State of Maine

Androscoggin River
Anadromous Fish Restoration Program

Department of
Marine Resources

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ANADROMOUS ALOSID RESTORATION IN THE ANDROSCOGGIN RIVER WATERSHED

Annual Report

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INTRODUCTION

The Androscoggin is Maine's third largest river. The watershed drains approximately 8,996 km^2. Historically, the Androscoggin provided access to a large and diverse aquatic habitat for great numbers of diadromous and resident fish species. For most species, the natural upstream migration barrier on the main stem of the Androscoggin River is Lewiston Falls, 35.2 rkm above tidewater. Although this site was an impassable barrier for most species, sea-run Atlantic salmon and American eel were able to ascend the falls and move upstream to Rumford, 128 rkm above Merrymeeting Bay. According to Atkins (1887)[1], Rumford Falls was an impassable barrier to migrating salmon and excluded them from New Hampshire waters of the Androscoggin River.

Alewife (*Alosa pseudoharengus)* reproduced in lake and pond habitat throughout the Androscoggin and Little Androscoggin River watersheds below Lewiston Falls, while American shad *(Alosa sapidissima)* and blueback herring (*Alosa aestivalis)* reproduced in the riverine areas of these watersheds. Fishermen caught Atlantic salmon (*Salmo salar*), which could ascend the earliest built low-head dams, in Lewiston as late as 1815. However, a dam built at head-of-tide in Brunswick in 1807 excluded river herring (alewife and blueback herring) and American shad from the upper sections of the Androscoggin River. The Little Androscoggin River, which enters the main stem Androscoggin on the west bank just below Lewiston Falls, supported large runs of diadromous fish. Sea-run fish ascended this major tributary up to Biscoe Falls, 56 rkm above the river's confluence with the main stem Androscoggin. By the early 1930's, construction of dams without fish passage capabilities, in combination with severely polluted waters, virtually eliminated all opportunity for fish to live and reproduce in the main stem and most of its tributaries. Since the early 1970's, substantial improvement in water quality and the provision of fishways at some of the dams have greatly enhanced the prospects for successful fish restoration within the lower Androscoggin River.

In 1982, Central Maine Power Company (CMP) reconstructed the hydroelectric facility in Brunswick-Topsham, the first upstream dam on the river. During reconstruction, CMP built a vertical slot fishway with a trapping

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[1] Atkins, C. G. 1887-1889. The River Fisheries of Maine. IN The Fisheries and Fisheries Industries of the United States 1887. Sec. V, Vol. 1, pt. XII, pp 673-728, Washington.

and sorting facility and a downstream passage facility capable of passing anadromous and resident fish species. It was at this time that the Maine Department of Marine Resources (MDMR) began the Anadromous Fish Restoration Program in the lower Androscoggin River watershed. American shad and alewives were the target species for spawning and nursery habitat in the lower main stem and tributaries below Lewiston Falls. In 1987, the Pejepscot Hydropower Project, the second dam on the Androscoggin River, provided upstream and downstream passage. In 1988, Worumbo installed upstream and downstream passage at the Worumbo Project, the third upstream dam on the river. This provided an opportunity for anadromous species to migrate upstream as far as Lewiston Falls.

Maine Department of Marine Resources personnel operate the fishway at the Brunswick-Topsham hydroelectric facility from May through October each year. Plant managers operate the passage facilities at the Pejepscot and Worumbo hydropower stations. Brunswick fishway staff closely monitors these locations during the annual anadromous fish run. Since 1982, MDMR personnel distributed over 985,561 adult river herring captured at the Brunswick fishway into otherwise inaccessible habitat on the Androscoggin and Little Androscoggin rivers. Since 1985, MDMR personnel have transferred over 7,649 pre-spawn American shad from the Merrimack, Connecticut, and Androscoggin rivers for release into the Androscoggin River below Lewiston Falls.

The restoration of native diadromous fish species to the Androscoggin River watershed has multiple benefits to the ecosystem. Restoring anadromous fish species to healthy habitat will allow the public to utilize these valuable resources for recreational and commercial purposes. The Androscoggin system has the potential to produce an annual sustained yield of 450,000 kg of alewives and 225,000 kg of American shad valued at $152,000 and $2,000,000 respectively. Reestablishment of large river herring runs could provide employment for a number of commercial fishermen. Opportunities for recreational fishermen

targeting American shad have developed in the lower Androscoggin River. The 450,000 kg alewife harvest will increase long-term average statewide landings by 33% and provide a substantial source of bait for Maine's

6,500 licensed lobster fishermen. Efforts toward improved water quality, habitat, and fish and wildlife populations improve the overall health of the ecosystem.

Executive Summary

The results of program activities over the previous ten years indicate this is an opportune time to restore anadromous fish to the Androscoggin River watershed. Improved habitat conditions, water quality, the presence of a diverse resident fish community, and evidence that it is ecologically feasible to restore native species such as American shad and river herring, indicate that the health of the ecosystem has improved. The new and existing tools utilized to restore the river have proven effective.

There are, however, three primary actions required for the long-term success of the restoration program. The first is to provide fish passage where it does not currently exist and improve existing fish passage efficiency for anadromous fish species to their historic range within the watershed. The second need is to address water quality issues and initiatives that will improve water quality in the river. The department needs to initiate an active working partnership with the EPA and DEP to address and improve the quality of fish habitat in the Androscoggin, specifically water quality. All relevant state agencies need to incorporate strategies into their water quality improvement plans and goals to reduce poor water quality impacts on the river ecosystem. The third need is to increase public awareness of the positive changes that have occurred in the watershed over the past 25 years and recognize the many opportunities that are available to restore these valuable natural resources.

Despite drought conditions that persisted during the 2001 and 2002 juvenile river herring emigration, sufficient numbers of adult river herring returned to the Brunswick fishway to stock all habitats available for restoration. A large number of older fish are returning to the fishway. This indicates that spring flow conditions the last two years allowed a large proportion of post spawn fish to return to the sea after spawning.

For the first time project staff was able to capture and transport adult blueback herring to the Androscoggin River. Staff transferred blueback herring from Cobbossee Stream in Gardiner, to the

Worumbo headpond where there is abundant spawning and juvenile habitat for this species.

A large number of striped bass ascended the Brunswick fishway in the spring. Fishway staff observed striped bass feeding on adult river herring in the fishway, at the entrance to the fish trap. In past years, few striped bass ascended the fishway despite the abundant forage. Occasionally fishway staff observes smaller striped bass feeding on juvenile river herring in the fishway in the fall.

American shad are present in the tailrace of the Brunswick-Topsham Hydropower Facility. Project staff was unsure how many American shad would return to the fishway based on stocking efforts in 2001 and 2002. Using an underwater video camera, fishway staff observed American shad circling in the tailrace, though they were reluctant to enter the fishway.

Through a National Science Foundation Grant investigating the overall health of Merrymeeting Bay, Bowdion College professor John Licther was able to confirm American shad spawning activity in the river below the Brunswick fishway. Plankton nets set at suspected spawning locations captured American shad eggs at several sites 1.0 – 3.0 km below the dam.

One of the largest Atlantic salmon captured at the Brunswick fishway occurred in 2006. The MASC sampled the female Atlantic salmon and obtained genetic samples to determine its origin. The salmon was 80 cm and passed the Worumbo fishlift on July 11, 2006.

PROJECT GOAL

Increase ecosystem health in the Androscoggin River watershed by restoring native diadromous fish species and their habitats. The primary focus is to restore the Alosine species, American shad (*Alosa sapidissima*), alewives (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) to the watershed, while increasing the restoration potential for other native fish species such as Atlantic salmon (*Salmo salar*) and American eel (*Anguilla rostrata*). To meet this goal, project staff implements several objectives and strategies.

PROJECT OBJECTIVES AND STRAGTGIES

Objective 1:

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

Strategies:

1. Trap upstream migrating adults at the Brunswick-Topsham Hydroelectric Project fishway and distribute them into upstream habitats that are inaccessible due to obstruction of passage by dams.

2. Conduct American shad fry stocking to increase juvenile abundance in nursery habitats and assess the success of fry stocking vs. natural reproduction.

3. Transport adult American shad from the Merrimack River, or other rivers, to increase American shad returns to the Androscoggin River.

Objective 2:

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

Strategies:

1. Count American shad and river herri

ng captured at the Brunswick-Topsham Hydroelectric Project fishway.

2. Collect biological data from American shad and river herring captured at the Brunswick-Topsham Hydroelectric Project fishway to determine the degree of repeat spawning of both American shad and river herring.

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 of the pre-spawn adult river herring run and collect biological data from adults captured at the Brunswick-Topsham Hydroelectric Project fishway.

2. Assess the timing and magnitude of the adult American shad migration upstream to the Brunswick-Topsham Hydroelectric Project fishway by conducting visual observations. Collect biological data from all captured adults.

Objective 4:
Assess the reproductive success of adults and productivity of juvenile alosines in the Androscoggin River watershed.

Strategies:

1. Evaluate juvenile river herring growth and emigration timing by sampling juvenile river herring emigrating from nursery habitats.

2. Assess newly implemented American shad management strategies at the Brunswick-Topsham Hydroelectric Project fishway through otolith analysis.

3. Conduct an alosine survey in the lower

Androscoggin River, below the Brunswick fishway, to determine abundance, origin, and community structure for alosines and native species.

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

Strategies:
1. Provide comments on required fish passage operations and downstream effectiveness study plans at hydropower dams.

2. Provide effective up and downstream passage for native diadromous fish species at dams currently without passage, through the FERC process and non-regulatory partnerships.

3. Review and analyze videotape data collected at the Brunswick-Topsham Hydroelectric Project fishway during the 2003-2004 seasons.

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

Strategies:
1. Conduct outreach activities and presentations on the program to public and scientific audiences.

2. Participate in the development and activities of the Androscoggin River Watershed Council.

Anadromous Alosine Restoration in the Androscoggin River Watershed

Objective 1:

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

Strategies:

1. Trap upstream migrating adults at the Brunswick-Topsham Hydroelectric Project fishway and distribute them into upstream habitat areas that are inaccessible due to the obstruction of passage by dams.

2. Conduct American shad fry stocking to increase juvenile abundance in nursery habitats and assess the success of fry stocking vs. natural reproduction.

3. Transport adult American shad from the Merrimack River, or other rivers, to increase American shad returns to the Androscoggin River.

Methods:

A vertical slot fishway is located adjacent to the Brunswick-Topsham Hydropower Project on the south bank of the Androscoggin River at head-of-tide. The fishway is 513 m long and consists of a series of 42 pools with a 30.5 cm drop between each pool. At normal headpond elevation, the water depth in the fishway pools is 162 cm and water flow is approximately 30 cubic feet per second (cfs). A supplemental attraction flow of 70 cfs provides a combined flow of 100 cfs at the fishway entrance. A fish trapping facility, located at the upstream end of the fishway, allows for the capture and processing of fish, which are crowded into a 1.9 m^3 capacity fish hoist, elevated to overhead holding tanks, and sorted by species for biological data collection, transport, or passage upstream.

The project maintains two GMC stocking trucks used to distribute adult river herring and American shad. One truck has a 1,100-gallon circular insulated tank and the other has a 750-gallon circular insulated tank.

Both tanks have an oxygen delivery system, oxygen flow meter, and a six-hp Honda water circulation pump. Fishway staff uses these trucks to transport river herring to currently inaccessible historic spawning and nursery habitats and American shad from the Merrimack River to release sites in Maine **(Figure 1)**. In most years, fishway personnel discharge approximately 20,000 fish through flexible hoses into the distribution trucks for transport upstream.

The production potential of the lower Androscoggin River is an estimated 94 adult river herring per surface hectare. The target stocking density for adult river herring is 14.83 fish per hectare (six fish per acre) of habitat.

When fishway personnel capture American shad trapped at the fishway, they pass them upstream, into the headpond, to continue their upstream migration. Fish lifts at the next two upstream dams provide passage that allows shad to migrate as far as Lewiston-Auburn. The resource agencies and the hydropower companies still need to evaluate the effectiveness of these lifts. Estimated production potential of the habitat within the lower river is 1.84 adult shad per square meter of water surface area. The existing 8,173,913 m^2 of suitable shad habitat in the Androscoggin and Little Androscoggin rivers could result in a return of 235,000 adult shad annually.

Maine receives pre-spawn shad from the Connecticut River or Merrimack River through a cooperative agreement with the Connecticut River American Shad Technical Advisory Committee (CRSTAC) and the states Massachusetts and New Hampshire. The release site, in the Androscoggin River below Auburn, is adjacent to spawning and nursery habitat.

Fisheries staff transports pre-spawn adult shad from the Merrimack River to the Waldoboro Shad Hatchery where the shad spawn in specialized tanks. Hatchery personnel collect the eggs and place them in incubators. As the eggs hatch, the fry flow from the incubators into grow-out tanks. The shad fry remain in the grow-out tanks until they are ready to transport to release sites. While the shad fry are in the hatchery, hatchery personnel expose the shad fry to an oxytetracycline (OTC) bath. Oxytetracycline marks the otoliths and differentiates them from naturally reproduced shad. All shad fry releases into the Androscoggin River occur below Lewiston Falls.

Since 1992, the MDMR and Time and Tide Resource Conservation and Development Area Council (T&T) have operated a hatchery to produce American shad fry and fingerlings for the restorati on programs on the Kennebec and Androscoggin rivers. The goal is to release an annual minimum of 1.9 million hatchery-reared fry from the hatchery into the Androscoggin River until a self-sustaining population is established.

Maine obtains broodstock for release into the Androscoggin River primarily from the Connecticut and Merrimack rivers. In 1997, MDMR transferred a limited number of broodstock from Maine's Saco River to the hatchery. Although MDMR researchers have not assessed genetic differences between shad stocks, MDMR will utilize native shad for restoration programs whenever possible. American shad stocks from geographically close rivers may be genetically similar and therefore, most suitable for restoration efforts in Maine. This approach may also protect existing Maine runs by reducing the mixing of stocks from other river systems. Once the population is at a self-sustaining level, brood stock from the Androscoggin may be available for continuing statewide restoration in other historic shad rivers in Maine.

Results:

Strategy 1. *Trap upstream migrating adults at the Brunswick-Topsham Hydroelectric Project fishway and distribute them into upstream habitat areas that are inaccessible due to the obstruction of passage by dams.*

The fishway at the Brunswick-Topsham Hydropower Project operates seasonally from May through October. The fishway typically opens the first week in May and closes the last week of October. The maintenance crew of Florida Power & Light Energy (FLPE) opened the Brunswick fishway May 7, in 2004. The fishway staff delayed the fishway opening until May 19, in 2005 because of high water **(Table 1; Figures 2 & 3)**. The fishway was operational on May 5, 2006. Maine Department of Marine Resources personnel staff the fishway beginning the same day the fishway opens for the season.

In 2005, adult river herring returns to the trap at the Brunswick fishway numbered 25,846 individuals. The catch was well below the 25-year average of 39,422 fish. The season ranked 13th highest out of the 25 seasons the fishway has operated. In 2006, adult returns increased slightly. The total number trapped at the fishway was 34,239 individuals, which ranked this year's catch at 11th highest overall **(Table 2)**. The years, 2002 – 2004 all had above average return rates. Two years, 2002 and 2004, set return records for the fishway during their respective year.

Figure 2. The Androscoggin River at Brunswick, Maine, May 20, 2005.

Figure 3. Water level in the Brunswick fishway, May 20, 2005.

Table 1. Brunswick fishway statistics for the 2004 - 2006 river herring runs.

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Fi
Nu

Number stocked in watershed lakes	20,668	16,567	23,214
Number passed into the Brunswick headpond	86,354	7,589	8,032
Number stocked out of basin	6,247	300	2,767

In general, for the past two years, all anadromous fish runs were down across the entire state. This includes runs on the major river systems as well as the coastal runs that empty directly into the tidal sections of the Gulf of Maine. The past two years the run was so poor on the Sheepscot River that project personnel could not transport alewives from Cooper's Mill Dam fishway to Branch and Travel Ponds in the Sheepscot River watershed as we have done in the past.

Table 2. Adult river herring habitat availability, number captured, and number stocked in Androscoggin River watershed lakes and ponds, 1982 - 2006.

Year	Habitat (hectares)	Run Size	Total Number Stocked	Mean Number of Fish/ha
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
2003
2004
2005
2006

Fishway staff distributed river herring to Sabattus, Little Sabattus, Lower Range, No Name, Marshall and Taylor Ponds, Sabattus River, Bog Brook, Taylor Brook, and the Brunswick headpond **(Table 3)**. All of these areas approached the target number or reached the target stocking density of 14.83 fish/ha (six fish/acre) except Sabattus Pond, which received 8.4 fish/ha in 2005. The stocking density for Sabattus Pond approximated the 14.83 fish/ha goal for 2006. Project staff stocked 4.9 and 5.1 fish/ha into the Worumbo, Pejepscot, and Brunswick headponds for the years 2005 and 2006 respectively.

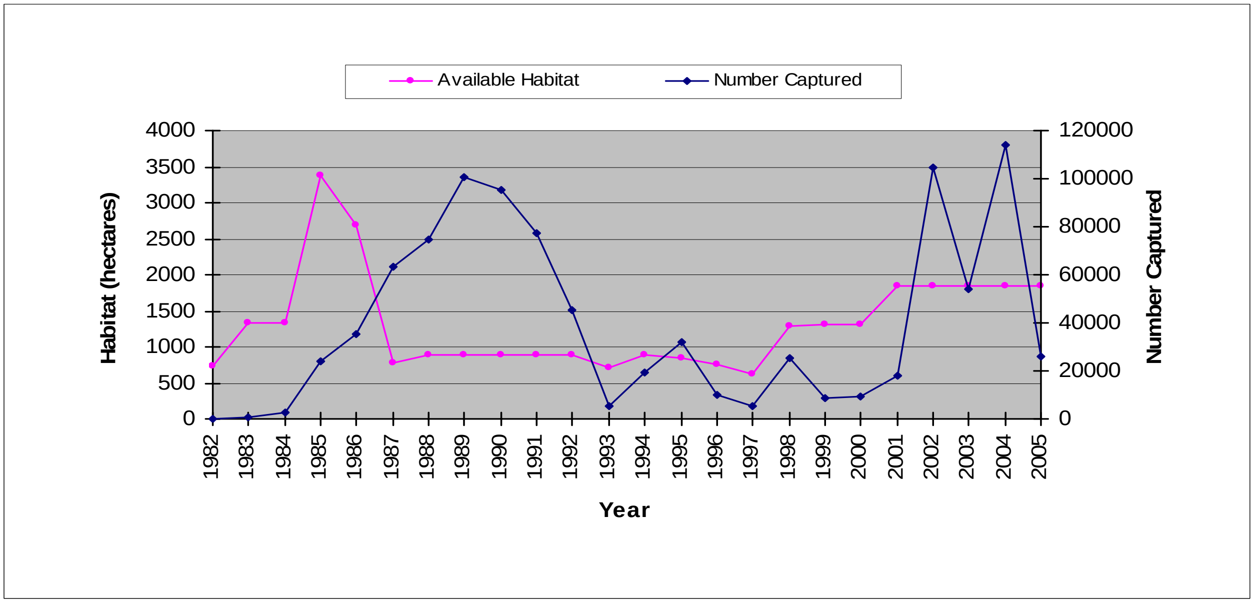
Table 3. Adult river herring distribution in the Androscoggin watershed by site, 2004 - 2006.

