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July 23, 1996

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Dear Bob:

Thanks for sending along the reprints. I'm sure that we can use some of the material for the next Fisheries History newsletter or two.

You asked about a mailing list for Atlantic salmon restoration publications. I'm not sure that there is one, partly because so many agencies and individuals are involved, each producing their own reports. I have enclosed a recent reprint that will pretty much bring you up to date for the situation in Maine. You can contact Jerry Marancik (address on reprint) as a good source for obtaining region-wide material on salmon restoration. He is the U.S. Fish and Wildlife Services' Anadromous Fish Coordinator for Maine.

In reading your Atlantic salmon manuscript, I have to agree with your less than optimistic outlook for restoration. I believe there is still a chance for the Penobscot River (runs this year, as you pointed out, should be higher than in many years). But I believe chances for the Merrimack and Connecticut (which receive most of the publicity) are nil. Those runs exist on the edge of the species' former range and are being restored using a hybridized "Penobscot" strain that is a mixture of Downeast Maine and Canadian stocks. (Frank Roberts is trying to piece together the exact makeup from original hatchery records).

A couple of years ago, I heard a USFWS coordinator state that the Merrimack River restoration was "very successful." He based that on the continually higher numbers of fry stocked each year. That is apparently the Government's definition of success -- not the 25 adult fish that returned last year despite tens of millions of dollars and decades of effort. The Connecticut River run has never been more than a few hundred, the Merrimack generally less than 50 each year.

I have read Catherine Carlson's documents (and her thesis) and have found her arguments very interesting, although, as you noted eloquently in your article, there are some biological gaps in her conclusions. There is no question in my mind that reports of the abundance of salmon in New England by the early colonists, were overblown -- partly to attract other settlers. It was somewhat like Columbus' many claims that were intended to increase the importance of what he found (he even said there were salmon in waters off Haiti). But there is no question that salmon existed when the first colonists were here. There are just too many reports of their existence.

Catherine Carlson's recommendation to look at primary literature is off base. Such documentation does not exist and didn't until well after pollution and dams caused declines -- as you point out. Also, Boyd Kynard was on Carlson's graduate committee. He thinks she did a tremendous amount of work and analysis, but may have an incomplete record of midden sites (many were not at locations typically near salmon runs or other potential run sites, but water falls are now submerged under present day dams). I liken it to a space ship dropping a sample bottle through Earth's atmosphere. Done seven times, it might come up with salt water, and one might conclude that Earth is a planet covered with salty water, which it largely is. Increase the sample size in the right locations, and the bottle might come back with dirt and terrestrial vegetation.

You might be on the lookout for an article in Fisheries (which apparently has been delayed) by Steve Shepard (now a hydro consultant and one of my former grad students), George Jacobson (a UM geologist), David Smith (UM history), and Frank Roberts (UM zoology/genetics). They looked at climatic changes to address that question about the presence of salmon. They believe the salmon may have been absent in New England some time back, but were able to show some parallels with salmon and climate in Europe. I gather that Catherine Carlson does not support all of their conclusions. When the paper will be out, I'm not sure. I have read a draft and have listened to a seminar by George Jacobson on the subject.

Thanks again for thinking of the Fisheries History Section newsletter.

Sincerely,

John Moring
Assistant Leader for Fisheries
and Professor of Zoology

JRM/sa

American Fisheries Society Symposium 15:38–46, 1995

Changes in Stocking Strategies for Atlantic Salmon Restoration and Rehabilitation in Maine, 1871–1993

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Abstract.—The culture of Atlantic salmon *Salmo salar* in Maine began in 1871, when 72,300 eggs were obtained from captured Penobscot River fish and fertilized and cultured in the basement of an old mill at Craig's Brook. Subsequently, a hatchery was built (Craig Brook National Fish Hatchery) that continues in operation today. Culture and stocking strategies and philosophy have changed during this 120-year period. Initially, most Atlantic salmon were reared to the eyed egg or fry stage, then stocked in southern New England rivers where runs were severely depleted. In 1890, the stocking strategy changed to the release of fingerlings (parr). Most runs of Atlantic salmon in Maine were extirpated in the twentieth century. After the establishment of the Maine Atlantic Sea Run Salmon Commission, the passage of several water quality laws, and the construction of fish passage facilities, restoration efforts began with a hybrid strain of Atlantic salmon derived from Canadian and native Maine river stocks. In the 1960s and 1970s, 2-year-old smolts were stocked. Later, with the use of heated water during culture, 1-year-old smolts dominated the program. In the 1990s, more emphasis is being placed on fry stocking and the use of river-specific stocks to maintain the remaining genetic integrity of the river populations in eastern Maine, where Atlantic salmon have never been extirpated. Other techniques used, with varying degrees of success, have included upstream trucking, reducing sportfishing harvest, and stocking in tributary systems rather than main-stem river locations. In future years, restoration success will be influenced by recent restrictions of commercial fisheries on the high seas, improved fish passage, genetic considerations, and refinements in habitat protection. The restoration and rehabilitation efforts in Maine waters would not have been possible without the stocking of hatchery-reared fish. However, high numbers of fish stocked, particularly at the smolt stage, have not resulted in large runs or higher angler catches. Other factors related to habitat, dams, and ocean mortality may be critical. In all likelihood, stocking fish will be necessary into the twenty-first century. Thorough evaluations of management strategies are critical to future management decisions.

Most estimates taken from fragmented reports by the first colonists concluded that indigenous runs of Atlantic salmon *Salmo salar* were large. Captain George Weymouth, aboard the ship *Archangel*, was looking for a northwest passage to India when he first viewed the Kennebec River. When he entered the mouth of the river in 1605, he reported seeing "Plenty of salmon and other fishes of great bigness." There is some question as to the magnitude of the runs before 1600 (Carlson 1988), but Stolte (1986) estimated the size of the New England spawning stocks at the time of colonization by Europeans as 300,000, based on available habitat.

Most runs of Atlantic salmon in New England began to decline in the 1850s. By 1866, many runs of Atlantic salmon in southern New England had been extirpated, and eggs were obtained from the Penobscot River, Maine, and elsewhere to stock in southern New England waters (Moring 1986). At the turn of the century, the Penobscot River was still considered the premier Atlantic salmon river of the country, despite the increased pollution from some 250 sawmills as early as 1837 (Netboy 1968). Commercial catches in the river and bay exceeded 15,000 fish in 1872; but by the end of the nineteenth century Atlantic salmon were declining rapidly in many rivers of Maine, primarily due to dams, pollution, and commercial fishing (Baum 1983; Moring 1987). Most runs of Atlantic salmon were extirpated in Maine by the mid-twentieth century. By 1947, only 40 salmon were commercially harvested in the Penobscot River (Netboy 1968). Salmon runs were eliminated in the state, with the exception of those on several smaller rivers of Downeast Maine, the easternmost portion of the state, where rivers were largely free of dams (Figure 1).

A separate state fisheries agency, the Maine Atlantic Sea Run Salmon Commission (Salmon Commission), was established in 1947 to restore Atlantic salmon to their former range in state waters. But it

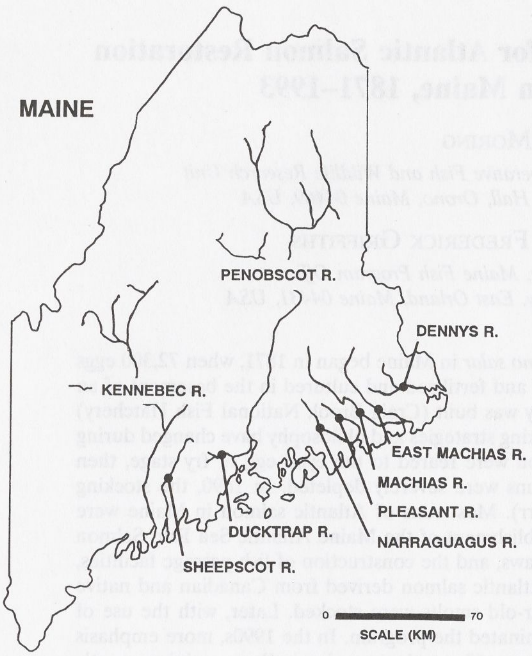

FIGURE 1.—Maine rivers with Atlantic salmon runs.

was not until the passage of the Maine Water Pollution Bill of 1965 and the Federal Water Pollution Control Act of 1972 (33 U.S.C.A. §§ 1251 to 1387) and the installation of more effective fish passage structures that the restoration began to show results. During the past 120 plus years of fish culture and stocking, management strategies for restoration and rehabilitation have shifted. However, changes were not always in response to strictly biological concerns; some had political or economic origins. Restoration is defined as the return of self-sustaining populations of fish to waters where they were extirpated, whereas rehabilitation involves the recovery of depressed populations.

Federal and state priorities differ somewhat in the management of Atlantic salmon. In the 1990s, restoration and rehabilitation of salmon is a cooperative function of the state of Maine, the federal government, and the Penobscot Indian Nation. Fish culture is the responsibility of the U.S. Fish and Wildlife Service, whereas management of Atlantic salmon is the responsibility of the Salmon Commission; these two agencies and the Penobscot Indian Nation work together on technical issues. In recent years, because of severe budgetary restrictions at the state level, federal agencies are temporarily playing a larger role in funding and monitoring. The federal government is primarily concerned with restoration of extirpated runs and not introductions to new waters (U.S. Fish and Wildlife Service 1989). The state of Maine's highest priority is to maintain and enhance the Atlantic salmon populations and sport fisheries in rivers in eastern Maine that have never lost their populations of Atlantic salmon; their second priority is to restore populations and sport fisheries on rivers with extirpated runs (Beland 1984). In this review, we document the changes in management strategies of the cooperating agencies, discuss their successes and failures, and predict which actions may be necessary for successful restoration and rehabilitation in the future.

Historical Perspective

Due to the decline in Atlantic salmon and other anadromous fish species in New England, a hatchery was constructed in a converted mill at Craig's Brook (now the Craig Brook National Fish Hatchery) in 1871 to receive and incubate Atlantic salmon eggs for stocking. Later, the facility was remodeled and expanded; it continues operations today, along with Green Lake National Fish Hatchery, as the source of Atlantic salmon used in restoration and rehabilitation programs in Maine. During the last decades of the 1800s, hatchery superintendent Charles Atkins developed techniques for stripping eggs from adult salmon, and by the mid-1870s the hatchery was incubating about 3 million eggs annually.

The hatchery was closed from 1875 to 1878, but reports of adult Atlantic salmon returning to rivers as far south as the Delaware and Susquehanna prompted the U.S. Fish Commission to re-open the hatchery in 1879. Until 1890, the hatchery produced fry for stocking. After 1890, the stocking of fingerlings (parr) was emphasized. When the Salmon Commission was established in 1947 and the Penobscot River was later designated as a Model Restoration River by the federal government, restoration efforts concentrated on the culture of 2-year-old smolts in order to mimic the age of migrating smolts produced in the wild. By 1984, by use of accelerated growth techniques such as heated water and improved diets, 1-year-old smolts became the norm. Currently, stocking policy has returned to the emphasis of Atlantic salmon culturists of 100 years ago—stocking fry. Managers believe that stocking fry will allow fish to become more acclimated to conditions in the wild, thus increasing the ultimate survival and homing of returning adults.

Runs of Atlantic salmon in the Penobscot River

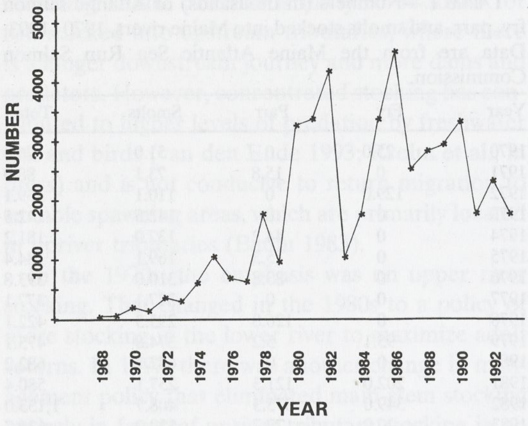

FIGURE 2.—Numbers of adult Atlantic salmon returning to the Penobscot River, Maine, 1968 to 1993. Data are from records of the Maine Atlantic Sea Run Salmon Commission.

steadily increased to a peak of 4,529 fish in 1986, but numbers of returning adults have declined since (Figure 2). Only 1,774 Atlantic salmon returned to the Penobscot River in 1993. This decline in numbers of returning fish led to a recent, temporary closure of the West Greenland commercial fishery and adoption of new management strategies, such as improved fry stocking, to increase the number of spawners.

Restoration and Rehabilitation Strategies

Stocking Eggs, Fry, and Fingerlings

Between 1866 and 1870, eggs from Atlantic salmon were brought from the Miramichi River, New Brunswick, and stocked into waters of several states, including rivers in Maine where salmon runs had declined (C. E. Atkinson, American Embassy-Tokyo, unpublished data). After Craig Brook National Fish Hatchery was constructed in 1871, eggs were obtained from Maine rivers. Eggs and fry were stocked until 1890, but the effectiveness of this program was never fully evaluated.

In 1890, there was a shift in focus to longer hatchery-rearing regimes and the stocking of parr (termed fingerlings at the time). The objective was to increase survival by eliminating the high mortality known to be associated with the vulnerable fry stage but, again, there was virtually no evaluation of stocking this life stage by federal or state agencies.

Development of the Penobscot Strain

Because the strains of Atlantic salmon native to the Penobscot and other major rivers in Maine were extirpated, restoration had to be accomplished using gametes acquired from elsewhere. The Penobscot River was the first system to be stocked using fish of nonnative origin (Moring 1993). The exact genetic composition of the Penobscot strain is unknown, but fragmented records indicate that it likely is a combination of genetic material from strains of fish taken from Canadian and Downeast Maine rivers (Ritter 1975; A. Meister, Salmon Commission, personal communication). As adults returned to the Penobscot River, their gametes provided the fish for subsequent stocking in the system, as well as in the Downeast rivers where runs were declining. Subsequently, eggs of the Penobscot strain were transported to the Merrimack, Connecticut, Pawcatuck, and other rivers in southern New England. Today, a portion of the returning adults are captured in a fish trap at the Veazie Dam on the Penobscot River (and previously at a trap on the Union River) and transported to Craig Brook National Fish Hatchery for broodstock. In 1993, 534 adults, including 283 females, produced 2.1 million eggs. This hybrid strain has now been stocked in the Penobscot drainage for more than six generations.

The slow pace of restoration may be attributable, in part, to the reliance on a nonnative, hybridized strain for restoring runs on the southern boundary of the species' historical range. As Reisenbichler and McIntyre (1986) have shown for *Oncorhynchus* spp. and Griffith et al. (1989) have shown for terrestrial animals, the farther the distance from the original source, the greater the amount of straying and lower the rates of survival of translocated animals.

2-Year-Old Versus 1-Year-Old Smolts

In the 1960s, emphasis shifted from parr stocking to the use of 2-year-old smolts. Most of Maine's remaining wild Atlantic salmon spend 2 years in freshwater before migrating to sea as smolts. Therefore, hatchery rearing was primarily directed at producing fish that were of sufficient size to undergo smoltification in the second year (some faster growing fish were often graded and released as 1-year-old smolts). By 1984, however, culturists used improved diets and heated water to accelerate the growth of juveniles so that the Atlantic salmon could attain near-optimal size for stocking as functional, 1-year-old smolts. In 1991, median size of 1-year-old smolts at Craig Brook National Fish Hatchery was 17.5 cm, and most were between 16.5 and 18.5 cm. Most 2-year-old smolts released in that year ranged from 19.5 to 25.5 cm (F. Griffith, U.S.

Fish and Wildlife Service, unpublished data). Fish that did not reach optimal size (approximately 17 cm in total length) in their first year were held over to release as 2-year-old smolts. In 1987, 718,200 smolts were stocked into Maine rivers, only 12% of them as 2-year-old fish.

Various questions remain unanswered concerning possible differences between the behavior of these two types of smolts. Downstream migration rates of 2-year-old smolts released in the lower river (Fried et al. 1978) were more rapid and continuous than those of 1-year-old smolts released 70 km upstream (Vanderpool 1992). The causes of the declines in numbers of adults returning each year since 1986 are complex and may include commercial harvest on the high seas, inadequate downstream fish-passage facilities, and riverine predation (Hosmer et al. 1979; U.S. Atlantic Salmon Assessment Committee 1991). However, declines in adult numbers may also be related to the age of smolts released. Although some of these factors have been evaluated, the effects of each independent variable have not been thoroughly addressed. Further, possible synergistic effects of different levels of several variables have not been evaluated.

Fry Stocking Versus Smolt Stocking

Smolt stocking has been a major component of Atlantic salmon restoration efforts in Maine since 1947. Culturing fish in hatcheries until the smolt stage has long been known to reduce mortality of juvenile salmonids compared with fish living in the wild (e.g., Cultus Lake studies, Foerster 1968). Stocking smolts, rather than a younger life stage, has been presumed to increase the returns of adults, which are a source of gametes as well as the source of political and financial support for the program.

Fry stocking has been the management practice in southern New England because of the poor survival of smolts used in those stocking programs and the low returns (averaging only 0.01 to 0.02% from stocked smolt to adult return). Survival of hatchery-reared smolts to returning adult stage in Maine rivers has averaged 0.3% since 1989, but models developed by the U.S. Fish and Wildlife Service predict that stocking larger numbers of fry, raised at less cost than smolts, will result in comparable or higher numbers of returns. Management theory today is that stocking fish at the fry stage allows fish to adapt to natural conditions and to home more adequately to suitable spawning habitat. As a consequence, management priorities in Maine since 1987 have resulted in increased emphasis on fry stocking.

TABLE 1.—Numbers (in thousands) of Atlantic salmon fry, parr, and smolts stocked into Maine rivers, 1970–1993. Data are from the Maine Atlantic Sea Run Salmon Commission.

Year	Fry	Parr	Smolts	Total
1970	25.0	0	51.0	76.0
1971	0	15.8	73.1	88.9
1972	129.0	0	110.1	239.1
1973	0	0	142.5	142.5
1974	0	44.2	137.0	181.2
1975	0	15.3	169.1	184.4
1976	0	83.8	310.0	393.8
1977	0	0	377.1	377.1
1978	0	126.8	295.3	422.1
1979	95.1	5.2	374.8	475.1
1980	0	0	682.2	682.2
1981	202.0	121.3	257.1	580.4
1982	349.0	375.3	408.7	1,133.0
1983	20.0	77.7	529.0	626.7
1984	134.0	56.9	838.0	1,028.9
1985	420.0	167.0	721.6	1,308.6
1986	125.0	53.6	778.5	957.1
1987	746.0	233.2	718.2	1,697.4
1988	376.0	39.9	935.1	1,351.0
1989	582.0	430.0	612.8	1,624.8
1990	963.0	538.5	677.3	2,178.8
1991	968.0	561.7	840.8	2,370.5
1992	1,178.0	523.2	895.2	2,596.4
1993	1,940.3	527.3	640.0	3,107.6

In 1993, 62% of the 3.1 million fish released into Maine rivers were fry. Large numbers of smolts are still being released, but there has been a substantial increase in the number of fry stocked into Maine waters (Table 1). If adult returns increase as the result of these additional fry stocked, we expect that the number of fish stocked as fry to continue to increase.

Miscellaneous Techniques

During the initial 15 years of restoration, many adult Atlantic salmon captured in the trap at the Veazie Dam were transported upstream and released above several dams on the river that had inadequate fish passage. Because of improved fish passage and concerns of the Penobscot Indian Nation that such procedures prevented returning Atlantic salmon from passing by tribal lands, trucking was eliminated and adult Atlantic salmon are now able to migrate upstream. Except for mortality and delay associated with upstream passage of adult fish around and over dams, this policy adheres to the long-term objectives of true restoration—the absence of human assistance.

Until the 1990s, most smolts were stocked directly into the main stem of the Penobscot and other Maine rivers, partly to increase numbers of returning adults. Survival is likely to be lower for fish stocked into upstream tributaries, where there is a longer downstream journey and more dams and predators. However, concentrated stocking has contributed to higher levels of predation by freshwater fish and birds (van den Ende 1993; Krohn et al., in press) and is not conducive to return migration to suitable spawning areas, which are primarily located in upriver tributaries (Baum 1983).

In the 1970s, the emphasis was on upper river stocking. That changed in the 1980s to a policy of more stocking in the lower river to maximize adult returns. In 1992, there was another change in management policy that eliminated main-stem stocking entirely in favor of upriver tributary stocking in an attempt to improve natal river imprinting and spawning success.

River-Specific Stocks

For rivers where populations have never been extirpated, it is appropriate to maintain whatever genetic uniqueness still exists, rather than dilute a natural run with fish from elsewhere. In 1992, the rehabilitation program began to shift from a policy of stocking smolts and fry from the Penobscot strain to one of river-specific stocking (i.e., only progeny from adults captured in a particular river will be stocked in that river).

To help clarify the potential genetic distinctions among river stocks, DNA samples were obtained from fish in the Downeast rivers in 1990, 1992, and 1993, and compared with samples taken from fish in the Gander River, Newfoundland; Craig Brook National Fish Hatchery and commercial aquaculture stocks; and from adults returning to the Penobscot River. Definitive results are not yet available; however, the river-specific broodstock program is progressing with the possibility that the nonextirpated runs in rivers of eastern Maine may still have unique genetic characteristics. Thus, separate stocking programs are appropriate.

This change in policy necessitated changes in facilities. Craig Brook National Fish Hatchery was converted during 1992–1993 from a smolt production facility with a single broodstock to a fry production facility with multiple broodstocks. The current program involves collecting wild parr from the different Downeast rivers and raising them to adult size in captivity. These broodfish will serve as the source for Atlantic salmon stocked in these rivers in the future.

Smolt Self-Release Ponds

Three circular, concrete-lined ponds (9.1 m diameter, 1.2 m deep) constructed by Bangor Hydro-Electric Company near the West Enfield Dam on the Penobscot River have been used for a portion of the smolt releases since 1989. Rather than stocking smolts directly into a river at a time deemed appropriate by humans, self-release ponds allow smolts to exit the ponds and enter the river at their own volition (Isaksson et al. 1978; Rottiers and Redell 1993).

A videotape system (J. Pippy, Department of Fisheries and Oceans, personal communication) monitored emigration to the river. An overnight rise in water temperature from 9 to 11°C on 7 May 1990 was followed by increased migration from the ponds. In 1991, a similar overnight rise in water temperature from 11.5 to 13°C on 12 May led to a similar peak in emigration on 13 May. Analysis of 1991 data showed positive correlations for the number of fish emigrating and water temperature (Spearman rank correlation coefficient, $r_s = 0.4547$; $P = 0.0047$) and hours of daylight ($r_s = 0.4204$; $P = 0.0096$), similar to the results found by Rottiers and Redell (1993). There was a marked 24-h periodicity to smolt emigration, with most movement between 2000 hours and midnight (Vanderpool 1992).

Despite these peaks in emigration from self-release ponds, a significant number of fish failed to leave by the time the water temperature reached 16°C in mid- to late-May, a temperature at which most riverine smolt migration had ceased. Fish only departed when the ponds were drained, leading to speculation that fish either were not true smolts or were unable to locate an exit. Out-migration delays also were experienced by Atlantic salmon held by Rottiers and Redell (1993). Smolts that did leave the ponds were often eaten by smallmouth bass *Micropterus dolomieu* at the pond exit tube (C. Fay, Penobscot Indian Nation, unpublished data). The ponds continue to be used to hold smolts that are stocked in mid-April as a logistical convenience during the period of peak stocking. All fish that have not departed by mid-May are released into the river when the ponds are drained.

Stocking Density Studies

From the earliest days of stocking fry, appropriate stocking densities have been questioned. Although some studies have shown higher survival of salmonids stocked at low densities (Hume and Parkinson 1984), stocking too few fry will underutilize habitat. Stocking too many fish will cause territorial interactions and emigration to increase (Gustafson-Greenwood and Moring 1990). Using a predictive model, Gibson (1992) found that stocking 40 fry per unit (1 unit = 100 m^2) of nursery habitat, as measured during detailed summer habitat surveys, was generally insufficient to saturate available habitat, and a density of 120 fry per unit was excessive. Based on a habitat classification system, stocking densities of 70 to 111 fry have been recommended for the Merrimack River (U.S. Atlantic Salmon Assessment Committee 1993). These densities are in accordance with studies in Vermont, where McMenemy (1989) found that low stocking densities of 20–40 fry per unit did not saturate the habitat, and in Maine, where 60 fry per unit is considered low (Fay 1990).

In Maine, fry are stocked by the Salmon Commission, which uses canoes to distribute the fish throughout an appropriate stretch of habitat. Currently, fry are stocked at a density of about 60 per unit, whereas age-0 parr are stocked at 17 to 24 per unit. Gibson (1994) recommended that optimal-quality habitat in a reach should be stocked with fry to the acceptable density before stocking fry in the next-best grade of habitat.

Angling Restrictions

Maine continues to be the only state in the country that has always had a legal sport fishery for sea-run Atlantic salmon. However, in the past decade, angling restrictions have been imposed to reduce angler harvest, allow more adult fish to reach spawning grounds, and hasten eventual restoration. Anglers removed 25% of the returning adults on the Penobscot River in the early 1980s, when bag limits were relatively liberal (Table 2). Season possession limits imposed in the late 1980s reduced angler harvest to about 11% of the run. When a limit of one adult Atlantic salmon per season was imposed for the 1992 season, sport catch on the Penobscot River was 497 fish (153 kept, 344 released), and angler harvest was reduced to 6.4% (U.S. Atlantic Salmon Assessment Committee 1993). In 1993, the angler catch on the river was 574 (124 kept, 450 released), reflecting a harvest rate of 7.0% (Salmon Commission, unpublished trap and rod records).

In 1994, anglers in Maine were allowed to keep only one grilse; all adult Atlantic salmon had to be released. This marks the first time that anglers have not been able to keep any large (two sea-winter) Atlantic salmon, a reflection of the growing acceptance of catch-and-release fishing and support of

TABLE 2.—Angler catches of Atlantic salmon from rivers in Maine, 1985–1986 and 1992–1993. The former period was during the peak runs and the latter period represents the most recent angler records.

River	1985	1986	1992	1993
Androscoggin	0	0	0	0
Aroostook	0	0	9	0
Dennys	20	15	12	4
Ducktrap	15	5	0	0
East Machias	31	13	9	3
Machias	30	43	10	12
Narraguagus	61	46	62	27
Penobscot	625	778	497	574
Saco	85	2	0	12
Saint Croix	20	55	2	1
Sheepscot	5	11	7	14
Union	1	5	0	0
Others[a]	0	0	1	12
Totals	893	973	612	659

[a]Includes Kennebec, Pleasant, and upper St. John rivers.

the restoration efforts, particularly by salmon angling clubs.

Discussion

Maine is fortunate to have the largest number of Atlantic salmon runs, the only nonextirpated populations of Atlantic salmon, and the most successful Model Restoration River—the Penobscot—in the United States. The ultimate objective of state and federal management programs is to maintain (and enhance) the runs of Atlantic salmon in the Downeast rivers and to restore runs in rivers, such as the Penobscot, that Atlantic salmon once inhabited. Yet, since the peak run of 1986, numbers of returning adults to Maine rivers have steadily declined, as have angler catches. The stocking program has been the key element in restoration efforts. Without the use of hatchery-reared fish, there would be no hope for restoration, and little optimism for the rehabilitation of depressed populations in rivers of eastern Maine. It appears that stocking will continue to be essential for years to come.

A Monte Carlo simulation model, using the best available data on survival rates at various life stages, river section, and spawning and age determinations, has predicted that a run of 5,500 is necessary for achieving a self-sustained population of Atlantic salmon in the Penobscot River (Marancik 1988). In recent years, less than a third of the needed fish have returned to the Penobscot River.

Stocking smolts, long the technique of choice in Maine, has not resulted in increased returns to the Penobscot River (Figure 3). Rather, the increased

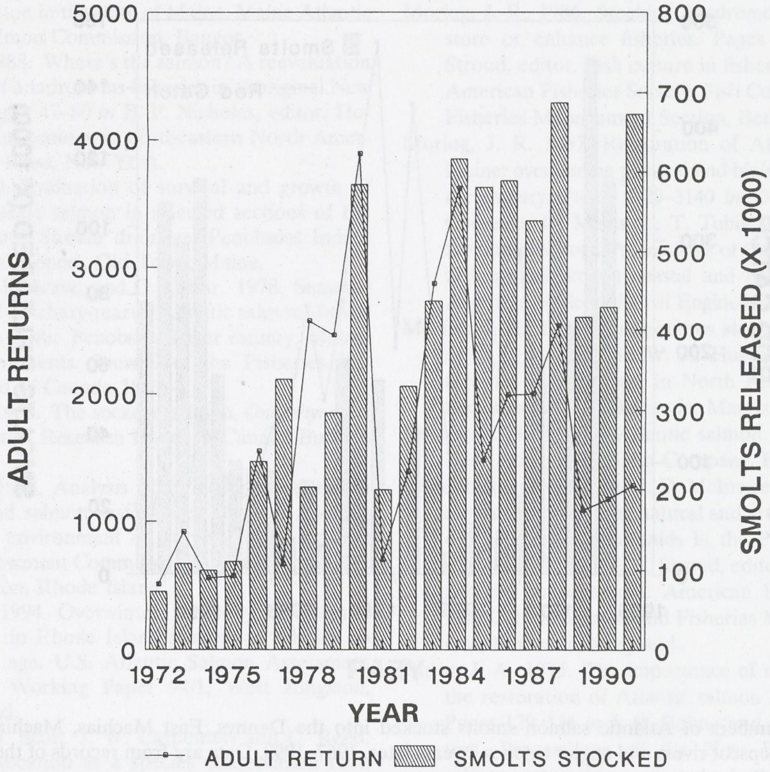

FIGURE 3.—Numbers of stocked Atlantic salmon smolts and the number of adults returning 2 years later, 1972–1991. Data are from records of the Maine Atlantic Sea Run Salmon Commission.

numbers of smolts stocked in the 1980s have been associated with declining numbers of adult fish returning to the river. In the wild rivers of eastern Maine, angler catches are inversely related to numbers of stocked smolts (Figure 4).

It would be easy to conclude that management practices have simply returned to the procedures used in the 1870s—stocking fry. However, the difference in approach between these two time periods is not related to the actual culture as much as it is to the disposition of the stocked fry. In the late 1980s and now in the 1990s, fry have been stocked with a more scientific approach toward density and habitat. In all likelihood, fry were stocked in the past at densities too low to be successful and in habitats that were inappropriate for instream residence. Stocking evaluation has just begun. Despite the years of marginal success from fry stocking in waters of southern New England, fisheries managers in Maine now are placing more emphasis on fry stocking. Reasoning that the steadily increasing incidence of fish spawning in the wild in Maine waters may be an indication of better habitat than that in southern New England, Maine managers are expecting better survival of stocked fry.

Stocking smolts has not resulted in continued improvement of runs in any of the Maine rivers, and producing smolts is considerably more expensive than producing fry. Whether stocking fry at appropriate densities will result in an improvement in adult returns awaits final evaluation.

Restoration and rehabilitation of Atlantic salmon runs in Maine has not been affected as much by cultural and stocking practices as by external factors. Dams, a culprit in the original demise of Atlantic salmon populations of New England, still have a major influence on fish passage and the susceptibility of Atlantic salmon to predators. More than 30% of the Penobscot River drainage that was originally accessible to Atlantic salmon is still unavailable to returning adults (Salmon Commission, unpublished data).

Atlantic salmon restoration in 1994 has reached an important milestone. Several management strategies have recently been implemented and show promise

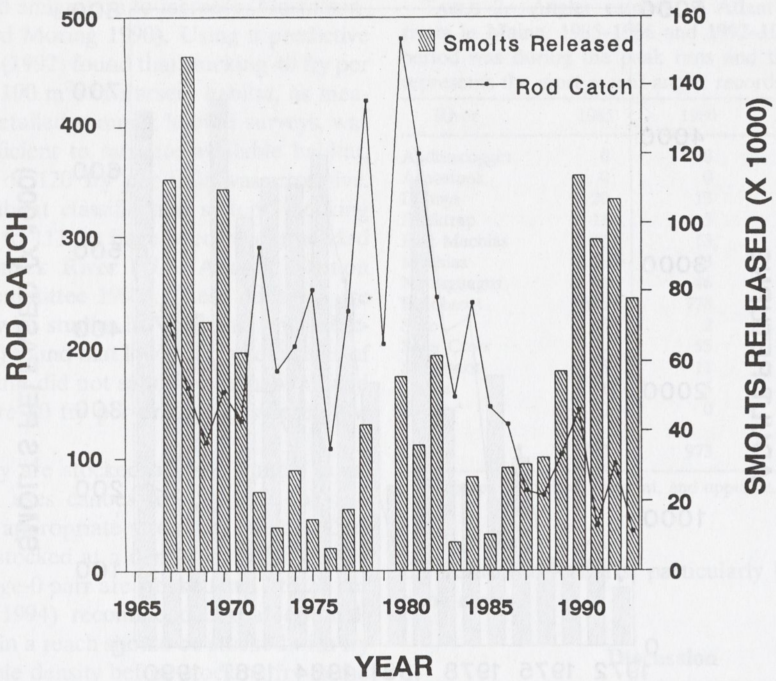

FIGURE 4.—Numbers of Atlantic salmon smolts stocked into the Dennys, East Machias, Machias, Narraguagus, Pleasant, and Sheepscot rivers and angler catches 2 years later, 1967–1993. Data are from records of the Maine Atlantic Sea Run Salmon Commission.

for increasing the returns of salmon to Maine rivers. Rather than a careful, stepwise series of scientific evaluations, the consequences of many actions will manifest themselves simultaneously. It will be difficult to assess which strategies may be effective and which may not. Short-term and long-term success will depend on several actions in the remaining years of the twentieth century: (1) the temporary closure of the West Greenland commercial fishery and negotiated agreements concerning Canadian fisheries must result in significantly higher oceanic survival and higher returns to the river; (2) the shift to a large fry-stocking program in tributaries must show positive results in terms of survival in the wild, higher numbers of resulting smolts, and a better reinforcement of homing back to natal rivers to increase natural reproduction; (3) angling restrictions will allow continued recreational fishing but will minimize sportfishing mortality of adult fish (*viz* catch-and-release only); and (4) the river-specific stocking program must secure sufficient broodfish each year without reducing the number of wild fish returning to spawn in Downeast rivers. Whatever the results in the next several years, future management strategies will continue to emphasize increasing the number of adult spawners returning to rivers, the numbers spawning in the wild, and the numbers of juveniles rearing in appropriate habitat.

Acknowledgments

We appreciate the contributions of biologists with the Maine Atlantic Sea Run Salmon Commission for providing unpublished records from the Atlantic salmon program, and Clem Fay, Penobscot Indian Nation, for providing additional records. William Krohn, National Biological Service, kindly reviewed the manuscript.

Cooperators of the Maine Cooperative Fish and Wildlife Research Unit are the University of Maine, Maine Department of Inland Fisheries and Wildlife, National Biological Service, and the Wildlife Management Institute.

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Moring

UNIVERSITY OF MAINE

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Fishery Office–University of Maine
5751 Murray Hall
Orono, Maine 04469-5751

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TO: BEHNKE

FAX: 19704915091

FROM: EDWIN CROSBY

FAX: 315762291906900

TEL: 13157622919

COMMENT:

FAX: 970-491-5091

ATLANTIC SALMON FISH CREEK CLUB, INC.

P.O. Box 67
Sylvan Beach, New York 13157

Edwin H. Crosby, III
President

MAY 27, 1998

DR. ROBERT BEHNKE
PROF. FISHERY BIOLOGY
COLORADO STATE UNIV.
FT. COLLINS, CO.

DR. BEHNKE,

Received your letter yesterday. Thank you for penciling us in for NOVEMBER 7, 1998. We have some problems here & are not quite sure whats going on.

We stocked 32,000 fry into tributaries & the main E. Branch of Fish Creek. 8,000 in the main stem, & 24,000 in 4 tributaries. Some were stocked 4,000 in 100 yards. This seems overkill to us, too much density. We are at a point where we requested a meeting between all parties regarding non-communication. This must have worked, as, U.S.F. & W. folks have formed an " ATLANTIC SALMON AD HOC COMMITTEE ". I am enclosing a copy of the notice sent to me. Our meeting will be JUNE 12, at the Salmon River Hatchery.

Here is something you might like. Atlantic Salmon are being caught in the Salmon River right now !! 7 to 11 lbs. with no tags !!! U.S.F. & W. placed 280 SEBAGO STRAIN broodstock in the Salmon River, all had tags. However, bright fish are now being caught without tags, and Fran Verdoliva says they are jumping 10-12 feet when hooked !! In fact, D.E.C. REGION 7 boss, Les Wedge (was at conference) caught an 11 pounder without the tag. The next day, he phoned Albany to tell them what is now going on at the flyfishing only section of the Salmon River. Funny thing, nobody is catching them in the lake, we believe they are not going out to deep water where the charter boat guys go. Maybe they are staying 1-5 miles near shore, in any event, they are coming in.

Also, local guy has photo in paper with " brown trout " which looks like an Atlantic Salmon. D.E.C. will identify the fish. It weighed 6.5 pounds, 25 1/2 inches long. According to the guide to tell a brown from an Atlantic, it is an Atlantic. We will see, let you know. The fish was caught in ONEIDA LAKE. Last Fall, an 11 pounder was caught, in Lake Oneida as well.

At the end of JULY, F.E.R.C. personnel will be arriving in the area to deal with NIAGRA MOHAWK & the fish ladders. However, NIMO has sold the hydro-electric facilities, and, the new owners have already had an engineer design a fish ladder for one of the hydro dams.

I don't know if I told you this, but, over on the other side of the lake (Canada) Atlantic Salmon came up a river near Toronto & spawned. A fisheries biologist put on a divers suit & when down to a redd, he took eggs from the outer edge of the redd, ALL EGGS WERE FERTILIZED !!!! Yes, these were hatchery fish put in months ago, but, any kind of news is good news. A report is due on this shortly.

John Albright, Atlantic Salmon Federation, just joined our CLUB, he is number 80 !!! We are doing very good, and have the usual problems, however, they are being addressed, and we can only get better. NEWS FLASH ---- Big meeting up in CANADA with ASF 2 weeks ago. THEY HAVE FORMED A COMMITTEE TO ADDRESS OUR REQUEST FOR THE " LAKE ONTARIO COUNCIL " of the ATLANTIC SALMON FEDERATION. John Albright is one member, one from N.B., &, one from QUEBEC. A meeting of the COUNCIL PRESIDENTS was so-so, as some of them were saying, "....well, they are landlocked Atlantics ". However, some were delighted to hear how we have been doing. WE ARE THE NUMBER ONE AFFILIATE of the ATLANTIC SALMON FEDERATION FOR ACTIVISM !! In fact, we are going so fast, they can't keep up.

We are of the opinion, that those folks working on Atlantic Salmon here are searching in the dark. They just don't want to work with those who do know, and, we try hard to get them to all work together. I am very good at getting the right people together and pushing them in the right direction. However, until we get some of these scientists to open up & fly right, we will continue to spin our wheels. One of our members takes samples of Fish Creek once a week, temp. PH, disolved oxygen, etc. By the way, the PH on Fish Creek has been 8.6 to 8.9 !! We try to help, but, all to no avail.

By having the Conference, and bringing in outside experts like yourself, it certainly has an effect on the way things turn out. Peter Basta, a member, and fisheries biologist from Vermont, has been giving us the scoop on whats not being done right. He believes they should be using PENOBSCOT STRAIN - sea run fish. PLUS, U.S. F. & W. folks are having a problem at the Allegheny Hatchery in PA. As Grand Lake strain eggs develop, they are dying. From 200,000 eggs, they only got 32,000 fry, & we got all of them. They have called in an expert to deal with this problem. They thought it was broodstock feed at first, now, they realize it is something entirly different. These things happen, oh well, better now, then when we want 300,000 fry next Spring.

TAKE CARE !! THANKS AGAIN DR. BEHNKE !!!

Edwin H. Crosby III

EDWIN H. CROSBY III

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Lower Great Lakes Fishery Resources Office
405 N. French Road, Suite 120A
Amherst, New York 14228

May 21, 1998

MEMORANDUM

TO: Edwin H. Crosby, III, Atlantic Salmon Fish Creek Club President

FROM: Sandra Lary, Fishery Biologist Sandra Lary

SUBJ: Atlantic salmon activities, information exchange and coordination

As you know, many Atlantic salmon related activities are underway in the Lake Ontario basin including habitat inventories and evaluations, broodstock development (by genetic strain) and egg production issues, assessments of egg and fry stockings, forage evaluation, etc. Individuals from federal, state, university, and non-governmental organizations are conducting the various activities in the U.S. and similar activities are also being conducted on the Canadian side of the lake. Therefore, the Atlantic salmon studies and related activities could benefit from improved communications and coordination between the various agencies and other partners. You identified a similar need in your recent memorandum that included an invitation to participate in an information exchange meeting.

We have been reviewing the options to develop a system for improved communication between the parties conducting Atlantic salmon research, agencies that support these research activities, volunteers and fishing clubs that provided assistance in public education and outreach and in providing field support, and involvement of local communities. Different formats may be needed, according specific purposes, in order to accomplish improved communication on roles and responsibilities.

Based on a similar need to organize lake trout studies, stocking and assessments, the participants in the lake trout program formed an Ad Hoc Task Group. We suggest the formation of an Atlantic Salmon Ad Hoc Task Group and are hereby taking the first step in its implementation. Similar to the Lake Trout Task Group, the Atlantic Salmon Task Group needs to limit its official membership to leadership, management and research participants. However, participation at meetings can not be limited, except that these will be working meetings, not public forums. The Task Group will bring together the scientific community to design and evaluate research and assessment activities in the basin, identify roles and responsibilities, and provide support and direction for other partners such as angling groups, Atlantic salmon clubs, and local community members. We also understand the need for periodic updates for the much larger numbers of other interested individuals (the public forum approach) that you are presently organizing. The new Task Group should assist and participate in such information exchange meetings, however, the Task Group will need to meet first.

At this time, we are forming the Atlantic Salmon Ad Hoc Task Group and will plan the first meeting to resolve a number of important research, management and coordination issues. This will be done in the near future. Bruce Carpenter (New York Rivers United) has agreed to serve as the coordinator and facilitator for this activity. Suggested membership, in alphabetical order, is as follows, with the lead person identified by an asterisk:

Biological Resources Division – J. Johnson*; J. McKenna; G. Ketola
Fish and Wildlife Service – S. Lary*; R. McDonald; D. Busch
New York DEC – A. Schiavone*; F. Verdoliva; L. Wedge; C. Schneider
New York State Conservation Council – Person to be identified*
Non-Governmental Organizations – B. Carpenter*; E. Crosby; Person from Trout Unlimited
Universities – (Lead Researchers) N. Ringler*; M. Murphy* C. Krueger*

The Task Group needs to meet and get activities (science) organized and coordinated. After this meeting, members or representatives of the Task Group will be in a much better position to participate in public meetings, such as the one your are attempting to organize.

