, bimodal and continuous.

Factors that may have affected shad movement during this study were environmental (water temperatures, river flow, tidal stage and sunlight). Others include turbine and fishway operation and the efficiency of the fishway. The Brunswick fishway is located at the head-of-tide on the Androscoggin River. Tidal changes range from 1.5 to 1.8m at the base of the dam and entrance to the fishway. As a result, water velocities, turbine operations and flows in the tailrace are constantly changing. It is unclear which factors have the greatest effect on shad behaviors in the tailrace and fishway. We do know, based on videotape data, that the choice of turbine operation does impact the circling patterns of the shad in the tailrace. Additional analysis this winter will incorporate some

of these factors to try to determine which variables we may be able to manipulate to facilitate upstream passage.

Figure 16. Unimodal frequency of cumulative time and events for all tagged shad by hour for all locations, July 13, 2004

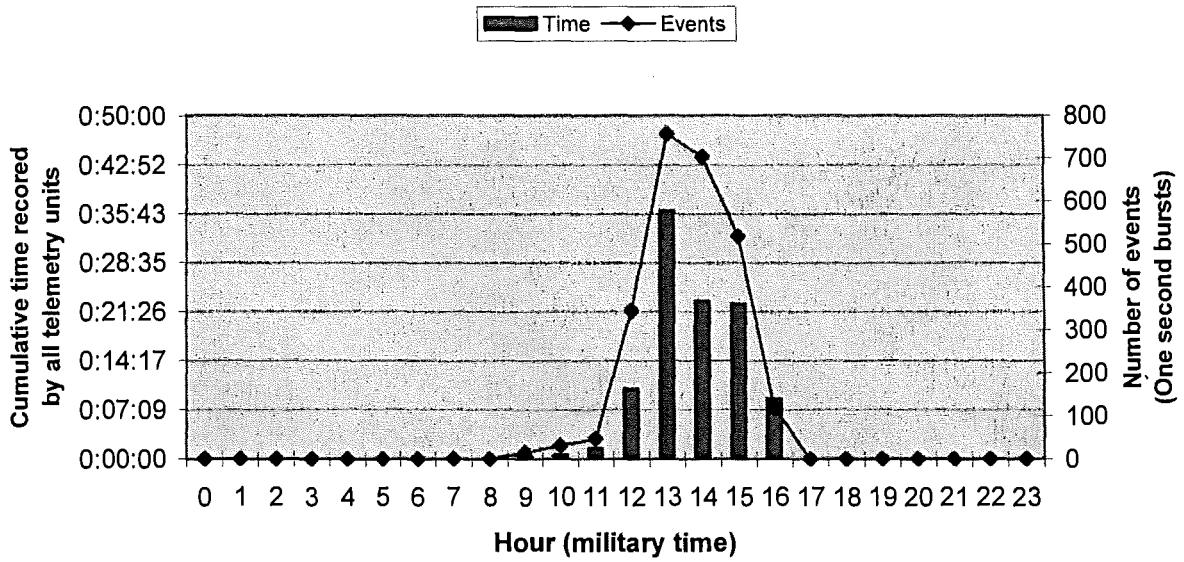


Figure 17. Bimodal frequency of cumulative time and events for all tagged shad by hour for all locations, July 4, 2004

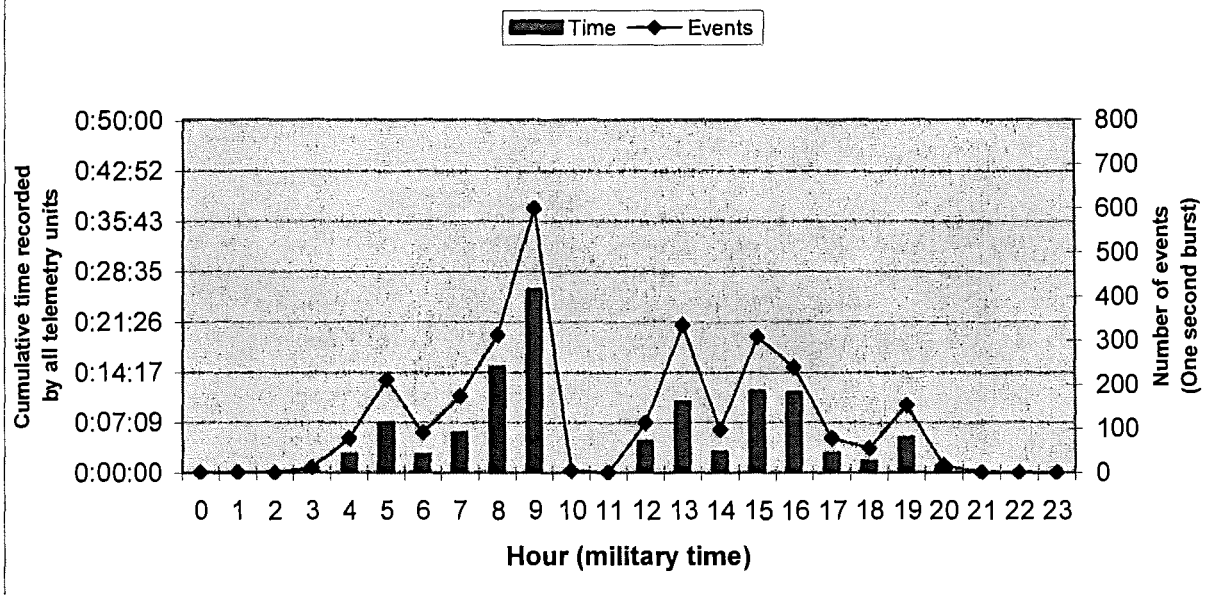
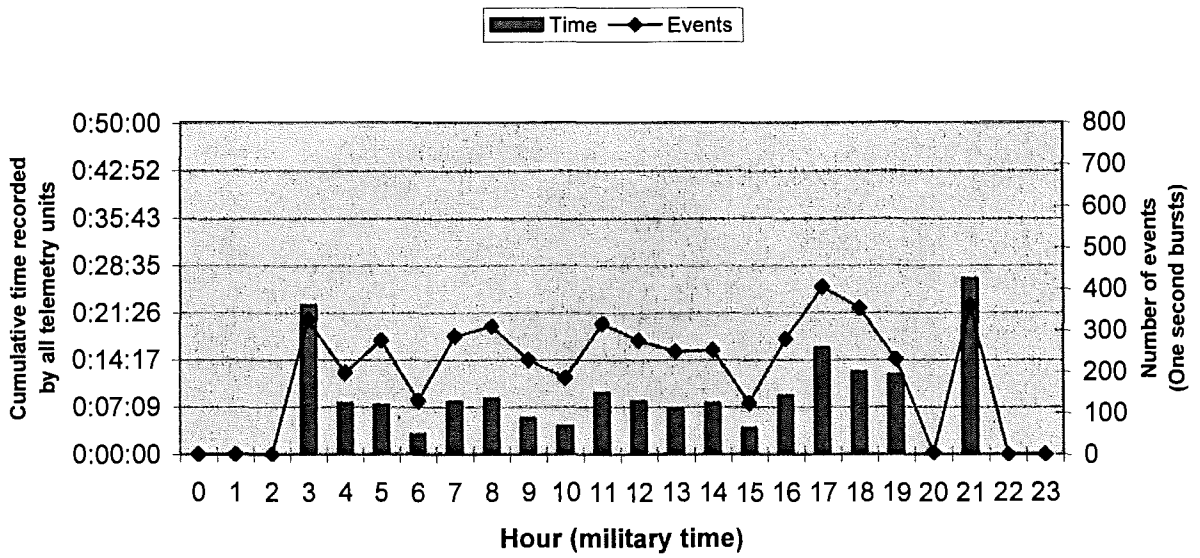


