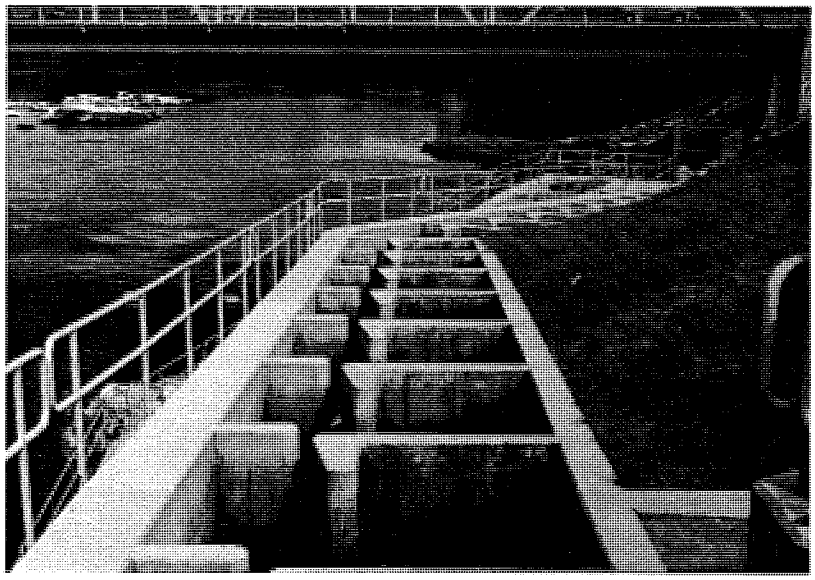
State of Maine

Department of Marine Resources

2003 Brunswick Fishway Report



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

March 2004

ANADROMOUS FISH RESTORATION IN THE ANDROSCOGGIN RIVER WATERSHED

2003 Report on the Operation of the Brunswick Fishway FERC #2284

Maine Department of Marine Resources
Stock Enhancement Division
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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. According to Atkins (1887), 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, fish data collection, and operational activities throughout the season (typically May through November). 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 pseudoharengus* 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 habitat areas.

Strategies:

1. Trap upstream migrating adults at the Brunswick fishway and distribute them into upstream habitat areas 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 habitat areas.

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.
4. Collect fish community data during the adult river herring emigration assessment conducted in the Sabattus River at the outlet of Sabattus Pond.

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.
3. Assess the post-spawn adult river herring emigration timing, magnitude, and condition from Sabattus Pond sampling.

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 alosids 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 accessibility of historic habitat for native diadromous and resident fish species to increase the abundance, survival, and natural reproduction in historic habitat.

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.

2003 BRUNSWICK FISHWAY MAINTENANCE AND OPERATION

- DMR met with the Brunswick dam owner, FPLE, in the spring of 2003 to review Brunswick Station operations, safety procedures, problems occurring with the fishway, and maintenance issues that remained from the fall 2002 season that required resolution prior to the startup of the fishway in May 2003.

- The fishway was officially opened for its 21th consecutive season on May 6, 2003.

- Prior to the 2003 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 installed a supplemental oxygen delivery system to provide oxygen to two overhead fish distribution tanks. The new system allowed DMR personnel to increase the number of alewives that were held in the tanks prior to distribution. Supplemental oxygen was used to aerate water when Atlantic salmon and American shad were held in the overhead tanks. Routine maintenance was conducted in the lower section of the fishway; the diffusion chamber grates and baffles were cleaned, inspected, and replaced if needed.

- 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.

- During the first week of operation, the isolation gates were not lowering to the bottom of the fish trap. Maintenance personnel corrected the problem later that day by adjusting the travel stop on the electric motor that operates the gate. As in 2001-2002, one of the four wheels of the fish crowder was missing. In 2001, a piece of pipe was welded onto the crowder in place of the wheel assembly. This modification worked fine throughout the 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.

- On, May 8 FPLE inspected and repaired the smaller of the two water pumps that supplies water to the two overhead holding tanks.

- The fishway was closed June 13 to replace and modify the weir boards in pool 6. The weir boards in pool 6 were lowered 12" to improve water flow between pools 5 and 6.

- On June 16, the springs on the hopper door broke and were replaced later that week.

- The fishway was closed August 13 and 14 to repair problems with the diffusion chamber. The grates were cleaned and reattached prior to restarting the fishway.

- September 16, FPLE noted problems with the attraction water and diffusion chamber. The fishway was shut down and the intake grates were cleaned to improve flow to the diffusion chamber.

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 811,000 adult river herring captured at the Brunswick fishway into otherwise inaccessible habitat on the Androscoggin and Little Androscoggin Rivers. These stocking efforts continue due to the lack of fish passage at subsequent upstream dams on the Little Androscoggin and Sabattus Rivers that prevent access to river herring spawning and nursery habitat areas.

The maintenance crew of FLPE opened the Brunswick fishway on May 6, 2003; MDMR personnel staffed the fishway beginning May 6. River herring were observed at the

fishway from May 12 through June 12. A total of 53,732 river herring were captured at the Brunswick fishway in 2003, down from the record 104,520 captured in 2002. The run peaked May 20 through June 3 when 52,921 river herring were captured. These twelve days accounted for 98% percent of the total number captured during the 2003 river herring run. On ten days, May 20 – May 27 and May 30 - June 3, the number of captured adults exceeded 1,000 fish (Table 1).

The number of river herring trapped during the 2003 season ranked 7th best out of the 21 seasons the fishway has been in operation (Table 2). The total number of river herring captured in 2003 exceeded the 21-year average of 38,654 (Figure1). Unlike pervious years, 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). Of the 53,732 adults captured, 20,392 were transported upstream; 29,420 were released into the Brunswick headpond; 152 were sacrificed for biological sampling; nine were transport mortalities; and 3,759 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 12, 2003 at a water temperature of 12.6°C and water flow of 6,550 (cfs) and trapping ended on June 12, at a water temperature of 17.9°C and water flow of 4,020 (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 11.6°C and 17.9°C, averaging 14.4°C (Figure 2). The water flows ranged between 2,950(cfs)

and 7,050(cfs), averaging 4,878(cfs) (Figure 3). Alewives trapped at the Brunswick fishway were sampled on four different occasions. Of the individuals sampled, 45% were female, while 55% were male. Females averaged 254mm fork length and weighed on average 197 grams. Males averaged 247mm fork length and weighed 180 grams (Table 5). 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.

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 (64.0%) and are likely spawning for the first time (Table 6). A significant number of alewives also returned as 5-year olds. The increased numbers of 5-year old fish in the 2003 samples may indicate a significant number of pre-spawn adult alewives stocked in the Brunswick headpond in 2002 (100,361) were able to successfully migrate downstream during high water events in June 2002. In comparison, sample results from 2002 indicate only 9% of the 2002 alewife run was 5-year old fish. Total alewife return numbers are expected to increase in 2004 as a portion of the production from Sabattus Pond return as 5-year olds.

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. Returning adult river herring to the Androscoggin River are predominantly four years old when they are captured.

Table 6. Ages of alewives sampled at the Brunswick fishway in 2003

	Number	Ave. TL (mm)	Ave. FL (mm)	Ave. Wt (g)	%M	%F	%U	% of Sample
Age 3 Alewives	1	270.0	233.0	165.2	0%	100%	0%	0.65%
Males								
Females	1	270.0	233.0	165.2				
Age 4 Alewives	97	280	247	182	57%	43%	0%	63.82%
Males	55	276	243	176				
Females	42	284	251	189				
Age 5 Alewives	50	289	255	201	52%	48%	0%	32.89%
Males	26	285	251	191				
Females	24	293	259	211				
Age 6 Alewives	4	286	253	199	50%	50%	0%	2.63%
Males	2	287	252	194				
Females	2	285	253	205				

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. The number of pre-spawn adult shad currently captured in the fishway trap at Brunswick is inadequate for a successful restoration program. 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 2003 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 69 consecutive days beginning June 2 and continuing through August 9. In 2003, a total of 299 adult shad were observed, 145 in June and 154 in July (Table 7). The water temperature when the shad were observed averaged 18.9°C in June (Figure 4). The river flow ranged between 1,770(cfs) and 9,870(cfs) in June (average of 4,001 cfs) (Figure 5). In July, a total of 154 shad were observed in the lower half of the fishway and the river. The water temperature when the shad were observed averaged 24.2°C in July. The river flow ranged between 1,780(cfs) and 2,610(cfs) in July (average of 2,203 cfs). No shad were observed in either May or August.

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 first 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.

Captured Shad:

In 2003, 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 seven adults were captured between June 9 and August 8 (Table 8). The decrease in the number of trapped adults was expected based upon the number of pre-spawn adults passed upstream in 1998 (Table 9). Biological data was collected on five of the seven shad captured in 2003, 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. Biological sampling was not conducted on two shad that passed through the trap during routine cleaning.

Table 11. Ages of American shad sampled at the Brunswick fishway in 2003

	Number	Ave. TL (mm)	Ave. FL (mm)	Ave. Wt (g)	%M	%F	%U	% of Sample
Age 3 Shad	*	*	*	*	*	*	*	*
Males								
Females								
Age 4 Shad	*	*	*	*	*	*	*	*
Males								
Females								
Age 5 Shad	4	457	384	*	100%	0%	0%	80%
Males	4	457	384					
Females								
Age 6 Shad	1	495	435	*	100%	0%	0%	20%
Males	1	495	435					
Females								
Age 7 Shad	*	*	*	*	*	*	*	*
Males								
Females								

In 2003, seven 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 July 10, with a mean water temperature of 24.3°C and a mean daily flow of 2,200 (cfs) (Figures 6-7). 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 2003 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 2004.

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. 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 (Figures 8-9).

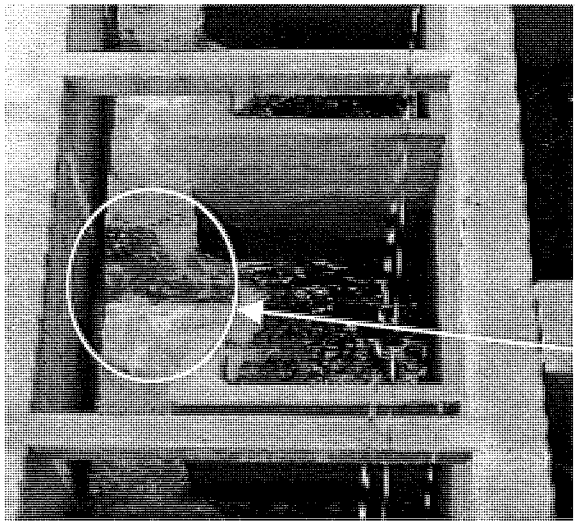


Figure 8. Modifications made by FPLE to increase the slot width and modify flow in the lower section (pools 1-6) of the Brunswick fishway to improve shad passage.