We are also in the process of developing "habitat assessment protocols" for use in identifying and mapping potential spawning/incubation and nursery habitats and also potential habitat restoration sites. We plan to have this protocol completed in the near future and hope that you and your Club will consider conducting some of this fieldwork.

We look forward to the continuation of cooperative efforts.

cc: OMNR – L. Stanfield
Atlantic Salmon Federation – J. Albright

07/10/1998 12:17

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TO: ____________________

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FROM: EDWIN CROSBY

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TEL: 13157622919

COMMENT: (315) 762-2919

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FAX: 970-491-5091

ATLANTIC SALMON FISH CREEK CLUB, INC.

P.O. Box 67
Sylvan Beach, New York 13157

Edwin H. Crosby, III
President

JULY 10, 1998

DR. ROBERT BEHNKE
COLORADO STATE UNIV.
FT. COLLINS, CO.

DR. BEHNKE,

Call me as soon as possible. We may have a schedule change in our conference. As you are aware, we requested your presence for November 7th, however, the enclosed ATLANTIC SALMON AD HOC TASK GROUP WORKSHOP agenda (draft) points out the reason for possibily moving the date forword one (1) week.

All parties agree this would be great !! Only problem is I have asked you to commit to the NOV. 7th date. Is it possible for you to attend the conference one (1) week earlier ??? This is getting bigger & bigger. Hopefully, you may want to attend all 3 days !! Prof. Ringler, (315-470-6770) is on vacation till the end of JULY, I am sure he would appreciate your presence for the workshop, moreover, he submitted a proposal to obtain $5,000.00 for travel, lodging, meals. Of course, our CLUB can kick in $2,000.00 to assist with everything.

Please call me evenings 8:30 to 12 P.M. as soon as you can. I do hope you can make it. Talked to Rick Cunjak, Univ. of New Brunswick today, he attended Atlantic Salmon meeting in Scotland with you. Hope to hear from you.

Sorry for any inconvience to you. Hope you can make it !!!!!!!!!

Edwin H. Crosby III

EDWIN H. CROSBY III

PHONE: 315-762-2919

ATLANTIC SALMON WORKSHOP
AGENDA (DRAFT)

We propose to organize a one or two-day workshop to bring together the members of the Atlantic Salmon Ad Hoc Task Group to exchange information, focus and coordinate activities, discuss research needs and propose specific actions that will move us forward on implementing a renewed Atlantic salmon restoration and management program in the Great Lakes (see attached proposal)

<u>LOCATION:</u> SUNY College Of Environmental Science And Forestry, SYRACUSE
<u>DATE:</u> October 29, 1998 (and/or October 30)

<u>WORKSHOP OBJECTIVES</u>

1) Assemble the best scientific expertise available to explore the potential for a renewed Atlantic salmon restoration program;
2) Review: Atlantic salmon restoration history
   Previous restoration attempts (What worked? What didn't?);
3) Consider the following questions:
   - to what degree will Atlantic salmon reproduction be impaired by early mortality syndrome? what are the most feasible remediation strategies?
   - to what extent will competition with other salmonid species likely impair successful reintroduction?
   - what are the appropriate life stage(s) for stocking?
   - to what extent will inaccessible spawning habitat constrain a self sustaining population in Lake Ontario?
   - what strain characteristics are most desirable for Atlantic salmon stocked to restore a self sustaining population. Are strains available with these characteristics?
   - where are the most appropriate streams for pilot programs?
   - what is the general attitude about Atlantic salmon by the public? Do fisherman desire an Atlantic salmon fishery? What actions could be taken to communicate restoration activities to the public and/or assess their attitudes?
4) Identify new research needs; and
5) List specific steps necessary to proceed with a renewed Atlantic salmon restoration program.

<u>WORKSHOP AGENDA</u>

8:45 - Welcome/Introductions (N. Ringler)
9:00-12:00 Atlantic Salmon Biology, Conservation, and Restoration (20 Minute Presentations)*
- NYSDEC Perspectives/ History/Management Plan (B. Lange, C. Schneider or L. Wedge)
- Canadian programs (L. Stanfield)
- Habitat (N. Ringler, C. Millard, R. McDonald, J. Johnson, M. Murphy)
- Intraspecific Competition (N. Ringler, J. Johnson)
- Thiaminase/alewife remediation (G. Ketola)
- Stocking Techniques (M. Murphy, S. Lary, J. Johnson) D. McDONALD
- Genetic strains/ recommendations (C. Krueger, M. Nemeth, ~~S. Lary~~)
- Public Perspectives (B. Carpenter, D. MacNeil, C. Dawson, V. Luzadis)
- Experiences from Maine (J. Mooring)

12:00 -1:00 Lunch
1:00 - 2:00 Review of Current Atlantic Salmon Activities in the Great Lakes
2:00 - 3:00 Facilitated Discussion of the Workshop Objectives/Questions
3:00 - 3:30 Identify Research Needs
3:30 - 4:30 Develop Workplan

* Note: Listed speakers are tentative/proposed

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P.O. Box 67
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0201

MAY 20, 1998

DR. ROBERT BEHENKE
PROF. FISHERY BIOLOGY
COLORADO STATE UNIV.
FT. COLLINS, CO.

DR. BEHNKE,

NOTICE: We have scheduled our " conference " for NOVEMBER 7, 1998, (Saturday). Please mark this down in your book, or, if this date is not suitable, please FAX: me about said date. Moreover, let me know if NOV. 14th, or, OCT. 31st would be better.

We just stocked 32,000 fry in tributaries of FISH CREEK, & the main branch yesterday. We are troubled by the density stocked in the tribs. Attached to this letter is OUR request for a meeting on JUNE 12th to air some problems we are having.

Also, I am enclosing for you a copy of the APRIL 9th letter from D.E.C., I am not sure, but I think I FAXED this to you. Yes, we are going to respond to said letter after the holiday.

Was told this day, the Atlantic Salmon Federation has formed a committee to set-up a " LAKE ONTARIO COUNCIL ". Moreover, someone would be invited to the Presidents Council Meeting in October, so they can have a full report on our progress to date. We have two (2) groups on the Canadian side of the Lake that would form Atlantic Salmon Clubs.

We now have 78 members !! Hope you are in good health. Your presence at this conference is vital. Thanks again for all your help.

Edwin H. Crosby III

EDWIN H. CROSBY III

PHONE: 315-762-2919
FAX: 315-762-2919-0690

GEORGE E. PATAKI
GOVERNOR

JOHN P. CAHILL
COMMISSIONER

STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
ALBANY, NEW YORK, 12233-1010

APR 9 1998

Mr. Edwin H. Crosby, III
Atlantic Salmon Fish Creek Club, Inc.
P.O. Box 67
Sylvan Beach, NY 13157

Dear Mr. Crosby:

Governor Pataki asked that I respond to your recent letter concerning Atlantic salmon management in Lake Ontario.

I appreciate the opportunity to clarify the policy of the Department of Environmental Conservation (Department) concerning Atlantic salmon management. Hatchery-reared Atlantic salmon are stocked in limited numbers (100,000) to establish a presence of this native species in Lake Ontario and produce trophy fishing opportunities. Harvest regulations are very conservative (one fish daily limit and 25-inch minimum size) and are intended to protect immature Atlantic salmon to encourage natural reproduction. Whatever natural reproduction occurs as a consequence is considered fortuitous. The restoration of a self-sustaining Atlantic salmon population is not presently a management goal.

The principal purpose of a restoration goal would be to restore the portion of ecological structure and function that was lost to the Lake Ontario ecosystem when the native Atlantic salmon population became extinct. A restored, self-sustaining population would not only yield angling opportunities, but would integrate all of the habitat and environmental quality attributes of the ecosystem that must be in place to support the complete life cycle of Atlantic salmon. Achievement of this goal would require minimal active human intervention for the completion of the Atlantic salmon life cycle; otherwise, the restoration of ecological function would not be attained.

The Department has not yet committed to a restoration goal for Atlantic salmon because significant technical issues that could impede or preclude success remain unresolved. These issues include:

- Reproductive viability. Circumstantial evidence suggests that Atlantic salmon in Lake Ontario likely suffer from a thiamine deficiency that impairs reproductive success.

- Competition with other trout and salmon. Other salmonid species, notably steelhead, already utilize spawning and nursery habitat accessible to lake-run fish.

- Habitat modification. So much of the original tributary range of Atlantic salmon has been modified by incorporation into canal systems or remains blocked by multiple dams, often with hydroelectric installations, that the potential size of a restored Atlantic salmon population may be severely limited by habitat availability and accessibility.

- Genetic strains and performance. Native Lake Ontario Atlantic salmon are extinct. The strains that have been utilized for stocking hatchery-reared fish into Lake Ontario have performed poorly.

The foregoing issues do not mean that Atlantic salmon restoration is an unworthy goal, or that it will not be adopted by the Department. The issues are substantial enough to warrant a cautious, step-wise approach to insure that prospects for success are reasonable before limited resources are significantly invested in a restoration project. Again, in our view, success would be defined as closure of the life cycle of Atlantic salmon with minimal active human intervention.

The Department is currently involved in a detailed evaluation of issues related to the feasibility of Atlantic salmon restoration with the Ontario Ministry of Natural Resources under the auspices of the Lake Ontario Committee of the Great Lakes Fishery Commission. The report of this evaluation is expected by May 1 and will be available for public review. Public consultation on the question of whether an Atlantic salmon restoration program should be initiated will than be carried by both agencies next autumn. Early in 1999, the Lake Ontario Committee will determine whether an Atlantic salmon restoration program will be adopted on a lakewide basis.

Thank you for your interest in the Department's Lake Ontario fisheries management program.

Sincerely,

John P. Cahill

ATLANTIC SALMON FISH CREEK CLUB, INC.

P.O. Box 67
Sylvan Beach, New York 13157

Edwin H. Crosby, III
President

MAY 12, 1998

RE: FISH CREEK HABITAT SUITABILITY
& PRODUCTION POTENTIAL STUDY.

TO WHOM IT MAY CONCERN,

It has been suggested, that as " primary partner " in said study, we request a 6 month review to discuss problems we are having. We believe that in order to most effectively utilize resources for a feasibility study, and conduct same in an efficient manner that will result in credible scientific results, is not happening. Currently, there is lack of focus & direction with the " principle Investigator ".

In order to correct shortcomings, we hereby request your presence at the N.Y.S. HATCHERY, ALTMAR, N.Y. on JUNE 12, 1998, time, 10:00 A.M. The 76 members of our Club are being left out of the loop.

Thank you for your willingness to comply with our request for a 6 month review, & discussion.

Edwin H. Crosby III

EDWIN H. CROSBY III

CC: U.S. F. & W., DEITER BUSCH
SUNY-ESF, PROF. RINGLER
PRIN. INVEST., MARGRET MURPHY
N.Y.S.D.E.C., AL SCHIAVONE
U.S.G.S., JIM JOHNSON
ATL. SAL. FED., JOHN ALBRIGHT
BOARD of DIRECTORS, ATL. SAL. FISH CREEK CLUB
SALMON RIVER COOR., FRAN VERDOLVIA
N.Y. RIVERS UNITED, BRUCE CARPENTER

SEE ATTACHED - PAGE TWO

ATLANTIC SALMON FISH CREEK CLUB, INC.

P.O. Box 67
Sylvan Beach, New York 13157

Edwin H. Crosby, III
President

MAY 12, 1998

RE: MEETING, JUNE 12, 1998

AREA'S OF CONCERN/DISCUSSION

1. CLARIFICATION OF EVERYONE'S ROLE.
2. PRINCIPAL INVESTIGATOR - WHAT DOES THAT ENTAIL ?
3. ATLANTIC SALMON FISH CREEK CLUB - WHAT ARE OUR RESPONSIBILITIES ?
4. HOW TO COORDINATE BETWEEN INTERESTED PARTIES, PROCEDURE, & POINTS OF CONTACT.
5. MEMO of UNDERSTANDING (resolution) - WE FEEL THIS IS NEEDED TO INSURE THAT, AS PRIMARY PARTNER, WE ARE INCLUDED IN ALL MATTERS PERTAINING TO FISH CREEK.
6. DISCUSSION OF WHATS TAKEN PLACE TO DATE - A BRIEFING BY THE PRINCIPAL INVESTIGATOR.
7. N.Y. RIVERS UNITED & THEIR POSITION REGARDING RE-INTRODUCTION OF ATLANTIC SALMON TO FISH CREEK.

EDWIN H. CROSBY III

8. Stewards of the stream
9. Eggs for the Fall
10. Signs for Salmon - Fish Creek

4-034046 Daniels CEC 8140

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ALBANY, NEW YORK 12230

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Pleistocene
N. J.
salmon
scale

Dr. Robert J. Behnke
Department of Fisheries and Wildlife
Biology
Colorado State University
Fort Collins, CO 80523

NEW YORK STATE MUSEUM

3140 Cultural Education Center
Albany, NY 12230
518/474-5812 FAX 518/473-8496

Biological Survey

otolith
Broecker - Nat. Hist.
young fish
- 1x

October 18, 1996

Dr. Robert J. Behnke
Department of Fisheries and Wildlife Biology
Colorado State University
Fort Collins, CO 80523

Dear Dr. Behnke,

I was glad to see your article in Trout on the Atlantic salmon. I am enclosing an article and photograph that may be of interest to you. Dr. Carlson is aware of this publication, but has not cited it as far as I know.

When I wrote the part on fish remains, I was not willing to stand too strongly behind the identification of an Atlantic salmon scale. Now that I have more experience examining scales, I have a much stronger opinion--I believe that the scale belongs to a salmon. There really aren't too many options--a scale without radii or ctenii from fresh water is probably from a salmonid. The shape of the scale and the position of the focus also point to a *Salmo* and not a *Salvelinus*. This scale was taken from a layer about 9000 year bp, or about 3000 years after the deposition of the first organic matter. A second possible salmonid scale was taken from a layer from about 11500 years bp.

I realize that two scales are pretty weak evidence, but it is evidence of the presence of these fish. Since this paper was published (in a rather obscure spot), I have looked over the material again and have begun to write it up for a fishery audience. The focus of the rewrite is on the zoogeographic significance of the find; these scales also provide support for some of the papers dealing with the presumed species composition of the Atlantic coastal refugia.

I would appreciate your opinion and comments.

Sincerely,

Bob

Robert A. Daniels
Curator of Ichthyology

Pergamon

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LATE-GLACIAL POLLEN, MACROFOSSILS AND FISH REMAINS IN NORTHEASTERN U.S.A. — THE YOUNGER DRYAS OSCILLATION

A Contribution to the 'North Atlantic Seaboard Programme' of IGCP-253, 'Termination of the Pleistocene'

D.M. Peteet,*† R.A. Daniels,‡ L.E. Heusser,† J.S. Vogel,§¶ J.R. Southon§¶ and D.E. Nelson§

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‡ *New York State Museum, Biological Survey Laboratory, 145 Jordan Rd., Troy, NY 12180, U.S.A.*

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The late-glacial environmental histories of Allamuchy Pond, New Jersey and Linsley Pond, Connecticut are reconstructed from pollen, macrofossil and fish scale remains. Accelerator mass spectrometry (AMS) ^{14}C dating of seeds and needles indicates that the first organic deposition, evidenced by fossil *Picea* (spruce) needles, occurred approximately 12,400 BP. A major regional warming began in the northeastern United States at this time, correlative with the Bølling/Allerød warming of Europe and Greenland. The increase in *Quercus* (oak) pollen and presence of *Pinus strobus* (white pine) needles demonstrates the magnitude of warming reached at about 11,000 BP. The subsequent decline of thermophilous species and increase in boreal *Picea*, *Abies* (fir), *Larix* (larch), *Betula papyrifera* (paper birch) and *Alnus* (alder) from 10,800–10,000 BP was a regional vegetational reversal. Thus we find a North American expression of the Younger Dryas with a mean annual temperature depression of 3–4° C. The subsequent classical southern New England pine pollen zone 'B' and *Pinus strobus* macrofossils signalled a return to warmer conditions at approximately 10,000 BP, regionally, within approximately 50–100 years. A large increase in *Quercus* follows. This study is unique in documenting a continuous late-glacial record of fish remains from Allamuchy Pond, New Jersey sediments, indicating that members of the families Centrarchidae (sunfish), Salmonidae (trout), Percidae (perch) and Cyprinidae (minnow) were regionally present.

INTRODUCTION

The recent refinement of the late-glacial Greenland ice core stratigraphy (Johnsen *et al.*, 1992; Taylor *et al.*, 1993; Alley *et al.*, 1993) enables improved correlation of late-glacial events throughout the North Atlantic region, ranging from Europe across the North Atlantic basin to eastern North America. The Greenland Summit ice core evidence for the onset of the Bolling interval is 14,450±250 BP, which translates to 12,500 ^{14}C years (Bard *et al.*, 1992), which is within 200 years of the GISP-2 estimate (Taylor *et al.*, 1993). The Bølling/Allerød-Younger Dryas oscillations are events clearly visible in the isotopes (Dansgaard *et al.*, 1989), snow accumulation (Alley *et al.*, 1993) and dust (Taylor *et al.*, 1993) shifts in ice cores, North Atlantic marine faunal records (Ruddiman and McIntyre, 1981; Broecker *et al.*, 1985; Lehman and Keigwin, 1992) and palynological data in Europe (Watts, 1980; Rind *et al.*, 1986) and eastern North America (Mott *et al.*, 1986; Peteet, 1987; Peteet *et al.*, 1990; Levesque *et al.*, 1993). The rapidity of the transitions, occurring within decades in Greenland, provide an exciting focus for examining various responses from the fossil record. Because of the abrupt nature of the late-glacial changes, AMS ^{14}C chronology is essential for dating and terrestrial macrofossils are the primary fossil of choice (Tornqvist, 1992). All dates are in radiocarbon years unless otherwise noted.

¶Present address: Center for Accelerator Mass Spectrometry, Lawrence Livermore Laboratory, Livermore, CA 94551, U.S.A.

Several key questions concern the last glacial–interglacial transition in the northeastern U.S. This study focuses on palynology, faunal and floral macrofossils and AMS radiocarbon chronology from three sites that present a regional picture. Linsley Pond, Connecticut and Allamuchy Pond, New Jersey (Fig. 1) are new sites, in addition to Alpine Swamp, New Jersey (Peteet *et al.*, 1990). A unique feature of the study is the continuous stratigraphic presence of fish remains from Allamuchy Pond, northwestern New Jersey. The following questions concern the biological response to major deglaciation in the northeastern United States:

(1) What was the timing of the first warming in southern New England and how does this compare with other North Atlantic records?

(2) What was the general pattern of warming in this region and how is it expressed in the sedimentary, paleovegetational and fish remains records?

(3) What is the timing and magnitude of the Younger Dryas cooling in the coastal northeastern U.S.?

(4) What patterns of tree migration are evident from the presence of macrofossils?

SETTING AND BACKGROUND

The climate of New Jersey and Connecticut has both continental and oceanic features. Linsley Pond, Connecticut, is situated in a maritime climate while Allamuchy Pond is about 60 km inland, in northwestern New Jersey. Mean annual temperature ranges from 7 to 10°C and is higher in coastal areas. Annual rainfall ranges from 110 to 125 cm.

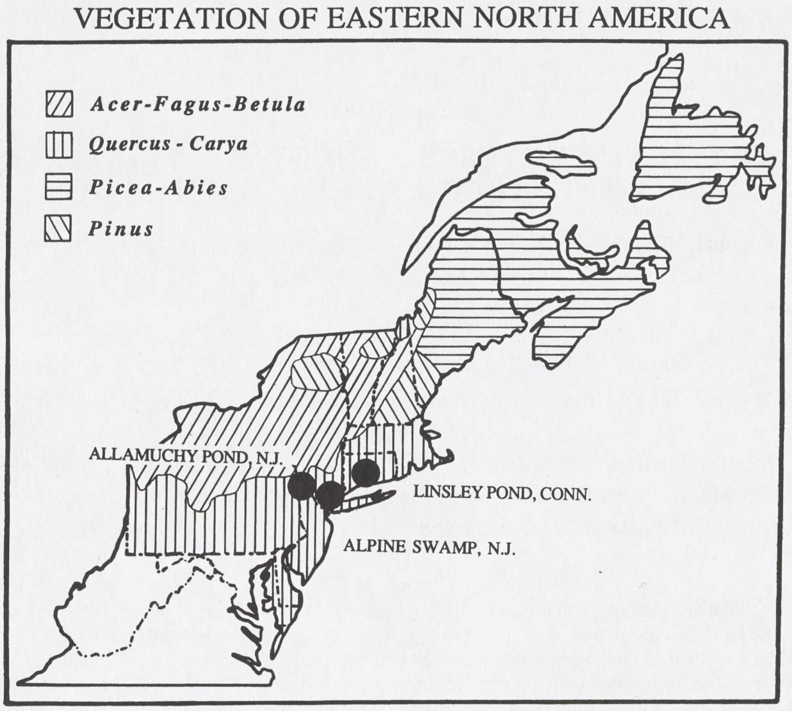


FIG. 1. Map of northeastern U.S. with location of three sites discussed (circles). Modern vegetation distribution after Kuchler, (1964).

Storms from the Great Lakes region, which pass down the St Lawrence Valley, contribute some of the precipitation, but most is derived from coastal storms of subtropical origin (van der Leeden and Troise, 1968).

The vegetation of the region is a transition zone between Hemlock-White Pine-Northern Hardwoods forests to the north (Braun, 1950; Kuchler, 1964) and deciduous forests to the south (Fig. 1). It is classified as Oak-Chestnut forest (Braun, 1950), but contains *Acer saccharum* (sugar maple), *Carya* (hickory), *Fagus grandifolia* (beech), *Betula lutea* (yellow birch), *Pinus strobus* and *Tsuga canadensis* (hemlock). The communities surrounding Linsley Pond and Allamuchy Pond have been vastly altered by human disturbance.

Geologic data concerning the timing of ice retreat from the classical Wisconsin terminal moraines in the New Jersey–Connecticut region are controversial. Estimates of retreat are as early as 17,000 BP (Borns, 1973; Connally and Sirkin, 1973; Cotter *et al*., 1985) to much later ages (i.e. 13,000 BP) because of the numerous problems in accepting bulk dates (Lowe and Walker, 1980; Karrow *et al*., 1984). The debate from Corry Bog, Pennsylvania focuses clearly on the argument, still unresolved, of the true age of basal sediments (Cotter *et al*, 1985; Karrow *et al*., 1984, 1986). AMS ^{14}C dating from many sites is needed to resolve the controversy in establishing a regional pattern.

The classic 'tundra' or 'herb' zone at the base of many of the southern New England pollen diagrams suggests that early deglaciation was followed by an open tundra landscape (Gaudreau and Webb, 1985). However, pine and spruce pollen is usually present, suggesting alternatively that a park-tundra existed, with some trees adjacent to the ice margin. The presence of spruce needles at Longswamp, Pennsylvania (Watts, 1979) during the herb zone indicates that this may have been the case. Whether or not scattered trees were regionally present as ice retreated awaits further site macrofossil investigations.

Geomorphological evidence supports the reconstruction of a periglacial climate which resulted in permafrost for several thousand years after ice retreat (Stone *et al*., 1991). Ice-wedge casts, pingo scars, eolian deposits and cryoturbation structures have been identified in Connecticut and Massachusetts (Stone and Ashley, 1992).

The basal sediments in this study are clays and silts, from which we screened macrofossils to determine the age of first regional organic deposition. The ages of these initial terrestrial macrofossils are used to infer a regional climatic warming from 12,600 to 12,300 BP. It is possible, of course, that large-scale ice retreat was even earlier and that remnant dead ice remained in the lakes for several hundred years. AMS radiocarbon dates from the southeastern U.S. show warming as early as 17,000 BP (Kneller and Peteet, 1993).

Linsley Pond (Fig. 1) at 65 m elevation is a small kettle lake in southern Connecticut (41°18′ N, 72°45′ W) in the headwaters of the Branford River in North Branford. It is strongly eutrophic, about 10 hectares in area, 14.8 m deep and has been extensively studied, beginning with Deevey (1939) and continuing with Vallentyne and Swabey (1955). We retrieved a 12 m core in 9.2 m of water about 9 m from the southeastern shore. The core was very organic throughout to 9.4 m and composed of silty organic sediment from 9.4 to 12 m.

Allamuchy Pond (Fig. 1) lies at an elevation of 218 m in a NE–SW trending valley near the western border of northern New Jersey (40°55′ N, 74°50′ W). The lake is oblong in shape, roughly 0.5 km long by 0.4 km wide. The core was taken in 7 m of water and is composed of soft gyttja from 0 to 7.0 m, then dark brown consolidated gyttja from 7.0 to 9.0 m. From 9.0 to 9.3 m depth it is olive-brown clay with some silt.

PREVIOUS FISH REMAINS STUDIES

Few reports mention the presence of fish remains in sediment cores. Lagler and Vallentyne (1956) retrieved two scales, one identified as belonging to a killifish (family Cyprinidontidae) and the other from a minnow (family Cyprinidae) from Linsley Pond, Connecticut and dated at 7500 BP. Pennington and Frost (1961) found scales and vertebrae 450 cm below the substrate surface in a core from Esthwaite Water in the English Lake District. The remains were either a trout or charr, with a probable age of 10,000 to 12,000 BP.

Casteel *et al.* (1977) discovered abundant fish scales and bones in cores from Clear Lake, California. Most of the remains were from *Hysterocarpus traski* (tule perch) and *Archoplites interruptus* (Sacramento perch). The majority of the remains were taken from sediments younger than 11,000 BP, but some were older than 20,000 BP.

Vallentyne (1960) conducted a survey of four ponds in New York and Ontario in an effort to examine the frequency of preservation of fish remains in lake sediments. He found no remains in the deep-water sediments of two of the lakes, but abundant remains, primarily of *Perca flavescens* (yellow perch), in the upper 15 cm of the third lake. He also examined cores taken from a hatchery pond in which a known number of fish had disappeared to roughly determine the percentage of scales and bones that might be preserved. He estimated that 6% were preserved. The results indicate that few remains are likely to be preserved and that preservation depends on several environmental factors.

METHODS

Sediment cores were retrieved from both ice-covered ponds in winter using a modified Livingstone piston corer (Wright *et al.*, 1984). The sediments were refrigerated, then sampled at 5 or 10-cm intervals for pollen and macrofossil analysis of the lower half of the cores.

Percent Organic Carbon

Several samples from each core were measured for loss-on-ignition according to Dean (1974). These samples were selected from four different pollen zones in an attempt to indicate whether or not a reversal in percent organic carbon was characteristic of the stratigraphy.

Pollen and Spores

Tablets of exotic *Eucalyptus* were added to the pollen samples to determine pollen concentration (Benninghoff, 1962). Samples were processed using 2–5 mL of sediment, following the procedures of Heusser and Stock (1984). These included treatment with KOH, HF and HCL, screening with 150 μm and 7 μm screens (Cwynar *et al.*, 1979), oxidation of some samples with a sodium chlorate mixture, acetolysis and silicone oil mounts. Nomenclature follows *Gray's Manual of Botany* (Fernald, 1970). A minimum of 300 pollen grains per sample was counted, including very few aquatics. Spores of cryptogams were tallied in addition to the pollen. Frequency of pollen was calculated based upon the total pollen sum and percentage of spores was based upon the sum of pollen and spores.

Macrofossils

Samples were taken at 5-cm intervals in Linsley Pond and at 10-cm intervals in Allamuchy Pond (about 50cc and 100 cc, respectively). The samples were soaked overnight in KOH, then washed through 0.5 and 0.1 mm mesh screens. The identifiable plant remains were stored in water and refrigerated prior to AMS ^{14}C dating at Simon Fraser University. Charcoal pieces were counted as numbers of macrofossil fragments retrieved.

AMS-dated macrofossils were combusted with CuO in sealed quartz tubes after normal acid/alkali washes. The samples were then combusted to CO_2 and measured as described by Nelson *et al.* (1986). Some of the very small samples had relatively large standard deviations due to uncertainty in the background to be subtracted due to contamination during processing (Vogel *et al.*, 1987).

Fish scales and/or vertebra numbers were also retrieved from the macrofossil screening. The scales were placed between microscope slides and viewed with transmitted light at 20X. They were compared to figures in Cockerell (1913), Lagler (1947) and Cooper (1940) and to scales from 85 species of fish representing all 32 families of fishes inhabiting inland waters in the northeastern U.S. The vertebrae were compared to skeletons belonging to Dr K.W. Gobalet, CSU, Bakersfield and skeletons at the New York State Museum, Albany.

RESULTS

The classical pollen stratigraphy for New England is utilized here because the pollen assemblage zones are identical to those first identified over fifty years ago (Deevey, 1939; Leopold, 1956). Some of the New England sites exhibit a basal 'T' tundra pollen zone with high percentages of herbs (see summary in Gaudreau and Webb, 1985). However, unlike Alpine Swamp (Peteet *et al.*, 1990), neither Linsley nor Allamuchy Ponds contain large percentages of basal herb pollen, suggesting that either we did not penetrate to this zone, or that it was not a feature of these sites.

Radiocarbon Dates

The AMS dates provide fine-resolution stratigraphic control of species-specific changes in the cores (Table 1, Figs 2–6). These AMS dates are our best efforts to date pollen assemblage zones which indicate regional vegetational changes. The major changes targeted by the AMS dates are: (1) the first indication of organic deposition 12,590±430 BP in Linsley Pond and 12,260±220 BP in Allamuchy Pond; (2) the beginning of the Younger Dryas cooling 10,740±420 BP in Allamuchy Pond and (3) the end of the Younger Dryas cooling 9920±230 BP in Linsley Pond. Unfortunately, in some samples, a large error bar results from the small sample size.

Percent Organic Carbon

The loss-on-ignition results (Table 2) suggest a gradual

TABLE 1. AMS Radiocarbon dates on identified macrofossils from Linsley Pond, Connecticut and Allamuchy Pond, New Jersey

Lab no.	Sample interval (m)	Size (μg)	^{14}C age (BP)
Linsley Pond, Connecticut			
RIDDL 1137	10.2–10.25 *Pinus strobus* needle	160	9920 ± 230
RIDDL 1138	10.8–10.85 *Betula pap*. cone bract	195	10,440 ± 230
RIDDL 1139	11.9–11.95 *Picea* needle	140	11,500 ± 300
RIDDL 1140	11.95–12 *Picea* needle	115	12,590 ± 430
Allamuchy Pond, New Jersey			
RIDDL 1236	7.8–7.9 *Pinus strobus* needle	200	9230 ± 160
RIDDL 1237	8.5–8.6 *Alnus* seed	78	10,740 ± 420
RIDDL 1238	9.0–9.1 *Picea glauca* needle	205	12,260 ± 220

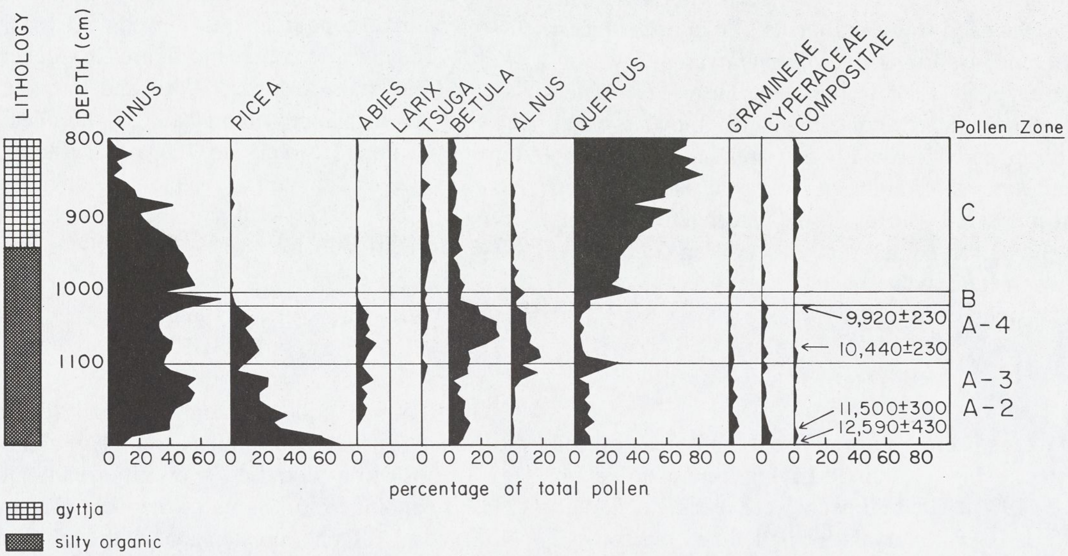


FIG. 2. Pollen percentage diagram of selected types, 8–12 m depth, Linsley Pond, Connecticut.

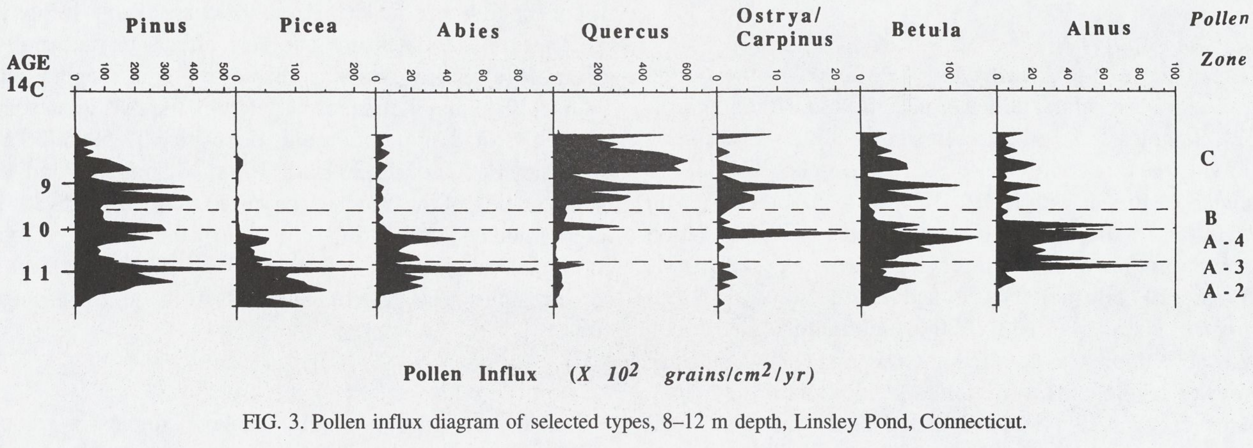


FIG. 3. Pollen influx diagram of selected types, 8–12 m depth, Linsley Pond, Connecticut.

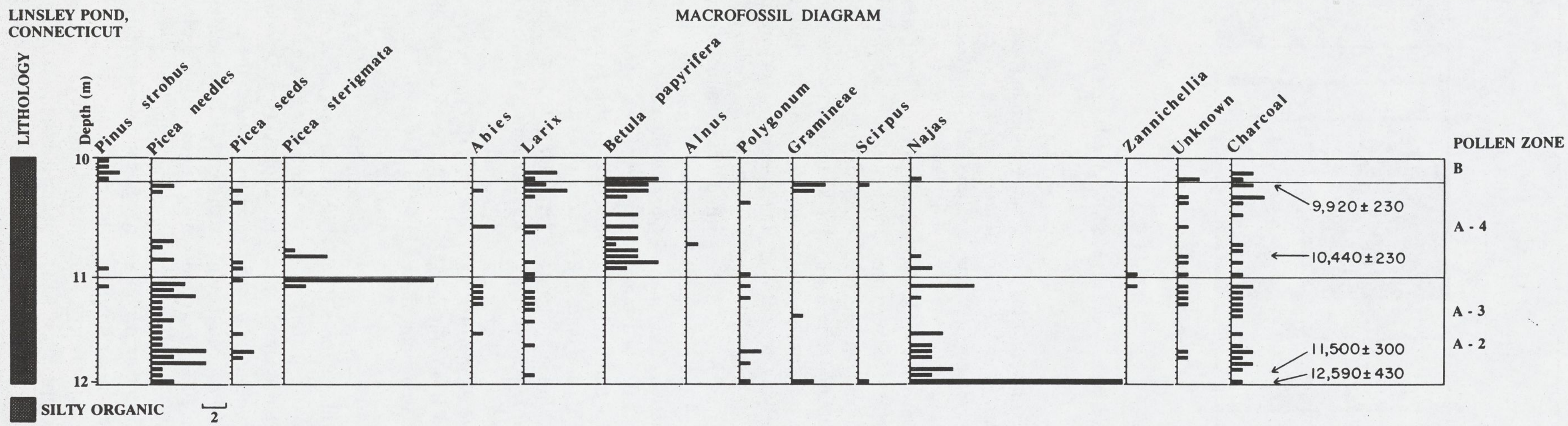


FIG. 4. Macrofossil diagram from 10–12 m depth, Linsley Pond, Connecticut. Samples represent material from 50 cc at 5-cm intervals. *Pinus*, *Abies* and *Larix* macrofossils are needles, *Betula papyrifera* remains includes cone scales and seeds and the remainder denote seeds.

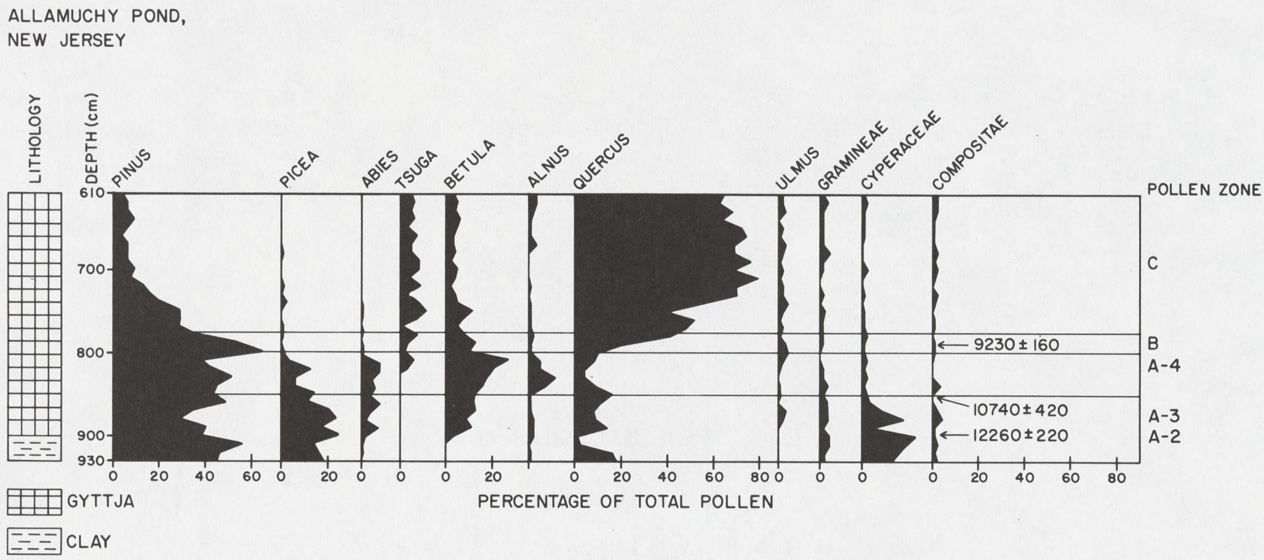


FIG. 5. Pollen percentage diagram of selected types, 6.1 to 9.3 m depth, Allamuchy Pond, New Jersey.

increase of percent organic carbon over time. In Linsley Pond, the values range from 26.3% in pollen zone A-3 to as high as 60.2% in pollen zone C. These percentages are very close to those in Alpine Swamp, New Jersey (Peteet *et al.*, 1990). In Allamuchy Pond, basal values are as low as 8.7% and increase in zone C to as high as 38.8%. Neither core results indicate a reversal in percent organic carbon with the vegetative change indicative of a cooler climate (zone A-4). However, of interest in Allamuchy Pond is a slight decrease from 31.3% in zone A-3 to 27.3% in overlying zone B.

Linsley Pond (Figs 2–4)

The pollen influx age model for Linsley Pond is based upon the AMS ^{14}C dates in Table 1. Calculation of sedimentation rates is based upon acceptance of the 11.925 m depth of 11,500 BP, the 10.825 m depth as 10,440 BP and the 10.225 m depth as 9920 BP. We used the 11,500 BP basal date on a *Picea* needle for calculation of the basal sedimentation rate because the older needles could have been reworked. Thus the sediment accumulation rates ranges from 0.104 cm/year (11.925 m to 10.825 m) to 0.115 cm/year (10.8 m to 10.225 m) and then to 0.103 cm/year (10.225 to 0 m). Figure 3 illustrates the changes in pollen influx based upon these sediment accumulation rates.

Pollen evidence (Figs 2,3). Five pollen zones are recognized in the core from a depth of 12 to 8 meters.

Zone LP-A-2-3, Picea-Quercus. The pollen assemblage is characterized by high percentages of *Picea* and *Quercus*, with significant percentages of *Betula*. Maximum percentages of *Quercus* rise to greater than 20%. *Alnus* and *Tsuga* percentages rise at the close of A-3, while *Picea* declines. *Pinus* increases upward in the zone, then declines just prior to the transition to A-4. The pollen influx diagram (Fig. 3) suggests that while *Picea* is a dominant pollen type in A-2, *Pinus* and *Quercus* are the major contributors at the close of this zone. In particular, these two genera have greater pollen influx values in portions of this zone than they do in portions of zone C. *Ostrya-Carpinus* influx is also higher in zone A-3 than in some portions of overlying zones B and C. *Tsuga* begins to increase in this zone.

Zone LP-A-4, Picea-Abies. Increases in percentages of four boreal trees are marked in zone A-4. As pollen percentages of *Picea*, *Abies*, *Larix* (larch), *Betula* and *Alnus* increase, *Quercus* percentages decline. The pollen influx diagram suggests that influx values of all genera decline markedly in this zone compared with A-3, excepting *Betula* and *Alnus*. At the close of this zone, *Ostrya-Carpinus* and *Tsuga* influx values again rise.

Zone LP-B, Pinus. This zone is dominated by *Pinus*, while the boreal conifers, *Betula* and *Alnus* species decline. *Quercus* begins to increase. Pollen influx of *Pinus* and *Quercus* increase in this zone, then drop off.

