Anadromous Alosid Restoration in the Androscoggin River Watershed

Semi-Annual Report

(January 1, 2006 – June 30, 2006)

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State of Maine

Androscoggin River
Anadromous Fish Restoration Program

Department of
Marine Resources

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State of Maine
Department of Marine Resources
Augusta, Maine

Project Leader: **Michael E. Brown**
Period Covered: **January 1, 2006 – June 30, 2006**

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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 was 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.

[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.

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 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 have 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 uses. 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 are expected to develop 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.

GOAL AND OBJECTIVES

The goal of this project is to restore native river herring and American shad to historic habitats in the Androscoggin and Little Androscoggin river watersheds.

To meet this goal, project staff implements several objectives and strategies.

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 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.

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 alosids 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 2002-2004 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 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.

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 and 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 in the watershed. The second need is to address water quality issues and initiatives that will improve water quality in the river. MDMR 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 24 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 **(Figure 1)**. 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.

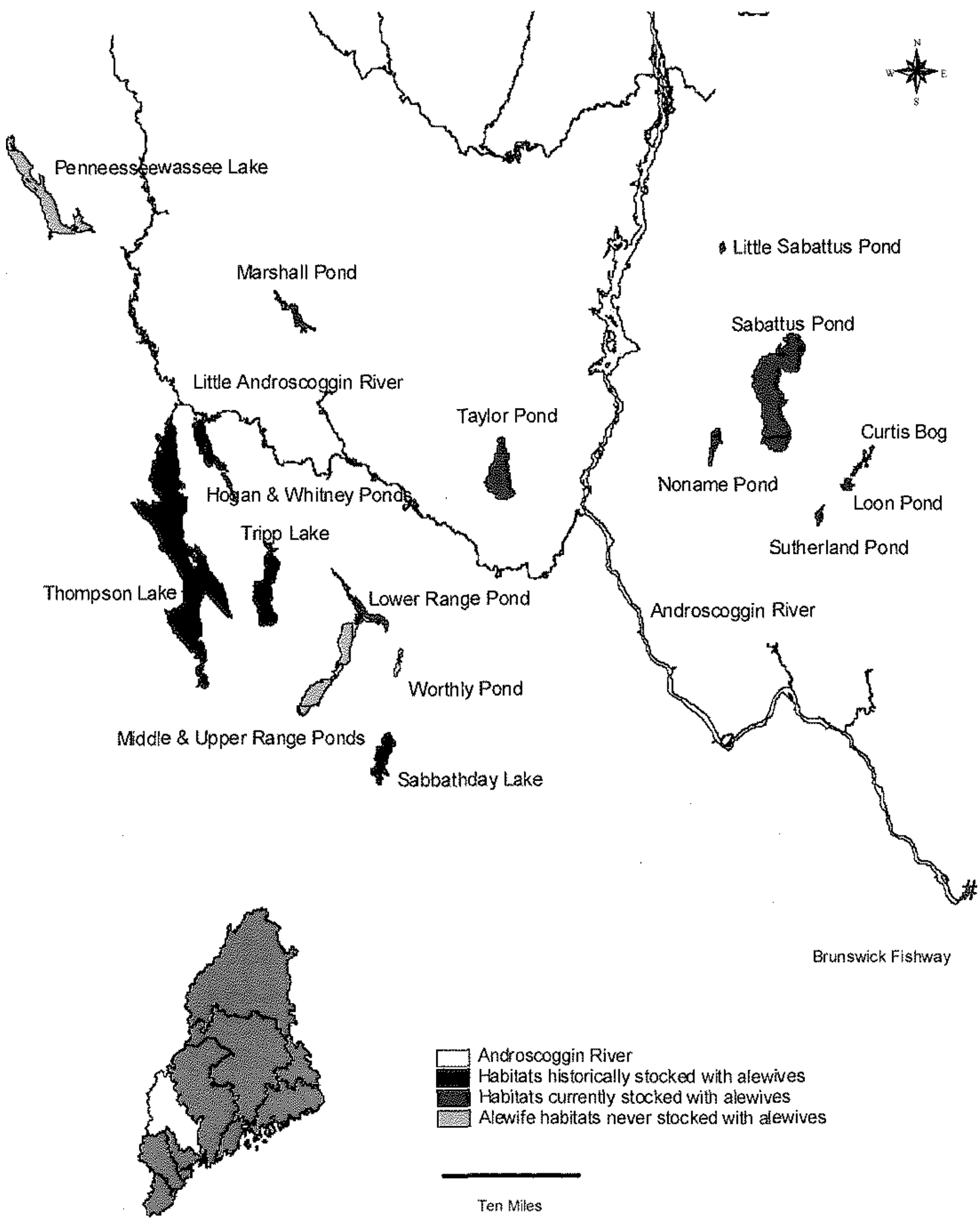
A large number of striped bass ascended the Brunswick fishway in the spring. Fishway staff observed striped bass feeding on adult river herring in the fishway, at the entrance to the fish trap. In past years, few striped bass ascended the fishway despite the abundant forage. Occasionally fishway staff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

Figure 1. Current status of historical habitat once occupied by unobstructed runs of anadromous alewives.



Anadromous Alosine Restoration in the Androscoggin River Watershed

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*).

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 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. It is 513 m long and consists of a series of 42 pools with a 30.5 cm drop between them. At normal headpond elevation, the water depth in the fishway pools is 162 cm and water volume 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 fishway staff to capture and sample fish. A 1.9 m^3 capacity fish hoist elevates trapped fish to overhead holding tanks where staff sorts the fish by species for biological data collection and passage.

Most years, fishway personnel discharge the majority of the river herring through flexible hoses into distribution trucks. MDMR uses trucks to transport the river herring to currently inaccessible historic spawning and nursery habitats. The production potential in the 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.

Fishway personnel capture American shad at the fishway and pass them upstream into the headpond so they can 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 both of these fish lifts. MDMR estimates production potential of the habitat between Brunswick and Lewiston Falls to be 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.

After a two-year absence, the adult pre-spawn stocking program resumed in 2002. Maine transports American shad from other states to increase the abundance and natural reproduction of shad in Maine's rivers. Maine receives pre-spawn shad from the Connecticut or Merrimack rivers through a cooperative agreement with the Connecticut River American Shad Technical Advisory Committee (CRSTAC) and the states of New Hampshire and Massachusetts. The release site, in the Androscoggin River below Auburn, is adjacent to spawning and nursery habitat.

Since 1992, the MDMR and Time and Tide Resource Conservation and Development Area Council (T&T) have operated a hatchery (Waldoboro Shad Hatchery) to produce American shad fry and fingerlings for the restoration 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 primarily from the Connecticut and Merrimack rivers. In 1997, MDMR transferred a limited number of broodstock from Maine's Saco River. 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-sustained level, broodstock from the Androscoggin may be available for continuing statewide restoration in other historic shad rivers in Maine.

Department 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 hatchery fry from naturally reproduced shad. All shad fry releases into the Androscoggin River occur below Lewiston Falls.

Throughout the sample season, project personnel collect otoliths from biological samples of adult alewives, adult American shad mortalities, and juvenile shad caught at the fishway or during the alosine survey. Lab staff extracts the sagittae (largest pair of otoliths) from the semi-circular canals located under the brain cavity. The otoliths are cleaned with warm water, then mounted distal side up, in CRYSTALBOND© on a glass slide. After drying, the project leader examines the otoliths using an Olympus BX40 microscope. The age of the fish is determined by counting the number of winter growth zones present. After comparing the otolith ages to the scale reading(s), the readers calculate the mode to determine the final age.

The presence of an OTC mark indicates that a juvenile shad is hatchery-reared rather than naturally spawned. Lab staff prepares the juvenile shad otoliths for the OTC analysis using the same techniques to prepare adult otoliths. The lab staff grinds down and polishes both sides of the otoliths using Brother's Method (*Brothers, E.*, 1989)[2] using 9, 3, and 1-micron lapping film. The otoliths are placed under an Olympus microscope that uses a mercury light source to activate the OTC and make it fluoresce.

Results:

The maintenance crew of Florida Power & Light Energy (FLPE) opened the Brunswick fishway May 5, 2006 and MDMR personnel staffed the fishway beginning the same day. The number of river herring trapped during 2006 ranked 11th highest out of the 24 seasons the fishway has been in operation. The total number of river herring captured was below the 24-year average of 39,422.