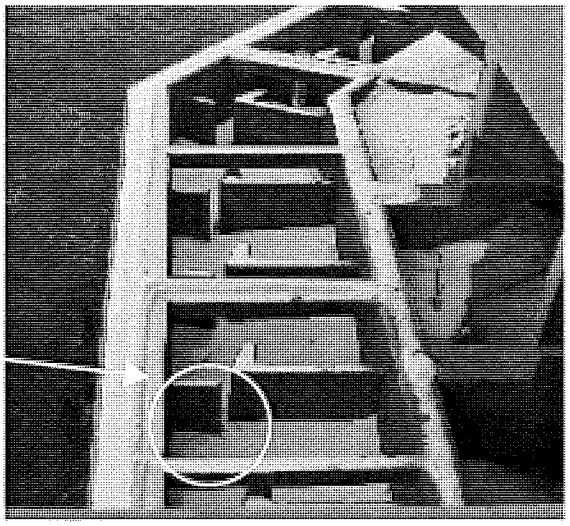


Figure 9. Existing fishway slot widths prior to modification by FPLE in November 2001.

In 2003, eight juvenile shad were sampled from the fish trap at the Brunswick fishway (Table 12). All juvenile shad captured at the fishway in 2003 were retained for otolith analysis. Capturing juvenile shad at the fishway is difficult due to the 1.5 inch bar spacing in the grating that makeup the trap. A large proportion of juvenile fish passing downstream pass undetected through the trap, downstream bypass, or the turbines. Five of the seven (71.0%) juvenile shad caught in the fishway trap were determined to

be of hatchery origin after the otoliths were analyzed. This is up from 13% in 2002 and likely reflects the large number of shad fry socked upstream in 2003 (2,076,369).

The DMR considers collection of this data essential for the effective management of the 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 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 in 2001; on July 1, 309,000 shad fry were released below Lewiston Falls; they were of Merrimack River origin, 23-26 days old. In 2002, 295,700 fry 7-10 days old were released at the Durham boat launch. Fry stocking increased dramatically in 2003. A record 2,076,369 6-8 day old fry were released into the Androscoggin River (Table 13).

Table 13. American shad fry released into the main stem Androscoggin River at Auburn, 2000- 2003

Date	Source	No. Released	Age	% Mortality	Loading Site Temp.(C)	Receiving Site Temp. (C)	Marking Method
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*
7/2/2001	Merrimack	308,600	23 - 26 days old	~1%	18.0	23.4	Tetra-cycline*
7/10/2000	CT x Kennebec	529,000	7 to10 days old	~5%	18.7	25.0	Tetra-cycline*
6/30/1999	CT x CT and CT x Saco	280,000	10 to 17 days old	~2.4%	17.3	24.7	Tetra-cycline*

* Fry were exposed to a four-hour tetracycline bath at the Waldoboro hatchery.

Record production at the Waldoboro Shad Hatchery produced excess fry that allowed increased stocking rates for the Androscoggin River. 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 418 pre-spawn adults transported from the Merrimack River, in addition to the seven 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.

2003 American Shad Study:

In 2003, 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 6 A.M. and stopped recording at 6 P.M. each day, beginning June 18 and ending August 8. In 2003, approximately 3,672 hours of video were recorded using the six cameras. Project personnel are currently reviewing videotape data collected during the 2002 and 2003 seasons.

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 two 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 two years, ten each of the last two years.

FPLE contributed four 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. Results from the second year of the study did provide information on shad behavior in and around the fishway, but because of the poor results from the first year of the study, the following information will report mainly on the second year.

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 both years of the study.

The results of the first year of the project were disappointing. Abnormally high water in the river soon after the shad were tagged is presumed to have pushed the tagged fish from the river system. Although some fallback behavior was expected while conducting the radio telemetry study, none of the ten tagged fish ever returned to the study area. One tag was located in the Androscoggin River approximately a 1.5 miles below the study area. The tag was stationary and was thought to be the result of mortality or regurgitation of the radio tag. All the major tributaries to Merrymeeting Bay were searched with a mobile radio receiver, but no additional traces of any tagged shad were found.

In addition to the shad radio tagged in 2002, DMR captured and tagged 24 additional shad caught in the tailrace of the Brunswick fishway. These shad were tagged with orange spaghetti tags, posterior to the dorsal fin on the left side of the body, to try to estimate the numbers of repeat visual observations being collected in and around the fishway. These 24 shad were captured over a period of three days beginning June 11,

2002. None of the tagged shad were ever observed either in the fishway or in the river adjacent to the fishway. However, during the 2003 shad migration, one of these tagged shad was captured June 23, 2003 at the Cataract fishway on the Saco River 40 miles south of the Androscoggin. The shad appeared healthy and was released above the fishway into the Saco River.

Radio telemetry equipment used during the 2003 American shad study was set up and tested on June 18, 2003. Doug Royer of Normandeau Associates was hired by FPLE to set up and test the equipment prior to the study. The gain settings on the radio receivers were set to avoid more than one receiver logging tag data from the same tag during the same time period. Also, by adjusting the receiver gains we were able to define the coverage area relatively easily. Coverage outside the fishway was limited to an area 15' from the location of the river camera location and coverage at the fishway entrance was restricted to 15' in front of the fishway entrance. Radio receivers attached to antennas located in fishway pools 0, 6, 23 and the fish traps were calibrated to pick up radio signals only in their respective pools.

Beginning June 19, the first two American shad were captured, tagged, and released at the Brunswick fishway. On July 20, eight additional shad were tagged and released. A total of seven males and three females were tagged over the two-day period. 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 94 – 103 and were recorded as such by the radio receivers.

Seven of the ten tagged shad spent little time in the study area. Most of these shad dropped out of the study area within an hour of being tagged. Three of the study shad spent large blocks of time in the study area. Shad #97, a male, spent six days in the study area. Shad #101, a female, spent 13 days in the study area. Shad #103, a male, spent five days in the study area.

In general, these three tagged shad made several attempts to enter and progress through the fishway during the period they were in the study area. They routinely passed within 15' 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 8 P.M. and returning to the study area between 4 and 6 A.M. On one occasion, shad #97 spent the night in the fishway, progressing at least as far as pool 6 and perhaps beyond. Shad #97 attempted to climb the fishway at least 50 times during the six days it was in the study area. During the days the shad were in the study area, it was not uncommon for them to disappear for 1 - 2 hours at a time before being picked up again by a receiving unit. 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 tracked in the study area displayed unique types of behavior during the relatively short time we were able to study them (Figures 10-12). Shad #97, a male, would enter the diffusion chamber early in the morning and later in the evening, but spend less time in the study area during the mid-day. Shad #101, a female, spent blocks of time in the river and in the vicinity of the fishway entrance and lower fishway. This fish tended to show up early in the morning and spent most of the time we tracked it circling the tailrace, entering the diffusion chamber, and attempting to progress through the fishway. This was the most persistent fish we observed in terms of the number of attempts to progress through the fishway, at least 91 times during the 13 days she was in the study area. This total may be higher, but we were unable to split out behavior recorded within the ten-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, but that is speculation based on the behavior of one fish. Shad #103, a male, spent most of its time in the tailrace during the mid-day. Although the shad was present at times in the morning and afternoon and passed within the vicinity of the fishway entrance during these occasions, a large portion of the shad's time was spent circling in the tailrace. This shad attempted to progress through the fishway at least 31 times during the five days the shad was monitored in the study area.

Figure 10. Total number of events recorded by location and hour of day for shad number 97 tagged during the 2003 Brunswick fishway radio telemetry study.

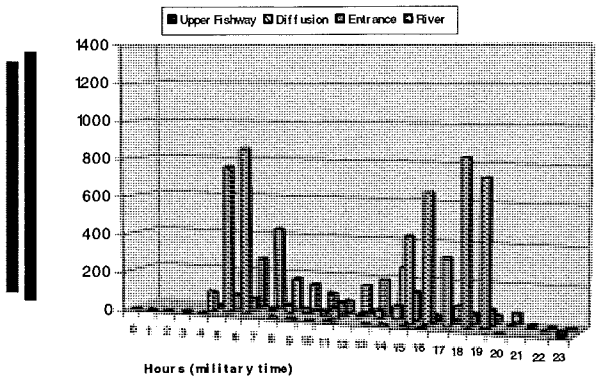


Figure 11. Total number of events recorded by location and hour of day for shad number 101 tagged during the 2003 Brunswick fishway radio telemetry study.

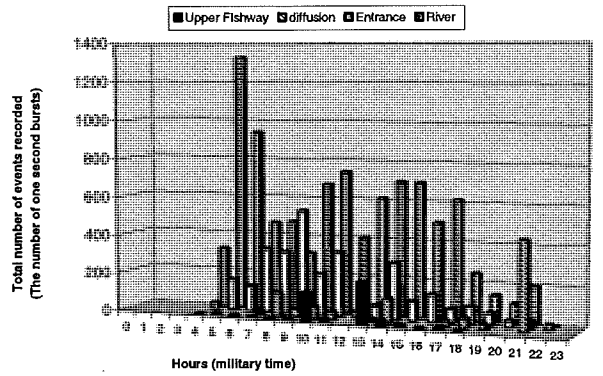
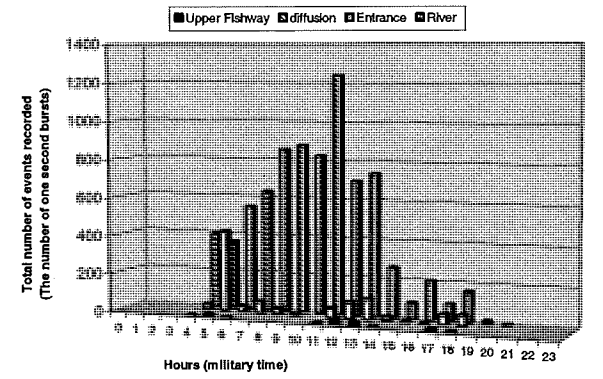


Figure 12, Total number of events recorded by location and hour of day for shad number 103 tagged during the 2003 Brunswick fishway radio telemetry study.



On four occasions - July 2, 12, 20 and August 10 - 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 once a week for four weeks. Contact with study fish was never made outside the study area on any of the sample trips. On July 12 and August 10, the entire Merrymeeting Bay complex was surveyed using the mobile receiver. The Androscoggin, Cathance, Muddy, Kennebec, and Eastern Rivers were searched without success.

