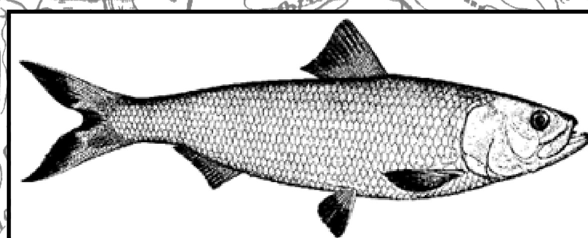
Alewife Restoration in the Union River Watershed



A Report by the River Ecology and Conservation Class

College of the Atlantic

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1. INTRODUCTION

The Union River Watershed—located in Hancock and Penobscot Counties, Maine—is approximately 500 square miles (URSG 2000). The Union River is composed of three main tributaries: the East, West, and Middle Branches. The total length of these branches includes 484 miles of streams and 81 miles of lakes and ponds (URSG 2000). Topographically, the watershed is mostly hilly, although marshes, bogs, and forested wetlands are also present (URSG 2000). These diverse habitats serve countless species of plants and animals. One of these species—the alewife, *Alosa pseudoharengus*—has suffered serious population declines in the last century. Alewife numbers in the watershed reached an all time low in the late 1970s and have never made a successful return. Because of the ecological, cultural, and economic importance of these fish, restoration of the large runs that were once common in the Union River Watershed has become an important local issue.

Restoration has been recently portrayed as a process capable of counteracting the rapid loss of biodiversity caused by humans. Reintroduction of species is an important tool within restoration. Simply put, reintroduction is "an attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated or become extinct" (IUCN 1998). The aim of reintroduction is to establish viable populations in the wild with minimal commitment to long-term management (Gamborg and Sandæ 2004). Reintroductions attempt to turn back the "environmental clock," to return a species to its pre-disturbance condition. Reintroduction of species is a controversial subject, with passionate supporters and ardent detractors.

To many people, reintroduction of alewives in the Union River Watershed is necessary. Abundant spring alewife runs are a mere remembrance of the past, of a time when alewives swam the length of the Union River without encountering concrete dams. Currently, there is an alewife run in the Union river, but it in no way matches the historical run. Arguments in favor of restoring runs are numerous and diverse. Alewives are an ecologically important species. Their spawning migrations serve as an influx of nutrients to streams, ponds, and lakes in the form of eggs, excretions, and decaying bodies. Alewives are a preferred food for other fishes and many birds.

The argument for reintroduction is also based on aesthetic, cultural, and economic values. Runs are a natural phenomenon that have captivated generations. Many people feel the desire to see them again or for the first time. Alewives were an integral part of Native American communities, serving as both a food source and fertilizer. Furthermore, declines in fish stocks used for lobster bait (e.g. herring) will necessitate that lobster fishermen seek alternative sources of bait. Alewives are an excellent candidate and have the potential to support a commercial fishing industry larger than the current alewife fishery.

Despite possible benefits from the reintroduction of alewives, some people oppose it on both ecological and moral grounds. It is thought that alewives could have a detrimental effect on the community ecology of the Union River, particularly on game fish. Moreover, these people argue that random species reintroductions will fail to deliver a “naturally” functioning ecosystem. Many opponents of reintroduction argue that habitat restoration, not species reintroduction, should be the goal of restoration.

The strongest moral objection to restoration was presented by Robert Elliot (1995). He equates restoration with art forgery, arguing that just as a copy of a painting can never match the value of the original, restored nature can never reproduce the value of original nature. Moreover, he claimed, reintroduction does nothing but to further our dominion over nature, inherited from a Western, Judeo-Christian tradition. For many opponents, alewife restoration is a means to satisfy a human desire for nature-based recreational experience (Katz 2000). Opponents of restoration also site a lack of consistency regarding stocking rates of alewives. A lack of data makes it difficult to determine what historic alewife runs may have looked like and the stocking rates necessary to achieve such runs today.

The decision to reintroduce alewives to the Union River is a difficult one. At first glance, restoration “appears to be a good thing, like mom and apple pie” (Callicott 2000), yet it has proven controversial (Light 2003). This report is an attempt to present relevant, unbiased information to stakeholders in that decision. First, we introduce the alewife´s natural history and cultural significance. We then examine the historic and present abundance and range in New England and the Union River Watershed. We outline various restoration methods that have been employed in anadromous fish restorations and discuss how these methods apply to alewives in the Union River. We then focus on specific management issues and on other current issues surrounding reintroduction. Finally we review scientific and anecdotal evidence for potential ecological and economic impacts of alewife restoration.

2. NATURAL HISTORY

The alewife is a member of the herring family, *Clupeidae*. Commonly confused with blueback herring, *A. aestivalis*, these two species are often collectively called river herring (USFWS). Most alewives are anadromous, like the ones in the Union River. However, landlocked populations exist in several lakes in Ontario and New York (NSDAF). Limburg (1998) has noted anomalous populations of non-anadromous, non-landlocked alewife in the Hudson River.

The alewife is a schooling fish found in coastal waters from Newfoundland to South Carolina (NSDAF). Marine populations are anadromous, returning to natal estuaries and river systems to spawn in spring (USFWS). However, for a majority of their adult lives, alewives live in coastal waters near natal estuaries (Fishbase).

Alewives are small, usually less than 30 cm long and 400 g in weight, laterally compressed, and have deep keels edged with saw-like keel scutes. They have silvery, iridescent sides, grayish-green backs and a single black spot on the shoulder immediately behind the gill cover at the level of the large eye (FOC 2004).

Alewives occur in nutrient-rich areas characterized by tidal mixing and upwelling. Feeding is through size-selective particulate and filter feeding and depends on prey density, size, and visibility (Stone and Jessop 1994). Alewives feed primarily on zooplankton—a majority of their diet consists of euphausiids. Stone and Jessop (1994) found adult daily rations ranging from 1.22 to 1.88% of body weight. A daily pattern of vertical migration has been noted in addition to seasonal changes in foraging areas and diet composition (Neves 1981, Stone and Jessop 1992). These changes reflect the alewife's opportunistic foraging behavior (Stone and Jessop 1994). Stone and Jessop (1994) found daily feeding activity peaked near mid-day for both adults and juveniles.

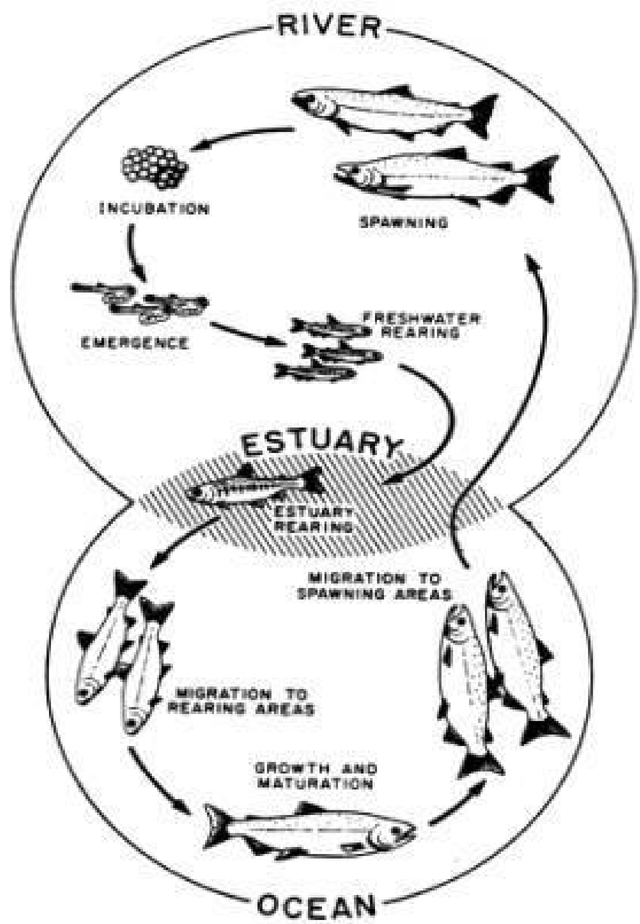
Alewives prefer marine temperatures of 7-11ºC and have an upper incipient lethal temperature of 31-34ºC (CMI 1996, Stone and Jessop 1994).

Females reach sexual maturity around four years, males in three (USFWS). Adult alewives can spawn multiple times within a 10-year lifespan. Nearly 75% of alewives entering Nova Scotia rivers have been found to be repeat spawners (NSDAF). Spawning is initiated when water temperatures reach 10.5 –12.0ºC and generally occurs in slow moving waters of natal river systems between 10.5 and 22.5ºC (CMI 1996, Limburg 1998, USFWS).

Alewives have been noted to spawn in a variety of habitats and substrates. Preferred spawning substrate is 75% mud or silt with detritus and vegetation (CMI 1996). Spawning is achieved by broadcasting sperm and eggs into the water column simultaneously (USFWS). After spawning, some alewives die; however, most return to their marine environment (CMI 1996, USFWS).

Fertilized eggs are about 1mm in size and are pelagic in slower moving waters. Eggs hatch in 3-5 days at temperatures ranging from 12.7-26.7ºC (CMI 1996, NSDAF) and larvae begin to feed externally in 3-5 days (USFWS). Juvenile alewives remain in the spawning ground throughout the spring and summer foraging on zooplankton and other macroinvertebrates (Stone and Jessop 1994). Young-of-the-year migrate downstream in fall, cued by changes in water temperature and moon cycles (Stokesbury and Dadswell 1989, USFWS). Migrations have been noted to primarily occur at night in response to a new moon period and decreased water temperatures (Stokesbury and Dadswell 1989).

Figure 1. Alewife Life Cycle:



Source: www.penobscotriver.org/ fisheries.htm

3. CULTURAL SIGNIFICANCE

Alewives have had a deep importance to various groups of Mainers: historically to Native Americans and early European immigrants, more recently to river communities and alewife fishermen. Non-economic values include use as fertilizer, food, and for aesthetic/recreational pleasure. They are also valued for their contribution to stream ecology and local economies.