Zone LP-C, Quercus. *Quercus* makes a dramatic increase in this zone, as *Pinus* declines. *Picea* and *Abies* percentages drop to less than 2%, while *Betula* and *Alnus* also decrease. *Quercus* influx values vary dramatically in this zone, reaching a maximum as well as very low values.

Macrofossil evidence (Fig. 4)

Evidence of the presence of boreal conifers as early as 12,590±430 BP in Connecticut is provided by the occurrence of *Picea* needles. (The needles are thought to be *Picea glauca*, because of the lack of hairs on the *Picea* twigs.) Published keys differentiating between *Picea glauca*, *Picea rubens* and *Picea mariana* needles have been found to be incomplete (see Delcourt, 1979). Maximum numbers of needles occur in the earlier part of this zone, near the basal sediments. These needles, seeds and sterigmata form the major terrestrial macrofossil component of zones A-3 and A-2, along with the needles of *Abies* and *Larix*. *Pinus strobus* needles and *Zanichellia palustris* seeds appear at the close of this zone. The large numbers of *Najas flexilus* seeds may indicate either the shallow water depth or a water quality parameter such as nutrient availability, temperature, or pH. It is interesting to note a similar pattern in large numbers of *Najas flexilis* at Criders Pond, Pa. during the late-glacial (Watts, 1979).

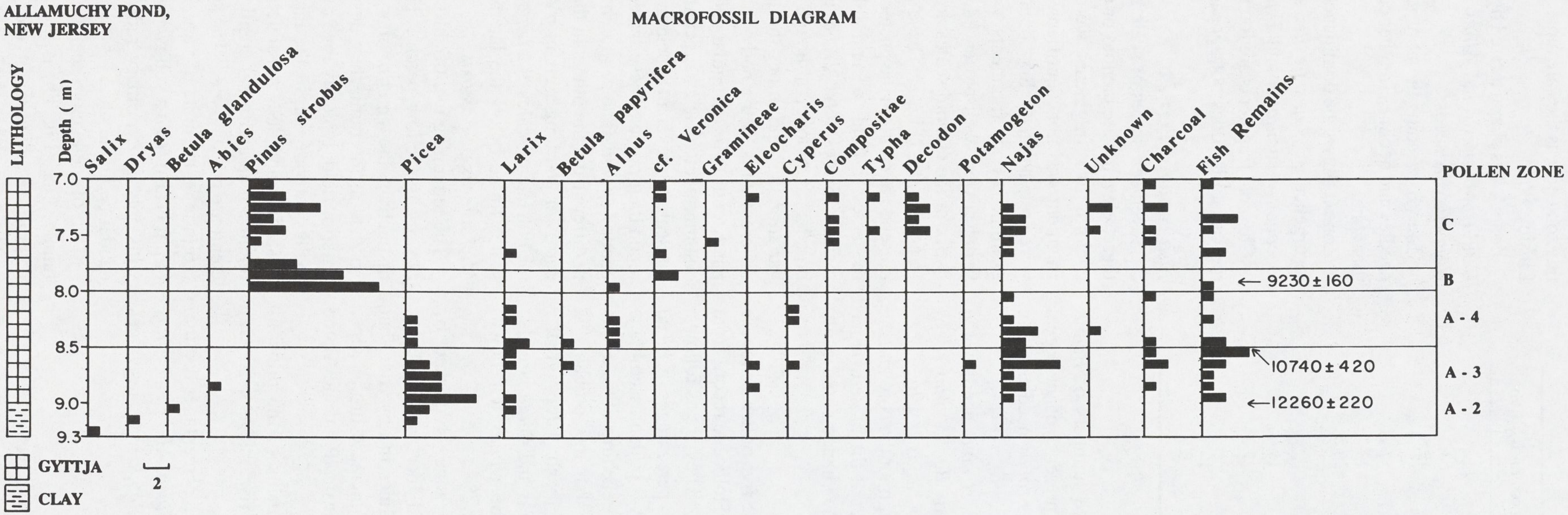


FIG. 6. Macrofossil diagram from 7 to 9.3 m depth, Allamuchy Pond, New Jersey. Conifer remains include needles or needle leaf bases (*Picea*), *Betula glandulosa* cone scale, *Dryas* and *Salix* leaf fragments, and the remaining are seeds unless designated otherwise.

TABLE 2. Loss-on-ignition results for selected samples from Linsley Pond, Connecticut and Allamuchy Pond, New Jersey

Depth (m)	Pollen zone	Loss-on-ignition
Linsley Pond, Connecticut		
9.0	C	60.2
9.5	C	45.5
10.25	A-4	34.6
10.50	A-4	27.8
11.0	A-3	28.4
11.5	A-3	26.3
Allamuchy Pond, New Jersey		
7.0	C	38.9
7.5	C	32.7
8.0	B	27.3
8.2	A-4	31.3
8.8	A-3	16.7
9.0	A-2	8.7

Zone A-4 is distinguished by large numbers of *Betula papyrifera* seeds and cone scales, the presence of the boreal conifers and disappearance of *Pinus strobus* needles along with decreases in *Najas flexilis*.

Zone B marks the return of *Pinus strobus* needles, the disappearance of *Picea*, *Abies* and *Betula papyrifera* macrofossils, along with the return of *Najas flexilis*.

Charcoal fragments are found throughout the core and the number of fragments is slightly higher at the close of zone A-4. However, we do not consider the change significant.

Allamuchy Pond (Figs 5,6)

Pollen evidence (Fig. 5). The same five pollen zones are recognized in the late-glacial to early Holocene record from Allamuchy Pond, New Jersey (Fig. 5). They are as follows: *Zone AL-A2-3, Picea-Quercus.* High percentages of *Picea* and *Quercus* dominate the A-2 and A-3 pollen assemblage zones, with percentages of *Quercus* reaching 20%. *Pinus* ranges from approximately 30–60%, but this probably is long-distance transport. Cyperaceae reach values greater than 20% in this zone as well and *Abies* and *Betula* are also noteworthy components of the A-3 zone. *Ulmus* (not shown) is present in percentages of less than 2%.

Zone AL-A-4, Picea-Abies. The zone is marked by decreases in *Quercus* and *Pinus* and increases in *Abies*, *Betula* and *Alnus*. *Picea* initially declines in this zone, but then also increases. *Tsuga* begins to increase in the upper portion of this zone, just as it does in Linsley Pond and Alpine Swamp (Peteet *et al.*, 1990).

Zone AL-B, Pinus. As the dominants of the previous zone decline, *Pinus* shows a dramatic rise, just as in Linsley Pond. *Quercus* also begins to rise.

Zone AL-C, Quercus. *Pinus* pollen percentages decline, while *Quercus* increases markedly. *Picea*, *Abies* and *Alnus* percentages continue to be low, while *Betula* indicates values close to 10%.

Macrofossil evidence

Botanical (Fig. 6). Basal Zone A-2 has a *Salix* leaf, *Dryas* leaf and *Betula glandulosa* cone scale, along with *Picea* and *Larix* needles. *Picea* needles increase in zone A-3 and an *Abies* needle demonstrates its presence in the Allamuchy region. *Najas flexilis* seeds are most abundant in this zone, just as they are most abundant in basal sediments of Linsley Pond.

Zone A-4 is characterized by *Picea* needles, *Larix* needles, *Betula papyrifera* and *Alnus* seeds and fewer numbers of *Najas flexilis* seeds.

Zone B contains the abrupt appearance of *Pinus strobus* needles and declines in other conifers. *Najas* also is absent in this zone.

Zone C shows the dominance of *Pinus strobus* needles, the resurgence of *Najas flexilis* and some emergents such as *Decodon verticillatus* and *Typha*.

Charcoal fragments are found throughout the samples, but the variability does not appear to be significant.

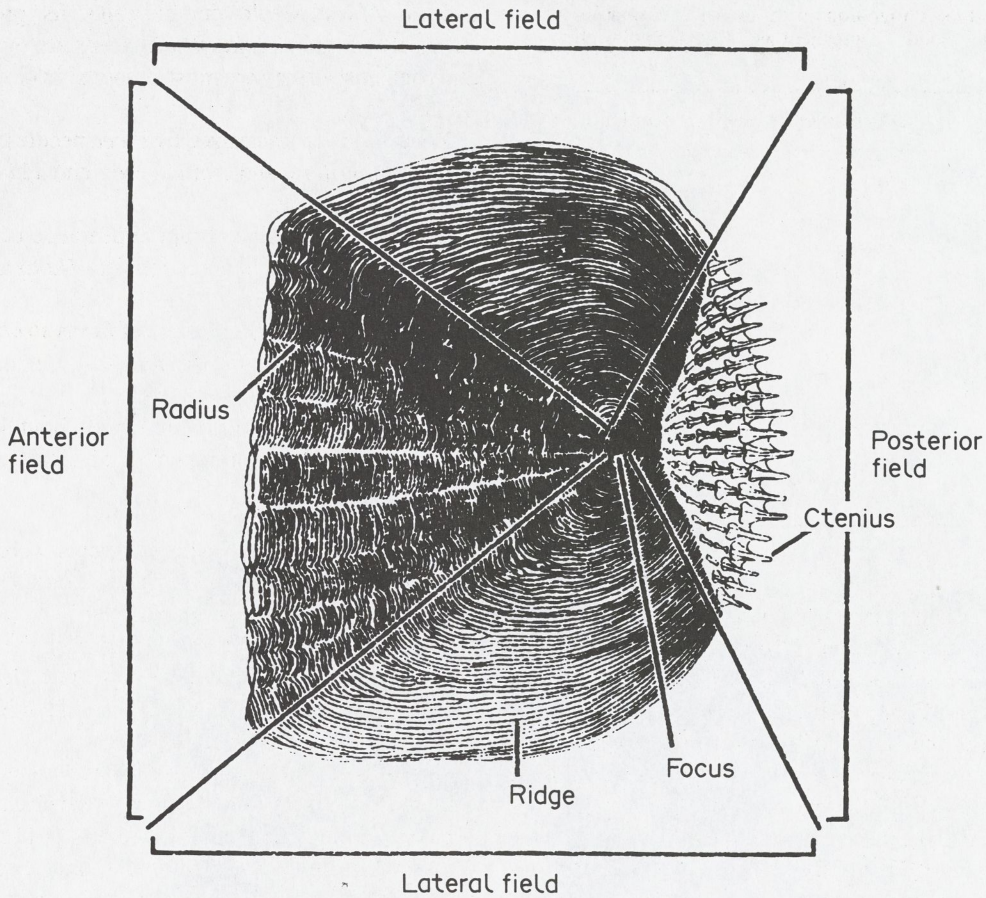
Fish remains (Figs 7,8)

Seventeen scales or scale fragments were examined. Of these, eleven were ctenoid or ctenoid fragments, three were cycloid, two fragments were probably cycloid and one fragment was not identifiable. Three of the ctenoid scales were regenerated. Six bone or bone fragments were examined. Four fragments were not identifiable, but two vertebra were well-preserved.

Six of the ctenoid scales are from members of the family Centrarchidae (Fig. 7). These scales are characterized by the presence of ctenii in the posterior field, 9–11 primary radii in the anterior field, a central focus and a crenate anterior margin. Scales tend to be quadrate or subquadrate and broader than long, although there is a wide amount of variation in shape among the species and among scales from different parts of the body on an individual fish. The ctenii patch tends to be triangular and does not reach the focus. The columns of ctenii are staggered so that the posterior margin of the scale is uneven in appearance. Apical and subapical ctenii retain their points. These scales are probably from fish in the genus *Lepomis*. The centrarchid scale within the layer 7.9–8 m differs from the others in that it is more circular and has a narrower and longer ctenii patch. This scale may be one of the non lateral scales of a *Lepomis*, but it also matches lateral scales found below the lateral line in fishes in the genera *Micropterus* or *Pomoxis*.

The remaining identifiable ctenoid scales are from *Perca flavescens* (yellow perch). The scales from this fish are distinctive: the anterior margin of the scales are deeply notched at the radii, they possess few primary radii in the anterior field, typically fewer than seven, the focus is closer to the posterior margin, the anterior margin of the ctenii patch is straight and does not touch the focus, only apical ctenii retain points and basal ctenii are quadrate and the rows of ctenii are not staggered. The scale from within interval 8.5–8.6 m is an example of variation within an individual (Fig. 8a). It is also from a yellow perch, even though it is quadrate with only four primary radii. It matches scales from the caudal peduncle area.

Two of the cycloid scales can be identified to a probable family. One (Fig. 8b) is probably from a minnow, family Cyprinidae, although it did not match any scale in the comparative material. North American cyprinids have scales distinguished by radii in the posterior field and a focus close



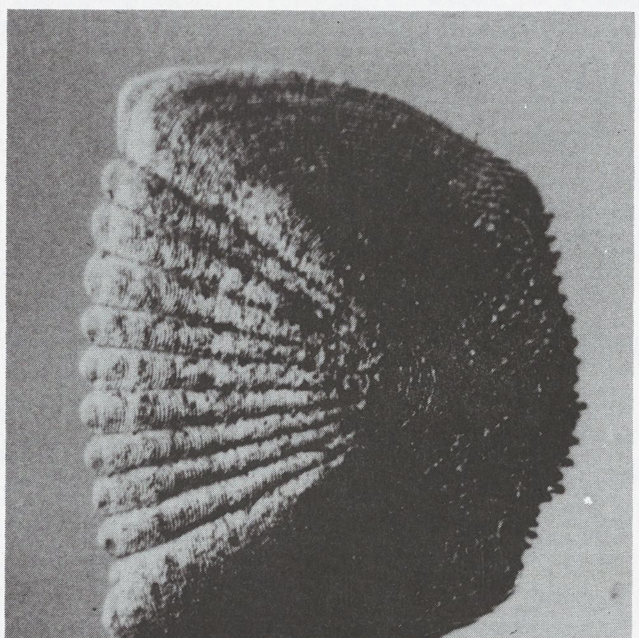


FIG. 7. Ctenoid sunfish scale at depth 7.9–8.0 m, Allamuchy Pond, New Jersey and schematic diagram of descriptive fish scale terms.

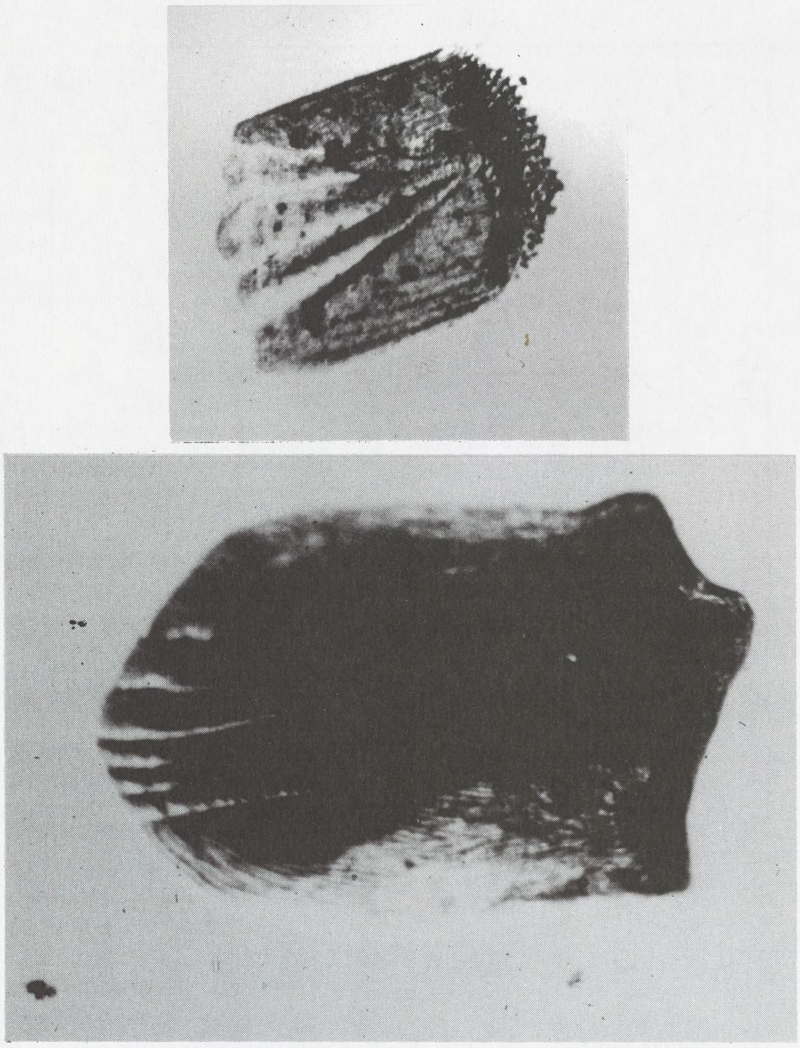


FIG. 8. (a) Ctenoid fish scale, from *Perca flavescens* (yellow perch), at 8.5–8.6 m, Allamuchy Pond, New Jersey (top). (b) Cycloid scale, probably from a minnow, family Cyprinidae, depth 7.35–7.4 m, Allamuchy Pond, New Jersey (bottom).

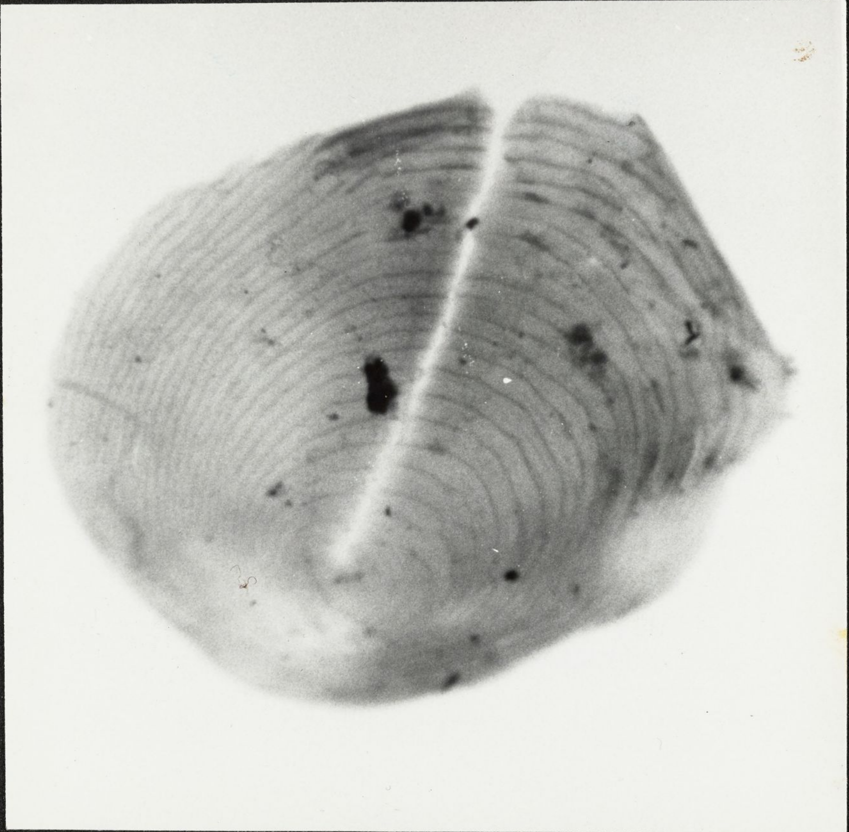
to the anterior margin. This scale meets these criteria but differs from the comparative material in its width/length ratio and in the presence of parallel radii. A second cycloid scale, from layer 8.8 to 8.9 m is tear-shaped. There are no radii on this scale and ridges encircle an ovoid focus. These scale characteristics are typical of fishes in the family Salmonidae. Other features of this scale are not characteristic of salmonid scales, but, since scales are variable, do not preclude a salmonid identification. The focus sits near the posterior margin of the scale, ridges are more crowded in the posterior field than the anterior field and the tear shape is unusual. However, this scale matches one figured by Cooper (1940) taken from a *Salmo salar*, land-locked Atlantic salmon, in Maine.

The two vertebrae are identified as yellow perch based on the angle of the neural arch and the number and position of struts on the centrum. One is a trunk vertebra, similar in appearance to the posterior-most in the series. The other is the anterior caudal vertebra.

DISCUSSION

Regional Vegetational and Climatic Change

The sequence of pollen assemblage zones is virtually identical for a large region of the northeastern U.S. and southern New England (Watts, 1979; Whitehead, 1979; Gaudreau and Webb, 1985; Peteet, 1987) including southern Connecticut (Deevey, 1939; Leopold, 1956; Davis, 1969; this paper), northern New Jersey (Peteet *et al.*, 1990; this paper), central Mass. (Davis, 1958), the Berkshires, Massachusetts (Whitehead, 1979) and eastern Pennsylvania (Watts, 1979). Cape Cod, Massachusetts, features the same *Picea-Alnus* rise concurrent with a *Quercus* decline (Winkler, 1985) and Hammock River Marsh, Connecticut (Shaw and van de Plassche, 1991) shows a similar pattern. The interpretation of most of these sites has been one of unidirectional vegetational change consistent with continued warming (see Peteet *et al.*, 1990 for full discussion). In contrast to this view, our macrofossil evidence in conjunction with AMS radiocarbon dating at three sites leads us to interpret the A-4 pollen zone (approximately 11–10,000 BP) as a marked *regional* vegetational change consistent with a Younger Dryas cooling. The presence of *Pinus strobus* needles are particularly important as an indicator of warming before and after the Younger Dryas. The modern distribution of *Pinus strobus* (Fig. 9) is temperate in contrast to the boreal distribution of *Picea*, *Abies*, *Larix* and *Betula papyrifera* (Fowells, 1965).



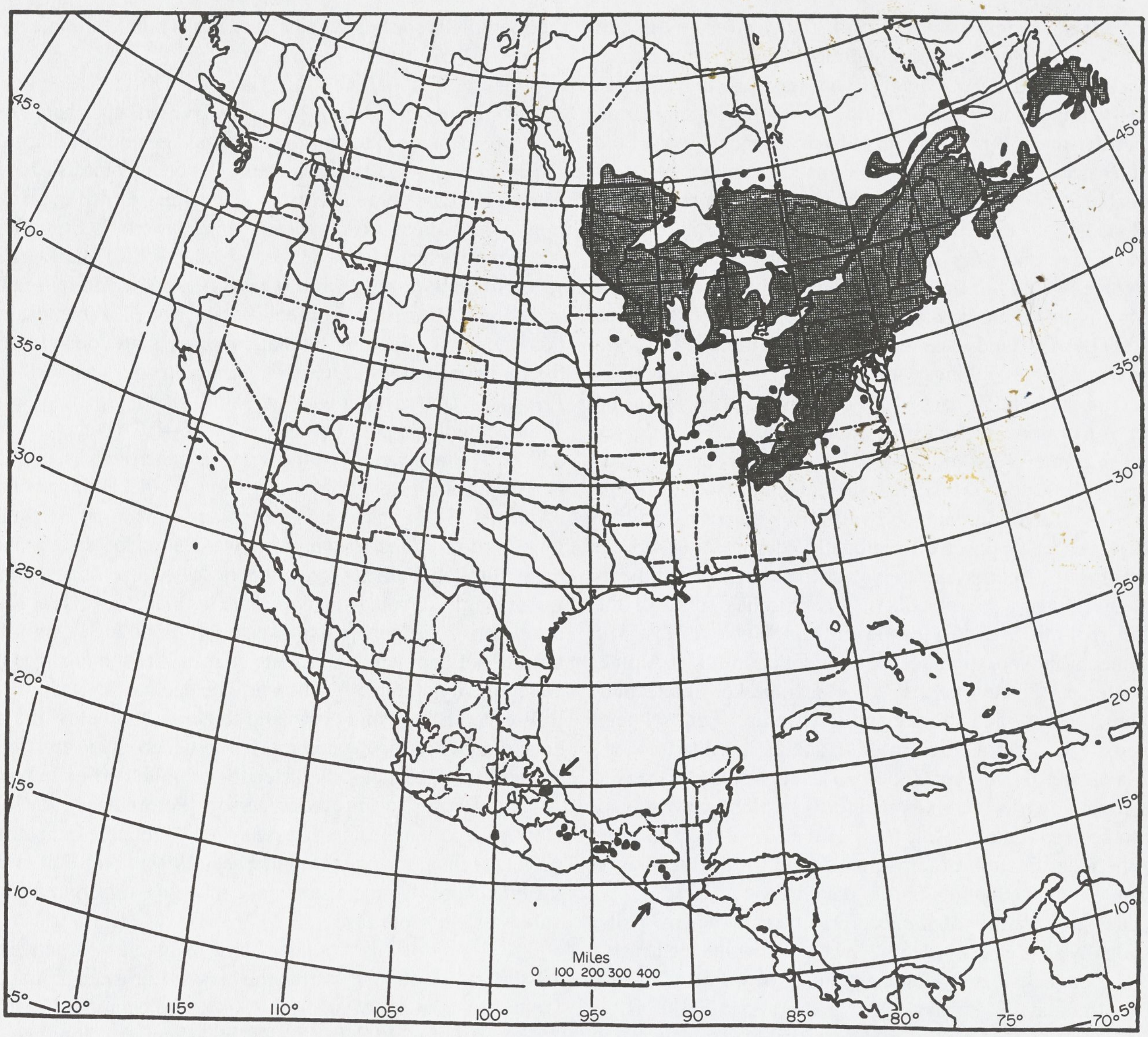


FIG. 9. The modern range of eastern white pine, *Pinus strobus* (after Fowells, 1965).

Zones LP-A-2 and AL-A-2, prior to 12,000 BP. The earliest vegetation at Allamuchy Pond occurred before approximately 12,260, as defined by an AMS-dated *Picea* needle (Fig. 6 and Table 1). At Linsley Pond the first *Picea* needle is 12,590±430 BP (Fig. 4 and Table 1), but the standard deviation is such that deposition could have begun in both basins at approximately the same time. This relatively late organic deposition compared with early estimates of deglaciation (17,000 BP, Borns, 1973; Connally and Sirkin, 1973) and a 15,210 BP date from Crider's Pond, Pennsylvania (Watts, 1979) suggests several alternative explanations. First, it is possible that these relatively old bulk dates are correct and that stagnant ice filled Linsley and Allamuchy Ponds for several thousand years before organic deposition began. Second, we can reject the bulk dates and suggest that ice retreat was actually much later than 17,000 BP locally and the ice retreat was rapidly followed by plant migration to the region. Basal bulk dates from Tannersville, Pennsylvania, (Watts, 1979) are 13,330 BP and Rogers Lake, Connecticut has a basal bulk organic date of 14,240±240 (Stuiver *et al.*, 1963; Davis *et al.*, 1980).

We prefer the second alternative because of the confidence in AMS dates compared with bulk radiocarbon dates and because of the regional AMS pattern for the dates of earliest identifiable macrofossils. For example, Alpine Swamp, New Jersey has a basal *Picea* needle date of 12,290±440, which is very similar to Allamuchy and Linsley Pond. Therefore, we conclude that deglaciation of the area occurred earlier than 12,400 BP, but how much earlier is difficult to ascertain until basal AMS ages are obtained from macrofossils from additional sites.

The initial vegetation at Allamuchy Pond (AL-A-2) was probably a mixture of shrubs, herbs and trees. Although *Pinus* pollen percentages reach values over 40%, it may be long-distance transport because *Pinus* macrofossils were not found here, nor in Alpine Swamp, New Jersey nor in northeastern Pennsylvania (Watts, 1979). The closest documented location of *Pinus banksiana* needles is from Criders Pond, in southeastern Pennsylvania. In contrast, *Picea* reaches values of 20% and was regionally present because *Picea* macrofossils appear in basal Linsley Pond sediments (Fig. 4) as well as in Tannersville and Crider's

Pond, Pennsylvania (Watts, 1979). *Picea* macrofossils are present in Allamuchy Pond sediments along with *Betula glandulosa* and *Dryas integrifolia,* just as they are in Longswamp, Pennsylvania (Watts, 1979). This combination of conifer-dwarf birch is found today in alpine regions of the northeastern U.S. and adjacent Canada (Fernald, 1970). It probably is best defined as a park-tundra environment.

Zone LP-A-3 and AL-A-3, 12,000 to 10,800 BP. While *Pinus, Picea* and *Quercus* are the dominant pollen types in this zone, we do not find evidence of the presence of *Pinus* macrofossils (*Pinus strobus*) near these sites until close to 11,000 BP. The landscape was apparently a mixture of *Picea, Larix* and *Abies*, along with a deciduous component of *Quercus* and significant contributions of *Fraxinus* and *Ostrya-Carpinus* in nearby Alpine Swamp, New Jersey (Peteet *et al.*, 1990) and Rogers Lake, Connecticut (Davis, 1969). We accept the significant percentages of *Quercus* (20%) and relatively high *Quercus* influx values to indicate the presence of this tree regionally, despite the lack of macrofossils. Acorns are rarely ever found in lake sediments and the modern 5% isopoll of *Quercus* lies south of the northern limit of oak trees (Davis and Webb, 1975). The sediments are very organic and total pollen influx at Alpine, New Jersey (Peteet *et al.*, 1990), Rogers Lake, Connecticut (Davis, 1969) and Tannersville Swamp, Pennsylvania (Watts, 1979) are as high in this zone as in mid-Holocene sediments. This view of Zone A-3 as representing a mixed thermophilous deciduous-boreal forest, which we previously hypothesized (Peteet *et al.*, 1990; Peteet, 1992) is reinforced by the identification of temperate *Pinus strobus* needles in Linsley Pond sediments in this pollen zone.

The appearance of *Larix* (pollen and macrofossils) regionally at three sites (Alpine Swamp, New Jersey, Linsley Pond, Connecticut and Allamuchy Pond, New Jersey) as well as at Tannersville, Pennsylvania (pollen) after 13,000 BP is noteworthy. *Larix* is very widely distributed today in the boreal and northern forest regions and grows under extremely varied climatic conditions. Possibly the increasing seasonality of climate was conducive to *Larix* growth, or perhaps *Larix* was simply migrating northward. The late-glacial presence of *Larix* at Rockyhock Bay, North Carolina (Whitehead, 1981) and Browns Pond in Virginia (Kneller and Peteet, 1993) suggests that *Larix* migrated north from the southeastern U.S. The presence of *Abies balsamea* at this same time (pollen and macrofossils) suggests that the climate was mesic and cool.

The close of this zone records the presence of *Pinus strobus* macrofossils in Linsley Pond (Fig. 4) along with high *Pinus* influx. *Pinus strobus* needles also are present at this time in Tannersville, Pennsylvania (Watts, 1979). The presence of this tree at the two sites is strong evidence for a warmer climate, as today its distribution is in the eastern portion of eastern North America (Fig. 9) where July temperatures range from 17 to 22°C (Fowells, 1965). A moisture surplus today occurs in all seasons of its range. The appearance of *Tsuga* at the close of this zone in Linsley Pond also suggests temperate and moist conditions. Although the percentages are low, *Tsuga* pollen is considered to be proportionately represented to basal area (Davis and Goodlett, 1960). The combination of boreal and thermophilous species suggests a cool and humid climate just prior to 11,000 BP.

Zones LP-A-4 and AL-A-4, 10,800–10,000 BP—Correlative with Younger Dryas. The striking change in pollen percentage in pollen zone A-4 has been noted since the 1930s (Deevey, 1939). The increase in boreal conifers *Picea, Abies and Larix* along with a clear increase in *Alnus* and *Betula* is typical of numerous northeastern U.S. pollen diagrams (Peteet, 1987; Peteet *et al.*, 1990). The *Betula* species is *Betula papyrifera* (Figs 4,6 as indicated by seeds and cone scale bracts), a boreal species as well. We interpret this regional rise in boreal species and decline in thermophilous trees (*Quercus, Pinus strobus,* as well as *Fraxinus, Ostrya-Carpinus* at some sites) to indicate a climatic cooling, possibly as great as 3–4°C (Peteet *et al.*, 1990). The absence of *Pinus strobus* macrofossils in this zone, both at Linsley Pond and at Tannersville, Pennsylvania (Watts, 1979), suggests that the colder climate arrested the migration of *Pinus strobus* northward after ice retreat and either limited pollen production or killed existing stands. Interestingly, at both sites, *Najas flexilis* macrofossils decline during this zone from maximal values in Zone A-3. This may or may not be related to climate change through changes in water quality affected by climate. The decline in total pollen influx at Linsley Pond compared to zones A-3 below it and zone B above it (Fig. 3) suggests less productivity overall, but the same result is not a characteristic of pollen influx in zone A-4 at Alpine Swamp, New Jersey (Peteet *et al.*, 1990). However, pollen influx values may not be reliable indicators of vegetational change, as Batterbee (1991) notes that even different cores from the same lake may give different influx values at the same level.

The timing of this Younger Dryas equivalent is between 10,800 and 10,000 BP, within the classic European Younger Dryas chronozone (Mangerud, 1974). The beginning of this zone is dated at 10,740±420 BP in Allamuchy Pond, New Jersey from one *Alnus* seed. The small size of the sample unfortunately precludes defining the precise timing of the onset of this cooling event. At Linsley Pond, our age model (Fig. 3) derived from available AMS dates (Table 1) places the onset as roughly the same as Allamuchy, which is close to 10,800 BP. The initiation of the Younger Dryas at 10,800 BP is similar to recent European AMS ages for the timing of this interval (Peteet, 1992), both in Ireland (Cwynar and Watts, 1989) and in France (Pons *et al.*, 1987). The termination of the cooling is dated from the first re-appearance of a *Pinus strobus* needle in Linsley Pond at 9,920±230 BP. If we use the sediment accumulation rates from the AMS-dated macrofossils in both cores, we find that this warming took place in 50 to 100 years, which parallels the sudden warming in Greenland noted by Dansgaard *et al.* (1989).

Zone LP-B, AL-B, 10,000–9000 BP

A sharp decline in boreal conifers, *Betula papyrifera* and *Alnus* along with a sudden increase in *Pinus* and a more gradual increase in *Quercus* denotes the warming that took place close to 10,000 BP. The macrofossil evidence for this warming is quite clear, as *Picea* and *Abies* needles and *Betula papyrifera* macrofossils all disappear within a century in this warmer zone. The sudden re-appearance of *Pinus strobus* indicates the rapid warming that apparently was responsible for the demise of the boreal conifers. No additional *Pinus* species are found in this zone at Allamuchy Pond, Linsley Pond, or Alpine Swamp, New Jersey. This suggests that the 'B' pine pollen zone represents a time of major *Pinus strobus* dominance in the northeastern U.S. However, the documentation of *Larix* needles in zones B (Linsley) and C (Allamuchy) indicate that it was able to remain at these wetland sites despite the changes in climate. *Larix* is often found today in wetlands of this northeastern U.S. region.

The duration of the classical 'B' Pine pollen zone is difficult to determine and more detailed analysis of this zone and the beginning of the 'C' zone is needed. However, a date of 9230±160 BP on a *Pinus strobus* needle in the B zone from Allamuchy Pond suggests that it lasted at least 600 and possibly a thousand years.

Comparison with extra-regional palynological sites

In southwestern New York, the palynological stratigraphy is not as striking a pattern as in more coastal sites. Allenberg Bog shows a *Quercus-Fraxinus* oscillation with *Picea*, but this oscillation appears to begin earlier and because it is not clearly matched in pollen influx, Miller (1973) interprets it simply as an increase of *Picea-Pinus* forests on the landscape. However, he accepts the presence of *Quercus*, *Fraxinus* and *Ostrya/Carpinus* in the 'A' pollen zone as possibly a regional signal, suggesting that these thermophilous trees occupied sites within tens of miles from the basins (Miller, 1973). A slight oscillation in *Quercus* pollen influx may record a cooling, but lack of chronological control precludes correlation with southern New England sites. It is interesting to note that recent macrofossil analysis shows that *Pinus banksiana* was in western New York at the Hiscock site 11,200 BP (Miller, 1990). Thus it was a possible source for the windblown pine pollen in the coastal sites.

Most palynological sites in the high mountains of the Adirondacks, New York were not deglaciated as early as the sites in New Jersey, Connecticut and southern New York (Whitehead and Jackson, 1990). However, a bulk date from Upper Wallface Pond, New York suggests that deglaciation took place there around 12,300 BP (Whitehead and Jackson, 1990). The sampling resolution and poor chronological control makes correlation with the southern New England sites marginal, but Heart Lake, Adirondacks, New York, does show a drop in thermophilous species (*Carya, Fraxinus, Ulmus, Ostrya-Carpinus*) concurrent with a *Picea* increase at 10,475 BP (Whitehead and Jackson, 1990). The *Picea* increase is immediately followed by an increase in *Alnus* and *Betula papyrifera,* which may indicate a successional advance of light-demanding species with the decline of *Picea.*

To the east, in the White Mountains of New Hampshire, Deer Lake Bog and Lake of the Clouds show a pattern similar to the general pattern of 11 to 10,000 BP, in which the thermophilous rise (*Quercus* at 10%) is suddenly followed by a *Quercus* decrease concurrent with a rise in *Picea*, *Betula* and *Alnus* and a drop in total pollen influx (Spear, 1989). *Picea* and *Alnus* then decrease with the subsequent rise of *Quercus*, *Pinus* and *Betula*. Although the deposition rates are low in the late-glacial sediment of these cores (less than 1 m per five thousand years versus 0.75 m per thousand years in southern New England), the palynological oscillation suggests that this thermophilous-boreal reversal is consistent from northern to southern New England. The large *Alnus* rise between 11,000 and 10,000 BP may indicate disturbance from severe winters, as suggested for sites to the south (Peteet *et al.*, 1990).

Although a number of sites in northern New England contain a late-glacial sequence back to at least 12,000 BP, many of these are unpublished (Davis and Jacobson, 1985). The available data have been interpreted to indicate progressive late-glacial and early Holocene warming (Davis and Jacobson, 1985). While some cores apparently do not have the resolution to record the late-glacial in detail, Gould Pond, Maine (Jacobson *et al.*, 1987) shows a clear *Picea-Alnus* rise concurrent with a *Quercus* decline between 11,000 and 10,000 BP, suggesting an extension of the regional pattern. Further research is needed to establish the timing of this pattern securely.

Sites in Atlantic Canada have recorded the Allerod/Younger Dryas through both lithological and palynological changes (Mott *et al.*, 1986; Mayle *et al.*, *in press*) as well as paleotemperature reconstructions of lakes based upon chironomid larvae (Levesque *et al.*, 1993). The pattern of vegetational change with the onset of the Younger Dryas is variable within Atlantic Canada and ranges from a change from woodland to shrub-tundra or from shrub-tundra to herb-tundra (Levesque *et al.*, 1993). However, the rise in *Alnus* is a common signal to these sites as well as those in northern and southern New England (Mayle *et al.*, *in press*).

In summary, the northern New England and adjacent Atlantic Canadian sites do show a late-glacial oscillation that often includes an increase in *Picea* and *Alnus* at the Younger Dryas chronozone, 11–10,000 BP. We interpret this vegetational change spanning 5 degrees of latitude as indicative of a major climatic cooling that took place in response to the cooling of the North Atlantic (Ruddiman and McIntyre, 1981; Broecker *et al.*, 1985) and changes in atmospheric circulation as evidenced from ice cores (Taylor *et al.*, 1993; Alley *et al.*, 1993).

Several questions concerning late-glacial climate in eastern North America indicate the importance of additional study, with particular emphasis on fine resolution analysis. Does the Younger Dryas interval include changes *within* this zone that can be interpreted climatically? Is the radiocarbon plateau (Amman and Lotter, 1989) visible in U.S. late-glacial records? Did the migration of *Pinus strobus* originate from regions to the south or from the western Great Lakes region? How long did the 'B' *Pinus strobus* zone last?

Allamuchy pond fish remains

Allamuchy Pond fish remains encompass a mix of scales that is not unexpected based on previous reports. Ctenoid scales are more numerous than cycloid since cycloid scales are less bony and will tend to decompose more rapidly (Hopkirk, 1988).

No recent reports document the fish assemblage in Allamuchy Pond today, but the assemblage present during the late-glacial and early Holocene is not unlike the assemblage found in ponds throughout the northeast today. It consisted of sunfish, minnow, trout and yellow perch. Other fishes are often present in modern ponds, but they are typically soft-rayed fishes like *Notemigonus crysoleucas* (golden shiners) and *Catostomus* sp.(suckers) or fishes without scales like *Ameiurus* sp (bullheads) or *Cottus* sp. (sculpins). It is, perhaps, not surprising then that the remains of these other fishes were not collected in the core.

However, several questions concerning the fish remain. The one ctenoid scale that matches the *Micropterus* (black bass) or *Pomoxis* (crappie) scale is puzzling since these fishes are not considered native to the area. The minnow scale appears more robust and thicker than any minnow scale from the comparative collection. Parallel radii are also unusual on minnow scales, although they were observed on a few scales in the reference material.

The most interesting scale is that of the salmonid, identified as a scale from *Salmo salar*, the Atlantic salmon. Atlantic salmon are an anadromous fish that make annual spawning migrations into coastal rivers and streams in North America and Europe. Some native land-locked populations also exist in Canada and New England. Historically, Atlantic salmon have not entered streams south of the Housatonic River system in Connecticut (Bigelow and Schroeder, 1953), although early explorers reported their presence in the Hudson River (see Smith, 1985). The presence of an Atlantic salmon in Allamuchy Pond in the Delaware River system is an important find and indicates that this species migrated north with the glacial retreat. Additional samples may aid in interpreting these data.

CONCLUSIONS

(1) Initial organic deposition, as evidenced by AMS ages on terrestrial macrofossils from these three lakes, began about 12,400 BP. This age, which roughly coincides with the Bölling warming in Europe (Watts, 1980) and Greenland ice cores (Johnsen *et al.*, 1992; Taylor *et al.*, 1993; Alley *et al.*, 1993) shows that the timing of significant climatic change as evidenced by major vegetational change, is similar across the North Atlantic. Thus it appears that a major climatic warming abruptly took place throughout at least half the Northern Hemisphere at this time, affecting vegetation significantly. This major warming was apparently caused or dramatically enhanced by increased North Atlantic Deep Water Production (Broecker *et al.*, 1985). However, the timing of the *initial* warming responsible for ice retreat allowing these lakes to form, is derived from sites to the south and appears to begin as early as 17,000 BP (Kneller and Peteet, 1993).

(2) Remains of *Picea* are found at all three sites in the basal sediments. *Larix* and *Abies* were also present and at the close of the late-glacial warm (Alleröd) interval, *Pinus strobus* macrofossils appear and *Quercus* pollen percentages and influx increase, suggesting further warming. A change in the abundance of the aquatic *Najas flexilis* possibly suggests a change in the nutrients, water depth, or water temperature. Fish remains occur throughout the core, but do not indicate species oscillations which are indicative of climate change. However, presence of Atlantic salmon in the sample is indicative of a general change in species composition that has occurred in the intervening 12,000 years.

