Board Discussion Paper on Alewife in the St. Croix River

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International Joint Commission
International St. Croix River Board

Introduction

The International St. Croix River Board (ISCRB) oversees compliance with the International Joint Commission's (IJC) Orders of Approval for flows and levels at structures in the St. Croix River and monitors transboundary issues relating to the ecological health of the St. Croix River. The Board is made up of 10 members, 5 from the U.S. Section and 5 from the Canadian section. Board members' expertise covers a wide variety of skills from water resources policy, planning, and engineering to ecological and metrological disciplines. Originally, two separate Boards were established by IJC to perform this oversight. The Boards were the "International St. Croix River Board of Control" and the "Advisory Board on Pollution Control". In September 2000, these two Boards were combined as a first step in implementing the IJC Watershed Approach. At the IJC's request, the new combined Board broadened its perspective, and formulated a work plan proposing IJC funded collaborative projects that address both the boundary water and the contributing watershed issues. One item in the Board's work plan is to assist watershed stakeholders and fisheries managers by supporting development of unbiased and scientifically sound information relative to the disputed alewife access issue.

Alewife, *Alosa pseudoharengus*, access to spawning habitat in the international waterway became a transboundary issue in May 1995 when a bill was passed by the Maine State Legislature to prevent alewife migration. The Woodland and Grand Falls fishways have been operated since 1995 to prevent alewife passage upstream on the St Croix River. (http://janus.state.me.us/legis/statutes/12/title12sec6134.html).

The International St. Croix River Board (referred to as the Board hereafter) in response to the need for scientific information commissioned a review by a local subject matter expert to "examine existing literature, unpublished reports, and available data on the life history of alewives in rivers in eastern Canada and northeastern U.S. and their interaction with other fish species such as bass, salmon, lake trout and landlocked alewives as well as other marine and aquatic biota including birds and mammals." The hope was that an unbiased analysis of available scientific information on the ecological roles of anadromous alewife populations would provide information to help resolve fisheries management controversies on the St. Croix River. The Board used the commissioned literature review as a partial basis of this report.

The St Croix River once supported large runs of anadromous species that ascended the unobstructed river system nearly to its headwaters (Havey 1963). Atkins (1887) reported: “The St Croix River is remarkable, even among the rivers of Maine, for the great extent of the lake surface among its tributaries. These lakes afforded breeding ground for great numbers of alewives, and, in the main river and its branches, here the salmon and there the shad found their favorite haunts. The exact limit of the upward migration of all these fishes is very naturally unknown with any degree of exactness, the entire upper portions of the basin being wilderness till long after the occupation of the lower banks and the erection of artificial obstructions; but the fact of their existence in great numbers in the river shows that they must have passed the only serious obstacle to their ascent, the natural fall at Salmon Falls near the head of tide and found their breeding grounds in the upper waters. From the first settlement of the country till 1825 there was annually a great abundance of salmon, shad, and alewives. Vessels from Rhode Island, from 100 to 150 tons burthen, followed the fishing business on the river and were never known to leave without full cargoes. There were also several seines belonging to the inhabitants, which were worked in the tideway of the river, the owners of which put up annually 1,500 to 2,000 barrels of alewives for exportation. At the same time shad were caught in great numbers, often more than a hundred of them being caught in a small net in a single night.”

The creation of dams throughout the system resulted in the loss of anadromous species and had significant effects on the ecosystem. These likely included changes in predator behavior and population dynamics, changes in marine derived nutrient delivery to freshwater systems, and changes in freshwater mussel populations. With the installation of fishways on the St. Croix in the 1970’s and 1980’s, anadromous populations began rebuilding. However, because alewife were the most abundant anadromous species, the subsequent blockage of alewife passage in 1995 precipitated a decline in anadromous fish abundance in the system (Figure 2). The following sections of this report discuss the ecological effects of the declining alewife population in the St. Croix. The Board, in taking a broader perspective, wishes to provide balance to the issue by presenting the following information on ecological effects of declining alewife populations.