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 ten-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. This option would prevent 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 have returned to the study area over the last two years (3 of 20), it is difficult to draw any conclusions based solely on the results of the radio telemetry study itself. The three shad that were monitored in the study area displayed different types of behaviors, some which may be sex dependent. 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 and10 P.M., although we did see one shad spend the night in the fishway. 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 three radio tagged shad – shad willing 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 2004:

During the 2004 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 32 sea-run salmon are captured annually at Brunswick, although Atlantic salmon returns have been below six salmon annually since 1996 (Table 14). During the 2003 sample season, a total of three Atlantic salmon were passed into the Brunswick headpond. The mean fork length of adult salmon captured was 724 mm. There were no visible fin clips or other identifying characteristics observed on any of these fish (Table 15). 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, conducted by the MASC, determined that all three scale samples were unique, showing indications that these salmon may have been aquaculture-raised. An investigation to the origin of these three salmon is being conducted by the MASC.

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 - 2003. 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 2003 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 2003, 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 - 2003.

Sea Lamprey:

Six sea lamprey were captured at the fishway in 2003. 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:

American eels were not captured in the fishway trap during 2003. 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 2003, four striped bass were captured at the Brunswick fishway. Eight were captured in 2002. None were captured or observed in the observation window/trapping area during the 2001 season.

Other Species:

From May 6 through October 22, 2003, 11 fish species and 53,993 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 2003, 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 2003 sample season is provided in Table 16.

Environmental Data:

Brunswick fishway air temperature, water temperature, and river flow data recorded from May through October 2003 are shown in Tables 18-23 and Figures 13-18.

Table 1. Adult river herring captured, water temperature and river flow at the Brunswick fishway, 2003

Date	Number	Temp. (C)	Water Flow (cfs)	% Total Run
12-May	4	12.6	6,550	0.01%
13-May	142	11.6	6,550	0.26%
14-May	159	11.7	5,649	0.30%
15-May	137	12.1	6,460	0.25%
16-May	35	12.1	7,050	0.07%
20-May	1,319	14.0	5,350	2.45%
21-May	7,181	14.6	4,400	13.36%
22-May	6,726	14.3	4,460	12.52%
23-May	6,240	14.2	4,350	11.61%
24-May	7,171	14.3	3,600	13.35%
26-May	3,788	14.3	2,950	7.05%
27-May	1,768	14.4	4,660	3.29%
28-May	672	14.7	4,940	1.25%
29-May	742	15.0	4,890	1.38%
30-May	3,193	15.2	5,840	5.94%
2-Jun	10,300	15.2	4,680	19.17%
3-Jun	3,821	15.5	3,140	7.11%
5-Jun	100	16.9	3,550	0.19%
9-Jun	231	17.1	4,480	0.43%
12-Jun	3	17.9	4,020	0.01%
03 Total/Ave.	**53,732**	**14.4**	**4,878**	**1.00**

Note: Flow Data from USGS Station 01059000 at Auburn, ME

Table 2. Adult river herring habitat availability, number captured and distribution in Androscoggin River watershed lakes and ponds, 1985 - 2003

Year	Habitat* (hectares)	Run Size	Total No. Stocked (Androscoggin and Kennebec)	Ave. 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

* Habitat area does not include the Brunswick headpond.

Table 3. Adult river herring distribution in the Androscoggin River watershed by site, 2001 – 2003

Source: Androscoggin / Kennebec

Habitat	2001	2002	2003
Sabattus Pond	1,575 / 9,176	0 / 10,695	10,700 / 0
Little Sabattus Pond	344 / 0	-	200 / 0
Taylor Pond	0 / 4,099	1,477 / 3,018	3,750 / 0
Taylor Brook	126 / 0	0 / 200	100 / 0
Tripp Pond	-	-	-
Lower Range Pond	1,274 / 615	0 / 3,104	1,740 / 0
Androscoggin River	13,375 / 0	100,361	29,420 / 0
Sabattus River	0 / 3,587	0 / 2,000	2,000 / 0
Marshall Pond	612 / 0	0 / 1,881	612 / 0
Bog Brook	671 / 0	0 / 399	690 / 0
Durham Boat Ramp	13 / 0	-	-
Loon Pond/Curtis Stream	0 / 609	-	-
Sutherland Pond/Curtis Stream	0 / 758	516 / 0	-
No Name Pond	-	-	600 / 0
TOTAL	**17,990 / 18,844 = 36,834**	**102,354 / 21,297 = 123,651**	**49,812 / 0 = 49,812**
Brunswick Headpond (passed upstream)	13,375 / 0	100,361 / 0	29,420 / 0
TOTAL PASSED OR STOCKED IN THE WATERSHED	**17,990 / 18,844 = 36,834**	**102,354 / 21,297 = 123,651**	**49,812 / 0 = 49,812**

Table 4. Adult river herring stocking densities, 2001 - 2003

Habitat	Hectares	2001 Densities (fish/hectares)	2002 Densities (fish/hectares)	2003 Densities (fish/hectares)
Sabattus Pond	723	14.9	14.8	15.0
Little Sabattus Pond	10	34.4	-	15.0
Taylor Pond	253	14.2	15.0	15.0
Taylor Brook	5	25.2	40.0	15.0
Tripp Pond	-	-	-	-
Lower Range Pond	117	16.1	15.0	15.0
Androscoggin River	473	-	-	-
Sabattus River	111	32.3	18.0	15.0
Marshall Pond	41	14.9	22.4	15.0
Bog Brook	24	28.0	16.6	15.0
Durham Boat Ramp	-	0.1	-	-
Loon Pond	28	21.8	-	-
No Name Pond	40	-	-	15.0
Sutherland Pond	21	36.1	24.6	-
Average		**21.6**	**15.7**	**15.0**
Total	**1,846**			

* Target stocking level is 14.83 fish/hectare (1 hectare = 2.471 acres) or 6 fish/acre

Table 5. Adult river herring sampled at the Brunswick fishway, 2003

Date	Sex	No.	Ave. Total Length (mm)	Ave. Fork Length (mm)	Ave. Weight (gm)
5/14/2003	F(32%)	8	302.6	267.1	238.7
	M(68%)	17	288.9	253.7	198.2
5/16/2003	F(38%)	10	292.5	259.0	215.0
	M(62%)	16	284.5	251.0	208.1
5/27/2003	F(47%)	24	286.3	252.6	190.9
	M(57%)	27	277.4	244.5	169.0
6/7/2003	F(54%)	27	282.6	249.0	183.4
	M(46%)	23	273.8	241.7	159.7

	Total Number	Ave. Total Length(mm)	Ave. Fork Length(mm)	Ave. Weight (gm)
Female	69	287.6	253.8	197.0
Male	83	280.1	246.9	179.9
Combined	152	283.5	250.0	187.7

Table 6. Ages of alewives sampled at the Brunswick fishway in 2003

	Number	Ave. TL (mm)	Ave. FL (mm)	Ave. Wt (g)	%M	%F	%U	% of Sample
Age 3 Alewives	1	270.0	233.0	165.2	0%	100%	0%	0.65%
Males								
Females	1	270.0	233.0	165.2				
Age 4 Alewives	97	280	247	182	57%	43%	0%	63.82%
Males	55	276	243	176				
Females	42	284	251	189				
Age 5 Alewives	50	289	255	201	52%	48%	0%	32.89%
Males	26	285	251	191				
Females	24	293	259	211				
Age 6 Alewives	4	286	253	199	50%	50%	0%	2.63%
Males	2	287	252	194				
Females	2	285	253	205				

Table 7. American shad observations at the Brunswick fishway, 1999 - 2003

Year / Month	Viewing Windows	Upper Fishway	Lower Fishway	Corner Pool	Outside Fishway	Total #	Mean Water Temp. (C)[1]
2003 May	0	0	0	0	0	0	13.2
June	0	0	118	8	19	145	18.9
July	0	0	20	0	134	154	24.2
August	0	0	0	0	0	0	23.8
2002 May	0	0	0	0	0	0	11.8
June	1	0	31	3	68	103	17.4
July	0	0	67	1	336	404	23.6
August	0	0	0	0	4	4	24.3
2001 May	0	0	0	0	0	0	15.3
June	3	0	61	0	176	240	20.1
July	0	0	0	0	0	0	23
August	0	0	0	0	0	0	24.6
2000 May	0	0	0	0	0	0	0
June	21	17	169	106	22	335	18.7
July	3	4	6	4	0	17	22.5
August	0	0	0	0	0	0	0
1999 May	16	0	5	15	5	41	19.4
June	38	0	73	218	150	479	22.9
July	0	0	1	5	0	6	25.0
August	0	0	0	0	0	0	26.1

Total	82	21	551	360	914	1928	

Table 8. American shad captured at the Brunswick fishway, 2001-2003

Date	No.	Water Temperature (C)	River Flow (cfs)
6/9/2003	1	17.1	4,480
6/14/2003	1	18.5	3,390
6/19/2003	1	18.0	5,709
7/1/2003	1	24.0	2,300
7/10/2003	2	24.3	2,200
8/8/2003	1	23.9	4,520
Total #	**7**		
Mean		**21**	**3,767**
Min / Max	**1 / 2**	**17.1 / 24.3**	**2,200 / 5,709**
6/5/2002	6	18.4	7,190
6/7/2002	1	17.3	8,740
7/18/2002	4	23.3	3,220
Total #	**11**		
Mean		**17.9**	**6,383**
Min / Max	**1 / 1**	**17.3 / 23.3**	**3,220 / 8,740**
5/25/2001	1	16.9	4,750
5/29/2001	9	16.5	4,580
6/3/2001	2	15.2	7,530
6/8/2001	1	16.4	6,860
6/13/2001	1	19.1	3,350
6/14/2001	2	20.2	4,100
6/15/2001	6	22.2	4,110
6/18/2001	1	22.8	3,140
6/22/2001	1	22.2	3,469
7/18/2001	1	22.2	3,030
7/19/2001	1	22.3	2,940
Total #	**26**		
Mean		**19.6**	**4,351**
Min / Max	**1 / 9**	**15.2 / 22.8**	**2,940 / 7,530**

Table 9. Adult American shad distribution in main stem Androscoggin River at Auburn, 1985 - 2003

Year	Number Distributed		Source		Mortality During Transport
		Androscoggin	Connecticut	Merrimack	
2003	424	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	**6,723**	**235**	**5,374**	**1,116**	**18.8%**

Table 10. Adult American shad captured at the Brunswick fishway, May – October 2003

Date	Total / Fork Length (mm)	Weight (kg)	Sex	Condition	Sample
9-Jun	-	-	U	descaled	-
14-Jun	470 / 405	-	U	descaled	scale / genetic
16-Jun	461 / 407	-	M	descaled	scale / genetic
1-Jul	495 / 435	-	M	dead	scale / genetic
10-Jul	440 / 382	-	M	good	scale / genetic
10-Jul	400 / 342	-	M	good	scale / genetic
9-Aug	-	-	M	good	-
Mean	**445 / 387**				
Number Males / Females / Unknown: 5 / 0 / 2					