(3) The Younger Dryas reversal appears in the three sites as the classical southern New England A-4 pollen assemblage zone in which *Picea, Abies*, *Larix*, *Betula* and *Alnus* increase at the expense of *Quercus* and sometimes *Fraxinus*, *Ostrya-Carpinus* and *Tsuga*. From macrofossil evidence, we know the *Betula* species is *Betula papyrifera*, a boreal species. Macrofossil evidence of *Pinus strobus* at Linsley Pond indicates a cool, humid climate prior to the more severe Younger Dryas cooling, suggesting a change in annual temperature of 3–4°C. (Peteet *et al.*, 1990). The timing of the Younger Dryas is roughly 10,800 to 10,000 BP, as evidenced by AMS ^{14}C dates. The best constraint on the close of the A-4 pollen zone, which correlates with the Younger Dryas chronozone (Mangerud, 1974), is the first re-appearance of a *Pinus strobus* needle in Linsley Pond AMS-dated at 9920±230 BP. This climatic warming occurred in approximately 50–100 years, based on sediment accumulation rates.

(4) The classical southern New England *Pinus* pollen assemblage zone B, approximately 10–9000 BP, is clearly marked by the sudden decline of boreal species and the resurgence of *Pinus*. The three lake macrofossil records indicate the presence of *Pinus strobus* needles in this zone, which in conjuction with other regional records suggests that this tree dominated the forest and the climate was much warmer than the previous millenium. It is difficult to determine the degree of warmth because this species extends from Atlantic Canada south to Georgia and increased along with *Quercus*, another thermophilous species.

(5) To our knowledge, this is the first continuous fish remains record for the eastern United States. The sequence of scales includes sunfish, minnow, trout and yellow perch. Too few remains were collected to assess the stability of the fish assemblage within the Bölling/Alleröd-Younger Dryas. Today, sunfish, minnows, trout and yellow perch are found in a variety of habitats and appear tolerant of a wide range of environmental variables associated with climate, such as temperature. One fish that has not persisted in the drainage in which Allamuchy Pond occurs is the Atlantic salmon. The loss of this fish from the assemblage may be related to climatic change.

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January 14, 1999

Dr. Robert Behnke
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Dear Dr. Behnke:

Matt Nemeth, a friend of mine and former employee of yours, suggested that I send you a copy of a fisheries conservation newsletter that I recently finished. I am hoping that, at least in some very small way, it will wake Maine people to the idea of Atlantic salmon restoration.

As an aside, I, a former westslope cutthroat researcher, enjoyed reading of your research as it was qualitatively described in *Year of the Trout*.

Regards,

Paul

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-Salmo Salar Advocate-

To restore wild Atlantic salmon to the state of Maine

Fall, 1998

www.peganet.net/personal_pages/jloc/ssa.html

The Atlantic salmon needs your help. The number of adult salmon returning to spawn in New England rivers numbered 300,000 annually just 200 years ago. Now only small wild populations of this environmental indicator species remain in the United States, solely in Maine. In 1997, the worst year in recorded history for salmon returns to Maine, only 1500 returned to spawn. This year's run of salmon appears to be even worse. Today, populations of the Atlantic salmon worldwide and in Maine are at all-time lows. Current spawning numbers are barely great enough to perpetuate each river's unique population.

Background. In the United States, Atlantic salmon once returned to almost all rivers and streams flowing to the sea, from the Connecticut in the south to the Saint Croix on the Maine-New Brunswick border. In Maine alone, Atlantic salmon were once found in at least thirty-four rivers (Rounsefell and Bond, 1948). Atlantic salmon returning to the state were steadily declining until the 1980s, when there was a slight increase in their numbers. That trend reversed itself in the late '80s through this decade, to the point where Maine Atlantic salmon are now on the brink of extinction. Restore: the North Woods, the Massachusetts-based conservation group, is given large credit for bringing the plight of the Atlantic salmon into the public eye with their 1993 petition to the federal government to provide Endangered Species Act protection to the species throughout its historic range in this country.

In 1995, the federal government proposed threatened status for Atlantic salmon in seven downeast Maine rivers that were thought to have some of the most genetically unique (most 'wild') salmon runs in the state. The federal proposal accurately stated that the salmon returning to these seven Maine rivers meet all criteria for listing. The proposal cited poaching, low natural survival of fish during their first winter at sea, and potential impacts from salmon aquaculture operations and fish hatcheries as three main factors threatening Atlantic salmon.

The state responded to the federal proposal with its own document, finalized in March, 1997. Although many are skeptical of its merit, the state plan (the Atlantic Salmon Conservation Plan for Seven Maine Rivers) was accepted in December, 1997 in lieu of federal listing under the Endangered Species Act. Despite the fact that runs in several of the rivers that the state plan mentions are almost extinct, the December 18, 1997 Federal Register withdrawing the proposal for endangered species listing said that "...listing is not justified at this time." However, nothing positive happened to salmon populations between the 1995 federal proposal and the 1997 withdrawal of the proposal to substantiate this conclusion. It must be emphasized that Atlantic salmon populations in the seven rivers (and several small streams in the state) meet all criteria for federal listing. The federal Endangered Species Act says that protection of a species is warranted under the act because of any one or a combination of factors, including "the present or threatened destruction, modification, or curtailment of a species' habitat or range." For Atlantic salmon, that range has become so small and perilous that in 1997, the worst year in recorded history for salmon returns to Maine, less than 400 returned to spawn in the seven rivers listed in the state plan. Amazingly, the federal government appears to have rescinded on its own sober report of these low population numbers by accepting the state plan even though the federal government said that "...the unique Atlantic salmon populations in the Sheepscot, Ducktrap, Narraguagus, Pleasant, Machias, East Machias and Dennys Rivers are in danger of extinction" (FWS, NMFS, 1995).

Problems with the state plan (Volunteer if you wish.) The state plan is a joke. The *plan* is only a long-winded *proposal* to initiate conservation activities. If salmon restoration is so important to policymakers of Maine, as they attest it is, why are all the initiatives in the state plan voluntary instead of compulsory? So much of the state plan relies on the consent of such diverse groups that there may never be the unnanimous approval for any conservation and restoration intiatives.

The state plan considers conservation in only seven rivers, despite others in the state that have wild, naturally reproducing stocks of Atlantic salmon (which get no attention whatsoever, under any plan). The rivers that the state plan mentions are the Dennys, Machias, East Machias, Pleasant, Narraguagus, Sheepscot and Ducktrap. The state plan fails to protect feeder streams that contain small Atlantic salmon runs and are part of larger river systems choked with dams and paper mills.

Out of sixteen authors for the plan, seven are from industry and only one is a biologist, a University of Maine professor (and, as such, a political apointee). The plan's merit is questionable by its authorship alone. Since federal approval of the state plan, cranberry grower Cherryfield Foods, of which operating manager Ragnar Kamp is a co-author of the plan, has already been cited for clearcutting without a permit, which could harm Atlantic salmon in the Pleasant River watershed. (And according to the state plan, "current agricultural practices in Maine are not considered a major threat to Atlantic salmon.") Mr Kamp authored the Maine salmon plan on behalf of a company that is not even nationally owned.

The federal plan would have mandated recovery and made federal funds available to foster recovery – funds that the state is simply unwilling to put into the recovery effort. The state sets no mandates for protection and claims that its plan provides "supplemental improvements to the strong network of federal, state, and local laws already at work in the seven river watersheds." But there are *no* federal laws pertaining to management or recovery of Atlantic salmon in these watersheds. And if these phantom laws are 'strong' laws protecting salmon, why is the state so adverse to having more of them?

It is convenient for the state and seven industry co-authors to produce a document that proposes voluntary regulatory compliance in watersheds that industries use so little. The Atlantic Salmon Conservation Plan for Seven Maine Rivers, is not a conservation plan at all, but written excuse by paper, hydroelectric and agriculture industries residing in Maine from being accountable in Maine's famous river systems for vast clearcutting, massive dams that block upstream *and* downstream salmon passage, and use of toxic pesticides that leech into watersheds where juvenile salmon feed and grow. Simply stated, the plan is *status quo*. It is a mandate for extinction. The plan reaffirms that major natural resource-extracting industries, the financially powerful co-authors of the plan, have never had an interest in preserving what is arguably the greatest fish species ever to grace American waters. After so many years of neglect, it is very suspicious for industry to seemingly show compassion for a species that its own activities have virtually obliterated.

Over and over again, the state plan emphasizes the importance of voluntary compliance and restoration of Atlantic salmon through existing regulatory framework even though it is recognized that existing regulations have destroyed Atlantic salmon stocks in the first place. Two-thirds of the original Atlantic salmon rivers in Maine have been extirpated of the species. The plan states that "Atlantic salmon stocks in the seven downeast rivers have been, and will continue to be, a high priority for the state of Maine..." despite the fact that the Atlantic Salmon Authority (ASA), the *only* state agency actively researching and attempting to restore Atlantic salmon to Maine rivers, is appropriated approximately $110,000 per year, less than a dime per year per Maine citizen. In fact, the budget of the ASA decreased by seventy-five percent between the years 1990 and 1994. Despite 'implementation' of the state plan, the ASA will receive only modest budget increases through 1999. The funding for the ASA is ridiculously low for an agency instructed to implement, monitor and enforce policies to protect and restore Atlantic salmon to a significant portion of their historic range in this country. As recently as 1997, ASA's request to hire two more biologists, with a very modest $84,000 price tag, was rejected by Governor King.

Rivers such as the Aroostock, Kennebec, Androscoggin and Saco are under 'passive' restortation status, meaning that the budget of the ASA is so low that it cannot even perform stocking to utilize the available juvenile salmon habitat in these rivers. And of the $60 million state budget surplus last year, there was never talk by Mr. King of appropriating even a single penny of it to salmon restoration, something ironic in as much as Maine wants to attract even more tourists and Atlantic salmon have supported lucrative recreational fishing industries in Canada and Russia. It is obvious, even after reading the executive summary of the plan, that Maine is excusing itself from any obligation to take salmon restoration seriously, to stand up to the paper and hydroelectric companies that decimated the species.

The state plan has no biological basis whatsoever. Rather than be concerned with salmon needs, the state falls back to a 'don't upset the apple cart' strategy where industry has its way, nothing changes, and the last Atlantic salmon in the United States are left to go extinct. I am so thoroughly disgusted with the plan that after reviewing it, I investigated the state's own definition of an endangered species. The Atlantic salmon is *excluded* from the state endangered and threatened species lists. "Maine's choice of the comprehensive, proactive approach to listing endangered species..." reads a 1997 report by the Maine Department of Inland Fisheries and Wildlife. The report goes *admits* that endangered species listing in Maine is a financial rather than a scientific decision by proclaiming that the state's approach to listing endangered species "is primarily responsible for Maine being largely free of costly and confusing conflicts from endangered species."

For its endangered/threatened list, the state specifies six biological parameters to be used in evaluating a species' risk of extinction. It is clear that Atlantic salmon meet all of these paramaters. These six parameters along with their pertinence to Atlantic salmon are: 1. population viability (for Atlantic salmon, very low within rivers and almost zero between rivers); 2. population size (less than fifty salmon returned in 1997 to the most productive river listed in the state's plan; populations at all-time lows in the state); 3. population trend (decreasingly steadily throughout the twentieth century); 4. population distribution (decreasing steadily for Atlantic salmon); 5. population fragmentation (riverine populations of Atlantic salmon do not mix in wild); and 6. endemism (wild, naturally reproducing Atlantic salmon occur in Maine, and nowhere else in the country). Amazingly, despite these facts, the state considers that Atlantic salmon are not endangered or threatened according to its own criteria.

It must be emphasized that the state is under no legal authority to restore even a single salmon to any of the rivers listed in the plan. The plan continually emphasizes that restoration of Atlantic salmon is beyond the best effort of the state and industries. However, in the first page of the executive summary, the plan stresses that "these seven downeast rivers are nonindustrial rivers, relatively uninfluenced by the history of industrial pollution and hydropower typical of many other salmon rivers." We infer, then, that the formerly large salmon populations in the Saco, Androscoggin, Kennebec and Penobscot were destroyed by the paper and hydropower industries. Thousands of scientific documents written about the subject of Atlantic salmon and indutrial mistreatment of Maine rivers verify this inference.

One of the basic proclamations of the state plan is that because Atlantic salmon spend such a large percentage of their life at sea, restoration is largely beyond the state's control. True to a point, but the Atlantic salmon is a species thousands of years old. Two hundred years ago, 300,000 adult salmon returned annually to New England rivers, and now the number is less than one percent of that. What got us to this population crisis in the first place?

Of the historic freshwater habitat available to Atlantic salmon in Maine rivers, only one-third is available to Atlantic salmon today (Beland, 1984). For example, eleven dams currently exist on the mainstem Kennebec River, and all are in need upstream *and* downstream fish passage facilities. The state also estimated that currently less than one percent of the Kennebec's total habitat *suitable* for Atlantic salmon spawning is *accessible* for Atlantic salmon spawning. Other major salmon producing river drainages that have major upstream and downstream artificial obstacles to fish passage include the Penobscot, Aroostock, Saco, St. Croix, and Androscoggin.

That the state has a falsely optimistic impression of its efforts is obvious in its reports. The state considers accessible habitat to be where adult salmon can spawn. However, on rivers such as the Penobscot, where the state claims that 100% of habitat suitable for spawning is accessible, *downstream* fish passage facilities are ineffective at several dams.

Nowhere on Earth have dams been proven to be compatible with the survival of anadromous fishes. 'State-of-the-art-fish-passage' is a phrase that describes the newest, latest technology in assisting fish that encounter dams and hydroelectric facilities. Fish passage includes such things as fish ladders and lifts for upstream migration, and strobe lights and screens for downstream migrations. Such fish passage techniques still have only limited effectiveness where they are implemented. At most dams throughout Maine, the measures have not been implemented due to lack of money to use and enforce these techniques.

And unfortunately, 'state-of-the-art' fish passage is open to interpretation. One measure that many hydroelectric facilities consider to be state-of-the-art and adequate mitigation is the trapping and trucking of fish around dams. Trapping and trucking has many shortcomings, including the infrequency with which trapping is conducted, the number of fish that escape trapping, and the stress and mortality that fish undergo when they are captured and transported. More importantly, *the indefinite annual removal of fish from rivers and their transport around artificial obstacles does not constitute restoration of a wild, unaided, naturally reprducing species to its native habitat.* Once we resort to such mitigative measures, we have resorted to rendering Atlantic salmon extinct. In short, wild Atlantic salmon will be restored only when the Maine government makes a financial and moral *commitment* to save them from extinction.

Hydroelectric generation in Maine in its present form should disturb us all. Here we have an industry that has been only minimally charged for harvesting the power of running water and, until recently, has been granted complete immunity from addressing the impact of dams on migrating fishes and other aquatic life. It is time that hydroelectric corporations adequately mitigate for the impacts caused by dams. Adequate mitigation will have occured when no significant upstream or downstream mortality is caused *and* when salmon migrate without the aid of out-stream human activities such as trucking fish around dams.

What you can do. The state's Atlantic salmon plan is available on the state web page under the 'Governor's Office' subheading: www.state.me.us/governor/a-plus.htm Unless he hears otherwise, Mr. King assumes that Maine citizens are pleased with his plan and will do nothing to change it. When writing the governor, stress that strong regulations and concrete timetables must be established in order to restore Atlantic salmon to the rivers of Maine. Governor King can be contacted at: State House Station #1 Augusta, ME 04333. Telephone 207-287-3531. His e-mail address is governor@state.me.us

Wood, paper and agriculture. The largest air and water polluter in Maine is the paper industry (Lansky, 1992). The paper industry bears its allegiance to Wall Street and history has shown us that its regard for air and water quality in Maine is negligible. We should be asking why the state's largest polluter has been invited to author a plan to protect an environmentally sensitive species.

Why is the Atlantic salmon is in decline? Until this century, Atlantic salmon in their home rivers never had to survive sulfur and nitrogen oxide air pollution and subsequent acid rain, hypoxic water, whole-tree logging, shortened rotations of clearcutting, soil compaction, intensive road building, pesticide application to kill hardwoods, climate change at the hands of the industrial society, and development (Lansky, 1992). Even a 1946 document reported that deforestation in the state had destroyed the water retention of watersheds, resulting in inadequate river flows (Harrington 1946). The decline in Maine's environmental quality has been steady, predictable and avoidable.

Perhaps the most important streams to Atlantic salmon are small headwater streams where cold, clean, highly oxygenated water feeds into larger streams and rivers where salmon spawn. Major salmon spawning sites lie downstream of small, cold streams. Often these small headwater streams are in rugged terrain where mud and silt from logging quickly runs off the land and into the water. Salmon eggs are highly vulnerable to siltation produced by modern logging practices.

Scientists have proven the effectiveness of buffer strips along stream corridors to filter out sediment, reduce streambed erosion and protect aquatic life. However, the Maine Land Use Regulation Commission does not require buffers from logging around streams that drain up to 300 acres. Presently, clearcutting is allowed to within 250 feet of rivers and to within 75 feet of streams. Additionally, there exists an almost unenforcable law within these buffer zones on rivers and streams: "selective cutting is permitted provided that no more than 40% of the total volume of trees 4 inches or more in diameter measured at 4.5 feet above the ground in a ten year period are removed." In other words, leave a few trees to make it look green. Logging is still allowed within the 250 foot 'buffers' around larger streams and rivers. Obviously, enforcement of an already flimsy regulation poses a problem unto itself.

And then there is the case of downeast blueberry cultivation. Some downeast blueberry fields are irrigated with water that is withdrawn from salmon streams. Additionally, blueberry cultivation uses velpar, an herbicide used in increasing amounts since the 1980s. The former Atlantic Sea Run Salmon Commission found velpar in the Narraguagas and Pleasant Rivers, a fact that was conveniently ommited from the state plan. It should also be noted that downeast river production of Atlantic salmon has been steadily declining as velpar use has increased. Velpar is one of up to fifteen different pesticides applied to blueberry fields in the state. Cranberry cultivation, a new enterprise in Maine, uses up to twenty different chemicals.

What you can do. Write or e-mail Governor King and your local congresspeople to request that they initiate forest practices reform to limit clearcutting, eliminate whole tree logging and expand buffer zones along streams and rivers. Also, eat organic berries for healthy groundwater and salmon streams.

Impacts from aquaculture. Washington County is home to the majority of rivers in which the state has planned restoration of salmon populations. Washington County is an area where the sea farming of Atlantic salmon is on the rise. In rivers close to aquaculture operations, such as the Dennys and the St. Croix, aquaculture escapees have comprised up to thirty percent of returning salmon in recent years.

Escaped salmon from aquaculture operations are *not* wild fish but have an ability to interbreed with wild fish and reduce the genetic fitness of wild, river-specific stocks. The major threat of aquaculture is the escape of artificially reared mature fish, and the introduction of their genes to a wild gene pool, reducing the ability of future generations of wild fish to live and reproduce in Maine rivers and streams.

What you can do. Don't eat *any* Atlantic salmon. Wild Atlantic salmon are at record low populations throughout their entire historic range in North America. Many biologists speculate that one cause of low marine survival is inadequate food supply. Pen-raised, domestic Atlantic salmon are fed a diet consisting of many of the same fishes that wild Atlantic salmon feed on when they are at sea.

Credit should be given to the Maine Aquaculture Association for their new participation in a river-specific smolt rearing and stocking restoration program in three downeast salmon rivers. However, this program is only intially funded by the Association. One gauge of the state's commitment to salmon restoration will be if they eventually pay for a program that the state plan praises when someone else pays the cost.

The number of domestic salmon that have escaped downeast aquaculture facilites and ascended into downeast Maine rivers has been increasing throughout the 1990's. Siginificant need exists to install fish weirs on these rivers to enumerate wild fish and to keep escaped aquaculture fish from ascending rivers. Write the governor and your local congresspeople to request that they co-sign legislation to increase funding for the Atlantic Salmon Authority for projects such as weir construction.

What's happening at sea. Over the past 35 years, commercial fishing at sea has taken a toll on salmon populations - salmon that could have returned to Maine. In 1975, the population of two-sea-winter salmon overwintering in West Greenland was approximately 850,000; by 1992, this population had dropped to 250,000. It is estimated that at least 200,000 salmon are necessary to maintain viable populations in North American rivers (*Atlantic Salmon Journal*, 1993), including the rivers in Maine. In 1989, it was estimated that roughly fifty percent of adult salmon that would otherwise return to New England rivers were being intercepted by commercial netters off Canada and Greenland (FWS, 1989). Greenland's landings are especially disturbing because their catches do not originate from their own rivers.

But, spearheaded by the Atlantic Salmon Federaton, a breakthrough was achieved this past spring when the Quebec and Labrador salmon fisheries were closed. Additionally, the North Atlantic Salmon Conservation Organization (NASCO) agreed to limit Greenland's salmon fishery for 1998 to 20 metric tons, or roughly 9,000 fish, less than two percent of Greenland's quota twenty years earlier. This latter agreement lasts for one year, and this virtual elminiation of the Greeeland high seas salmon fishery will have to be approved again next year by NASCO, an international governing board for salmon fishing in the Atlantic. As of 1997, the plan's seven rivers had actual escapement (from saltwater nets) of only ten percent of their goal.

It is important to note that factors at sea are not entirely to blame. The state, in only the second paragraph of its 434-page plan, is quick to proclaim out that "the decline in downeast river [salmon] stocks likely represents...a cyclical stock fluctuation strongly influenced by low marine survival beyond Maine territorial waters and overfishing on the high seas." So as Maine distances itself from core factors in the state that are causing the Atlantic salmon decline, why is it so afraid of the federal listing if it is "has taken all reasonable steps to assure successful restoration..." of the species? The state is adimate that the salmon decline is due to problems at sea. However, something is major is also happening at home. *The survival of hatchery-reared smolts released into the Penobscot River has declined from nearly 1% in the late 1970's to approximately 0.2% in the 1990's, and the survival of wild smolts in the Narraguagus River has decreased from 3-5% in the 1950's to 0.5-1.5% in recent years* (Baum et al., 1995). (my emphasis)

Canadian and Greenland boats that fish the North Atlantic and catch salmon originating from Maine rivers and streams represent a serious threat to the species. What makes the problems of high seas fishing even worse is that most New England salmon spend two winters at sea before returning to spawn for the first time, thus increasing their vulnerability at sea for a full extra year beyond that of salmon in many parts of eastern Canada (FWS, NMFS, 1995). Studies surmise that without the pressure of the Greenland and Labrador fisheries, returns of spawning Atlantic salmon to Maine rivers could increase to 2.5 times their normal levels (FWS, NMFS, 1995)

Despite my repeated attempts in 1997 and 1998 to obtain their stances on buyouts of Canadian and Greenland fishers who take our salmon from the North Atlantic, only one of the four Maine delegates to the U.S. Congress, Senator Snowe, provided me with an opinion on the buyout effort. This past May, Senator Snowe called for a moratorium on high seas Atlantic salmon fishing, a move that was enacted through the efforts of NASCO, the Atlantic Salmon Federation and the Canadian government. Offices of the other three Maine delegates to Congress knew nothing about attempts to end high seas fishing for Atlantic salmon. They did not respond to my requests for further information on this matter.

What you can do. Like the other three Maine delegates to the U.S. Congress, Senator Snowe has failed to adequately address problems that are affecting salmon *within* the state. However, Senator Snowe deserves credit for calling for a moratorium on commercial high seas fishing for Atlantic salmon. Canada's Minister of the Department of Fisheries and Oceans, David Anderson, deserves great praise for his move this past spring to place a one year moratorium on Labrador's commerical Atlantic salmon fishery. Write him to commend his efforts and to urge him to continue the moratorium next year and into the future: Honorable David Anderson, Minister Dept. of Fisheries and Oceans; House of Commons; Parliament, Wellington St; Ottawa, Ontario Canada K1A-0A6 Email: Min@dfo-mpo.gc.ca

The United States is a member of NASCO. Write Maine's Senator Collins and Representatives Allen and Baldacci and, after providing them some basic background information, request that they support the American contigent of NASCO in its efforts to eliminate the high seas fisheries again in future years, including in 1999 when the suspension of the West Greenland salmon fishery is up for reauthorization. Write: Senator Collins or Snowe; U.S. Senate, Washington, D.C. 20510. Representative Allen or Baldacci; U.S. House of Represenatives; Washington, D.C. 20515

What is wild? The case of Cove Brook and Togus Stream. What is the state plan proposing to protect and what is it ignoring? The seven downeast rivers have populations of salmon that are relatively pure in their genetic composition. That is, the genetic composition of each river's fish is unique to that river.

Says the state plan; “Although numerous Maine rivers once contained naturally reproducing salmon populations, the limited financial and personnel resources available currently limit the statewide salmon restoration program to…sixteen rivers…” (seven ‘active’ restoration and nine ‘passive’ restoration). Cove Brook and Togus Stream are not two of these. We should have great difficulty believing that the state is interested in protecting Atlantic salmon and has “taken all reasonable steps to assure successful restoration...” if it fails to mention, even once in a 400+ page plan, two streams that have the most distinct wild Atlantic salmon stocks in the entire country.

An August, 1997 report by the National Biological Service indicated that Cove Brook and Togus Stream have very distinct – very wild - runs of Atlantic salmon (King et al., 1997). That is, these streams have Atlantic salmon that, in terms of their genetic composition, are significantly different from each other and from other rivers in Maine. *Why are Cove Brook and Togus Stream omitted from the plan?* Simply put, Cove Brook and Togus Stream, as part of the lower Penobscot and lower Kennebec, respectively, are linked to rivers where industry has long skated free from environmental responsibility.

Due to historically high levels of out-river stocking, the genetic composition of salmon runs in the Penobscot, Dennys, Machias, East Machias, Pleasant, Narraguagus, and Sheepscot Rivers has become fairly homogenized. Although salmon in these seven rivers are fairly genetically similar, they are still genetically unique from Canadian rivers, Cove Brook, Togus Stream and the Ducktrap River (the latter three having very genetically distinct salmon runs). It is convenient for business interests to raise the argument that the salmon population in the Penobscot, for example, is genetically 'watered-down,' when it is actually a mix of wild salmon populations from a number of other Maine rivers. Some people see salmon protection as unwarranted and claim that downeast rivers lack genetically isolated salmon populations. Lack of complete genetic isolation of these salmon - a result of out-river stocking in the past - is a poor excuse to postpone substantial, adequate protection to a n endangered species that is also a vital gauge of river health in Maine.

Dams. One of the salmon restoration and management strategies that the Baum et al. (1995) report cites is the improvement of fish passage. Major fish passage problems exist around artificial obstructions. This has been shown to be the case on the Columbia River in the Pacific northwest for over sixty years. As of 1989, 105 dams on eleven formerly major New England salmon rivers required additional fish passage facilities (FWS, 1989). This means that each river of the eleven considered for restoration has an average of almost *ten* impediments to salmon migration. Federal law *requires* that fish passage facilities be provided at dams licensed for the production of hydroelectric energy under the Federal Power Act. However, the Federal Energy Regulatory Commisssion has not adequately enforced the act so as to make hydroelectric facilities comply. For instance, Bangor Hydroelectric Company has never built a fish passage facility at Ellsworth Dam on the Union River despite a mandate in 1987 that it be required to.

One of the goals of the federal endangered spceies act is to restore a species to the point where it is self-sustaining. Therefore, it is not surprising that the state was so adimate about having its own plan approved by the federal government because the state government and Maine’s hydroelectric facilities have had no interest in returning Maine’s salmon runs to their original self-sustaining character.

The first problem with dams is that they entirely eliminate or restrict upstream migration. Current technology at some dams permits a high rate of successful upstream passage using state-of-the-art facilities such as fish ladders and fish lifts. But given a best-case scenario on a river such as the Kennebec, an Atlantic salmon determined to spawn in the main river near Moosehead Lake would have to negotiate eleven dams on its upward journey (there are more dams on Kennebec tributaries), and any young salmon would have to negotiate the same eleven dams on their way to sea. *None* of these eleven dams on the Kennebec have fish passage facilities for either upstream or downstream migration (FWS, NMFS, 1995).

The Penobscot, Saco, Androscoggin, and St. Croix, where fish passage exists at some dams, still cause significant mortaility to smolts - young salmon leaving for sea. Studies on both coasts have shown that in their present form, the majority of dam turbines create very high rates of mortality for all juvenile anadromous salmonids. Slackwater is a common occurrence above dams. Without natural river flow, juvenile salmon become disoriented, which increases the time required to successfully migrate below dams. Subsequently, smolts are unable to migrate to sea in time to take full advantage of food that diminishes in abundance later in the year. The state feels that ocean mortality is a significant issue, and this is one case where an occurence in Maine's rivers is having a negative impact on the health of salmon when they enter the sea: increased time nativgating a river delays entry into the sea and delays marine feeding in preparation for the first winter at sea.

Many of the devices used to keep outmigrating salmon from hydroelectric turbines, such as screens and lighting techniques, are ineffective in the form which they are used. For example, despite downstream fish passage facilities at the West Enfield Dam on the Penobscot River, eighty-five percent of fish still went through turbines (Atlantic Salmon Assessment Committee, 1993). Other aids to downstream fish migration around dams are expensive to install and maintain in a way that minimizes mortality. Hydroelectric companies have been reluctant to install devices that facilitate downstream fish passage, presumably because prices for the more effective techniques are too expensive. However, the responsibility of hydroelectric operators to *adequately* mitigate the impact to salmon and other fish species caused by operations is theirs alone. So far, salmon restoration is simply not a priority to hydroelectric operators.

Due to dams on all major rivers in New England, the Atlantic salmon has lost vast amounts of habitat. The Federal Energy Regulatory Commission (FERC) recently issued a landmark ruling that the privately owned Edwards Dam on the Kennebec River must be removed. Governor King and all four U.S. delegates from Maine supported removal of the structure. Removal of the dam will open up seventeen miles of mainstem river spawning habitat and miles of feeder streams that also serve as spawning habitat. However, much needs to be done to restore the Kennebec to where salmon can successfully and completely utilize the river.

Disturbingly, the King administation and Maine Department of Environmental Protection backed the Basin Mills hydroelectric proposal on the Penobscot River, a move that certainly did *not* affirm their support for salmon restoration. The DEP stated that Atlantic salmon populations on the Penobscot River will probably never be self-sustaining and the dam would have little fisheries-related impact (Maine DEP, 1993). But FERC, the final voice on the Basin Mills construction, vetoed the project because it feared a siginificant, negative impact to Atlantic salmon in the Penobscot River. *Due to the Basin Mills Dam alone, the potential size of any future salmon stock on the Penobscot River would have been reduced by thirteen percent.* (FERC, 1997). The Basin Mills proposal, and more specifically the mitigative measures for its construction, represents power company thinking that has destroyed other formerly great salmon rivers such as the Columbia: power generation is the primary concern and fish conservation/restoration, regardless of whether a species is endangered, is a burdensome issue that must be dealt with cost-effectively.

A major impediemnt to Atlantic salmon restoration is that the agencies in charge of this task have rescinded on their commitment to protect the species. But at its own request, the state has inherited responsibility for restoring naturally reproducing populations of wild salmon to Maine's rivers. In 1995, the Atlantic Sea Run Salmon Commission proclaimed a ten-fold increase in the amount of habitat accessible to Atlantic salmon since 1947 (Baum et al., 1995). However, by admission of that same report, "even the most efficient fish passage facilities do not pass all the salmon reaching a stream" (Baum et al., 1995).

What you can do.

Within five years, five hydroelectric dams on salmon rivers in the state will be up for relicensing. Write the Federal Energy Regulatory Commission and request that they relicense these dams only under the condition that state-of-the-art fish passage facilities are constructed and maintained. Also, commend FERC on its decisions to remove Edward's Dam and deny licensing to the Basin Mills project on the Penobscot River: FERC, Licensing Dept., 888 1st St., NE, Washington, D.C. 20002 e-mail: contentmaster@FERC.Fed.US

Where we stand. In 1966, then Department of Interior Secretary Stewart Udall released a report citing the Atlantic salmon as a species in danger of extirpation from the United States. Thirty years later, the salmon is no better off. Despite neither the state or federal government admitting it, Atlantic salmon in the United States are endangered. Despite what industry would have us believe, people and Atlantic salmon can coexist in Maine.

The status quo has failed miserably. In 1989, the U.S. Fish and Wildlife Service predicted that total U.S. Atlantic salmon returns to New England Rivers would increase to 13,520 by 1996 (FWS, 1989): less than 2000 salmon actually returned in 1996. By 1997, less than 400 Atlantic salmon returned to the seven rivers listed in the state plan. Not a single Atlantic salmon returned to spawn in 1997 in the Dennys, one of the most pristine watersheds left in the state. In 1998, even fewer Atlantic salmon are returning to Maine than in 1997. The Atlantic Salmon Authority and other well intended organizations have lacked the political autonomy and financial resources to appropriately research and restore salmon.

The state must feel that the public does not know enough or care enough about Atlantic salmon for it to improve its conservation agenda. In 1995, the Atlantic Sea Run Salmon Commission (now the ASA) stated that "given the limited financial and personnel resources available to the commission, the statewide program is currently focused upon...16 rivers" [out of 34 historically]. And of these 16, nine are under 'passive' restoration status - 'limited activities as resources allow.' Additionally, the ASA has admitted that "there are a number of small coastal streams in Maine which have been known to contain small salmon populations...[that] are not included in the plan because little is known about the quantity and quality of salmon habitat," despite the ASA having annual Atlantic salmon stock assessment as a restoration and management strategy (Baum et al., 1995). It is shocking that a state supposedly so committed to salmon protection is purposely omitting research and protection of small streams, such as Togus Stream and Cove Brook - homes to wild, self-sustaining salmon. With the species close to extinction, why is the state not taking any measures to protect these Atlantic salmon? That so little is known about salmon in the likes of Togus Stream and Cove Brook is another testament to Maine's lack of commitment to salmon conservation.

What is wrong with the state plan ultimately falls in the hands of the governor. Mr. King's strong support for a weak, unenforceable plan is yet another indication that he has made natural resource conservation a low priority in his administration. For example, Mr. King failed to eliminate dioxin from kraft pulp and paper mills operating in the state (L.D. 1577 in the 118th Legislature) despite pledging to and knowing that dioxin is extremely harmful to aquatic life and, as such, threatens juvenile Atlantic salmon and the freshwater food supply on which they depend.

The state plan was written in response to the federal proposal. Even though the federal proposal lacks significant domestic accountability for the decline of Atlantic salmon, the state plan is worse than the federal plan on all counts. As deforestation is intensified, acid rain-creating chemicals are spewed into the air, and dioxin is pumped into rivers, one is left to wonder how committed the state is to salmon restoration.

Stocking is now seen as a necessity to restore salmon to rivers from which they have been extirpated. Stocking in the past has reduced genetic adaptations of each river's unique salmon. On the bright side, river-specific stocking, where possible, is now standard practice for the Atlantic Salmon Authority and the U.S. Fish and Wildlife Service. This means that salmon will stand a better chance to spawn successfully because they will return to spawn in the same river from which their parents were taken.

The Endangered Species Act requires that endangered and threatened species be protected throughout the country. It is a sad testament to our political system that a species not only endangered, but teetering on the verge of extinction, has not been protected *as mandated by law.* The Atlantic Salmon Authority remains the only state agency to "manage the Atlantic salmon fishery in the state and conduct and coordinate all projects involving research, planning, management, restoration or propagation of the Atlantic salmon" and be the state's liaison with federal, regional, and other state authorities on issues pertaining to Atlantic salmon.

Does this sound like a task for just two people? The ASA is so under-budgeted that, despite its many tasks, is staffed by only two biologists, and only one as the state was formulating its laisse-faire plan. Despite this individual presumably being an expert on Atlantic salmon needs, he did not even co-author the state plan.

What they might say. Some varying complaints have been raised against protecting the Atlantic salmon in Maine. Some of the most frequently cited objections are listed below:

Objection: There are no wild Atlantic salmon left in Maine.
Response: Saunders (1981) stated that "Although there has been considerable transplantation through release of hatchery-reared fish, particularly in the maritime provinces and Maine, there appears to have been no breakdown of isolating mechanisms with the resulting loss of genetic diversity." Wild Atlantic salmon still are highly genetically aboriginal in some small streams in Maine. In more well known, larger streams and rivers, where out-river stocking occurred in the past, there remains a significant aboriginal component to the gene pool when compared to rivers in Canada and Europe. Indeed, a recent federal government report states that several river-specific Atlantic salmon populations appear to be reproductively isolated (FWS, NMFS 1995). Wild, naturally reproducing Atlantic salmon even of limited unique genetic character, such as in the Penobscot, are the only gene linkage to their genetically pure ancestry. The original need for stocking in the state in the first place was *not* high seas fishing or any other factor in the ocean: it was blatant habitat destruction of rivers at the hands of the paper and hydropower interests. These activities have extirpated salmon from twenty Maine rivers. That out-river stocking was implemented for so many years is a poor excuse by the problem's creators to further deny protection to salmon and rid themselves of a problem they created.

Objection: Industries are important to the people of Maine. Industrial needs should be primary.
Response: Of the major industries in Maine, only a small percentage are headquartered there. Some are not even nationally owned. All bear their allegance to Wall Street rather than the working class of the state. Multinationals often strive for workforce reduction through mechanization and relocation to third world countries where labor is cheaper, unions are poorly organized, and environmental reulations are often nonexistent. Mainers must realize that when confronted with demands for environmental improvement, industry will invariably whitewash the public into thinking that jobs are at stake, then rally support from the very people whose jobs their mechanization eliminated and whose water and air they poisoned. Nothing has shown that industry and environment cannot coexist. The real fear by industry is that environmental stewardship will *create* jobs and reduce corporate profit. Dioxin-free paper production, selective tree harvest, and installation of high-tech fish passage are actions that will actually foster employment *and* Atlantic salmon. Industries will start being truly beneficial to the state the day they commit to the long-term health of Maine people and their environment.

Objection: The damage caused by hydroelectric operations on salmon streams in Maine is mitigated so as to have no net negative impact on wild Atlantic salmon.
Response: Depending on who stands to financially gain, the response will vary. FERC denied the Basin Mills Dam on the Penobscot in large part due to the irreversible negative impact the new dam would have caused to Atlantic salmon. Governor King has consistently favored construction of the dam despite evidence presented by FERC that the dam would be harmful to salmon. Fish passage is nonexistent or inadequate at the majority of salmon river dams throughout Maine. In their *best* form, dams still block many fish from moving upstream and downstream, destroy habitat, alter river flow, create slackwater where juvenile fish become disoriented, and kill salmon trying to migrate to sea. Dam construction is simply bad for salmonids. No evidence exists otherwise.

A call for action. The definition of a plan is an order to execute. The state 'plan,' all 434 pages, is only a proposal of things that "should" be done, written only in small part by scientists that have had their hands tied by politicians assuring us that the threat of Atlantic salmon extiniction is indeed a high priority to them.

It has been repeatedly shown that restoring full, naturally reproducing runs of Atlantic salmon to rivers where they are endangered or extirpated is a slow process, not an overnight phenomenon. Nature can be destroyed far faster than it can be repaired. Salmon restoration to even a single river takes money, research, commitment, and most importantly, patience. The state plan lacks makes almost no mention of concrete actions that 'have been done' or 'will be done' to directly enhance salmon recovery. I would think that the state, being so 'commited' to salmon recovery, would immediately initiate concrete, financially supported measures to enhance recovery.

As a lay person, the highest priority to help Atlantic salmon is to stay informed with the issues and track the effectiveness of Maine's salmon plan now that ocean fishing was vitually eliminated in 1998. Annual catch statistics and minutes of Atlantic Salmon Authority meetings are at: www.state.me.us/asa/catchstats.html Meeting minutes since acceptance of the state plan have already given a sober indication of the success of the state's underfunded restoration process. Contact the Atlantic Salmon Authority and obtain additional updates on returning fish and restoration efforts. Counts for 1998 and subsuquent years should be obtained in late autumn for the most complete information on annual runs. Atlantic Salmon Authority 650 State St. Bangor, ME 04401 207-941-4449 e-mail: edbaum@state.me.us

Monitor the 1999 buyout effort of high seas salmon fishing permits by inquring with Senator Snowe's office or writing the Canadian Department of Fisheries and Oceans. Additionally, write the U.S. Fish and Wildlife Service, a cooperating agency in salmon restoration, and obtain their annual evaluation of the success of the state plan, which they are supposed to be monitoring: U.S. Fish and Wildlife Service 300 Westgate Center Drive Hadley, MA 01035. The federal government can again designate the Atlantic salmon as a candidate species for protection under the ESA if stocks continue to decline in Maine rivers.

The U.S. Fish and Wildlife Service and the National Marine Fisheries Service administer and apply the ESA to Atlantic salmon populations. However, only in certain rivers have they designated endangered species status for the salmon. In large rivers such as the St. Croix, Kennebec and Penobsot, the services have given salmon 'candidate status.' This means that these fish are not afforded protection as they await the services to study the merits of listing under the ESA. Additionally, small streams such as Togus Stream and Cove Brook do not even have 'candidate status,' meaning that no plan exists to study or document these salmon through public funds. Write the services and tell them that they need to swiftly move to study the salmon populations in these streams and provide them with endangered species protection.

Voice your opinion to Governor Angus King and the state congresspeople in your district. It is widely agreed that the leadership for salmon restoration in the state lies with the governor. He fought vigorously for a plan in which he has publicly proclaimed his confidence. The Atlantic Salmon Authority had a general fund appropriation of only $110,000 for fiscal year 1997. It has asked for appropriations to increase annually to $1 million by 2002. Let the governor and your representatives know that successful Atlantic salmon restoration needs far greater funding and that congresspeople can show their commitment to restoration by pushing for expanded funding for the Atlantic Salmon Authority. *The state will commit to Atlantic salmon restoration when it fully funds recovery efforts in river systems from which the salmon has been extirpated at the hands of state-sanctioned industries such as paper and hydropower.*

Will the state plan work? Governor King claims that the state "has taken all reasonable steps to assure successful restoration..." of Atlantic salmon. It is critical to track the environmental record of the plan's principal proponent over his second term.