As mentioned in the introduction, alewives were used as corn fertilizer, both by Native Americans and European settlers. While this may not be common practice today, alewife fishermen Chap Pannett and Dennis Smith have experimented with this technique in their gardens with good results. According to Smith, the corn "grew like the devil." However, Rick Welch warns that fertilizing with alewives attracts "every coon and cat" in the neighborhood.

Although not as common today, Mainers have smoked and pickled alewives for generations. They were an important resource for poor people and widows during the latter part of the 1800s. Smith recalls a time when every store in the area sold smoked alewives during the spring run.

In Damariscotta, alewives have traditionally had a special recreational importance. Maine Rivers executive director Naomi Schalit says that during the spring run Damariscotta used to host an alewife festival in which an "alewife queen" was elected and given two bushels of alewives as a prize. The demographics of Damariscotta have changed, however, and the town no longer hosts the festival. But the alewives remain a focal point to the community and the stone built fish ladder and harvesting system have been incorporated into a public park, where residents and visitors both young and old come to see the thick schools of fish migrating upstream.

Pannett and Smith still relate their memories of the alewife population prior to its crash in the late 1970s. Alewife runs were so thick, Pannett says, that you could almost walk across the river on the alewives' backs. Smith agrees and relates an amazing site on the Narraguagus River, where a railroad track skirts a spawning site. He remembers seeing thousands of alewives leap from the water with the pounding of each passing train.

Both men describe their love of walking along the shores of coastal streams, watching the fish and wild animals. Smith marvels at the incredible strength of alewives hurtling their way over small waterfalls. To Pannett, alewives represent a healthy native ecosystem, and he appreciates the eagles, herons, and osprey that follow the alewife migration. He views being an alewife fisherman as an ecological balancing act: he must limit his take to insure return migrations and he must clear the stream of obstructions to allow their passage. If he allows too many of the fish to pass upstream, they will deplete the oxygen in the lakes and kill other fish. "We're all linked together," says Smith, we have to think about the all the species impacted by our actions."

Finally, alewives are important for local economies and represent a commitment to place for many Union River communities. Pannett inherited the alewife business from his parents, and with the pride of a family businessman, he says that when he gets old he hopes to see the next generation of family stream stewards take over. Such family businesses have thrived in Maine for hundreds of years in some cases.

4. RANGE AND ABUNDANCE

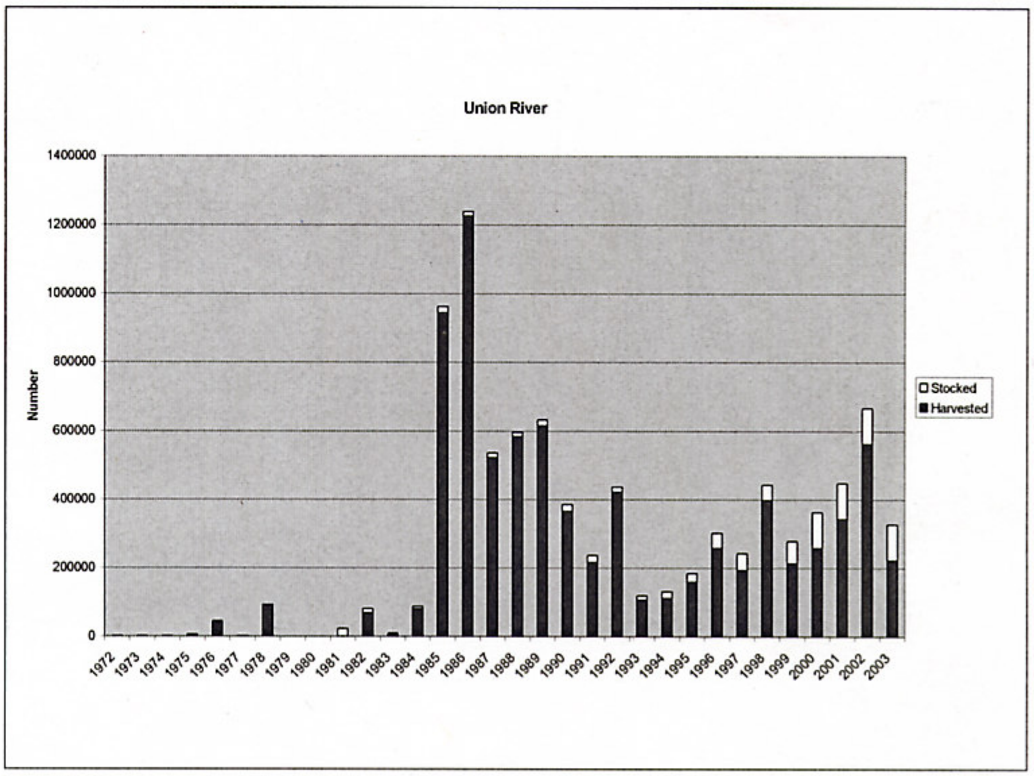
4.1 Historic Abundance in Downeast Rivers

There is limited data on historical anadromous fish runs in the Downeast region rivers (Squires 2003). On the Union River, one of the only historical accounts was written by Atkins in 1887: "No river fisheries now exist here, though formerly salmon, shad, and alewives abounded." From this account, we gather that a population of alewives was present in the area prior to 1887. There are many other accounts of alewife populations predating 1887 for rivers throughout New England and Downeast Maine.

There are documents dating as far back as 1622, that indicate the use of alewives as fertilizer for corn cultivation and as bait for fisheries; they were also smoked or pickled by locals for export or local consumption throughout New England (KRC). In 1735 the Massachusetts Bay Colony passed the first law "to prevent the destruction of…alewives." This legislation states "that no dam shall, hereafter, be erected across any river or stream, (through) which alewives or other fish have been accustomed to pass…" (KRC). There are reports that the Sebasticook River had more alewives than any other fish, to the extent that thousands of barrels were caught every spring. When damns and weirs were built from 1809-1817 catches declined greatly; however, there is no report of how extensive the decline was (KRC). From 1807-1848 many petitions were passed by towns and private parties in attempt to increase alewife and other anadromous fish populations to their original numbers (KRC).

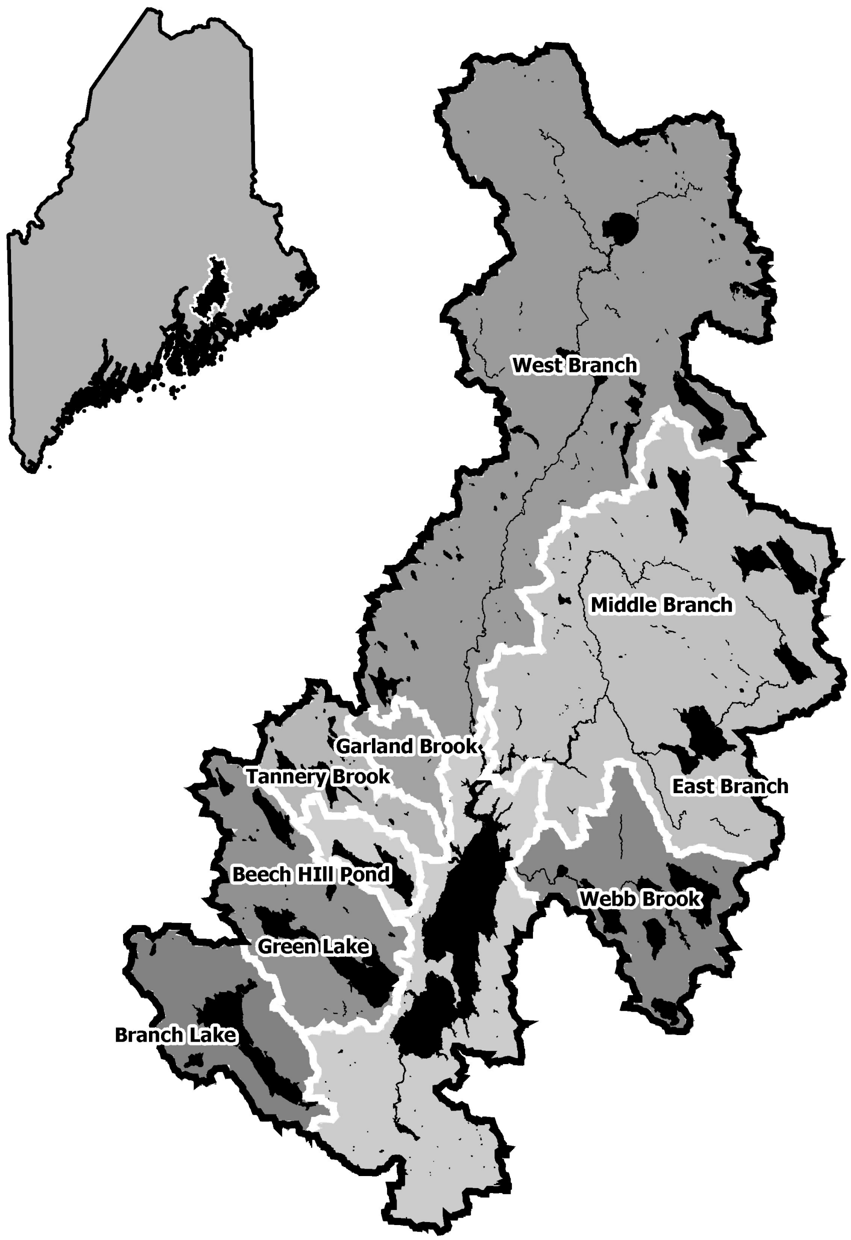
Although historical records of Union River populations are lacking, since 1970 data has been collected on the landing numbers at the Ellsworth Dam. From 1970-1984, the annual alewife landing was miniscule (below 1500), with no landing between 1979 and 1981, and two exceptions in 1976 and 1978 each having about 10,000. In 1985 the landing reached just under 100,000, fluctuating annually thereafter, but remaining above 10,000 (Squires 2003). The landings represent the total number of fish caught at the Ellsworth Dam, which is a good estimate of how many enter as only transported fish make it past the dam (Squires 2003).