During the past three years, the timely arrival and number of Androscoggin River adults captured at the Brunswick fishway for transport and release were greater than the amount of upstream spawning and nursery habitat available. The adult release target for the Androscoggin Watershed is 27,358 river herring into 1,886 ha of upstream habitat available for restoration. Of the 34,239 adults captured, project personnel transported 23,214 upstream into Androscoggin Watershed lakes and ponds, released 8,032 into the Brunswick headpond, sacrificed 167 for biological sampling, counted 59 fishway/transport mortalities, and transported 2,767 out-of-basin to stock additional habitats in other watersheds. The run was so poor on the Sheepscot River that project

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

personnel could not transport alewives from Cooper's Mill Dam fishway to Branch and Travel Ponds in the Sheepscot River Watershed as done in the past.

Despite the periodic high river flows and fluctuating water temperatures during the run, this project did not utilize the Kennebec River as a source of pre-spawn river herring. The Kennebec River herring run was as unpredictable as the Androscoggin River run. The Kennebec utilized all the river herring available to them to stock habitat in the Kennebec River Watershed. On one occasion, the Kennebec River Project transported 289 alewives from the Androscoggin River to Weserunsett Lake in the Kennebec drainage. As the season progressed, it became obvious that the number of river herring returning to the Androscoggin River would be sufficient and that transfers from other watersheds would not be needed **(Table 1)**.

Table 1. Adult river herring distribution in the Androscoggin Watershed by site, 2004 – 2006.

	Source: Androscoggin River at the Brunswick Fishway		
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	**107,022**	**24,156**	**23,214**
Brunswick Headpond (passed upstream)	86,354	7,589	8,032
TOTAL PASSED OR STOCKED IN THE WATERSHED	**107,022**	**24,156**	**31,246**

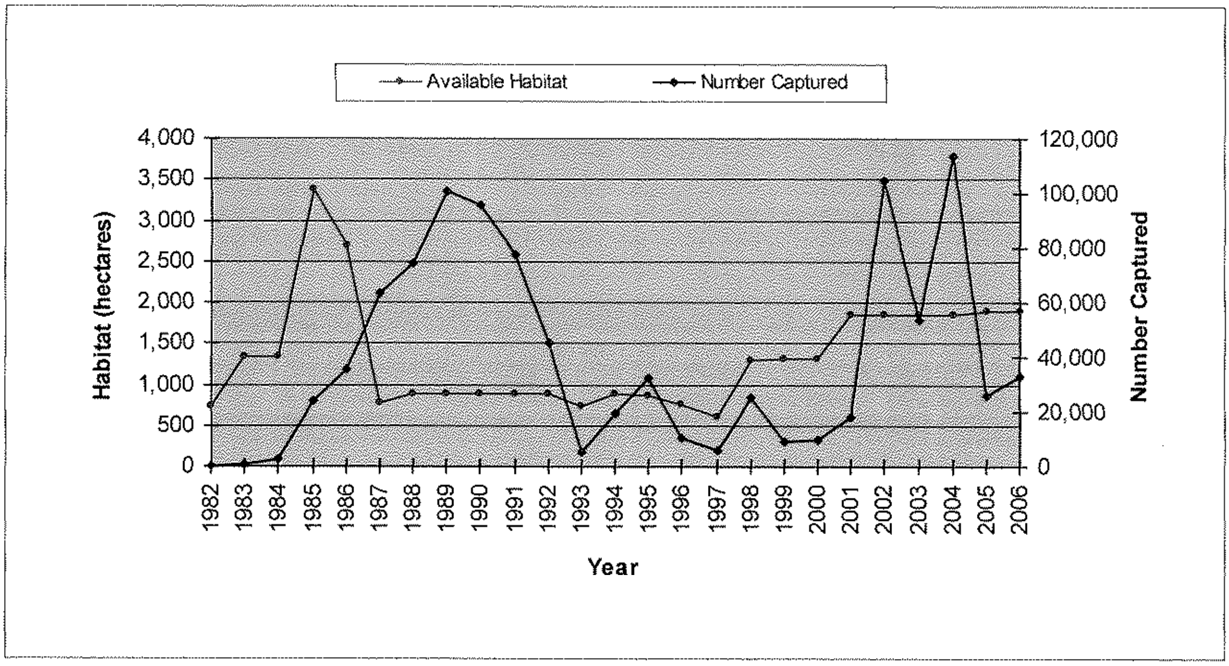
Project staff released 31,246 adult river herring into the Androscoggin River Watershed, releasing 23,214 fish into eight upstream habitats totaling 1,373 ha, excluding the main stems of the Androscoggin and Little Androscoggin. Fishway staff distributed river herring to Sabattus, Little Sabattus, Lower Range, No Name, Marshall and Taylor Ponds, Sabattus River, Bog Brook, and the Brunswick headpond. All of these areas approached the target number or reached the target stocking density of 14.83 fish per hectare (six fish/acre). Project staff stocked 5.2 fish per hectare into the Worumbo, Pejepscot, and Brunswick headponds.

The below average number of adult river herring captured in 2006 is likely the result of high river flows, low water temperatures, and flow attraction away from the fishway entrance. In addition, continuation of a major drought in 2002, likely reduced the numbers of fish available to return and spawn in 2006 (**Table 2, Figure 2**).

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

Year	Habitat (hectares)	Run Size	Total Number Stocked	Average Fish / hectare
1982	723	0	2,326	1.3
1983	1,328	601	6,305	4.2
1984	1,328	2,650	8,359	2.6
1985	3,377	23,895	37,773	11.2
1986	2,678	35,471	17,763	6.6
1987	770	63,523	11,892	15.4
1988	887	74,341	13,183	14.9
1989	887	100,895	13,814	15.6
1990	887	95,574	11,725	13.2
1991	887	77,511	13,574	15.3
1992	887	45,050	12,351	13.9
1993	722	5,202	7,448	10.3
1994	887	19,190	14,549	16.4
1995	852	32,002	10,591	12.4
1996	747	10,198	14,288	19.1
1997	612	5,540	11,524	18.8
1998	1,299	25,189	20,805	16.0
1999	1,318	8,909	8,671	6.6
2000	1,318	9,551	20,414	15.5
2001	1,846	18,196	23,459	12.7
2002	1,846	104,520	23,290	12.6
2003	1,846	53,732	20,392	11.0
2004	1,846	113,686	20,668	11.2
2005	1,886	25,896	16,867	9.1
2006	1,886	34,239	23,214	18.2

Figure 2. Adult river herring captured vs. habitat availability in the Androscoggin River Watershed, 1985 - 2006



Since 1998, MDMR resumed stocking alewives into several ponds considered prime spawning habitat, especially Sabattus Pond. For the past seven years, one of the main objectives of the program has been to optimize the number of alewives 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, we felt we could increase the number of returns and increase the long-term yearly average. During the period, 2002 – 2004, the annual catch at the Brunswick fishway exceeded the yearly average. Two of those years set river herring return records for the fishway. Maintaining increased stocking levels and increased vigilance in monitoring downstream passage are critical steps toward improving the number of river herring returning to the Androscoggin.

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 bluebacks 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.

The absence of available fry and pre-spawn adult shad will prevent this project from accomplishing **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.***

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 3 & 4)**. 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 Merrimack River typically ranges from 52,000 to 73,000 individuals.

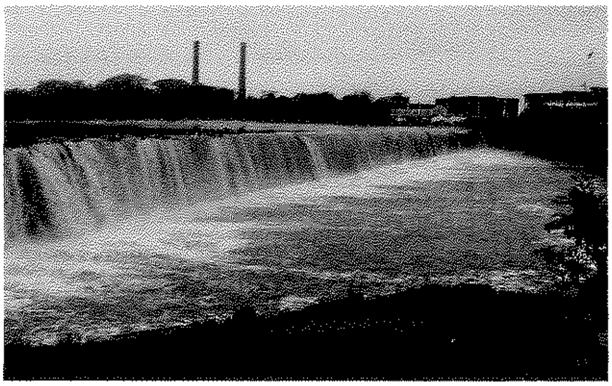


Figure 3. Typical early spring spill conditions at the Essex fishway on the Merrimack River in Lowell, MA.

Figure 4. 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 183 shad transported were in poor condition and several of the largest female fish died soon after arriving at the hatchery. The hatchery manager predicts that fry production will range between 100,000 to 250,000 fry **(Table 3)**. Typical production at the hatchery ranges between 3-million to 10-million fry annually.