Habitat	2004	2005	2006
Sabattus Pond	10,090	6,113	10,796
Little Sabattus Pond	172	252	318
Taylor Pond	3,672	3,871	3,875
Taylor Brook	59	200	-
Tripp Pond	-	-	-
Lower Range Pond	1,654	2,551	2,499
Sabattus River	3,112	1,610	2,493
Marshall Pond	619	762	1,629
Bog Brook	690	600	999
Durham Boat Ramp	-	-	-
Loon Pond/Curtis Stream	-	-	-
Sutherland Pond/Curtis Stream	-	-	-
No Name Pond	600	608	605
TOTAL	**20,668**	**16,567**	**23,214**
Brunswick Headpond (passed upstream)	86,354	7,589	8,032
Total passed/stocked in the watershed	**107,022**	**24,156**	**31,246**

The adult release target for the Androscoggin watershed is 27,358 river herring into 1,846 ha of upstream habitat available for restoration. In 2003 and 2004, the timely arrival and number of Androscoggin River adults captured at the Brunswick fishway for transport and release was greater than the amount of upstream spawning and nursery habitat available. This was not the case in 2005. The number of river herring returning to the Androscoggin was not large enough to stock all available habitats **(Figure 4)**. The number of returns in 2006 was high enough to allow fishway staff to stock all available habitats. The

Kennebec River Restoration Project utilized a small number of surplus alewives to stock habitat in the Kennebec River watershed.

Figure 4. Numbers of adult river herring captured vs. habitat availability in the Androscoggin River watershed, 1982 - 2006



On two occasions, June 5 and June 6, 2005, fishway staff passed river herring into the Brunswick headpond instead of stocking spawning habitat because large numbers of fish arrived at the trap during those days. The trap could not safely hold these fish in until the following day. This did not occur in 2006. Additional help at the fishway allowed fishway staff to transport more fish during a shorter period.

The numbers of adult river herring captured in 2005 and 2006 is likely the result of high river flows and flow attraction away from the fishway entrance. In addition, a major drought in 2001 and 2002, and a documented fish kill at the Worumbo Hydropower Station during 2001, likely reduced the numbers of fish available to return and spawn in 2005 and 2006 (**Figure 5)**.

Since 1998, MDMR resumed stocking alewives into several ponds consider ed prime spawnin g habitat for river herring, especially Sabattus Pond. For the past seven years one of the main objectives of the program has been to optimize the number of river herring stocked in lakes and ponds within the watershed based on available habitat. Returns from the 1985 stocking effort precipitated one of the largest runs recorded at the fishway. By maintaining an increased stocking level, in the 23,000 fish range, the project can increase the number of returns and increase the long-term yearly average. Maintaining high stocking levels and increased vigilance in monitoring downstream passage are critical steps toward improving the number of river herring returning to the Androscoggin annually.

Unfortunately, the fishway trap did not capture any American shad at Brunswick in 2005 and only three in 2006. Shad passed above the Brunswick dam, into the headpond, have the ability to migrate as far upstream as Lewiston-Auburn. Automated fish lifts at both the Pejepscot and Worumbo hydropower sites lift once every two hours from 8:00 a.m. through 4:00 p.m. daily. In 2006, Pejepscot personnel did not observe American shad passing into the Pejepscot headpond. Hydropower personnel at Pejepscot, the next hydropower dam upstream from Brunswick, sporadically monitored the fish lift to determine if shad were using the lift to migrate upstream.

Worumbo hydropower personnel monitored upstream passage at the Worumbo site daily while the fish lift was in operation. Worumbo staff counted fish passed upstream during each lift. A control gate traps fish in the upstream passage canal until personnel open the upstream gate and count the fish passing upstream. Worumbo prepares an annual report of fish passage activities recorded at Worumbo and presents the report at an annual meeting of Miller Hydro and MDMR in March each year.

In addition to stocking alewives in the Androscoggin River watershed, fishway staff collected a small number of blueback herring from Cobbssee Stream in Gardiner, Maine and transferred these fish to the Worumbo headpond. Fishway staff captured 1,719 adult pre-spawn blue back herring between June 14 and 15. This is the first attempt at restoring blueback herring to the river above head-of-tide. Fishway staff rarely captures blueback herring at the

Brunswick fishway, although they often observe them in the tailrace of the Brunswick-Topsham Hydropower Project.

Strategy 2. *Conduct American shad fry stocking to increase juvenile abundance in nursery habitats and assess the success of fry stocking vs. natural reproduction.*

Fisheries staff first released American shad fry, raised at the Waldoboro Shad Hatchery, into the Androscoggin River in 1999. Since then, the Androscoggin has received at total of 4,028,307 shad fry for the restoration project. The earliest shad releases consisted of Connecticut River, Connecticut River/Saco River stock or Connecticut River/Kennebec River stock in origin. Beginning in 2001, all the shad fry raised and released were Merrimack River origin.

Fisheries staff released a record 2,076,369 6-8 day-old fry into the Androscoggin River in 2003. Record production at the Waldoboro Shad Hatchery produced excess fry, which allowed the project to increase the stocking rate for the Androscoggin River. The hatchery reared approximately 10-million fry at the facility over a 7-week period. The hatchery operated beyond its designed capacity and was fortunate to produce this number of fry without experiencing some type of system failure. The limiting factor for the hatchery is the number of grow-out tanks the facility can hold. The hatchery attributes the high production to the increased numbers of adult females transported to the hatchery and a shorter holding time in the grow-out tanks compared to previous years.

The hatchery reduced the Androscoggin River's 2004 allotment to 538,613 7-10 day-old fry based on production at the hatchery **(Table 4)**. Hatchery production decreased to approximately 5-million fry, the majority going to the Kennebec and Sebasticook river restoration programs.

Table 4. Numbers of American shad fry released into the main stem Androscoggin River at Auburn, 1999 - 2006.

Date
2006
8/2/2005
7/7/2004
6/30/2003
7/1/2003
7/2/2003
7/17/2002
7/2/2001
7/10/2000
6/30/1999

In 2005, the hatchery produced approximately 1.2-million fry from the 180 shad successfully transported to the hatchery. Because funding for the hatchery comes from the hydropower companies operating on the Kennebec River, MDMR fisheries staff stocked the majority of the fry raised at the hatchery into the Kennebec and Sebasticook river watersheds. Fisheries personnel stocked 96,551 of the 1.2-million shad fry raised at the hatchery into the Androscoggin at the Pejepscot boat launch. Production at the hatchery in 2006 was extremely low, producing only 262,101 fry. The total fry allotment went to the Kennebec River Restoration Project. Typically, the Kennebec River Project allots a proportion of the fry raised to the Androscoggin River Project in exchange for in-kind work contributed by this project.

All fry received an OTC mark prior to release. Marking the fry allows project personnel to distinguish hatchery fry and returning adults from wild fry and wild adult returns. Project staff uses the OTC mark to determine the origin of samples collected at the Brunswick fishway and assess the success of the hatchery program for Maine's river restoration projects.

Since project staff stocked neither wild adult shad, nor marked fry, this project could not complete **Objective 1; strategy 2** – ***Conduct American shad fry stocking to increase juvenile abundance in nursery habitats and assess the success of fry stocking vs. natural reproduction,*** for 2006.

Strategy 3. *Transport adult American shad from the Merrimack River, or other rivers, to increase American shad returns to the Androscoggin River.*

In February 2006, MDMR requested 1,600 from the Merrimack River for the Androscoggin River Restoration Program and the Waldoboro Shad Hatchery. The American Shad Technical Advisory Committee granted the request. However, for the second consecutive year, the American shad run on the Merrimack River was extremely poor. Extreme high water throughout the shad migration prevented the operation of the Essex fish lift **(Figures 6 & 7)**. As of June 28, the fish lift had passed only 146 shad. As a result, the American Shad Technical Advisory Committee withdrew the number allotted to Maine. The annual shad run on the Merrima ck River typically ranges from 52,000 to 73,000 individuals. The 2005 shad run was only slightly more than 7,000 individuals.

Figure 6. Typical early spring spill conditions at the Essex fishway on the Merrimack River in Lowell, MA in May 2005.

Figure 7. Spring spill conditions observed at the Essex fishway on June 24, 2006.

Because of the high water, the Kennebec River Restoration Project did receive a permit to transport 500 shad from the Holyoke fishway, on the Connecticut River, to the Waldoboro Shad Hatchery. The 187 shad transported were in poor condition and several of the largest female fish died soon after arriving at the hatchery. The hatchery produced only 262,101 fry for release. Typical production at the hatchery ranges between 3-million to 10-million fry annually.

Prior to releasing American shad into the river, the Maine Department of Inland Fisheries and Wildlife (MDIF&W) requires a pathology assessment of 60 shad from the donor water to ensure there are no pathogens that may affect native fishes. The health testing takes 14 days to complete. To meet this requirement, and successfully transport shad back to the Androscoggin River, project staff needs to obtain shad at the beginning of the run. When high water delays the run, or fish return in an unpredictable manner, obtaining a timely sample is difficult. The last two years, there were so few fish that fisheries personnel were reluctant to kill any fish. Once the health assessment results indicate the shad are disease free, fisheries staff can begin transporting shad back to the

Androscoggin River. The testing requirement makes it difficult to switch from once broodstock source to another in the middle of the shad run.

The disease testing

requirement does not apply to the hatchery because hatchery personnel do not release spawning stock into the wild; they are held in a closed hatchery system then killed after spawning. Obtaining shad for the hatchery is easier than obtaining shad to stock the river.

Additional activities conducted in support of meeting this objective include the following:

- Staff completed the Brunswick fishway report for the 2005 season.

- Staff updated the Androscoggin River Management Plan for diadromous fish species.

- The project leader worked with the ASMFC Shad and River Herring Technical Committee to provide data for the 2006 American Shad Assessment.

- Staff reintroduced blueback herring to the Androscoggin River, below Lewiston Falls, for the first time since the early 1800's.

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. Count American shad and river herring captured at the Brunswick-Topsham Hydroelectric Project fishway.

2. Collect biological data from American shad and river herring captured at the Brunswick-Topsham Hydroelectric Project fishway to determine the degree of repeat spawning of both American shad and river herring.

Methods:

State fisheries biologist collect biological data daily to characterize the migratory and resident fish species using the Brunswick fishway ladder (described under Objective 1) in conjunction with environmental measur ements, such as air/water temperatures, river flows, and headpond levels. The Brunswick-Topsham Hydroelectric Project provides upstream and downstream passage for diadromous and resident species, such as Atlantic salmon, American eels, white suckers, and striped bass. Fishway personnel pass most native species into the upstream headpond from the sorting tank through a 25.4 cm flexible pipe leading into the fishway above the upstream gate. Fishway staff intentionally releases some non-indigenous species, such as brown trout and smallmouth bass, above the dam, while fishway personnel release others, such as white catfish and pike, into the river below the dam.

Fisheries biologists collect length data from all fish species captured at the fishway from the date it opens through the end of the fishway season in late October. Fishway personnel measure all Atlantic salmon for total and fork lengths, check for tags and/or clips, collect scale samples, and release the salmon into the Brunswick headpond. The Maine Atlantic Salmon Commission (MASC) will determine the age and origin of the salmon and provide these data to the MDMR. Beginning July 1999, fishway personnel began collecting fin clips from Atlantic salmon for genetic analysis to determine the origin of the adults for management purposes.

Results:

Strategy 1. *Count American shad and river herring captured at the Brunswick-Topsham Hydroelectric Project fishway.*

In 2005, fishway personnel observed river herring at the fishway from May 23 through June 13. During this period, MDMR trapped 25,846 river herring at the Brunswick fishway. The Androscoggin river herring run was below average compared to previous years. On four days, the run exceeded 2,000 fish. These four days accounted for 96.0% of the total number captured during the river herring run **(Table 5)**. During the 2006 run, abnormally warm temperatures and low flows in April indicated that the run might start earlier than normal. The fishway opened May 5 and fishway staff trapped the first river herring May 6. The river herring run ended June 6, with a total count of 34,239 individuals for the season. High river flows interrupted the run for 10 days in the middle of the season by pushing the run back into the estuary. On seven days, the daily count exceeded 2,000 fish. These seven days accounted for 82% of the 2006 run. The run was slightly below the 25-year average of 39,422 fish annually **(Table 6)**. Historically, despite the start date of the run, or the date the fishway opens, the run is over by the end of the second week of June. Once the water temperatures reach 18^{o}C the number of fish ascending the fishway drops dramatically. Fishway staff does capture some river herring at water temperatures as high as 22^{o}C, but they represent only a small percentage of the annual run.

Table 5. Numbers of adult river herring captured, water temperatures, and river flows recorded at the Brunswick fishway, 2005.

Date	Number	Water Temp(C)	River Flow (cfs)	Cumulative Number	% Total Run
5/23/05	305	11.2	12,600	305	1.18%
5/31/05	200	12.5	22,900	505	1.95%
6/3/05	5,564	14.0	14,600	6,069	23.48%
6/4/05	9,745	16.0	12,200	15,814	61.19%
6/5/05	6,707	17.0	9,710	22,521	87.14%
6/6/05	2,803	15.5	9,340	25,324	97.98%
6/7/05	181	17.0	7,220	25,505	98.68%
6/8/05	301	18.6	7,740	25,806	99.85%
6/9/05	10	19.0	6,980	25,816	99.88%
6/10/05	10	19.5	6,670	25,826	99.92%
6/13/05	20	22.0	6,300	25,846	100.00%
Total/Mean	**25,846**	**16.6**	**10,569**		

Table 6. Numbers of adult river herring captured, water temperatures, and river flows recorded at the Brunswick fishway, 2006.

Date
5/6/06
5/7/06
5/8/06
5/9/06
5/11/06
5/15/06
5/19/06
5/22/06
5/24/06
5/25/06
5/28/06
5/29/06
5/30/06
5/31/06
6/1/06
6/2/06
6/3/06
6/4/06
6/5/06
6/6/06
Total/Mean

In 2005, fishway staff did not catch any America n shad in the trap at the

Brunswick fishway **(Table 7)**. The 2006 season was only slightly better. Three native shad trapped at the fishway during the season passed into the Brunswick headpond.

Nineteen shad passed through Brunswick during the years, 2003 (7) and 2004 (12). The project leader expected a decrease in the number of adults ascending the Brunswick fishway based upon the number of native pre-spawn adults passed upstream and the number of pre-spawn adult shad transported from the Merrimack River in 2001 and 2002, but not to the degree observed. Based on published data, expected returns to the fish trap should range from 1,674 to 1,938 individuals. Expected hatchery returns should approximate 1:400 based on Susquehanna River data from the Pennsylvania Fish and Boat Commission. Expected returns from pre-spawn stocking should range from 4:1 to 7:1 based on data from the Columbia River.

Table 7. Adult American shad distribution in the main stem Androscoggin River at Auburn, Maine, 1985 - 2006.

Year	Number Distributed		Source		Mortality During Transport
		Androscoggin	Connecticut	Merrimack	
2006	3	3	-	-	0.0%
2005	0	-	-	-	0.0%
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	35				
1990	35				
1989	41				
1988	51				
1987	9				
1986	22				
1985	11				
Totals	**7,6**				

The upstream passage facilities at the Brunswick fishway do not effectively pass American shad. The vertical slot fishway design used on the Farming ton River in Connecticut experiences the same problems observed at Brunswick. American shad are unwilling to ascend the fishway to the trap at the top of the fishway. At the Rainbow fishway on the Farmington River, most shad do not ascend to the trap located halfway up the fish ladder.

Strategy 2. *Collect biological data from American shad and river herring captured at the Brunswick-Topsham Hydroelectric Project fishway to determine the degree of repeat spawning of both American shad and river herring.*

Fishway personnel collect biological data from American shad to determine the number of repeat spawning fish returning to the fishway. Fisheries staff determines the number of repeat spawning American shad and river herring returning to the Androscoggin River using scale analysis. Project personnel use scale samples to identify spawning checks present in the scale samples collected. Due to the inefficiency of the fishway in passing shad upstream, it is impossible to determine if these fish had spawned above the fishway in previous years and were returning, or had spawned below the fishway in the lower river in previous years, and captured at the fishway for the first time. Regrettably, there were no adult shad returns to the trap at Brunswick fishway in 2005.

Project staff used the same method to determine the rate of repeat spawning for river herring. The ability of returning river herring to ascend the fishway, the number of individuals sampled, and the likelihood of successful downstream passage after spawning occurs in the river or lake and pond habitats within the watershed make assessing the rate of river herring repeat spawning an easer task. Typically, river herring migrate downstream soon after spawning in late spring while water levels are still high enough to facilitate downstream passage.

In 2005, three tagged river herring returned to the fishway. Project staff tagged these fish in 2004 as part of and upstream passage study under high flow conditions for the Pejepscot Hydropower Project. Fishway personnel retained these fish and catalogued selected scales for use in identifying spawning marks in future years.

In 2005, analysis of scale samples indicated that a large number of age five river herring (67.1%), returned to spawn for the second time **(Table 8; Figure 8)**. In addition, 14.7% of all age four river herring were repeat spawners. In total, repeat spawners comprised 47.3% of the 2005 river herring run, an unusually large number when compared to 30% of the run in 2004. This was likely the result of excellent downstream passage of adult fish in 2004, combined with poor recruitment of fish from the 2001 year-class.

Table 8. Number and percent, by age, of repeat spawning river herring sampled at the Brunswick fishway in 2005.

Age	Sex	Total Number	Number of Repeat Spawners	% Repeat Spawning
3	M	1	0	*
	F	0	0	*
4	M	39	7	17.9%
	F	22	2	9.1%
5	M	44	33	75.0%
	F	35	20	57.1%
6	M	9	9	100.0%
	F	0	0	*
	Total	150	71	47.3%

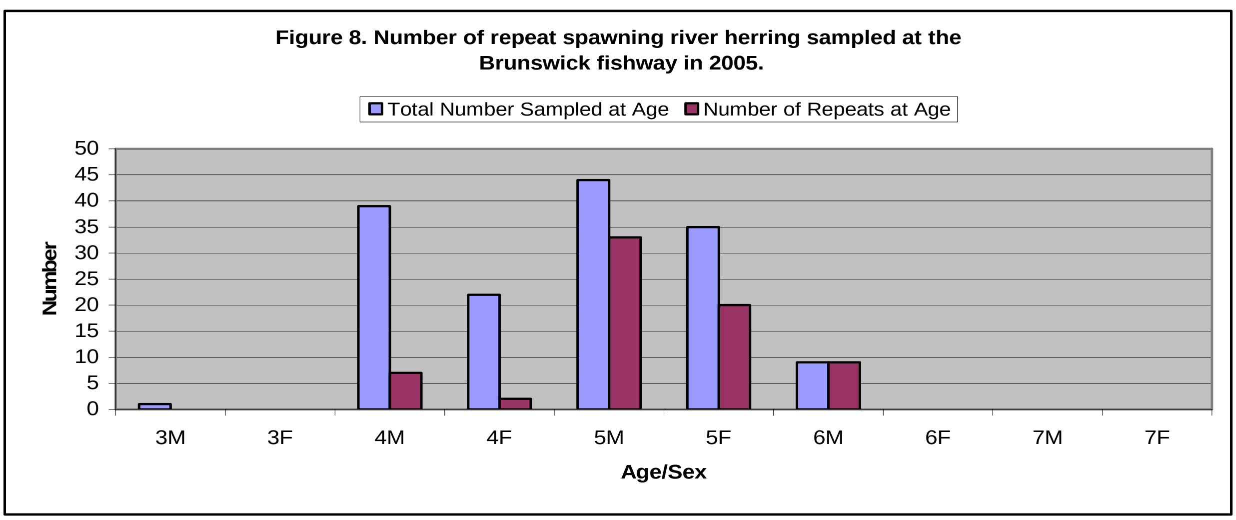


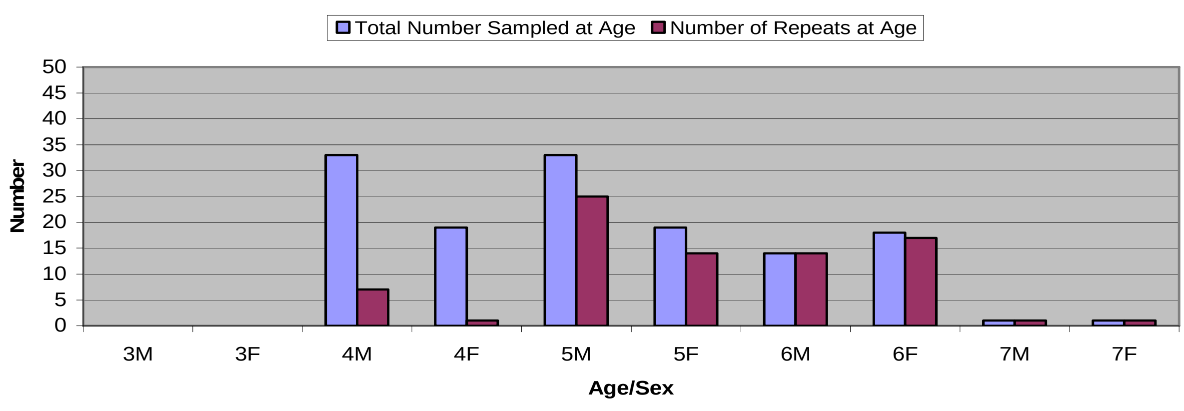
Figure 8. Number of repeat spawning river herring sampled at the Brunswick fishway in 2005.