Figure 18. Continuous (non-modal) frequency of cumulative time and events for all tagged shad by hour for all locations, July 9, 2004



On three occasions, July 6, 12, 19, a mobile receiver was used to listen for radio signals at five locations down river. The river was divided into five one-mile sections and sampled at mid-day. Contact with study fish was never made outside the study area on any of the sample trips.

The setup of the radio receivers and the configuration of the radio tags affected the quality of information collected during the study. The one-second-pulse rate from the radio tags sometimes was not recorded because of simultaneous receptions by the same receiving unit from multiple tags. When this occurred, an error message was printed and stored in the receiving unit. A one-minute continuous time-out feature was used to limit the amount of data collected and stored by the receiving units if a tag should be regurgitated or a shad die within the study area. The time-out feature was reduced from the ten-minute time-out feature used in 2003. This option prevents thousands of useless records from being stored as single data lines in the receiver and perhaps filling its memory, preventing more desirable data from being recorded. However, this feature also masked some of the fine scale movements into and out of the fishway that we had hoped to record. After analyzing the results, we can make some

general statements concerning the behaviors that we were able to record within the study area.

Based on the number of study fish that returned to the study area for more than one day (6 of 20), it is difficult to draw any conclusions based solely on the results of the radio telemetry study. The shad that were monitored in the study area displayed different types of behaviors, some which may be gender dependent. During the 2003 study, when gender was determine during the time of tagging, one individual determined to be a female displayed a strong desire to ascend the fishway. The study fish we monitored tended to arrive at the fishway early in the morning, generally between 4 and 6 A.M. and leave between 8 and 10 P.M. We also observed the study fish frequently moving in and out of the fishway and never make it to the trap at the top of the fishway. Similar information collected by the underwater video cameras indicate the same types of behaviors displayed by the 20 radio tagged shad, willingness to enter the fishway, but unwilling to ascend it very far. There are several things that we can do next year to refine the study goals and objectives. One is to have additional dropper antennas in fishway pools 3, 14, and 34 to monitor progress through the fishway. Another is to reduce or eliminate the continuous time-out option on the radio receivers so we can determine the extent of each shad's movement between two antennas in close proximity (fishway entrance and the diffusion pool). As always, it would be great to have additional money to tag a larger number of fish to ensure we have enough study fish in the study area during the shad migration.

Work Planned for 2005:

During the 2005 American shad run, six underwater cameras will be deployed in the fishway to record shad behaviors around the modifications made to the fishway in November 2001 by FPLE. If these modifications prove successful, then the same modifications will be made to additional pools. The USFWS may provide funds to purchase radio tags that will be used to track American shad in the tailrace and within the fishway as shad attempt to ascend into the Brunswick headpond. FPLE has agreed to contribute spare radio receivers to record the movements of radio-tagged shad. In

addition to radio tagging, visual tags may be applied to a number of shad caught in the tailrace of the fishway.

Atlantic Salmon:

An active Atlantic salmon restoration program is not in place for the Androscoggin River, other than providing upstream passage past the first three dams on the river. However, an average of 30 sea-run salmon are captured annually at Brunswick, although Atlantic salmon returns have been below 12 salmon annually since 1996 (Table 14).