Adult pre-spawn releases into the Androscoggin River did not occur in 2005 and will not likely occur in 2006 because of the lack of available broodstock throughout New England. In 2004, MDMR released 917 adult shad from the Merrimack River into the Androscoggin River below Auburn, the second highest stocking total since the beginning of the project. If our allotment of shad from the Merrimack River remains at the 2004 level, adult transfers to the Androscoggin River should resume in 2007.

Table 3. American shad fry released into the main stem Androscoggin River at Auburn, 2000 - 2006

Date	Source	Number Released	Age	% Mortality	Loading Site Temp.(C)	Receiving Site Temp (C)	Marking Method
2006	Extreme high water and poor hatchery production limited the numbers of fry available to the Androscoggin River Restoration Project in 2006.						
8/02/05	Merrimack	96,551	7 to10 days old	~0.0%	23.5	25.5	Oxytetracycline
7/07/04	Merrimack	538,613	7 to10 days old	~0.0%	20.9	22.0	Oxytetracycline
7/02/03	Merrimack	2,076,369	6 - 8 days old	~0.0%	20.0	22.0	Oxytetracycline
7/17/02	Merrimack	295,725	10 - 17 days old	~1.0%	18.5	23.2	Oxytetracycline
7/2/01	Merrimack	308,600	23 - 26 days old	~1.0%	18.0	23.4	Oxytetracycline
7/10/00	CT x Kennebec	529,000	7 to10 days old	~5.0%	18.7	25.0	Oxytetracycline

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

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

- Fishway staff stocked four out-of-basin locations with alewives from the Brunswick fishway

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

<u>Objective 2:</u>

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

<u>Strategies to characterize and assess the fish community structure</u>:

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 rate of repeat spawning of both American shad and river herring.

<u>Methods:</u>

Fishway staff collects biological data on a daily basis to characterize the composition of migratory and resident fish species using the Brunswick fishway ladder in conjunction with environmental measurements, such as air/water temperatures, river flows, and headpond levels. Analysis of scale samples collected provides an estimate of the number of repeat spawning fish returning to the Brunswick fishway. Spawning checks provide a chronological record of the reproductive history of the fish captured in the fish trap.

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 all 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. In past years, the Maine Department of Inland Fisheries and Wildlife requested that fishway personnel not pass sea lamprey upstream and instead return them to the river below the dam. Current research indicates sea lamprey may be beneficial to Atlantic salmon restoration efforts. Sea lampreys maintain the interstitial spaces in the bottom substrate, a critical component for the parr life stage of the Atlantic salmon. 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, into the river below the dam.

MDMR collected length data from all fish species captured at the fishway from the time it opened through the end of the study period. 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) determines the age and origin of the salmon and provides 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. The collection of genetic material continued through the 2000-2006 sample seasons.

Results:

Fishway personnel observed river herring at the fishway from May 6 through June 6. In 2006, MDMR trapped 34,239 river herring at the Brunswick fishway. The 2006 river herring run was slightly below average compared to pervious years. On seven days, the run exceeded 2,000 fish. These seven days accounted for 82.0% of the total number captured during the 2006 river herring run **(Table 4)**.

Table 4. Adult river herring captured, water temperature and river flow at the Brunswick fishway, 2006

Date	Number	Water Temp(C)	River Flow (cfs)	Cumulative Number	% Total Run
5/6/06	186	13.0	6,490	186	0.54%
5/7/06	3,856	12.4	5,830	4,042	11.81%
5/8/06	5,338	12.7	4,700	9,380	27.40%
5/9/06	2,794	13.1	4,680	12,174	35.56%
5/11/06	1,745	12.8	4,880	13,919	40.65%
5/15/06	306	10.6	19,500	14,225	41.55%
5/19/06	165	12.3	17,600	14,390	42.03%
5/22/06	250	11.9	19,600	14,640	42.76%
5/24/06	3	12.4	15,300	14,643	42.77%
5/25/06	231	12.2	12,700	14,874	43.44%
5/28/06	1,050	13.9	8,590	15,924	46.51%
5/29/06	3,271	15.0	8,450	19,195	56.06%
5/30/06	6,807	15.0	8,160	26,002	75.94%
5/31/06	1,972	15.7	7,170	27,974	81.70%
6/1/06	3,698	16.4	5,900	31,672	92.50%
6/2/06	2,208	17.2	5,630	33,880	98.95%
6/3/06	20	17.8	3,430	33,900	99.01%
6/4/06	289	16.6	6,870	34,189	99.85%
6/5/06	45	16.5	13,000	34,234	99.99%
6/6/06	5	17.5	12,700	34,239	100.00%
Total/Mean	**34,239**	**13.9**	**9,394**		
Note: Flow Data from USGS Station 01059000 at Auburn, ME					

Through June 30 2006, MDMR captured three American shad at the Brunswick fishway **(Table 5)**. With the shad run only half over, we hope to capture more individuals. Genetic and scale samples collected are brought back to the lab and indexed. Genetic samples are filed and stored awaiting genetic analysis when additional funding for this project becomes available. Laboratory staff process scale samples, recording age and reproductive history for each individual. Fishway personnel collected biological data from all shad captured, including length and sex. Fishway personnel read scale samples to determine the age of each shad migrating upstream through the fishway. Fishway staff passes all American shad upstream into the Brunswick headpond after sampling. Pejepscot hydropower personnel do not count the number of fish passing upstream through this project. However, the Worumbo hydropower license requires its staff to conduct daily counts for all species passed upstream when the fish lift is in operation.

Table 5. Adult American shad distribution in the main stem Androscoggin River at Auburn, 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	357	-	357	-	31.0%
1990	354	1	353	-	21.0%
1989	414	-	414	-	25.5%
1988	513	-	513	-	1.2%
1987	92	-	-	92	11.0%
1986	224	-	-	224	17.00%
1985	115	-	-	115	35.80%
Totals	**7,652**	**250**	**5,374**	**2,033**	**17.8%**

Preliminary data indicate the expected 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. Using return data from the Connecticut, Susquehanna, and the Columbia rivers, MDMR expects returns to the Brunswick-Topsham Hydropower Station tailrace to range from 875 – 953 individuals. Hatchery returns should approximate 1:400 based on Susquehanna River data from the Pennsylvania Fish and Boat Commission. Returns from wild and pre-spawn stocked shad should range from 4:1 to 7:1 based on data collected from the Columbia River.

Causes for the decline in both American shad and river herring return numbers in 2006 are unclear. Certainly, the droughts of 2001 and 2002 and a fish kill observed at the Worumbo Hydropower Project in 2001 play a large role in determining river herring returns to the Androscoggin. Drought conditions experienced in 2001 and 2002 may have played a larger role than expected for shad in the river system. Reduced river flows may have exacerbated turbine mortality where shad must co-exist with hydropower production. Certainly, the efficiency of the Brunswick fishway as it relates to upstream passage of American shad plays a large role.

From May 5 through June 30, 2006, fishway personnel counted 11 fish species and 34,426 individual fish passing upstream at the Brunswick fishway **(Table 6)**.

Table 6. Adult fish species captured while migrating upstream at the Brunswick fishway through June 2006

	May	June	July	August	September	October	Species Total
American shad (*Alosa sapidissima)*	-	3	-	-	-	-	3
landlocked salmon (*Salmo salar*)	4	2	-	-	-	-	6
Atlantic salmon (*Salmo salar*)	-	1	-	-	-	-	1
brook trout (*Salvelinus tontinalis)*	1	-	-	-	-	-	1
largemouth bass (*Micropterus salmoides*)	-	2	-	-	-	-	2
river herring *(Alosa aestivalis)(Alosa pseudoharengus)*	27,974	6,265	-	-	-	-	34,239
sea lamprey (*Petromyzon marinus*)	-	-	-	-	-	-	0
smallmouth bass (*Micropterus dolomieu*)	9	13	-	-	-	-	22
striped bass (*Morone saxatilis)*	1	66	-	-	-	-	67
white catfish (*Ictalurus catus*)	-	2	-	-	-	-	2
white sucker (*Catostomus commersoni*)	81	1	-	-	-	-	82
black crappie *(Pomoxis nigromaculatus)*	1	-	-	-	-	-	1
Monthly Totals	28,070	6,356	0	0	0	0	34,426

The most common species captured in both May and June was alewife. In comparison, white sucker and smallmouth bass was a distant second. Compared to previous years, numerous striped bass ascended the fishway. Typically, the number of striped bass caught in the trap at the top of the fishway is less than 20 individuals for the entire year. This year fishway staff observed striped bass feeding on adult river herring in the observation window just below the trap entrance. The average total length for striped bass caught in the trap was 43 cm. Fishway staff returned all striped bass downstream to the hydropower tailrace.