Figure 2. Alewife Run Numbers 1972-2003:



From: Tom Squires, DMR

Figure 3. Union River Watershed and Sub-basins:



Map: College of the Atlantic GIS Laboratory

4.2 Historic and Present Range in the Union River Watershed

4.2.1 Introduction

The Union River Watershed begins at the mouth of the Union River a few miles below the town of Ellsworth, Maine. It continues north to the Oxhead Ponds near the border of Penobscot and Hancock Counties. The watershed lies almost entirely within Hancock County and extends as far west as Goose Pond in Dedham and as far east as the Lead Mountain Ponds east of Aurora, bordering Washington County.

Based on information obtained from interviews with the Fisheries Division of Maine Inland Fish and Wildlife (IFW), and from various residents of the Union River Watershed, this section outlines the historic and present range of alewives throughout the watershed. The information is based on interviews with Greg Burr (IFW), Raymond Hanscom of Southwest Harbor, and Gil Grindle of Surry. These sources were chosen because they are either known authorities on the watershed or because they were recommended by multiple sources due to their life-experiences and knowledge of the watershed. Hanscom and Grindle are referred to as residents of the watershed.

In many instances below, you will notice a discrepancy between the information given by IFW and the information given by the residents of the watershed. Both IFW and the residents are aware of these contradictions. IFW stated that such contradictory information can be normal for issues concerning present and past fish populations.

4.2.2 Leonard Lake

Presently Leonard Lake provides 90 acres of spawning habitat for alewives. The lake may also serve as a passageway for alewives migrating to Branch Lake. Before the construction of the Ellsworth Dam and the subsequent creation of Leonard Lake, the area would most likely have acted as a passageway for alewives rather than a spawning site as alewives prefer to spawn in still water. The area of the Union River that would later become Leonard Lake was—in its naturally flowing form before 1907—a series of short falls and rapids through which alewives could migrate. All sources were in agreement regarding this information.

4.2.3 Branch Lake

IFW stated that there are impassible waterfalls on the stream that accesses Branch Lake. They conclude therefore that alewives have never been in Branch Lake. However, accounts from residents of the watershed indicate the historic presence of alewives in Branch Lake[1]. None of the interviewed watershed residents knew whether the lake is a present spawning site.

[1] Whereas IFW frequently sites certain waterfalls and access streams as impassable to alewives, personal accounts of alewife history in the watershed frequently indicate that alewives may have indeed migrated

There are two dams that may block access to Branch Lake for migrating alewives. There is a small outlet dam at the base of Branch Lake and another dam where Branch Lake Stream meets Leonard Lake. These dams likely exclude alewives from the lake regardless of whether alewives can migrate through the waterfalls during high flows in Branch Lake Stream.

4.2.4 Graham Lake

Before the creation of Graham Lake dam, the area of the Union River that was to become Graham Lake was marshy and winding and had a very shallow gradient. This section of the river was a passageway for migrating alewives. Currently, alewives use Graham Lake as a spawning site and possibly as a passageway for further upstream migration. Graham Lake presently provides about 9,300 acres of spawning habitat for alewives.

4.2.5 Green Lake and Ponds and Lakes Accessed Via Green Lake

Presently there is a small hydroelectric dam at the entrance of Green Lake. IFW has stated that this dam excludes alewives from the lake. IFW stated that previous to the creation of this dam, alewives most likely migrated to Green Lake (through Reeds Brook), using the lake as a spawning site. Before access was blocked from Green Lake, the lake provided 2,900 acres of spawning habitat for alewives.

There are a number of lakes and ponds that drain into Green Lake. If alewives used Green Lake as a spawning site before the creation of the dam at the base of the lake, then it is possible that alewives would have used these other lakes and ponds as spawning habitat. These lakes and ponds include Goose Pond and Phillips Lake. Presently there is a dam blocking the flow of Phillips Lake into the watershed. As a result of this dam, alewives could not access Phillips Lake even if Green Lake was accessible.

4.2.6 Beech Hill Pond

According to accounts from a resident of the watershed, Beech Hill Pond was a spawning site for alewives before beaver dams blocked the access brook to the pond. Presently there are beaver dams in the stream that connects Beech Hill to Graham Lake. These beaver dams create impassable barriers to the migration of alewives.[2] As a result, it is likely that alewives no longer spawn in Beech Hill Pond.

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past these falls and other natural obstacles in the past. When the alewives migrate upstream in the spring the waters are higher than they are throughout the rest of the year. Residents believe that this helps the alewives navigate sizeable barriers (other than those created by humans and beavers). When IFW was later asked about the discrepancy between their accounts and those of the residents, IFW stated that it may have been possible for alewives to navigate certain barriers such as waterfalls during the spring high flows.

[2] Interviews with watershed residents revealed that aside from human-constructed dams, beaver dams are one of the most significant impediments to migrating alewives. During the time period that many of these

IFW stated that alewives could never reach Beech Hill Pond due to the impassible gradient of the outlet stream. The presence of beaver dams was not discussed. Currently there is a small dam at the outlet of Beech Hill Pond. IFW stated that this dam has deteriorated to a large extent. It is possible that this dam would no longer exclude alewives from Beech Hill Pond if beaver dams did not block alewife migration in the access brook.

4.2.7 Ponds Accessed Via Tannery Brook (Floods Pond, Burnt Pond, Springy Ponds)

IFW stated that alewives probably did not reach the ponds above Tannery Brook. According to IFW, the small and shallow size of Tannery Brook restricts the migration of alewives to the ponds above. IFW also stated that regardless of whether alewives could historically reach the ponds via Tannery Brook, beaver dams currently block migrating alewives from reaching Floods Pond, Burnt Pond, the Springy Ponds, and other ponds accesses via Tannery Brook. Furthermore, there are small outlet dams at the base of Floods Pond and Burnt Pond that exclude alewives from entering these ponds.

4.2.8 Webb Pond, Little Webb Pond, and Ponds Accessed Via Webb Pond (Scammons Pond, Abrams Pond, Molasses Pond)

Webb Pond is currently a potential spawning site for alewives, although beaver dams and fish weirs along Webb Brook may block migration routes. IFW stated that alewives may presently migrate into Webb Pond. If accessible, Webb Pond provides 915 acres of spawning habitat for alewives. Little Webb (a small pond in Webb Brook between Graham Lake and Webb Pond) may provide 77 acres of spawning habitat.

There is a dam at the base of Webb Brook where the brook flows into Graham Lake. This dam is about three feet high and does not span the entire length of the brook. This means that, provided there are no fish weirs impeding this last free-flowing section of the brook, this dam does not block migrating alewives.

From Webb Brook, Little Bog River leads into Scammons Pond. There is a dam at the base of this pond excluding alewives from Scammons Pond, Abrams Pond, and Molasses Pond. There is also a dam at the base of Molasses Pond that would also prevent alewives from entering Molasses Pond.

The historic presence of alewives in these ponds was not ascertained. However, one resident believes that more alewives would migrate to Webb Pond if there were fewer beaver dams in the streams and better fish passage facilities at the Graham Lake and Ellsworth Dams. Based on that assumption, there may have been more alewives in Webb Pond before the population crash in the late 1970's than are present now.

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accounts come from, beavers were still being trapped extensively. This means that when these accounts were taken there were likely fewer beavers creating dams in streams that impede alewife migration.

4.2.9 Ponds Accessed Via East and Middle Branch of Union River

IFW has stated that Whetstone falls on the East Branch of the Union River below Route 179 prohibits the migration of alewives into the East and Middle Branches of the Union River. Based on this information, IFW concluded that alewives have never been in the Union River beyond these points.

A resident of the Union River watershed, however, stated that alewives may have migrated beyond these waterfalls years ago when the spring high water made these waterfalls passable, before the Ellsworth and Graham Lake dams were built. The resident was not certain of this, however, and other consulted sources contest this point.

There are dams at the base of Lower and Upper Lead Mountain Ponds and at Hazlam Pond. These ponds drain into the Middle Branch of the Union River. The size and condition of these dams has not been ascertained, and therefore it is unknown whether they are, or would be, complete impediments to migrating alewives.

4.2.10 Ponds Accessed Via West Branch of Union River (Hopkins Pond, Great Pond)

Hopkins Pond is accessed via Frost Brook and Jellison Meadow Brook. (Frost Brook flows from Hopkins Pond into Jellison Meadow Brook and into Graham Lake.) IFW stated that these access brooks are probably too narrow and shallow for alewives to successfully migrate into Hopkins Pond. Unfortunately, no information on the presence of alewives in Hopkins Pond, historic or present, was gained through interviews with watershed residents.

There are no dams on the West Branch of the Union River or in its tributaries. However, IFW stated that alewives could not migrate past the Mariaville Falls on the West Branch of the Union River. Therefore, IFW concluded that alewives have never migrated past these falls and into Great Pond.

Despite this, certain residents of the watershed claim to have seen alewives migrating upstream beyond Mariaville Falls. One resident has seen alewives in Indian Camp Brook in Amherst and as far north as Great Pond. These residents have not seen alewives this far up the Union River in many years. These residents believe beaver dams and poor fish passage facilities at the Graham Lake and the Ellsworth Dams are possible reasons for the decline.

Figure 4. Mariaville Falls on the West Branch of the Union River:

Photo credit: Union River Watershed Coalition

5. ANADROMOUS FISH RESTORATION METHODS

5.1 Introduction

There are several methods for reintroducing anadromous fish runs to an obstructed waterway. Although most fish restoration efforts focus on dam removal or on transporting fish above dams, river obstruction is not the only cause of anadromous fish declines. Successful restoration efforts must address additional factors such as habitat quality. These factors are especially important when dam removal is not an option. The following are the practices most relevant to the reintroduction of alewives into the Union River Watershed.

5.2 Trap and truck

The "trap and truck" method involves trapping spawning adults in parts of a river below an impoundment and transporting them to locations above it. This method is employed as a cost-saving alternative to installing fish ladders. This method has become controversial due to the largely unquantified effect it has on the behavior and health of the returning fish (OTA 1995). It has been successfully used in places where fish have a series of obstacles such as a few dams or a large reservoir with no current to direct fish upstream.

Adverse effects of this management option include disorientation, disease and mortality, delay in migration, and interruption of the homing instinct—which can lead to straying (becoming confused and not migrating upstream once released from the transport tank). Another limitation of this method is that the truck employed is usually not large enough to transport the fish at peak season (OTA 1995).