Table 14. Number, mean length and origin of sea-run Atlantic salmon returning to the Androscoggin River and captured at the Brunswick fishway 1983- 2004

	Sea-Run Hatchery				Sea-Run Wild				Mean Fork	Total
Age	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat	Length(mm)	
Year										
1983	1	16	0	0	0	3	0	1	*	21
1984	4	79	1	0	0	7	0	0	*	91
1985	1	18	0	0	0	2	0	0	*	21
1986	0	72	1	0	0	8	0	0	*	81
1987	2	20	3	0	0	1	0	0	729	26
1988	2	11	0	0	1	0	0	0	723 (TL)	14
1989	1	17	0	0	0	1	0	0	712 (TL)	19
1990	6	168	0	1	1	9	0	0	706	185
1991	0	9	0	0	0	12	0	0	759 (TL)	21
1992	2	9	0	0	1	3	0	0	658	15
1993	1	33	0	0	1	9	0	0	727	44
1994	2	16	0	1	0	6	0	0	707	25
1995	2	12	0	0	0	2	0	0	710	16
1996	2	19	1	0	1	16	0	0	708	39
1997	0	0	0	0	0	1	0	0	*	1
1998	0	4	0	0	0	0	0	0	737	4
1999	1	1	0	0	0	1	2	0	700	5
2000	1	3	0	0	0	0	0	0	652	4
2001	1	4	0	0	0	0	0	0	718	5
2002	0	2	0	0	0	0	0	0	809	2
2003	0	3	0	0	0	0	0	0	724	3
2004	*	*	*	*	*	*	*	*	688	12
Total	**29**	**516**	**6**	**2**	**5**	**81**	**2**	**1**		**654**

During the 2004 sample season, a total of 12 Atlantic salmon were passed into the Brunswick headpond. The mean fork length of adult salmon captured was 688mm. Four salmon had visible fin clips or other identifying characteristics that suggest that these fish were hatchery reared and released as smolts in the Penobscot (Table 15).

Table 15. Atlantic salmon captured on the Androscoggin River at the Brunswick fishway, May - October 2004

Date	Total Length (mm)	Fork Length (mm)	Clips/Marks	Water Temp. (C)
13-May	555	520	Both Ventrals	15.5
20-Jun	825	807	None	20.3
27-Jun	850	830	No Adipose	20.2
25-Jun	790	765	None	20.9
13-Jul	646	623	None	22.6
16-Jul	578	546	None	21.2
21-Jul	546	514	None	22.5
29-Jul	788	765	None	21.9
29-Jul	811	788	None	21.9
29-Jul	668	645	None	21.9
22-Oct	890	835	No Adipose	11.3
22-Oct	650	617	Adipose Punch	11.3
Total number of fish	**12**			
Mean	**716**	**688**		**19.3**
Min. T° (C)				**11.3**
Max. T° (C)				**22.6**

The Maine Atlantic Salmon Commission determined, based on the condition of the fins, that one of these fish may have been the result of natural reproduction or possibly fry stocking in the Little River, a tributary to the Androscoggin, or possibly another nearby river system. Subsequent scale analysis will be conducted by the MASC to determine the origin of these fish if possible.

In June 1999, the Maine Atlantic Salmon Technical Advisory Committee (MSTAC) agreed to include the Androscoggin River in an ongoing genetic sampling program. Fin clips were collected from all salmon captured at the fishway during 2000 - 2004. Genetic

analysis may be conducted in the future to determine the origin of the salmon captured at Brunswick to provide more effective management in the watershed. Through participation in the MSTAC, it was discovered that 15 schools in the Androscoggin River watershed participated in the 2004 Fish Friends, Salmon-in-Schools, and Adopt-a-Salmon Family Programs. In these programs, the U.S. Fish & Wildlife Service provides salmon eggs to schools in the spring for students to rear and release as fry into salmon nursery habitat identified in their watershed. In 2004, the fry from these programs were released into the Little River, a tributary that enters the Androscoggin between the second and third upstream dams. Atlantic salmon fry releases occurred in the same locations during the spring of 2000 - 2004.

Sea Lamprey:

Eight sea lamprey were captured at the fishway in 2004. Several more sea lamprey were observed attached to the sides of the fishway throughout the months of June and July. Sea lamprey are released downstream and not allowed to pass above Brunswick.

American Eel:

Two American eels were captured in the fishway trap during 2004. However, they are rarely captured in the trap since upstream migrating juveniles may be small enough to pass through the trap grating. American eel released above the Brunswick dam may use the fish passage facilities located at the next two dams to reach and utilize upstream habitat. Upstream migrating juvenile eels utilize these habitat areas for an average of 20 years to grow to adulthood before emigrating to reproduce in the Sargasso Sea.

Striped Bass:

In 2004, one striped bass was captured at the Brunswick fishway. Four were captured in 2003. Eight were captured or observed in the observation window/trapping area during the 2002 season.

Other Species:

From May 7 through October 28, 2004, 12 fish species and 114,336 individual fish were captured, sampled, or passed at the Brunswick fishway, including American shad and river herring. Juvenile American shad and river herring captured from August – September were migrating downstream from nursery habitats upstream. The most common species captured in May, other than river herring, was white sucker. In June, the most common species was smallmouth bass. Juvenile alosids and adult smallmouth bass were the dominant fish species using the fishway from July – October.

Unlike previous years, no white catfish were captured in 2004, although they were observed at several locations in the fishway. Normally, all white catfish are sampled and tagged with a spaghetti tag prior to release downstream; total length is recorded and the tag is applied posterior to the dorsal fin. Recapturing tagged fish will provide important information on growth and migration within the Androscoggin River/Merrymeeting Bay estuary. White catfish are a non-indigenous species unintentionally introduced into Maine waters and are not passed upstream. They were first discovered in the Eastern River, a tributary of the Kennebec, in 1997, and appear to be rapidly expanding their range. The exact rate and location of expansion and the potential effects on native fish communities are undetermined. A full summary of fish community data by month through October of the 2004 sample season is provided in Table 16.

Table 16. Adult fish species captured at the Brunswick fishway, 2004

	May	June	July	August	September	October	Species Total
American Eel (*Anguilla rostrata*)	-	-	1	1	-	-	2
American Shad (*Alosa sapidissima*)	-	10	2	-	-	-	12
Landlocked Salmon (*Salmo salar*)	1	1	-	-	-	-	2
Atlantic Salmon (*Salmo salar*)	-	3	7	-	-	2	12
Brook Trout (*Salvelinus tontinalis*)	-	-	-	-	-	-	0
Brown Trout (*Salvelinus trutta*)	1	-	-	-	-	2	3

Table 16 Continued.