Through June 2006, fishway personnel captured two white catfish in the fish trap at the top of the fishway. During the past several 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. Normally when the 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. Tag returns 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 and location of expansion and the potential effects on native fish communities are undetermined.

The fish trap did not produce any American eels during the sample period May - June. However, the trap rarely captures eels because 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.

An active Atlantic salmon restoration program is not in place for the Androscoggin River other than providing upstream passage past the first three dams on the river. However, an average of 29 sea-run salmon are captured annually at Brunswick, 1983 – 2006, although annual returns have been below 13 salmon since 1997 **(Table 7)**.

Table 7. Number, mean length, and origin of sea-run Atlantic salmon returning to the Androscoggin River and captured at the Brunswick fishway 1988 - 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	5	0	0	0	0	0	0	684	10
2006	*	*	*	*	*	*	*	*	563	1
Total	35	529	6	2	5	82	2	1		665

Through June of the 2006 sample season, MDMR passed one confirmed Atlantic salmon into the Brunswick headpond. The mean fork length of adult salmon captured was 563 mm, down from 761 mm in 2005. There were several fin clipped salmon captured at the fishway **(Table 8)**. The trap at the Brunswick fishway routinely captures fin-clipped or tagged Atlantic or landlocked salmon stocked in other river systems. 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. The Maine Atlantic Salmon Commission will conduct scale analysis on selected scales to determine age and conclude whether these salmon are sea-run or landlocked salmon. Salmon under 500 mm are classified as landlocked salmon when caught at the Brunswick fishway as directed by MASC protocols.

Table 8. Atlantic and landlocked salmon captured ascending the Androscoggin River at the Brunswick fishway, May – June 2006

Date	Total Length (mm)	Fork Length (mm)	Clips/Marks	Water Temp. (C)
6-May	508	495	BV	13
7-May	521	490	RV	12.4
7-May	503	484	LV	12.4
8-May	-	-	passed while cleaning	12.7
5-Jun	500	479		16.5
19-Jun	561	583	BV	19.6
27-Jun	585	563		20.9
Total number of fish	**7**			
Mean	**530**	**516**		**15.4**
Min. T(°C)				**12.4**
Max. T(°C)				**20.9**

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 analyzes in the future to determine the origin of the salmon captured at Brunswick. Knowing the origin of the 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 springs of 2000 - 2006.

Tables 9 - 10 and **Figures 5 - 6** show environmental data collected at the Brunswick fishway, including air temperatures, water temperatures, and headpond levels from May through June 2006 **(Appendix)**.

Fishway personnel collect biological data from both American shad and river herring to determine the number of repeat spawning fish returning to the fishway. Through scale analysis, MDMR determines the number of repeat spawning American shad returning to the Androscoggin River. Project personnel use scale samples to identify spawning checks present in the scales samples collected. Due to the inefficiency of the fishway, 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 were captured at the fishway for the first time. The same method is applied 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 repeat spawning for river herring 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.

Results of the scale sample analyses indicate that a large number of age five river herring (75.0%) returned to spawn for a second time **(Table 11)**. In addition, 15.4% of all age four river herring were repeat spawners. In total, 58.0% of the 2006 river herring run was comprised of repeat spawners, an unusually large number when compared to 47.3% of the run in 2005. This is likely the result of excellent downstream passage of adult fish in 2005, combined with poor recruitment of fish from the 2002 year class. Typically, four-year-old fish make up the majority of the annual run as they return to spawn for the first time. It is common to have a small proportion of the annual run comprised of three-year-old fish. Typically, these fish are males and will often return as four-year-olds. Based on the consistent amount of habitat available for restoration over the past five years and the numbers of pre-spawn adults transported upstream, post-spawn survival of emigrating adults is likely a large factor in determining the number of returns the following year.

Table 11. Number, length, and percent of repeat spawning river herring captured at the Brunswick fishway in 2006

Age	Sex	Total Number	Mean TL (mm) (repeats only)	Mean FL (mm) (repeats only)	Mean Wt (g) (repeats only)	Number of Repeat Spawners	% Repeat
3	M	0	*	*	*	0	*
	F	0	*	*	*	0	*
4	M	33	272	240	178	7	21.2%
	F	19	286	251	205	1	5.3%
5	M	33	285	251	198	25	75.8%
	F	19	287	255	210	14	73.7%
6	M	14	283	249	198	14	100.0%
	F	18	294	259	225	17	94.4%
7	M	1	285	253	209	1	100.0%
	F	1	314	277	266	1	100.0%
	Total	138					57.9%

Study results indicate that a large proportion of the age-4 river herring had spawned as 3-year-olds. Typically, river herring spawn at 4-years-old for the first time. The number of 3-year old fish captured in the trap in 2005 indicated that the number of recruits to the 2002 year class were below average. Explanations for the large number of 4-year-olds having already spawned are that these fish entered the estuary, stopped feeding, and developed a false spawning check or, these fish spawned in the estuary below the fishway due to high water conditions that prevented upstream passage at the fishway. The percent of age-5 fish that spawned the previous year is typical of what we would expect to observe in a fish of that age.

Through June, fishway staff sampled only three American shad. Based on the results of the scale analysis, both the age-5 and age-6 shad had previously spawned **(Table 12)**. Unfortunately, with so few shad to analyze, the results do not indicate any significant trends.

Table 12. Repeat spawning American shad sampled at Brunswick fishway, 2006

Age	Sex	Number	Total Length (mm)	Fork Length (mm)	Number of Repeat Spawners
4	M	1	491	430	0
5	M	1	460	409	1
6	F	1	481	425	1

One of our main objectives for 2006 was to investigate differential shad growth, wild fry vs. hatchery fry, in the three headponds located above Brunswick, to assess production and ultimately, determine which habitat is best suited to receive fry and pre-spawn adult stocking. Unfortunately, fry production from the pre-spawn adult shad transported to the Waldoboro Shad Hatchery was so low that fry were not available for release into the Androscoggin in 2006.

The original goal was to have 500,000 hatchery fry and 300 pre-spawn adults in each of the three headponds. Weekly sampling would occur at each location to collect samples of shad to assess growth and origin. We were not able to attain the mix of hatchery vs. wild shad that we had hoped and as a result, we were not able to assess growth as we had planned. MDMR traditionally stocks all shad fry and pre-spawn adults in the Worumbo headpond. Worumbo is the largest of the three headponds on the lower Androscoggin River. Weekly sampling would have provided a reasonable way to determine differences in growth within the same habitat. We plan to conduct this study in 2007 if funding and study fish are available.

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

- Visited the Sabattus Pond water control gates during 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:

Fishway personnel maintain the Brunswick fishway daily and collect biological data from adult river herring and American shad ascending the fishway. Fishway personnel collect approximately 150 adult river herring samples during the upstream migration. Samplers collect total and fork lengths, sex, and scale samples from each individual. Samplers cut open the body cavities of each fish to determine species, sex, and 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 adult American shad captured including length, sex, and the condition of the fish. Samplers catalog all scale samples and fin clips brought back to the laboratory. Samplers extract otoliths from all American shad mortalities retrieved from the fishway. It is possible that these are marked adults 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 age analysis 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)[3] 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 in an attempt to reach a consensus. 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 move 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, river flow, and water temperature at the time of the observation, as well as the behavior of the shad.