Table 11. Ages of American shad sampled at the Brunswick fishway in 2003

	Number	Ave. TL (mm)	Ave. FL (mm)	Ave. Wt (g)	%M	%F	%U	% of Sample
Age 3 Shad	*	*	*	*	*	*	*	*
Males								
Females								
Age 4 Shad	*	*	*	*	*	*	*	*
Males								
Females								
Age 5 Shad	4	457	384	*	100%	0%	0%	80%
Males	4	457	384					
Females								
Age 6 Shad	1	495	435	*	100%	0%	0%	20%
Males	1	495	435					
Females								
Age 7 Shad	*	*	*	*	*	*	*	*
Males								
Females								

Table 12. Juvenile American shad sampled at Brunswick fishway, 2003

Date	Total Length (mm)	Fork Length (mm)	Weight (g)	Water Temp (c)	River Flow (cfs)
28-Aug	74	66	2.8	21.7	1,870
28-Aug	82	73	4.4	21.7	1,870
28-Aug	81	73	4.0	21.7	1,870
28-Aug	77	68	3.4	21.7	1,870
28-Aug	70	62	2.2	21.7	1,870
29-Aug	52	45	0.7	21.7	2,230
Average	72.7	64.5	2.9	21.7	1,930
10-Sep	81	73	3.6	20.5	2,340
10-Sep	83	74	3.8	20.5	2,340
Average	82.0	73.5	3.7	20.5	2,340

Table 13. American shad fry released into the main stem Androscoggin River at Auburn, 1999 - 2003

Date	Source	No. Released	Age	% Mortality	Loading Site Temp.(C)	Receiving Site Temp. (C)	Marking Method
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*
7/2/2001	Merrimack	308,600	23 - 26 days old	~1%	18.0	23.4	Tetra-cycline*
7/10/2000	CT x Kennebec	529,000	7 to10 days old	~5%	18.7	25.0	Tetra-cycline*
6/30/1999	CT x CT and CT x Saco	280,000	10 to 17 days old	~2.4%	17.3	24.7	Tetra-cycline*

* Fry were exposed to a four hour tetracycline bath at the Waldoboro hatchery.

Table 14. Number, mean length and origin of sea-run Atlantic salmon returning to the Androscoggin River and captured at the Brunswick fishway 1983 - 2003

	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	*	*	*	*	*	*	*	*	718	3
Total	**29**	**513**	**6**	**2**	**5**	**81**	**2**	**1**		**642**

Data source: U.S. Atlantic Salmon Assessment Committee Annual Report 1998/10

SW - # Sea Winters/number of years at sea
Repeat - repeat spawner
TL - total length measured; all others are fork length
* - Data unavailable

Note: 1998 average fork length differs from Table 10 because total length data were used where fork lengths were not available

Table 15. Atlantic salmon passed upstream on the Androscoggin River at the Brunswick fishway, May – October 2003

Date	Fork Length (mm)	Total Length (mm)	Clips/Marks	Water Temp. (C)
25-Jun	718	745	none	21.5
23-Jul	680	693	none	23.8
30-Sep	775	766	none	18.4
Total no. of fish	**3**			
Average	**724**	**735**		**21.2**
Min. T° (C)				**18.4**
Max. T° (C)				**23.8**

Table 16. Numbers of fish captured by month at the Brunswick fishway during the 2003 sample season

	May	June	July	August	September	October	Species Total
American Eel (*Anguilla rostrata*)							0
American Shad (*Alosa sapidissima*)		3	3	7	2		15
Atlantic Salmon (*Salmo salar*)		1	1		1		3
Brook Trout (*Salvelinus tontinalis*)	2						2
Brown Trout (*Salvelinus trutta*)	1						1
Common shiner (*Notropis cornutus*)		1					1
Largemouth Bass (*Micropterus salmoides*)							0
Pumpkinseed Sunfish (*Lepomis gibbosus*)				1			1
River Herring (*Alosa aestivalis*)(*Alosa pseudoharengus*)	39,297	14,458		1	8	51	53,815
Smallmouth Bass (*Micropterus dolomieu*)	4	23	3	3	2		35
Spottail Shiner (*Notropis hudsonius*)			1				1
Striped Bass (*Morone saxatilis*)			2	1			3
White Catfish (*Ictalurus catus*)							0
White Perch (*Morone americana*)							0
White Sucker (*Catostomus commersoni*)	56						56
Unitentified Fry							0
Monthly Totals	39,360	14,486	10	13	13	51	53,933

Table 17. Brunswick fishway air and water temperatures and headpond levels during May 2003

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	Flow(cfs)
1	-	-	-	8,510
2	-	-	-	7,970
3	-	-	-	9,990
4	-	-	-	14,700
5	-	-	-	12,000
6	-	-	-	9,240
7	12.2	10.3	40.5	7,710
8	9.2	11.2	40.0	6,690
9	7.3	11.7	39.0	6,450
10	12.3	11.2	39.0	6,550
11				6,460
12	7.4	12.6	39.0	6,550
13	6.6	11.6	39.0	6,550
14	8.2	11.7	39.0	5,649
15	10.7	12.1	39.0	6,460
16	7.1	12.1	39.5	7,050
17	15.8	13.6	39.0	6,370
18				5,860
19	18.2	13.7	39.0	5,669
20	13.3	14.0	39.0	5,350
21	14.2	14.6	39.0	4,400
22	11.2	14.3	38.5	4,460
23	9.6	14.2	38.5	4,350
24	7.3	14.3	38.5	3,600
25				3,540
26	12.2	14.3	37.5	2,950
27	11.0	14.4	39.0	4,660
28	13.0	14.7	38.5	4,940
29	11.3	15.0	39.0	4,890
30	15.7	15.2	39.0	5,840
31				5,930
Mean	**11.1**	**13.2**	**39.0**	**6,495**

Table 18. Brunswick fishway air and water temperatures and headpond levels during June 2003

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	Flow(cfs)
1				5,920
2	17.7	15.2	38.5	4,680
3	14.7	15.5	38.5	3,140
4				2,510
5	12.1	16.9	39.0	3,550
6	15.0	16.5	38.5	2,720
7	16.5	17.5	38.5	3,230
8				4,120
9	13.9	17.1	39.0	4,480
10	15.8	16.5	38.0	4,100
11	16.6	18.6	39.0	3,580
12	18.6	17.9	37.5	4,020
13	15.5	18.5	38.0	3,930
14	13.8	18.5	38.0	3,390
15				7,670
16	13.5	18.4	41.0	9,870
17	14.0	18.7	41.0	8,169
18	15.8	18.8	39.0	6,969
19	14.8	18.0	39.0	5,709
20	17.4	18.7	39.0	4,100
21				1,800
22	18.6	19.8	38.5	1,770
23	15.6	19.7	38.5	3,560
24	17.8	20.1	37.5	2,290
25	19.7	20.5	38.5	2,190
26	23.0	21.3	38.0	2,100
27	21.9	22.5	38.0	2,700
28	24.9	23.9	39.0	2,340
29				2,470
30	19.4	23.3	37.5	2,960
Mean	**16.9**	**18.9**	**38.6**	**4,001**

Table 19. Brunswick fishway air and water temperatures and headpond levels during July 2003

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	Flow (cfs)
1	21.0	23.1	37.5	2,300
2	19.4	22.9	38.0	2,290
3	19.0	22.9	37.0	2,330
4	26.6	24.0	38.0	2,590
5	-	-	-	2,610
6	28.9	25.4	38.0	2,110
7	25.1	25.1	38.0	2,200
8	18.3	25.7	38.0	2,250
9	22.2	25.6	38.5	2,240
10	16.4	24.3	38.5	2,200
11	16.3	24.1	38.5	1,830
12	-	-	-	1,850
13	24.0	22.6	39.0	2,110
14	17.5	22.6	39.0	2,410
15	17.8	23.3	38.0	2,570
16	17.0	24.0	38.0	2,270
17	-	-	-	2,030
18	18.9	23.3	38.5	2,130
19	-	-	-	1,850
20	22.2	23.5	38.0	1,810
21	20.6	23.7	38.0	2,230
22	20.3	23.5	38.0	1,780
23	20.3	23.8	38.5	1,870
24	20.5	23.5	38.5	2,440
25	19.6	23.4	38.5	2,670
26	18.4	23.7	37.5	2,340
27	-	-	-	2,300
28	19.8	23.9	38.0	1,870
29	18.5	23.7	38.5	2,380
30	18.7	23.3	38.5	2,150
31	17.9	23.4	38.0	2,280
mean	**20.2**	**23.8**	**38.2**	**2,203**

Table 20. Brunswick fishway air and water temperatures and headpond levels during August 2003

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	Flow(cfs)
1	18.0	23.9	38.5	2,310
2				2,030
3				1,900
4	24.5	22.5	38.5	2,410
5	24.7	22.9	38.5	2,450
6	25.7	23.8	38.0	3,750
7	25.8	24.3	39.0	6,060
8	21.8	23.6	39.0	5,510
9	21.9	23.8	39.0	4,520
10				4,550
11	38.2	24.7	39.0	8,450
12	23.5	24.0	41.0	9,050
13	27.0	23.3	39.0	6,570
14	26.1	23.7	38.5	5,100
15	24.2	24.4	38.5	5,000
16				4,010
17				3,810
18	24.9	23.9	38.5	1,950
19	28.8	24.0	39.0	2,610
20	21.2	23.6	38.0	2,240
21	27.8	24.4	38.5	2,660
22	23.4	25.9	38.5	4,020
23				1,840
24				1,850
25	20.3	22.7	38.5	1,840
26	22.9	22.6	38.0	1,860
27	28.3	22.1	39.0	1,840
28	18.4	21.7	38.5	1,870
29	18.5	21.7	38.5	2,230
30				1,830
31				1,840
Mean	**24.4**	**23.5**	**38.7**	**3,483**

Table 21. Brunswick fishway air and water temperatures and headpond levels during September 2003

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	Flow(cfs)
1				1,830
2	18.4	21.1	38.5	1,800
3	11.4	20.6	39.0	2,650
4	22.5	20.3	38.5	2,440
5	23.1	20.9	38.0	3,350
6				2,720
7				2,690
8	13.7	20.7	38.0	2,810
9	18.1	21.1	38.5	2,440
10	20.3	20.4	39.0	2,340
11	21.2	20.7	38.5	2,210
12	14.7	20.0	38.0	2,190
13				1,729
14				1,760
15	23.6	21.2	39.0	2,230
16	19.5	20.6	39.0	1,770
17	22.9	20.6	38.0	2,670
18	20.1	20.2	38.5	3,570
19	18.9	19.6	39.0	3,720
20				2,410
21				3,010
22	21.5	20.4	39.0	4,230
23	16.0	19.9	38.0	3,750
24	21.4	20.1	39.0	5,639
25	20.0	19.8	39.0	7,280
26	14.0	19.2	39.0	5,669
27				5,550
28				4,630
29	20.8	18.9	40.0	3,950
30	8.8	17.8	40.0	3,080
Mean	**18.6**	**20.2**	**38.7**	**3,204**