Common shiner (*Notropis cornutus*)	-	-	-	-	-	-	0
Largemouth Bass (*Micropterus salmoides*)	-	-	-	-	-	-	0
Pumpkinseed Sunfish (*Lepomis gibbosus*)	-	-	-	-	-	-	0
River Herring (*Alosa aestivalis)(Alosa pseudoharengus)*	102,026	12,025	-	-	-	-	114,051
Sea Lamprey (*Petromyzon marinus*)	7	1	-	-	-	-	8
Smallmouth Bass (*Micropterus dolomieu*)	41	6	6	6	2	-	61
Spottail Shiner (*Notropis hudsonius*)	-	-	-	-	1	-	1
Striped Bass (*Morone saxatilis)*	-	-	-	-	-	1	1
White Catfish (*Ictalurus catus*)	-	-	-	-	-	-	0
White Perch (*Morone americana*)	-	-	-	-	-	-	0
Rainbow Trout (*Salmo gairdneri*)	-	2	-	-	-	-	2
White Sucker (*Catostomus commersoni*)	181	-	-	-	-	-	181
Monthly Totals	102,257	12,048	16	7	3	5	114,336

Environmental Data:

Brunswick fishway air temperature, water temperature, and river flow data recorded from May through October 2004 are shown in Tables 17-22 and Figures 19-24.

Table 17. Brunswick fishway air and water temperatures/headpond levels, May 2004.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	Flow (cfs)
5/1/2004				8,240
5/2/2004				6,410
5/3/2004				6,390
5/4/2004				6,080
5/5/2004				12,200
5/6/2004				11,300
5/7/2004				9,200
5/8/2004				8,840
5/9/2004	10.0	12.8	40.0	7,230
5/10/2004	13.9	12.9	39.5	7,020
5/11/2004	12.5		39.5	5,150
5/12/2004	14.1	13.1	40.0	4,170
5/13/2004	14.8	15.5	39.0	5,820
5/14/2004				4,430
5/15/2004	16.9	14.8	38.5	4,000
5/16/2004	15.2	16.1	39.0	3,900
5/17/2004	15.9	16.2	38.5	4,450
5/18/2004	11.2	16.5	39.0	4,680
5/19/2004	14.9	16.2	39.0	4,850
5/20/2004	13.3	16.9	39.0	4,620
5/21/2004	12.1	17.3	39.0	4,770
5/22/2004	7.5	17.9	38.0	4,690
5/23/2004	8.2	16.5	39.5	4,730
5/24/2004	10.9	16.3	39.5	5,360
5/25/2004	9.0	15.4	39.0	6,140
5/26/2004	7.3	15.1	40.5	8,970
5/27/2004	9.0	14.8	41.0	9,910
5/28/2004	8.9	15.5	41.0	9,340
5/29/2004	13.8	13.7	41.0	8,950
5/30/2004				7,960
5/31/2004	16.7	14.3	39.0	6,720
Mean	**12.2**	**15.4**	**39.5**	**6,662**

Table 18. Brunswick fishway air and water temperatures/headpond levels, June 2004.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	Flow(cfs)
6/1/2004	9.7	14.5	39.0	6,310
6/2/2004	8.6	13.0	39.0	4,700
6/3/2004	11.0	13.0	39.0	5,620
6/4/2004	17.6	15.1	39.0	6,540
6/5/2004	17.5	16.0	39.0	6,270
6/6/2004	14.0	16.0	39.0	5,870
6/7/2004	11.8	15.1	39.0	5,260
6/8/2004	9.9	14.9	39.0	3,300
6/9/2004	20.0	16.3	37.5	4,120
6/10/2004				3,050
6/11/2004	14.6	17.4	38.0	2,840
6/12/2004	20.7	18.7	39.0	1,870
6/13/2004	19.3	18.2	39.0	1,830
6/14/2004	14.0	17.8	38.5	2,750
6/15/2004	16.5	19.1	39.0	2,700
6/16/2004	18.9	19.2	38.0	2,680
6/17/2004	23.1	20.4	38.5	2,730
6/18/2004	18.7	21.4	38.0	3,140
6/19/2004	14.4	21.3	38.5	1,830
6/20/2004	14.9	20.3	38.5	1,810
6/21/2004	18.2	19.5	38.5	2,230
6/22/2004	16.5	20.0	38.5	2,300
6/23/2004	17.1	20.1	39.0	2,380
6/24/2004	13.0	20.3	38.0	2,400
6/25/2004	15.5	20.9	38.0	2,340
6/26/2004	16.2	20.9	38.5	1,700
6/27/2004	20.7	20.2	39.0	1,640
6/28/2004	18.3	20.4	37.5	2,470
6/29/2004	14.4	20.3	38.5	1,970
6/30/2004	16.9	20.8	39.0	1,950
Mean	**15.9**	**18.3**	**38.6**	**3,220**

Table 19. Brunswick fishway air and water temperatures/headpond levels, July 2004.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	Flow (cfs)
7/1/2004	15.2	20.9	38.5	2,150
7/2/2004	18.6	21.5	38.5	2,330
7/3/2004	24.4	22.7	38.5	1,910
7/4/2004	24.9	22.9	38.0	1,900
7/5/2004	20.1	22.2	37.5	1,890
7/6/2004	20.2	21.8	37.5	2,180
7/7/2004	18.0	21.6	38.5	2,170
7/8/2004	16.5	21.7	38.5	2,070
7/9/2004	16.2	21.8	39.0	2,070
7/10/2004	21.7	21.7	37.5	2,750
7/11/2004	22.8	21.9	38.5	3,920
7/12/2004	17.5	22.0	39.0	3,980
7/13/2004	19.9	22.6	38.5	4,130
7/14/2004	17.4	22.4	38.0	3,520
7/15/2004	15.3	21.3	38.5	3,550
7/16/2004	18.3	21.2	38.5	3,620
7/17/2004				2,660
7/18/2004	25.6	22.7	38.5	2,610
7/19/2004	19.4	23.2	38.5	3,340
7/20/2004	19.6	22.8	37.5	3,070
7/21/2004	21.2	22.5	38.5	2,800
7/22/2004	18.4	23.2	38.5	3,110
7/23/2004	19.1	23.6	37.5	3,540
7/24/2004				2,490
7/25/2004	20.7	22.3	39.0	3,150
7/26/2004	22.4	22.4	38.5	3,760
7/27/2004				3,760
7/28/2004	18.2	22.4	38.0	3,510
7/29/2004	22.5	21.9	38.0	3,290
7/30/2004	23.1	22.2	38.0	3,030
7/31/2004				2,030
mean	**19.9**	**22.2**	**38.3**	**2,913**