A list of some of the groups fighting to restore Atlantic salmon to Maine

*Friends of Kennebec Salmon P.O. Box 2473 Augusta, ME 04338-2473
*Restore: The North Woods P.O. Box 1099 Concord, MA 01742 508-287-0320
*Atlantic Salmon Federation P.O. Box 429 Saint Andrews, N.B., Canada E0G-2X0 800-565-5666

Recommended reading

**Mountain in the Clouds: A Search for Wild Salmon*, Bruce Brown: Simon and Schuster, New York.
**Beyond the Beauty Strip: Saving What's Left of our Forests*, M. Lansky: Tilbury House, Gardiner, ME

Salmo Salar Advocate's author is Paul Rudershausen, a longtime Maine resident and a fishery biologist that has studied fisheries issues for ten years. His private funds solely supported the generation and distribution of *Salmo Salar Advocate*. Mr. Rudershausen is currently researching the influence of water diversion on estuarine and marine fishes in southwest Florida. For comments he can be reached at: paulrudershausen@hotmail.com

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YOU ASKED, YOU GOT IT

I'VE BEEN A TU MEMber for several years, have written letters as part of the Grassroots Activist Network, and helped with river cleanups. Over the course of many trout fishing trips, I have learned how to read water, become a believer in the importance of stalking and presentation, and developed my casting skills. I use only very light tackle and single-hook artificials, and I practice strict catch-and-release. Yet it seems that TU doesn't recognized me as a trout fisherman. Why? Because I use spinning tackle.

Somehow people have gotten the idea — perhaps through magazines and chapter meetings — that the only proper way to fish for trout is with a fly, and that fly fishing is morally superior to other methods. In truth, it has no claim to superiority, morally or otherwise, just as golf at the country club isn't morally superior to golf on public courses.

I doubt that TU set out to ignore people who don't fly fish, but in never mentioning alternatives, the discrimination is just as damaging as if it were intentional. TU can become a much stronger organization with a larger following by embracing all who care about trout and salmon. Let's not let elitism harm the cause of conservation.

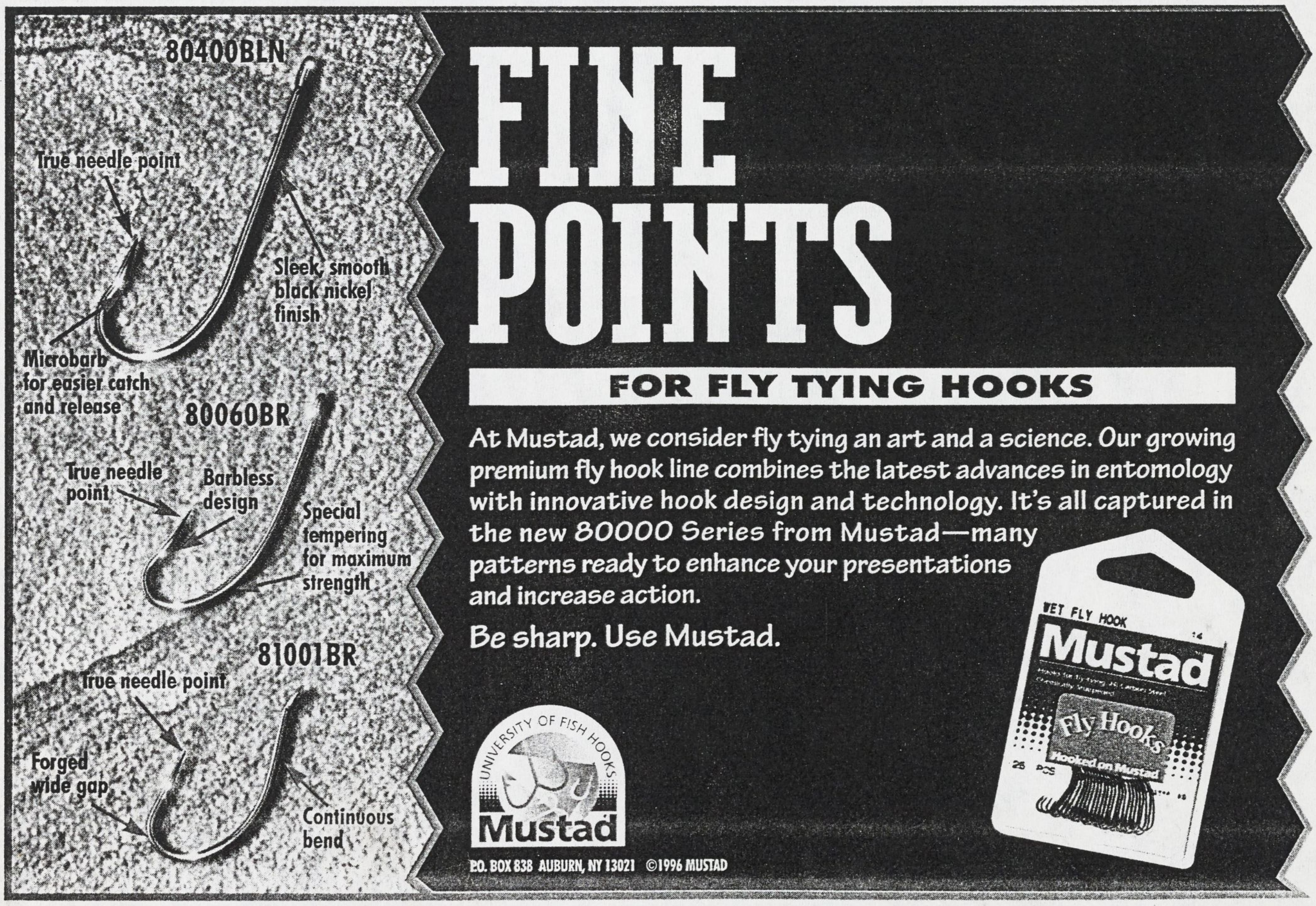
Clif McCormick
Cary, North Carolina

Our ears must have been burning when Mr. McCormick wrote this letter. We hope Steve Wright's article about the common ground shared by fly and spin anglers as well as my column and that of TU's President, all appearing in this issue, foster greater appreciation of different angling methods and an awareness that fish need all types of conservationist-anglers, regardless of angling preference. — Ed.

REBUTTAL TO "ABOUT TROUT"

IT WAS MORE THAN A little irritating to find Dr. Behnke implying that my motivations are not to advance scholarship, but to "get attention" by proposing "outrageously wrongheaded" explanations for the demise of Atlantic salmon in New England. I have given seminars over the years to salmon restoration biologists, sent them reprints of my dissertation and articles, have had telephone calls from heads of state and federal agencies concerned with salmon restoration, and have been interviewed by the media, but there are always attempts to ignore my research because of the political implications, the monies and careers at stake, and the inability of applied science to administer skepticism or self-criticism. I know that I am as popular as a "skunk at a tea party" in salmon restoration circles, as one retired biologist recently wrote to me in support of my research. I welcome new ideas that would support or refute my science, but unfortunately Dr. Behnke does not do that.

Dr. Behnke's primary criticism of my research is that my explanation for the lack of salmon bones in Indian middens ignores the soil conditions in New England that are too acidic to preserve salmon bones. *(continued on page 58)*



LETTERS *(continued from page 13)*
He quotes Dennis Stanford, an archaeologist who works with mammoth and bison bone sites on the Great Plains, that, "it is possible that bone remains once existed in New England but have since disintegrated." My 1992 Ph.D. dissertation from the University of Massachusetts at Amherst addresses this question, and it is absolutely true that in acidic soils, you don't get good bone preservation. However, as any archaeological textbook attests, one of the best types of archaeological site for bone preservation is shell middens with alkaline soils caused from the leaching of calcium carbonate. The excellent preservation of fish bones in New England is demonstrated by the fact that from the 75 sites in New England that I analyzed (most of which are shell middens), the bones of over 40 species of fish were identified, although not salmon. Shad bones have far more delicate skeletons than salmon, so if these fish's bones managed to survive in these sites, then there is no reason to suspect that the salmon's shouldn't have also. There is also a misconception that because fish bones are small, they're not durable. My grandmother prepared home-canned salmon in a pressure cooker under far greater heat than an aboriginal stew or smoke fire. One of the reasons that I disliked eating salmon sandwiches made from my grandmother's salmon was because she left the salmon vertebrae in the meat, so I was constantly having to spit out those hard little (pressure-cooked) bones.

In the Pacific Northwest, large quantities of salmon were traditionally fished by aboriginal peoples as the fish schooled along the ocean shore before entering the rivers to spawn, and the coastal shell middens contain large quantities of salmon bones, but not so in New England. Also on the Pacific Coast, aboriginal peoples harvested salmon once they entered the estuaries and rivers, and the archaeological sites reflect this; but not so in New England. Even in some sites in New England where dense middens of shell are absent (for example, the Turners Falls site on the Connecticut River, the Eddy site at Amoskeag Falls on the Merrimack River, and the Eddington Bend site on the Penobscot River), fish are preserved, probably because of the saturation of the soils with organics and fish oil at these excellent shad fishing locations.

One conclusion of my research is that salmon were not present in prehistoric times. However, I also noted that the historical accounts tell a different story, i.e., that salmon were present during the Colonial period. Dr. Behnke quotes Steve Brooke stating, "We know they [salmon] existed in *large numbers* during historic times," (emphasis mine) but I have argued that we don't know that at all. Whereas salmon are noted in the historical accounts of fish, their numbers are open to interpretation because the accounts are not quantitative. In addition, there is the fact that the predictions of vast salmon runs of the past were based on later 19th century historical accounts of a secondary nature (i.e., rewritten regurgitations of original 16th and 17th century primary documents), and that their numbers may have been embellished because salmon was a high status fish to the English and the early colonial "promoters" of the region. Furthermore, there's additional potential for "salmon inflation" in the accounts — before Linnean classification, unfamiliar species were described in European terms, such as the shad as "white salmon."

"The salmon restoration program has failed to recognize that the salmon situation today is due to a complex set of climatological variables, and less so with the effects of industrialization."

"Large" is also highly subjective and relative. By Dr. Behnke's estimates there were 500,000 salmon in the combined runs of New England during optimum time (although how he arrives at this figure is unclear if the maximum of the three largest rivers was only 170,000). But even if 500,000 is reasonable, the amount is tiny compared with last year's (1995) combined species salmon run in the Fraser River in British Columbia, where even in a situation of declining stocks, there were approximately 20 million fish for this single river system.

However, even if salmon were not as abundant as the secondary historical accounts suggest, salmon were, nonetheless, present historically, and this is a quantitative leap over the prehistoric record. Since the historical presence of salmon indicates that environmental conditions must have provided favorable salmon habitat, I investigated climate records of the historic period and discovered that the Colonial period corresponded with a temporary climatic cooling called The Little Ice Age (AD 1450 - 1800). I proposed that because salmon are a coldwater species, the conditions during the Little Ice Age would have created favorable salmon habitat, causing a southern expansion of their range into the rivers of New England where they had not been prehistorically. This neatly explains why there were no salmon bones in archaeological sites (because conditions were too warm prior to the Little Ice Age), but also why we see them referenced in the historical accounts. During the warming trend that ended the Little Ice Age in the late 1700s, conditions became again unfavorable, and significantly, the extinction of the salmon corresponds in time to the termination of the Little Ice Age. This suggests that climatic change, not dam construction (which happened historically after the fact of salmon decline), was the cause of salmon extinction. The salmon restoration program has failed to recognize that the salmon situation today is due to a complex set of climatological variables, and less so with the effects of industrialization (dams and pollution).

Despite the fact that the paleontological record of fishes from the Pleistocene also shows negative evidence for salmon, Dr. Behnke argues that this can be overruled because the genetic evidence supports its presence before this last prehistoric glacial period. Since I had also proposed mechanisms for the colonization of North American rivers by stocks originating in Europe, and the potential for glacial refugia, I also reviewed genetic evidence of stock divergence. I discussed this with Dr. William Davidson at Memorial University, who at the time (1991) told me that the genetic evidence on salmon stock divergence is ambiguous; however, he agreed that there was nothing to rule out the possibility of a very recent origin (migration), within the last 1,000 years, of salmon to North America. More recently, in a 1995 letter to me, Dr. Robert Kendall of the American Fisheries Society noted that in regards to the genetic evidence for stock divergence, "As far as I know, no genetic clock has been properly calibrated for fishes, and all estimates of time since the divergence of populations are speculation."

I have never felt that it is my role (or expertise), as an archaeologist, to evaluate public policy on salmon restoration, but as a citizen of the United States, I can legitimately ask about the way in which public tax dollars are spent to "protect" and "enhance" salmon, including the building of research facilities named after prominent politicians at the expense of other, possibly more real, environmental problems in archaeological and fisheries science. My inter-disciplinary research suggests that salmon restoration is an expensive experiment with little hope of returns in the post-Little Ice Age climate. In attempting to understand why it is that salmon restoration continues in its rut of failed attempts since 1870, I have come to understand the social role of sportfishing and the status of the "aristocratic salmon." That class and aristocratic sportfishing still has everything to do with it is evidenced in Dr. Behnke's final comment that, "For a connoisseur of the arts [read 'noble sportfishermen'], such comparison valuation [between wild and hatchery reared salmon] would be simple: an original Van Gogh compared to a mass-produced facsimile. Others, such as a commercial fisherman [read 'the working class'], might have a very different value system." Don't get me wrong, however — I am not against sportfishing. My grandparents were avid salmon sportfishers; I learned to tie flies at the age of 12, and my brother, one of the best steelhead fishermen in B.C., runs a sport-salmon fishing business where I too have experienced the sing of the reel. It's the reinvention of nature that I find problematic.

Catherine Carlson, Ph.D.
Archaeology Program Director
University College of the Cariboo

DR. BEHNKE RESPONDS

I ENDORSE THE GENeration of controversy in such issues as the historical (and prehistorical) abundance of New England salmon regardless of the motives of the provoker. New ideas, new paradigms, and progressive change cannot come about unless conventional wisdom and the status quo are vigorously challenged.

I will avoid the terms science or scientific. The only "scientific" tests of your hypotheses concerns your hypothesis that salmon did not occur in New England before about 1500 A.D. (which would be refuted by documenting archaeological or fossil remains of *Salmo salar* before this time) and your hypothesis that climatic warming commencing in the late 18th century is the cause of New England salmon extinction, not dams and pollution (there are historical records that refute this hypothesis).

When salmon first came to North America and what was their historical abundance are questions for which only indirect evidence can be used and this requires interpretation and professional judgment.

In your paper, "The (in) significance of Atlantic salmon," you state that you analyzed "30,000 fish bones" from prehistoric sites of aboriginal people (and no salmon bones were found). Did you make a concerted effort to find scales and otoliths? Typically, otoliths are the most durable bones in a fish, often the only remnants left after thousands of years. Sifting for otoliths with fine mesh screening is time consuming and often ignored in archaeological studies. I assume you have read a 1993 paper by Peteet, *et. al.* published in *Quaternary Science Reviews*, vol. 12, pp. 597-612, that mentions fossil scales from New Jersey that match the scales of *S. salar*. This paper does not illustrate these reputed salmon scales, but I received further information and a photograph, which I will forward to you. One scale was taken from a deposit dated to 11,500 years ago. The other is dated at 9,000 years. These dates approximate the retreat of the glacier front from this area (the edge of a southern or Atlantic glacial refugium for fishes). The scale is far from perfect and as an archaeologist with a specialty in fish remains, I assume you are more knowledgeable in scale identification than I am, but do you know of any family of North American freshwater fishes except *Salmonidae* that lacks radii or any form of sculpturing on their scales? If these fossil scales from New Jersey are from a salmonid fish, the only possible species would be brook trout or Atlantic salmon. The scale in the photo is definitely not from a brook trout.

Concerning your hypothesis that climatic change doomed New England salmon to extinction with or without dams and pollution, we can assume from your line of reasoning that during the period from about 1800 to about 1900, New England salmon were rapidly declining toward extinction in all rivers with and without dams. You cited 29 references in your paper but omitted the best documented historical account of New England salmon, that by W. C. Kendall published in 1935 in the *Memoirs of the Boston Society of Natural History*, vol. 9, no. 1.

Commercial fishing for salmon in the Connecticut River apparently began about 1700. Catches were not recorded, but Kendall cites a price of a penny a pound in Hartford. Connecticut River salmon were sold in New York City until dams eliminated all salmon by 1797. Samuel Mitchill (1816, *Fishes of New York*) mentioned that in former years the New York City market was supplied by Connecticut River salmon, but in 1816 they were shipped in on ice from Maine's Kennebec River.

Kendall cited the Kennebec as the second most productive New England river (after the Penobscot). The Kennebec lost most of its salmon in 1837 when a dam was constructed at Augusta. The Androscoggin River in Maine, probably the third most productive New England river, also lost its salmon to blockage by a dam about the same time. In 1888, the total commercial salmon catch in Maine was 205,149 pounds. Most of this (75-80 percent) must have been Penobscot salmon because it and several small rivers were the only rivers still maintaining salmon. The Penobscot, by this time, was badly impaired by dams and toxic pollution from pulp mills — it was operating at a much reduced capacity. Amazingly, in 1930, when the Penobscot reached the stage of advanced, almost terminal degradation as a salmon river, it still produced a commercial catch of 88,295 pounds.

"Although I agree with you that New England salmon were never as abundant as implied in folklore, they were probably much more abundant than you seem to believe."

A reading of Kendall's history of the loss of salmon in New England rivers after dam construction does not allow for a reasonable conclusion that climate, not dams, caused the demise of New England salmon. For detailed documentation of the demise of salmon in the Merrimack River associated with dams and pollution, see Stolte (1981) "The Forgotten Salmon of the Merrimack," U.S. Dept. of Interior.

Although I agree with you that New England salmon were never as abundant as implied in folklore, they were probably much more abundant than you seem to believe. Their abundance under pristine conditions based on my very gross estimate is that about 90 percent of the time (nine years out of 10), total numbers of salmon on spawning runs to the 30 or so New England rivers would have ranged between 100,000 (poor years) to 500,000 (good years). This is a conservative estimate based on area available for egg to smolt production compared to European rivers where data are available. I would also point out that in 1930, the Miramichi River, Canada, which has a watershed area less than the Penobscot (about 30 percent smaller and only about half the area of the Connecticut River basin) had a run of about 250,000 salmon. If one examines the latitude of the Miramichi (ca. 47° N. Lat.) with Maine rivers, it will be seen there is not a great difference (ca. 1°). Thus, any inexorable climatic shift operating since the late 18th century to doom New England salmon certainly should have been apparent on the Miramichi by 1930. If the Miramichi with only about 10 percent of the watershed area of all New England salmon rivers could have runs of this magnitude, a maximum run size of 500,000 for all New England rivers before dams, pollution and watershed degradation, is conservative.

Concerning the timing of the arrival of Atlantic salmon in North America, before or after the last glacial epoch, in lieu of definitive archaeological or fossil evidence, I use indirect evidence of genetic divergence. I cited a consistent difference in chromosome numbers between North American and European salmon to argue for a preglacial timing. You cite a 1989 paper by Davidson, *et. al.* and personal communication with Dr. Davidson that the genetic evidence does not preclude your premise that salmon first came to North America (that is, separated from European salmon) only about 1,000 to 10,000 years ago.

I would cite a paper by Taggart, *et. al.*, 1995, *Canadian Journal of Fisheries and Aquatic Sciences*, vol. 52, pp. 2305-2311, concerning DNA markers. In this study, 2,847 salmon from Spain, France, Ireland, Great Britain, Sweden, Norway, and Iceland were compared with 247 salmon from Maine, Nova Scotia, New Brunswick, and Newfoundland. Virtually complete separation was found between European and North American salmon. "North American" markers (in 96.5 percent of North American salmon) were not found in any European salmon. The dominant European marker (in 99.9 percent of European salmon) was found in 3.6 percent of North American

Workgroup 5
Why aren't there more (wild) Atlantic salmon overall?

Co-Leaders: Robert J. Behnke and Donna L. Parrish

Members: Steve Gephard, Lars Hansen, Steve McCormick,
Geoff Petts, Gordon Reeves, Eric Verspoor

Background
by
Robert J. Behnke

Presently there are more Atlantic salmon than during the entire existence of the species *Salmo salar*. By 1995, commercial cage culture approached 500,000 tonnes. Obviously, there can be enormous distinctions in human perception between cultured and wild salar, otherwise there would be no basis for our workshop.

How many Atlantic salmon existed in historic and prehistoric times?

Short-term and long-term cycles. Maximum annual commercial catch for North Atlantic (North America and Europe) during the past 50 years reached about 12,000 tonnes. If total exploitation was 60%, total biomass of all salmon returning to spawn would be 20,000 tonnes. Catch data does not include Baltic Sea or northern Russia (White and Barent seas of Arctic Ocean). Adding northern Russia and Baltic salmon plus illegal catch, angler catch, and taking into account resident lake salmon, suggest that in the most recent long-term (last 50 year period), maximum annual abundance was in the range of 25,000 - 35,000 tonnes for wild adult Atlantic salmon (with some hatchery supplementation). What might have been abundance in ancient times prior to dams, pollution, and watershed degradation? That is, all Atlantic Ocean rivers from Portugal through France and Germany (such as the Rhine) and in New England of North America producing salmon at full potential. A gross assumption can be made that maxima of "ancient" historic abundance would be at least twice that of recent maxima or in the range of 50,000 to 100,000 tonnes of mature fish. If mature salmon (grisle plus multi winter fish) averaged 4-5 kg, such biomass would represent from about 10-12 million to about 20-24 million salmon returning to spawn.

In relation to modern times, such abundance would seem fantastic, but it pales in comparison to Pacific salmon (pink, chum, and sockeye of the genus *Oncorhynchus*). In 1995, 217 million salmon were commercially harvested in Alaska alone. One Alaskan river basin, the Kvichak (with Lake Iliamna), has had historical runs of sockeye salmon estimated up to 42 million. With an average weight of 2.4 kg, the biomass of sockeye returning to the Kvichak River alone can reach 100,000 tonnes.

Obviously, Atlantic salmon have different limitations restricting their abundance compared to Pacific salmon. There are differences in habitat volume and food supply for salmonid fishes between the North Pacific and the North Atlantic, but the main limitation concerns freshwater life history. Typically, two or three years are required from hatching to smolt migration. This makes Atlantic salmon comparable to steelhead (*O. mykiss*). Determinants of abundance, egg-smolt survival and density and smolt-adult survival, are comparable between Atlantic salmon and steelhead. Efforts to enhance marine survival are essentially limited to strict control or elimination of commercial fisheries and illegal fisheries. Freshwater enhancement can include watershed restoration, flow and temperature moderation, improvement of habitat quality, fertilization, and hatchery supplementation. Once smolts enter the ocean, their survival over the next one to three years depends on ocean conditions that cannot be accurately predicted--the uncertainty principle is invoked when forecasting future runs.

Some unanswered questions concern why *S. salar* is so stenobiotic, virtually obligatory anadromous or obligatory lacustrine, whereas morphologically and anatomically similar *S. trutta* is represented by an array of intraspecific groupings adapted to exist in a great range of aquatic environments. Why does salar lack significant intraspecific differentiation and had no preglacial relicts in the Mediterranean-Adriatic region similar to trutta? Similar differences characterize the genus *Oncorhynchus*, obligatory anadromous or lacustrine Pacific salmons and the eurybiotic *O. mykiss* with differentiation into several geographical races and preglacial relicts.

General References

Gibson, R. J. And R. E. Cutting (editors) 1993. Production of juvenile Atlantic salmon, Salmo salar, in natural waters. National Research Council Canada Special Publication of Fisheries and Aquatic Sciences 118.

Groot, C., and L. Margolis (editors) 1991. Pacific salmon life histories. University of British Columbia Press.

Mills, D. 1989. Ecology and management of Atlantic salmon. Chapman and Hall.

Mills, D. (Editor) 1993. Salmon in the sea and new enhancement strategies. Fishing News Books.

Proposed Outline for Workgroup

I. Definition of "wild" salmon
   A. Are naturally produced offspring of hatchery-reared salmon wild?
   B. Does "wild" mean anything not raised either in a hatchery or a net pen?

II. Factors that influence abundance
  A. Life history characteristics
    1. Anadromous vs. land-locked
    2. Iteroparity vs. semelparity; compare to Pac. salmon
    3. Emphasis of freshwater phase; compare to Pac. salmon
    4. Specific traits--especially parr maturity and increased numbers of grilse
  B. Productivity of the freshwater environment
    1. Watershed size
    2. Length of river
    3. Forested vs. non-forested
    4. Competitors and predators
    5. Micro- vs. macro-habitat heterogeneity
    6. Latitude
    7. Thermal regime
    8. Gradients
  C. Estuarine and marine environments
    1. Productivity in areas near natal rivers and in migration path
    2. Thermal regimes in nearby areas and in migration patch
    3. Predators?
    4. Any competitors?
    3. Other factors??
  B. Fishing
    1. Direct and indirect impacts
    2. Harvesting of salmon prey
    3. Unreported harvests?
  C. Impacts
    1. Dams
    2. Pollution
    3. Logging
    4. Global warming
    5. Estrogen effects
    6. Other
  D. Stress of impacts
    1. Increased overwinter mortality of juvenile stages.
    2. Increased % parr maturity?
    3. Increased mortality in summer from high temperatures?
    4. Increased mortality from higher sediment loads and poorer water quality.
    5. Migrations are altered even when there is fish passage.
    6. Many more!
  D. Management practices
    1. Regulating fisheries
    2. Emphasis on stocking
    3. Genetics of fish stocked
    4. Data collected are appropriate to determine numbers?

III. Estimates of abundance

A. How have they been made (directly and indirectly)?
B. Are these estimates reliable?
C. Can we compare data across methods?
D. Are estimates of historical abundance reliable?

IV. How do we relate all of the above factors to abundance? Below are just a few examples.

A. How does watershed type and size and specific life history traits interact?
B. How does exploitation (fishing) and life history traits interact?
C. How does fishing and ocean environment interact?
D. What are the differential affects of scale on abundances?
C. Other interactions?

III. Cyclical nature of abundances

A. Are there cyclical fluctuations in abundances?
B. If so, what are specific factors contribute to this?
C. Do our index streams provide us with this information?

VI. Enhancement and restoration

A. Can we enhance abundance? If so, how? Is this locally or globally?
B. What role does fishways and hatcheries play?
C. What roles do habitat improvements play?
D. What role does closing fisheries play?
E. What role does aquaculture play?

Preliminary Schedule

Monday evening (1.5 h). Establish goals for group. Discuss outline and decide which areas need further development and which areas will not be beneficial for one reason or another. Decide which areas we do not need to cover in detail because of overlap with other workgroups.

Tuesday (2 h). Work from revised outline; try to work through much of I, II, and III. The real work for our group is in IV. We need to take all of the information previously reviewed and come up the relationships that contribute to differing abundances.

Tuesday evening (1.5 h). Discuss IV using specific examples. Are there data to show the relations in IV? Talk briefly about V and VI for the purpose of the open house on Wed.

Wednesday (0.6 h). Open House.

Wednesday (2.5 h). Finish IV, V and VI. Review what we have thus far.

Thursday morning. Workgroup Summaries

Thursday afternoon (2 h). Wrap up discussion. Incorporate feedback from summary session.

Rangeley Hammar Newfoundland lake brook trout dwarf char

Gibson 96 dwarf salmon

Work Group III members: Julian and Rick asked me to put something together to suggest a relevant bibliography for our workgroup. They were away during this time that we are to send out apropriate background materials, so I have tried to incorporate our ideas and references into an essay, which I hope is not too rambling. Anyway I hope it will give us a background to be working on, and of course we are hoping for feed back for further background material and criticisms, so that we can more clearly define our questions and to get an infrastructure in working order.

An essay and preliminary ramblings on subject matter of work group III. - How do we develop a conservation plan for salmon?

(A) Ecosystem and life history knowledge.

The basis of any conservation plan for Atlantic salmon is the knowledge of the species' physical, physiological and biotic requirements, for all life history stages, throughout the life cycle, and the mechanisms for attaining maximum fitness of the individual and for perpetuation of populations. A conservation plan would sustain present salmon populations, and safeguard the ecological processes and genetic diversity for the maintenance of the resource, by identifying and suggesting mitigative controls on factors constraining or having negative effects on the ability of salmon populations to thrive in present situations, and would suggest means of increasing or restoring populations where some influences, usually of anthropogenic origin, have led to the demise or decrease of populations, such as loss of water quality or physical habitat.

General climatic requirements, but related to evolution and migratory ability of the species (Black et al., 1986; Hammar 1987; Mc Dowall 1988) , can be gathered from the range occupied. The native range of the Atlantic salmon has been described by MacCrimmon and Gots (1979) as extending in streams along the Atlantic coast in North America from the Hudson River drainage in New York State (41°N) northward as far as the Frazer River in Labrador (56° 40'N), and to southern Ungava Bay in Quebec (58°N); and in Europe southward from Iceland, the Barents Sea (Pechora River), and southwestern part of the Kara Sea (Kara River) along the Atlantic coastal drainage to northern Portugal (Douro River) and the Bay of Biscay. These authors point out that water temperature must be considered to be a principal factor in establishing the native range of the salmon. Allen (1941) observed that there was a strong geographical correlation between the amount of growth of salmon parr and the length of the growing season. Power (1969) suggested that 100 growing days above a water temperature of 6°C were a minimum requirement. However, Jensen and Johnsen (1986) found in a Norwegian river fed by glacial water that water temperatures exceeded 10°C for less than 10 days a year and were about 7°C for only about 67 days a year, yet this was adequate for producing smolt of average age 5.2 years, suggesting that there may be genetic adaptation to rigorous conditions. Nevertheless, the longer photoperiod and therefore available feeding time during the summer at the relatively higher latitudes of northern European rivers should also be taken into consideration, and Metcalfe and Thorpe (1990) were able to explain 82% of the entire geographical variation in smolt ages by an index of growth opportunity, which took account of summer changes in both temperature and daylength. Highest weights of young salmon are achieved at 13-19°C, and most efficient growth at 16°C (Dwyer and Piper 1987). Fish will feed as low as 3.8°C, but amongst eight species of salmonids Atlantic salmon had the highest temperature requirements for survival, feeding and growth, and had an upper incipient lethal temperature of 27.8 ± 0.2°C (Elliott 1991). There is evidence that cold sea temperatures in the spring, when smolt are migrating, reduce the survival of post-smolt, possibly related to osmotic stress. Adult salmon over the winter are found predominantly within water temperatures of 4-10°C, and there is evidence that in winters when this thermal habitat is reduced that survival is poorer (Reddin and Friedland 1993). Long term trends in climate change, as hypothesised as occurring with anthropogenically induced global warming, would have effects on the range occupied by the species, and probably on marine survival, due to temperature, hydrological and marine current changes, affecting optimum temperatures for growth and survival, and abundances of prey and predators. Other than general efforts to minimise the causes of global warming, little can be done about controlling marine temperatures, although it may be possible to derive predictive models on changes in distribution and survival concomitant with climate and ocean current changes (Minns et al. 1995; Mangel 1994; Jensen 1991; Antonsson et al., 1996). However, changes in freshwater temperatures and discharges can be induced by artificial means, such as by impoundments, changes in stream morphology, changes in riparian vegetation, and discharges from industry. Changes in temperature may have negative or positive effects on production, depending on the temperature levels effected, although higher temperatures may have additional effects such as increasing toxicity of certain chemicals, reduced oxygen, enhancement of parasites, increases in competing species, etc. In addition, times of migration, of smolts and adults, would be affected, and could interfere with previously adapted behaviours. Conservation would therefore have to include temperature regulatory effects. "Bottlenecks" would include: spring seeps that provide refuges in times of high water temperatures in the summer, and during critically low discharges in the winter, where groundwater discharges could be affected by logging and road building exercises in the watershed; migratory time of smolts affecting arrival in the estuary at inappropriate times, related to sea temperatures, food and predators, e.g. reservoirs built on salmon rivers for hydroelectric development affect both the temperature and hydrological regimes (Saltveit 1990). In fact there is evidence that stocks of salmon in subcatchments respond differently to temperature (and photoperiod?) stimulants, and migrate at different times, related to appropriate arrival times in the estuary. These effects, which are likely to be adversely affected by hydroelectric developments, are poorly documented and presently represent an impediment to planning a conservation strategy.

Further ecological requirements can be defined by studies of the geomorphology of rivers inhabited by salmon (Heggenes 1996). Productive salmon rivers are characterised by pool and riffle type habitats with a substrate of boulders, rubble, cobble and gravel. These occur where the substrate is coarse and there is a gradient of 0.2% to 1.2% (Elson 1975), with highest parr densities at moderate stream gradient of 1.2-1.4%, but low densities at a gradient greater than 2% (Amiro 1993). Mills (1973) noted that spawning areas were favourable where gradient was less than 3%. Densities of young salmon are highest where coarse materials, such as rubble and boulders are present, probably related to size of territories and sites for orientation and crevices for hiding. In addition habitat complexity is necessary to provide suitable winter habitats (Cunjak 1996). Fine sediments have been shown to reduce production of salmon, by imbedding the substrate, thereby reducing the habitat for invertebrates on which young salmon feed, and reducing resting and hiding areas for young salmon, and by suffocation of eggs and developing fry in the redds (reviews by Gibson 1993, Stanley and Trial 1995). The relatively smaller streams (second to third order) are usually more productive than larger rivers, possibly related to stability of discharge, water velocities, temperatures, and input of organic matter and terrestrial invertebrates. Although a range of discharge is required to redistribute substrate materials, and to prevent the accumulation of fine materials, there is a negative relationship between salmon production and range of discharge (reviewed in Gibson 1993). Therefore more information is required on the optimum range of discharge, and the value of high floods at several year intervals. A conservation plan must address the effects of perturbations within the watershed, such as logging, road building, loss of riparian vegetation and hydroelectric dams that would change the hydrological regime and the change in sedimentation. Proponents of hydroelectric dams have sometimes suggested that regulation of discharges will increase production, but ignore the effects of imbedding, or alternatively loss of finer materials such as spawning gravels which are not replaced due to the dam ("armouring" of the stream bed), or encroachment of vegetation, depending on the circumstances, etc. (Barinaga 1996; Kellerhals and Miles 1996). Impoundments can change the species community in some systems, with negative effects on young salmon and migrating smolt.

Generally the most productive parts of a river system in boreal areas is downstream from lakes, due to stabilization of the hydrological and thermal regimes, and the output of seston, giving rise to abundant filter feeding invertebrates, enhancing the food supply of fish. Dams at lake outlets negate this effect. This important effect is almost always ignored in environmental impact studies. Also, in some systems juvenile salmon occupy the lentic habitats, although highest production remains in the lotic environments. Since this type of distribution generally is where there is a depauperate fish fauna, it appears that release of piscine competition and predation allows the realized niche of young salmon to approach the fundamental niche (reviewed in Gibson and Myers 1986; Gibson 1993). It is possible genetic adaptations have allowed some stocks to better use lentic environments than other stocks. However interactions within a species community are difficult to quantify, and competitve effects have only been described in a general way. Nevertheless a conservation plan should include stringent regulations to prevent introductions of exotic fishes, and a plan to eliminate such species where they might appear. The prevention of the introduction of parasitic and disease organisms would be included in such a plan.

Artificial barriers have done much to cause the demise of many salmon stocks (e.g. Westman and Kallio 1987). This is well recognised, but plans for mitigation usually relate only to adult upstream migrants and, sometimes, to emigrating smolt (e.g. O'Farrel et al., 1996). Effects on stream ecology and on juvenile rearing and production are frequently ignored. Even with fishways, migrants, both adult and smolt, may be held up longer than normally, and some will not migrate. Fishways are presently not designed to allow upstream migration of fry and parr, yet recent work (e.g. Erkinaro and Niemela 1995) has shown that these stages can make significant migrations, both up and downstream, from a few hundreds of metres up to >10 km, and will colonise tributaries or lakes where adult spawning does not occur. Any conservation plan must take these movements into account.

Water chemistry is a major field involving factors controlling salmon stocks, and ranges from toxic chemicals that kill the species to chemicals that enhance production. The effects of heavy metals from mining effluents may be well documented, but subtle effects of manufactured organic chemicals such as pesticides and herbicides on fitness of the salmon or on production of their prey may be less well documented. Some chemicals, such as calcium, nitrates and phosphorus may enhance production where these nutrients are limiting (Perrin et al. 1987; Gibson and Haedrich 1988; Johnston et al., 1990; Slaney et al., 1994). In an urban river of St. John's, Newfoundland, the Waterford River, enrichment from farms and sewage has reduced the insect diversity (20 families, as opposed to 34 in a nearby rural stream) but has increased the biomass of some groups suitable as prey, so that experimentally introduced salmon have shown phenomenal production related to other systems in the Province (Gibson and Colbo, in prep.). Although the latter river might not be perceived as a healthy river, has conservation of salmon been compromised, and should artificial enrichment of rivers to increase salmon be encouraged, even though some groups of invertebrates might be locally extirpated?

The Proceedings of a workshop (Kelso, ed., 1996) on habitat conservation and restoration strategies in the Great Lakes, Canada, also covers river conservation, and is pertinent to our present workshop. A number of papers deal with integrating across scales and time frames, e.g. fine scale, medium scale and large scale observations of stream characteristics provide different descriptions of fish habitat (Cunjak 1996; Lewis et al., 1996; Rabeni and Sowa 1996; Richards et al.,1996). Landscape-scale considerations of habitat take into account large-scale movements of fish and effects of physiographic variables and land use (Lewis et al., 1996). Similarly Bird (1996) pointed out that microhabitat criteria (water velocity, substrate, etc.) should be stratified into mesohabitats (pool, riffle scale) to account for scale effects in habitat selection. Steedman et al. (1996) suggest that historical information can provide valuable information towards conservation and restoration.

Salmon stocks can be differentiated over large areas, e.g. N. American vs European (Altukhov and Salmenkova 1987; Bermingham et al. 1990). However, stocks from individual rivers are difficult to differentiate by present methods, although it is claimed that in some systems there are several stocks, on the basis that the smolts migrate at different times, or the adults return at different ages, such as grilse, 2-sea winter salmon, or at different times, such as "spring" salmon, summer runs, and fall runs. The genetic makeup of stocks from different tributaries within some systems can be differentiated (Youngson et al. 1994). Anadromous and "landlocked" salmon can be genetically differentiated in some systems but not in others (Verspoor and Cole 1989; Gibson et al. 1996). Salmon are less heterozygous than other salmonids, and genetic differences are less marked, although the ranges in life history strategies suggest that genetic stocks exist (Fleming 1996).

Smolt and post smolt mortality may be high in estuarine and coastal marine areas, related to predation, disease, and thermal or osmotic stresses (Sigholt and Finstad 1990; Usher et al., 1991). Some hydroelectric developments may have changed the normal pulse regime of estuaries, whereby nutrients and detrital matter are recycled. It has been suggested that in some areas of cage rearing of salmonids that disease organisms and parasites are enhanced, thereby making wild emigrating salmonid smolt more susceptible to infection.

Salmon stocks have shown remarkable resilience to exploitation, possibly due to their life history strategy of maturing at various sizes and ages, and therefore conserving genetic diversity with a relatively small population (Saunders and Schom 1985). Emphasis therefore must be put on conservation of habitat, which must be related to all life history stages, and to scales within the ecosystem (e.g. Maddock and Bird 1996). The Canadian federal government has a policy (DFO 1986) for protection of fish habitats whose purpose is to ensure the net gain of fish habitats in Canada. The fundamental attribute of fish habitat to be protected (restored or enhanced in the case of compensation) is its productive capacity. An attempt was made to define freshwater productive capacity for Atlantic salmon (CAFSAC 1990). Nevertheless, emphasis is usually placed on maximum exploitation of the resource. Since management of exploitation of stocks is based on dividing the resource amongst users, but allowing sufficient spawning escapement to conserve stocks, it is essential to be able to estimate the stock recruitment curves for various systems, which entails knowledge of the numbers, the fecundity for fish in a certain system, and productive capacity of the system. High seas and coastal interceptory fisheries of mixed stocks complicate the issue. Exploitation should preferably be of terminal and stock specific fisheries, and taking into account the productive capacity of the system. Much scattered work has been dispensed on the problem but few long term studies have been accomplished to resolve the major questions. Required egg depositions for various systems have been estimated to range from 0.75 m^{-2} in less productive systems to 21 m^{-2} in some European systems (Elson 1975; Symons 1979; Egglishaw *et al.* 1984; Prevost and Chaput in press), depending on climate, river fertility, fluvial geomorphology and fish community. Models for stock-recruitment have explained 40-50% of the variability in populations, growth 17%, and habitat 30-40% (Prevost and Chaput in press). Nevertheless, in most countries fisheries management has failed to prevent general declines and over exploitation of the remaining stocks.

Rec Stock / Recr Stock / Produc. capacity determines it.

We need long term studies on "model" systems. The problem is that the political will to do this is declining. John Gibson provides us with the following example. The Department of Fisheries and Oceans (DFO) decided 17 years ago that the freshwater habitat was the most important area of research to improve management of salmon, and recommended that experimental rivers be set up in Newfoundland, and that other countries be encouraged to do the same. Five rivers were to be manipulated over ten years, with monitoring of adult salmon, smolt and parr for 16 years (Doubleday 1988). This was reduced to one river where stocks were manipulated over six years, 1985-1990, (Gibson 1995), and now all freshwater research on salmon production in the Province has been cancelled. How do we ensure long term studies? Some research strategy, with co-operative support from universities, private organisations such as the Atlantic Salmon Federation, corporate sponsorship (other than those with conflicting invested interests) and local fishermen, anglers and the community might be the answer (similar to CIRSA?). With international cooperation governments might be encouraged to commit themselves to long term support.

A research strategy must involve using modern technology and methods to minimise destructive methodology such as regular sacrificing of individuals, electrofishing in heat of mid-summer, counting-fences as barriers to migration, etc. For example stress on migrating fish can be virtually eliminated by using electronic counting devices rather than manual methods.

(B) Public education and advocacy.

A number of scientists comment on this aspect in "Forum: Economic Growth and Environmental Quality", which is a series of papers in Ecological Applications 6 (1), 1996. The opening paper is by Arrow et al. They point out that, if human activities are to be sustainable, we need to ensure that the ecological systems on which our economies depend are resilient. The problem involved in devising environmental policies is to ensure that resilience is maintained, even though the limits on the nature and scale of economic activities thus required are necessarily uncertain. They recommend institutional reforms that would compel private users of environmental resources to take account of the social costs of their actions. They emphasise the need for reforms that would improve the signals that are received by resource users. Harte (1996) assesses the two generally held views of future development, one of which is that nature is the ward of humanity, and the other that it is the steward. He believes that the commonsense values underlying the nature-is-steward vision are not being communicated adequately to the public. He claims that we are losing the educational battle because the science underlying the nature-is-steward vision does not appear to be as convincing, let alone as dazzling, as is the science underlying the people-are-stewards vision of continuing growth and of conversion of wild habitat to manacled rivers and manicured forests. Fuentes-Quezada (1996), in the same journal, points out that it is in the global interest to keep as much biodiversity as possible at the genetic, species, and ecosystems levels.