Table 22. Brunswick fishway air and water temperatures and headpond levels during October 2003

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	Flow(cfs)
1	14.5	17.1	40.0	3,400
2	13.5	16.3	40.5	3,920
3	4.6	15.2	41.0	3,860
4	12.8	15.0	41.0	3,930
5				4,210
6	3.2	13.9	40.5	3,489
7	11.2	13.8	41.0	4,450
8	11.5	13.5	41.0	3,920
9	8.6	13.7	41.0	3,820
10				3,780
11				3,530
12	8.2	13.3	40.5	3,380
13	10.5	13.1	40.5	3,690
14	11.4	12.8	41.0	3,910
15	15.5	12.9	41.0	6,520
16	9.8	12.5	42.0	14,599
17	9.1	12.6	41.5	13,200
18				8,440
19				6,540
20	3.5	10.8	39.5	5,649
21	3.4	10.1	40.0	6,090
22	3.6	9.8	41.0	12,000
23	Fishway closed for the season			
24				
25				
26				
27				
28				
29				
30				
31				
Mean	**9.1**	**13.3**	**40.8**	**5,742**

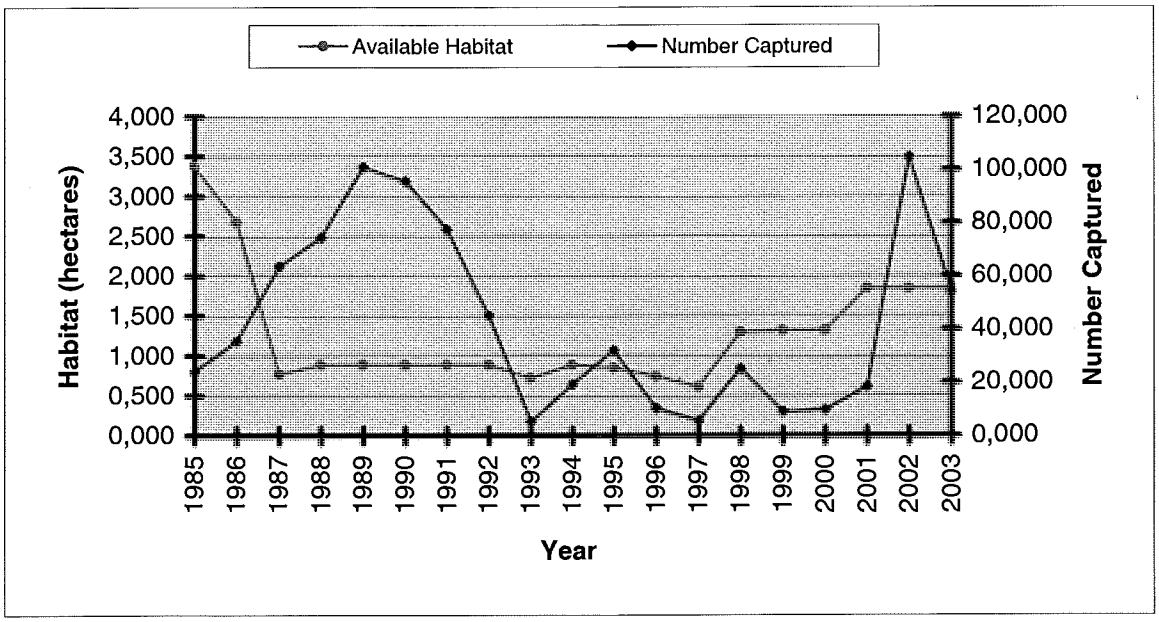


Figure 1. Adult alewife run size and habitat availability in the Androscoggin River watershed, 1985-2003

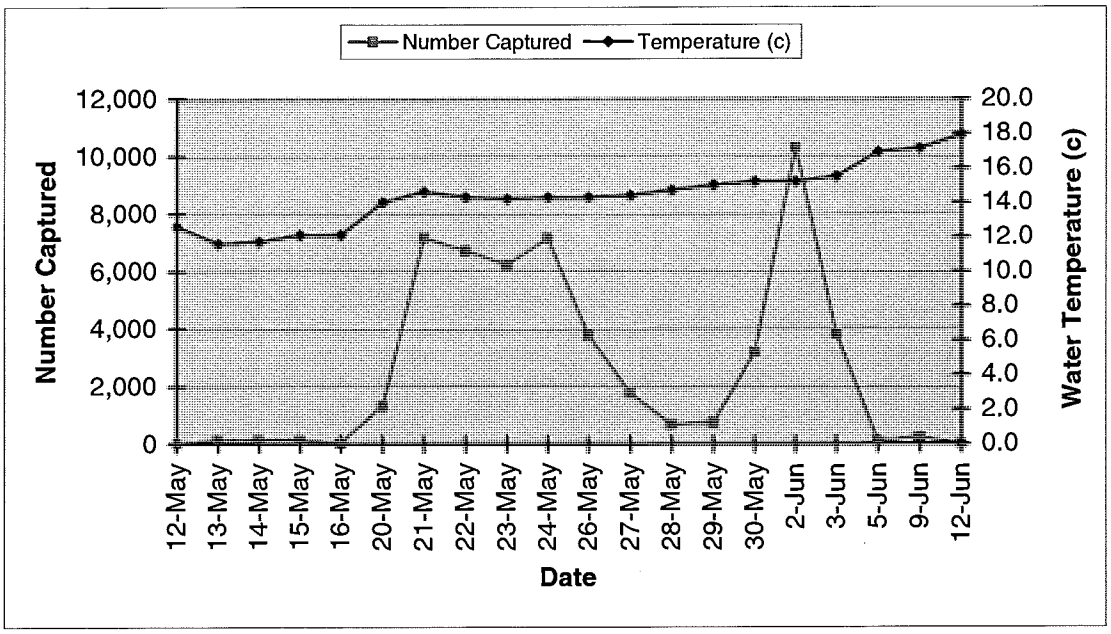


Figure 2. Number of adult river herring captured vs. water temperature at the Brunswick fishway, May – June 2003

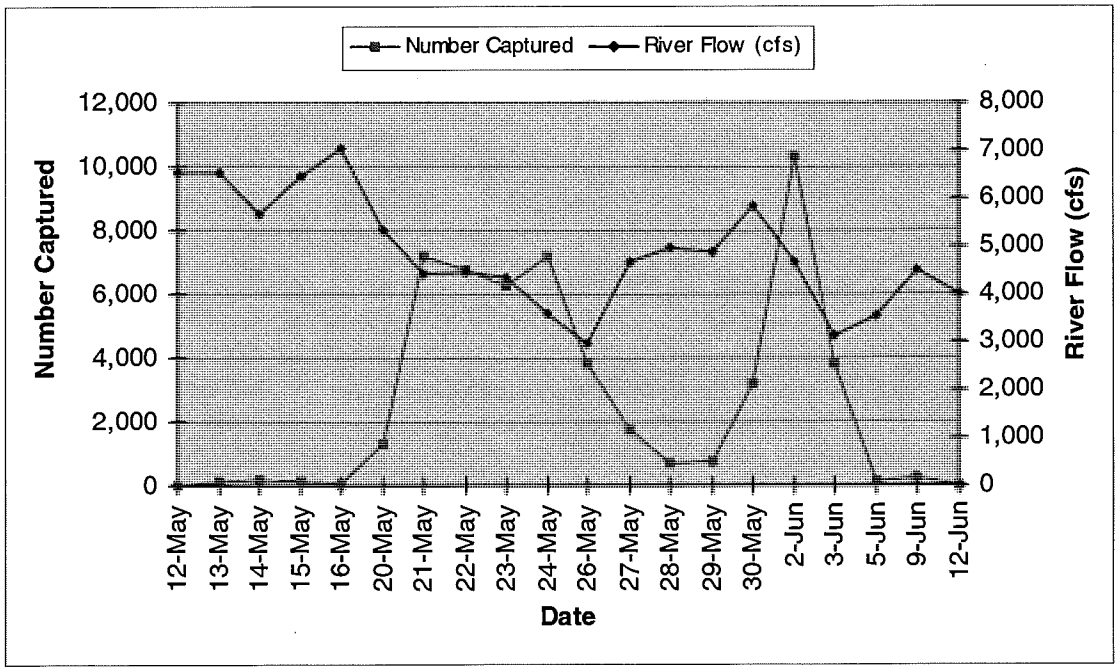


Figure 3. Number of adult river herring captured vs. river flow (cfs) at the Brunswick fishway, May – June 2003

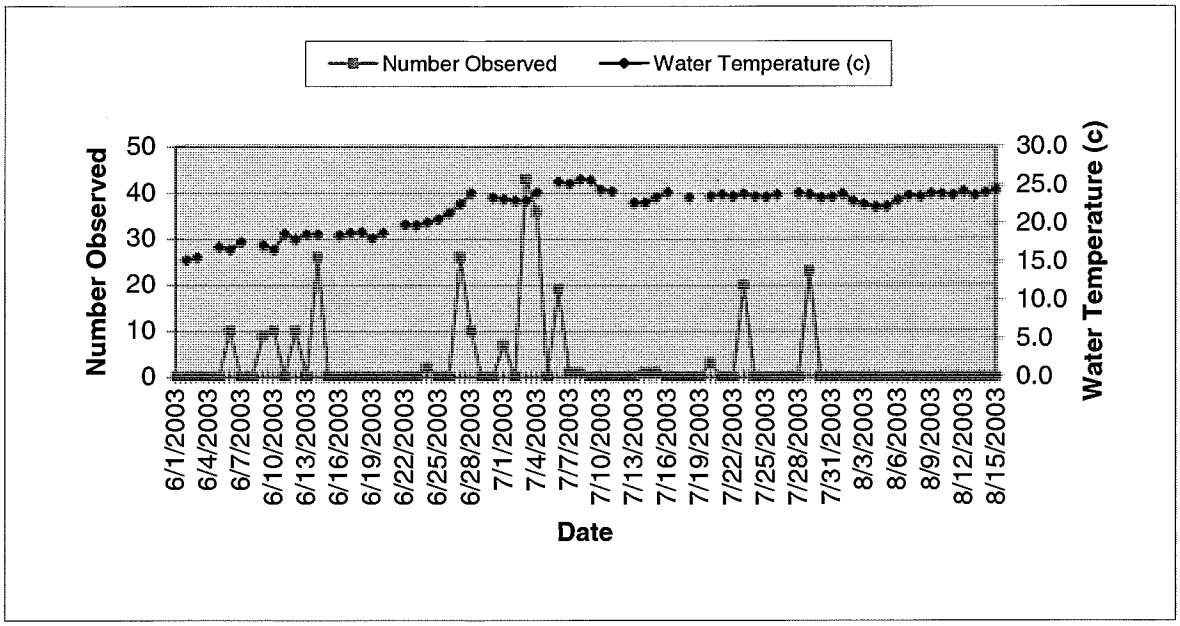


Figure 4. Number of American shad observed vs. water temperature at the Brunswick fishway, June – August 2003