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

Results:

River herring arrived at the Brunswick fishway beginning May 6, 2006 at a water temperature of 13.0 °C and river flow of 6,490 (cfs). Trapping ended June 6, at a water temperature of 17.5 °C and river flow of 12,700 (cfs). Compared to the 2005 season, alewives did not begin ascending the fishway until water temperatures warmed. In 2005, fish first arrived at water temperatures of 11.2 °C, a difference of 1.8 °C. The 2006 river herring run was longer than the 2005 run. High river flows that delayed the 2005 run were not as sever as those observed in 2006. During April 2006, river flows were down and abnormally warm air temperatures indicated that the run may be early compared to past years. By mid-May, river flows were increasing and air temperatures dropped to seasonable levels. Approximately 40.0% of the run occurred over the first 11 days the fishway was open, May 6 – May 11. During the run, the water temperature ranged between 10.6 °C and 17.8 °C, averaging 13.9 °C **(Figure 7)** with some of the coldest water temperatures occurring in the middle of the run. The river flows ranged between 4,680 (cfs) and 19,600 (cfs), averaging 9,394 (cfs) **(Figure 8)**. The 2005 and 2006 river flows were much greater than those observed in 2004 when flows ranged between 1,836 (cfs) and 9,910 (cfs) averaging 4,879 (cfs). As a result, the flows diminished attraction flow to the fishway and fish may have had a difficult time finding the fishway entrance.

Figure 7. Number of adult river herring captured vs. water temperature at the Brunswick fishway, May – June 2006

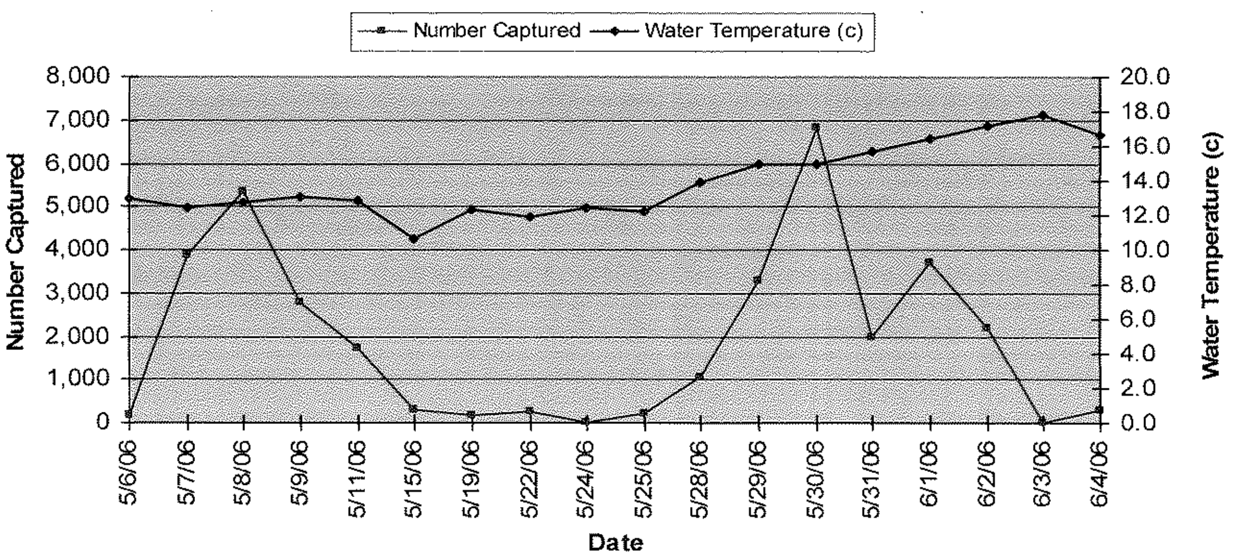
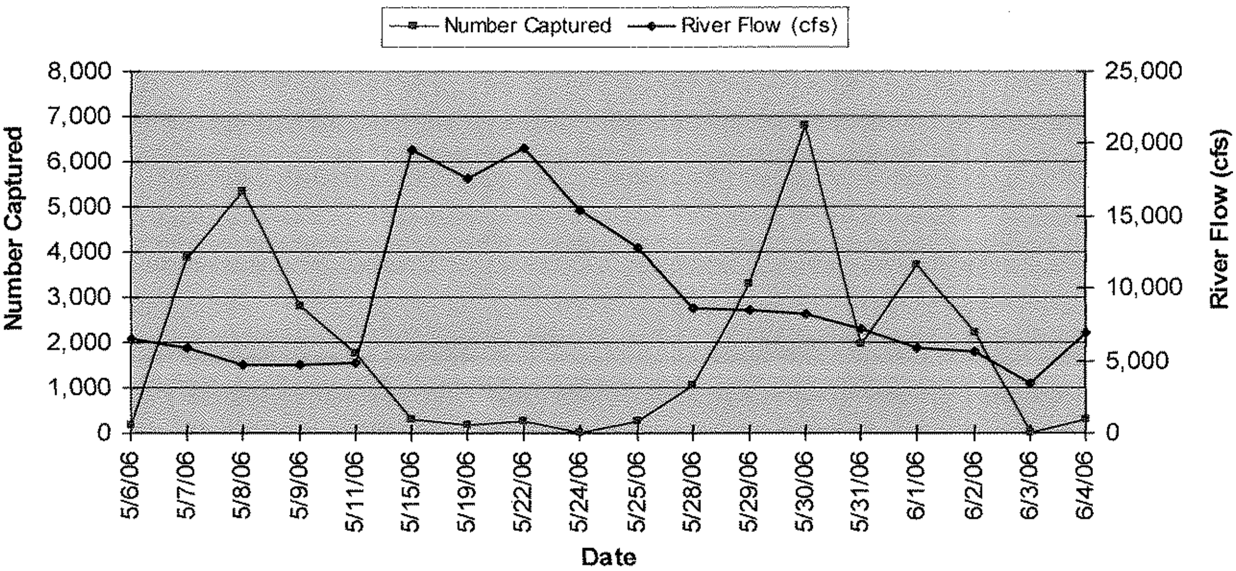


Figure 8. Number of adult river herring captured vs. river flow at the Brunswick fishway, May – June 2006



The timing of the 2006 run was similar to years past excluding the shorter and weaker run of 2005. Water temperatures and river flows during the 2006 runs fluctuated during the spawning migration as they did in 2005 but to a lesser extent. High flows during the middle of the 2006 run did delay upstream passage for a period of 11 days. The high flows likely prevented large numbers of fish arriving at the trap during any one day. This made trapping and trucking alewives an easier task.

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 9 & 10)**.

Figure 9. Heavy rains in mid-May destroyed the Damariscotta fish trap and reduced escapement into the lake by 200,000 fish.

Figure 10. The historical Damariscotta fishway observation walk was closed to visitors for several days during flooding.

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 13)**. 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 14)**.

Two trends observed from 2004 through 2006 are the increased fork lengths and weights for both sexes of river herring during this period. 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.

Table 13. Adult river herring sampled at Brunswick fishway, 2006

Date	Sex	Number	Mean Total Length (mm)	Mean Fork Length (mm)	Mean Weight (g)
5/7/2006	Female	10	295	260	237
	Male	40	283	249	200
5/15/2006	Female	22	290	257	217
	Male	36	279	245	184
5/22/2006	Female	30	285	252	200
	Male	24	277	244	179
6/6/2006	Female	2	283	249	178
	Male	3	278	245	167

	Total Number	Mean Total Length(mm)	Mean Fork Length(mm)	Mean Weight (g)
Female	64	288	255	211
Male	103	280	247	189
Combined	167	283	250	197

Table 14. Adult river herring sampled at 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

Normally, the majority of the Androscoggin river herring run is comprised of 4-year-old fish, ranging from 65 – 75%. This was not the case in 2005 or 2006. The numbers of four-year-olds present in the 2005 and 2006 run was below average. This indicates that recruitment from the 2001 and 2002-year classes was not as strong as previous year classes. Of the total number sampled in 2006, only 38% of the fish were four years old. Five-year-old fish comprised 38% of the sample and six-year-old fish comprised an additional 23%, a much larger proportion than we have observed in the past.

When compared to the 2004 samples, age four fish are down 27% and 30% for the years 2005 and 2006 respectively. Age five fish increased 25% in 2005 and 9% in 2006. The largest increase occurred with the six-year-old fish, up 21% over 2004 values, a distinct shift in the age structure of the 2005 and 2006 river herring runs **(Tables 15 & 16)**.