On the Susquehanna River in Pennsylvania the trap and truck method is used in conjunction with fish lifts. Alewives are among the species transported at the site, and the Susquehanna River Anadromous Fish Restoration Committee has seen positive results from their efforts (NFC). There is a proposed restoration project on the Penobscot River that would employ the trap and truck method. There is concern among fishermen that the fish will be transported around the traditional fishing grounds near the dam. Trapping and transporting by tank truck is the method currently used for restoration efforts on the Androscoggin River. This method was used on the Kennebec River at Augusta until the dam was removed in 1999 (KRC). Currently the run on the Kennebec is around one million individuals and growing. Before pollution, dams, and over-harvesting came about the run was around six million (Maine Rivers).

Figure 5. A Trap and Truck Facility at the Ellsworth Dam:

Photo credit: Thupten Norbu

5.3 Fish Ladders

Fish ladders are the most frequent method of transporting fish upstream past dams (OTA 1995). Fish ladders generally consist of a series of gradually inclining steps with resting pools located at regular intervals. Fish ladders differ in terms of hydraulic form, building materials, and function. Selection of the appropriate ladder type and construction material depends on the size and behavior of the target species, the dam size, and the local flow regime as well as availability of funds (CRWC 2000). The “pool and weir fishway” ladder design has proved successful in facilitating upstream passage of certain anadromous fish, especially salmonids (OTA 1995). This type of fish ladder consists of pools arranged in steps, separated by overflow weirs to provide plunging flow. These ladders have ample resting areas to provide leaping fish with hydraulic assistance in moving upstream. Such fish ladders are inappropriate for alewives because alewives—like most clupeids—rarely leap over obstacles (OTA 1995). More moderately sloped fish ladders with continuous flow are needed for this species. Fortunately, several standard fish ladder designs have been developed for non-leaping fish such as alewives, and after many years of experimentation, the basic requirements of upstream fish passage facilities for alewives are now reasonably well understood. Some conventional fishway designs have been in place long enough that the design specifications have become almost generic (OTA 1995). New England has two fish ladders that were constructed specifically for alewife migration (i.e. Damariscotta Falls in Maine and the junction of the Squamscott and Exeter Rivers in New Hampshire).

5.4 Fish Elevators/Lifts

Fish elevators, or lifts, are generally used on dams over 90 feet tall. A mechanized lift provides migration of fish over dams and into spawning areas. Fish—guided by artificial currents—swim into chambers at the base of the dam which are then mechanically lifted over the dam and emptied on the other side. Lifts have been used to transport fish over large dams such as the Conowingo Hydroelectric Dam on the Susquehanna River in Pennsylvania. On the Saco River in Maine the Department of Marine Resources (DMR) has installed a fish lift on the Skelton Dam, the highest dam in the state at 75 ft (SMRPC). This fish lift allows anadromous fish access to an additional 3.3 miles of river (Mercer 2002). In general fish lifts are used to facilitate passage for large numbers of fish in situations where there are too many fish to employ the trap and truck method and when the obstruction is too high for a fish ladder. Fish lifts are costly and often not economically feasible. Dam removal is most often less costly, though the negative effects may be greater. When studies were done regarding the Fort Halifax Dam on the Kennebec River, Florida Power and Light (FPL) Energy estimated the cost of a fish lift at $3 million to $4 million, whereas breaching the dam would cost under $800,000 (Hickey 2004).

There are other types of fish lifts, such as fish locks, which operate similar to traditional boat locks (SCDNR). Fish pumps are another system currently under study. Such pumps tend to disorient the fish and can even cause physical injury such as loss of scales (OTA 1995). Though there are continuous studies on the most effective fish passages, it seems that for the Union River, for now, using trap and truck and fish ladders where available are the most feasible practices. More research on fish passages can be found in OTA (1995).

5.5 Dam Removal

Because they obstruct waterways and prevent fish from reaching spawning grounds, dams are often implicated as the major factor responsible for the decline of anadromous fish. Consequently, dam removal is the most obvious and effective solution to restoring anadromous fish runs because it restores the waterway without requiring additional maintenance (OTA 1995). Dam removal has both costs and benefits. Each dam has to be evaluated separately (OTA 1995). The removal of a dam is a major disturbance and causes drastic change to the river both above and below the dam. When a dam is breached (removed) the sediment that has accumulated for years at the bottom of the reservoir erodes and flows down river where it eventually is deposited. This can cause high morality in downstream aquatic communities as well as loss of reservoir habitat (Stanley and Doyle 2003). The flow rates below the breached dam fluctuate and different sedimentation patterns evolve, causing changes in stream form. Sometimes dam removal is not feasible due to the effect of these factors on existing land uses.

5.6 Stocking

Information on stocking can be unreliable as people define the term in several ways. Though it refers to the action of purposefully putting fish back into a certain section of a watershed, where those fish originate depends on the definition of the word. To some people, stocking implies the use of fish from hatcheries. Hatchery production of young fish (larvae and juveniles) is used to reestablish dwindling or extirpated populations. Eggs are collected from adults spawning in other river systems and are fertilized in a laboratory and reared to the juvenile stage. The juveniles are then introduced into the river system undergoing restoration (ideally within which water quality and impediments to migration have been addressed) to restore the historic run. Some people refer to stocking as the mere action of taking fish from one part of a river to another, as with the use of trap and truck. Another confusion arises designating the introduction of fish from a different river and the transport of fish along a river. Although there are no alewife hatcheries in Maine, the term “stocking” is used freely in regard to alewife management.

5.7 Water Quality Improvements

In some cases, removing obstructions to alewife migration may not be sufficient to restore the population. The fish also need suitable habitat with certain water quality standards. Degraded water quality—low pH values and high levels of aluminum in particular—have recently been implicated as a key factor impairing efforts to restore anadromous fishes, especially the Atlantic salmon (Kircheis 2004). Water that is very acidic can damage the skin, gills, and eyes of fish, and prolonged exposure to sub-lethal pH levels can cause stress, increase mucus production, and encourage epithelial hyperplasia (thickening of the skin or gill epithelia) with sometimes-fatal consequences (Helfman et al. 1997). Changes in pH will also affect the toxicity of many dissolved compounds, potentially making a number of pollutants more harmful. Highly acidic soils can decompose and release toxic aluminum ions. An increased abundance of aluminum ions are a threat to alewives because they bind to fish gills and interfere with osmoregulatory (salt balance) proteins, often with fatal consequences for fish that migrate between fresh and salt water (Whiting, pers. com.)

Mark Whiting from the Maine Department of Environmental Protection reports that alewife kills from low pH have been observed in the Downeast rivers each fall as the young-of-the-year fish migrate to sea (pers. com.). Whiting suggests the same phenomenon is most likely occurring in the East and Middle Branches of the Union River because which are fairly acidic, with low buffering capacity. The West Branch has more buffering capacity and a pH that remains near 7 (Whiting, pers. com.). Further investigation is currently being undertaken by NOAA Fisheries and several governmental and non-governmental committees, all primarily focusing on the effects of water quality on Atlantic salmon (Kircheis, pers. com.). However, when considering alewife restoration, it is important to take results from these studies into account because clupeids tend to be more vulnerable to acidic conditions than salmon (Whiting, pers. com.).

In Norway and Sweden, the liming of rivers and lakes has been used extensively since the late 1980s to mitigate acidification (and hence the release of toxic aluminum ions), this effort is thought to have played an important role in bringing salmon back to many rivers there (Hindar 2004). The Committee on Water Enhancement (assembled under the Project SHARE Research and Management Committee) plans to implement a pilot liming project on a portion of the Dennys River to assess the suitability of liming as an option for Maine's rivers. The pilot project—in which a liming doser will be used to deliver a calcium product to buffer against pulses of aluminum and pH that are affecting salmon survival in Downeast Maine—is expected to be fully operational in spring or summer of 2005 (Kircheis 2004). Although this project focuses on salmon, it is likely that the outcomes may affect alewives as well.

6. ALEWIFE MANAGEMENT PRACTICES IN THE UNION RIVER WATERSHED

6.1 Ellsworth Dam Fish Passage

The first obstacle alewives encounter in their migration up the Union River is the Ellsworth Dam (also referred to as the Leonard Lake Dam), 62.3 feet tall and 377 feet long. The crest elevation behind the dam is 64.5 feet and flood-control flashboards increase the elevation to 66.7 feet. There is one powerhouse located on the dam with four turbines capable of producing over 9 megawatts of power at peak performance. Because of the inadequate storage capacity of Leonard Lake, a 25-foot earthen dam was constructed above the lake, creating Graham Lake, which serves as a reservoir for the Ellsworth Dam.

The license to operate the Ellsworth dam as a hydroelectric power facility came up for renewal in 1987. Pursuant to its license renewal, Bangor Hydro submitted a fish passage plan relying solely on a trap and truck method for accommodating upstream fish migration. FERC issued an order modifying Bangor Hydro's fish passage or pathway plan to conform to FWS prescriptions—FWS wanted Bangor Hydro to construct permanent facilities to accommodate runs of 2.3 million alewives and up to 1000 salmon. It would not be possible for Bangor Hydro to utilize the trap and truck method to move this many fish; in order to comply with FWS, Bangor Hydro would have to build more appropriate fish passage. In Bangor Hydro v. FERC (316 U.S. App. D.C. 298; 78 F.3d 659. 1996) the Court of Appeals held that Bangor Hydro did not have to comply with these FERC and FWS fish passage conditions because inadequate evidence was produced to show such measures were necessary to produce healthy alewife runs. In 1999, FERC approved BangorHydro's sale of the Ellsworth Dam and the facilities to Pennsylvania Power and Light, Maine (PPLM).

Under Article 401 of the 1987 FERC license, PPLM was required to maintain minimum flows. The dam must release 105 cubic feet per second (cfs) from July 1st to April 30th and 250 cfs from May 1st to June 30th. These dates correspond to alewife upstream migration. In addition, FERC required a Comprehensive Plan for protection and development of the fisheries in the Union River Watershed to be produced as a condition of license renewal. The Comprehensive Plan's mission is to "manage all sport and commercial fish species in the Union River for optimum habitat utilization, abundance, and public benefit" (URSG 2000).