This trend continued in 2006. The number of river herring returning to the fishway to spawn for at least a second time remained high compared to the 2004 data, and higher than 2005 data results **(Table 9; Figure 9)**. The reasons for this trend are likely, poor recruitment in 2001 and 2002 due to significant drought conditions during the fall of these years and a documented fish kill at the Worumbo Hydropower Station that also effected recruitment of the 2001 year-class. There were fewer successful juvenile migrants during this period, which effected adult returns during 2005 and 2006.

Table 9. Number and percent, by age, of repeat spawning river herring sampled at the Brunswick fishway in 2006.

% Repeat Spawning
*
*
21.2%
5.3%
75.8%
73.7%
100.0%
94.4%
100.0%
100.0%
57.9%

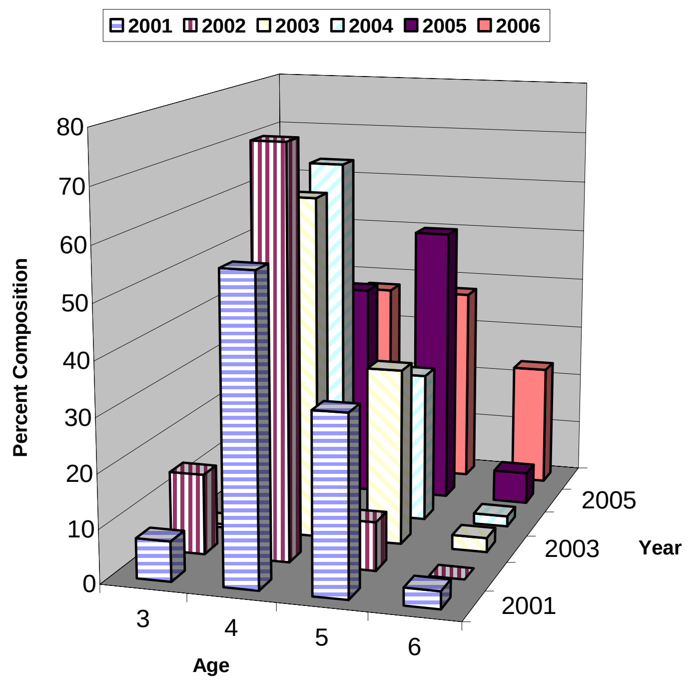
Figure 9. Number of repeat spawning river herring sampled at the Brunswick fishway in 2006.



Typically, four-year-old fish make up the majority of the annual run as they return to reproduce for the first time **(Figure 10)**. It is common to have a small proportion of the annual run comprised of three-year-old fish. The youngest fish

returning to the fishway are males and they often return the following year as four-year-olds. Based on the consistent amount of habitat available for restoration over the past five years and the number s of pre-spawn adults transported upstream, post-spawn survival of emigrating adults is a large factor in determining the total run the following year, especially when downstream migration of juveniles in the fall is poor.

Figure 10. Year-class composition of adult river herring returning to the Brunswick fishway, 2001 - 2006.



Data Collected From Other Species:

Data were collected from all species that ascended the Brunswick fishway in 2005 and 2006. Annual comparisons of these data show that the number of fish species ascending the fishway is similar between years. Although the numbers of fish that use the fishway fluctuate annually, anadromous fish predominantly use the fishway

From May 23 through October 28, 2005, fishway personnel counted 13 fish species and 26,719 individual fish passing upstream through the Brunswick fishway. The most common species captured in both May and June was river herring. In comparison, smallmouth bass and striped bass were second and third respectively **(Table 10)**.

Table 10. Numbers of adult fish, by species and month, captured at the Brunswick fishway through October 2005.

	May	June	July	August	September	October	Species Total
Atlantic Salmon (*Salmo salar*)	-	6	-	-	1	3	10
Brown Trout (*Salvelinus trutta*)	1	-	-	-	-	-	1
Common Carp *(Cyprinus carpio)*	-	-	1	-	-	-	1
Pumpkinseed Sunfish (*Lepomis gibbosus*)	-	-	-	-	2	1	3
River Herring *(Alosa aestivalis)(Alosa pseudoharengus)*	505	25,341	-	-	1	782	26,629
Smallmouth Bass (*Micropterus dolomieu*)	-	12	8	4	6	1	31
Spottail Shiner (*Notropis hudsonius*)	-	4	5	-	1	-	10
Striped Bass (*Morone saxatilis)*	-	14	4	-	-	-	18
White Catfish (*Ictalurus catus*)	-	-	2	-	-	-	2
White Perch (*Morone americana*)	-	-	-	-	-	1	1
Rainbow Trout (*Salmo gairdneri*)	1	-	-	-	-	-	1
Black Crappie *(Pomoxis nigromaculatus)*	-	-	-	-	-	1	1
White Sucker (*Catostomus commersoni*)	-	11	-	-	-	-	11
Monthly Totals	507	25,388	20	4	11	789	26,719

In 2005, fishway personnel caught two white catfish in the fish trap at the top of the fishway. The last two years underwater cameras recorded their presence at several locations in the fishway, though most did not ascend to the trap at the top of the fishway. Based on the numbers observed over the past 2-year period, it is not clear why some years they migrate to the top of the fishway and some years they do not.

When fishway staff captures white catfish, they sample and tag them with a spaghetti tag prior to release downstream. Fishway personnel record total length and apply a tag posterior to the dorsal fin on the right side of the fish. 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 introduced into Maine waters and are not passed upstream. Commercial fishermen first discovered white catfish in the Eastern River, a tributary of the Kennebec, in 1997, and they appear to be rapidly expanding their range. The exact rate, location of expansi… undeter…

Another … nd in the … Androscoggin River is the no…) **(Figure 11)**. Over the past 10 yea… tablished populations in the main st… r below Lewiston Fall and the Litt… r below Hackett's Mills. During … herring migration in 2004 Worumb… passed eight pike over 106 cm into … nd. The effects of their presence on native fish species are unclear. It is likely that pike will displace, to some extent, chain pickerel (*Esox niger*) and bass species as the top … wer Androscoggin River and other waters into which it … ersonnel have observed pike eating both adult and juve… abattus River.

Figure 11. Northern pike mortality retrieved from the Brunswick fishway, June 2005.

The fish… Through August 2006, 11 species and 34,491 individual fish passed … October 2005 though some were captured in 2006. However, the trap rarely captures eels because upstream migrating juveniles are small enough to pass through the trap grating. American eels 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 habitats for an average of 20 years to grow to adulthood before emigrating to reproduce in the Sargasso Sea.

	May	June	July	August	September	October	Species Total
American Eel (*Anguilla rostrata*)	-	-	4	5	-	-	9
American Shad (*Alosa sapidissima)*	-	3	-	-	-	-	3
Landlocked Salmon (*Salmo salar*)	4	2	-	-	-	-	6
Atlantic Salmon (*Salmo salar*)	-	1	4	-	-	-	5
Brook Trout (*Salvelinus tontinalis)*	1	-	-	-	-	-	1
Largemouth Bass (*Micropterus salmoides*)	-	2	3	-	-	-	5
River Herring *(Alosa aestivalis)(Alosa pseudoharengus)*	27,974	6,266	-	-	-	-	34,240
Smallmouth Bass (*Micropterus dolomieu*)	9	13	39	1	-	-	62
Striped Bass (*Morone saxatilis*)	1	66	8	-	-	-	75
White Catfish (*Ictalurus catus*)	-	2	-	-	-	-	2
White Sucker (*Catostomus commersoni*)	81	1	-	-	-	-	82
Black Crappie *(Pomoxis nigromaculatus)*	1	-	-	-	-	-	1
Monthly Totals	28,071	6,356	58	6	0	0	34,491

Table 11. Numbers of adult fish, by species and month, captured at the Brunswick fishway through August 2006.

upstream through the Brunswick fishway **(Table 11)**. A large number of striped bass appeared at the fishway in June. Some fed on river herring in the fishway during the upstream migration. This behavior, and the large number of striped bass observed in the fishway, is not typical.

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. An average of 29 sea-run salmon are captured annually at Brunswick, 1983 – 2005, although annual returns have been below 12 salmon since 1996 **(Table 12)**.

Table 12. Numbers, mean lengths, and origin of sea-run Atlantic salmon returning to the Androscoggin River and captured at the Brunswick fishway, 1988 - August 2006.

Age	Sea-Run Hatchery				Sea-Run Wild				Mean Fork Length (mm)	Total
	1SW	2SW	3SW	Repeat	1SW	2SW	3SW	Repeat		
Year										
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	3	8	0	0	0	1	0	0	688	12
2005	3	7	0	0	0	0	0	0	664	10
2006	*	*	*	*	*	*	*	*	536	10
Total	**27**	**326**	**1**	**2**	**5**	**61**	**2**	**0**		**434**

Ten Atlantic salmon passed into the Brunswick headpond in 2005. The mean fork length of adult salmon captured was 664 mm, down slightly from 688 mm in 2004 **(Table 13)**. The Atlantic salmon run at the fishway through August 2006, produced ten salmon. Additional salmon should migrate through the fishway in the fall, increasing the total count for the year.

The salmon retuning to the fishway in 2006 are smaller than those observed in either 2005 or 2004. The mean fork length of salmon returning to date is 536 mm **(Table 14)**.

There were no fin clipped salmon captured at the fishway in 2005, but several marked salmon returned to the fishway in 2006. The Brunswick fishway routinely captures clipped or tagged salmon stocked in other river systems. Many of these salmon are strays from the Penobscot River. Fishway personnel searched for additional tags but none were located. Conversations with the MASC indicate that visual implant tags (VIE), an elastomer injected around the eye or throat, may work out over time, and may not be present during inspection. Coded wire tags (CWT), injected into the muscle tissue, can only be located with a CWT reader, which we do not possess. The Maine Atlantic Salmon Commission will conduct a scale analysis on all the salmon to determine age and determine if they are sea run or landlocked fish. Salmon under 500 mm total length are classified as landlocked salmon when caught at the Brunswick fishway as directed by MASC protocols.

Table 13. Atlantic salmon captured ascending the Androscoggin River at the Brunswick fishway, May – October 2005.

	Total Length (mm)	Fork Length (mm)	Water Temp. (C)
10-Jun	740	740	20.0
12-Jun	*	*	20.6
13-Jun	813	784	21.9
13-Jun	750	724	21.9
14-Jun	741	698	21.7
14-Jun	760	743	21.7
1-Sept	597	571	22.3
10-Oct	575	558	17
21-Oct	651	648	9.8
24-Oct	533	514	9.1
Mean	**684**	**664**	**18.6**
Min. T^{o} (C)			**9.1**
Max. T^{o} (C)			**22.3**

Table 14. Atlantic salmon captured ascending the Androscoggin River

at the Brunswick fishway, May – August 2006.

In June 1999, the Maine Atlantic Salmon Technical Advisory Committee (MSTAC) agreed to include the Androscoggin River in an ongoing genetic sampling program. Starting in 2002, project personnel began collecting fin clips from all salmon captured at the fishway. The MASC hopes to conduct genetic analysis in the future to determine the origin of the salmon captured at Brunswick. Knowing the origin of Atlantic salmon returning to the Androscoggin will allow fisheries managers to implement management strategies that may restore Atlantic salmon to the watershed.

MSTAC has 15 schools in the Androscoggin River watershed that participate in the 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 fall for students to rear and release as fry into salmon nursery habitat identified in their watersheds. In 2006, these schools released fry into the Little River, a tributary that enters the Androscoggin between the second and third upstream dams. Atlantic salmon fry releases occurred at the same locations during the spring of 2000 - 2006.

Each winter a number of commercial and recreational fishermen spend the winter pursuing rainbow smelt (*Osmerus mordax*) in Maine's tidal rivers **(Figures 12 & 13)**.

Figure 12. A
Androscoggin
fishway.

The rainbow smelt fishery begins in October and ends in late April. The rod and reel fishery occurs during open water while the hook and line fishery occurs primarily during the winter. A dip net fishery in the early spring, during the spawning run, has strict limits and a number of the most popular spawning locations are closed during this period. Some commercial fishermen use floating platforms to harvest smelt as early as November **(Figure 14)**. The majority of smelt fishing activity occurs during the winter in heated fish houses. Each fishing house has several baited lines that fishermen extend through the ice and place just above the bottom. Fishing occurs throughout the day, but the best fishing is often at night.

There are no current estimates of Maine's smelt population. The last major research project, conducted in the 1970's, and focused on migration within the Merrymeeting Bay Estuary. Maine listed smelt as a species of concern during the past year and proposed research is planed for 2007. There are no licensing requirements for the coastal smelt fishery. This may be one reason the fishery is so popular. Several commercial smelt camps operate in Maine's mid-coast region. An eight-hour fishing session costs between $12.00 and $14.00 per person, including bait and fishing camps typically hold 1- 6 people.

Figure 14. A commercial fisherman's smelt camp on a floating platform in early December on Oyster Creek, Damariscotta, Maine.

Tables 15 - 24 and **Figures 15 - 24** present environmental data collected at the Brunswick fishway, including air temperatures, water temperatures, and headpond levels during 2005 and from May through

August 2006 **(Appendix)**.

Additional activities conducted in support of meeting this objective include the following:

- Visited the Sabattus Pond water control gates during 2005 and 2006 to insure they continue to provide downstream passage for emigrating juvenile alewives and adult American eels from May - November.

- Follow-up visits to the Sennebec rock-ramp fish passage structure during both the upstream and downstream migration period of diadromous fish to assure the structure was in working order.

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 of the pre-spawn adult river herring run and collect biological data from adults captured at the Brunswick-Topsham Hydroelectric Project fishway.

2. Assess the timing and magnitude of the adult American shad migration upstream to the Brunswick-Topsham Hydroelectric Project fishway by conducting visual observations. Collect biological data from all captured adults.

Methods:

State of Maine fisheries biologists maintain the Brunswick fishway (described under Objective 1) and collect biological data daily from adult river herring and American shad ascending the fishway. Fishway personnel collect approximately 150 adult river herring samples during the upstream migration. Biological data collected from each individual includes total length, fork length, sex, otoliths, and scale samples. Samplers open the body cavity of each fish to determine species, sex, and to remove and weigh gonads. Samplers collect scale samples from the left side of each fish, posterior to the dorsal fin, 1.3 cm above the lateral line and place them in numbered scale envelopes.

Fishway personnel collect biological data from all adult American shad captured, including length, sex, genetic samples, and the general condition of the fish. Samplers catalog all scale samples and fin clips collected in the field and bring them back to the laboratory. Staff extracts otoliths from all American shad mortalities retrieved from the fishway. It is possible that these are marked, hatchery reared, shad returning to the river to spawn.

Scale and otolith samples collected from river herring and American shad captured at the Brunswick fishway provide information used to classify the age structure of returning adults. Scales are prepared for ageing by dipping them into lukewarm water, rubbing them clean and allowing them to dry completely. Scale readers position the prepared scales between two glass slides and place them in a Micron 780A microfiche reader. Age is determined using Cating's method *(Cating, J.* 1954)[2] by distinguishing and counting the annuli present. One scale reader examines five or more scales from each fish. If the scales are in poor condition, or difficult to read, a second scale reader reads the scales independently. If there are still discrepancies, the scales are reread a third time by the original reader.

Fishway personnel collect visual observation data on American shad adults present in and around the fishway. However, fishway personnel cannot collect biological data from these fish since most do not ascend to the top of the fishway or into the trap. Visual observations are conducted throughout the run in five general areas; at the fishway entrance (in the river), the lower fishway, the corner pool halfway up the fishway, the upper fishway, and the viewing window located

at the top of the fishway just outside the trap. Fishway personnel record the location, number of shad, time of day, water temperature at the time of observation, and behavior of the shad.

Results:

[2] Cating, J. 1954. Determining Age of Atlantic Shad from Their Scales, Fishery Bulletin of the Fish and Wildlife Service 85: 187-199

Strategy 1. *Assess the timing and magnitude of the pre-spawn adult river herring run and collect biological data from adults captured at the Brunswick-Topsham Hydroelectric Project fishway.*

Fishway staff trapped river herring at the Brunswick fishway beginning May 23, 2005 at a water temperature of 11.2 °C and river flow of 12,600 (cfs). Trapping ended June 13, at a water temperature of 22.0 °C and river flow of 6,300 (cfs) **(Figures 25 & 26)**. Compared to the 2006 season, when alewives begin ascending the fishway May 6, at a water temperature of 13.0 ^{o}C and a river flow of 6,490 cfs. The river herring run terminated June 6, at a water temperature of 17.5 ^{o}C and river flow of 12,700 cfs **(Figures 27 & 28)**. The warm air temperatures and low river flows that occurred during the early spring of 2006 provided an opportunity for the river herring run to start earlier than in previous years. In mid-May, cool spring temperatures and heavy rains during the middle of the migration interrupted the run temporarily.

The 2005 river herring run was brief. Approximately 96.0% of the run occurred over four days, June 3 – June 6. During the run, the water temperature ranged between 11.2 °C and 22.0 °C, averaging 16.6 °C. The river flows ranged between 6,300 cfs and 22,900 cfs, averaging 10,569 cfs. The 2005 river flows were much greater than those observed in 2006, when flow range between 3,430 cfs and 19,600 cfs, averaging 9,394 cfs. As a result, the increased flows diminished attraction flow to the fishway and fish may have had a difficult time finding the fishway entrance. Seven days accounted for 82.0% of the run in 2006. Typically, the majority of the run occurs over a span of 4-10 days depending on environmental conditions at the fishway.

Figure 25. Number of adult river herring captured by day, vs. water temperature at the Brunswick fishway, May - June 2005.