Table 15. 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 4	52	277	244	181	63%	37%		37.68%
Males	33	275	242	175				
Females	19	281	247	190				
Age 5	52	284	251	198	63%	37%		37.68%
Males	33	283	250	194				
Females	19	284	252	203				
Age 6	32	290	255	214	44%	56%		23.19%
Males	14	283	249	198				
Females	18	295	260	226				
Age 7	2	300	265	237	50%	50%		1.45%
Males	1	385	253	209				
Females	1	314	277	266				
All Ages	138	283	250	197	59%	41%		100.00%
Males	81	280	247	189				
Females	57	288	255	211				

Table 16. Ages of adult river herring sampled at the Brunswick fishway in 2005

	Number	Mean TL (mm)	Mean FL (mm)	Mean Wt (g)	%M	%F	%U	% of Sample
Age 3	1	*	*	*	100%	0%	0%	0.67%
Males	1	255	230	143				
Females	0							
Age 4	61	274	243	171	64%	36%	0%	40.67%
Males	39	271	241	163				
Females	22	278	247	185				
Age 5	79	287	253	194	56%	44%	0%	52.67%
Males	44	283	250	185				
Females	35	292	258	207				
Age 6	9	286	254	192	100%	0%	0%	6.00%
Males	9	286	254	192				
Females	0							
All Ages	150	281	249	185	62%	38%	0%	100.00%
Males	93	278	246	176				
Females	57	286	254	199				

Likely causes for this shift are the drought conditions experienced in 2001 when juveniles were emigrating from nursery habitats and a documented fish kill occurring at the Worumbo Hydropower Project upstream of Brunswick. The effects of high river flows and cold water temperatures during the 2005-2006 upstream spawning migration are not events likely to favor one year class of returning fish over another. As predicted in the last report, the effects poor recruitment in 2001-2002 affected the age composition of the run in 2006.

Through June of the 2006 season, fishway staff captured three American shad in the trap at the Brunswick fishway **(Table 17)**. The shad captured in 2006 ascended the fishway mixed in with schools of alewives during the early part of June. This was unusual; typically, shad do not ascend the fishway until the river herring run concludes. The 2006 shad catch is discouraging but expected. During the 1999 and 2000 season, the trap caught totals of 87 and 88 individuals respectively. In 2000, the catch total was the largest number captured since the beginning of the restoration program in 1982. 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. 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. The effectiveness of the Brunswick fishway also plays a large role in determining how many shad ascend the fishway to the trap.

Table 17. American Shad captured at the Brunswick fishway, 2006

Date	Number	Sex	Age	Water Temperature (c)	River Flow (cfs)
6/2/2006	1	M	5	17.2	5,630
6/4/2006	1	M	4	16.6	6,870
6/5/2006	1	F	6	16.5	13,000
Total Number	**3**				
Mean				**16.8**	**8,500**
Min / Max				**16.5 / 17.2**	**5,630 / 13,000**

In 2006, MDMR recorded detailed visual observations from the fishway walk during the shad run **(Figure 11)**. Fishway personnel monitored selected pools for 60-second intervals to standardize observations between individual pools and the river adjacent to the fishway. So far during the 2006 shad run, fishway personnel observed 15 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 18)**.

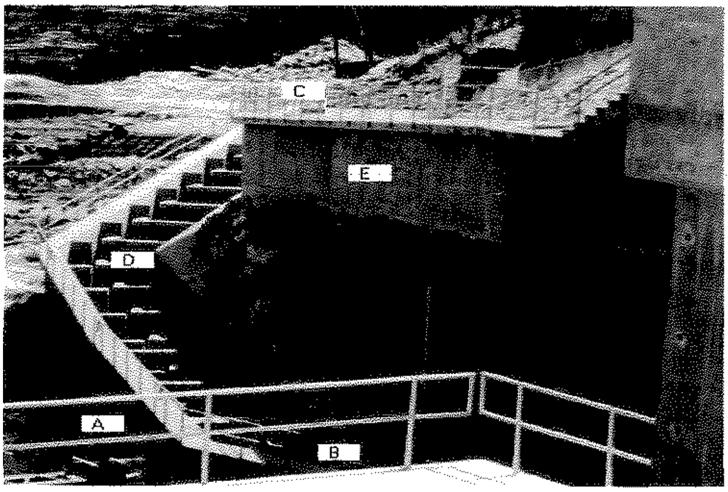


Figure 11. Brunswick fishway; (A) location of river observations, (B) lower fishway, (C) corner pool, (D) pool 14, (E) upper fishway - pool 31.

MDMR 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. 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 still need to enter and analyze the 2003 data. Since shad rarely ascend to the top of the fishway, MDMR needs to develop an alternative method to measure restoration success and modify management goals.

Table 18. 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	0	18.3
July	*	*	*	*	*	*	*
August	*	*	*	*	*	*	*
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
2004 May	0	0	0	0	0	0	15.1
June	0	0	244	7	82	333	18.3
July	0	0	38	0	41	79	22.2
August	0	0	0	0	0	0	22.7

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 2006 in the Sabattus River watershed to the Sabattus Pond Dam Commission.

- The Project Leader completed the ASMFC Shad and River herring Technical Report to fulfill Maine's reporting requirements. Attended the ASMFC Shad and River Herring Technical Committee meetings in Virginia.

- Attended east coast shad assessment meetings and conducted Maine's portion of the **2006 American Shad Assessment** in conjunction with ASMFC Assessment Team members.

- Assisted Bowdoin College Principal Investigators locate suspected spawning locations of American shad in the Androscoggin River below the Brunswick fishway. Investigators are attempting to locate and verify shad spawning location in the lower river as part of an NSF grant to investigate the overall health of Merrymeeting Bay.

<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 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 all American shad and other native species.

Methods:

Beginning in late July, 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 12)**. 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. Staff collects fish community data (species, number, and length) while conducting the alosine survey in the Androscoggin River below Brunswick.

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 13)**. 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 20 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.

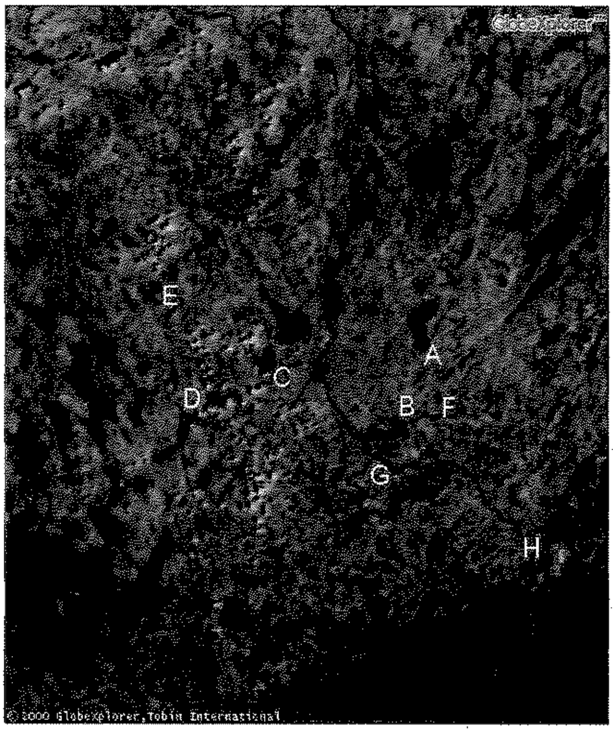


Figure 12. Juvenile alewife sample locations in the lower Androscoggin River Watershed. **A:** Sabattus Mill Dam, **B:** Farwell Dam, **C:** Brookside, **D:** Lower Range Outlet, **E:** Marshall Pond Outlet, **F:** Southerland Pond, **G:** Main Stem Androscoggin River, **H:** Brunswick-Topsham Hydropower Facility.

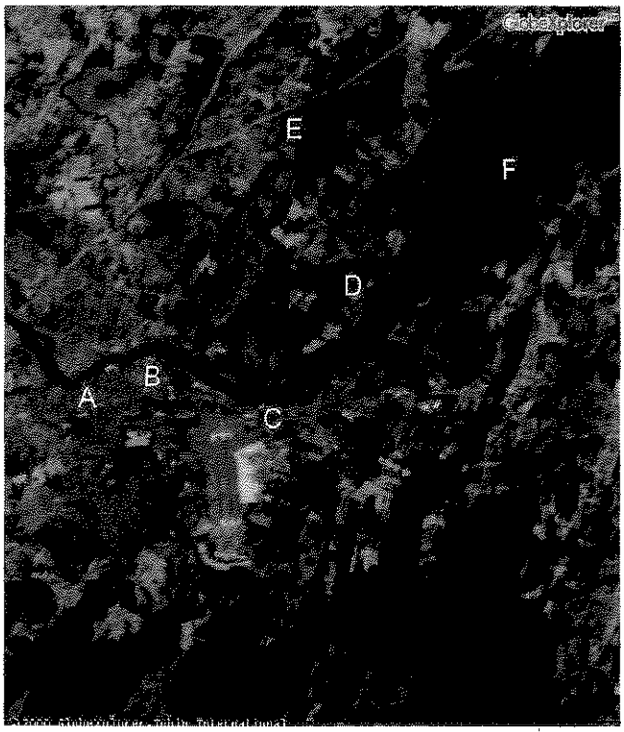


Figure 13. Alosine survey locations in the lower Androscoggin River below the Brunswick fishway. **A:** Brunswick-Topsham Hydropower Facility, **B:** Zeke's, **C:** Driscoll Island, **D:** Mustard Island, **E:** Cathance River, **F:** Merrymeeting Bay.