Alewife Ecological Roles

Both juveniles and adults of anadromous species are prey for fishes, birds, and mammals. Eagle and osprey information are provided as an examples of how reduced alewife populations has affected predator populations in the St Croix. Nesting eagles heavily use alewife runs during the peak period of high food demand and nestling eaglet development. At the time alewives run, regular provisioning of readily accessible foods can boost brood size and overall productivity. On the St Croix, alewives have become less abundant among food debris collected during nest visits conducted during 2003-2004 compared to their incidence during nests visited from 1976-1987 (C. Todd, 2005 IF&W personal communication). The predominant impact on bald eagles seems to be the loss of foraging aggregations of birds using the elevated food abundance provided by alewife runs in late-spring. Specifically, groups of 20 - 40 eagles seen daily along the Saint Croix below Grand Falls Dam during the 1980s and early 1990s no longer occur: certainly reflecting diminished food availability, notably alewives (C. Todd, 2005 IF&W personal communication). The loss of foraging aggregations infers diminished survivorship and is against the trend reported in all other major bald eagle populations. Although nesting pairs have been stable since 1995, these non-breeding eagles (immatures and subadults <5 years old) are the future breeders in a population largely regulated by survival rates (C. Todd, 2005 IF&W personal communication). Ospreys initiate breeding in May and their numbers and productivity may better correlate to alewives, because they are almost strict piscivores. Former aggregations of nesting ospreys in the St. Croix estuary are no longer evident and overall numbers seem to have either declined or the birds have dispersed (C. Todd, 2005 IF&W personal communication). Because alewives are prey for a variety of pisciviorous predators, their decline puts more predation pressure on those species left in the system. There may be additional data on trends in pisciviorous predator population and on other fish prey species in the drainage; however, the data reported are adequate to demonstrate an ecological effect related to blocking the alewife spawning migration on the river.

Anadromous species effectively transfer nutrients from the marine system to typically less productive freshwater environments (Durbin et al. 1979, Garman and Macko 1998, MacAvoy et al. 2000). Mechanisms of direct deposition for alewives included discharge of urea, gametes, and deposition of post-spawn adult carcasses (Durbin et al. 1979). Further assimilation, transport, and, ultimately, supplemental/secondary deposition of these nutrients also likely resulted from the activities of predators and scavengers present along the migration routes. White tail deer have even been reported to forage on alewife carcasses (Case and McCullough 1987). Conversely, juvenile outmigrants of these sea-run species represented a massive annual outflux of forage resources for Gulf of Maine predators, while also serving to complete the cycling of imported base nutrients back to the ocean environment.   The dynamics and ecological significance of this nutrient cycling function by anadromous fish species assemblages has been well established for North American Pacific coast ecosystems (e.g., Bilby et al. 1996, Gresh et al. 2000, Beechie et al. 2003, Stockner 2003). The biological significance of marine derived nutrients in North American Atlantic Coast Rivers is less studied (Garman and Macko 1998, MacAvoy et al. 2000, Nislow et al. 2004). In part because these types of diffuse mutualism are only recently being recognized (Hay et al. 2004).

Dams that block the migration of fish species can have a direct influence on the distribution of freshwater mussel species relying on those fish as hosts, particularly when anadromous species are eliminated from upstream stretches of a river. Mussels, through filter feeding, take energy from the water and transfer it to the benthic environment by excreting material that is food for benthic invertebrates. Their movement helps to stir the sediments making conditions more favorable for benthic invertebrate communities. Mussels, often the greatest component of a lake’s aquatic biota biomass, are important in the storage & cycling of key nutrients such as carbon, calcium, potassium, phosphorus, and nitrogen. Anadromous populations of alewives are secondary hosts for the freshwater mussel with the common name alewife floater (Davenport and Warmuth 1965, Nadeau et al. 2000). In Maine, the alewife floater is fairly widespread and common in coastal regions, but seems more prevalent Downeast where rivers have been less affected by dams and water quality issues. Historically, its distribution was probably as far inland as its anadromous fish hosts could travel before dam construction however, it is now absent from southern coastal areas, probably because of the loss of alewife runs. Facilities that pass alewives facilitate population expansion (Smith 1985). In the St Croix, it has been found as far upriver as Vanceboro. However, as this is a long-lived species it would take more years for it to disappear from the upper drainage.