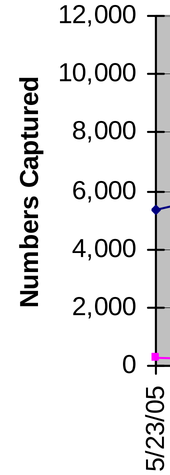
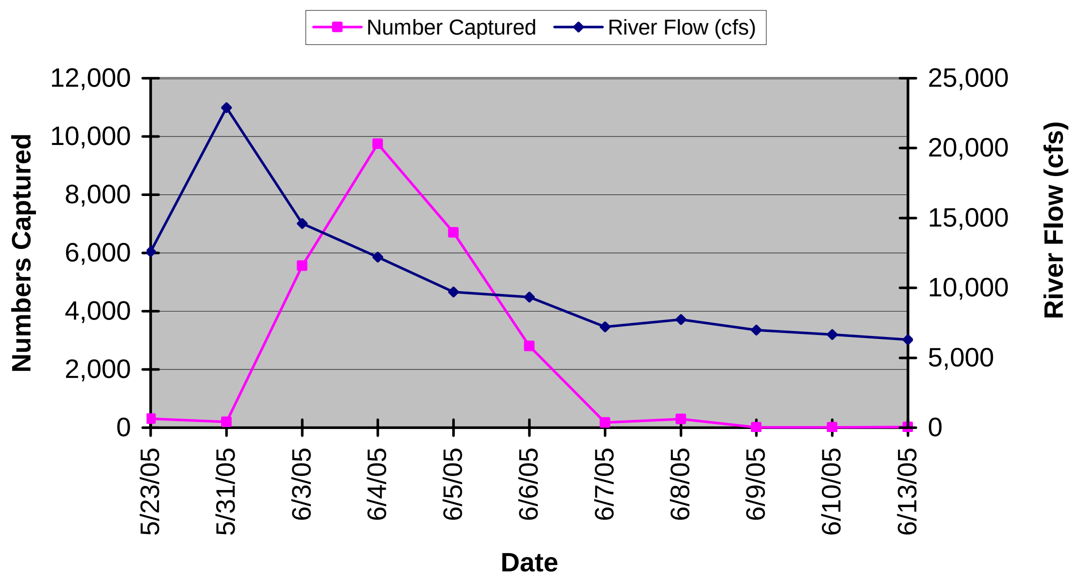


Figure 26. Number of adult river herring captured by day, vs. river flow at the Brunswick fishway, May - June 2005.



Number Captured
River Flow (cfs)
Numbers Captured
River Flow (cfs)
12,000
10,000
8,000
6,000
4,000
2,000
0
25,000
20,000
15,000
10,000
5,000
0
5/23/05
5/31/05
6/3/05
6/4/05
6/5/05
6/6/05
6/7/05
6/8/05
6/9/05
6/10/05
6/13/05
Date

Figure 27. Number of adult river herring captured by day, vs. water temperature at the Brunswick fishway, May - June 2006.

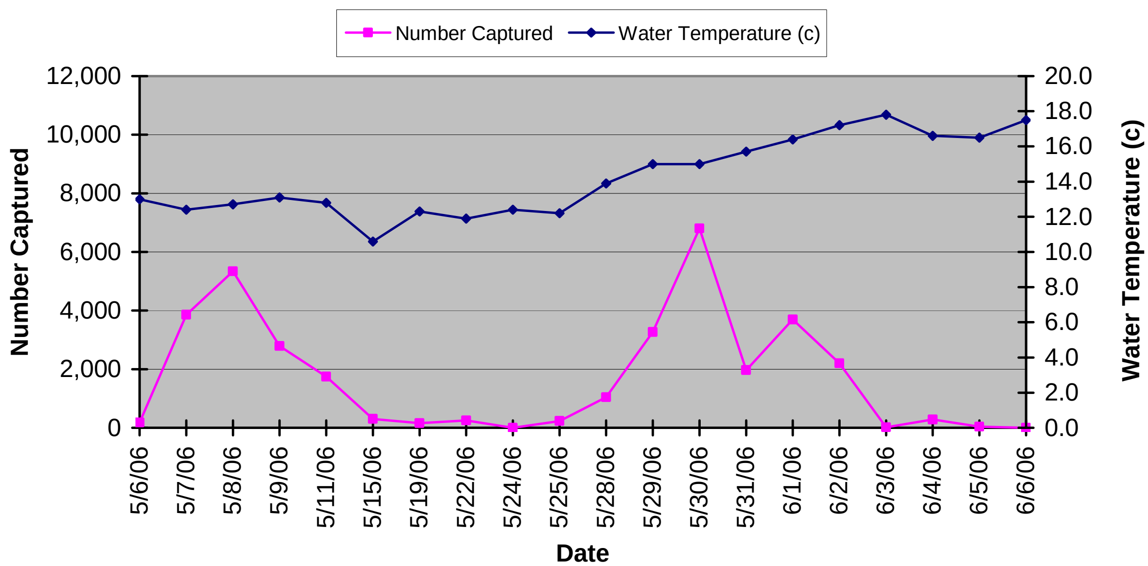
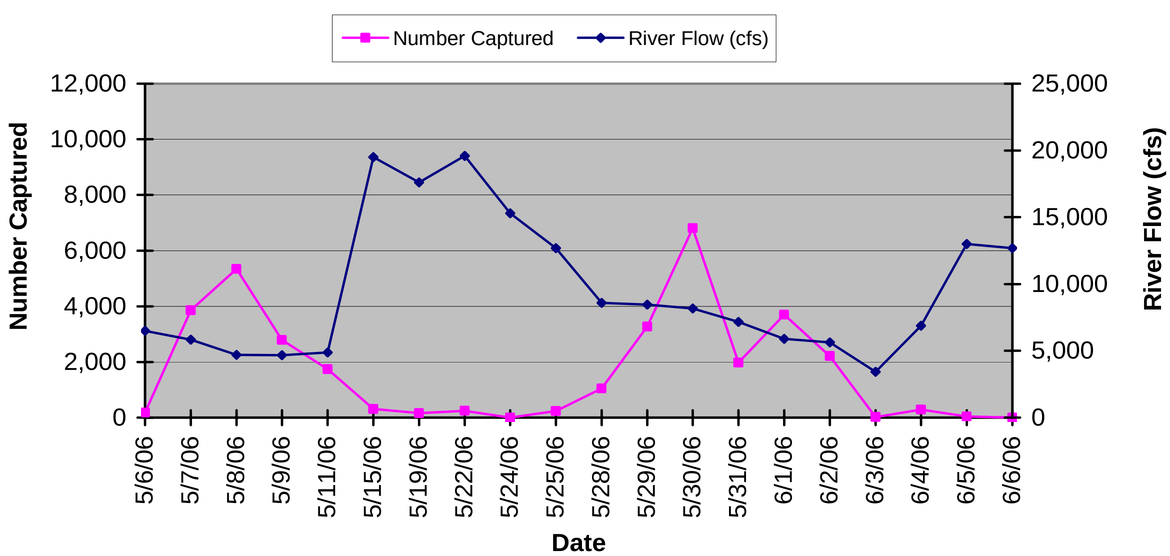


Figure 28. Number of adult river herring captured by day, vs. river flow at the Brunswick fishway, May - June 2006.



Several environmental factors affect the annual river herring runs throughout the state. These include rainfall, river flows, and air and water temperatures. Unfortunately, many of these environmental factors were unfavorable during the time river herring were migrating at other sites throughout the state. Several of the smaller streams that have river herring runs suffered because of short periods of intense rainfall. The Brunswick area escaped the large amounts of rain that fell in southern Maine and southern New England **(Figures 29 & 30)**.

Figure 29. Heavy rains in mid-May 2006 destroyed the Damariscotta fish trap and reduced escapement into the lake by 200,000 fish.

Figure 30. The town of Damariscotta closed the historical Damariscotta fishway observation walkway to visitors for several days during flooding.

In 2005, project personnel sampled river herring on three separate occasions. Of the individuals sampled, 38.0% were female, while 62.0% were male. Females averaged 254 mm fork length and weighed on average 199 g. Males averaged 246 mm fork length and weighed 176 g **(Table 25)**.

In 2006, project personnel sampled 167 river herring over four sampling sessions. The laboratory staff used only 138 of the 167 scale samples collected for the age analysis. Several (29) of the scale envelopes were mislabeled and could not be accurately attributed to the corresponding length data. Of the individuals sampled, 38.0% were female, while 62.0% were male. This is the same ratio observed in 2005 samples. Females averaged 255 mm fork length and weighed on average 211 g. Males averaged 247 mm fork length and weighed 189 g **(Table 26)**. Typically, average lengths and weights of pre-spawn alewives are relatively consistent from year to year, showing very little variation within sex. The proportion of males to females caught during the annual river herring run is normally consistent between years, 2004(1.52), 2005(1.63), 2006(1.61).

Table 25. Adult river herring sampled at the Brunswick fishway, 2005.

Date	Sex	Number	Mean Total Length (mm)	Mean Fork Length (mm)	Mean Weight (g)
5/23/2005	Female	21	285	252	194
	Male	29	292	259	215
5/31/2005	Female	16	294	260	202
	Male	34	281	249	180
6/7/2005	Female	20	274	243	179
	Male	30	269	240	154
		Total Number	**Mean Total Length(mm)**	**Mean Fork Length(mm)**	**Mean Weight (g)**
	Female	57	286	254	199
	Male	93	278	246	176
	Combined	150	281	249	185

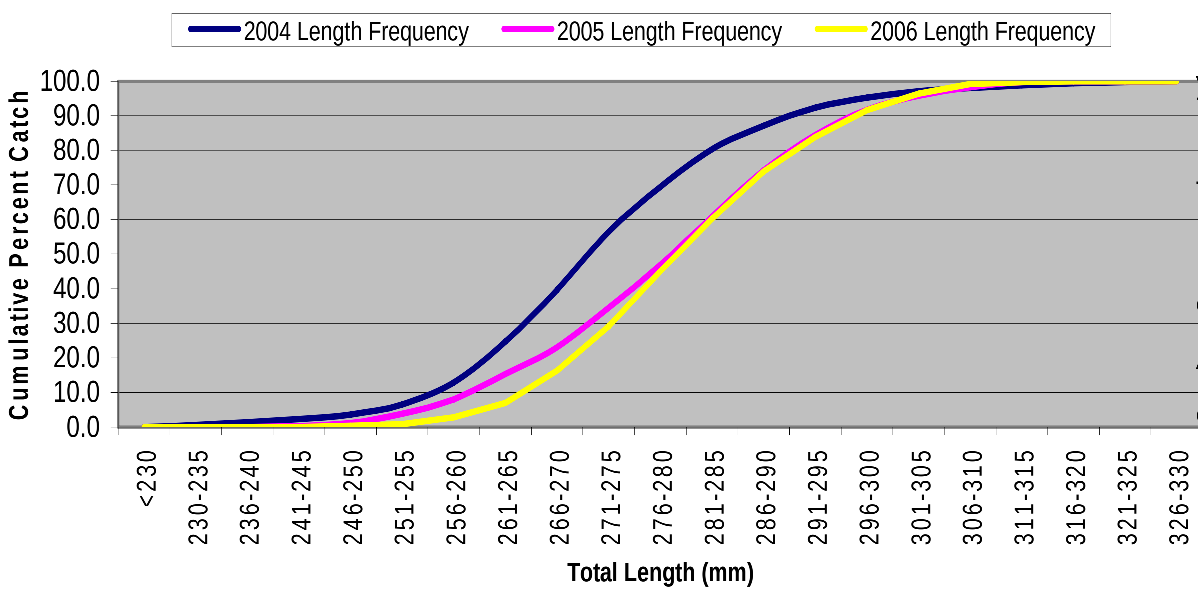
Table 26. Adult river herring sampled at the Brunswick fishway, 2006.

Date	Sex	Number	Mean Total Length (mm)	Mean Fork Length (mm)	Mean Weight (g)
5/7/2006	Female	10	295	260	236.6
	Male	40	283	249	200.3
5/15/2006	Female	22	290	257	216.9
	Male	36	279	245	184.2
5/22/2006	Female	30	285	252	200.1
	Male	24	277	244	178.8
6/6/2006	Female	2	283	249	177.7
	Male	3	278	245	167.1
		Total Number	**Mean Total Length(mm)**	**Mean Fork Length(mm)**	**Mean Weight (g)**
	Female	64	288	255	210.9
	Male	103	280	247	188.7
	Combined	167	283	250	197.2

The 2006 sample results indicate that during the last two years recruitment to the fishery has declined. The 2001 and 2002 year-classes of river herring appear weaker compared to previous year-classes. The strengths of the 2006 and 2005 runs indicate fish from these two year-classes are less abundant than those produced by the 2000 year-class. Two reasons for the weaker runs include poor downstream passage that prevented juvenile river herring from migrating to sea in 2001 and 2002, and a documented fish kill in 2001 at the Worumbo Hydropower Station.

Two trends observed from 2004 through 2006 are the increased fork lengths and weights for both sexes of river herring during this period. Individual sample weights and lengths have increased the last two years, and a distinct shift in the age structure is apparent **(Figure 31)**.

Figure 31. Cumulative percent length frequencies of river herring sampled at the Brunswick fishway, 2004 - 2006



The total lengths have increased 3.0% and 2.5% for males and females respectively. Total weights show a more dramatic increase. Male weights increased 14.0% and female weights increased 13.0%. The shifts in lengths and weights are likely the result of a larger proportion of older fish coming back to the fishway. Aging data indicate that in proportion, many more age 5-7 fish are returning than in previous years.

The majority of the Androscoggin river herring run is normally comprised of 4-year-old fish, ranging from 65.0 – 75.0%. This was not the case in either 2005 or 2006. The number of four-year-olds present in the 2005 biological samples was below average. O[illegible] the total number sampled in 2005, only 41.0% of the fish were four-years-old. Five-year-old fish comprised 53.0% of the sample, a much larger proportion than we have observed in the past. The 2006 sample results are the first indication of the 2002 year-class failure. There were no three-year-old fish in the samples collected. The age four and age five fish each comprised 38% of the fish sampled. Age six fish, which normally comprise a small percentage of the total sample, was 23%. For the first time age seven fish were present, though they totaled only 1% of the sample.

When compared to the 2004 sample results, age four fish are down 27.0% and age five fish are up 25.0%, a distinct shift in the age structure of the 2005 river herring run **(Tables 27 - 29)**. The shift in the 2006 age structure is even more dramatic. The number of age four river herring declined by 30% while the numbers of age five and age six river herring increased by 10% and 20% respectively.

The af[illegible]ver flows and cold water temperatures during the 2005 and 2006 u[illegible]ning migration are not events likely to favor one year-class of returning fish over another. The shift in age structure is simply the effect of the large 2000 year-class progressing through the fishery. With a limited number of new recruits, it is the older fish that are predominantly returning to the fishway. A cautious approach needs to be taken while planning the 2007 broodstock allocation. If the 2003 year-class is poor, very few river herring may return to the fishway in 2007. If this is occurs then perhaps at sea survival, or bycatch in ocean fisheries, may have a larger impact than in previous years.

Table 27. 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

Table 28. Ages of adult river herring sampled at the Brunswick fishway in 2005.

	Number
Age 3	4
Age 4	118
Age 5	49
Age 6	3
All Ages	174

Table 29. Ages of adult river herring sampled at the Brunswick fishway in 2006.

	Number	Mean TL (mm)	Mean FL (mm)	Mean Wt (g)	%M	%F	%U	% of Sample
Age 3	1	255	230	143	100%	0%	0%	1%
Age 4	61	274	243	171	64%	36%	0%	41%
Age 5	79	287	253	194	56%	44%	0%	52%
Age 6	9	286	254	192	100%	0%	0%	6%
All Ages	150	281	249	185	62%	38%	0%	100.00%

	Number	Mean TL (mm)	Mean FL (mm)	Mean Wt (g)	%M	%F	%U	% of Sample
Age 3	0	-	-	-	-	-	0%	0%
Age 4	52	277	244	181	63%	37%	0%	38%
Age 5	52	284	251	198	63%	37%	0%	38%
Age 6	32	290	255	214	44%	56%	0%	23%
Age 7	2	300	265	237	50%	50%	0%	1%
All Ages	138	283	250	197	59%	41%	0%	100.00%

Strategy 2. *Assess the timing and magnitude of the adult American shad migration upstream to the Brunswick-Topsham Hydroelectric Project fishway by conducting visual observations. Collect biological data from all captured adults*

During 2005, MDMR did not catch any American shad in the trap at the Brunswick fishway. The 2005 shad catch was discouraging but expected. During the 1999 and 2000 seasons, the trap caught totals of 87 and 88 individuals respectively. In 2000, the catch total was the largest number recorded since the beginning of the restoration program in 1983. Prior to 2000, the maximum number of captured adults was five fish in 1998.

The decreased run size is likely a result of the number of adult shad MDMR released in 2001 and the effectiveness of the Brunswick fishway. In 2001, MDMR released 26 native Androscoggin River shad and 308,600 hatchery fry into the river. Expected returns from these stocking efforts should range from 875 to 953 individuals. However, this number does not take into account mortality during downstream migration or at-sea survival specific to the Androscoggin River and the Gulf of Maine. The effectiveness of the Brunswick fishway also plays a large role in determining how many shad ascend the fishway to the trap.

Through June of the 2006 season, fishway staff captured three American shad in the trap at the Brunswick fishway **(Table 30)**. The shad captured in 2006 ascended the fishway mixed in with schools of alewives during the early part of June. This was unusual, normally shad do not ascend the fishway until the river herring run concludes.

Dat
6/2/20
6/4/20
6/5/20
Total Nu
Mea
Min / M

In 2006, MDMR recorded detailed visual observations from the fishway walk during the shad run **(Figure 32)**. Fishway personnel monitored selected pools for 60-second intervals to standardize observations between individual pools and the river adjacent to the fishway. During the 2006 shad run, fishway personnel observed 50 shad in the fishway and the river immediately adjacent to it. In May, fishway personnel did not document shad in or around the fishway. In June, fishway staff observed 14 shad, primarily in the river adjacent to the fishway and fishway pools 1 – 6. One shad was located in pool 23, halfway up the fishway **(Table 31)**.

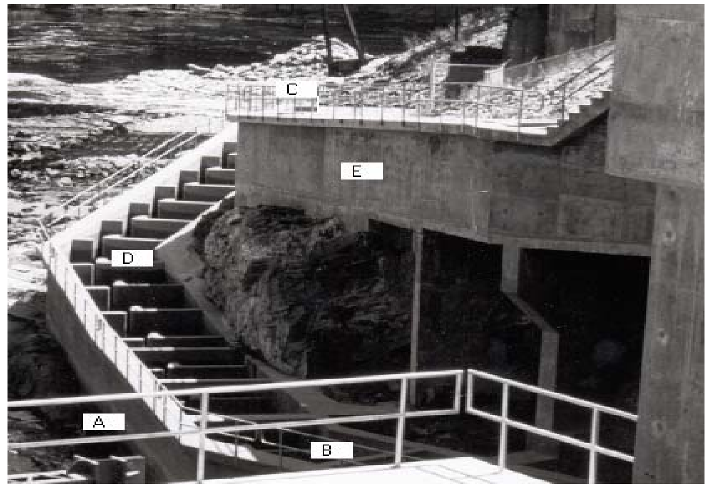


Figure 32. Brunswick fishway; **(A)** location of river observations, **(B)** lower fishway, **(C)** corner pool, **(D)** pool 14, **(E)** upper fishway - pool 31.

Fishway staff conducts visual observations at the fishway to develop an index of abundance for shad returning to the fishway and uses these data in conjunction with underwater video data and numbers of shad caught in the fish trap to assess the number of annual returns. In 2006, MDMR did not deploy the underwater cameras to observe shad behavior in the fishway and the tailrace.

Table 31. Number of American shad observed at the Brunswick fishway, 2004 - 2006

Year / Month	Viewing Windows	Upper Fishway	Lower Fishway	Corner Pool	Outside Fishway	Total Number	Mean Water Temp. (C)
2006 May	0	0	0	0	0	0	12.6
June	0	0	1	1	13	15	18.3
July	0	0	0	0	35	35	23.8
August	0	0	0	0	0	0	22.5
2005 May	0	0	0	0	0	0	10.7
June	0	0	1	0	7	8	18.4
July	0	0	9	0	50	59	23.8
August	0	0	0	0	0	0	23.1

Clearly, as with any study, visual observations of shad made from the fishway walk 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 is to 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.