Throughout the sample season, project personnel collect otoliths from biological samples of adult alewives, adult American shad mortalities, and juvenile shad caught at the fishway or during the alosine survey **(Figure 14)**. Lab staff extracts the sagittae (largest pair of otoliths) from the semi-circular canals located under the brain cavity. Laboratory staff cleans the otoliths are cleaned with warm water, then mounts the otoliths, distal side facing up, in CRYSTALBOND© on a glass slide. After drying, the project leader examines the otoliths using an Olympus BX40 microscope. By counting the winter growth zones present, the age of the fish is determined. After comparing the otolith ages to the scale reading(s) the readers calculate the mode to determine the final age.

The presence of an OTC mark indicates that a juvenile shad is hatchery-reared rather than naturally spawned. Lab staff prepares the juvenile shad otoliths for the OTC analysis using the same techniques to prepare adult otoliths. The lab staff grinds down and polishes both sides of the otoliths using Brothers' Method (*Brothers, E.,* 1989)[4] using 9, 3, and 1-micron lapping film. Laboratory staff places the otoliths under an Olympus microscope that uses a mercury light source to activate the OTC and make it fluoresce **(Figure 15)**.

Figure 14. Juvenile American shad otolith extracted from a 10-day-old hatchery fry.

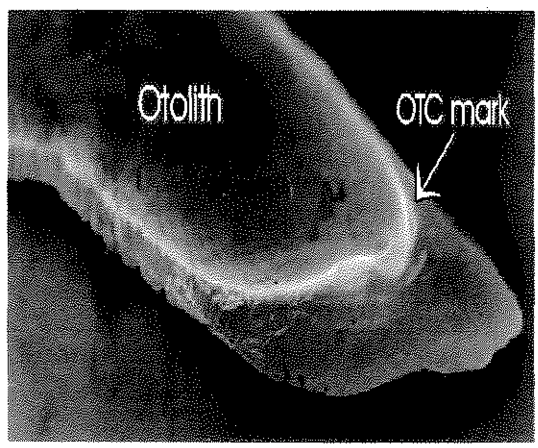


Figure 15. A longitudinal section of an American shad otolith showing the presence of an OTC mark.

Results:

This portion of the project for the current award (July 2006 – June 2007) will not begin until July 2006. The following data are from the 2005 grant award (July 2005 – June

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

2006). These results were reported in the semi-annual report; *Grant # NA05NMF4051120, Project #:AFC-37, July 1, 2005 - December 31, 2005*

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 concluded 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 Androscoggin and Little Androscoggin watersheds. Due to perceived conflicts with inland fishery resources, this pond was not available for river herring restoration from 1987 to 1997.

Field staff stocked 24,156 alewives 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 19)**. 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 19. 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. High water levels made collecting samples difficult. Traditional sample locations were underwater or too dangerous to sample **(Figure 16)**.

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.

Figure 16. River flow at the Old Mill sample location on the Sabattus River, located 135 meters below the outlet of Sabattus Pond, in early October 2005. Typically, the remains of the old granite structure are out of water and are used to access sampling locations along the river.

Field staff visited Marshall Pond, which is historically 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 sampled 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 20)**.

Table 20. 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	1	62.0	-	9.3	13.4	10,800
13-Oct	49	92.0	5.5	10.3	12.9	8,710
17-Oct	14	91.1	5.6	12.7	12.0	34,200

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 favorable environmental conditions in specific nursery habitats that allowed early emigration. The largest juveniles observed at Brunswick were likely comprised of Sabattus Pond individuals that we were unable to obtain earlier in the season. Although we 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.

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 in the restoration program. By manipulating the numbers of fry released vs. the numbers adult fish stocked, we can compare differential growth and production of the 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 had 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 the 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. Fishway personnel passed several juvenile shad caught in the fish trap without sampling.

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.

The poor shad run on the Merrimack River precluded more than a few hundred shad for transport back to Maine. All these fish went to the hatchery program in Waldoboro. Throughout the season, fishway staff searched for emigrating shad but did not observe any. Many of the shad likely spilled over the dam during period of high water.

Through September 2005, field staff sampled three sample sites on six occasions in the lower Androscoggin River below Brunswick **(Table 21)**. 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 had 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 we 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. MDMR attributes many of these differences to life stage requirements, lower than normal tides, cloud cover, sample time, and 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 but juvenile alosines and striped bass.

Table 21. 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 #	Expanded #	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	

Date	Sample Site	Water T (°C)	Species	Sample #	Expanded #	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	25.0	Yellow Perch	8		46
	Zeke's	25.0	Yellow Perch	12		41
	Total/Mean	25.0		225	1,340	

Table 21. Continued.

Date	Sample Site	Water T (°C)	Species	Sample #	Expanded #	Mean TL (mm)
8/4/05	Mustard Island	25.0	Banded Killifish	21		23
	Driscoll Island	25.0	Smallmouth Bass	5		69
	Zeke's	25.0	Smallmouth Bass	9		48
	Mustard Island	25.0	Spottail Shiner	26		42
	Zeke's	25.0	Spottail Shiner	50	207	37
	Mustard Island	25.0	Sunfish	2		146
	Driscoll Island	25.0	Sunfish	2		119
	Zeke's	25.0	White Perch	1		40
	Zeke's	25.0	White Sucker	1		44
	Zeke's	25.0	Yellow Perch	24		45
	Total/Mean	25.0		141	207	

Date	Sample Site	Water T (°C)	Species	Sample #	Expanded #	Mean TL (mm)
8/19/05	Driscoll Island	24	Alewife	1		75
	Mustard Island	23.0	Banded Killifish	1		21
	Zeke's	24.0	Banded Killifish	3		60
	Driscoll Island	24.0	Banded Killifish	26	64	79
	Zeke's	24.0	Creek Chub	2		74
	Driscoll Island	24.0	Creek Chub	3		121
	Driscoll Island	24.0	Largemouth Bass	2		97
	Driscoll Island	24.0	Smallmouth Bass	23		94
	Zeke's	24.0	Smallmouth Bass	2		50
	Mustard Island	23.0	Smallmouth Bass	1		89
	Driscoll Island	23.0	Spottail Shiner	50	88	53
	Zeke's	24.0	Spottail Shiner	74		39
	Driscoll Island	24.0	Striped Bass	10		72
	Mustard Island	23.0	Sunfish	1		127
	Driscoll Island	24.0	Sunfish (Red-breast)	10		110
	Zeke's	24.0	Sunfish	2		54

Table 21. Continued.

8/19/05	Driscoll Island	24.0	White Perch	42		67
	Driscoll Island	24.0	White Sucker	4		72
	Zeke's	24.0	Yellow Perch	2		56
	Driscoll Island	24.0	Yellow Perch	25	62	62
	Total/Mean	23.8		284	214	

Date	Sample Site	Water T (°C)	Species	Sample #	Expanded #	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
	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	

Table 21. Continued.

Date	Sample Site	Water T (°C)	Species	Sample #	Expanded #	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
	Zeke's	20.5	Smallmouth Bass	7		88
	Driscoll Island		Largemouth bass	7		145
	Driscoll Island	20.5	Spottail Shiner	3		64
	Zeke's	20.5	Spottail Shiner	71		54
	Driscoll Island	20.5	Sunfish	15		109
	Zeke's	20.5	Sunfish	1		55
	Driscoll Island	20.5	White sucker	5		125
	Total/Mean	20.5		136	0	

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:

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 USFWS 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.

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 17 & 18)**. 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.