Fisheries Management

The St. Croix River has a moderately diverse fish community, including resident freshwater (native and non-native), anadromous, and catadromous species. A few additional freshwater fish species are found only in the lakes within the drainage in Maine and New Brunswick (Figure 1). The principal freshwater fisheries in the St. Croix basin are for native salmonids (lake trout, landlocked salmon, brook trout) and non-native species (smallmouth bass, white perch). Historically there was a fishery for alewife in the St Croix, however current low runs preclude an allowable harvest.

Smallmouth bass were likely introduced into the drainage sometime prior to 1900. The consequences of this introduction on native fish species can only be inferred from recent introductions and contemporary species assemblages (Whittier and Kincaid 1999). However, it is likely that the introduction either directly or indirectly reduced diversity of small-bodied fish species, created more homogeneous fish communities, increased competition among small-bodied fish, reduced energy flow to native game fishes, altered planktonic and benthic communities, and potentially changed habitat complexity (Jackson 2002, MacRae and Jackson 2001). Further the trophic status of native salmonids likely changed. Vander Zanden et al. (2004) found that in Ontario the trophic niche of lake trout when pelagic prey fishes (i.e. smelt, alewives) were absent was related to bass presence. Lake trout feed primarily on zooplankton in the presence of bass, and minnows in the absence of bass. This shift was caused by smallmouth bass significantly influencing the occurrence and abundance of small-bodied fishes (mainly minnows). Lake trout were buffered from impacts of bass on minnows in lakes containing pelagic prey fishes. Like most bass introductions, the ecological consequences of introduction were overshadowed by the popularity and economic benefits of the fishery (Jackson 2002) that developed in the drainage.

In the early 1980's, Maine and New Brunswick freshwater fisheries biologists became concerned about the poor status of the smallmouth bass population in Spednic Lake (Cronin 1985, Smith 1998). A number of factors were likely involved including the presence of alewife/herring, water level manipulations, and recreational fishing. However, reports of declining smallmouth bass populations coincident with introductions of alewife to Spednic Lake fueled a fisheries management controversy. Increased abundance of young-of-the-year (YOY) smallmouth bass when anadromous alewives were denied access to the lake (Jordan 1991) supported local arguments that linked low recruitment of smallmouth bass to the presence of alewife. Changes to water level and fisheries management favoring successful bass spawning both occurred at the same time. There are only two articles dealing directly with interactions between anadromous alewife and smallmouth bass; one peer-reviewed (Hanson and Curry 2004) and one interagency report (Kircheis et al. 2002). Of these, only Hanson and Curry (2004) tried to determine the possible relationships between the two species. They provide evidence that young-of-the-year (July to September) alewives and smallmouth bass share some food sources. Neither study provided conclusive evidence of interspecific interactions that resulted in population level effects on either species. Further, there is no evidence that, with thoughtful management, alewives populations and smallmouth bass fisheries cannot co-exist.

The focus on alewife presence as a sole cause is difficult to justify given there are clear links between water level (Ploskey et al. 1996, Neves 1975), temperature (Shuter et al 1980, 1985, Finlay et al. 2001, Goff 1985, MacLean et al. 1981), wind (Goff 1985) and reproductive success, young of the year survival and year class strength. A variety of models have been successful in predicting bass year class strength using these variables and others (Shutter et al. 1980, 1985, Dong and DeAngelis 1989, Saito et al. 2001, Clark et al. 1998, Polaskey et al. 1996). Using these modeling concepts could provide insight into the factors that influenced smallmouth year class strength and the fishery in Spednic Lake.