Additional activities conducted in support of meeting this objective include the following:

- Staff presented a report of activities scheduled for 2005 in the Sabattus River watershed to the Sabattus Pond Dam Commission.

- Analyzed, assessed, and presented Maine's American shad data to the ASMFC American Shad and River Herring Technical Committee.

- Served as Maine's representative on the ASMFC American Shad and River Herring Technical Committee.

<u>Objective 4</u>

Assess the reproductive success of adults and productivity of juvenile alosids in the Androscoggin River watershed.

<u>Strategies:</u>

1. Evaluate juvenile river herring growth and emigration timing by sampling juvenile river herring emigrating from nursery habitats.

2. Assess newly implemented American shad management strategies at the Brunswick-Topsham Hydropower Project fishway through otolith analysis.

3. Conduct an alosine survey in the lowe

r Androscoggin River, below the Brunswick fishway, to determine abundance, origin, and community structure for alosines and native species.

Methods:

Beginning July 1, field staff conducts weekly sampling at pond and lake habitats stocked with alewives in the spring. Sampling continues throughout the summer and into the fall **(Figure 33)**. Field staff measures habitat parameters such as water temperature, conductivity, and dissolved oxygen using an YSI Model 85. Field staff collects juvenile alewife samples using dip nets or beach seining methods identical to those used in the lower river.

Each year, MDMR conducts a juvenile survey to sample alosine abundance in the lower Androscoggin River. Sampling occurs at three sites in the lower river every two weeks corresponding with the period of seaward migration by juvenile alosines. The upriver site (Zeke's) is located on the east side of the river, approximately 1.0 km below the Brunswick-Topsham Hydroelectric Project. The mid-river site (Driscoll Island) is located on the east side of the river, approximately 4.3 km below the Brunswick-Topsham Hydroelectric Project. The downriver site (Mustard Island) is located on the west shore behind Mustard Island, approximately 8.5 km below the Brunswick-Topsham Hydroelectric Project **(Figure 34)**. The beach seine used to collect samples is 17 m long and 1.8 m deep, with a 1.8 m bag at the center. The 6.35 mm mesh net is fitted with a lead line at the bottom and 7.6 cm floats spaced at 30.5 cm intervals along the top line.

The method of beach seining requires a member of the sampling crew to hold one end of the net (tied to a 2.1 m pole) stationary in an upright position at the water's edge while a boat operator backs the boat directly away from shore, deploying the net. A 6 m piece of rope tied to the 2.1 m pole on the other end of the net is held taut by the boat operator, allowing the net to assume a fishing position. The boat operator then backs the boat toward shore, stops the motor, exits the boat, grasps the pole, and pulls that end onto shore. Once on shore, the field staff slowly retrieves the net to a point approximately 14 m up the shoreline. Upon reaching shallow water, fish swim to the bag section of the net. Field staff removes all fish from the bag section of the net and places them in a bucket for identification and sampling.

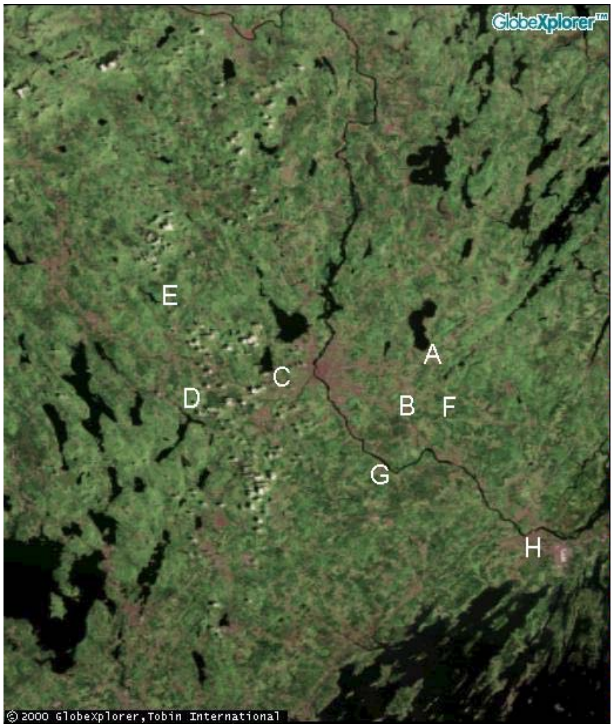


Figure 33. Juvenile alewife sample locations in the lower Androscoggin River Watershed. **A**: Sabattus Mill Dam, **B**: Farwell Dam, **C**: Brookside, **D**: Lower Range Outlet, **E**: Marshall Pond Outlet, **F**: Southerland Pond, **G**: Main Stem Androscoggin River, **H**: Brunswick-Topsham Hydropower Facility.

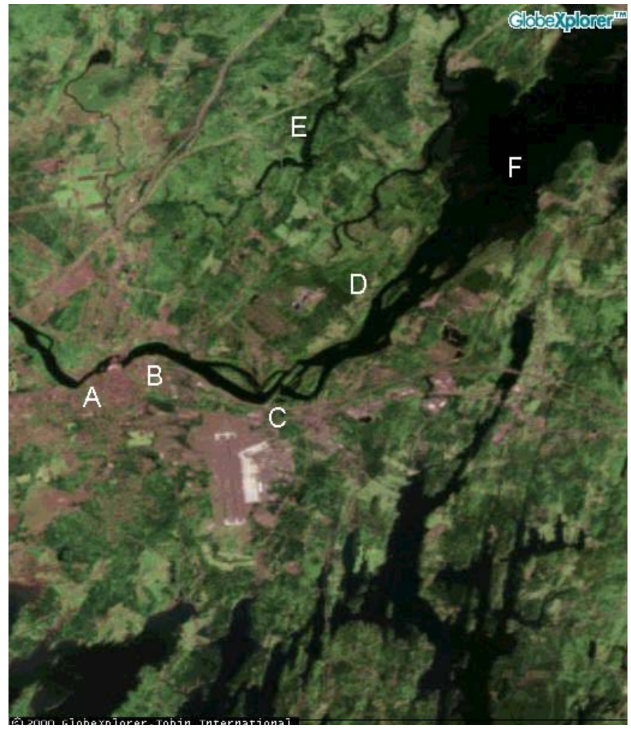


Figure 34. Alosine survey locations in the lower Androscoggin River below the Brunswick fishway. **A**: Brunswick-Topsham Hydropower Facility, **B**: Zeke's, **C**: Driscoll Island, **D**: Mustard Island, **E**: Cathance River, **F**: Merrymeeting Bay.

Throughout the sample season, project personnel collect otoliths from juvenile shad caught at the fishway or during the alosine survey **(Figure 35)**. Lab staff extracts the sagittae (largest pair of otoliths) from the semi-circular canals located under the brain cavity. Laboratory staff cleans the otoliths with warm water, then mounts the otoliths, distal side facing up, in CRYSTALBOND© on a glass slide. The laboratory staff grinds down and polishes both sides of the otoliths using Brothers' Method (*Brothers, E.*, 1989)[3] using 9, 3, and 1-micron lapping film. After drying, the project leader examines the otoliths using an Olympus BX40 microscope. The Olympus microscope uses a mercury light source to activate the OTC and make it fluoresce **(Figure 36)**. The presence of an OTC mark indicates that a juvenile shad is hatchery-reared rather than naturally spawned. Lab staff prepares

[3] Brothers, E. 1989. Otolith Marking, American Fisheries Society Symposium 7: 183-202

the juvenile shad otoliths for the OTC analysis using the same techniques to prepare adult otoliths.

Figure 35. A juvenile American shad otolith extracted from a 10-day-old hatchery fry.

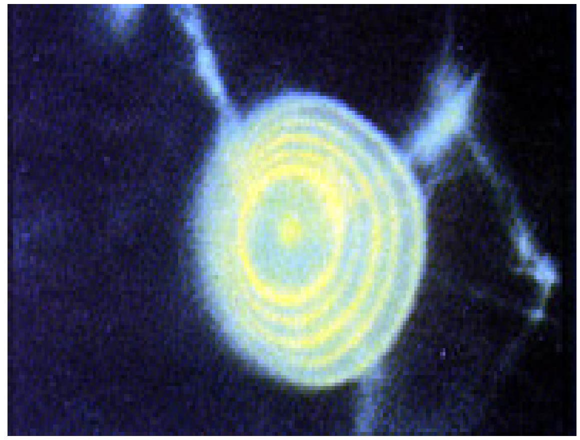


Figure 36. A longitudinal section of an American shad otolith showing the presence of several OTC marks.

Results:

***Strategy 1**. Evaluate juvenile river herring growth and emigration timing by sampling juvenile river herring emigrating from nursery habitats.*

Historically, juvenile alewives sampled upstream of the Brunswick dam were collected randomly at, or downstream, of sites that were stocked with adults. Years of sampling show that many areas in the Androscoggin watershed are productive spawning and nursery habitats and have provided data on the size of juvenile river herring at the time of emigration. Based upon these data, the number of river herring released, and annual returns, MDMR concludes that the restoration of river herring to the watershed is ecologically feasible. One obstacle to the success of the program is the lack of available habitat. The amount of habitat available for restoration relates to public support and perceptions of the program. Sabattus Pond is the single largest river herring spawning and nursery

habitat in the lower Andro scoggi n and Little Androsc oggin watersh eds. Due to perceive d conflicts with inland fishery resourc es, this pond was not available for river herring restoration from 1987 to 1997.

Field staff stocked 24,156 alewives in ten upstream habitats in 2005. Starting July 1, MDMR measures initial stocking success by determining the timing and magnitude of juvenile emigration from nursery habitats. Field staff collected biological samples at inland sample locations once a week if emigrating fish were present **(Table 32)**. Unlike the past three years, significant rainfall during the late summer and fall provided optimum conditions for downstream passage. Spill conditions existed at all dams in the watershed during the period when juvenile alosines were migrating downstream. In addition to above average rainfall, the annual drawdown that occurs at Sabattus Pond allowed adequate amounts of water to transport emigrating alewives downstream to the main stem Androscoggin River.

Table 32. Juvenile alewives sampled from inland nursery habitats during the 2005 sample season.

Location	Visits	Water Temperature °C			Number of Samples	Total Length (mm)			Weight (g)		
		Min	Max	Mean		Min	Max	Mean	Min	Max	Mean
Bog Brook	0	0	0	0	0	0	0	0	0	0	0
Little Androscoggin	53	5.5	26	16.367	0	0	0	0	0	0	0
Little Sabattus Pond	6	6.0	20.0	9.7	0	0	0	0	0.0	0.0	0.0
Loon Pond	0	0	0	0	0	0	0	0	0	0	0
Lower Range Pond	34	7.5	28	17.545	1	70	90	82.7	1.9	4.5	3.596
Marshall Pond	16	6.5	23	15.733	0	0	0	0	0	0	0
No Name Pond	11	6	24	15.364	0	0	0	0	0	0	0
Sabattus Pond	1	22.5	22.5	22.5	0	0	0	0	0	0	0
Sabattus River	125	6.0	26.5	17.7	0	0	0	0	0	0	0
Sutherland Pond	0	0	0	0	0	0	0	0	0	0	0
Taylor Brook	16	12	25.5	21.031	7	41	91	75.9	1.2	5.8	3.134
Taylor Pond	0	0	0	0	0	0	0	0	0	0	0

It was difficult to determine exactly when juveniles began dropping out of Sabattus Pond. Extended periods of high flow during mid-summer made sampling difficult. An estimated 7.8 million juveniles emigrated from the system

through the summer and fall. Field staff checked the Sabattus River on 125 different occasions, a significant increase over 2004 when staff conducted only 70 sample visits. There were no samples collected during any of these sampling visits, although field staff did observe juveniles. Traditional sample locations were underwater or too dangerous to sample **(Figure 37)**.

Figure 37. River flow in early October 2005 at the Old Mill sample location on the Sabattus River, located 135 meters below the outlet of Sabattus Pond. Typically, the remains of the old granite structure are out of water and field staff uses it to access sampling locations along the river.

Field staff sampled Taylor Pond/Stream, which empties into the Little Androscoggin River, 16 times from July through October. Due to the limited number of sampling visits made to the pond outlet, samplers did not collect juveniles from this site. Samplers did collect 229 juveniles at other locations along the outlet stream. Total lengths ranged from 41 mm to 91 mm, averaging 76 mm. Mean weights ranged from 1.2 g to 5.8 g, averaging 3.1 g. The 2005 mean sample lengths and weights are significantly different from mean sample lengths and weights calculated in 2004. In 2004, total lengths ranged from 93 mm to 114 mm, averaging 101 mm. Mean weights ranged from 5.5 g to 9.9 g, averaging 7.0 g. The reasons for these differences are likely the amount and duration of high water throughout the downstream migration period. High water early in the migration period allowed juveniles to emigrate earlier than in 2004. As a result, the juveniles spent less time in the lake feeding and growing to lengths typically observed in samples collected later in the migration period.

Field staff visited Marshall Pond, which is historica lly difficult to sample, on 16 occasions. High water and newly constructed beaver dams changed the locations of sample sites. Field staff did not observe or sample juvenile alewives from Marshall Pond. The only other site that produced samples in 2005 was Lower Range Pond. Field staff collected 24 individuals at the outlet dam. Total lengths ranged from 70 mm to 90 mm, averaging 83 mm. Mean weights ranged from 1.9 g to 4.5 g, averaging 3.6 g. Field staff sampled the remaining stocking locations less often because of past difficulties in obtaining adequate sample numbers.

The Sabattus watershed is the best nursery habitat available to the restoration program. Mean lengths and weights of individuals collected there are larger than in any of the other habitats sampled. The ponds within the watershed are shallow and warm, with high primary production. As a result, food availability and abundance are higher than the ponds in the Little Androscoggin River watershed.

Fishway staff observed few juvenile alosines passing downstream through the Brunswick fishway in 2005. Water levels in the main stem of the Androscoggin River were sufficient to provide downstream passage throughout the summer. Spill over the dam and overflow gates provided downstream passage not typically available in most years. The above average rainfall created extremely high river flows and flooding in the fall. Fishway personnel observed the first juvenile alewives migrating downstream through the Brunswick fishway on September 1, 2005.

In October, fishway staff sampled 64 juvenile alewives at the fishway. The total lengths of the fish sampled ranged from 59 mm to 105 mm, while weights ranged from 1.5 g to 8.0 g **(Table 33)**.

Table 33. Juvenile river herring sampled at the Brunswick fishway, 2005.

Date	Number	Mean Total Length (mm)	Mean Weight (g)	Air Temp C	Water Temp C	Mean River Flow (cfs)

12-Oct	
13-Oct	
17-Oct	

The ranges of lengths and weights were down significantly from 2004 sample results. The decrease may be a result of the decreased sample number collected in 2005 or favorabl e environmental conditions in specific nursery habitats that allowed early emigration. The largest juveniles observed at Brunswick were likely comprised of Sabattus Pond individuals that field staff were unable to obtain earlier in the season. Although field staff attempted to collect juvenile alewife samples from mid-summer until ice-over, increased numbers of samples collected in the late fall will skew the results toward larger mean lengths and weights.

Juvenile alosines may use the upstream passage at the Brunswick fishway for emigrating anytime from July – October. It provides alternative downstream passage to the dedicated downstream passage located between turbines one and two. Juvenile river herring were present in the fishway from September through October. The numbers observed at the fishway varied daily. The grate spacing in the fish trap and sorting area is large enough to allow juveniles to move freely through the trapping area. As a result, fishway staff could only observe or sample a fraction of the juveniles using the fishway as downstream passage.

Strategy 2. *Assess newly implemented American shad management strategies at the Brunswick-Topsham Hydropower Project fishway through otolith analysis.*

The MDMR currently employs three restoration strategies to achieve American shad restoration goals for Maine's rivers. Maine passively manages most of its shad rivers. Most of these rivers are small rivers with historic runs of shad that persist without active management or specific monitoring. Maine stocks the larger rivers with fry or pre-spawn adults to supplement existing runs of shad to increase annual returns.

On the Kennebec and Sebasticook Rivers, the MDMR releases marked hatchery fry into the impoundments above the first several dams on these rivers. These rivers do not receive adult transfers from other river systems. Time, cost, and the level of transport mortality make the prospect of adult transfers less desirable than utilizing hatchery fry. Fisheries managers on the Kennebec River passively manage wild shad in these rivers below the first dams and no effort to assess their numbers is in place. None of the dams on these rivers have upstream passage and, as a result, no easy way to enumerate the numbers of fish wanting to pass upstream.

On the Androscoggin River, project personnel use both marked fry and pre-spawn adults from the Merrimack River to achieve restoration goals. By manipulating the numbers of fry released vs. the numbers adult fish stocked, staff can compare differential growth and production of wild fish compared to the known number of fry released. Historically, the numbers of hatchery fry sampled at the fishway were low, 5 -13%. In 2003, five of eight (62%) of the juvenile shad were determined to be hatchery origin but the sample size was too small to be considered reliable, although approximately 2.1 million hatchery fry were released into the Androscoggin River. Other river systems, namely the Susquehanna River in Pennsylvania, have much better success with hatchery programs. Approximately 80% of the shad returning to the Susquehanna result from hatchery fry releases.

In 2004, fishway staff collected 58 juvenile shad from the fish trap at the Brunswick fishway, exclusive of the 22 shad retained as training fish for project personnel. Fishway staff retained all juvenile shad sampled at the fishway in 2004 for otolith analysis. The field staff observed two distinct size classes while collecting these samples. Analysis of the shad otoliths indicated 25% of sample was hatchery origin, all in a smaller size range. The mean total length of the marked shad was 77 mm while the mean total length for the unmarked shad was 90 mm.

Capturing juvenile shad at the fishway is difficult due to the 37.5 mm spacing between the bars that make up the trap grating. A large proportion of juvenile fish passing downstream pass undetected through the trap, downstream bypass, or the turbines.

In 2005, low hatchery production limited the number of fry available to the Androscoggin Restoration Project. Fisheries staff conducted one release of 96,551 marked fry into the river. There were no wild fish either stocked or passed above Brunswick in 2005 to draw a comparison.

Analysis of limited stocking and return data available from the Brunswick fishway shows a correlation between the numbers of adult shad stocked and the number of returns observed. Fry stocking has not occurred long enough to produce any meaningful trends. Improved upstream passage may increase returns to within the ranges expected **(Figures 38 & 39)**.

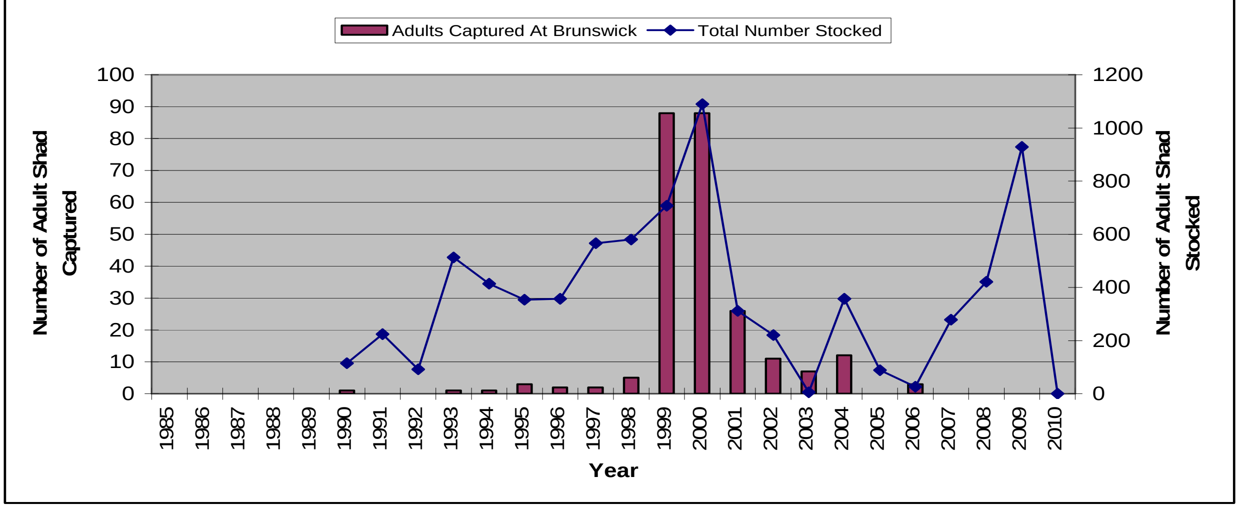


Figure 38. Numbers of adult American shad captured at the Brunswick fishway vs. numbers of adults stocked above Brunswick five years earlier.