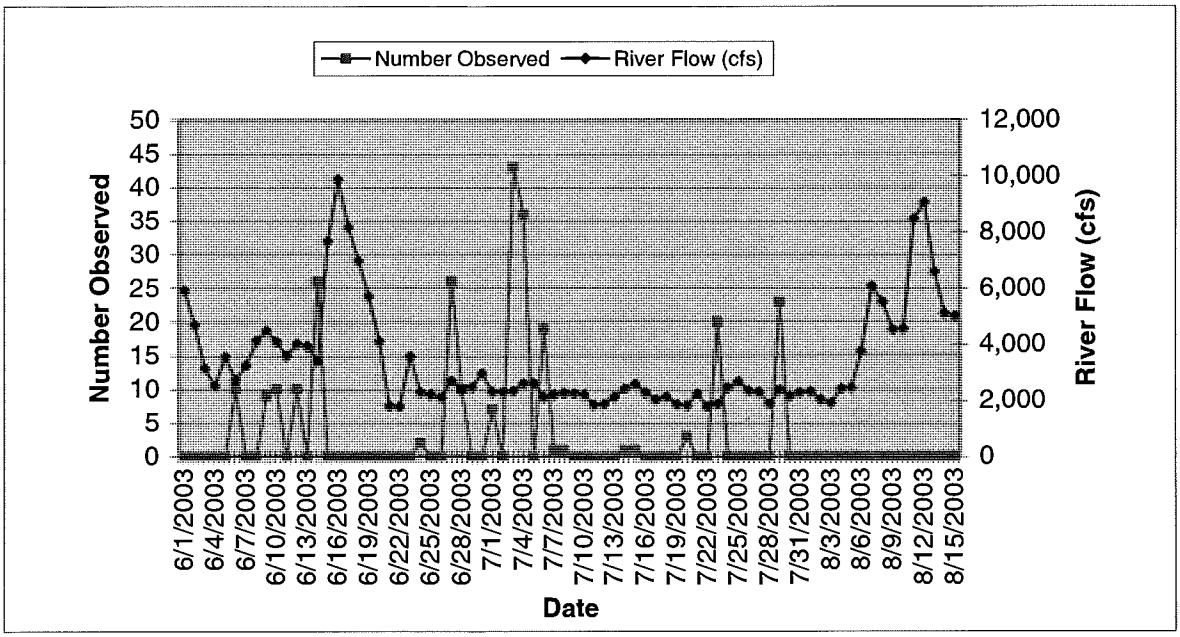


Figure 5. Number of American shad observed vs. river flow (cfs) at the Brunswick fishway, June – August 2003

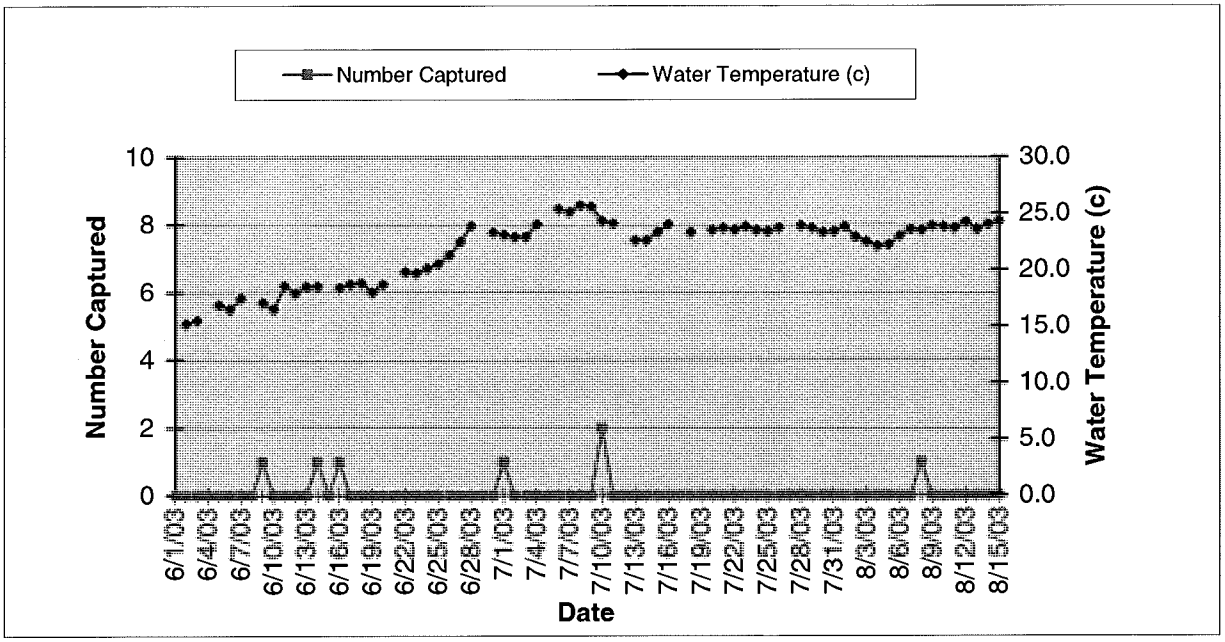


Figure 6. Number of adult American shad captured vs. water temperature at the Brunswick fishway during June – August, 2003

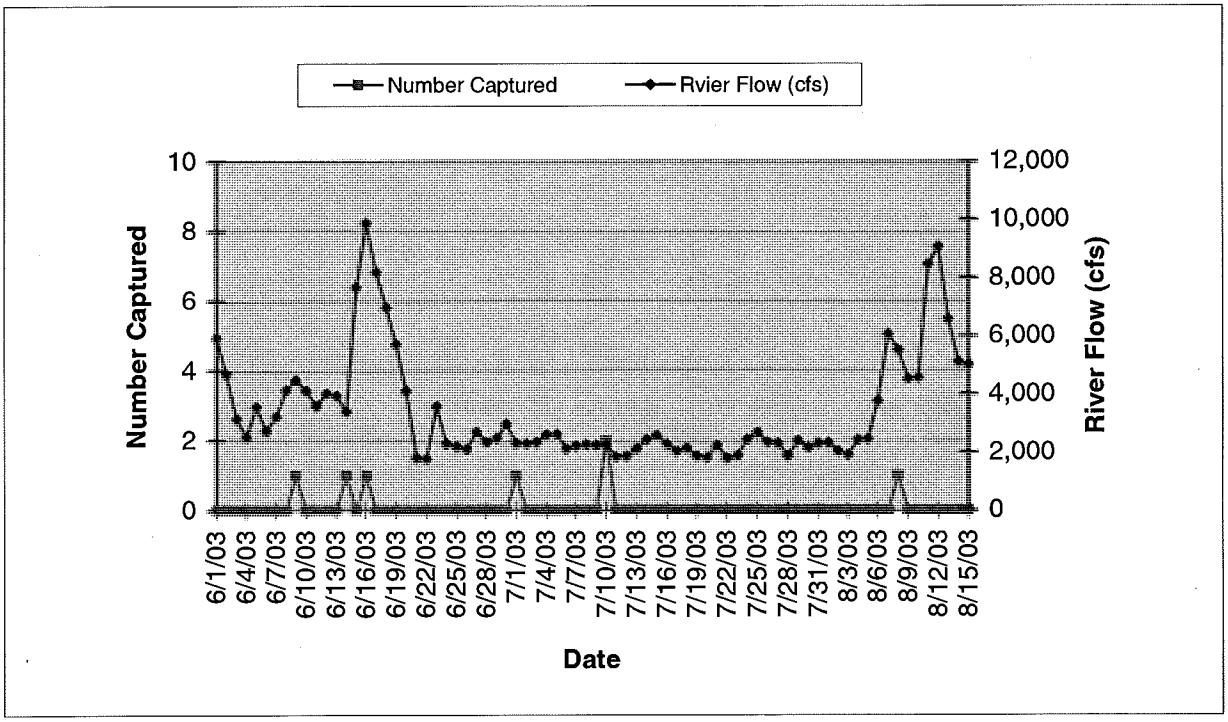


Figure 7. Number of adult American shad captured vs. river flow (cfs) at the Brunswick fishway during June – August, 2003

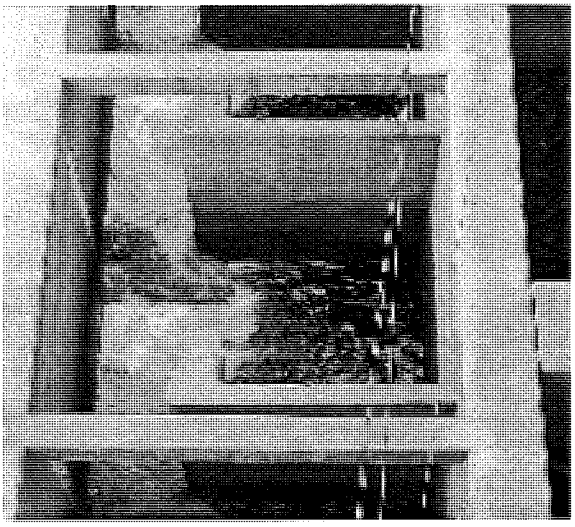


Figure 8. Modifications made by FPLE to increase the slot width and modify flow in the lower section (pools 1-6) of the Brunswick fishway to improve shad passage.

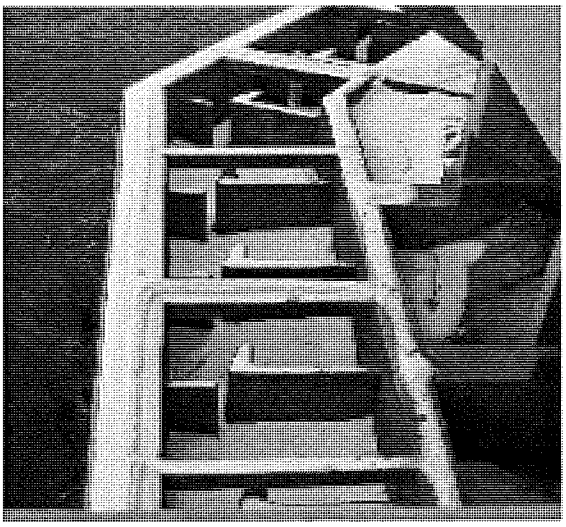


Figure 9. Existing fishway slot widths prior to modification by FPLE in November 2001.

Figure 10. Total number of events recorded by location and hour of day for shad number 97 tagged during the 2003 Brunswick fishway radio telemetry study.