Figure 6. The Ellsworth Dam, a Front View:

Figure 7. The Ellsworth Dam, a View from Above:

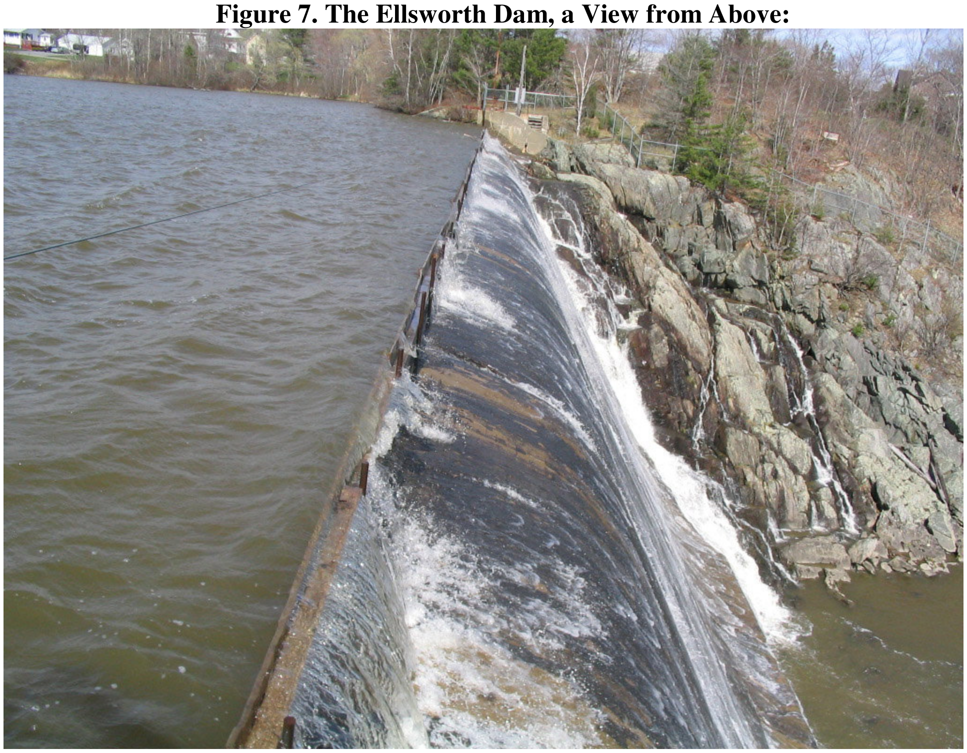

Photo credit: Thupten Norbu

6.2 Comprehensive Fisheries Management Plan for the Union River

The Comprehensive Management Plan was the first step in an evaluative process examining management of Union River fisheries. The Plan was a compromise between all stakeholders—groups with vested interests in the alewife fishery in the Union River Watershed. This plan was created in 2000 pursuant to a FERC re-licensing stipulation imposed on PPLM. This plan was put together by what would become known as the Union River Fisheries Coordinating Committee (URFCC). This group is comprised of members from the Maine Department of Marine Resources (DMR), Maine Department of Inland Fisheries and Wildlife (IFW), Maine Atlantic Salmon Commission (MASC), U.S. Fish and Wildlife Service (FWS), the City of Ellsworth, PPLM, Maine Council of the Atlantic Salmon Federation, Union Salmon Association, Union River Watershed Coalition (URWC), Friends of Union River, National Marine Fisheries Service, and interested members of the public. The URFCC meets annually to assess the previous year's fisheries activities.

The Comprehensive Plan was developed for a five year period between 2000 and 2005. The Plan outlines the implementation of measures that would allow the Union River to attain an Alewife run of 2,000,000 harvestable adults. This estimate provides for a "spawning escapement" of 315,000 alewives per year. The spawning escapement refers to the number of alewives able to reach upstream spawning sites (in this case the escapement is transported upstream). This spawning escapement is equivalent to 15% of the projected run. This DMR recommendation is based on alewife management practices in other coastal Maine rivers, particularly the Kennebec River (SPO 1993). To accomplish this during 2000-2005 as the Comprehensive Plan outlines, the returning alewife runs will be documented and downstream migrating alewives will be measured for length to determine if the population is at "carrying capacity" (URSG 2000). Currently no information is being collected on downstream migration.

The Comprehensive Plan also addresses the possibility of conflict between alewives and smallmouth bass populations. To examine these effects, IFW will "analyze stomach contents of post-spawner adults to help evaluate [the] extent of predation on zooplankton and juvenile smallmouth bass" (URSG 2000).

The aim of creating a migratory pathway for alewives in this section of the river necessitates adequate upstream and downstream fish passage at both the Graham Lake and the Ellsworth dams. PPLM, through the City of Ellsworth's harvesting contractor, employs a "trap and truck" method for addressing migratory fish passage. A private contractor for the town of Ellsworth sells any alewives trapped in excess of the stocking regulation as lobster bait. The Ellsworth trapping facility utilizes two fiberglass tanks for fish transportation. This enables the movement of fish from the fishway and trap without delay.

PPLM employs three surface weir downstream bypasses on the Ellsworth Dam to allow migrating fish to move downstream of the dam. Graham Lake Dam has one weir bypass. PPLM does not count the number of alewives that migrate downstream.

There are many ponds and lakes that drain into the Union River above Leonard Lake and into Graham Lake. A number of these ponds and lakes have dams at their outlets. These dams restrict alewife access to the lakes and ponds above. The exclusion of alewife access from Branch Lake, Green Lake, Beech Hill Pond, Floods Pond, and Burnt Pond are objectives for mitigation under the Comprehensive Fisheries Management Plan.

Graham Lake, as well as the West, Middle, and East Branches of the Union River have sport-fisheries that are important to the local economy and way of life. An objective of the Management Plan is to "resolve conflicts between [anadromous] fish and resident species management." IFW believes that a restoration of 2,000,000 alewives with an annual escapement of 315,000 may adversely affect the existing smallmouth bass populations in these areas. In an attempt to increase the alewife population and escapement without disturbing the smallmouth bass population, URFCC has proposed two studies. One study will evaluate the impact of transporting 100,000 alewives on the Graham Lake smallmouth bass population. The other study will determine the annual escapement rates needed at the Ellsworth Dam to attain a return of 2,000,000 harvestable alewives. The result of these studies, due for evaluation by the URFCC in 2005, will likely influence the objectives outlined in the Management Plan.

To protect the integrity of the resident species there, in light of the possibility that conflict could arise between these species and alewives, the exclusion of alewives from Branch Lake, Green Lake, Beech Hill Pond, Floods Pond, and Burnt Pond are objectives of the Comprehensive Fisheries Management Plan.

Figure 8. Entry Point for Downstream Bypass on the Ellsworth Dam:

Figure 9. Downstream Fish Bypass on the Ellsworth Dam:

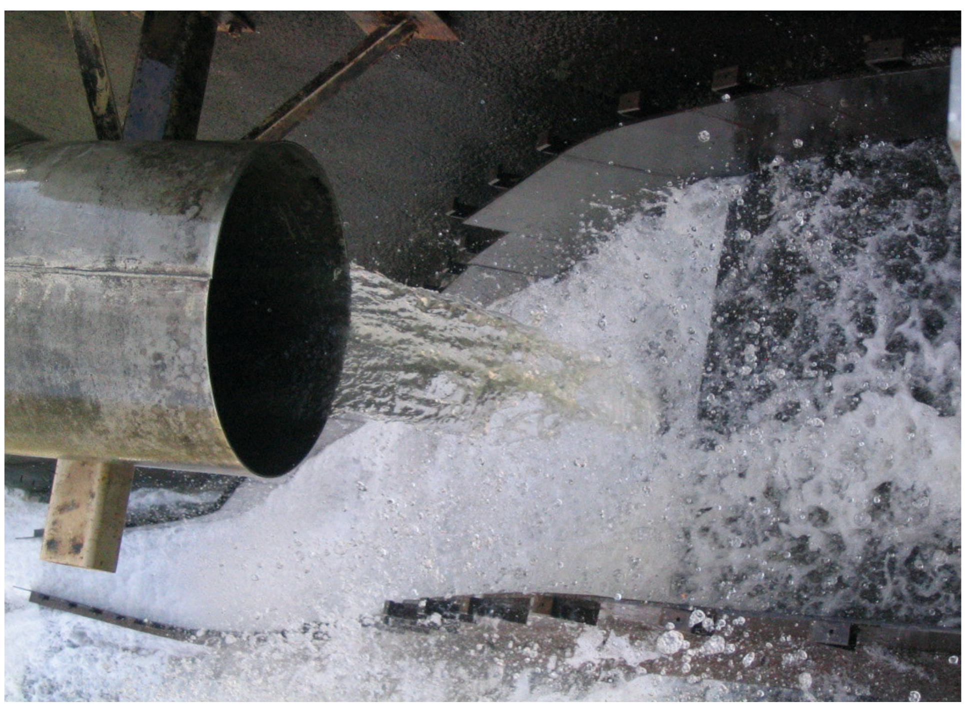

Photo credit: Thupten Norbu

6.3 URFCC Annual Reports and Restoration Activities

Pursuant to the July, 2000, Comprehensive Plan, the URFCC has filed 3 annual reports with FERC and FWS that summarize each year's management activities and outline future strategies. Each annual review was also submitted to the Federal Regulatory Energy Commission (FERC) in connection with Article 406 of PPLM's license that "requires submittal of a fish passage plan for [FERC] approval" (URSG 2000).

6.3.1 2000 Fish Returns

The alewife harvest in 2000 was conducted May 13 through June 18. 362,610 river herring—consisting "predominantly of alewives with the possibility of some blueback herring" (Hall 2002)—were trapped in the 2000 migration season by the City of Ellsworth's harvesting contractor. Of these, 101,790 adult alewives were trucked to Graham Lake and 2700 to Leonard Lake. 258,120 were sold commercially.