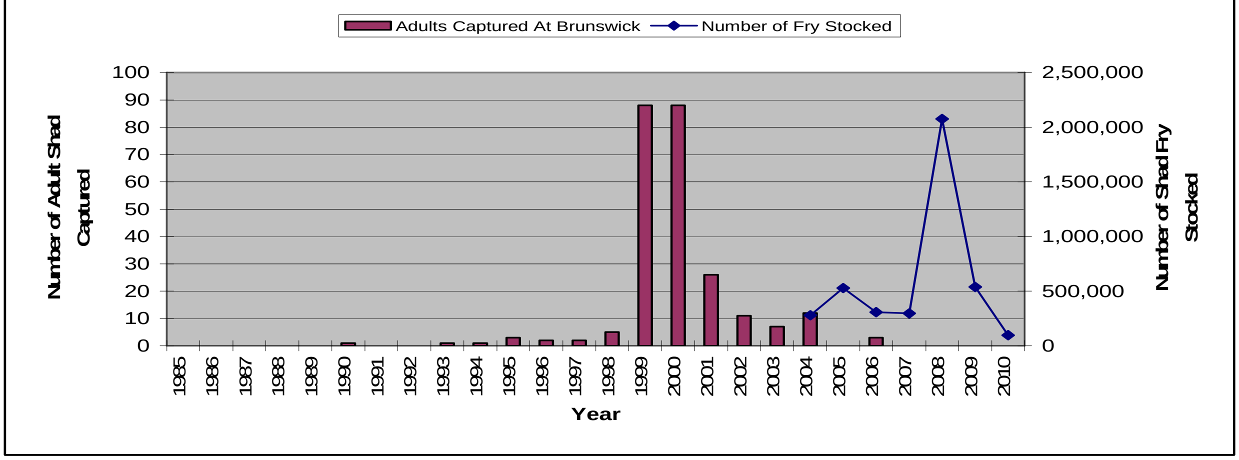


Figure 39. Numbers of adult American shad captured at the Brunswick fishway vs. numbers of shad fry stocked above Brunswick five years earlier.

Other than the inefficiencies of the vertical slot fishway at Brunswick, causes for the decline in both American shad and river herring numbers in 2005 are unclear. Certainly, the drought of 2001 and the fish kill observed at the Worumbo Hydropower Project play a large role for river herring on the Androscoggin River. However, all river herring and American shad runs are down across the state and the American shad runs are down across the entire east coast. This fact leads to questions of at-sea survival for both species. Despite closures of all coastal intercept fisheries for American shad along the east coast, shad runs are still declining. If specific in river survival factors are the main cause for the decline, it is unlikely all the east coast rivers would experience diminished return rates for 2005. Drought conditions experienced in 2001 may have played a larger role than expected for shad and river herring in the major river systems along the east coast, but Maine has several coastal river herring runs that dump directly into tidal waters. These runs escape the impacts of turbine mortality normally associated with major river systems where fish must coexist with hydropower production.

Strategy 3. *Conduct an alosine survey in the lower Androscoggin River, below the Brunswick fishway, to determine abundance, origin, and community structure for alosines and native species*.

Through September 2005, field staff sampled three sample sites on six occasions in the lower Androscoggin River below Brunswick **(Table 34)**. The highlight of the 2005 sample season was the number of young of the year striped bass caught in the lower river. There is a small native population of spawning striped bass in the Merrymeeting Bay Estuary and any juveniles captured are of great interest. The precise location and timing of striped bass reproduction within the Merrymeeting Bay complex is unknown.

There were no young of the year striped bass captured at any of the sample locations in either 2003 or 2004. In 2002, sampling efforts resulted in young-of-the-year striped bass at each of the three sample locations. Through September 2005, sampling efforts captured 27 juvenile striped bass, all captured at the Driscoll Island sample site. This is the largest total captured in the lower

Androscoggin since the survey began. The striped bass total lengths range from 64 mm to 112 mm. Field staff saved these samples to provide genetic material for future genetic analysis.

The total number of juvenile alosines captured while sampling the lower Androscoggin River during 2005 indicates a decrease in abundance compared to 2004 results, though the numbers captured in 2005 are consistent with results from the 2003 survey. MDMR expected an increase in the juvenile index for these species in 2005, but our sampling efforts did not reflect this.

Through September 2005, field staff captured only one American shad while conducting the alosine survey. A decrease in the numbers of adult American shad observed in the tailrace at the Brunswick fishway indicated that juvenile shad abundance in the lower river might be lower than in previous years. The field staff saves juvenile shad collected while conducting the alosine survey to determine their origin, hatchery vs. wild. Although staff would not be able to determine the release site, the Androscoggin or Kennebec, it would indicate that hatchery fish are dropping out of the river systems in preparation of going to sea.

The alosine survey captured 12 different fish species in 2004 and 16 species in 2005. White perch, yellow perch, spottail shiner, and banded killifish were the most common during both years. Excluding striped bass and alosines, the survey found similar species at all sample sites throughout the sample period. The numbers of individuals within species did show some differences between sample sites and sample date. Many of these differences may relate to life stage requirements, lower than normal tides, cloud cover, sample time, or changes occurring at the sample locations.

The Androscoggin River below Brunswick has a sandy substrate and annual changes occur at these sample locations. Spring runoff and high flows redistribute sand at these locations. Some years, the sites are shallower or deeper than the previous year. The most stable site is Zeke's, just below the Brunswick fishway. Absent from survey catches were smelt, northern pike, white catfish, and brown bullhead. Night or early morning sampling may be better times to capture these species.

Program changes that incorporate an increased number of sample sites, adjusting sampling times (currently at low tide), and modifications to sample gear may increase the power of the index and provide a better understanding of alosine production and habitat utilization within this system. The addition of 3-4 sampling sites, in conjunction with maintaining the traditional sites, could be helpful in locating additional habitats preferred by juvenile alosines and striped bass.

Table 34. Results of the 2005 Androscoggin River Alosine Survey conducted at three sites below the Brunswick fishway, in the lower Androscoggin River, during the 2005 sample season.

Date	Sample Site	Water T (°C)	Species	Sample Number	Expanded Number	Mean TL (mm)
7/7/05	Driscoll Island	22.0	banded killifish	1		47
	Zeke's	22.0	banded killifish	1		40
	Driscoll Island	22.0	blueback herring	74		33
	Mustard Island	22.0	four-spine stickleback	3		25
	Zeke's	22.0	smallmouth bass	1		95
	Mustard Island	22.0	spottail shiner	1		19
	Driscoll Island	22.0	spottail shiner	1		110
	Zeke's	22.0	spottail shiner	67	372	27
	Zeke's	22.0	yellow perch	48		29
	Total/Mean	22.0		197	372	

Table 34 . continued.

Date	Sample Site	Water T (°C)	Species	Sample Number	Expanded Number	Mean TL (mm)
7/22/05	Mustard Island	25.0	American shad	1		17
	Driscoll Island	25.0	banded killifish	31		64
	Driscoll Island	25.0	smallmouth bass	3		112
	Zeke's	25.0	smallmouth bass	14		47
	Mustard Island	25.0	spottail shiner	52		25
	Driscoll Island	25.0	spottail shiner	52	1,234	24
	Zeke's	25.0	spottail shiner	28	106	33
	Driscoll Island	25.0	sunfish	1		82
	Driscoll Island	25.0	white catfish	1		18
	Mustard Island	25.0	white perch	1		13
	Zeke's	25.0	white sucker	21		41

	Driscoll Island	24.0	striped bass	10		72		
								Dris
	Mustard Island	23.0	sunfish	1		127		
	Driscoll Island	24.0	sunfish (red-breast)	10		110		Dris
	Zeke's	24.0	sunfish	2		54		
	Driscoll Island	24.0	white perch	42		67		Dris
	Driscoll Island	24.0	white sucker	4		72		
								Dris
	Zeke's	24.0	yellow perch	2		56		
	Driscoll Island	24.0	yellow perch	25	62	62		
								To
	Total/Mean	23.8		284	214			

Date	Sample Site	Water T (°C)	Species	Sample Number	Expanded Number	Mean TL (mm)
9/6/05	Driscoll Island	22.0	alewife	4		78
	Mustard Island	22.0	banded killifish	26		26
	Driscoll Island	22.0	banded killifish	18		78
	Driscoll Island	22.0	fallfish	1		120
	Driscoll Island	22.0	largemouth bass	2		144
	Driscoll Island	22.0	smallmouth bass	4		95
	Zekes	22.0	smallmouth bass	4		67
	Zekes	22.0	spottail shiner	37		45
	Driscoll Island	22.0	spottail shiner	52	283	61
	Driscoll Island	22.0	striped bass	17		94
	Zekes	22.0	sunfish	1		70
	Driscoll Island	22.0	sunfish	1		109

Table 34. continued.

	Driscoll Island	22.0	white perch	51	709	77
	Driscoll Island	22.0	white sucker	5		91
	Driscoll Island	22.0	yellow perch	41		71
	Total/Mean	22.0		264	992	

Date	Sample Site	Water T (°C)	Species	Sample Number	Expanded Number	Mean TL (mm)
9/20/05	Zeke's	20.5	American eel	1		60
	Mustard Island	20.5	banded killifish	6		36
	Driscoll Island	20.5	banded killifish	1		82
	Zeke's	20.5	banded killifish	4		39
	Mustard Island	20.5	smallmouth bass	1		198
	Driscoll Island	20.5	smallmouth bass	15		132

Objective 5: Increase the accessibility to 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 operations and downstream effectiveness study plans at hydropower dams.

2. Provide effective up and downstream passage for native diadromous fish species at dams currently without passage through the FERC process and non-regulatory partnerships.
3. Review and analyze videotape data collected at the Brunswick fishway during the 2002-2004 seasons.

Background for Strategy 1

From the early 1800s to the present, numerous companies constructed hydropower and storage dams on the Androscoggin and Little Androscoggin rivers. Construction occurred without implementation of upstream fish passage facilities, resulting in the destruction of diadromous fish runs above head-of-tide. Until the early 1980s, only remnants of diadromous fish runs existed in the tidal sections of the Androscoggin between Brunswick and Merrymeeting Bay. In 1982, the Central Maine Power Company incorporated upstream and downstream fish passage facilities during the reconstruction of the hydroelectric facility at head-of-tide in Brunswick. Five years later, Pejepscot provided upstream and downstream passage at the second upstream dam on the Androscoggin, and in 1988, the Worumbo Project installed passage facilities at the third upstream dam. With these facilities in place, habitat became accessible to diadromous fish species as far upstream as Lewiston Falls for the first time in 180 years.

During the Federal Energy Regulatory Commission (FERC) re-licensing process for the projects listed above, MDMR staff recommended fish passage facilities be

installed at project dams to enhance upstream and downstream passage of diadromous fish. With the exception of the Brunswick-Topsham Hydropower Project and Lower Barker Mills, where upstream and downstream fish passage efficiency studies were not required, all other FERC-licensed dams have passage efficiency study requirements. The licensees have hired consultants or used in-house staff to carry out studies reviewed and approved by MDMR staff.

Methods:

Annual meetings are held with the owners and operators of the Pejepscot and Worumbo Projects to discuss the diadromous fish restoration program, define operational procedures and outline plans for required downstream efficiency studies. In addition, MDMR conducts regular monitoring of operation compliance and maintenance checks at these sites from April through November.

Results:

Strategy 1. *Provide oversight, review, and comments on required fish passage operations and downstream effectiveness study plans at hydropower dams.*

In March 2006, the project leader met with representatives of the Worumbo and Pejepscot hydropower stations. The reasons for these meetings are to discuss study progress, modification, and operation of the hydropower stations as it relates to upstream and downstream fish passage.

During the Worumbo meeting, we discussed the results of the past years progress and plans for the upcoming 2006 season. Worumbo and MDMR provide operational plans, important dates, and contact information to manage the most common situations encountered during the season. The project leader reviewed the dates to open the fishway and facilitate downstream passage. Worumbo established a call system to notify MDMR of any bird activity in the tailrace of the hydropower station that may indicate fish passing through the turbines.

Worumbo presented a report of upstream fish passage results for 2005. The station operators count the number of fish passing upstream twice a day and submit a report to the resource agencies at the end of the year.

Both Worumbo and Pejepscot hydropower stations need to complete upstream fish passage studies under high flow conditions. These studies are temporarily on hold while waiting for alewife populations to increase and provide enough fish for the study. The U.S Fish & Wildlife Service and state resource agencies reviewed and approved the study plans submitted by the hydropower stations.

Worumbo also needs to complete a downstream efficiency study for juvenile alosines. Preliminary studies, conducted in 2005, indicate that tag size and tagging methods need to improve before Worumbo can successfully tag and recapture juvenile alosines for this study.

Figure 40. Hydraulic conditions during high flows will require modifications to the site and upstream passage at two locations below the dam, indicated by the green arrows.

Figure 41. Juliet dam is the first dam located on the Sabattus River. Field staff located and [illegible]

Strategy 2. *Provide effective up and downstream passage for native diadromous fish species at dams currently without passage through the FERC process and non-regulatory partnerships.*

The Sabattus River has six non-hydropower dams that need upstream passage if alewives are to reach Sabattus Lake. In 2006, project staff visited the Juliet Dam, the first dam on the Sabattus River, to search for migrating alewives. A small number of alewives (200-300) held below the dam for a short period during the upstream migration **(Figures 40 & 41)**. Federal funding is needed to provide upstream passage at all the dams on the river. Because of the number of fish passages that are needed, it will be difficult to raise funds for all these locations at one time. The Project Leader will continue to search for funding for these projects.

Project staff continues to work on reviewing and analyzing videotape data from 2003 through 2004. The large backlog of data collected requires a considerable amount of time to review, enter, and analyze. Further modifications to the Brunswick fishway are on hold until the data analysis is completed. Once the data analysis is complete, and suggests which changes were most successful, project staff will recommend further action. Preliminary data indicate that none of the modifications solved the immediate problem of American shad not ascending the fishway. Each year river conditions, stocking rates, operation of the fishway, and fishway hydraulics were slightly different. Fluctuating headpond levels and mechanical failures throughout each season introduce variables that are difficult to measure when comparing years. None of the modifications resulted in large runs of American shad up the fishway and into the Brunswick headpond.

<u>Sabattus dredging project</u>

For several decades, the Maine Electronics Company operated in the town of Sabattus adjacent to the Sabattus River. Processing water and effluent from the plant drained into river just above the third dam. Since the plants closure, and after assessment of the river sediments adjacent to the plant, the Maine Department of Environmental Protection ordered the company owner to remove the heavy metals that they discharged into the river.

During the fall of 2005, Maine Electronics hired a dredging company to remove and process the contaminated sediment from the designated clean-up area. The company dredged a section of the river, approximately 550 m long by 55 m wide and 15 cm deep. A silk curtain retained dredge spoils within the work site **(Figure 42)**. The barge pumped dredged materials from the river to a processing site set up in the parking lot at the electronics plant **(Figures 43 & 44)**. During cleanup, the decontamination equipment returned processed water from the dredged materials back into the river. After dewatering, the heavy metals were

removed from the sediment by the processing equipment and the processed sediment was trucked to an approved disposal location.

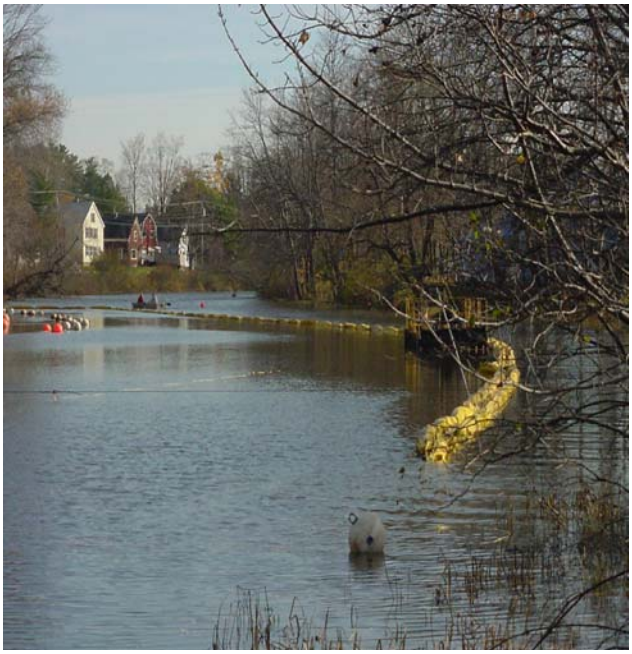


Figure 42. The silk curtain deployed around the work site to contain dredged materials.

Figure 43. The dredging barge used to remove sediment and pump it to the processing location.

Figure 44. The processing plant set up in the Maine Electronics parking lot.

Strategy 3. *Review and analyze videotape data collected at the Brunswick fishway during the 2002-2004 seasons*.

Currently, project personnel needs to analyze a backlog of video data collected in 2003 and 2004. During the period January through August, project personnel have reviewed all data from 2003 and one-half of 2004. Project personnel entered the data and the data analysis is ongoing. Once the analysis is complete, the project leader will produce a comprehensive report detailing project results.

Additional activities conducted in support of meeting this objective include the following:

- Project leader met with the Brunswick Hydropower owner (Florida Power and Light, Inc., formerly Central Maine Power) in March to review Brunswick station operations, problems occurring with the fishway water attraction valve, and maintenance issues requiring resolution prior to the start-up of the fishway in May 2006.

- During the first week of May, project staff notified the Worumbo and Pejepscot facilities to begin operation of the upstream passage facilities to pass the upstream migrating anadromous fish species passed above Brunswick.

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 public presentations on the program to public and scientific audiences.

2. Participate in the development and activities of the Androscoggin River Watershed Council.

Methods:

The Androscoggin River runs through the states of Maine and New Hampshire before emptying into Merrymeeting Bay and finally, the Gulf of Maine. Traditional user groups include the pulp and paper industry, hydropower, textile mills, town sewer districts, and the public. Recent improvements in water quality throughout the watershed, because of the Clean Water Act, and improved watershed management techniques, have increased the number of user groups over the past two decades to include fishing guides, white-water canoeists, swimmers, and hikers. The MDMR is also one of the new user groups on the river. In 1983, the MDMR began the anadromous fish restoration program on the Androscoggin River. The restoration program requires the MDMR to interact and communicate with a number of traditional and nontraditional user groups that cooperatively manage the watershed. While implementing the restoration program, project staff works closely with local watershed groups, land trusts, towns, and private landowners to educate and answer questions concerning MDMR activities in the watershed. We accomplish this task through presentations to lake associations, land trust meetings, an annual canoe trek on the Androscoggin River, and cooperative management with other state agencies.