Table 20. Brunswick fishway air and water temperatures/headpond levels, August 2004.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	Flow(cfs)
8/1/2004				1,950
8/2/2004				2,510
8/3/2004				2,440
8/4/2004	22.1	24.8	39.0	3,080
8/5/2004	18.0	24.3	38.0	3,000
8/6/2004	15.4	23.5	38.5	2,420
8/7/2004				1,780
8/8/2004				1,790
8/9/2004	19.3	22.4	39.0	2,750
8/10/2004	23.2	22.7	38.5	1,770
8/11/2004	19.0	23.2	39.0	2,400
8/12/2004				3,160
8/13/2004	21.1	23.2	38.5	4,700
8/14/2004	25.4	22.8	39.0	6,980
8/15/2004				7,990
8/16/2004	19.4	22.8	39.0	5,900
8/17/2004	18.3	22.4	39.0	3,640
8/18/2004	18.0	22.3	38.0	3,850
8/19/2004	19.1	22.6	38.5	4,530
8/20/2004	21.5	22.3	39.0	5,350
8/21/2004				4,900
8/22/2004				3,160
8/23/2004	18.3	20.5	38.0	4,450
8/24/2004	15.2	21.4	39.0	4,530
8/25/2004	15.9	21.4	38.0	4,130
8/26/2004	18.7	21.2	38.0	3,210
8/27/2004	18.8	21.2	38.0	3,070
8/28/2004				1,960
8/29/2004				1,890
8/30/2004	21.7	22.5	38.5	4,070
8/31/2004	21.8	23.1	38.5	3,470
Mean	**19.4**	**22.5**	**38.6**	**3,575**

Table 21. Brunswick fishway air and water temperatures/headpond levels, September 2004.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	Flow(cfs)
9/1/2004	20.5	22.0	38.0	4,160
9/2/2004	14.7	21.5	39.0	5,310
9/3/2004	12.6	21.5	39.0	5,320
9/4/2004				4,160
9/5/2004				3,100
9/6/2004	11.6	21.6	38.0	1,850
9/7/2004	19.4	21.0	38.8	3,510
9/8/2004	19.3	21.4	38.0	2,690
9/9/2004	17.1	21.1	38.0	4,030
9/10/2004	20.5	20.5	39.0	5,860
9/11/2004				6,640
9/12/2004				6,480
9/13/2004	20.5	20.3	39.0	5,660
9/14/2004	12.2	19.5	39.0	5,010
9/15/2004	14.9	19.0	39.0	4,110
9/16/2004	16.2	19.0	37.5	3,970
9/17/2004	12.9	19.1	39.0	3,660
9/18/2004				2,120
9/19/2004				2,170
9/20/2004	10.9	16.3	39.0	4,250
9/21/2004	14.9	16.7	39.0	3,850
9/22/2004	14.5	17.7	39.0	3,790
9/23/2004				3,770
9/24/2004	16.2	18.3	39.0	3,700
9/25/2004				2,850
9/26/2004				2,720
9/27/2004	17.9	17.9	38.0	2,830
9/28/2004	15.8	18.0	38.5	2,830
9/29/2004	11.0	17.2	39.0	3,190
9/30/2004	9.6	16.2	39.0	3,790
Mean	**15.4**	**19.3**	**38.7**	**3,913**

Table 22. Brunswick fishway air and water temperatures/headpond levels, October 2004.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	Flow(cfs)
10/1/2004	13.4	16.5	39.5	3,780
10/2/2004	14.1	17.3	39.0	2,520
10/3/2004	8.8	17.3	39.5	2,100
10/4/2004	6.6	16.3	39.0	3,150
10/5/2004	8.6	15.5	39.0	3,110
10/6/2004	6.5	15.0	39.5	2,760
10/7/2004	8.7	14.6	38.5	2,480
10/8/2004	13.1	14.7	39.0	2,210
10/9/2004	14.7	15.0	39.0	2,390
10/10/2004	13.9	15.5	39.0	2,450
10/11/2004	11.0	15.2	38.5	3,050
10/12/2004	8.8	14.3	38.5	2,810
10/13/2004	10.9		38.0	3,240
10/14/2004	13.4	13.4	38.0	2,860
10/15/2004	11.0	14.1	39.5	3,800
10/16/2004	14.5	14.1	39.3	4,010
10/17/2004	11.5	13.7	39.3	5,170
10/18/2004	7.6	13.1	39.5	5,580
10/19/2004	7.4	12.6	39.3	4,430
10/20/2004	5.4	11.9	39.5	3,800
10/21/2004	8.2	11.7	39.5	4,030
10/22/2004	7.5	11.3	39.5	3,790
10/23/2004	6.0	11.1	36.8	5,180
10/24/2004	7.1	10.7	39.5	5,210
10/25/2004	9.0	10.4	39.3	3,330
10/26/2004	8.7	10.0	38.5	1,860
10/27/2004	10.6	9.6	39.5	1,840
10/28/2004	6.8	9.3	39.5	1,920
10/29/2004				2,040
10/30/2004				2,660
10/31/2004				3,190
Mean	**9.8**	**13.5**	**39.0**	**3,250**