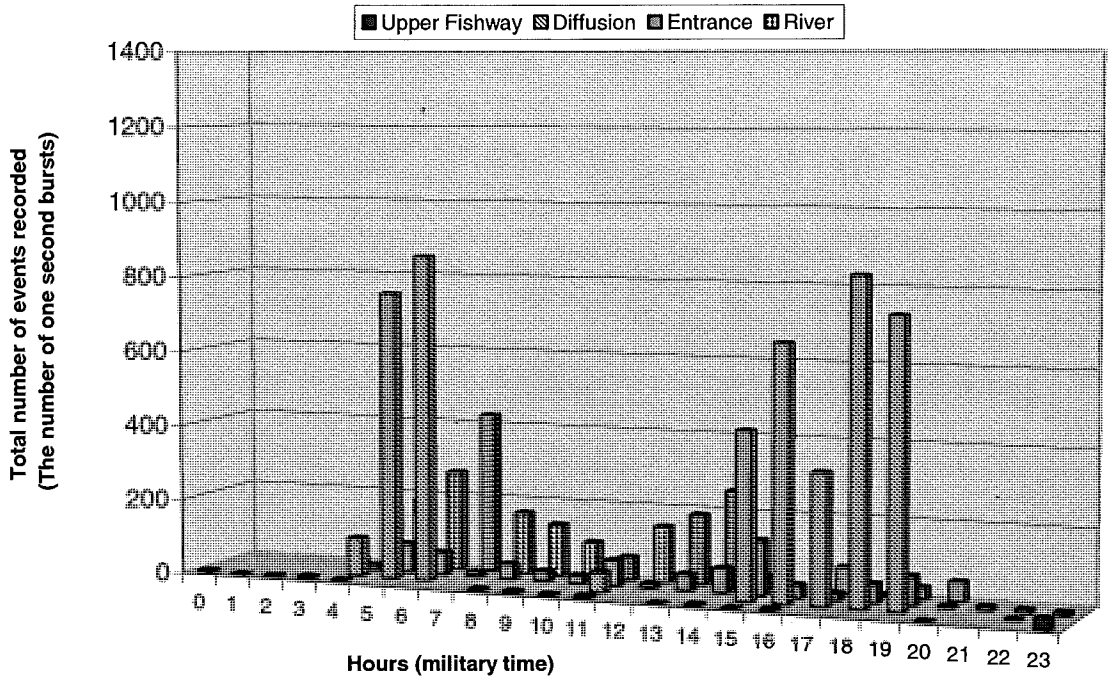


Figure 11. Total number of events recorded by location and hour of day for shad number 101 tagged during the 2003 Brunswick fishway radio telemetry study.

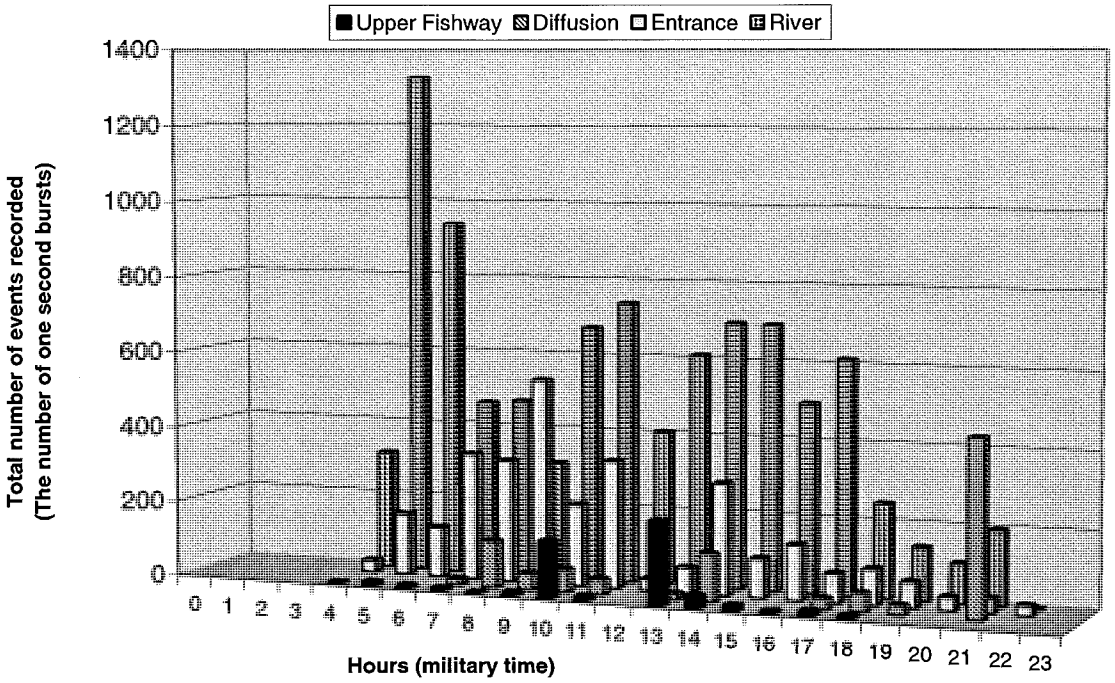
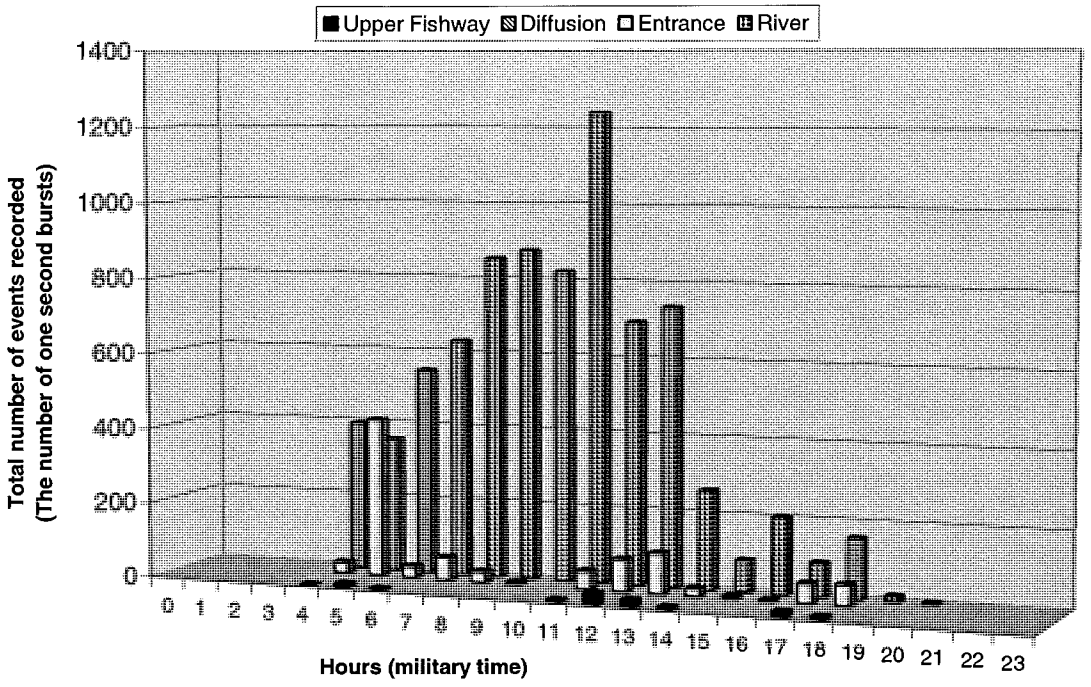


Figure 12. Total number of events recorded by location and hour of day for shad number 103 tagged during the 2003 Brunswick fishway radio telemetry study.



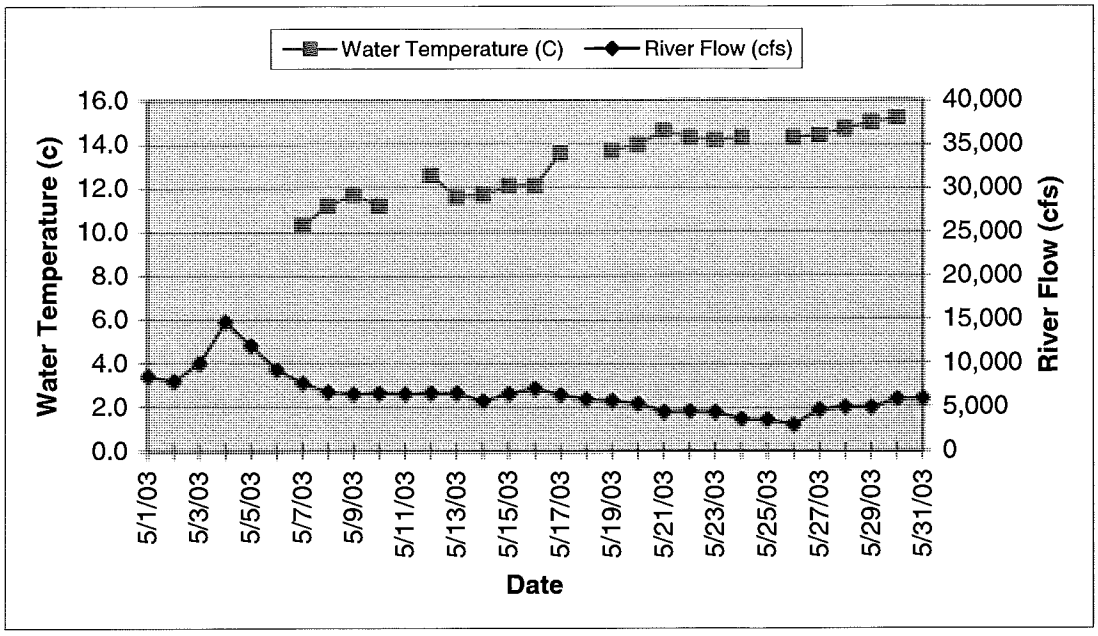


Figure 13. Water temperature and river flow (cfs) recorded at the Brunswick fishway in May, 2003