Results:

The Maine Department of Environmental Protection (DEP) has allowed the three towns surrounding Sabattus Pond - Sabattus, Wales, and Green - to form an interlocal dam commission that establishes lake levels for Sabattus Pond. Project personnel are currently working with the commission to establish a lake level that will benefit all users. The project leader is continually working in cooperation with the Town of Sabattus to improve downstream passage of river herring and American eels from Sabattus Pond. The project leader also met with the president of the Sabattus Lake Association (SLA) regarding the Sabattus Pond adult alewife restoration program and association concerns on potential impacts to the lake. Included in the discussions were stocking plans for 2006, the anadromous fish run size at Brunswick, stocking rates throughout the watershed, juvenile and adult sampling activities planned for 2006 in Sabattus River, the fall water level drawdown, and recreational fishing activities. The

project leader informed association members when sampling activities were scheduled and when stocking would begin and end.

Project personnel monitored the water control structure at the outlet of

Sabattus Lake from July 1 through December 1, 2005. Sample results indicate that juvenile alewives and adult American eels are able to successfully utilize the new gate structure and emigrate from the lake throughout the summer. This is a significant improvement over past years. The period of outward migration was restricted to the annual drawdown of the lake that traditionally occurred in mid-October. Project staff anticipates better survival of emigrants because of these changes.

Project personnel continue to work with the Androscoggin Land Trust to conduct an inventory of two tributaries that empty into the Little River, a tributary of the Androscoggin. These streams are important to MDMR because electro-fishing surveys found Atlantic salmon parr utilizing habitat located at these locations. We are also working with the ARWC to develop a series of GIS map layers that will provide towns along the entire watershed information on unique habitats in the watershed, special fish habitat, and large tracks of undeveloped land along the river in need of protection. The ARWC will provide GIS data to interested town planners, conservation commissions and other interested parties free of charge.

Additional activities conducted in support of meeting this objective include the following:

- Project leader participated as a member of the Androscoggin River Watershed Council’s Organizing and Bylaws Committee. The council informed members of lower watershed activities of interest and provided data to the Council of the Land for Maine's Future Program, which acquires fish and wildlife habitats for protection. MDMR prepared articles on the restoration of diadromous fish species in the Androscoggin watershed for the biannual council newsletter in May 2006.

- The project leader and technician prepared a display and gave presentations on one day of the annual Androscoggin River Source-to-the-Sea Canoe Trek in mid-July. The display and present ation began at the canoe launch site. The presentation continued while paddling a designated stretch of river. We discussed the goal of the Androscoggin River Restoration Program and ongoing activities underway to restore native diadromous fish species to the watershed.

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

<u>Appurtenances:</u>

Gates:	1 - 7' x 10' motorized & instrumented sluice gate at fishway exit. This gate to be closed when pond level reaches

Fish Crowder

Fish Hopper

500-gallon capacity with electric hoist at fish trap

<u>Related Work:</u>

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

Fish species observed using the Brunswick fishway 1983 – 2005

Alewife
American Eel
American Shad
Atlantic Salmon
Black Crappie
Bluegill
Blueback Herring
Brook Trout
Brown Trout
Carp
Chinook Salmon
Coho Salmon
Common Shiner
Crayfish
Creek Chub
Emerald Shiner
Golden Shiner
Landlocked Salmon
Largemouth Bass
Pumpkinseed Sunfish
Rainbow Smelt
Rainbow Trout
Sea Lamprey
Smallmouth Bass
Spottail Shiner
Striped Bass
White Catfish
White Perch
White Sucker
Yellow Perch

APPENDIX

Table 15. May 2005 - Brunswick fishway air and water temperatures / headpond levels.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level (feet above sea level)	River Flow (cfs)
5/1				29,600
5/2				26,800
5/3				23,100
5/4				19,200
5/5				16,000
5/6				14,700
5/7				13,800
5/8				13,000
5/9				10,700
5/10				10,000
5/11				9,960
5/12				9,880
5/13				10,700
5/14				8,940
5/15				8,730
5/16				8,700
5/17				8,900
5/18				9,050
5/19	14.1	12.1	41.5	8,980
5/20	15.3	12	41.5	8,790
5/21	12.2	12.3	41	8,560
5/22				7,710
5/23	10.9	11.3	41.5	12,600
5/24	8.9	10.9	42.5	28,900
5/25	6.6	9.9	43.5	32,400
5/26	9.2	8.8	41.5	26,900
5/27	10.7	8.9	42	34,100
5/28	15.9	9.4	43	32,200
5/29	16.7	10.2	41.5	26,000
5/30	10.8		41.5	23,200
5/31	10			

Mean	**11**
MIN.	**6.**
MAX.	**16**

Table 16. June 2005 - Brunswick fishway air and water temperatures / headpond levels.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level (feet above sea level)	River Flow (cfs)
6/1	14.6	12.8	41.5	21,900
6/2	19.3	13.0	42.0	18,100
6/3	19.8	14.3	41.5	14,600
6/4	20.6	15.7	41.5	12,200
6/5	20.6	16.9	41.0	9,710
6/6	11.3	16.9	41.0	9,340
6/7	22.8	17.2	41.0	7,220
6/8	25.3	19.0	40.5	7,740
6/9	24.3	19.6	40.5	6,980
6/10	24.5	20.0	39.0	6,670
6/11				6,200
6/12	17.6	20.6	39.0	5,510
6/13	29.7	21.9	38.5	6,300
6/14	13.9	21.7	39.5	6,830
6/15	10.0	19.4	41.0	13,000
6/16	11.2	20.2	40.5	19,900
6/17				19,700
6/18	14.6	15.0	41.5	19,600
6/19	17.6	15.1	41.0	18,700
6/20	21.1	15.6	41.5	16,900
6/21	23.6	16.0	42.0	13,100
6/22	20.7	17.2	41.0	11,100
6/23	19.1	17.9	41.0	9,440
6/24				8,660
6/25				6,430
6/26	28.9	20.8	38.5	6,130
6/27	26.1	21.8	38.5	6,240
6/28	23.2	22.3	39.0	5,220
6/29	24.9	23.7	38.5	4,050
6/30	24.0	23.0	38.0	3,800
Mean	**20.4**	**18.4**	**40.3**	**10,709**
MIN.	**10.0**	**12.8**	**38.0**	**3,800**
MAX.	**29.7**	**23.7**	**42.0**	**21,900**

Table 17. July 2005- Brunswick fishway air and water temperatures / headpond levels.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level (feet above sea level)	River Flow (cfs)
7/1	16.9	22.2	38.0	4,100
7/2	25.1	22.7	39.0	5,250
7/3	24.6	24.0	39.0	5,220
7/4	23.6	24.7	39.0	5,170
7/5	23.5	23.8	38.0	4,590
7/6	20.9	23.5	38.0	4,560
7/7	18.5	22.5	37.5	4,220
7/8	17.3	21.9	38.5	4,190
7/9	16.6	21.7	39.0	5,310
7/10				5,180
7/11	28.7	22.9	39.0	6,070
7/12	22.5	23.3	39.0	6,100
7/13	17.8	22.8	39.0	6,180
7/14	21.2	22.6	39.0	6,130
7/15	25.0	23.0	39.0	5,140
7/16	27.2	23.8	38.0	4,150
7/17	21.5		38.0	3,390
7/18	22.8	24.2	38.5	3,530
7/19	22.7	24.2	38.0	3,110
7/20	26.9	24.8	37.5	2,985
7/21	25.8	25.1	39.0	2,735
7/22	29.4	25.7	38.0	2,610
7/23				2,490
7/24				2,470
7/25	23.3	24.7	38.5	2,790
7/26	30.4	25.1	38.0	1,950
7/27	29.1		38.5	2,000
7/28	20.2	25.5	38.5	2,000
7/29	25.2	25.7	37.5	2,820
7/30				2,280
7/31				2,180
Mean	**23.3**	**23.8**	**38.4**	**3,900**
MIN.	**16.6**	**21.7**	**37.5**	**1,950**
MAX.	**30.4**	**25.7**	**39.0**	**6,180**

Table 18. August 2005 - Brunswick fishway air and water temperatures / headpond levels.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level (feet above sea level)	River Flow (cfs)
8/1	22.3		38.0	2,450
8/2	22.8			2,770
8/3		Fishway closed		2,870
8/4		Fishway closed		2,800
8/5		Fishway closed		2,730
8/6		Fishway closed		2,460
8/7		Fishway closed		1,990
8/8		Fishway closed		2,750
8/9		Fishway closed		2,250
8/10		Fishway closed		2,220
8/11		Fishway closed		2,070
8/12		Fishway closed		2,030
8/13		Fishway closed		1,730
8/14		Fishway closed		1,720
8/15		Fishway closed		2,000
8/16				1,670
8/17	22.2	23.8	39.0	2,330
8/18	18.4	23.3	39.0	1,650
8/19	17.6	23.1	39.0	2,200
8/20				1,640
8/21				1,890
8/22	25.0		39.0	2,640
8/23	21.6	23.2	38.9	2,560
8/24	19.7	23.7	39.5	3,400
8/25	22.4	23.2	40.0	3,150
8/26				2,290
8/27	25.2	22.9	38.5	2,470
8/28				3,430
8/29	22.8		40.0	3,370
8/30	21.2	22.5	39.0	2,740
8/31	22.1	22.5	39.5	3,300
Mean	**21.8**	**23.1**	**39.1**	**2,438**
MIN.	**17.6**	**22.5**	**38.0**	**1,640**
MAX.	**25.2**	**23.8**	**40.0**	**3,430**

Table 19. September 2005 - Brunswick fishway air and water temperatures / headpond levels.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level (feet above sea level)	River Flow (cfs)
9/1	24.4	22.3	40.0	4,690
9/2	23.3		39.0	5,910
9/3				5,860
9/4				5,750
9/5				3,540
9/6	20.8	21.3	38.5	1,690
9/7	21.0	21.3	39.0	1,670
9/8	22.2	21.4	38.5	1,560
9/9	18.2	21.8	38.5	2,760
9/10				1,600
9/11				1,640
9/12	24.2	20.4	39.0	2,860
9/13	19.0	20.7	38.5	2,490
9/14	20.2	21.5	39.0	2,580
9/15	21.2	21.5	39.0	2,820
9/16	19.4	21.5	37.5	2,790
9/17				2,270
9/18				2,260
9/19	19.3	19.9	38.0	2,460
9/20	14.2	20.2	38.5	2,570
9/21				2,520
9/22	18.3	19.7	38.0	2,700
9/23	18.2	20.1	38.5	2,830
9/24				2,720
9/25				2,840
9/26	16.5	18.5	38.5	3,110
9/27	15.4	18.4	37.5	2,780
9/28	15.7	18.1	38.5	2,500
9/29	16.8	18.2	38.5	2,620
9/30	11.6	17.4	38.5	2,320
Mean	**19.0**	**20.2**	**38.6**	**2,890**
MIN.	**11.6**	**17.4**	**37.5**	**1,560**
MAX.	**24.4**	**22.3**	**40.0**	**5,910**

Table 20. October 2005 - Brunswick fishway air and water temperatures / headpond levels.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level (feet above sea level)	River Flow (cfs)
10/1				2,480
10/2				2,910
10/3	18.1	17.0	37.5	2,680
10/4	16.8	17.6	39.0	2,880
10/5	17.1	17.6	39.0	2,910
10/6	15.1	17.4	38.0	3,460
10/7	18.1	17.1	38.0	3,620
10/8				5,290
10/9				10,200
10/10	11.7	14.9	42.5	20,900
10/11	12.8	14.8	42.0	16,300
10/12	9.3	13.4	41.5	10,800
10/13	10.3	12.9	40.5	8,710
10/14	11.9	12.7	40.5	8,460
10/15				11,000
10/16				29,700
10/17	12.7	12.0	42.5	34,200
10/18	7.8	11.1	42.5	31,300
10/19	11.4	10.6	41.0	24,200
10/20	7.3	10.3	41.5	19,600
10/21	9.1	9.8	42.0	13,500
10/22				11,400
10/23				12,200
10/24	7.0	9.1	41.5	12,200
10/25		Fishway closed	for the season	
10/26		Fishway closed	for the season	
10/27		Fishway closed	for the season	
10/28		Fishway closed	for the season	
10/29		Fishway closed	for the season	
10/30		Fishway closed	for the season	
10/31		Fishway closed	for the season	
Mean	**12.3**	**13.6**	**40.6**	**12,538**
MIN.	**7.0**	**9.1**	**37.5**	**2,480**
MAX.	**18.1**	**17.6**	**42.5**	**34,200**

Table 21. May 2006 - Brunswick fishway air and water temperatures / headpond levels.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level (feet above sea level)	River Flow (cfs)
5/1				5,910
5/2				6,100
5/3				5,740
5/4				5,870
5/5				6,530
5/6	17.3	13.0	39.0	6,490
5/7	10.7	12.4	39.0	5,830
5/8	11.4	12.7	39.0	4,700
5/9	12.6	13.1	39.0	4,680
5/10	9.2	13.2	38.5	3,940
5/11	10.3	12.8	39.0	4,880
5/12	9.6	12.9	39.0	6,960
5/13	11.9	11.7	41.0	21,900
5/14	12.9	12.2	41.5	29,600
5/15	9.8	10.6	42.0	19,500
5/16	10.3	10.7	41.5	14,400
5/17	15.2	11.0	41.5	18,000
5/18	13.4	11.8	41.5	18,600
5/19	11.5	12.3	41.5	17,600
5/20	14.0	12.1	42.0	21,900
5/21	16.2	11.9	41.5	22,700
5/22	13.9	11.9	42.0	19,600
5/23	11.1	11.9	41.5	17,700
5/24	13.9	12.4	41.0	15,300
5/25	16.3	12.2	41.5	12,700
5/26	17.1	12.6	41.3	11,100
5/27	23.0	13.2	41.0	9,830
5/28	25.3	13.9	40.5	8,590
5/29	23.8	15.0	40.5	8,450
5/30	18.7	15.0	40.0	8,160
5/31	13.6	15.7	40.0	7,170
Mean	**14.3**	**12.6**	**40.6**	**11,949**
MIN.	**9.2**	**10.6**	**38.5**	**3,940**
MAX.	**25.3**	**15.7**	**42.0**	**29,600**

Table 22. June 2006 - Brunswick fishway air and water temperatures / headpond levels.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level (feet above sea level)	River Flow (cfs)
6/1	19.7	16.4	39.0	5,900
6/2	17.3	17.2	39.0	5,630
6/3	14.2	17.8	39.0	3,430
6/4	13.8	16.6	39.0	6,870
6/5	15.7	16.5	41.0	13,000
6/6	15.1	17.5	41.8	12,700
6/7	14.0	17.4	42.0	12,200
6/8	13.2	16.0	42.0	13,100
6/9	16.6	15.2	42.0	20,600
6/10	15.7	15.0	42.0	24,300
6/11	11.9	14.5	41.5	34,000
6/12	20.9	14.4	42.0	31,500
6/13	20.6	14.5	41.0	24,200
6/14	18.9	15.5	41.0	18,500
6/15	17.1	16.2	41.5	16,300
6/16	22.8	16.9	41.8	14,600
6/17	25.3	17.7	41.5	12,200
6/18	26.6	18.6	41.0	9,770
6/19	20.8	19.6	40.5	8,090
6/20	24.5	20.2	39.0	7,740
6/21	19.5	20.8	40.0	8,290
6/22	22.4	21.6	40.5	9,710
6/23	21.1	21.8	40.0	7,680
6/24	19.8	22.4	39.0	7,210
6/25	18.0	21.6	39.0	6,680
6/26	18.6	22.2	39.0	6,760
6/27	20.2	20.9	39.0	9,260
6/28	20.8	22.0	42.0	12,800
6/29	19.3	21.6	41.5	11,800
6/30	18.6	21.7	41.0	10,500
Mean	**18.8**	**18.3**	**40.6**	**12,844**
MIN.	**11.9**	**14.4**	**39.0**	**3,430**
MAX.	**26.6**	**22.4**	**42.0**	**34,000**

Table 23. July 2006 - Brunswick fishway air and water temperatures / headpond levels.

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level (feet above sea level)	River Flow (cfs)
7/1	24.8	21.4	41.0	9,730
7/2				8,890
7/3	23.0	21.4	40.0	7,820
7/4				7,010
7/5	26.3	21.7	39.0	7,150
7/6	19.0	21.9	39.0	6,590
7/7	23.8	22.1	39.0	6,410
7/8	21.7	22.5	40.0	6,220
7/9	22.3	22.9	39.0	6,030
7/10	23.6		38.5	5,040
7/11	23.4	23.4	38.0	3,000
7/12	27.1	23.2	37.5	3,030
7/13	19.5	22.7	39.0	3,980
7/14	28.3	23.0	39.0	3,450
7/15	29.5	25.0	38.0	3,660
7/16				4,410
7/17	22.6		38.5	4,520
7/18	26.7	25.2	38.5	4,410
7/19	22.1	25.3	38.5	3,830
7/20	23.5	24.8	38.5	4,970
7/21	20.5	25.3	38.5	3,770
7/22	24.4	25.4	37.5	3,250
7/23				3,850
7/24	22.2		39.0	5,060
7/25	22.6	24.4	39.0	6,030
7/26	22.1	25.1	38.5	5,020
7/27	22.6		38.0	4,210
7/28				3,330
7/29	28.0	25.4	39.0	6,470
7/30				0
7/31	21.4		38.5	0
Mean	**23.6**	**23.6**	**38.8**	**4,875**
MIN.	**19.0**	**21.4**	**37.5**	**0**
MAX.	**29.5**	**25.4**	**41.0**	**9,730**

Table 24. August 2006 - Brunswick fishway air and water temperatures / headpond levels

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level (feet above sea level)	River Flow (cfs)
8/1	24.9	25.3	38.5	6,260
8/2	25.4	25.4	38.5	6,270
8/3	21.4	25.2	38.8	6,430
8/4	20.9	24.0	38.5	6,160
8/5				6,610
8/6				6,250
8/7	21.5	24.3	39.0	4,720
8/8	21.8	23.8	38.8	4,140
8/9	21.7	23.7	39.0	4,080
8/10	20.4	23.3	38.5	3,980
8/11	19.7	23.5	39.0	4,130
8/12				4,120
8/13				4,110
8/14	20.4	21.4	39.0	3,760
8/15	19.8	22.0	38.5	3,340
8/16	18.9	22.4	38.5	2,760
8/17	22.2	22.5	37.5	2,910
8/18	20.6	22.5	38.0	2,900
8/19				2,910
8/20				3,120
8/21	19.6	21.8	38.0	3,310
8/22	21.2	21.0	39.0	5,320
8/23	21.2	22.3	39.0	6,360
8/24	16.1	21.8	39.0	5,780
8/25	15.6	21.5	40.0	4,110
8/26				3,340
8/27				3,350
8/28	16.0		38.5	3,330
8/29	17.9		38.8	4,000
8/30	14.5	19.1	38.5	3,800
8/31				3,720
Mean	**20.1**	**22.8**	**38.7**	**4,367**
MIN.	**14.5**	**19.1**	**37.5**	**2,760**
MAX.	**25.4**	**25.4**	**40.0**	**6,610**

Figure 15. Water temperatures and river flows recorded at the Brunswick fishway in May 2005.