The facility was operated for Atlantic salmon from June 19 through September 19. Eight Atlantic salmon were collected. Two of these salmon were released at Goodwin's Bridge on the West Branch, Union River. The six that remained, all deemed aquaculture escapees, were sampled by MASC or released below the fishway. Any alewives trapped following the commencement of the salmon harvest season were returned to the river below the fishway. No injuries or mortalities were recorded during trapping operations.

6.3.2 2001 Fish Returns

The 2001 alewife harvest was conducted between May 11 and June 21. 446,850 river herring were collected; 101,385 were trucked to Graham Lake and 2700 to Leonard Lake. 342,765 were sold commercially. Two Atlantic salmon were collected between May 11 and October 25, both were found to be of aquaculture origin. Several alewives were trapped during the salmon season and were returned to the river below the facilities. No mortalities or injuries were recorded during trapping operations.

6.3.3 2002 Fish Returns

The alewife harvest in 2002 ran from May 12 through June 26. 666,967 alewives were captured at the Ellsworth trapping facilities, 104,625 were transported to Graham Lake and 2700 to Leonard Lake. 559,372 were sold commercially. Eleven Atlantic salmon were collected between June 27 and October 19. Six of these were aquaculture escapees and were released downstream of the dam. Four were salmon that had been initially stocked in the Union River; these were released at Goodwin's Bridge on the West Branch and the other was released downstream due to excessive water temperature. Alewives trapped during the salmon migration season were returned to the river downstream. No mortalities or injuries were reported.

6.3.4 2003 Fish Returns

In 2003, from May 13 to June 18, 326,497 river herring were trapped. 104,220 were trucked to Graham Lake and 2700 to Leonard Lake. 219,577 were sold commercially. One Atlantic salmon was trapped in July. It was released downstream because of excessive water temperature. Several alewives were released downstream following the onset of the salmon migration. No mortalities or injuries were reported.

6.4 Next Steps

In order to increase the Union River Watershed alewife return to satisfy the Comprehensive Plan, PPLM would need to construct an alternative upstream fish passage. As outlined in the Bangor Hydro v. FERC case (316 U.S. App. D.C. 298; 78 F.3d 661. 1996), the fishways that PPLM would be required to build would cost $2 million (in 1996) and would result in $30,000 of lost power benefits annually. Scott Hall, Manager of Environmental Services for PPLM indicated that PPLM has no intention of modifying their means of fish passage any time in the near future. They are primarily concerned with counting returning numbers and plan to employ the "trap and truck" method indefinitely.

DMR is the state agency advocating for the restoration of historical alewife runs. DMR is a strong proponent for increasing the alewife escapement population to 315,000 because of their importance as bait to local saltwater fisherman. Much of the DMR's data is from historical data from other river systems and the 1993 Kennebec River Resource Management Plan that was created by the State Planning Office (SPO).

Traditionally 15% of the returning alewife run would be allowed migrate upstream to spawn. Based on the figures compiled by the SPO in 1993, it is DMR's contention that an annual return of 235 alewives per acre is adequate to sustain a healthy alewife community. Of these, 200 per acre would be harvested as bait, and 35 per acre, or 15%, would be allowed to migrate upstream to spawn.

Since the Comprehensive Plan was published, IFW has rescinded their support of the Plan's projected numbers. Based on the Lake George Study (Kircheis et al. 2002) IFW feels that a more appropriate surface acreage of alewives is be six, not 35 as the Comprehensive Plan requires. Burr told us that at the current levels, 100,000 alewives in Graham Lake is 12 alewives/acre. Burr also said that 315,000 alewives would mean 42 alewives/acre in Graham Lake. However, our calculations show that if the area of Graham Lake is 9,300 acres, even if all 315,000 alewives were stocked into Graham Lake the density would still only be 33.8 alewives per acre.

Burr of the IFW stressed that the IFW was most assuredly in favor of alewife restoration. However, IFW does have concerns about alewives becoming established beyond their historical range. Burr stated that most places that traditionally had alewife runs have them now as well. IFW's concern over encouraging an increase in alewives stems from the possible competition for resources between alewives and sportfish such as smallmouth bass.

One of the biggest problems in assessing the affect alewives have on smallmouth bass populations in the Union River Watershed stems from the low population density of juvenile smallmouth bass in Graham Lake. Smallmouth bass prefer rocky habitat; due to Graham Lake's woody and silty substrate, the young are dispersed throughout the lake. Electrofishing and rod and reel catches are only effective in determining population size in the larger/older fish. Since it impossible to accurately assess smallmouth bass populations in the main area where alewives are being restored, IFW is hesitant to endorse any increase in restoration efforts.

Currently, the URFCC plans to meet in 2005 to write the results of the assessment of the activities for the past five years. They will be revising and updating the plan, making additional evaluations and reporting results. They will also reach agreement on next steps concerning the Union River Watershed fishery management. FWS will be advocating for an increase in the numbers of alewives that are currently transported upstream. These measures will not necessarily require the construction of new fish passage. It has not been determined how the URFCC will remedy the problem of increasing alewife populations without modifying fish passage.

The FERC license that was issued for operation of the Ellsworth Dam in 1987 expires in 2018. Though FWS would like to discontinue the utilization of trap and truck as the sole means of fish passage, it is unlikely this will occur until PPLM applies for re-licensing. Before the Union River's alewife population is restored to its former dimensions, URFCC studies must try to determine the various potential effects of reintroduction.

7. ALEWIFE RESTORATION: ECOLOGICAL AND HUMAN IMPACTS

7.1 Ecological Impacts

7.1.1 General Trophic Interactions

Alewives are an important food source for a variety of organisms in both marine and freshwater habitats. Oceanic predators include cod, haddock, bluefish, weakfish, tuna, halibut, American eel, striped bass (schools of which may follow alewife runs for several miles upriver), and various marine mammals (Schalit et al. 2003). The high fat content of spawn-laden adults migrating upstream makes them highly desirable prey (Kircheis et al. 2002). In streams, estuaries, and inland ponds, large and small-mouth bass, pickerel, pike, white and yellow perch, turtles, crayfish, and salmonids feed on alewives (Schalit et al. 2003). Gulls, terns, cormorants, herons, bald eagles, and osprey exploit alewife resources across fresh and salt water, and terrestrial predators such as mink, fox, raccoons, skunks, weasels and fishers also include alewives in their diets (Schalit et al. 2003). At the spawning grounds, the billions of eggs and sperm released provide protein-rich forage for zooplankton, bryozoans, clams, and other filter feeders. About 25% of adult alewives die during downstream migration and their decaying bodies introduce nutrients to the stream system as well as providing forage for scavengers and detritivores (Durbin et al. 1979). Anadromous alewives consequently represent a significant influx of marine-derived nutrients into freshwater systems.

Alewives are largely planktivorous and feed on copepods, amphipods, mysid shrimp, small crustaceans, and insect larvae of the orders Diptera, Coleoptera, and Ephemeroptera. Adults occasionally consume other small fish, fish larvae, and eggs, and can even be cannibalistic, eating juvenile alewives (Moring and Mink 2002). Migrating adults, however, do not feed on their upstream migration. They resume eating upon reaching brackish water on their return to the ocean. Young alewives are strictly planktivorous and their feeding habits may decrease populations of large herbivorous zooplankton and allow the preponderance of smaller, “less efficient” grazers (Kircheis et al. 2002). This can in turn lead to greater abundance of what Kircheis et al. (2002) describe as “obnoxious forms” of blue-green algae, which reduce water clarity and deplete hypolimnetic oxygen. The renewed presence of alewives in streams and ponds can result in a restructuring of the plankton community (Kircheis et al. 2002). An interagency study in Lake George, Maine, on the reintroduction of alewives revealed a marked decrease in the abundance of Cladocera (evidently the alewives’ principle food item in that location) and a simultaneous increase in Rotatoria, smaller herbivorous zooplankton (Kircheis et al. 2002).

The alewife is the only known vertebrate host for the larvae of the freshwater mussel *Anodonta implicata*, or alewife floater (Nedeau 2003). These mussels spend their larval stage attached to the gills of alewives. *Anodonta implicata* was extirpated from many coastal watersheds in New England in the last four centuries, coinciding with the construction of dams in these rivers and the consequent exclusion of alewives (Nedeau 2003). Thus, the presence of alewives and their ecological impacts is directly connected to this species of freshwater mussel and its ecological role as a filter feeder, food source, and biological "storage unit" of nutrients and minerals including carbon, nitrogen, potassium and calcium.

7.1.2 Interactions with other Fishes

Frequently aired concerns of anglers that reintroduction of alewives will adversely affect the current populations of commercially and recreationally important fish fall into four major categories:

- predation
- competition
- water quality
- feeding ecology

These can have the following effects:

- depleting native/current fish stocks
- suppressing the recovery of depleted native fish stocks
- providing food for invasive species through surplus biomass and nutrient inputs
- changing community structure

Most studies on the impact of alewife reintroduction focus on lakes or ponds and observed patterns should be transferred to river systems with caution.

Competition between alewives and other forage fishes is of concern to fishermen. It has been well documented that alewives cause zooplankton communities to shift from large to small species (Kircheis et al. 2002, Brooks and Dodson 1965). This creates the potential for another species of the Union River to be incompatible with alewives should they depend on planktonic community structure.

In a study done in Smith Mountain Lake, Virginia, the compatibility of alewives and gizzard shad, *Dorosoma cepedianum*, was assessed (Tisa and Ney 1991). These two species appear to spawn at different times and grow at different rates, thereby temporally separating themselves to avoid competition. Additionally, a spatial separation of larvae is observed, with gizzard shad occupying the uplake, littoral areas and alewives occupying the downlake, pelagic zones. On the other hand, yellow perch, *Perca flavescens*, and alewives of Lake Ontario, do not reveal any signs of compatibility. The inverse relationship between yellow perch year-class strength and abundance of alewives was confirmed by experimental data presented by Mason and Brandt (1996). Unfortunately, few studies—if any—exist on the competition of anadromous alewives with other forage fishes in river systems.