Although loss and degradation of habitats are acknowledged to be the major negative factors that have caused the demise or declines of salmon stocks, enforcement of regulations is weakly applied unless there is "political will", or in other words public awareness and public political pressure. A relatively minor example of the advantages of public interest, but repeated in other areas in the last decade, could be the city rivers of St. John's, Newfoundland. Up to fifteen years ago fisheries regulations concerning habitat were consistently ignored, wetlands were filled in, streams channelised or put underground, riparian vegetation removed for developments, storm sewers, with added effluents, discharged directly into streams, etc., (Gibson and Haedrich 1988; Steele *et al.* 1993), but environmental groups fought to control the destruction, and with political pressures have ensured that habitat regulations were enforced, and enhancement programmes have followed. Despite bureaucratic resistance for ten years, a local group finally had permission to stock salmon as fry, which are thriving and salmon runs are likely to be restored. The example has encouraged other municipalities on the island to follow suit. The environmental movement concomitant with public education on the values of habitats has slowed loss of habitats across the country, and improved waters in some areas.

Unfortunately, in Newfoundland, and probably elsewhere, the erosion of aquatic habitats continues. For example, in Newfoundland many salmon rivers have been lost or degraded by hydroelectric developments. At present 94% of the power needs of Newfoundland and Labrador are generated by hydroelectricity, with 60% of the island's power generated by 35 hydroelectric stations. The major available sources have been harnessed, but a further number of small projects are proposed, and generally the Provincial Government acquiesces unless there is considerable public opposition. Strong corporate and special interests often promote practices that are detrimental to salmonid protection and restoration. A recent example is that of Star Lake in central Newfoundland, a large 15.7 km^2 lake, which provides an unusual trophy brook trout fishery, isolated above a falls and inaccessible to anadromous fishes. The outlet is to be dammed, and an adjacent watershed is to be diverted into the system, increasing the lake's area by 50%, creating a fluctuating reservoir, with an 8 m overwinter drawdown. The only competent scientific study that has been done was by Hammar and Filipsson (1985), and they describe the only two species present in the lake as a dwarf arctic char, and a brook trout, the larger trout being piscivorous and feeding on the arctic char and on small trout. Johan Hammar (pers.comm.) points out that if the project goes ahead there will be a rapid deterioration of significant littoral fish food organisms, and a major loss of spawning grounds. Unique genetic stocks and a scientifically valuable ecosystem would be lost. Although the resource would be destroyed, of major consequence both scientifically and economically, a remarkably superficial and inept Environmental Impact Study (EIS) concluded that effects would be minor and mitigable. This has been accepted by both levels of government, and the project will probably go ahead. Other such hydroelectric projects are planned. A solution to preventing such damaging projects is public awareness of the real consequences, such as happened with the halting of the further destruction of the Nechako River, a tributary of the Fraser River, a project initially approved by all levels of government, but which would have had serious effects on the salmonid resource if it had proceeded.

An important step in public awareness and to guide conservation would be to document degradation and loss of salmon habitat and salmon stocks, similar to the general methods of Netboy (1968) and Watt (1989), but more specifically. For example many large watersheds in Newfoundland have been diverted or dammed for hydroelectric purposes, without mitigation for effects on salmon. Extensive logging and road building, which would effect changes on hydrology and sedimentation, and many improperly installed culverts causing obstructions to fish migration, must have had severe negative effects on the salmon stocks. Yet no quantitative estimation has been made of these factors on salmon production, although it is known that the salmon resource is radically reduced, most likely through loss and degradation of habitats, and aggravated by over exploitation of the remaining resource.

The philosophy of ecosystem management and the necessity of public education and communication is discussed in an article in Fisheries 21 (12): 6-11, (Schramm and Hubert 1996). They suggest that the concepts of optimum sustained yield and ecosystem management are similar. Ecosystem management involves changing the spatial and temporal scales of management from a focus on the local scale and immediate benefits to broader geographical scales (the entire watershed ~~and beyond~~) and long-term benefits. There must be a collaborative approach involving a diverse array of stakeholders. Communication among resource managers and their agencies is necessary. Communication within agencies is necessary, and managers and field staff must understand the philosophy, how to implement it, and how to communicate it to the public.

Spatial - entire H_2O shed
Temporal long-Term

(C) Legislative mechanisms for conservation.

We must have specific legal, political tools by which all must abide to ensure conservation. It is important to identify such tools. For example, some liability should remain with the proponent, which at present is not the case. If the proponent were responsible for restoring any damage incurred by activities in a watershed, including unforseen consequences a decade or more later, and had to pay for both initial and follow up scientific studies, which would be supervised and ensured to be competent by some watershed regulatory committee, representing all user groups, the EIS would at least be honest, and all users would be aware of the consequences of the project. Public participation and participation by all user groups, and to include scientific involvement, would ensure better enforcement of regulations than presently exist. The user of a natural system might be legally required to buy insurance that would cover the costs of environmental restoration in the case that the user's activities led to environmental degradation

(Costanza and Perrings 1990; Costanza and Cornwall 1992).

In an earlier e-mail Julian suggested that the approach that we are all users of the resource was similar to the integrated conservation strategy employed by Gordon Hartman and others in British Columbia for their scientific panel of advising on forest ecosystem conservation (Clayoquot Sound Scientific Panel. 1995). Mart Gross pointed out that the Panel unfortunately does not develop the "value" component of nature in ways that stakeholders can clearly understand (dollars), and suggests that one of the most important things we could do for salmon conservation is to develop the "value" side of conserving them. We should probably push for identification of the "Evolutionary Significant Units" (Waples 1995), why they have value, and how to protect them.

In Newfoundland there has been an economic analysis of water use (Government of Newfoundland and Labrador and Environment Canada 1996), in which hydroelectric power generation was valued at $45 million per year, compared to $15 million for recreational uses. However, it is difficult to put a monetary value on loss of habitat and biodiversity, which at present we try to meet with emotional evaluations. Wilson (1992) has pointed out that every scrap of biological diversity is priceless, but that we are in the midst of one of the great extinction spasms of geological history, brought about by mankind. Nevertheless, we are part of nature, and nature is part of us, and we have a committment to take all responsible action to protect every species and race in perpetuity. He suggests that bioeconomic values grow with familiarity, and quotes the Sengalese conservationist Baba Dioum, "In the end, we will conserve only what we love, we will love only what we understand, and we will understand only what we are taught". Wilson suggests that the wise procedure is for the law to delay, science to evaluate, and familiarity to preserve.

The collapse of many fisheries, such as that of the cod fishery and change of the ecosystem in the Northwest Atlantic, brought about by over exploitation by man, is a lesson that must be learned. Society will need to shift away from its traditional egocentric view of the world, in which the external environment is viewed only in terms of human uses, and move towards an ecocentric view, in which humans are part of the ecological fabric (Anon. 1996).

(D) Specific projects.

Bob Newbury suggests that in addition to the three general themes above, that more specific salmon conservation projects and strategies as case studies be included. There is a lot of disparate work going on in many countries at different levels of jurisdiction that is aimed at improving salmon habitats without any central data base. Many of the agencies involved are action oriented and look to examples of successful projects rather than research studies. A case study book would provide some insight into what now exists, with a view to applying some successful techniques more widely. An example of such a case study book has been prepared by the Danish Ministry of Environment and Energy (1996). In addition to their 25 examples there is a proposed format for a project questionnaire in Appendix A. Our workgroup possibly could modify this and suggest that it be circulated in Atlantic salmon regions as a first step in developing a conservation plan. Possibly awards could be given out for successful projects that would recognise the local people who did the projects.

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Everybody should read as much as they can on the subject. As part of the infrastructure individual members should present certain points in their main area of expertise or interests. For example, from feedback so far perhaps Mart Gross could present something on Evolutionary Significant Units. Perhaps Bob Newbury could present something on the idea of a case study book on specific salmon conservation projects. Rick Cunjak is interested in E.O. Wilson's "Biophilia" hypothesis. Anyway, after more feedback we can be more precise.

7, 13
Chapman
27 date

United States Department of the Interior

UNITED STATES GEOLOGICAL SURVEY
BIOLOGICAL RESOURCES DIVISION

Vermont Cooperative Fish and Wildlife Research Unit
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Burlington, VT 05405
802-656-3011

MEMORANDUM

DATE: January 26, 1998

TO: Bob Behnke, Steve Gephard, Steve McCormick, and Gordon Reeves

FROM: Donna L. Parrish DLP

SUBJECT: Workgroup manuscript

Enclosed is the draft of our workgroup paper for submission to CJFAS. I worked very hard to incorporate all of your comments. However, it was clear that we each chose different aspects that we thought were weaknesses. To be honest, some of those were in direct conflict and you may or may not be completely satisfied with how those areas were edited. All I can say is that I did the best I could to treat all of the comments as fairly as possible.

Your enclosed copy has black and white figures. These will be in color in the journal. Hopefully, with not too much effort you can still discern the patterns despite the lack of color. I did not want to ask for too many color prints before we get the to the version that will be published.

Thanks again for your efforts in providing sections and comments on the rough draft. Special thanks the efforts of Steve G. and Steve M. on the maps, and to Gordie, thanks for the help of Kathryn. She certainly made these a priority and she was a delight to work with. Thanks to Bob for always responding so quickly with additional information.

As you know, we probably won't hear anything about the manuscript for 3-4 months, but I will keep you informed when I receive any information. Best wishes for the remainder of the winter and here's hoping spring is not too many more months off, especially after our recent ice storm.

Why aren't there more Atlantic salmon?

Donna L. Parrish, Robert J. Behnke, Stephen R. Gephard, Stephen D. McCormick, and Gordon H. Reeves

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Abstract: Our goal is to gain an understanding of the historic limitations on Atlantic salmon abundance and why in recent years there has been a decline in wild anadromous salmon numbers throughout the native range. We employed a best-case scenario approach to make estimates of historical abundance and to illustrate constraints on Atlantic salmon numbers, we present the evolutionary divergence of Atlantic and Pacific salmon as an argument for lower estimates of historic productivity in Atlantic salmon populations. However, these differences do not explain the reasons for declines over the last few hundred years. In depicting the current status of salmon runs on rivers historically supporting salmon, we show wide-spread declines and extirpations in Europe and North America in primarily southern regions of the range. Many of these declines or extirpations can be attributed to the construction of main stem dams, pollution (including acid rain), and total de-watering of streams. Additionally, the negative effects of exploitation by commercial fisheries is shown through increases in salmon returns during the time of fishing moratoria. In many cases most factors affecting salmon numbers do not act singly, but rather in concert, which masks the contribution of single factors. Salmon researchers and managers should not look for a single factor in declining numbers of salmon, but rather, seek solutions through the understanding of hierarchical effects integrated across time and space.

Introduction

As a part of the series of papers from the Atlantic salmon (*Salmo salar*) workshop held in March 1997, our goal is to address the question: why aren't there more Atlantic salmon? To effectively answer this question we must focus on both scales of time and space, which coincidentally incorporates the symposium topic of integrating across scales.

There is an irony to our question in that Atlantic salmon are now more abundant than at any time previously. According to calculations (by R.J.B) from data obtained in the Idaho Aquaculture News and National Marine Fisheries Service reports, virtually all (~98% of the biomass) of the present abundance is because of artificial culture of salmon as a food fish. In contrast, wild Atlantic salmon numbers have been in a general decline. In this paper, we address only anadromous populations, thereby omitting aquaculture fish and resident populations.

First, we need to know how many salmon existed historically to understand why there aren't more now. From this exercise, we can ask more questions: why are there inherently fewer Atlantic salmon than Pacific salmon? Does the vastness and the productivity of the watersheds supporting Pacific salmon account for the differences in population sizes? Or, are there evolutionary constraints on Atlantic salmon numbers compared to those of Pacific salmon?

Next, we portray the spatial patterns of the status of Atlantic salmon populations in rivers of Europe and North America. We then question why there have been declines in the abundance of Atlantic salmon in many rivers throughout the range. Conveniently, there is a plethora of literature attributing various causes to declines, particularly extinctions, of salmon populations. Unfortunately, most of this information is somewhat uncertain because it lies in the realm of anecdotal reports reflecting certain biases or in the gray literature, which is written without critical review and often lacking factual support. Here, despite these limitations, we attempt to provide convincing information on the many possibilities causing current salmon declines.

Historic and Recent Abundances

To understand the suspected magnitudes of decline in Atlantic salmon numbers in recent times, we need to know how many salmon existed historically and be able to extend those estimates to the present day. To arrive at historical estimates, it is possible to take a best-case scenario approach, playing a game of "ifs," where each "if" is based on a questionable assumption, then make a leap of induction to arrive at an inflated estimate for abundance of salmon. This is the approach taken here to arrive at maximum estimates of salmon abundance.

For Atlantic salmon rivers in the USA, Rostlund (1952) made an assumption that historic runs of Atlantic salmon were in quantity per unit area similar to those of Pacific salmon. First, Rostlund (1952) estimated that 14 to 15 million pounds of salmon would represent the possible annual yield of 28 New England (USA) rivers, ranging from the Housatonic (Connecticut) to the St. Croix (Maine). If annual yield represented 50% of the total spawning runs, then total abundance of Atlantic salmon returning to New England rivers each year would have been on the order of 12,000 to 14,000 t. This would have been the abundance of legend and folklore, but it is a gross overestimate and such an assessment must be considered in the realm of "scientific" folklore. As discussed below, the quantity per unit area, or smolt density, is quite different from Atlantic salmon to Pacific salmon. If steelhead (*Oncorhynchus mykiss*) were used as a surrogate for quantity per unit area, Rostlund (1952) might have come close to reality.

Crozier and Kennedy (1993) presented data on the River Bush, Northern Ireland, suggesting it may be one of the most productive Atlantic salmon rivers in the world. The watershed of the River Bush is 33,700 ha. Stream water surface area is 84.5 ha, of which, 41 ha is usable salmon habitat. This amount of usable habitat equals 4,100 habitat units of 100 m^2 each. From 1973 to 1991, smolt migrations ranged from 14,509 to 44,958, or from about 3 to 11 smolts per habitat unit. Marine survival, calculated from catch and escapement of grilse returning the following year ranged from 25 to 36%, averaging 33%. Therefore, a best-case scenario for the River Bush would be about four returning salmon per habitat unit.

According to estimates of the U.S. Fish and Wildlife Service and the National Marine Fisheries Service (1995), the Connecticut River, USA, historically contained 262,500 habitat units for Atlantic salmon spawning and rearing. The total for all other New England rivers is about 300,000 habitat units. Using the best-case scenario prediction from the River Bush, four returning salmon per unit, the run to the Connecticut River would have been more than 1 million salmon and more than 2.2 million to all New England rivers. Virtually all were multi-sea-winter (MSW) fish averaging about five kg (Kendall 1935). Estimated total annual abundance in biomass would have been about 11,000 t according to this scenario of extrapolation. It is interesting to note that this estimate is rather close to that of Rostlund's (1952).

The indirect method of assessing historic (or prehistoric) abundance by habitat units and assumptions on marine survival contain obvious flaws. All habitat units are not equal in smolt production capacity among rivers or in the same river in different years. Marine survival can be highly variable. There are short-term and long-term cycles influencing both the freshwater and marine phases of life history.

The most direct quantitative data on overall abundance is commercial catch statistics. Catch statistics, however, require assumptions on escapement to estimate total abundance and such data are not available over a broad geographical region. For better precision, catch statistics should be based on salmon caught in or near the mouths of their home rivers, at the time of maximum weight before spawning. Open sea fisheries, such as those off Greenland and north of the Faroes, introduce inherent errors. For example, what would be the survival and weight gain of salmon until the time of return to home rivers if they were not taken in the open sea fishery? Clearly, data from open sea fisheries tends to underestimate salmon production.

Catch data based on coastal and river fisheries should ideally apply only to sexually mature salmon returning to spawn. If only grilse are involved, estimates of catch plus escapement would be assumed to essentially represent total marine biomass, recognizing that the present year's smolts may have entered the sea one to three months before the grilse return. With MSW salmon (and repeat spawning salmon that may skip a year between spawnings), considerable biomass of immature salmon remains in the sea, not accounted for in abundance estimates based on catch plus escapement. This is comparable to abundance estimates for Pacific salmon based on catch plus escapement. Each year during the harvest of chinook salmon (*Oncorhynchus tshawytscha*) returning to spawn, several year classes are still growing in the ocean (Healey 1991).

Mills (1989: Fig. A.1) depicted the total North Atlantic commercial salmon catch from 1960 through 1987. The catch data indicate a high abundance cycle from the mid-1960's to the mid-1970's, with catch maxima of about 12,000 t in 1967 and 1973. During this period, the open sea fishing on immature salmon peaked, reaching a maximum of about 3,000 t. If these salmon were not caught in the open sea and returned to their home waters the following year, the total biomass of sexually mature fish in the 1965-1975 period would have been greater. Reddin and Friedland (1993: Fig. 4.1) illustrated total commercial catch for North Atlantic salmon from 1960 through 1991with Canadian catch separated from that of other countries. The estimates (Reddin and Friedland 1993) generally agree with those of Mills (1989), except for a maximum of ~10,000 t compared to ~12,000 t and the estimates show a rather consistent correlation between the Canadian catch and the European catch of salmon. Based on data from Mills (1989) and Ritter (1993), the average Canadian catch was about 30 to 35% of the total catch of the North Atlantic basin during 1960-1991.

No comprehensive, basin-wide escapement data are available for total abundance estimates of sexually mature Atlantic salmon. During periods of past high abundance, it can be expected that the commercial fishery was intensive and exploitation rates of the most abundant runs were high. For example, Crozier and Kennedy (1993) give exploitation rates for the River Bush (Ireland) salmon runs from ~ 60 to 90% over many years. So, if an overall exploitation rate of 60% is used for the North Atlantic basin during catch maxima of about 12,000 t, then total abundance in biomass of all salmon returning to their home rivers would be on the order of about 20,000 t. If the salmon of the Barents and White seas of the Arctic Ocean of northern Russia and salmon of the Baltic Sea are added to the North Atlantic estimates, the total maximum annual biomass of all Atlantic salmon returning to spawn during the past 50 years could have been on the order of 25,000 to 35,000 t.

Evolutionary constraints on abundance

Any estimates of maximum abundance of Atlantic salmon, even with best-case scenarios and speculative extrapolations, would still pale in comparison to those of Pacific salmon. For example, in 1995, the commercial catch of Pacific salmon in Alaska alone was 217 million fish or about 500,000 t (Holmes and Burkett 1996). To understand why these differences in abundance occur, we need to understand the evolution and ecology of these two species.

Probably during the Miocene a common ancestral species separated into two isolated groups, one in the North Pacific basin and one in the North Atlantic basin. The North Pacific isolate gave rise to the genus *Oncorhynchus* and the North Atlantic group to *Salmo* (Behnke 1992). A major difference between evolution in *Oncorhynchus* and *Salmo* is the much greater diversity of extant species in Pacific salmon and their evolution reflects a consistent trend to reduced dependence on freshwater and increased potential for marine growth (Groot and Margolis 1991). Pacific salmon reliance on freshwater ranges from *O. masou*, with many resident freshwater populations and with anadromous populations in which half or more of the life span occurs in freshwater, to pink (*O. gorbuscha*) and chum salmon (*O. keta*) that smolt and enter the ocean soon after emergence (Groot and Margolis 1991).

Atlantic salmon is the sole extant species of the evolutionary line leading to anadromous specialization in the North Atlantic basin. The trend to increase adult abundance by reducing dependency on freshwater and increasing smolt production per unit area in Pacific salmon is not apparent in Atlantic salmon. If ocean feeding for salmon is not limiting, then this fact alone indicates that the abundance of naturally reproduced Atlantic salmon was and will not be as great as that of Pacific salmon; especially pink, chum, and sockeye (*O. nerka*) salmon.

Atlantic salmon abundance is comparable to steelhead (the anadromous form of *O. mykiss*) abundance in equivalent-sized spawning and rearing rivers because of similar life histories, therefore, density per unit area estimates for Atlantic salmon and steelhead are similar. In the Keogh River (British Columbia) about 2.7 steelhead smolts per 100 m^2 is produced (Ward and Slaney 1993), which is slightly less than the minimum number in the River Bush (3 smolts per 100 m^2) for Atlantic salmon (Crozier and Kennedy 1993). Because productivity in steelhead populations is akin to that of Atlantic salmon populations, steelhead can be a useful surrogate for Atlantic salmon, especially in the development of techniques for enhancement and restoration.

Current status of Atlantic salmon

We reviewed available information to develop maps showing the current status of wild anadromous Atlantic salmon in the world. Status categories for these maps are based solely on current numbers of adults returning to the rivers. Categories ware: Extirpated (E)—no returns for at least 10 years, Extirpated with restoration (E/R)—no returns for many years followed by the initiation of a program to reintroduce salmon, Declining (D)—long term decrease (>10 years) in numbers of adults returning, or Stable (S)—no consistent decline in numbers of adults returning during last 10 years. Categories were determined by us with substantial input of participants from Europe and North America at the March 1997 workshop as well as other biologists polled after the meeting. This approach does not allow for determining the status of salmon in every river historically supporting salmon; nonetheless, employing our approach allows us to portray patterns of salmon status across broad geographical areas, which was our ultimate goal.

Maps of Europe (Fig. 1 and Table 1) and North America (Fig. 2 and Table 2) indicate that many rivers historically supporting Atlantic salmon populations on these continents have experienced great declines or extirpation. (Note: Figure 1 does not show the entire range of Atlantic salmon, which extends to the Pechora River, Russia, northeast of the White Sea. Rivers not shown on the European map are considered stable.) Most watersheds in the southern portions of the salmon range are extirpated (E or E/R; Figs. 1 and 2) and salmon in the Baltic Sea are almost completely dependent on hatchery stocks. It is not coincidental that these areas have the highest human population densities and have experienced the greatest environmental damage because of human activity (see below). In Europe, some populations considered to be relatively stable (S) are in Iceland, Ireland, Scotland, and those northern rivers that drain into the Norwegian, Barents and White seas. Most U.S. populations were extirpated, but many large watersheds are targeted for restoration. A few small drainages near the Canadian border retain native, albeit, declining runs. Generally, Canadian rivers range from stable populations in the north, to declining populations in the mid-section, to extirpated runs (including those under restoration) in the southern reaches (Fig. 2). In North America, most of the U.S. rivers are under restoration (E/R), whereas, many rivers in Canada continue to be stable (S) (Fig. 2). However, some areas along the St. Lawrence in Canada are (E/R) and the St. John in New Brunswick and many southeast Nova Scotia rivers are examples of rivers that are declining (D).

What causes declines in Atlantic salmon abundance?

It is unmistakably evident from the European and North American maps that the current status of many salmon rivers is declining or extirpation. Why is there such a wide-spread decline in salmon abundance? Armstrong et al. (1998: Fig. 1) provides a useful depiction of hierarchical effects on Atlantic salmon populations, based on spatial and temporal scales. Clearly, many of the causal factors shown in Armstrong et al. (1998) act in concert, which can often mask the contribution of individual components, thereby, complicating our ability to discern individual mechanisms. In many cases of extirpation, however, single factors have been identified. Below we provide descriptions of some of the causes implicated as contributing to the demise of Atlantic salmon populations, such as dams, pollution, degradation and loss of habitat, and exploitation. Several factors are covered in other contributions in this supplement and will not be covered here in detail. These are the effects of: competition (Fausch 1998), introductions (Youngson and Verspoor 1998), pathogens and diseases (Bakke and Harris 1998), predation (Hansen and Quinn 1998; Mather 1998), prey (Poff and Huryn 1998; Hansen and Quinn 1998); and ocean conditions, especially related to thermal distributional patterns (Friedland 1998), on salmon populations.

Dams

Dams in streams can impact rivers and salmon populations in several ways. Most importantly, dams block the upstream spawning migration of Atlantic salmon, and although helpful, fish ladders can only partially mitigate this blockage. Downstream migration of smolts can also be affected by dams and other hydroelectric projects. Passage through power-generating turbines can cause direct mortality of between 10 and 50% smolts, resulting from the direct contact with turbine blades or high cavitation, pressure changes, water speed and turbulence within the turbines (Mills 1989). Turbines may also cause delayed, stress-related mortality and cause smolts to be more susceptible to predators that gather in large numbers below dams. Smolts can also become trapped in power or irrigation canals. Altered migratory cues through changes in seasonal hydrography and creation of reservoirs behind rivers can cause delays in migration, which can reduce smolt survival (McCormick et al. 1998). These reservoirs can also serve as refuge habitat for smolt predators.

The construction of dams without fish passage has extirpated entire salmon runs in many rivers. In New England, dams caused the local extinction of Atlantic salmon on the Connecticut and Merrimack rivers and had negative consequences in several Maine rivers (Moffitt et al. 1982), as well as, those throughout Canada (Dunfield 1985) and Spain (Garcia de Leaniz and Martinez 1986). Marshall et al. (1994) reported that the construction of the three hydroelectric dams with fishways on the St. John River in Canada did not result in complete extirpation of salmon runs, but caused a drastic decline in abundance.

Pollution

Pollution of rivers with a wide variety of contaminants has resulted in reduced numbers and death of many aquatic organisms (Moore 1998). Sewage, which included human waste was one of the major pollutants that reduced numbers of salmon in the River Thames in England

(Grimble 1913 cited in MacCrimmon and Gots 1979), industrial pollution eliminated salmon in the rios Miera and Besaya in Spain (Garcia de Leaniz and Martinez 1988) and pesticides were to blame in New Brunswick (Canada) rivers (Elson 1967). Heavy metals were implicated in the interruption of the salmon run in the York River in Quebec (Canada), although it is unclear whether this pollution event actually resulted in the long-term reduction of salmon numbers (Saunders and Sprague 1967). Pollution eliminated salmon in the Saint Croix River (New Brunswick) for a number of years, but some salmon have returned after clean up of papermill effluent (R. Saunders, St. Andrews, NB, pers. comm).

Pollution in the form of acidification affects salmon in northern Europe as well as North America (Moore 1998). In Norway, salmon populations in 25 rivers were driven to extinction because of lethal pH levels (Hesthagen and Hansen 1991). An experiment conducted in four streams in Atlantic Canada, showed that all parr died in streams with a pH < 4.7 (Lacroix and Townsend 1987). Conclusively, a broad range of pollutants have had negative effects on salmon behaviorally and physiologically, which is manifested from the molecular to the population level (Moore 1998).

Degradation and Loss of Habitat

Habitat for the freshwater phase of the Atlantic salmon life cycle is of obvious importance, but precisely what constitutes good, ideal or limiting habitat is still the subject of much research (e.g. Caron and Talbot 1993; Scruton and Gibson 1993; Gibson 1993) and likely a number of factors vary with geographic region in contributing to abundance and productivity. Water quality (e.g. sediment load, pH, conductivity, oxygen, nutrient levels), temperature, flow volume (particularly in summer and winter), depth, stream width, substrate size, and overhead cover have been identified as physical habitat factors that can affect salmon abundance (Scruton and Gibson 1993). Anthropogenic activities that impair salmon habitat include forestry, agriculture, industrialization, hydroelectric power, and urban development (Bardonnet and Bagliniere 1998; Elliott 1998). The impacts of these activities include reduced flows, channelization, siltation, stream bed disturbance, rock and gravel removal, stream diversions, removal of overhead cover, reduced water quality and changes in seasonal hydrographs and thermographs (Levings et al. 1989). These alterations have destroyed the natural stream geometry required for appropriate flows and hydrologic function (Newbury 1998).

With the exceptions of dams and water pollution noted elsewhere, examples of habitat degradation or improvements that have affected adult Atlantic salmon populations are, to our knowledge, nonexistent. Watt (1989) found a correlation between habitat loss in Atlantic Canada (16% decrease because of agricultural and forestry practices, dams, and acidification) and long-term catch trends of Atlantic salmon in Canada (17% decline of productive capacity). Examples of habitat alterations affecting juvenile production in fresh water are also rare. Hvidsten and Johnson (1992) showed that juvenile Atlantic salmon densities were lower in areas of the River Soya (Norway) that had been channelized, and that adding rock in the channelized area increased salmon parr densities. In the River Gaula (central Norway) the density of Atlantic salmon juveniles was higher along river banks that were protected from erosion than along unaltered river banks (L'Abee-Lund and Heggberget 1995). On a cautionary note, the results from these studies are difficult to assess because changes in migration numbers may or may not relate to changes in population size or productivity (Everest et al. 1991; Reeves et al. 1991). A larger literature exists on impacts of habitat improvements on Pacific salmon and trout; although, there is uncertainty of the mitigative success of these improvements (Levings et al. 1989; Hartman et al. 1996).

Potentially one of the most severe alterations of fish habitat is flow depletion from withdrawals for industrial, domestic, and agricultural uses. When a river is completely de-watered the obvious result is no water, no fish. The Nepaug River, Connecticut, USA, a former salmon river, has no flow at its mouth because all water is diverted to supply drinking water to the City of Hartford (S.R.G., pers.observ.). However, most water withdrawals divert only a portion of the total stream flow and assessing the impacts on salmon in relation to magnitude and timing of the altered hydrograph is not a simple matter. The nature of the problem has been well-described and potential impacts speculated upon for streams in Scotland (Mills 1980), England (Dill et al. 1975; Harris 1980), Ireland (Piggins 1980), and the Rio Ascon in Spain (Garcia de Leaniz, Servicio de Montes, pers. comm.). None of these examples, however, present conclusive data of a direct cause-effect relation between water withdrawal and abundance of salmon. However, Hvidsten and Hansen (1988) showed smolt survival was lowest during years with low stream discharge, providing circumstantial evidence that discharge reductions from deliberate water withdrawals can reduce the number of salmon.

Exploitation

Commercial fishing is a form of predation often resulting in mortality exceeding the capabilities of compensatory mechanisms, and thus, fishing can have great effects on the sustainability of populations. Major commercial fisheries for Atlantic salmon of North America and Europe have been in existence in Greenland since the 1950's (Møller Jensen 1986). Prior to the recent moratorium, salmon from the USA and Canada have also been harvested in the Canadian fishery (Friedland 1994). These fisheries have removed substantial numbers of salmon during this time period, many that were destined to return to their home river. A run reconstruction model for North American salmon provided a conservative exploitation rate of 35% for the years of 1974 to 1991 (Rago et al. 1993), which was almost half of those fish that were to return to rivers the following year (Friedland 1994).

Effects of fisheries can best be shown by determining the changes in the abundance of salmon returning during a fishing moratorium. For example, numbers of grilse returning to 20 Newfoundland rivers have generally increased (O'Connell 1997) following the closures of Newfoundland fisheries in 1992 and 1993. Gibson et al. (1996) indicate that adult returns increased in the Highland's River where returning fish were monitored the years after the 1992 fishing moratorium; but, the returns were not without variation; i.e. in 1997, the grilse run declined severely in some rivers (Gibson et al. 1996). In the early 1960's, the number of spawners in the Northwest Miramichi were greatly affected by commercial fisheries in Greenland, Newfoundland, and the local fishery in Miramichi Bay and estuary (Saunders 1969). Those fisheries harvested about 90% of the MSW spawners with much less effect on grilse. For a few years following a closure of the fishery, there was a positive effect on numbers of salmon in the runs (Richard Saunders, St. Andrews, NB, pers. comm.).

Concluding Remarks

Assessing the current status of a species requires incorporating data across temporal and spatial scales. To understand current abundance, we must know something about past abundance. We have reviewed available data to speculate upon the historic abundance of Atlantic salmon. Our exercise suggests that Atlantic salmon were always less numerous that any of the Pacific salmon (*Oncorhynchus spp.*), with the exception of *O. masou*. Clearly, the numbers of anadromous Atlantic salmon have declined dramatically during the past 400 years in many parts of the native range.

Efforts in the past have attempted to summarize the status of Atlantic salmon populations at the regional level (e.g. Atkins 1874; Kendall 1935; Garcia de Leaniz and Martinez 1988) as well as global level (Netboy 1968; MacCrimmon and Gots 1979). In this paper, we have updated information regarding the declines and extirpation of runs, but a more comprehensive treatment is warranted. The information we have presented shows that Atlantic salmon stocks continue to decline despite the efforts of many nations to study, protect, and restore runs. To identify causal mechanisms, we reviewed a list of factors that could potentially be related to declines in Atlantic salmon abundance. We identified dams, pollution (including acid rain), loss of habitat (e.g. de-watering of rivers), and exploitation as causal to extirpations and declines in numbers of returning adults.

The factors we have identified as contributing to species decline operate at different scales. Obviously, dams affect salmon abundance at the individual river level. This is probably the best documented factor for declines in salmon and solutions are well-understood but not always effectively pursued. Complete river de-watering is another river-specific factor. Pollution can operate at the individual river level (i.e. point source pollution) but also may affect salmon at a more widespread, regional level via non-point source pollution. Acid rain is a good example of a regional effect (Hesthagen and Hansen 1991). It is possible that there are many undocumented cases where widespread, regional pollution is influencing the abundance of salmon.

Exploitation can operate locally (e.g. home-water fisheries) or globally (e.g. distant-water/interceptor fisheries). The fisheries at West Greenland and the Faroes Island are the best known distant-water fisheries for Atlantic salmon (Ritter 1993). Impacts of home-water fisheries are more easily documented than those of distant-water fisheries, yet in many cases, impacts can be masked by other factors. Impacts of distant-water fisheries are difficult to prove conclusively in light of the myriad of factors operating within the home rivers on both sides of the Atlantic Ocean. Rigorous scientific analyses are required to document impacts by fisheries, particularly commercial fisheries.

There are other factors (e.g. competition and predation) for which substantial, albeit, equivocal information is available showing negative impacts on abundance, growth, and survival of salmon. The issue is not whether these factors are detrimental, but whether we have the ability to detect impacts to the criterion we chose, which was numbers of returning adults. Many effects are hierarchical, which include a broad range of lagtimes (Armstrong et al. 1998); therefore, we cannot expect to show all effects within similar time frames or spatial scales. Attributing declines to single factors is in many cases impossible because factors acting in concert result in synergistic effects.

The impact of changing ocean conditions in recent years has been identified as an important factor affecting Atlantic salmon populations (Friedland 1998). Ocean conditions may result in a common pattern of salmon abundance for many different rivers (Friedland 1998), but the magnitude of the run for each river is highly variable, regardless of the oceanic pattern. The magnitude of differences in numbers of salmon returning provides evidence that much of the influence on absolute numbers may be controlled more by local factors (i.e. not those at the oceanic scale). Lawson (1993) demonstrated that freshwater factors and long-term marine cycles negatively affect coho salmon stock size concurrently through imperceptibly slow, downward trends. As a result, stocks may approach extirpation before managers recognize the importance of the freshwater problem. This example reinforces the notion that in most cases of salmon declines and extirpations, multiple factors across scales of time and space are responsible. Therefore, although more work explaining the impact of ocean conditions is warranted, we should not abandon efforts to increase freshwater production because the freshwater component is the only aspect over which we have any control (except for fishery regulations).

Current and future impacts on Atlantic salmon populations are addressed by many of the papers contained in this supplement as well as those from other venues. Specifically, Mather et al. (1998) discusses the potential effects of two high profile topics; i.e. global climate change and intensive aquaculture. Presently, aquaculture fish can have major negative effects on wild salmon by introducing new diseases and parasites (Johnsen and Jensen 1994; Bakke and Harris 1998) that could have indirect effects on reproductive success (Youngson and Verspoor 1998). Aquaculture escapees have been observed spawning among wild salmon (Webb et al. 1991), and if interbreeding occurs, could affect performance traits of wild fish (Hindar et al. 1991; Gross 1998). Other potential negative effects of aquaculture are local eutrophication in areas surrounding net pens and alteration of normal salmon migratory patterns (Saunders 1991). Fortunately, these potential impacts have come to the attention of various governing and advisory groups, including The North Atlantic Salmon Conservation Organization (NASCO) (Windsor 1993).

For more successful restoration and retention of stable Atlantic salmon populations throughout the range, we need to employ a more holistic approach as advocated by Botsford et al. (1997) for management of fisheries. We should apply science to management in relation to temporal and spatial scales (Armstrong et al.1998) and these components should be incorporated into a conservation plan for Atlantic salmon (Dodson et al. 1998). By combining and implementing the perspectives presented in this supplement, including gaining public support for Atlantic salmon conservation (Dodson et al. 1998), we hope the status of many salmon rivers reported here as declining or extirpated with restoration will be changed in upcoming years to a new category of increasing abundances.

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Table 1. Current status of Atlantic salmon populations in the major river basins of Europe and Iceland.

Number	River Basin or Region (Country)	Status
1	Iceland	S
2	Ireland (Shannon, Erne, and Lee rivers: D)	S
3	Scotland	S
4	Wales	D
5	Southern and Central England	E
6	Northern England	D
7	Thames River (England)	E/R
8	Duoro River (Spain)	E
9	Mino River (Spain)	E/R
10	Northern Galicia (Spain)	D
11	Austurias (Spain)	D
12	Cantabria (Spain)	D
13	Cantabria/Vasco (Spain)	E
14	Vasco (Spain)	E/R
15	Adour River (France)	D
16	Garronne River (France)	E/R
17	Dodogne River (France)	E/R
18	Loire River (France)	D
19	Britanny and Normandy (France) (Orne, Vire, and Rance rivers: E)	S

Table 1. (continued).

Number	River Basin or Region (Country)	Status
20	Seine River (France)	E
21	Coastal N. France, Belgium, Netherlands, and Germany	E
22	Rhine River (Germany)	E/R
23	Southern Baltic (Germany, Poland, Lithuania, Latvia, Estonia, Russia)	E
24	Denmark	E
25	Northern Sweden and Finland (North Baltic)	D
26	Northern Norway, Finnmark, Russia (Norwegian, Barents and White seas)	S
27	Norway and S. Sweden	D
28	Glama River (Norway)	E/R

Table 2. Current status of Atlantic salmon populations in the major river basins of North America (USA and CAN) and Greenland. States in the USA are: CT=Connecticut, MA=Massachusetts, ME=Maine, NH=New Hampshire, RI=Rhode Island. Provinces in Canada are: NB=New Brunswick, NF=Newfoundland, NS=Nova Scotia, PQ=Quebec.

Number	River Basin or Region (State or Province, Country)	Status
1	Housatonic River and coastal drainages(CT,USA)	E/R
2	Connecticut River (USA)	E/R
3	Coastal drainages (CT, RI, & MA,USA) (Pawcatuck River, RI: E/R)	E
4	Merrimack River (MA & NH, USA)	E/R
5	Saco River and coastal drainages (NH & ME, USA)	E/R
6	Androscoggin River (ME, USA)	E/R
7	Kennebec, Sheepscot, Ducktrap rivers (ME, USA)	D
8	Penobscot River (ME, USA)	D
9	Downeast Rivers (Dennys, Machias, Narraguagus, Pleasant, E. Machias) (ME, USA)	D
10	St. Croix River (ME, USA and NB, CAN) (Western NB coastal drainage:D)	E/R
11	St. John River (NB, CAN)	D
12	Bay of Fundy (NB, CAN) & Southeast and Atlantic Nova Scotia (CAN)	D
13	Gulf of St. Lawrence (NB & NS, CAN)	S
14	Miramichi River (NB, CAN)	S
15	Nepisiguit River & coastal drainage (NB, CAN)	S
16	Restigouche River (NB, CAN)	S
17	Gaspé Peninsula drainage (PQ, CAN)	S

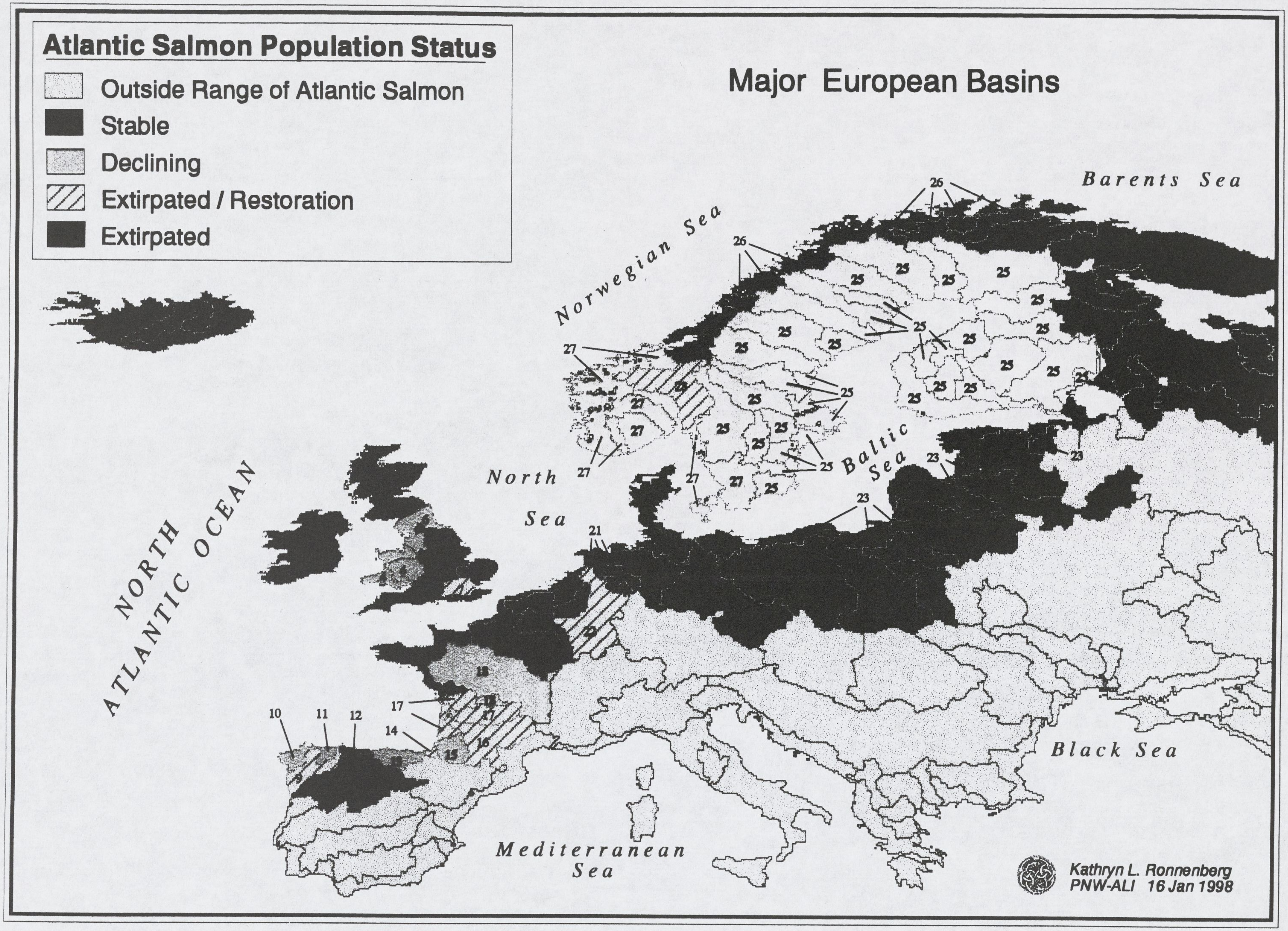
Table 2. (continued).