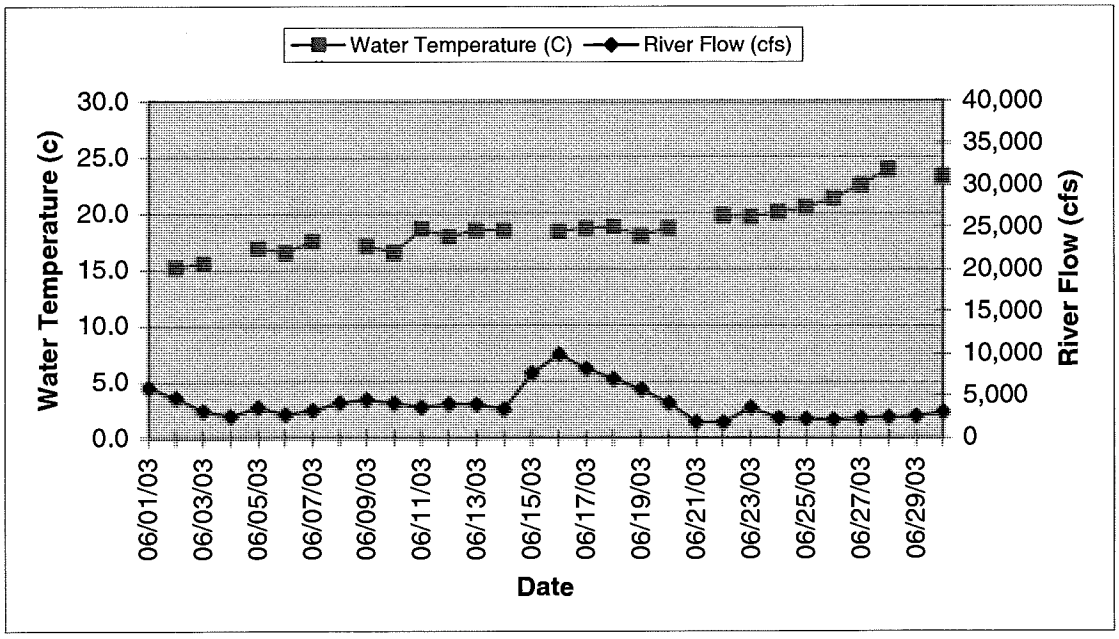


Figure 14. Water temperature and river flow (cfs) recorded at the Brunswick fishway in June, 2003

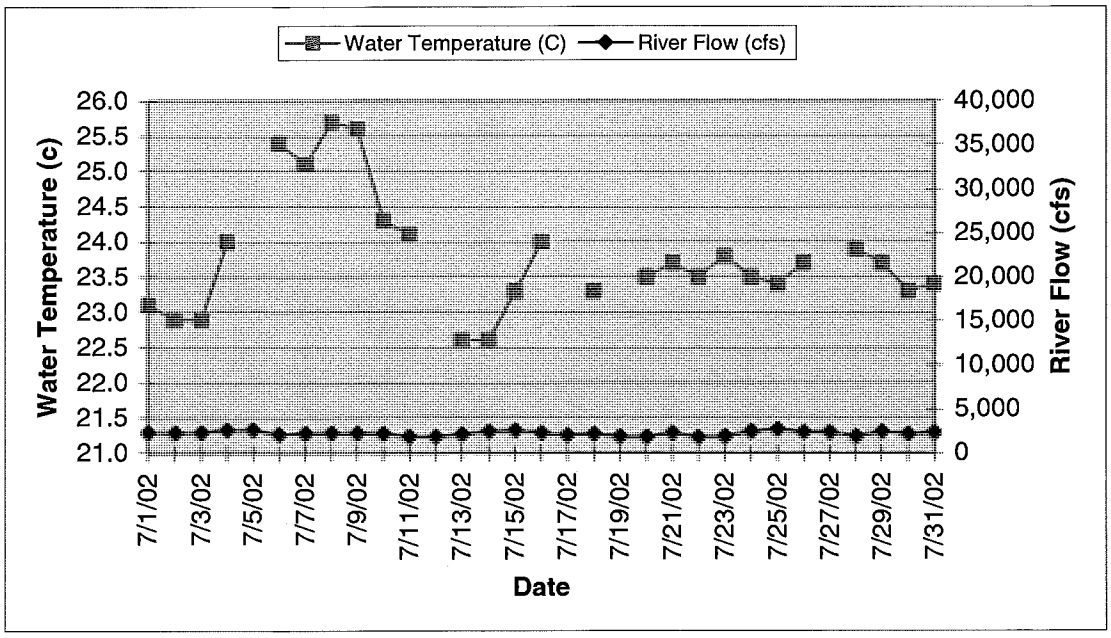


Figure 15. Water temperature and river flow (cfs) recorded at the Brunswick fishway in July, 2003

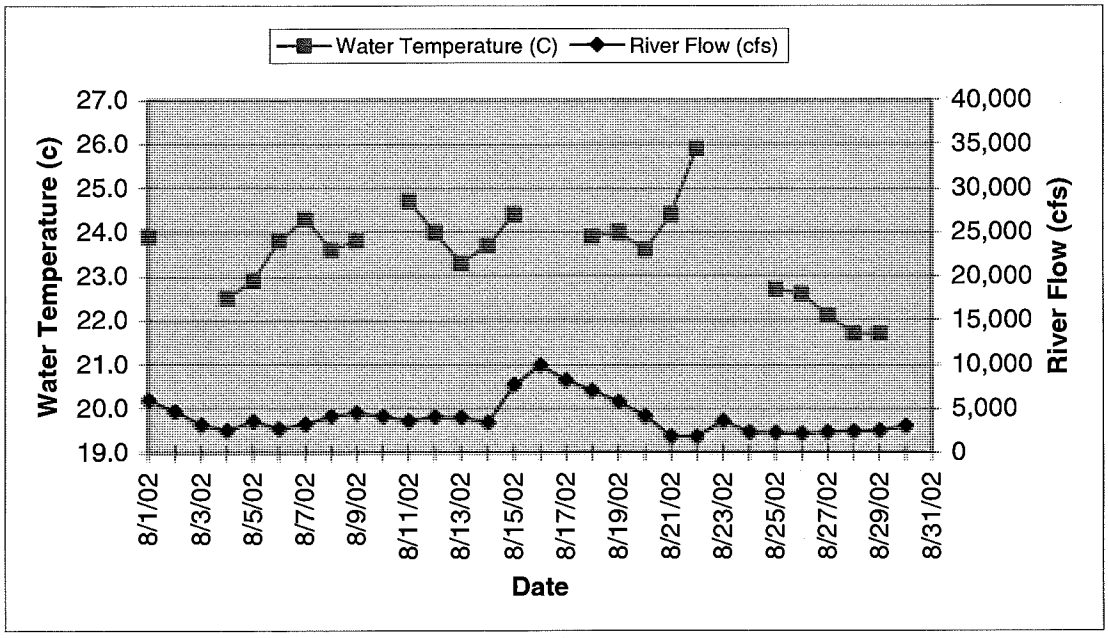


Figure 16. Water temperature and river flow (cfs) recorded at the Brunswick fishway in August, 2003

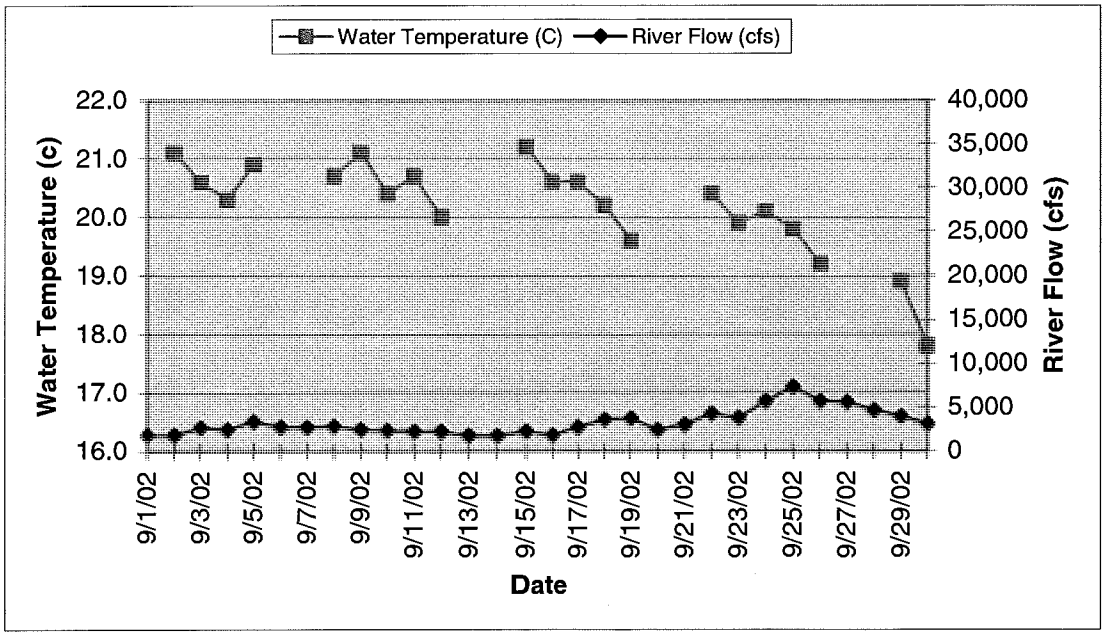


Figure 17. Water temperature and river flow (cfs) recorded at the Brunswick fishway in September, 2003

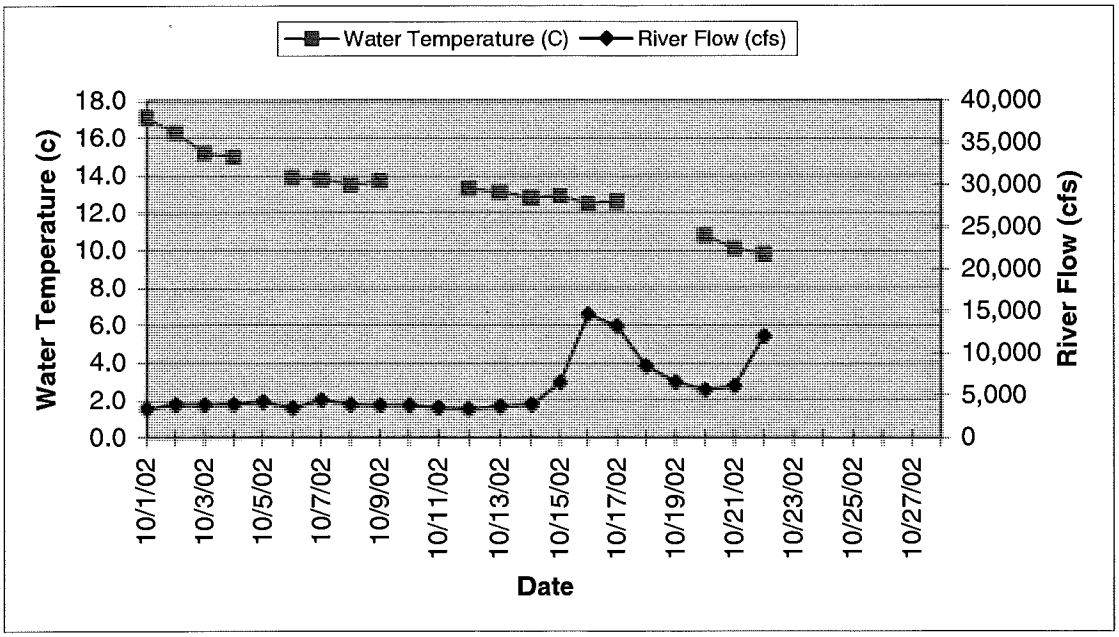


Figure 18. Water temperature and river flow (cfs) recorded at the Brunswick fishway in October, 2003

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 - 2003

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