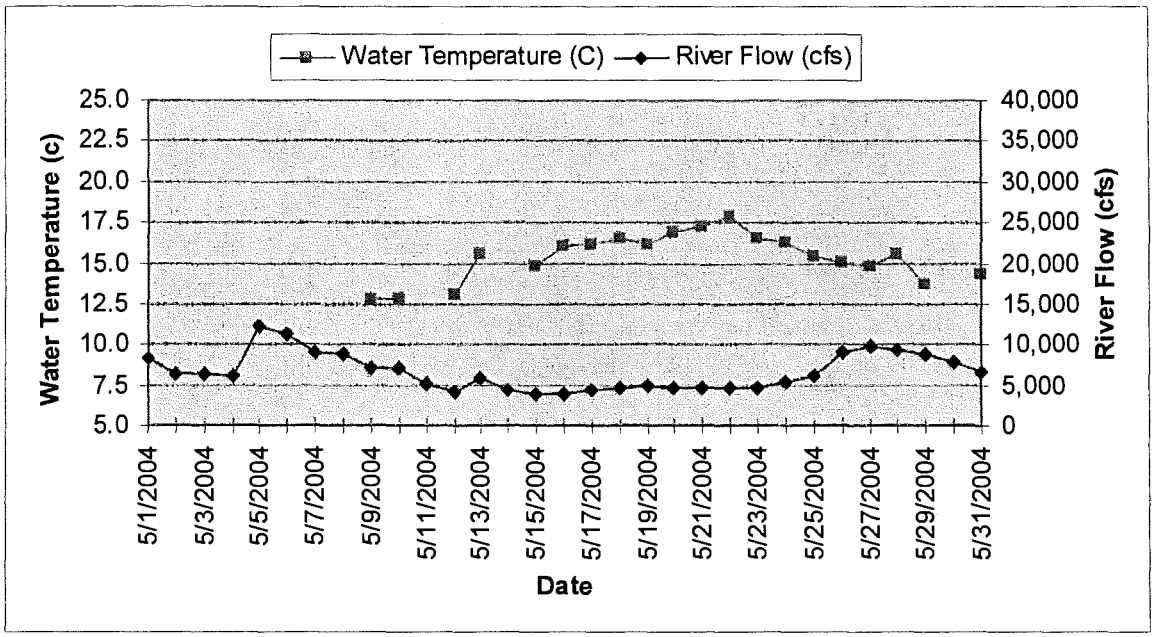


Figure 19. Water temperature and river flow recorded at the Brunswick fishway in May, 2004

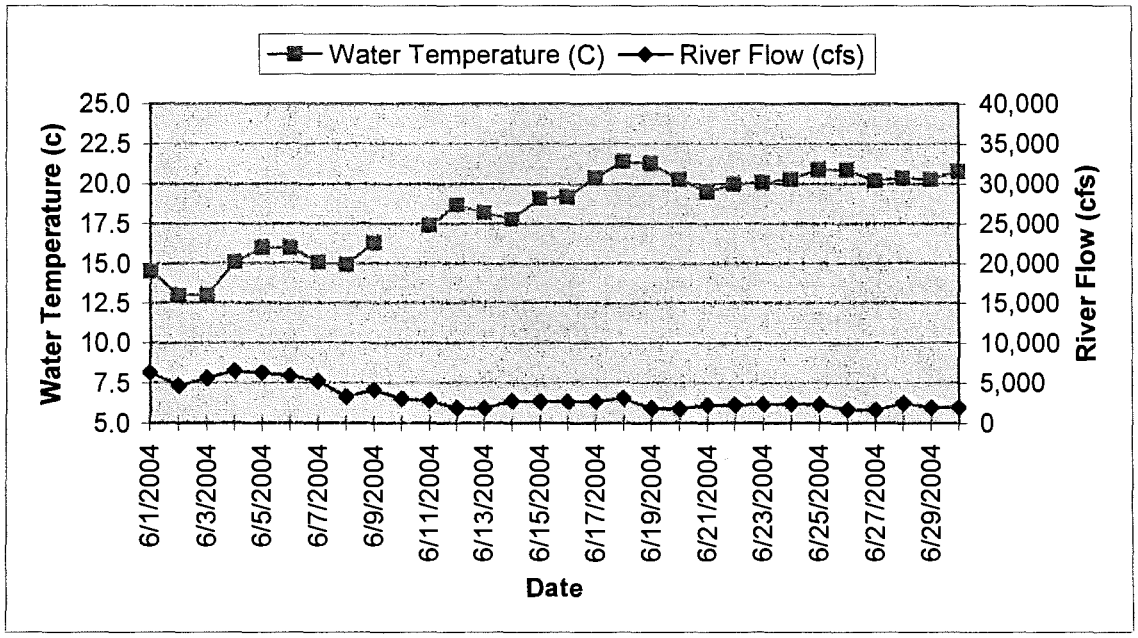


Figure 20. Water temperature and river flow recorded at the Brunswick fishway in June, 2004