In general, alewives prove to be good prey for valuable fishes (i.e. fishes desired by fishermen). White perch, *Morone americana*, at sizes between 200-250 mm in length living sympatric with alewives were observed feeding on young-of-the-year alewives in two Maine lakes (Moring and Mink 2002). White perch of the same length from a lake without alewives, conversely, were not seen feeding on another species of fish, but on Cladocera. Lack of abundant forage species such as alewives may force predatory fishes to feed on macroinvertebrates, thus delaying their growth and reducing their reproductive potential.

Porath et al. (2003) surveyed the abundance of walleye, *Stizostedion vitreum*, and white bass, *Morone chrysops*, before and after the introduction of alewives into a Nebraskan lake. The abundance of walleye did not change significantly after the restoration of alewives, yet the abundance of white bass declined. It is believed that the decline in white bass densities is correlated with direct competition or larval predation of white bass by alewives. Walleyes also exhibited an increase in body condition following the introduction of alewives.

The Lake George study previously mentioned (Kircheis et al. 2002) also examined the effects of restoration on other fish species present in the lake. The average size and weight of brown trout, smallmouth bass, chain pickerel, white perch, brown bullhead, burbot, pumpkinseed sunfish, redbreast sunfish, and yellow perch did not change before, during, or after alewife stocking. Rainbow smelt population sizes were lowest while alewives were stocked, with young-of-the-year (YOY) at lower percentages than usual. The study did not establish the cause, which could include high trawl catches, commercial harvest for two years, or competition with juvenile alewives. Smelt YOY grew faster during the years that alewives were stocked, and stomach samples indicated a shift in diet in the presence of alewives.

7.1.3 Alewives at Sea

Alewives spend a considerable portion of their lives at sea, where they also play an important ecological role. Just as in freshwater, alewives provide food for a number of marine fishes. In fact, it was suggested declines in forage species such as alewives played a significant role in the collapse of the Atlantic cod, *Gadus morhua* (Ames 2004). Coastal Atlantic cod used to co-migrate with alewives and blueback herring, *Alosa aestivalis*, thereby obtaining an abundant source of food (Ames 2004). Hence, Atlantic cod populations would benefit from healthy alewife populations.

7.1.4 Water quality

Restoration of alewives could have potential affects on water quality. Streams with anadromous salmonids—for instance—have enhanced primary production, which eventually translates into greater density and biomass of commercially or ecologically important fishes. However, runs are usually dense, and this higher abundance of individuals in a river is believed to decrease dissolved oxygen concentrations—a major limiting factor to biological populations.

Browder and Garman (1994) showed that during the spring alewife run concentrations of ammonium increased considerably in a Virginia stream. On a stream without alewives ammonium concentrations remained constant during the two-year period studied. Regardless, even the highest total ammonium values recorded were below toxicity levels for freshwater fishes and macroinvertebrates.

Alewives also supply streams with important nutrients by means of fish mortality. Of these, the most important ecologically are phosphorous (P), nitrogen (N), and carbon (C). Leaf detritus is often the most important source of energy in stream communities, and P and N are fundamental in stimulating microbial activity (Durbin et al. 1979). A healthy alewife run could increase the overall food production of a system via increased nutrient inputs.

Dissolved oxygen concentration, another important parameter of stream health, was measured before, during, and after introduction of alewives into Lake George, Maine (Kircheis et al. 2002). They found that dissolved oxygen remained stable at all instances. Moreover, a chlorophyll (a) concentration—a proxy for primary production—was significantly higher after the introduction of alewives.

7.1.5 Summary of Ecological Effects

The studies cited show that alewives impact the systems they enter, especially in terms of nutrient levels. In river systems, these effects were temporary and lasted as long as the fish were at high density during runs. In lake systems, the stocking of alewives has correlated with changes in some fish populations, notably rainbow smelt and yellow perch. However, none of these studies documented any adverse effect on sport fish that are commercially important in the Union River Watershed. In fact, it seems likely that larger predatory species would benefit from a higher abundance of alewives for forage.

7.2 **Economic Impacts**

7.2.1 Economic Value of Alewives

Throughout Maine, towns control the licensing for alewife harvests. Damariscotta has one of the largest runs in Maine, and the town has historically used the income from alewives to support local schools. Although there has been a decline in the alewife population in the Union River, Ellsworth still issues permits to fish alewives for commercial purposes, earning 40% of the license holder's revenue as a permit fee. Following table shows annual licensee earning and revenue to the Town of Ellsworth from the alewife harvest (Ellsworth City Hall):

Year	Total Revenue	Licensee Revenue (60%)	Town Revenue (40%)
1997	$11494.00	$6896.40	$4597.60
1998	NA	NA	NA
1999	$12672.00	$7603.20	$5068.80
2000	$15296.00	$9177.60	$6118.40
2001	$22,851.00	$13710.60	$9140.40
2002	$37,489.50	$22493.70	$14995.80
2003	$14818.50	$8891.10	$5927.40

Alewives have been harvested in Maine for economic purposes for many years. There is a high demand for alewives for use as lobster bate. During spring, the usual fresh bait—herring—is unavailable. Frozen herring deteriorates quickly and is less desirable, making alewives an important spring commodity in the lobstering industry. Alewives are sold to lobstermen up and down the coast. Young says that during the spring harvest, lobstermen drive to the stream to pick up the fish and there are several lobstermen waiting at any given time. Only local residents are able to acquire alewife-fishing permits, thus alewife profits are retained within the community.

While lobstermen, alewife fishermen, and riverside towns clearly benefit from healthy alewife populations, impacts to bass fisheries are uncertain. Boat dealers, fishing guides, tackle shops, fishing licensers, and tournament organizers all have a stake in small mouth bass. Although bass fishing is a seven billion dollar industry nationwide, its importance in Maine is limited in general, especially in Hancock County. According to Mark Osgood, who organizes 12 sport fishing tournaments a year and attends many more, limitations to the financial importance of the bass in Maine are the short guiding season and state laws limiting tournament sizes. The slow relative growth rate of smallmouth bass in Maine compared to smallmouth bass in Florida, the southern edge of their range, dampers the tourist draw as well.

There is an argument over whether increases in alewife populations would negatively impact the bass population. Sport fishermen like Osgood and Norm Molten, believe that more alewives mean more smallmouth bass. However, Maine Inland Fish and Wildlife contends that an increase in the alewife population could jeopardize the bass population. Stakeholders' concerns and arguments suggest that increase in the alewife population could either positively or negatively impact the bass population depending on the degree of increase in the alewife population.

The data indicates that a certain increase in the alewife population could potentially benefit both bass and alewife fishermen. Such an increase in the alewife population could increase income for alewife fishermen while also increasing the recreational bass fishery. However, without doing empirical studies it is hard to determine the appropriate balance between alewives and bass.

7.2.2 Political Controversy in Maine

Given the potential ecological impacts and the high level of economic and cultural investment in alewives, controversies over restoration have developed. There is, for example, a quiet political tension between the Department of Marine Resources (DMR), who supports the restoration of native fishes, and the Department of Inland Fisheries and Wildlife (IFW), who manage and protect freshwater sport fisheries. Ted Squires of DMR does not like the term "reintroduction" since many streams already support small alewife runs. He affirms that alewives are important for Maine river ecosystems. They are near "the bottom of the food chain," he says, "and otters, raccoons, osprey, eagles, and striped bass all feed on alewives, especially juveniles." He notes that striped bass represent an important sports fishery that benefits from healthy alewife runs.

According to Rick Jordan, IFW is willing to see alewives to make come-back, but the department does not want them to be stocked in high densities or beyond their historic range. "Everyone wants a balance," says Greg Burr, also of IFW. Jordan sites an example from Spednic Lake on the Canadian border where increases in the alewife population may have decimated the young smallmouth bass population. In 1981, The Canadian government rebuilt a poorly constructed fish ladder, which had allowed approximately 150,000 fish upriver. Within a few years, some two and a half million fish were moving past the dam and there were hardly any young bass in the river. There may, Jordan says, be an issue with alewives out-competing juvenile bass for food resources in Maine rivers if alewives are reintroduced in high numbers. Denis Smith contends that the Spednic Power Company drawing the water level down fifteen feet killed the young bass in Spednic Lake, eliminating bass habitat. Many sport fishermen we talked to disagreed with the IFW analysis as well.

According to Mark Osgood, alewife reintroduction will benefit existing sport fisheries, including the controversial small-mouth bass. Both he and Smith site the case of Alamoosic Lake where a natural alewife run coexists with record setting pike and smallmouth bass populations. Norm Molton agrees with Osgood, musing that more alewives equal a bigger sport fishery. Although alewives may have an impact on young small-mouth bass, adults of this species eat adult alewives. The more alewives in Graham Lake, the better, Molton says. He would like to see a fish ladder built on the Union to move the alewives upriver, rather than the current trap and truck method.

One fisherman suggested that IFW is relying on faulty information regarding the relationship between alewives and smallmouth bass. Apparently on one lake with an alewife run, the IFW suggested there was a negligible population of bass, but this fisherman caught some of his biggest smallmouth bass ever in this lake. This conflict of opinion is played out in an effort on the part of Denis Smith to restore an alewife run on Mount Desert Island, Maine, and IFW's denial of necessary permits, apparently out of concern for the bass in Long Pond

8. CONCLUSION

In this document, we have sought to present an unbiased report on all factors pertaining to the potential restoration of alewife runs in the Union River Watershed. This paper was written with the intent to inform policy, not to argue in favor of one side. Decisions regarding management of the Union River must be made collectively among stakeholders. Based on the information we have gathered, we recommend several studies and agency actions that may aid stakeholders in making responsible, informed decisions.

There are three potential scenarios for alewife management on the Union River. The number of fish stocked above the Ellsworth and Graham Lake Dams could decrease, increase, or stay the same. If the number of fish stocked were to decrease, densities could drop to as low as 6 alewives per acre in Graham Lake, which would require no modification of fish passage at the Ellsworth and Graham Lake Dams. If the number of fish stocked were to stay the same, the density of alewives would remain at 12 per acre in Graham Lake, which would also require no modification of fish passage at the dams. If the number of fish stocked were to increase, densities could rise as high as 35 alewives per acre in Graham Lake, which would require improved fish passage at the dams.