The Board supports the fisheries steering committee alewife management plan and believes a thorough analysis of the Spednic Lake situation be considered to provide scientific data to assist fisheries managers in both counties. These are the reasons the Board supported the Maine Rivers project on the St. Croix River. Efforts should focus on thermal and hydrologic conditions during years when alewives had access to the lake and subsequent years when they were denied access. This analysis should include temporal and spatial overlap of alewife and smallmouth bass in the littoral area of spawners and juveniles for both species based on habitat preferences. Predicting habitat use by the species will likely require modeling depth (a function of water level management) and thermal conditions in Spednic Lake based on available limnological and meteorological data. The approach could also be extended to the impoundments and riverine habitat downstream of Spednic Lake.

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Landlocked salmon	White sucker
Brook trout	Brown bullhead
Lake trout	Banded killifish
Lake whitefish	Burbot
Round whitefish	Fourspine stickleback
Rainbow smelt	Brook stickleback
Northern redbelly dace	Threespine stickleback
Finescale dace	Blackspotted stickleback
Lake chub	Ninespine stickleback
Golden shiner	White perch
Common shiner	Pumpkinseed
Blacknose dace	Redbreast sunfish
Blacknose shiner	Yellow perch
Creek chub	Slimy sculpin
Fallfish	Chain pickerel
Fathead minnow	Smallmouth bass
Pearl dace	Alewife (landlocked)
Longnose sucker	Rainbow trout

Native Introduced Reported

Figure 1. Freshwater fish species in the St. Croix drainage (from Cronin et al. 2002).

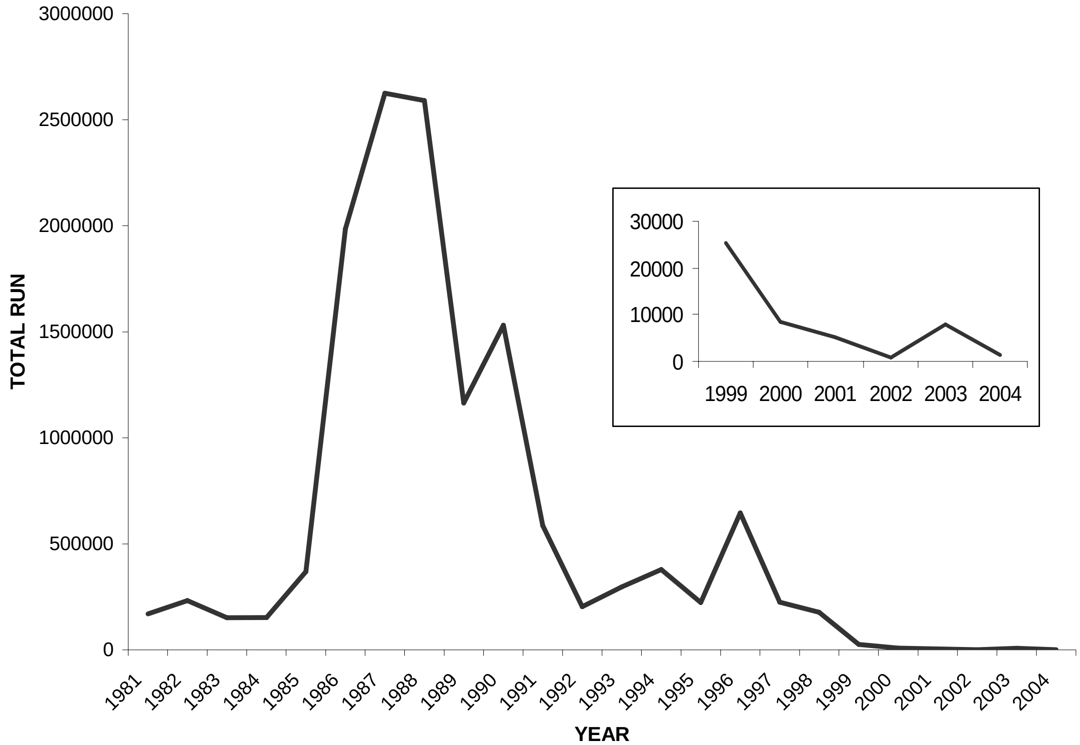

Figure 2. The total run of alewives to the St. Croix River from 1981 to 2004, with an inset of recent (1999 to 2004) low returns. (data from Maine Department of Marine Resources).