Number	River Basin or Region (State or Province, Country)	Status
18	South Shore St. Lawrence (PQ, CAN)	E/R
19	N. Shore St. Lawrence River (PQ, CAN)	E/R
20	N. Shore St. Lawrence (PQ, CAN)	S
21	Anticosti Island (PQ, CAN)	S
22	Labrador (NF,CAN)	S
23	Ungava River drainage (PQ, CAN)	S
24	Greenland	S
25	Newfoundland (CAN)	S

Figure Headings

Figure 1. Map of Atlantic salmon population status for major watersheds throughout original range in Europe. Numbering of watersheds is in Table 1. Note: Distance to Iceland is not to scale and range in Russia is truncated.

Figure 2. Map of Atlantic salmon population status for major watersheds throughout original range in North America and Greenland. Numbering of watersheds is in Table 2. Note: Distance from Greenland to North America not to scale.


Atlantic Salmon Population Status
Outside Range of Atlantic Salmon
Stable
Declining
Extirpated / Restoration
Extirpated
Major European Basins
Barents Sea
Norwegian Sea
North Sea
Baltic Sea
NORTH ATLANTIC OCEAN
Mediterranean Sea
Black Sea
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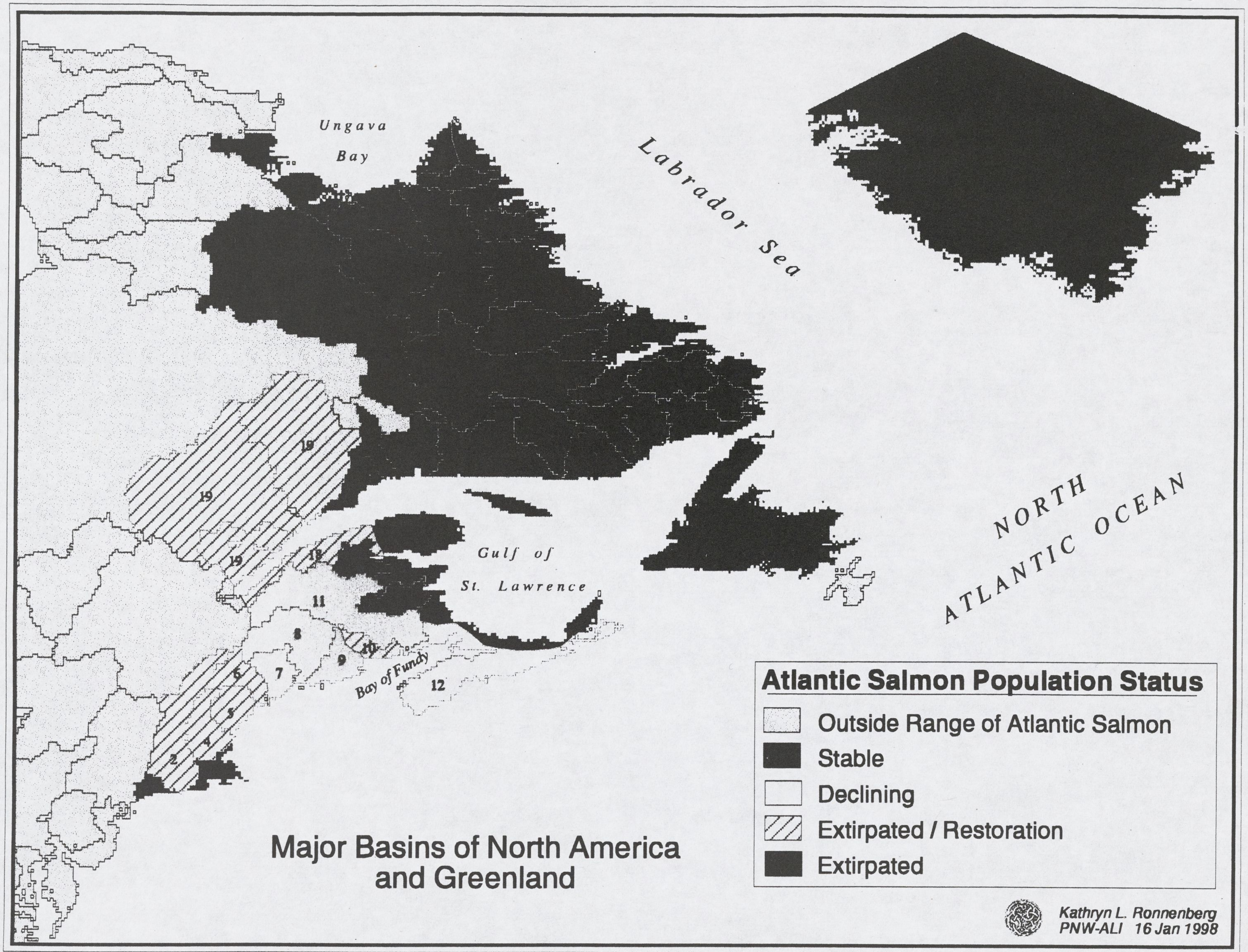
Kathryn L. Ronnenberg
PNW-ALI 16 Jan 1998


Ungava Bay
Labrador Sea
NORTH ATLANTIC OCEAN
Gulf of St. Lawrence
Bay of Fundy
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Atlantic Salmon Population Status
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Stable
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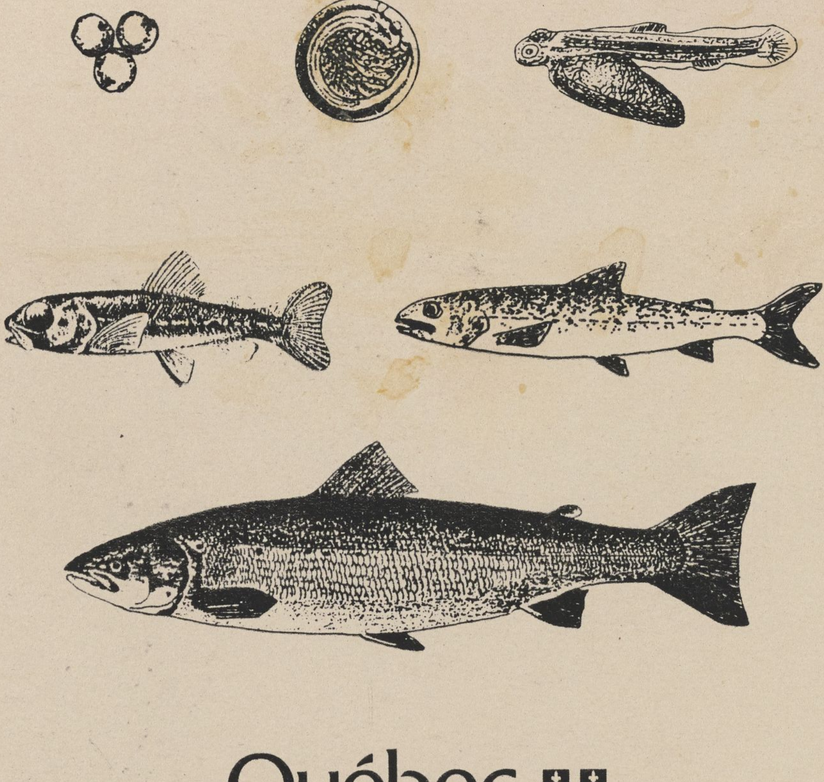
NOMENCLATURE DE STADES DU SAUMON ATLANTIQUE
Salmo salar Linné, 1758

Vianney Legendre
Jacques F. Bergeron



Québec

NOMENCLATURE DE STADES DU SAUMON ATLANTIQUE[1]

Salmo salar Linné, 1758

Français	Anglais	Définition
oeuf vert	green egg	oeuf fécondé, en développement
oeuf oeillé	eyed egg	oeuf dont le noir des deux yeux de l'embryon est devenu visible. Dit aussi: oeuf embryonné
alevin	fry	poisson juvénile, déjà éclos (ci-dessous, voir stades)
alevin vésiculé	sac fry, alevin	alevin, depuis l'éclosion jusqu'à la résorption complète ou presque du sac vitellin. Peut nager, mais retombe sur le fond à l'arrêt du frétillement
alevin, alevin libre	fry, free swimming fry	alevin nageant après résorption du sac vitellin; commence à s'alimenter. Peut se maintenir entre deux eaux suite au remplissage volontaire de sa vessie natatoire par de l'air
alevin avancé	advanced fry	alevin, plus tard en saison, s'alimentant depuis quelque temps. Terme de pisciculture
tacon	parr	juvénile des salmonidés avec des taches foncées sur les deux côtés du corps
tacon 0[2]	parr 0	tacon n'ayant pas encore atteint l'âge d'un an
tacon 1+	parr 1 +	tacon âgé d'un an ou plus
saumonneau	smolt	juvénile en eau douce dont les taches latérales foncées devenues masquées par l'argenture (guanine). Généralement âgé de 2 à 3 ans (exceptionnellement jusqu'à 11 ans). Stade où il quitte sa rivière pour la mer (dévalaison): se situe généralement au début de l'été, dans certaines rivières jusqu'au début de l'automne.
madeleineau[3]	grilse	saumon ayant passé un hiver en mer (plus ou moins un an en mer). Saumon remontant la Loire, en France, vers la fête de sainte Madeleine, le 12 juillet
lingard[4]	kelt, slink[5]	saumon de l'un ou de l'autre sexe, ayant frayé

Notes explicatives

(1) Il peut y avoir jusqu'à plus de 50 noms de stades pour le Salmo salar.

(2) Aussi tacon 2 + jusqu'à tacon 11 + ...

(3) Aussi en Bretagne: castillon. Nous n'employons pas ce terme car l'origine en est inconnue: "Je n'ai jamais pu découvrir l'origine ou l'étymologie de ce mot" (Latour 1928:28).

(4) Aussi charognard. Dans les Provinces Maritimes du Canada: saumon noir, black salmon.

(5) Kelt, terme usuel britannique; slink, canadianisme anglais.

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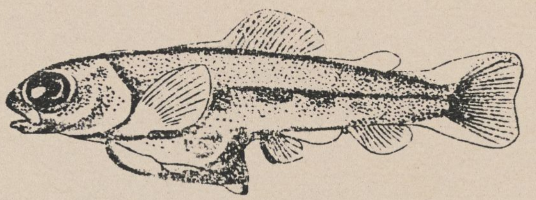
Gouvernement du Québec
Ministère du Loisir, de la Chasse et de la Pêche
Service de l'aménagement et de l'exploitation de la faune
6255, 13e avenue
Montréal, Québec
H1X 3E6

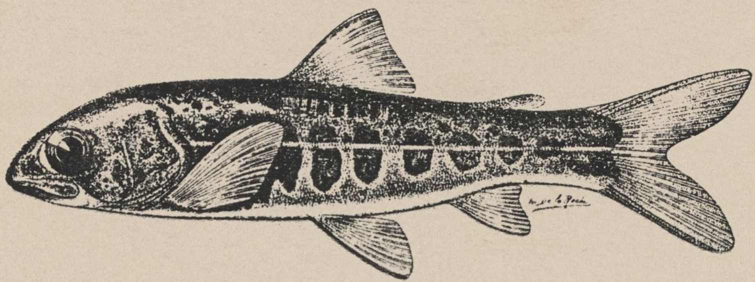
Juillet 1987

Montage et illustrations: Paul-Aimé Roy
Traitement de texte: Diane Jacques

Alevin à l'éclosion



Alevin de 5 semaines



Tacon immédiatement avant la descente en mer

Dessins tirés de: Roule, Louis 1920. Étude sur le saumon des eaux douces de la France au point de vue de son état naturel et du repeuplement de nos rivières. République française. Ministère de l'Agriculture. Direction générale des Eaux et Forêts. Pêche et Pisciculture. Imprimerie nationale. Paris. 178 p.

Gouvernement du Québec
Ministère du Loisir, de la Chasse et de la Pêche
Direction régionale de Montréal

Bob,
this report is very
interesting

Journal of Fish Biology (1991) 39 (Supplement A), 343–348

High frequency of natural hybrids between Atlantic salmon, *Salmo salar* L., and brown trout, *S. trutta* L., in a Swedish river

H. Jansson, I. Holmgren, K. Wedin and T. Andersson
Salmon Research Institute, S-810 70 Älvkarleby, Sweden

Among 332 parr from the Swedish River Grönån examined by electrophoresis, 44 (13%) were hybrids between Atlantic salmon and brown trout. The hybrid frequencies in three sections of Grönån were significantly different (23, 8 and 2%). All hybrids are evidently of natural origin, and possible factors promoting hybridization are irregular overlapping spawning times, lack of separate spawning grounds, and involvement of sneakers.

Key words: natural hybridization; Atlantic salmon; brown trout.

I. INTRODUCTION

It has long been known that viable hybrids between Atlantic salmon, *Salmo salar* L., and brown trout, *S. trutta* L., can be produced artificially (e.g. Alm, 1955; Dangel *et al.*, 1973), but the lack of clear morphological characters by which hybrids could be identified with certainty precluded screening for their presence in natural populations for many years. However, advances in protein electrophoresis have proved this method to provide unequivocal identification of hybrids (e.g. Vuorinen & Piironen, 1984), and hybrids have been reported from many areas where the two species occur sympatrically (Payne *et al.*, 1972; Solomon & Child, 1978; Beland *et al.*, 1981; Crozier, 1984; Verspoor, 1988; Semyonova & Slyn'ko, 1988; Garcia de Leániz & Verspoor, 1989).

In September 1989, sampling of Atlantic salmon parr for electrophoretic analysis was carried out in the River Grönån, south-west Sweden. During sampling, a number of parr intermediate in morphology between Atlantic salmon and brown trout were observed. Twelve of the intermediate parr were analysed electrophoretically and six were found to be hybrids. Furthermore, among 150 under-yearling Atlantic salmon 15 proved to be hybrids (Jansson *et al.*, unpubl. obs.). The finding of hybrids was quite unexpected since natural hybridization has been regarded as a rare event in Scandinavia (Heggberget *et al.*, 1988; Verspoor, 1988).

Thus, 10% of the parr were hybrids, but this is not an accurate estimate of the hybrid frequency since the subject of sampling was Atlantic salmon. An extended sampling of parr for electrophoretic analysis was performed in September 1990 in order to get a more accurate estimate of the hybrid frequency and to study the ratio between Atlantic salmon, brown trout and hybrids in Grönån. Another aim was to study the proportion of hybrids which could be identified morphologically. Here we report the results of this investigation and discuss factors that may promote hybridization between Atlantic salmon and brown trout in the river.

0022-1112/91/39A343+06 $03.00/0

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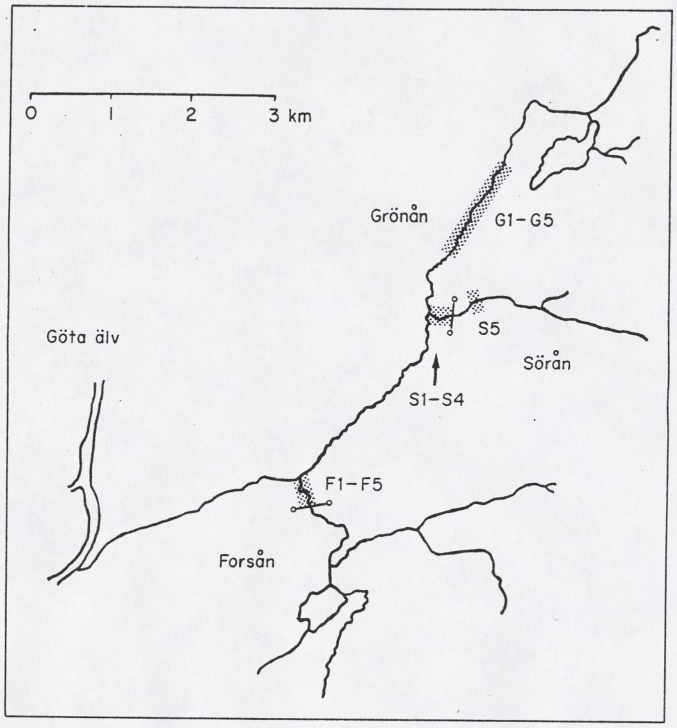

FIG. 1. Location of sampling sites in the River Grönån (shaded areas). Obstructions to upstream migration are shown as lines with circles.

II. MATERIALS AND METHODS

The Grönån is a small river which drains into the River Göta älv about 30 km north of Gothenburg on the Swedish west coast. In September 1990 a total of 332 salmonid parr were sampled by electrofishing in three different sections of Grönån, the main stream and the tributaries Sörån and Forsån. Within each section sampling was carried out at five sites (Fig. 1). The fish were frozen and transported to the laboratory where each individual was classified at trout-like, intermediate or salmon-like based on external characters.

Starch gel electrophoresis of the diagnostic enzymes glucose-6-phosphate isomerase (E.C. 5.3.1.9, GPI) and phosphoglucomutase (E.C. 5.4.2.2, PGM) was performed by using muscle and adipose fin homogenates separated in a buffer described by Ridgway *et al.* (1970). Hybrid frequency differences were tested by the *G*-test with Williams' correction (Sokal & Rohlf, 1981).

III. RESULTS

The electrophoretic analysis revealed a total hybrid frequency of 13% in Grönån. There were no significant differences in hybrid frequencies between sampling sites within sections. Between sections, however, the differences in the frequencies of hybrids were highly significant ($G=24{\cdot}44$, d.f. $=2$, $P<0{\cdot}001$) with 23% hybrids in the main stream, 8% in Sörån, and 2% in Forsån (Table I).

Besides the common enzyme phenotypes of Atlantic salmon, brown trout and their hybrid a few variants were found: one salmon with the genotype *GPI-1,2*100/100/100/185*, one trout with *GPI-3*100/110* and six trout with *PGM*100/75*. The

TABLE I. Numbers of Atlantic salmon (AS), brown trout (BT) and hybrid (H) parr from 15 sampling sites in three sections of the River Grönån: the main stream and the tributaries Sörån and Forsån

Site	n	Number of AS	Number of H	Number of BT	Hybrid frequency (%)
Main stream					
G1	22	2	6	14	27
G2	30	3	8	19	27
G3	31	10	2	19	6
G4	34	11	9	14	26
G5	32	11	9	12	28
Total	149	37	34	78	23
Sörån					
S1	21	8	2	11	10
S2	16	3	2	11	13
S3	25	6	1	18	4
S4	26	14	2	10	8
S5	14	6	1	7	7
Total	102	37	8	57	8
Forsån					
F1	12	11	0	1	0
F2	14	13	0	1	0
F3	23	20	1	2	4
F4	16	14	0	2	0
F5	16	13	1	2	6
Total	81	71	2	8	2

latter polymorphism is probably the same as reported by Vuorinen & Piironen (1984) although they designated it differently. One hybrid showed an aberrant GPI phenotype with six bands in contrast to the common hybrid phenotype with ten bands. The absent isozymes were those produced by the brown trout *GPI-1**, which indicates that this locus was repressed in this individual.

Of the 44 hybrids, 11 were under-yearlings which indicates that hybrids were represented by more than one year class. The result of the morphological examination showed that hybrids are hard to detect when only external characters are used. Only 36·4% of the hybrids were classified as intermediate, while 56·8% were trout-like and 6·8% salmon-like. Among brown trout 97·9% were trout-like and 2·1% intermediate. The precision in Atlantic salmon classification was not so good, only 88·3% were salmon-like, 10·3% intermediate, and 1·4% trout-like. This can be explained by the fact that many Atlantic salmon had trout-like characters such as yellowish adipose fins.

IV. DISCUSSION

The high proportion of hybrids in Grönån raises the question whether the hybrids are naturally or artificially produced. There is no doubt that the hybrids are natural since no known stockings have been made since 1978 when Atlantic salmon smolts were released near the mouth of Grönån (Håkan Carlstrand, personal communication). The presence of under-yearling hybrid parr in 1989 and 1990 is strong evidence of natural hybridization since hatchery-reared fish almost exclusively are released as smolts.

The significant difference in hybrid frequencies between sections is worth noting. The frequencies in Forsån and Sörån are not extreme, but 23% hybrids in the main stream is remarkable, and indicates a very labile reproductive barrier between the two species. Johnson & Wright (1986) have shown that female hybrids are able to produce unreduced eggs which produced gynogenetic diploids and triploids when backcrossed to male Atlantic salmon. We have not observed any enzyme phenotype indicating triploids, but in the light of the high proportion of hybrids in the main stream the possibility of gynogenetic diploid hybrids cannot be ruled out.

Other reports on natural Atlantic salmon × brown trout hybrids show frequencies of 0·3% in the British Isles (Solomon & Child, 1978), 0·4% in Northern Ireland (Crozier, 1984), 0·9% in North America (Verspoor, 1988), and 2·3% in Spain (Garcia de Leániz & Verspoor, 1989). These values must be regarded as conservative estimates since the subject of sampling was either Atlantic salmon or brown trout, and locally frequencies were higher. In spite of this, the frequency (13%) in Grönån must be considered as very high for natural hybrids. The high incidence of hybrids (31·4%) among adult fish in the Narova River reported by Semyonova & Slyn'ko (1988) is probably the result of hatchery operations since the populations of Atlantic salmon and brown trout in this river are maintained artificially (Kazakov, 1985). Thus the frequency in the main stream of Grönån (23%) is the highest so far reported for natural hybrids.

It is obvious that the reproductive barrier between Atlantic salmon and brown trout is severely reduced in Grönån. Temporal and spatial segregation are important isolating mechanisms for salmonids and Heggberget *et al.* (1988) suggested that temporal segregation is the main mechanism segregating Atlantic salmon and brown trout during spawning. In Grönån there is no evidence of separate spawning times, and local observations indicate that both species migrate upstream for spawning shortly after a rain period when the water level rises. Irregular overlapping spawning times may be one of the main reasons for hybridization in Grönån.

Stockings of non-native populations may promote hybridization when the introduced stock has a different spawning time, or when novel areas are colonized. It is possible that stockings in Göta älv have promoted hybridization in Grönån. However, this is contradicted by the fact that the hybridization rate increases with the distance from Göta älv, and that there are no indications of newly colonized areas. Hybridization can also be expected when one species is rare due to shortage of conspecific mates (Hubbs, 1955). This can explain the hybridization in Forsån where Atlantic salmon predominates, but does not explain the hybridization in Sörån or the main stream.

A more likely explanation is that the narrow and shallow Grönån (approximately 2–5 m wide and 0·2–1·0 m deep at our sampling sites) limits spatial segregation of the two species. In combination with high population densities, the lack of separate spawning grounds may explain the high hybridization rate. Fertilization of eggs by sneaking of mature male parr has been suggested as a factor promoting hybridization (Crozier, 1984; Verspoor, 1988). The number of sexually mature parr in Grönån seems to be high, and a frequency of 100% has been reported for Atlantic salmon in Forsån by Bohlin *et al.* (1986). There is also evidence of resident brown trout acting as sneakers. One female and two male Atlantic salmon were transferred to a spawning ground above an obstruction to upstream migration in Sörån. Two hybrid parr were found at this spawning ground, one in 1989 and one in 1990, which shows that resident brown trout have been involved in the spawning. The significantly higher proportion of hybrids in the main stream may be the result of resident brown trout, which are more abundant in this section, or of sexually mature parr, acting as sneakers.

The factors promoting natural hybridization are likely to be numerous and complex, and may vary between different rivers. In Grönån irregular overlapping spawning times, lack of separate spawning grounds, and involvement of sneakers may well be the cause of hybridization. The high frequency of hybrids in Grönån, and significant differences within the river, clearly shows that generalizations about hybridization rates within regions such as Scandinavia cannot be made.

We thank Ingemar Alenäs, Ulf Carlsson, Wilton Holmgren, Jack Olsson and Gunnar Larsson for generous help during the sample collection and for valuable information, and Torgny Bohlin, Karl Fredga and Torbjörn Öst for helpful comments on the manuscript. This work was supported by the Swedish Council for Forestry and Agricultural Research, and the National Board of Fisheries.

good thanks to Kent

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Bob,
Few odds and ends
from the new rod and reel.
Articles would it have
interested you much

Predator

THINK of this month's cover as a Rorschach test for anglers: Which do you see first? The fishermen here all looked at the photograph and, through various subtleties—whistles, grunts, droolings, dropped jaws; the occasional simple, heartfelt "Ooh!"—expressed admiration for that outrageous brown trout.

The non-fishermen here (admittedly there are some, but not on this staff) were more impressed with the attractiveness of the setting and the person, and how harmoniously all the visual elements work together. And what did they think of the trout? Well, it seems they've heard so many fish stories from the rest of us that they thought it was just normal . . . .

I am sorry to say that the women in this outfit, anglers or not, all looked upon this cover and wanted to know, "Did she really catch that thing?" Whereupon I would draw myself up into a righteous huff—I mean, what a bunch of cynics, right?—and announce that of course she caught it, and all by her little self. Her husband merely took the picture. He netted it, too.

She is, as you may know, Cathy Beck. With husband Barry, she owns and operates a very fine fly shop called Fishing Creek Outfitters—formerly Beckie's Fly Fishing Specialist—in Benton, Pennsylvania. Barry and Cathy have fished, and presented fly-fishing programs to angling clubs, all over the place. It runs in the family too: Their 12-year-old daughter Annie just appeared on ESPN, fly-fishing with Jerry McKinnis in a show called "Fishing Buddies."

There is always a story behind such a fish, and here it is. One afternoon in June 1988, a friend came into the Becks' shop to say he'd been down on Fishing Creek and watched a minnow fisherman lose "the biggest trout he'd ever seen"—the man had it almost on shore when, at the last minute, the well-meaning stranger who was trying to net it for him fumbled the grab. This led to harsh words and nearly a fistfight.

Two weeks later, after one of their fishing schools, Barry and Cathy went out to eat at a local restaurant. The pool in which the minnow misadventure had taken place is right behind the restaurant, and so on the spur of the moment, and with the monster trout in mind, they rigged up and eased into the water after dinner. On her third cast, Cathy turned to Barry and said "Oh, I'm hung up on the bottom. Must be a branch or something, 'cause it's kind of springy . . . ." And then the "branch" came straight up and erupted through the surface of the pool.

Even pros like Cathy get exercised over such a brown trout. She figures it took 25 minutes to land it. Barry claims it was more like 10. In any event, land it they did, with Barry on the net. Silence descended over the evening as they looked at the fish and the enormity of it began to sink in. At 27¼ inches—what's that, eight pounds or so?— it is now regarded as the biggest brown trout taken on a fly in Fishing Creek.

Can you believe this

Now guess who arrives on the scene? I swear, he can smell big salmonids from miles away. None other than Ernest Schwiebert, in the flesh. Ernie knows trout like Bo Jackson knows every sport except bocci ball. He examined the fish closely, and proceeded to deliver one of those famous perorations that used to keep "Ernie's Army" spellbound, back when he was maintaining a higher profile: The fish, a male, had spawned the fall before; likely it was the final year of his prime, and his last spawn. The pool is small, but it's about a mile and a half upstream from a dam, and Ernie theorized the fish had moved upstream from the deeper water there in search of food. No insects for a great-jawed predator such as this; he needs protein in bigger chunks—frogs, mice, leeches, other fish, the occasional bird too slow-witted to live. (Note Cathy's Woolly Bugger still in his mouth.) Probably it was the only trout in the pool, the embodiment of death to lesser fish.

There are big trout in Fishing Creek. A six-plus-pounder had come out of the same pool a few years before. Ernie went on to take a 23-incher himself, two miles away, a couple of days later. And in 1985 a verified 17½-pound, 35-inch brown was taken in the bigger water downstream; one watcher told the Becks he thought it was a muskie.

Good show.

Silvio Calabi

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Alaskan Hummers

JAN/FEB hit the "Alaskan Experience" right on the nail's head. I've been at King Salmon for seven months with the Air Force and the fishing couldn't be better. The salmon are awesome, but I pass them up for the rainbows and grayling. You expect salmon to be large but really, where can you find 12- and 16-pound rainbows in the lower 48? And what about 4½-pound grayling? It doesn't get any better than this. I don't have to fly out either—they're right in the Naknek River. I've also stumbled upon perhaps the best fishing car yet: the HMMV, the military's new jeep replacement. Hatchback, sunroof (OK, turret) and 4WD. It gets where the fish are and the canoe fits on top. I'm extending for another fishing season here. If you're up on the Naknek (lake or river) and you see a squat, ugly green "Lotus" parked by the water, I'm close by, catching the fish of a lifetime. If you fly-fish, come. Just leave the fish and take your trash out with you.

Ken Smith
King Salmon, Alaska

KUDOS for the great Alaska profiles. I was fortunate to fish Alaska last June, and all other exotic trips pale in comparison. Alaska is indeed a total experience and the trip was worth the cost even before I took rod from case.

I found the June fishing to be superb. As a bonus, it's light enough to fish for over 20 hours a day, if you don't collapse from sheer exhilaration. There are indeed "strange things done in the midnight sun." I stayed at Kulik Lodge, a five-minute walk from the Kulik River. After flying-out during the day and a fortifying dinner, it was icing on the cake to fish for 16- to 25-inch rainbows in the evening, using either a leech pattern on the bottom or a sockeye smolt dead-drifted just under the surface. The only drawback was no salmon in these rivers in June; but there were also no bears near the river, so I wasn't constantly looking over my shoulder.

Fishing "The Last Frontier" was an incredible experience. It's not a once-in-a-lifetime trip, though; once you've been, you have to go back.

Daniel R. Cerven
Address unknown

Logjams

JAN/FEB has an interesting perspective on the emotional conflict between forest-related industries and recreationists. As one active in both, I discovered a revealing contrast in two separate articles.

In "Conservation," Ted Williams dramatically denigrates an industry's motives, practices and the presumed negative impact of logging in the Northwest, with the complicity of the US Forest Service.

Just pages after, Carolyn Roth in "After the Apocalypse" presents an encouraging post-fire report from Yellowstone, suggesting the fire was "long overdue, and looking good." It describes good fishing and elaborates on survival and the resilience of nature following this disaster.

Had the destruction of trees in Yellowstone been by man's action (logging) instead of by his inaction (let it burn), can you imagine how it would have been perceived and reported? It strikes me that if the latter is accurate, it provides substantial hope that reasonable people willing to understand both interests can create forest policies and practices acceptable to both.

James R. Batchelder
Pittsburgh, Pennsylvania

I AM flabbergasted, shocked and awed. How else can I describe my feelings about someone who pontificates from an airliner at 35,000 feet and then retreats to a sanctuary 3,000 miles away? Safe on the East Coast, Ted Williams can brainwash unknowing sportsmen with tales of how the Northwest will soon be bare of trees and erode into the rivers to bury our beloved salmonid spawning beds. With such knowledge and insight, perhaps Mr. Williams could single-handedly replace five government agencies and provide 131,000 jobs to former forest industry workers!

"The Spotted Fish Under the Spotted Owls" [Jan/Feb] is so full of misinformation, half-truths and factoids that I cannot refute them all in less than a book. Having lived here for 21 years as a professional forester, I know the truth of the matter. This is where I live, work, recreate, hunt and fish. I cannot retreat from here to criticize what I have seen. But I refuse to create an exclusive playground for Maryland fishermen and their ilk. I intend to help make Oregon and its citizens prosper—safe, secure and happy in an environment that protects people *and* the natural resources.

Where to begin . . . . Douglas fir trees do not "average 500 years of age." Few even attain that age in a climate of winter winds, summer fires, insects, disease and rot. I am still searching for the mythical 1,000-year-old forests of Oregon.

Timber companies never just pause to replant trees. Strict forest practice laws *require* that all lands be replanted soon after harvest. Timber companies make conscious decisions to replenish their private lands. Federal law also mandates reforestation of all national forest lands. I would hardly call 100 million seedlings a "pause"—that is the number of trees replanted each year!

Spotted owls and old growth: Give an owl a second-growth forest and he is apt to adopt it as home. Just southeast of Portland I can guide Mr. Williams to 10 pairs of spotted owls, all living in a second-growth forest. Indeed, the more we look, the more bird we find in all ages of forest. Are these just demented owls that don't know where they are expected to live?

Multiple use: Nearly 40 percent of the national forests are already off-limits for harvest. Trees in those areas provide scenic beauty and wildlife habitat, and *protect stream courses and water quality*. Recreationists hike, fish and camp in these wilderness, roadless areas, watersheds, scenic rivers, campgrounds and special-interest areas. One third of the forest produces only limited amounts of timber in conjunction with other more important uses. About 30 percent of the national forest is intensively managed to provide trees for paper, lumber, plywood, rayon and cellophane. Even these lands must be managed to protect soil, wildlife and water. "Cut out and get out"?—to where do we "get?"

I guffawed loudly—not to say barfed—when I read about "Mapleton's ancient trees." (Please define "ancient." A tree 100 years old? I suppose from 35,000 feet all trees look the same.) Mapleton is part of the Siuslaw National Forest, a 581,000-acre land mass covered with second-growth timber. Because it's near the Pacific, the area is shrouded in fog and bathed in rain most of the year. Some drainages receive over *eight feet* of rain annually. But freakishly dry weather over 100 years ago allowed forest fires to sweep most of the trees from the land. The ancient old growth that remains today is found only in small isolated groves, not in any vast tracts of 1,000-year-old trees as envisioned by Mr. Williams.

Gosh, why would any forest worker fear losing his job or home? How could any father worry about feeding a family or getting kids through college? Gee, those concerns seem so insignificant compared to a visiting backpacker having a meaningful outdoor experience.

The article was a piece of preservationist trash that does not belong in any sportsman's magazine. It has misrepresented and distorted the image of our great Pacific Northwest. Yes, management mistakes have been made in the past. Yes, there is controversy as the future of forest management and 131,000 jobs is decided. It is one thing to shut down a faceless industry full of greedy timber barons from 3,000 miles away. It is quite another to look a man in the eye and tell him a bird is more important than his wife and kids.

Mickey Bellman
Salem, Oregon

Williams Strikes again

Ted Williams replies:
DO you really believe the choice is between our owls and your kids? Do you really believe land incapable of sustaining old-growth birds can sustain people who make their living removing, at nonsustainable yield, old-growth plants? Do you really believe that when you scatter seeds of just one species on a clearcut and mouth the word "reforestation" you have made a new forest? Oregon is one of the few states where there are no requirements to become a "professional forester." Judging from your letter, I'd say that's a lucky break for you.

We've cut 30 million acres of our old growth and have only 1.4 million acres left. This we are liquidating at a rate of 60,000 acres per year. So, with or without owls, the party's over. The old trees aren't going to be there anymore. Get it?

Before becoming "a professional forester" did you attend some sort of school? Whoever taught you that "Douglas fir trees do not 'average 500 years of age,'" had it right, but you should learn to read better. I said "virgin Douglas firs." Did the school attempt to teach you basic logic? If so, what happened? I am myself amazed, flabbergasted and shocked—by the process with which you conclude that I didn't walk through a forest because I flew over it. But such logic explains how you are able to deduce that spotted owls do well in second growth because 10 pairs are still alive in it. (Would you say that humans do well under bridges because sometimes they are found living there?) And such logic explains how, from a reference to Mapleton's scattering of ancient trees, you can establish a belief on my part that the district is basically primeval.

Why do you think it is that "40 percent of the national forests are already off limits for tree harvest"? Mostly, it is because trees do not grow on lakes, rivers, roads, grass-lands, deserts, rocks, icefields and slopes above timberline. Your industry controls virtually all the public's best tree-growing land; if that's not enough to keep you in business, maybe it's time to vet your business practices.

Viewed from another angle, your statistic means that private industry (which long ago denuded its own holdings) gets to cut timber on 60 percent of the public's forestland. You do it very crudely, tearing up the earth and devastating the public's fish and wildlife in the process. Public funds pay for your access roads, which further devastate fish and wildlife, and when all the checks and bills are tallied, the public's logs don't even pay their way out of the woods. You call it "multiple use." I call it cutting out and getting out.

"To where do we get?" you ask. Good question.

Correction

THE correct price of *Fishing for Northern Pike* (March "Videos") is $49.95. □

environmental issues, as well as to initiate conservation programs"—presumably by marshalling its combined readerships of millions. One of the first tasks, according to the president of TM, is to get the striped bass named a National Game Fish.

Some of the 10 councillors are known outside Times Mirror's offices: Rip Cunningham and Spider Andresen, of *Salt Water Sportsman*; Duncan Barnes, editor of *Sports Afield*; Clare Conley and Lonnie Williamson, of *Outdoor Life*; and George Reiger, *Field & Stream*. OK, guys, now let's see the dirt fly.

FAIRY Tales of man and moods and trout,
Lands and waters, care and cause without.
Quixotic games, a river's chuckling sound.
To solitude and love, where self is found.
—from Mel Krieger's Club Pacific brochure. Honest.

SIXTY POUNDS OF SALMON

For once, a camera when you need it

MIKE Crosby's awesome 60-lb. (est.) Atlantic salmon will go unsung in the record books due to his law-abiding nature. Crosby, who owns a fly shop in Halifax, Nova Scotia, caught the monstrous salmon on New Brunswick's Restigouche.

Crosby had been fishing for only half an hour when he saw a tremendous shadow move under his fly. The fish struck, but when Crosby responded there was nothing. (He later found that the salmon's kype was so large its jaw couldn't close properly.) Heart pounding, Crosby changed to a #2 longshank Brown Bug and this the fish was able to grab. The giant swirled—which Crosby described as "like looking inside a washing machine"—and ran downriver. Somehow, despite an 8-lb. tippet and several reel-stripping runs, Crosby brought the salmon to the boat. Thereupon he let it go, as NB law stipulates. He wasn't even able to weigh it.

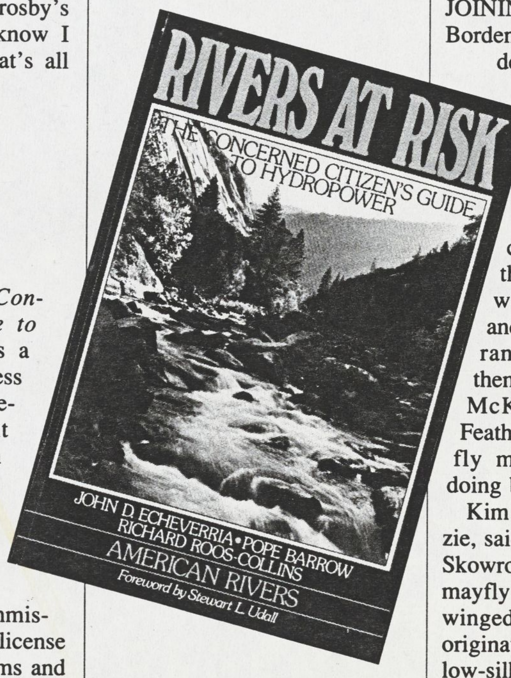
Crosby's crocodile

But his guide managed to snap a few clear photos of the ancient alongside the boat. By comparing and counting, Crosby (and later government biologists) realized that half the salmon took up at least eight ribs of the big freight canoe. Further examination showed the fish measured 31 inches from the tip of his nose to the center of his dorsal fin, which made his overall length a stunning 60 to 62 inches.

A 55-inch Atlantic salmon of average girth weighs an even 60 pounds. Crosby's beast sported an unusually long hook, so five inches was deducted from the estimated size of the fish, which still put it over 60 pounds. To his everlasting credit, Crosby released a Canadian record and a world record. The current IGFA 8-lb. tippet mark for an Atlantic salmon is a measly 31 pounds 8 ounces—a runt next to Crosby's leviathan. He said, "I know I caught that fish, and that's all that matters."

RIVER MANIFESTO

RIVERS at Risk: The Concerned Citizen's Guide to Hydroelectric Power is a new book from Island Press and American Rivers—respectively, a non-profit publisher of conservation literature and a nonprofit group dedicated to preserving our rivers and river landscapes. Now, as the Federal Energy Regulatory Commission (FERC) tries to relicense more than 200 hydro dams and conservationists are organizing to reclaim the rivers for recreational and environmental purposes, this book is timely.



A how-to guide and reference, *Rivers at Risk* provides start-to-finish information on how to approach FERC. The book spells out the processes and paperwork that shield any government agency: explanantions of the relicensing process, how to introduce environmentally sound changes to existing dams, how to get expert and legal advice, and ways to attract favorable press, to build community interest and statewide concern, and then final jump—approaching FERC to do battle.

In the Environmental Decade, basic changes must stem from the us, the voters—they'll never come from filibusters in Congress. American Rivers has done a tremendous service to conservationists and communities by giving us the needed tools to breach the bureaucratic chasms.

Rivers at Risk is $29.95 (cloth) or $17.95 (paperback) from Island Press, Box 7, Covelo, CA 95428. 1-800-828-1302.

McKENZIE ADDS CONTRACT TIERS

Expanding with regional patterns from the East, West & South

JOINING Gary Borger and Bob Borden as contract fly tiers under the McKenzie label are Bob Skowronski, of Sharon, Vermont; Lee Clark, of St. Helen's, Oregon; and Jack Montague of Florida, who will also become the company's sales rep in that state. Their patterns will be produced overseas and sold here under an arrangement that will earn them royalties on the sales. McKenzie and Umpqua Feather Merchants are the only fly manufacturers currently doing business this way.

Kim Short, head of McKenzie, said he was impressed with Skowronski's productive eastern mayfly patterns and his unusual winged ant. Lee Clark is the originator of Clark's Stonefly, a low-silhouette pattern that floats well and is also effective in the

VERLYN KLINKENBORG

People need heroes

Theodore Gordon, Modern Fly Fisherman

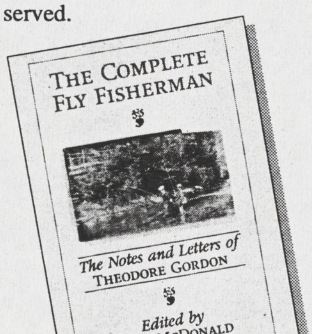
Plus a British stream-keeper and Helen Shaw's new tying book

A VERY good batch of books this time. In fact, this is a collection you can pack up and carry with you on a season-opening trip. You simply could not do better than to be immersed in either Frank Sawyer or Theodore Gordon during those long evenings in early April when you have been reminded during the day how slow spring can be to warm up and how quickly it can retreat to winter.

The Complete Fly Fisherman: The Notes and Letters of Theodore Gordon

By John McDonald, editor. (NY; Nick Lyons Books, 1989.) 574 pages: index, appendices; preface by Arnold Gingrich. $29.95 hardcover.