The Comprehensive Fisheries Management Plan for the Union River outlines the scenario of increasing the number of alewives stocked to 315,000 fish per year. The plan is unclear where these 315,000 fish would be stocked, but it is our understanding that they will be stocked in Leonard and Graham Lakes. There is the possibility that some fish may migrate beyond Graham Lake up Webb Brook to Webb Pond (provided there are no obstructions blocking access to Webb Pond from Graham Lake), as well as up the West Branch of the Union River. The plan prescribes management for alewives within Reaches I-IV of the river. Within this range, the plan is clear where it does not want alewives: Branch, Green, Beech Hill, Floods, and Burnt ponds, but does not state any clear management strategy for ponds other than those explicitly excluded and those currently inhabited by alewives.

If the stakeholders decide to stock some of the 315,000 alewives into ponds other than Leonard and Graham Lakes, the density of alewives will be less than if the fish were stocked entirely into Leonard and Graham Lakes. This would necessitate that the Comprehensive Plan outline methods for moving the fish into and out of these currently obstructed ponds.

Regardless of how and where the fish are stocked, all 315,000 fish will need to be transported above Ellsworth and Graham Lake dam. In the case of BangorHydro v. FERC (316 U.S.App. D.C. 298; 78 F.3d 659. 1996), all parties agreed that current trap and truck methods would be insufficient to accommodate runs of 315,000 alewives, and that improved fish passage will have to be constructed at the Ellsworth and Graham Lake Dams. This improved fish passage would most likely be in the form of a fish ladder, since other mechanisms for passage are either too expensive (fish lifts) or not applicable (dam removal). The legal process through which FERC can require PPLM to install a fish ladder is discussed in detail in Appendix A.

The possible effects alewife restoration could have on smallmouth bass populations within the watershed is a heavily contended issue among stakeholders. Although the small-mouth bass fishery creates limited revenue in Maine, particularly in Hancock County, this fishery still has both recreational and commercial importance. IFW recognizes the importance of small-mouth bass; from the studies they cite on the affects of alewives on small-mouth bass populations, they have reason to be concerned about the small-mouth bass population in the face of increasing alewife runs.

To begin with, there is concern that large alewife runs affect water quality. Ammonium levels may increase during the runs, but not to toxic levels; thus ammonia levels are not a particularly important effect. Oxygen levels have proved to remain steady. Alewives, on the other hand do add nutrients to increase the overall plant productivity of a stream or river by contributing decaying biomass.

Juvenile alewives remain in the spawning ground throughout the spring and summer foraging on large zooplankton and macroinvertebrates, allowing smaller zooplankton species populations to grow. Alewives are thought to compete with juvenile small-mouth bass during this period. There is only one study in Nebraskan Lake performed by Porath et al. that has supported this hypothesis, but the study was on white bass rather than small-mouth bass. Rick Jordan, an IFW biologist, stated that the juvenile small-mouth bass population was decimated in Spednic Lake due to an increase in the alewife population from 150,000 individuals to 2.5 million, but Denis Smith, a local fisherman, argued that the juvenile small-mouth bass population fell due to loss of habitat from a fifteen-foot drop in water level that year.

Adult alewives occasionally consume other small fish (e.g. juvenile small-mouth bass), which has also caused concern about impacts on the small-mouth bass fishery, but studies have shown that migrating adults cease feeding on their way upstream and resume upon reaching brackish water on their return to the ocean. The hypothesis that alewives do not have an effect on small-mouth bass populations is supported by the Lake George study, which found that the average size and weight of small mouth bass did not change before, during, or after the introduction of alewives. Also, Alamoosic Lake has record-setting small-mouth bass and pike with a natural alewife run. None of the studies to date have brought about conclusive evidence of the effects of alewives on small-mouth bass populations. Most of the studies have been performed on landlocked populations of alewives, rather than populations that spend most of their life-cycle in the sea like the Union River Alewives. It is obvious that more research needs to be conducted before we can attempt to predict probable interactions. Based on the information presented in this paper, one might come to the conclusion that the effects of alewives on the small-mouth bass population are temporary and last only as long as the alewives are in the run in high densities.

Even if alewives affect small-mouth bass populations in a negative way, large alewife runs also have multiple benefits. Many sport and commercial fisheries benefit from large alewife runs because alewives are good prey source for cod, haddock, bluefish, tuna, striped bass, yellow perch and several others. Adult alewives are also a prey source for adult small-mouth bass, which could increase small-mouth bass populations and growth rates. Alewives are also a prey source for birds (osprey, gulls, terns, bald eagles), and mammals (mink, raccoons). Alewife eggs and sperm are forage for zooplankton, a fact which could positively impact juvenile small-mouth bass populations indirectly by increasing zooplankton populations. Large alewife runs would also benefit the lobster industry since there is a high demand for alewives as lobster bait during the spring run when fresh herring is unavailable.

An objective of the management plan is to "resolve conflicts between diadromous fish and resident species management." The plan calls for a restoration of 2,000,000 alewives, and an escapement of 315,000. If 2,000,000 alewives migrated each year, then about 235 alewives per acre on Graham Lake would be harvested and 35 per acre would be left to spawn. With alewife densities this high, IFW is very concerned about the small-mouth bass population, they believe 6 per acre is more appropriate, based on Lake George studies, in order to prevent a decrease in the small mouth bass population. It has been proposed that if the population of alewives increased in Graham Lake, there would be more migration up the Graham Lake tributaries, such as Webb Brook, in effect decreasing the amount of alewives per acre. If this is the case, then studies should be performed to see where the alewives are going when they are trucked to Graham Lake.

The Comprehensive Management plan also stated several studies that should be done to examine the effects of alewives on small mouth bass populations. IFW will "analyze stomach contents of post-spawning adults to help evaluate [the] extent of predation on zooplankton and juvenile small mouth bass." URFCC will also conduct a study to evaluate the impact of transporting 100,000 alewives on the small-mouth bass population and a study to determine the annual escapement rates needed to achieve the goal of 2,000,000 harvestable alewives. These studies are to be evaluated by 2005, but it is unclear whether they will be completed or not. All three of these studies will provide much of the data needed to better understand the possible effects of increased alewife populations on small-mouth bass, and it is therefore essential that they get underway.

There are both benefits and costs to increasing the number of alewives present in the Union River Watershed. The possible negative effects on the small-mouth bass fishery are unclear and need to be studied more thoroughly, as there is reason to believe alewives both harm and help small-mouth bass populations. The benefits include supporting many other sport and commercial fisheries and wildlife that prey upon alewives. A policy decision needs to be made based on all the evidence presented and its impacts on culture, economics, and the environment.That being the case, we recommend more thorough monitoring of current conditions and clear plans for management and monitoring in the future if alewife stocking is to increase.

The following are questions or valuable pieces of information that should be attained to better inform stakeholders and minimize unanticipated negative impacts:

- Locations of present spawning sites—specifically any along Webb Brook or the West Branch
- Numbers of alewives (adults and juveniles) migrating over the Ellsworth Dam out to sea
- Locations of alewife stocking and ponds accessible to alewives from stocking locations
- All sites and methods for alewife transport
- Funding and staff sources to monitor reintroduction and impacts over an extended period
- River-specific studies examining the effects of increased alewife runs on smallmouth bass in the Union River
- Public opinion on the issue of alewife runs

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9. APPENDIX

The Comprehensive Plan calls for 315,000 alewives to be transported upstream of the Ellsworth Dam and for a portion of those to be moved upstream of the Graham Lake Dam. In the case of BangorHydro v. FERC (316 U.S.App. D.C. 298; 78 F.3d 659. 1996), all parties agreed that current trap and truck methods would be insufficient to accommodate runs of 315,000 alewives and that improved fish passage will have to be constructed at the Ellsworth and Graham Lake Dams. This improved fish passage would most likely be in the form of a fish ladder, since other mechanisms for passage are either too expensive (fish lifts) or not applicable (dam removal).

The only way that PPLM could be required to modify the Ellsworth and Graham Lake Dams would be through a stipulation on their FERC license. The last time this license came up for renewal (1987), FERC initially ordered BangorHydro to construct improved fish passage. However the Court of Appeals later ruled that BangorHydro did not need to modify their fish passage, as insufficient evidence was produced to show that modification of the dam would be necessary for healthy alewife runs.

The FERC license for the Ellsworth dam will expire on December 31, 2018, before which time PPLM must apply for a renewal. In determining whether to issue a renewal and what restrictions to place on that renewal, FERC will be following the guidelines set forth in the Federal Power Act of 1920, the National Environmental Policy Act of 1970, and the Electric Consumers Protection Act of 1986 whereby FERC is required to give full and equal consideration to such purposes as energy conservation, fish and wildlife protection and enhancement, recreational opportunities, and general environmental quality, in addition to FERC's historic considerations of safety, economic feasibility, power needs and production capacity, and economic development. In issuing any subsequent licenses, FERC will have to ensure that the project does not conflict with any existing comprehensive plans for the river, such as the Comprehensive Fisheries Management Plan.

PPLM could be required to improve fish passage on the dam if it can be shown that the absence of such passage would conflict with the Comprehensive Fisheries Management Plan for the Union River, that without such passage FERC will not be adequately and equitably protecting fish and wildlife and that such passage does not conflict with the purposes of the Federal Power Act, or that improved fish passage is in the public interest based on equal consideration of all relevant factors.

There is the possibility that PPLM will have to apply for an amendment of their FERC license prior to the 2018 renewal date. As a concession for the removal of the Veazie dam in as early as 2008, FERC has approved the installation of an additional turbine at Graham Lake Dam. Adding this turbine would require PPLM to apply for an amendment to their license, wherein FERC will have to consider fish passage provisions at the Graham Lake Dam. If it can be shown that the project at Graham Lake will impact fish throughout the watershed due to cumulative effects and the connectivity of the system, this amendment process could include a re-evaluation of fish passage mechanisms at the Ellsworth Dam as well. If State and Federal Fish and Wildlife agencies then make the case that a fish ladder is necessary to accommodate healthy alewife runs as prescribed in the Comprehensive Plan, FERC could require improved fish passage at either or both dams as a stipulation on the amended license.