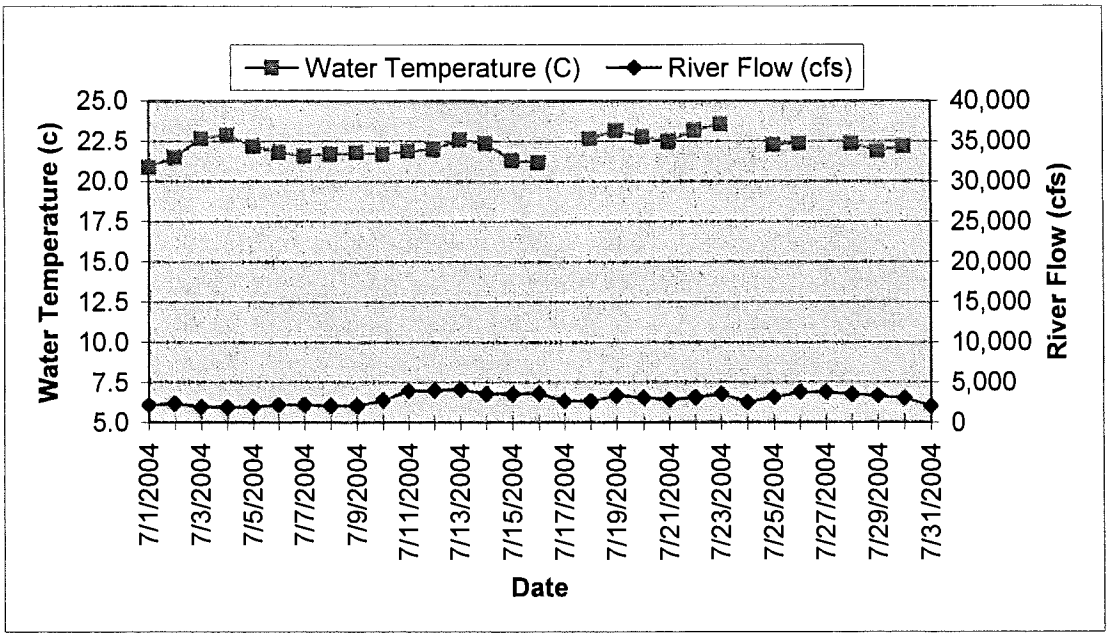


Figure 21. Water temperature and river flow recorded at the Brunswick fishway in July, 2004

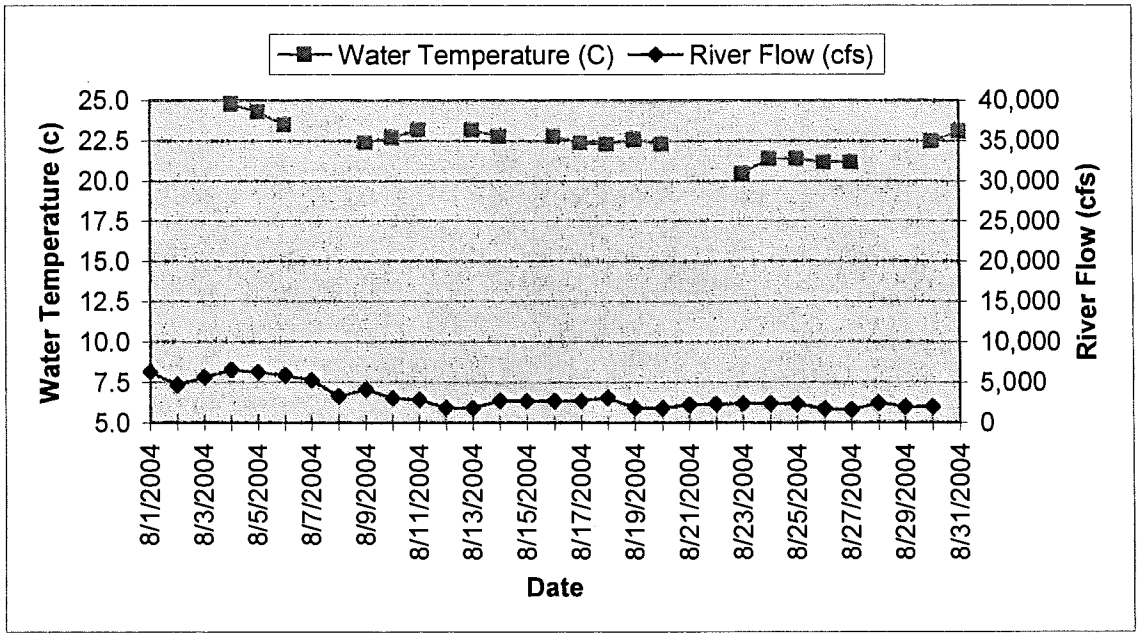


Figure 22. Water temperature and river flow recorded at the Brunswick fishway in August, 2004

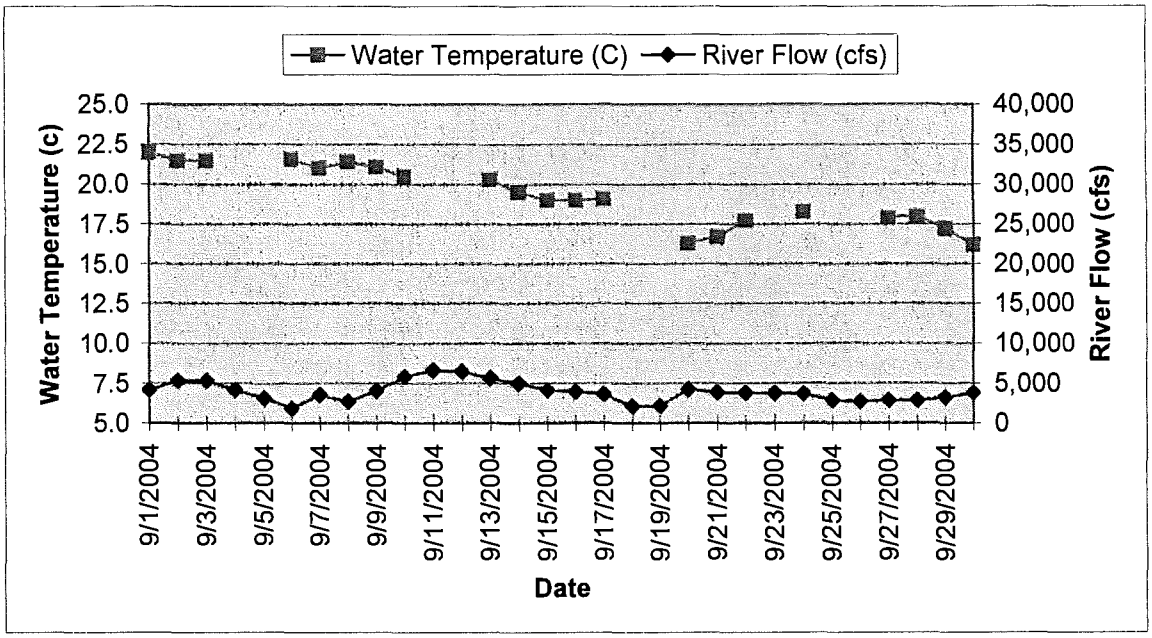


Figure 23. Water temperature and river flow recorded at the Brunswick fishway in September, 2004