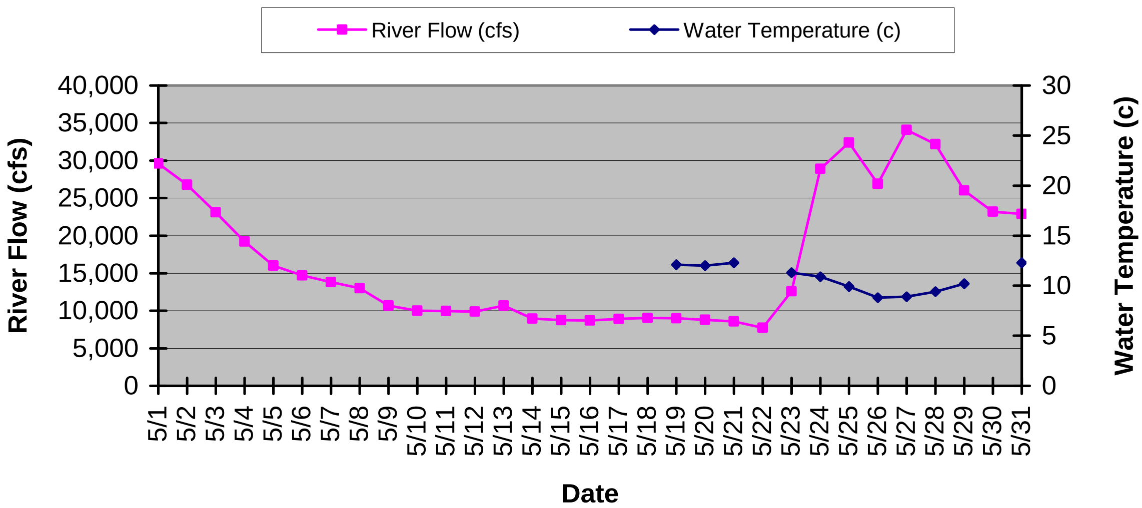


Figure 17. Water temperatures and river flows recorded at the Brunswick fishway in July 2005.

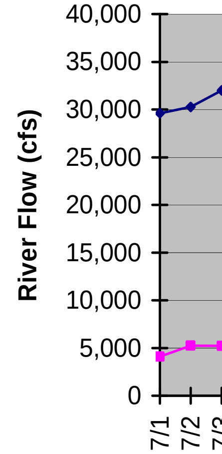


Figure 16. Water temperatures and river flows recorded at the Brunswick fishway in June 2005.

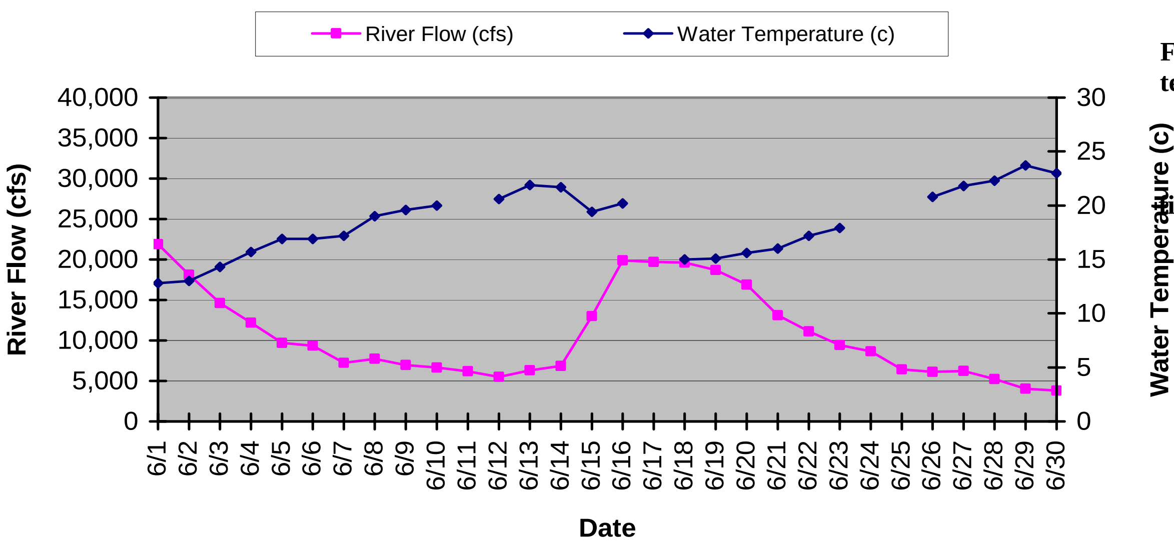
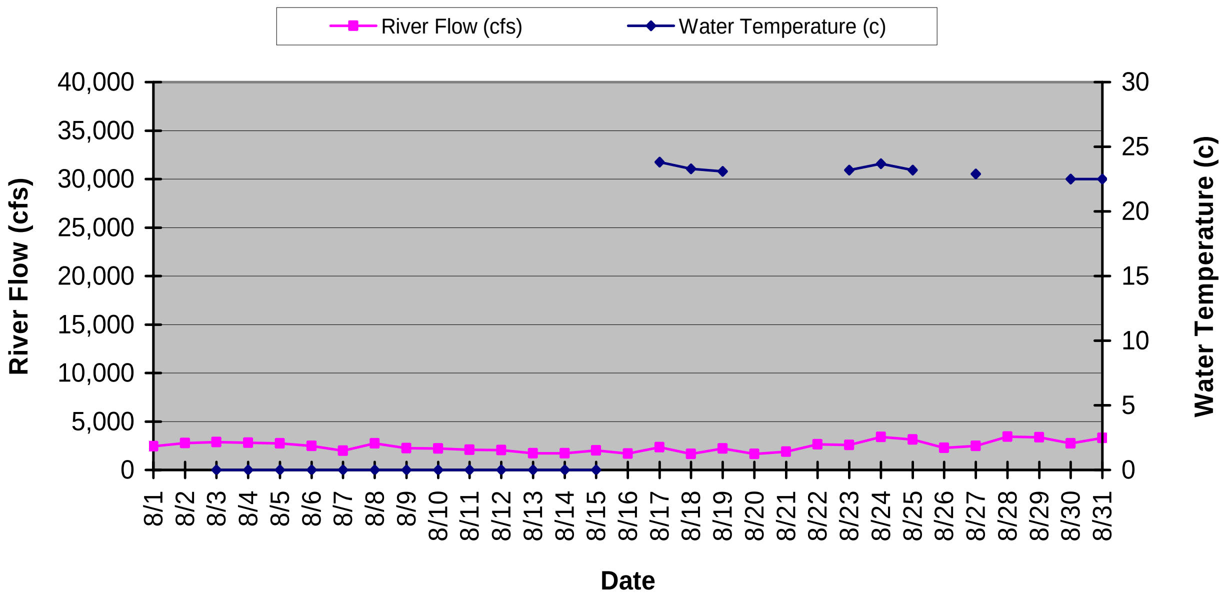


Figure 18. Water temperatures and river flows recorded at the Brunswick fishway in August 2005.



River Flow (cfs)
Water Temperature (c)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
30
25
20
15
10
5
0
River Flow (cfs)
Water Temperature (c)
8/1 8/2 8/3 8/4 8/5 8/6 8/7 8/8 8/9 8/10 8/11 8/12 8/13 8/14 8/15 8/16 8/17 8/18 8/19 8/20 8/21 8/22 8/23 8/24 8/25 8/26 8/27 8/28 8/29 8/30 8/31
Date

Figure 19. Water temperatures and river flows recorded at the Brunswick fishway in September 2005.

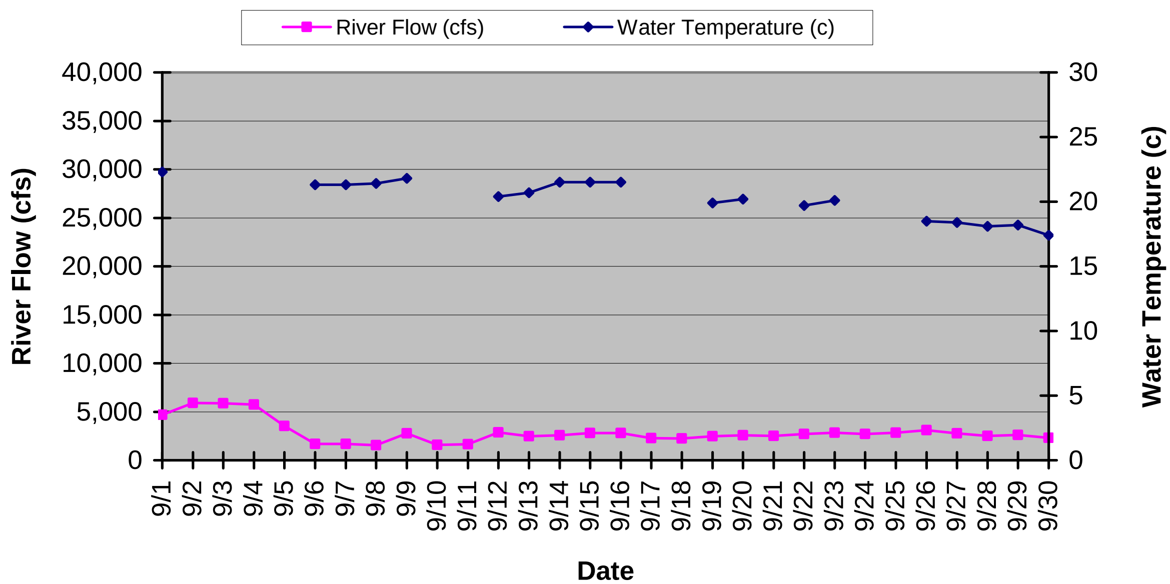


Figure 20. Water temperatures and river flows recorded at the Brunswick fishway in October 2005.

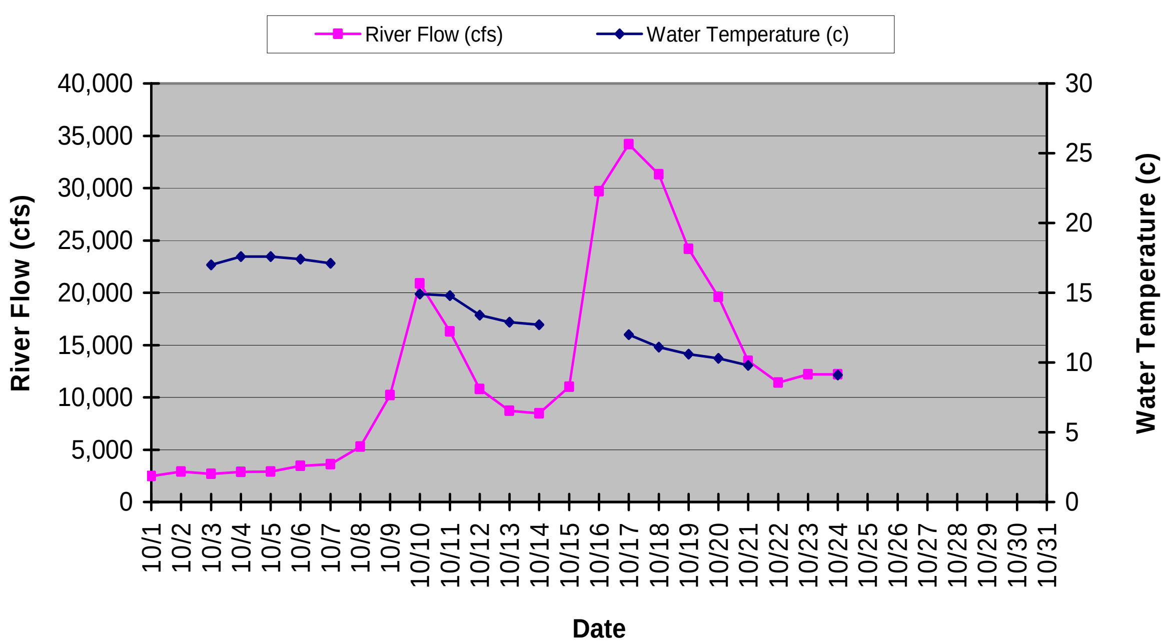


Figure 21. Water temperatures and river flows recorded at the Brunswick fishway in May 2006.

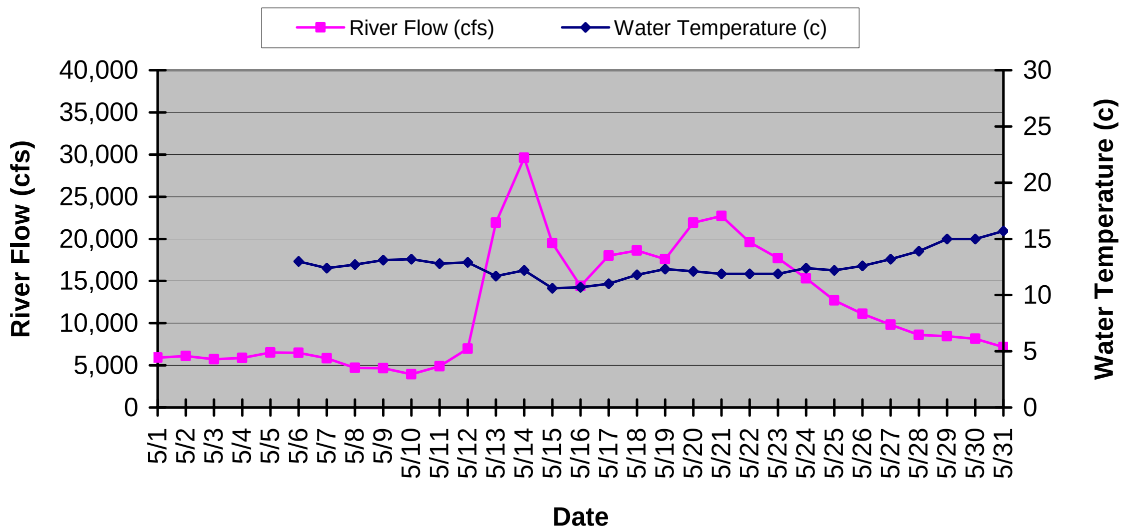


Figure 22. Water temperatures and river flows recorded at the Brunswick fishway in June 2006.

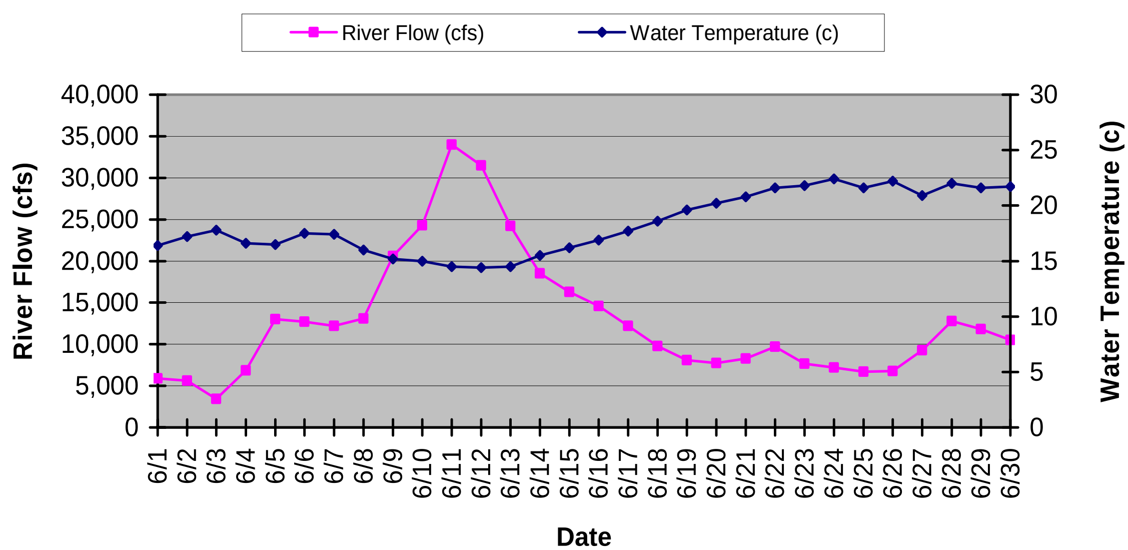


Figure 23. Water temperatures and river flows recorded at the Brunswick fishway in July 2006.

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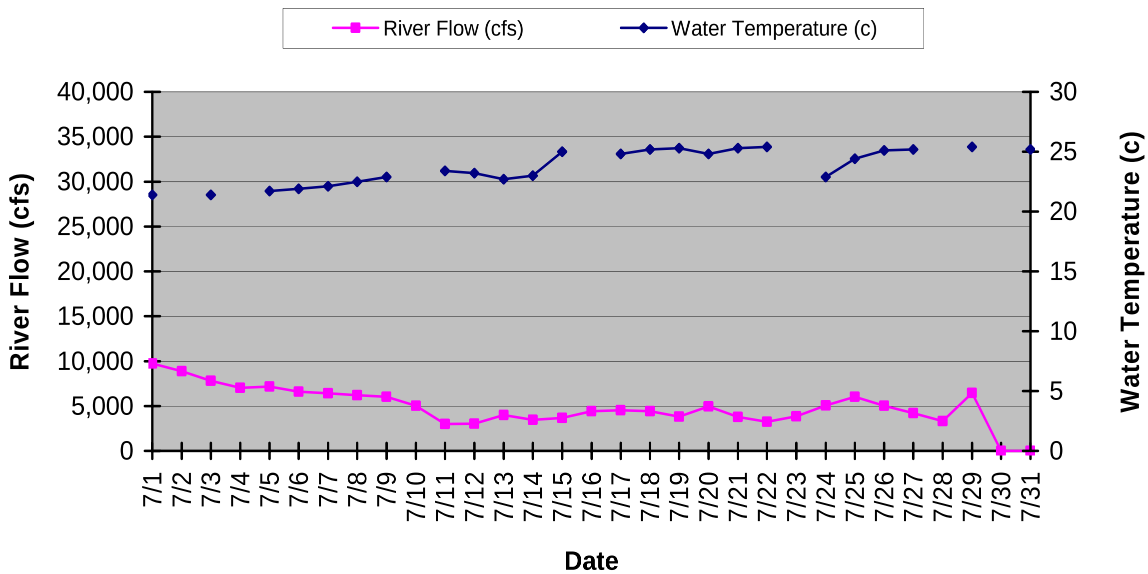

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Figure 24. Water temperatures and river flows recorded at the Brunswick fishway in August 2006.

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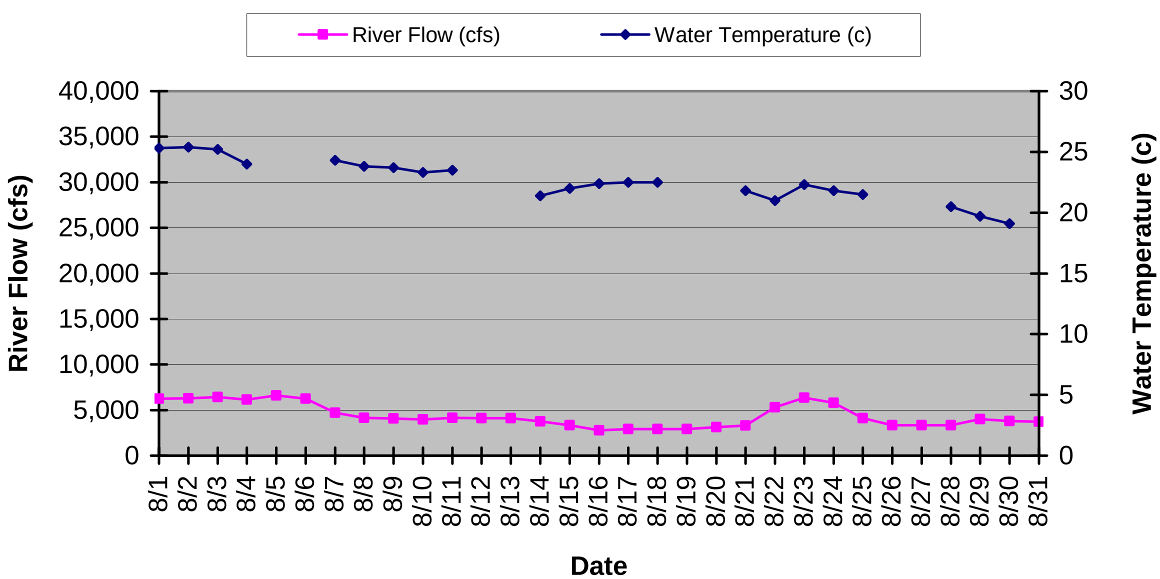

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