Figure 17. Juliet dam is the first dam located on the Sabattus River. Field staff located adult pre-spawn alewives at two locations below the dam, indicated by two green arrows.

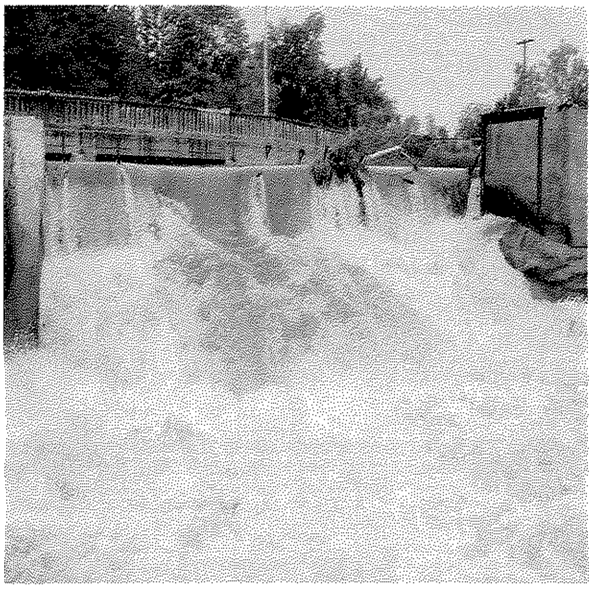


Figure 18. Flow conditions during high flows will require modifications to the site so that upstream passage can withstand spring runoff.

Project staff continues to work on reviewing and analyzing videotape data from 2002 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, and 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.

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.

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

<u>**Strategies**</u>**:**

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.

<u>**Methods:**</u>
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. MDMR 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 when stocking would begin and end and.

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. MDMR expects 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 presentation 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
Appurtenances:	
Gates:	1 - 7' x 10' motorized & instrumented sluice gate at fishway exit. This gate to be closed when pond level reaches elevation 43.0+

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

Related Work:

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

Fish species observed using the Brunswick fishway 1983 - 2006

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

APPENDIX

Table 8. May 2006 - Brunswick fishway air and water temperatures, headpond levels and river flows

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	River Flow(cfs)
5/1/2006				5,910
5/2/2006				6,100
5/3/2006				5,740
5/4/2006				5,870
5/5/2006				6,530
5/6/2006	17.3	13.0	39.0	6,490
5/7/2006	10.7	12.4	39.0	5,830
5/8/2006	11.4	12.7	39.0	4,700
5/9/2006	12.6	13.1	39.0	4,680
5/10/2006	9.2	13.2	38.5	3,940
5/11/2006	10.3	12.8	39.0	4,880
5/12/2006	9.6	12.9	39.0	6,960
5/13/2006	11.9	11.7	41.0	21,900
5/14/2006	12.9	12.2	41.5	29,600
5/15/2006	9.8	10.6	42.0	19,500
5/16/2006	10.3	10.7	41.5	14,400
5/17/2006	15.2	11.0	41.5	18,000
5/18/2006	13.4	11.8	41.5	18,600
5/19/2006	11.5	12.3	41.5	17,600
5/20/2006	14.0	12.1	42.0	21,900
5/21/2006	16.2	11.9	41.5	22,700
5/22/2006	13.9	11.9	42.0	19,600
5/23/2006	11.1	11.9	41.5	17,700
5/24/2006	13.9	12.4	41.0	15,300
5/25/2006	16.3	12.2	41.5	12,700
5/26/2006	17.1	12.6	41.3	11,100
5/27/2006	23.0	13.2	41.0	9,830
5/28/2006	25.3	13.9	40.5	8,590
5/29/2006	23.8	15.0	40.5	8,450
5/30/2006	18.7	15.0	40.0	8,160
5/31/2006	13.6	15.7	40.0	7,170
Mean	**14.3**	**12.6**	**40.6**	**11,949**

Table 9. June 2006 - Brunswick fishway air and water temperatures, headpond levels and river flows

Day	Air Temp (°C)	Water Temp (°C)	Headpond Level	River Flow(cfs)
6/1/2006	19.7	16.4	39.0	5,900
6/2/2006	17.3	17.2	39.0	5,630
6/3/2006	14.2	17.8	39.0	3,430
6/4/2006	13.8	16.6	39.0	6,870
6/5/2006	15.7	16.5	41.0	13,000
6/6/2006	15.1	17.5	41.8	12,700
6/7/2006	14.0	17.4	42.0	12,200
6/8/2006	13.2	16.0	42.0	13,100
6/9/2006	16.6	15.2	42.0	20,600
6/10/2006	15.7	15.0	42.0	24,300
6/11/2006	11.9	14.5	41.5	34,000
6/12/2006	20.9	14.4	42.0	31,500
6/13/2006	20.6	14.5	41.0	24,200
6/14/2006	18.9	15.5	41.0	18,500
6/15/2006	17.1	16.2	41.5	16,300
6/16/2006	22.8	16.9	41.8	14,600
6/17/2006	25.3	17.7	41.5	12,200
6/18/2006	26.6	18.6	41.0	9,770
6/19/2006	20.8	19.6	40.5	8,090
6/20/2006	24.5	20.2	39.0	7,740
6/21/2006	19.5	20.8	40.0	8,290
6/22/2006	22.4	21.6	40.5	9,710
6/23/2006	21.1	21.8	40.0	7,680
6/24/2006	19.8	22.4	39.0	7,210
6/25/2006	18.0	21.6	39.0	6,680
6/26/2006	18.6	22.2	39.0	6,760
6/27/2006	20.2	20.9	39.0	9,260
6/28/2006	20.8	22.0	42.0	12,800
6/29/2006	19.3	21.6	41.5	11,800
6/30/2006	18.6	21.7	41.0	12,250
Mean	**18.8**	**18.3**	**40.6**	**12,902**

Figure 5. Water temperatures and river flows recorded at the Brunswick fishway in May 2006

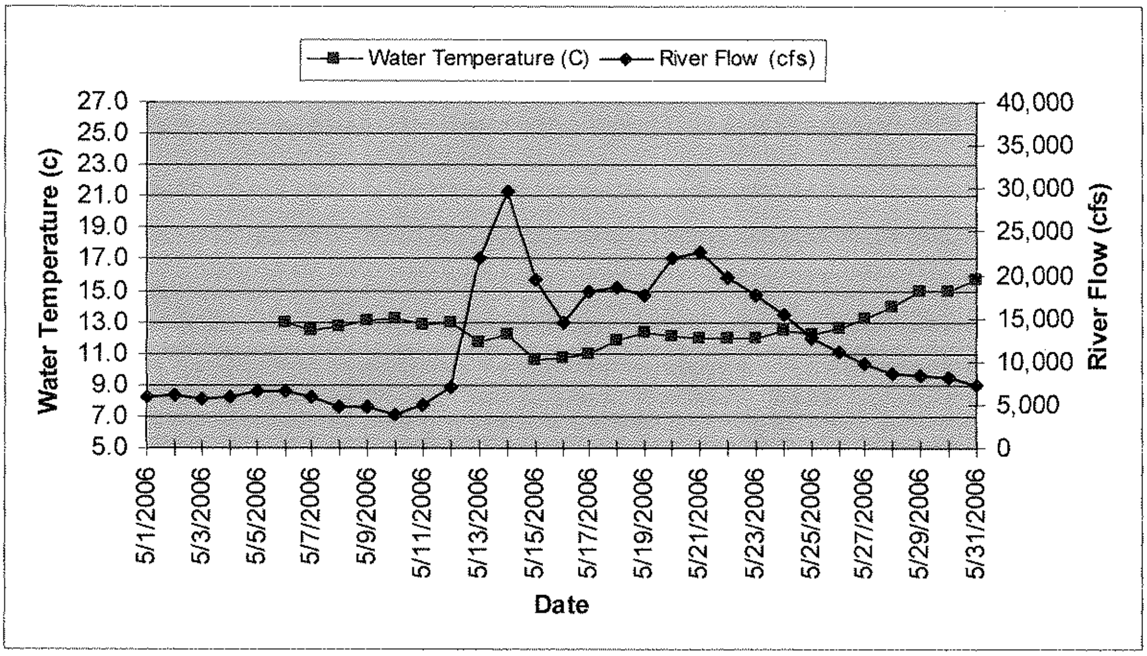


Figure 6. Water temperatures and river flows recorded at the Brunswick fishway in June 2006