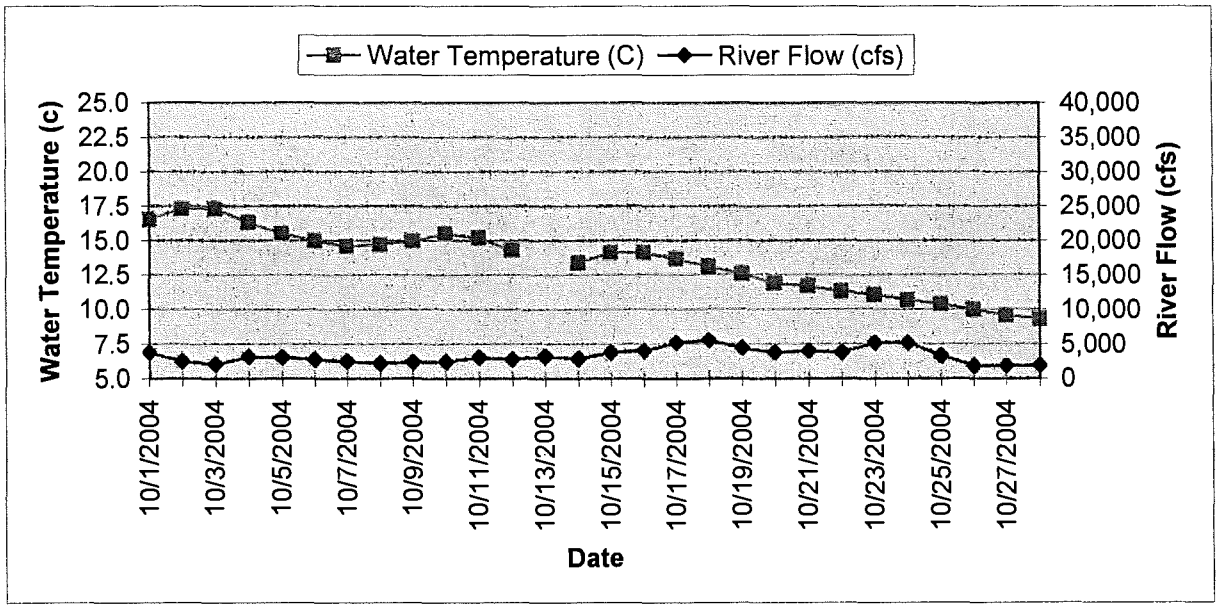


Figure 24. Water temperature and river flow recorded at the Brunswick fishway in October, 2004

Brunswick Fishway Specifications

Type:	Vertical Slot
Description:	Reinforced concrete w/precast baffles
Overall Length:	570' +/-
Floor Elevations:	Elevation 34.0 at fishway exit
	Elevation -5.0 at fishway entrance
Floor Slope:	1 on 10
Pool Size:	8'-6"W x 10'-0"L with 11" wide slot
Drop per Pool:	12"
Design Populations:	85,000 shad per year
	1,000,000 alewives per year
Fishway Operating Range:	Maximum headwater elevation 43.0
	Maximum tailwater elevation 7.5
	Q = 30,000 CFS
	Normal headwater elevation 39.4
	Normal tailwater elevation 2.5
	Q = 4,400 CFS
	Minimum headwater elevation 37.4
	Minimum tailwater elevation -1.0
	Q = 0 CFS
Design Flow:	30 CFS
Supplementary Attraction Flow:	70 CFS (gravity)
Total Attraction Flow:	100 CFS
Fishway Entrance Jet Velocity:	4.0 FPS to 6.0 FPS
Tailrace Velocity:	5.0 FPS maximum
Appurtenances:	
Gates:	1 - 7' x 10' motorized & instrumented sluice gate at fishway exit. This gate to be closed when pond level reaches elevation 43.0+
	1 - 4' x 10' motorized & instrumented sluice gate at entrance to downstream

Appurtenances, cont.:

Gates:	Migrant passage on north side of powerhouse
	2 - 27" diameter motorized & instrumented sluice gates at intake of supplementary attraction flow system
	2 - pneumatic trap gates at fish trap
	Stop logs at fishway entrance & exit
	Trash rack: 1 10' x 12' at fishway exit with 5 3/4" clear bar spacing
Fish Crowder	1" x 4" grating on motorized trolley at fish trap
Fish Hopper	500-gallon capacity with electric hoist at fish trap

Related Work:

Existing Overflow Spillway	Addition of flashboards (120 L.F.) to elevation 42.0 to prevent discharge into tailrace at river flow 20,000 CFS
Fish Barrier Wall	Reinforced concrete semi-gravity type with top at elevation 21.0 to prevent discharge into tailrace at river flows up to 20,000 CFS
Overall Length	170' +/-
Maximum Height	30' +/-
Appurtenances	Sluice gate for dewatering intermediate pool

Species observed using the Brunswick fishway 1983 - 2004

Brook trout

Brown trout

Smallmouth bass

Largemouth bass

White sucker

Striped bass

American shad

Coho salmon

Carp

Sea lamprey

Rainbow trout

Chinook salmon

White perch

Yellow perch

Atlantic salmon

American eel

Landlocked salmon

Sunfish (Bluegill)

Sunfish (Pumkinseed)

Pumpkinseed Sunfish

Creek chub

Golden Shiner

Common Shiner

White catfish

Spottail Shiner

Rainbow Smelt

Crayfish