NOT long ago, Nick Lyons published Paul Schullery's *American Fly Fishing: A History* in which we were given our medicine on the subject of Theodore Gordon (1854-1915). It was a useful, if not particularly pleasant experience. Schullery surveyed Gordon's reputation, by which I mean he laid out property lines with great care and rigor. Gordon is not the father of American fly-fishing, nor did he introduce the dry fly to America, nor did he begin the study of angling entomology in the United States. He was an antisocial crank who was unkind to his mother and lived in rotten health for most of his life. Strict accuracy has been served.



And to all of this I say nuts. Schullery is unquestionably right. But shall I recite to you the list of great poets and novelists and painters who defrauded their landladies or slept with their sisters or drank the bottle dry and then beat their wives or husbands with it? It's a long list. None of this changes the underlying quality of their work. In their company, Theodore Gordon is too pious by half.

I mention all this because Nick Lyons has just performed yet another service to this sport by reissuing *The Complete Fly Fisherman,* which has been unavailable for many years. Upon re-reading it, I am inclined to make one observation. On one score at least we would do well to call Gordon the "father" of something: He is the one writer among early American fishing writers who sounds completely familiar to us, in whom we recognize trout-fishing as we know it. (Remove the words "basket" and "kill" from his writings and he sounds more familiar still.) I'm not saying that Gordon's techniques or his flies or his tackle necessarily resemble or anticipate ours, though of course they do. I say that his voice is one that the finest American writers on trout angling have wisely embraced. Gordon's best audience was British anglers; he contributed many notes and letters to their important periodical, the *Fishing Gazette*. And for those British readers, Gordon employed a prose that was profoundly American (test him against Sawyer or Skues in the manner I suggested above).

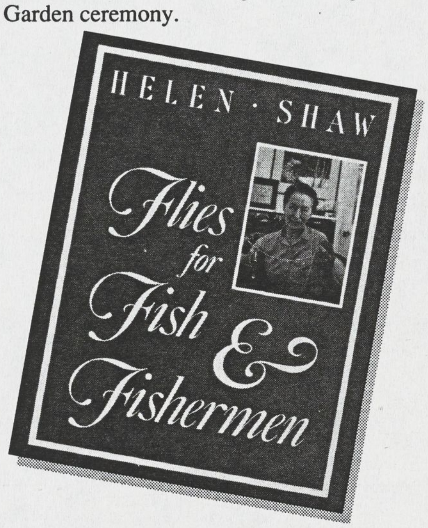
Schullery says we invented Gordon to fit our own demands, making him into what fly-fishing needed; "a mystical, reclusive, gifted, tragic character." The flaw in the argument is that the greatest part of Gordon's reputation arose because serious anglers took the time to read him for themselves. It isn't just hearsay. And at a mere touch of Gordon's prose, the mystical, the reclusive, the tragic disappear, for his writing is utterly of this world—cheerful and full of observation.

But the attraction of Gordon's writings is greater than just prose or the fact that (as MacDonald says) his writing is "without a mean thought." The simple truth is that Gordon takes us farther inside the contemplative angler's experience, his habits of mind, than anyone else of his day or of ours. He depends on almost none of the stock landscapes, characters and cliches, the glib superficiality that riddles the work of his contemporaries and predecessors. Reading him, we feel again and again the sense of absorption that comes over us when we too are absorbed by some streamside problem, when the distractions around us are running water, peepers in the trees, a mayfly landing on our glasses. Gordon is claimed (falsely, Schullery argues) as the father of American fly-fishing. I think instead that he may have been the father of the modern American fly fisher. Read him for yourself and see what you think.

Flies for Fish & Fishermen

By Helen Shaw. (Harrisburg PA: Stackpole Books, 1989.) 187 pages: color plates by Donato Leo; black & white photos by Hermann Kessler. $34.95 hardcover.

THIS book is subtitled "The Wet Flies." It may indeed be the ultimate wet-fly book, for it presents patterns and fundamental techniques for tying nearly 300 of them. The wet fly has been unnecessarily out of fashion for some years now, and there is a pleasant, old-fashioned nature about this book as well. Perhaps it is just the color plates, which closely resemble (except for their quality, which, like that of all photographs in this book, is superb) the ones that appear in fly-fishing books of a certain vintage: rank after rank of fly lined up like a White House color guard during a Rose Garden ceremony.



But don't let that put you off. I find it very attractive. Helen Shaw guides tiers through seven different forms of wet fly. In her slightly misleading nomenclature, "form" refers to predominant body material. The seven forms here are herl, chenille, floss, yarn, dubbing, quill and tinsel. That adds up to an intensive seminar in constructing an artful-looking wet fly, instruction that will be useful for tiers at all levels. It also whets the appetite for what I hope will be Shaw's next book, "The Dry Flies." Be warned, however, *Flies for Fish and Fisherman* is strictly a tier's book; not a word here on what happens

Fisheries History Section

NEWSLETTER

1995, No. 1 (July) **Mark Jennings and John Moring, Co-Editors**

NEW EDITORS

Mark Jennings and John Moring recently took over as co-editors of the Fisheries History Section Newsletter. We hope to produce several issues each year and include information of interest to those curious about the many aspects of fisheries history.

We need your help! Any tidbits, announcements, new books and articles, photographs, museum exhibits, historical anecdotes, or other items will be welcome and can be submitted to either Mark or John at:

Mark Jennings, 39913 Sharon Avenue, Davis, CA 95616 (telephone: 916-753-2727); or John Moring, Department of Zoology, University of Maine, 5751 Murray Hall, Orono, ME 04469-5751 (telephone: 207-581-2582).

PRESIDENT'S MESSAGE - JULY 1995

This is the first newsletter in some time, due to the retirement of our past Editor. The Fisheries History Section is certainly one of the most diverse in its membership, since those interested in history need not be historians. In fact, you don't even need to be an old curmudgeon, though some would say it helps. It seems that the older we get, the more we see the past in current situations. This may be wisdom, in part, or it may be the historians within us.

My mind is just a little preoccupied with "old stuff" today, as I spent a few days this month vacationing with my family at our cottage on Mount Desert Island, Maine, adjacent to Try Mount Desert Island, Maine, adjacent to Try House Point. The try works set up on the Point by my ancestor, Capt. Benjamin Bensen, and used for boiling whale blubber to get whale oil, are long gone. But each time I walk along Steamboat Wharf Road and gaze at Try House Point, I can imagine the sights, sounds and smells, the vessels being loaded and unloaded, the men flensing, the cooking caldrons, the oily smoke and the steady supply of barrels coming and going to support the try works in the first half of the 1800s. Our verbal family history of that era hasn't been recorded and I fully realize how important it is to make a written record of that "fishery" for posterity. Each of us can do our bit to assure that our personal fisheries history, as well as the wisdom of past generations will not be lost. I encourage you to share your perspectives with our membership by contributing a short article to the Newsletter, and to contact Joe Hunn if you would like to work on an oral history piece.

The Annual Meeting of the Society will be August 28-31, 1995 in Tampa, Florida, and there are a few special activities and events which I would like to bring to your attention, since the Fisheries History Section will be involved in these:

August 26, Saturday (0800-1700) - AFS Executive Committee (EXCOM), Hyatt Hotel (visitors welcome).

August 27, Sunday (0800-1500) - EXCOM meeting, Hyatt Hotel (visitors welcome).

1530-1730 - Fisheries History Section Business Meeting, Hyatt Hotel.

1730-1900 - Fish Culture Hall of Fame Reception, co-sponsored by the Fish Culture Section and Fisheries History Section. All Hall of Fame members, Section members and their guests are welcome.

August 28-31, Monday through Thursday - AFS Annual Meeting.

The final note relates to the AFS Calendar. I would like each of you to search your memories, or other depositories of valuable memorabilia, and find at least one date of a significant fisheries event (past, present, or future) which we can add to the calendar for next year. We want to significantly increase the items in the calendar to make it more interesting, and you are the key! My telephone number is 508-281-9267 and my FAX is 508-281-9117. Or you can drop me a postcard or letter at 549 Washington Street, Gloucester, MA 01930. Thanks for your support, and I hope to see you in Tampa in August.

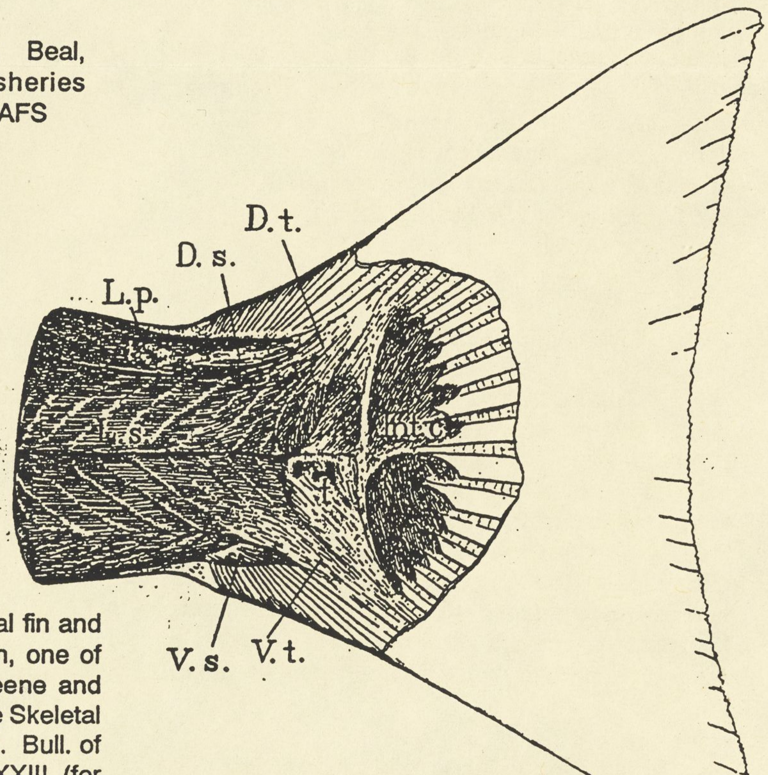
Sincerely, Ken Beal,
President, Fisheries
History Section, AFS

ELECTION RESULTS

Ballots were counted in Fall 1994, with the following results:

Ken Beal (MA), President
508-281-9267
John Moring (ME), President-Elect
207-581-2582
Venice Brown Beske (WY), Secretary-Treasurer
307-777-7982
John Leonard (MN), Past President
612-725-3447

Ken's two-year term will continue through the AFS Annual Meeting in Detroit in 1996. John's term will extend through the Annual Meeting in Hartford in 1998. The next round of elections will be in 1996.



The superficial muscles of the caudal fin and caudal peduncle of the chinook salmon, one of the drawings from Charles Wilson Greene and Carl Hartley Greene's classic work, "The Skeletal Musculature of the King Salmon." 1915. Bull. of the U.S. Bureau of Fisheries, Vol. XXXIII (for 1913): 21-59, and plates.

*****FEATURE ARTICLE*****

HISTORICAL VIGNETTE NO. 1: A STORY OF YOUTHFUL FISH PEDDLERS, BY CLOUDSLEY LOUIS RUTTER (contributed by Mark Jennings)

During the last decade of the 19th century, Cloudsley Louis Rutter (1867-1903) was one of several bright and upcoming Assistants hired by the old United States Fish Commission to gather fisheries catch statistics in various parts of North America. With two semesters of study completed under Drs. David Starr Jordan and Charles Henry Gilbert of Stanford University, one of Rutter's first assignments was to collect aquatic specimens and observe the fishermen in Lake Erie and Lake St. Clair during the summer and fall of 1894. It was several years after this assignment with the United States Fish Commission that he sketched out the following story of one of his experiences with two local entrepreneurs. Although Rutter tried to sell the story to The Youth's Companion (of Boston, Massachusetts) shortly before his untimely death in 1903, his manuscript was returned by the editor and thereafter remained amongst the family papers for the next 90 years. My thanks to Cloudsley's grandson, Dr. Richard R. Rutter, for making this manuscript available to me and the readership. Thus, this story appears in print for the first time, an interesting example of how fisheries biologists of the last century made do with the local resources in moving their collecting equipment.

YOUTHFUL FISH PEDDLERS

by the late Cloudsley Rutter
Naturalist of the *U.S.S. Albatross*
United States Fish Commission

The following story is related by one of the Assistants in the Division of Scientific Inquiry of the United States Fish Commission.

A few years ago while studying the fisheries of Lake Erie, I went from Dunkirk, New York, to a point four miles west to visit a pound-net, the only one in that part of the lake. As I had to stay overnight, I dismissed my conveyance, and depended on chance for a means of returning the next day. I had with me a small naturalist's seine, and a collecting can with alcohol for specimens.

The next morning, the wind blew so that the pound-net could not be lifted (it is a matter of record that the net was lifted as soon as I departed), and as I had no other business there I was ready to return to Dunkirk early. I inquired of the fisherman how I could get my net back to town, and he said that I might hire the fish peddlers as he would have no fish for them that morning, and probably they would be glad to take it for me. So about nine o'clock I went over to the fish shanty and inquired when the peddlers would arrive.

"They're here now," the fisherman answered; "didn't you see their wagon out there?" I had not, and was about to remark so when a boy not over seven years old came in, and the fisherman continued, "Here's one of them,"

Supposing the boy to have come with an older one, I said, " Johnie, won't you tell your brother to come in?" But the fisherman said, "Oh, he's the one to talk to. His brother is a little fellow." And his brother was a little fellow, certainly under six, but I did not see that that was any reason for emphasizing the word little, as the term would describe either of them. These two boys, mere infants, had a small express wagon with which they hauled from twenty to fifty pounds of fish to their home town about four miles away, making eight miles round trip!

I then inquired of the senior member of the firm what he would charge to haul my net to Dunkirk. As Dunkirk was also four miles from their home, this would make twelve miles for the boys during the day, instead of eight. The "manager" did not know how much to charge. He evidently did not want to cheat me, and yet wanted to make as much as possible. As I wanted to get his idea of the value of his services, I did not make an offer. By way of helping him out, I asked how much he made by selling fish.

"Made a dollar yesterday," he answered.

I was a little surprised, and wanted to know what they sold their fish for.

"Sold 'em for a dollar."

"And what did you pay for them?" I

asked.

"Paid half a dollar." And I could not make his understand that he had made but half a dollar.

Then I pressed him to know what he would charge to take my net to Dunkirk, and he finally said, "Would twenty-five cents be too much?" For hauling the net four miles! When I told him I would give him twenty-five cents and his brother twenty-five cents, and the wagon twenty-five cents, he ran for the wagon and began loading the net. The "little" fellow was not so anxious, but "the one to talk to" was evidently boss, and they soon started, the older pulling, the other pushing behind. The net weighed about ten pounds and the can two, so they had an easy load.

I returned later, and when I reached the fish house in Dunkirk I found the boys waiting for me and eating their lunch which they had brought with them. When I paid the twenty-five cents, they trudged off as happy as if they had not already walked eight miles with four more before them. They had evidently investigated the collecting can for the older one said to the man at the fish house, "That is the blabdest fellow I ever saw. He won't eat fish till they are soaked in whiskey!"

RECENT FISH HISTORY LITERATURE

Professional history journals include articles of interest to fisheries historians. We plan to include notes on such recent literature from sources not often seen by fisheries biologists:

Journal of the West, Vol. 33, no. 4 (1994). "Salmon, Seals, and Science: The Albatross and Conservation in Alaska, 1888-1914," by Kurt Dunbar and Chris Friday.

Pacific Historical Review, Vol. 64, no. 1 (1995). "Tragic Remedies: A Century of Failed Fishery Policy on California's Sacramento River," by Michael Black.

American Fisheries Society Symposium 15, Harold Schramm and Robert Piper, editors (1995). "Changes in Stocking Strategies for Atlantic Salmon Restoration and Rehabilitation in Maine, 1871-1993," by John Moring, Jerry Marancik, and Fred Griffiths.

"Coldwater Fish Stocking and Native Fishes in Arizona: Past, Present, and Future," By John Rinne and Joe Janisch.

"History, Genetic Variation, and Management Uses of 13 Salmonid Broodstocks Maintained by the Wyoming Game and Fish Department," By Charles Alexander and Wayne Hubert.

Forcing the Spring: The Transformation of the American Environmental Movement, by Robert Gottlieb (Covelo, California: Island Press), 1993. 412p. $27.50.

Organizing Asian American Labor: The Pacific Coast Canned-Salmon Industry, 1870-1942 by Chris Friday (Philadelphia: Temple University Press), 1994. 276p. $34.95.

Pioneering Naturalists, by Howard Evans (New York: Henry Holt and Co.), 1993. 294p. $12.95 (paper).

GRANT INFORMATION

Early Europeans began fishing for cod off the New England and Canadian coasts in the 1500s. Gloucester, Massachusetts, was established in 1623 as a fishing station, and became the birthplace of the U.S. fishing industry. For centuries, the stocks of cod and haddock supported ever increasing fishing effort, but today, both the Canadian and New England fishing industries are suffering from drastic declines in these and other groundfish stocks. In 1994, the U.S. Congress authorized the Northeast Fisheries Assistance Program, recognizing this economic and social crisis. The program included a grant program of $9 million, half of which has already been awarded, and the projects selected for the second half should be announced in July.

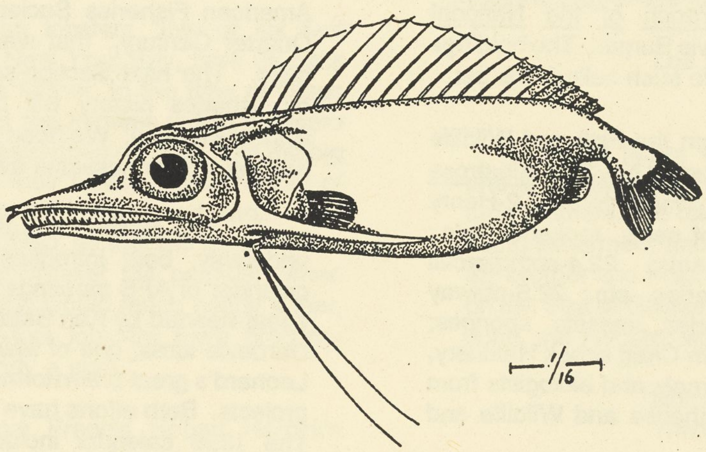
The 28 proposals funded with the first $4.5 million addressed three primary goals: (1) developing fisheries and markets for those species for which harvestable surpluses exist; (2) restoring groundfish (cod, haddock, flounders and related species) through aquaculture and hatchery programs; and (3) developing alternative employment of new business opportunities for fishermen affected by declining groundfish stocks. The approved projects include 11 which addressed underexploited species, 9 in aquaculture, and 10 which focused on new business opportunities. (Two approved proposals addressed more than one goal). Of the 28 projects selected for funding, there were 16 from individual fishermen, fishing corporations, or processors, 6 from aquaculture companies, 2 from universities, 2 from maritime training organizations, and 2 from agencies which assist the industry with employment opportunities and other services.

The objectives in the second round of funding are similar to the first, with emphasis on new business opportunities, aquaculture, harvesting and marketing opportunities for underutilized species and reducing bycatch mortality in routine fishing operations. There were 240 proposals submitted, with about $44 million in requested funding. It is anticipated that 30-35 proposals will be funded with the $4/5 million available. (For further information, contact Kenneth Beal or Harold Mears at 508-281-9267).

WHERE ARE THE SALMON?

Be on the lookout for an upcoming article in Fisheries, entitled, "Did the range of Atlantic salmon expand southward into New England during recent centuries?" The authors--George Jacobson, David Sanger, David Smith, and Frank Roberts, from the Plant Biology and Pathology, Anthropology, History, and Zoology departments, respectively, at the University of Maine, and Steve Shepard, a fish biologist with Bangor Hydro-Electric Company--looked at interesting historical evidence on the presence of Atlantic salmon in New England.

Atlantic salmon were surely present when European visitors reached North America. Yet, how many of the reports may have been exaggerated in order to attract colonists is unknown. Several recent papers by Carlson report studies that found no evidence that native Americans used Atlantic salmon, based on riverine midden sites from 1,000 to 10,000 years ago. There are some who suggest that salmon were never present in New England. The



1. A young sailfish, 14 mm long, from G. Brown Goode's "Materials For a History of the Sword Fishes." 1883. Report of the Commissioner for 1880, U.S. Commission of Fish and Fisheries, Part VIII: 287-394.

- quantitative w. mol. genetic

- anadromy - residency
- life history types.
- adaptiveness

- disease - resistance
  whirling - Ceratomyxa
- gene loci?

- Hand 100 → 10,000x mutation rate

- New England
- virtually no grilse (why good ocean survival)
- Canada - 1/2 25-50%.. (1-2 yr 50% - sum - 100%

45:10

Trade off.

PHONE CALL

Date ______________

M. ______________

You were called at ______________

By M. ______________

Return the call to ______________

The message was ______________

UNIVERSITY OF MAINE

Maine Cooperative Fish and Wildlife Research Unit
Fisheries—Zoology Department
313 Murray Hall
207/581-2582
FAX 207/581-2537

Mailing Address:
Maine Coop. Fish & Wildl. Res. Unit
Fisheries—Zoology Department
University of Maine
5751 Murray Hall
Orono, Maine 04469-5751

September 16, 1996

Dr. Robert J. Behnke
Department of Fisheries and Wildlife Biology
Colorado State University
Fort Collins, CO 80523

Dear Bob:

I'm not sure that I answered your question in your letter of several weeks past. You asked if it were possible to get a draft copy of the article by Shepard et al. on the possible absence of Atlantic salmon in New England in the past.

I did talk to Frank Roberts -- one of the co-authors -- several weeks ago to ask, if it was okay with authors, to send you a copy. If he hasn't contacted you, you may wish to contact him directly: Department of Zoology, University of Maine, 5751 Murray Hall, Orono, Maine 04469-5751, or telephone 207-581-3210.

Sincerely,

John Moring
Assistant Leader for Fisheries

JRM/sa

authors offer a slightly different theory: that the presence of salmon in New England may be a comparatively recent event in geological time, a product of fluctuating climate and other factors. They examine this possibility using global climatic information, biological concepts, use of fish by native peoples, and parallels between the presence of salmon in Europe and North America.

NATIONAL ARCHIVES PHOTOS

Not everyone knows that the National Archives of the United States houses over 7 million photographs that are in the public domain. These still pictures are housed in the new Archives building in College Park, Maryland (8601 Adelphi Road; telephone 301-713-6000; FAX 301-713-6920) and are available for inspection and/or ordering. The collection is available Monday through Saturday, although hours and access to archivists vary. It is best to call ahead if you are planning a visit. By planning ahead, an archivist can help you plow through the volume of material.

To make the task easier, there is a book (cost approx. $25) entitled, Guide to the Holdings of the Still Picture Branch of the National Archives, by Barbara Lewis Burger. The holdings are extensive and include such collections as:

42,900 items from the Fish and Wildlife Service, 1870-1962, including No. 22.1-Albatross expeditions around the world; No. 22.2-Henry Wood Elliott paintings of seals, rookeries, etc.; No. 22.3-fishing vessels; 22.4-commercial fisheries, lobster hatcheries, etc.; 22.5-railway cars, Albatross, hatcheries, vessels, sponges; 22.6-glass negatives from Craig Brook Hatchery, Maine; 22.7-general animals and biologists from the Bureau of Sport Fisheries and Wildlife and Biological Survey.

Smithsonian Collection 106.4-prints, negatives, and slides taken by Hugh Smith showing fish and marine life and fishing industries around the world.

....and many others. Almost every government agency has representative photos and many private, donated collections are also available.

MID-YEAR REPORT

The following is taken from the mid-year report of the Fisheries History Section presented by President Ken Beal to the AFS Executive Committee at its spring meeting in Biloxi, Mississippi, on March 18, 1995:

The new officers assumed their positions of office following the Section's annual business meeting in Halifax, Nova Scotia, during the 1994 Annual Meeting. There was a brief delay in completing the election, due to the fact that the ballots were mailed out too late to provide timely replies prior to the AFS meeting. Our congratulations to John Moring and Venice Beske for their election wins, and our thanks to valued Section members Carlos Fetteroff and Nick Parker for their willingness to stand on the ballot.

The Section sponsored a major session at the Annual Meeting, titles "Fisheries History: the Development of Fisheries Disciplines," with John Moring as convener. It was generally agreed that, of the 10 excellent presentations, it was Mary Frye's concluding paper, titled "The American Fisheries Society Matures: The Last Quarter Century," that was the frosting on the cake. The next Section-sponsored symposium on fisheries history will be held at the 1996 Annual Meeting. We hope to be able to continue holding similar sessions every two years.

The Section has two unique endeavors underway, both introduced in 1993-1994: a calendar of AFS meetings and historical events, spear-headed by Ken Beal, and commemorative Dardevle lures, one of Mark Jennings and John Leonard's great brainstorms and time-consuming projects. Both efforts have been very successful. The 1995 calendar includes a photograph of Spencer Fullerton Baird, first U.S. Commissioner of Fisheries, and is nearly out of print. The Dardevle lures have also sold well, and these are becoming eagerly sought-after collectors' items. In addition, our oral history project continues under the outstanding efforts of Joe Hunn, with many of the recordings and other memorabilia collected being stored in Spearfish, South

Dakota.

The Section's Newsletter, after 3 years under the talented guidance and direction of Rick Martens, is now without an editor, as Rick has decided to "retire" to other professional pursuits. We will miss his good work and "can-do" attitude.

Sincerely, Kenneth, L. Beal,
President, Fisheries History Section

HISTORICAL QUOTES

"My recent studies have made me more adverse than ever to the new scientific doctrines which are flourishing in England (Darwin's theories on evolution). This sensational zeal reminds me of what I experienced as a young man in Germany, when the physio-philosophy of Oken had invaded every centre of scientific activity; and yet, what is there left of it? I trust to outlive this mania also."

Louis Agassiz, Harvard Professor of Geology and Zoology, from a collection of correspondence edited by Elizabeth Agassiz in 1893.

"The Pilgrim lobsters "five or six feet long," ascribed to New York Bay, take us back one hundred years further, to the time of Olaus Magnus....No doubt the Pilgrims would measure a lobster as some fishermen do now, with the big claws stretched to their fullest extent in front of the head. In this condition the actual length of an animal is about doubled, so that the length of the New Jersey record breaker (34 pounds), when distended in this way, would reach nearly 4 feet, and the Pilgrim 6-foot lobsters have probably been stretched nearly a yard."

From Francis Hobart Herrick's "Natural History of the American Lobster," Bulletin of the U.S. Bureau of Fisheries, 1909 (issued 1911).

"In 1885 more than six salmon were taken in the Bangor (Maine) pool by Fred Ayer who thus demonstrated that the salmon fishing with the fly is as good on the Penobscot as in any salmon river in the world. During the same season, Mrs. George W. Dillingham of New York landed a ten-pounder, thus becoming the first lady to take a salmon on a fly in the Penobscot."

W. C. Kendall, quoting from the *Bangor Whig*, 1885.

"Man is not much good at helping the fish, but he is learning slowly. If so, the fish will do their part, they will persist, perhaps even increase."

Roderick Haig-Brown, *Return to the River*

"For a number of years there appears to have been in many sections of this country an increasing popular prejudice against the German carp....most parts of the country are generally against the carp as a food fish. It is even stated by many that it is utterly worthless."

Leon Cole, "The German Carp in the United States," Report of the U.S. Bureau of Fisheries for 1904 (issued in 1905).

"Atlantic salmon fishing is for me....an intriguing thing which is not only a sport but an integral part of the joy of living."

Lee Wulff, *The Atlantic Salmon*

"Our father was a Presbyterian minister and a fly fisherman who tied his own flies and taught others. He told us about Christ's disciples being fishermen, and we were left to assume, as my brother and I did, that all first-class fishermen on the Sea of Galilee were fly fishermen and that John, the favorite, was a dry-fly fisherman."

Norman Maclean, *A River Runs Through It*

NEXT NEWSLETTER

The feature article in next month's newsletter is "Frederic Morton Chamberlain and the Discovery of Internal Coded Wire Tags for Marking Fishes," by Mark Jennings.

THE FISHERIES HISTORY SECTION NEWSLETTER

"Fishing apparatus was in great demand this morning; and most of the party, as soon as breakfast was over, were enjoying the Waltonian sport, in angling for the delicious salmon-trout with which the stream abounds. Our bait is the large insect resembling the cricket, heretofore described, myriads of which are creeping and hopping along the grass and other vegetation of the valley. Every angler was more or less successful, according to his luck or skill. A quantity of fish, weighing each from two to five pounds, was taken."

Edwin Bryant, from the journal he kept of his cross-country trip, July 27, 1848, on the Weber River, Utah.

AFS Fisheries History Section
c/o John Moring
University of Maine
5751 Murray Hall, Orono, ME 04469-5751

FIRST CLASS

ORONO MAINE AUG-7'95 U.S.POSTAGE 0.32 PB METER 6752424

000230 DL 9912
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CO State Univ
Fort Collins, CO 80523

2800

Locked
depth distrib
landlocked
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Seasonal Depth Distributions of Landlocked Atlantic Salmon, Brook Trout, Landlocked Alewives, and American Smelt in a Small Lake

Robert T. Lackey

Department of Fishery and Wildlife Biology
Colorado State University, Fort Collins, Colorado 80521, USA

Lackey, R. T. 1970. Seasonal depth distributions of landlocked Atlantic salmon, brook trout, landlocked alewives, and American smelt in a small lake. J. Fish. Res. Bd. Canada 27: 1656–1661.

Seasonal depth distributions of landlocked Atlantic salmon (*Salmo salar*), brook trout (*Salvelinus fontinalis*), landlocked alewives (*Alosa pseudoharengus*), and American smelt (*Osmerus mordax*) were determined monthly in Echo Lake, Maine, using vertical and horizontal gillnets.

Salmon were wide-ranging fish, but generally not captured in very shallow or very deep water. Brook trout were primarily an inshore species, not often captured in water deeper than 25 ft, and nearly always found close to the lake bottom. The majority of captured alewives were taken from shallow to middepths (0–30 ft) in summer and fall and in deep water during winter and spring. Smelts were widely distributed, but the majority were captured in water deeper than 30 ft every month.

No clear temperature or dissolved oxygen preference could be shown for any of the four species.

Received October 20, 1969

Few seasonal depth distributions of fish species have been intensively studied. One technique to determine depth distribution is the use of vertical gillnets. Tibbles (MS, 1956) used this method with success to study the distribution of yellow perch (*Perca flavescens*) in Lake Mendota, Wisconsin. Horak and Tanner (1964) reported the results of vertical gillnetting in a Colorado reservoir to determine the summer distributions of rainbow trout (*Salmo gairdneri*), kokanee (*Oncorhynchus nerka*), white sucker (*Catostomus commersoni*), and yellow perch (*P. flavescens*). The distributions of white catfish (*Ictalurus catus*) and rainbow trout were determined with vertical gillnets by von Geldern (MS, 1964) for a California lake.

The purpose of this study was to determine seasonal depth distributions of four fish species inhabiting Echo Lake, Maine, from June 1967 to May 1968, using both vertical and horizontal gillnetting. Water temperature and dissolved oxygen were measured to evaluate their effect on fish distribution.

Study area — Echo Lake, located on Mount Desert Island, Maine, is partially in Acadia National Park. Surface area is approximately 237 acres (96 ha) and the maximum depth is 63 ft (19.2 m). The lake is oligotrophic and of glacial origin (Fig. 1).

Landlocked salmon were introduced in 1965 as age 0+ fall fingerlings. Brook trout were stocked periodically as fingerlings (age 0+). Adult land-

Printed in Canada (J1624)

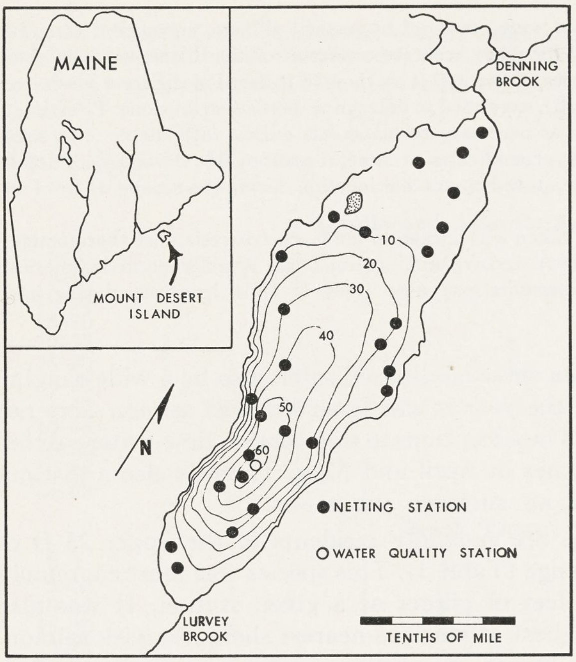

FIG. 1. Echo Lake, Mount Desert Island, Maine, showing depth contours in feet and sampling stations.

locked alewives from Cayuga Lake, New York, were introduced in June 1966, and successfully spawned that summer and each summer since. A smelt population was maintained by natural reproduction.

Materials and methods — Small-meshed vertical gillnets (02 and 03 filament nylon with $\frac{1}{4}$- and $\frac{1}{2}$-inch bar mesh, respectively) were designed and built (Lackey, 1968) to determine the depth distributions of small fish in Echo Lake. Six lengths of nets were used. The numbers of $\frac{1}{4}$- and $\frac{1}{2}$-inch mesh of each length were as follows:

	Length (*ft*)					
	10	20	30	40	50	60
$\frac{1}{4}$-inch	3	3	1	1	1	1
$\frac{1}{2}$-inch	3	3	1	1	1	1

Twenty-six sampling stations (Fig. 1) were selected at depths corresponding to the above six net lengths. The number of stations at each depth was roughly proportional to the lake surface over that depth. Selection of sampling stations was affected by several considerations, including their proximity to swimming and boating areas. Each station was marked by two large rock anchors separated by a distance twice the depth (Lackey, 1968).

During summer months, 14–19 nets were set for 48 consecutive hr each week. Each net was cleared of fish at least every 12 hr and usually more frequently. Captured fish were recorded by species, length, and depth of capture.

During winter sampling, ice was cut with a chain saw to permit placement of gillnets or, if ice was thick, with a gasoline-powered ice auger. Sampling during these months was limited to once or twice per month.

Although a few salmon and trout were captured in vertical gillnets, concurrent sampling with horizontal gillnets was necessary for more accurate estimates of the distributions of these species. Two 500-ft gangs, each composed of five 100-ft sections (8 ft deep) of different mesh sizes ($1\frac{1}{2}$-, 2-, $2\frac{1}{2}$-, 3-, and $4\frac{1}{2}$-inch stretch mesh), were used to determine depth distributions. To estimate depth of capture with these nets, it was necessary to make sets with a fathometer or in areas of known depth. By setting both gangs perpendicular to shore, it was possible to sample all depths simultaneously. Usually both nets were moved to another location during the second 24 hr of the 48-hr sampling period.

Water temperature profiles were taken with a custom-made electric resistance thermometer. Dissolved oxygen was determined by the Alsterberg modification of the Winkler method (American Public Health Association, 1965). Determinations were made at 10-ft intervals during each sampling period.

Results — Distribution data show landlocked salmon to be a wide-ranging fish (Table 1). During most of the year it was observed that salmon were not captured near the lake bottom. The exceptions to this were shallow-water catches in October and deep-water catches in April and May. There is also a distinct increase in depth of capture as summer progresses.

Brook trout in Echo Lake are generally residents of the upper 25 ft of water, but not limited to this range (Table 1). This species was most commonly captured in the lower several feet of gillnet at a given station. It was also observed that captures were highest at stations nearest shore. As with salmon, there is a distinct increase in depth of capture in August.

Alewives were usually captured in nets set in deep water. In summer and fall, alewives occupy the upper depths of the lake, mainly away from shore and bottom (Table 1). With the onset of winter, there is a marked movement to deeper waters, where the species remains until the following summer.

Smelt depth distribution followed no clear pattern (Table 1), except for an increase in depth of capture as summer progressed.

Temperature and dissolved oxygen preferences could not be shown for any of the four species.

Discussion — Landlocked salmon, unlike brook trout, are a wide-ranging fish and favor open water, away from the lake bottom. Feeding habits of salmon (Lackey, 1969) in Echo Lake also indicate a distinctly pelagic existence. Salmon in Echo Lake tended to move to deeper water as summer progressed. Similar movement of salmon has been shown in two Newfoundland ponds (Leggett and Power, 1969).

Brook trout in Echo Lake are generally near the lake bottom when captured, as reported by Flick and Webster (1962) in a New York lake and Chapman et al. (1967) in an Oregon lake. Further, food habits indicate much inshore bottom foraging (Lackey, 1969).

Depth distribution of alewives in Echo Lake follows the general patterns previously described (Galligan, 1962; Gross, 1953, MS, 1959; Reigle, 1969), but differs somewhat in timing. Seasonal differences account for this. In summer and fall, alewives occupy the upper depths of the lake, mainly areas away

TABLE 1. Depth distributions of landlocked Atlantic salmon, brook trout, landlocked alewives, and American smelt based on combined vertical and horizontal gillnetting in Echo Lake, 1967–68.

	1967							1968				
Depth (*ft*)	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Landlocked Atlantic Salmon												
0–5		1	1		22			1				1
5–10	1	2		2	5					1		1
10–15				2	2			1				
15–20			1									
20–25	2		2			2						
25–30	1	1	1	1		4						
30–35	1	4	2									
35–40	1	7	4	1								
40–45		1										1
45–50			1									1
50–55			3	2								3
55–60			1	1							5	9
Brook Trout												
0–5		1			3			6			2	3
5–10		3		1				6	1		1	2
10–15		3		1	1			1				
15–20		4										
20–25			4			3						
25–30				1		2						
30–35			1									
35–40												1
40–45												1
45–50												
50–55			1									
55–60			1									2
Landlocked Alewives												
0–5		2	10			3				3		
5–10	34	97	6							3		
10–15	23	32	13	1		200				4		
15–20	35	15	1		3					3		
20–25	21	5	6		1					5	4	
25–30	10		4				1			5	4	
30–35		2		1	1					22		
35–40		5	1	2				15		21		
40–45								38		69		
45–50					1			38		68		
50–55	1							39		69	1	2
55–60								40		71	57	3
American Smelt												
0–5					2							1
5–10	4	16	3		2							
10–15	7	2			1							
15–20	8	3	2	3	2							
20–25	11	1	1		2							
25–30	16	6	5		2	4						
30–35	35	49	22		7							
35–40	38	69	26	1	4							
40–45	4	3	18	2	8							
45–50	5	10	30	3	5							
50–55	1		9		1						1	
55–60			11								2	1

from shore and bottom. With the onset of winter, there is marked movement to deeper waters, where the species remains until the following summer.

Galligan (1962) studied the distribution of alewives in Cayuga Lake, and reported a pronounced inshore movement in late June and July associated with shallow-water spawning habits. During late summer and fall, Cayuga Lake alewives moved to deeper water. Galligan hypothesized that alewives took up a pelagic distribution in winter. Gross (1953, MS, 1959) reported similar findings in Lake Hopatcong, New Jersey.

Reigle (1969) studied alewife distribution in southern Lake Michigan with a bottom trawl. His results are similar to those reported here even though sampling methods were different. From January to April, alewives were captured in the deeper water of Lake Michigan (35 fath or deeper). In April and May alewives were taken over a wide range of depths. During spawning season (mid-May through June), alewives were found only in shallow water. Trawl catches decreased during July, August, and September, which indicated a vertical scattering of alewives. Trawling later in the year showed alewives in water 0–35 fath. Reigle reported a pronounced movement into deep water in December and January.

None of the four species studied showed a clear preference for any particular temperature, although temperature preference was difficult to evaluate because of an extreme annual range. The only consistent trend that might be associated with temperature was the progressively greater average depth of capture as summer progressed, then a rise in depth of capture in early fall.

Acknowledgments — I thank Dr W. H. Everhart, Professor of Fisheries, Colorado State University, and Mr K. A. Havey, Maine Department of Inland Fisheries and Game, for assistance during the study and for reviewing the manuscript. This research was financed by the Maine Department of Inland Fisheries and Game.

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Age at Sexual Maturity in Icelandic Stocks of Atlantic Salmon (*Salmo salar*)

DENNIS L. SCARNECCHIA

Institute of Freshwater Fisheries, P.O. Box 754, Reykjavík, Iceland

SCARNECCHIA, D. L. 1983. Age at sexual maturity in Icelandic stocks of Atlantic salmon (*Salmo salar*). Can. J. Fish. Aquat. Sci. 40: 1456 – 1468.

For Icelandic stocks of Atlantic salmon (*Salmo salar*) in 77 rivers, the combination of June ocean temperature, length of river ascended by the salmon, discharge of the river in July–September, and latitude explained much of the variation in percentages of grilse — 72% for females and 62% for males. For both sexes, percentage of grilse was directly related to ocean temperature but inversely related to length of river, discharge of river, and latitude. For stocks in 23 Southwest Coast rivers, length of river explained 72% of the variation in percentage of females that were grilse. Females in stocks south of the thermal gradients separating Atlantic from Arctic or Polar water tended to return as grilse; females north of the gradients tended to return after more than one winter at sea. The decline in percentages of grilse clockwise from southwestern to northeastern rivers corresponded closely with the decline in June ocean temperatures between these areas. I hypothesize that the salmon stocks have adapted their age at sexual maturity to the length and discharge of the rivers, natural mortality rates during their second year at sea, and average expected ocean temperatures, reflecting conditions for growth and survival, that the smolts encounter. Age at maturity appears not to be a direct causal response to any of these physical factors, and appears best understood only with reference to the entire life history pattern of each stock.

SCARNECCHIA, D. L. 1983. Age at sexual maturity in Icelandic stocks of Atlantic salmon (*Salmo salar*). Can. J. Fish. Aquat. Sci. 40: 1456 – 1468.

Pour la plupart des stocks islandais de saumons atlantiques (*Salmo salar*) dans 77 rivières, une combinaison des facteurs suivants : température de l'océan en juin, longueur de la rivière remontée par le saumon, débit de la rivière en juillet–septembre et latitude expliquent une bonne partie de la variation du pourcentage de castillons — 72 % pour les femelles et 62 % pour les mâles. Chez les deux sexes, le pourcentage de castillons est en relation directe avec la température de l'océan mais en relation inverse avec la longueur de la rivière, son débit et la latitude. Dans le cas de stocks de 23 rivières de la côte méridionale, on peut relier à la longueur de la rivière 72 % de la variation du pourcentage de femelles castillons. Les femelles dans les stocks situés au sud des gradients de température séparant l'eau atlantique de l'eau arctique ou polaire tendent à retourner en rivière comme castillons; au nord de ces gradients, les femelles ont tendance à retourner en rivière après plus d'un hiver en mer. La diminution des pourcentages de castillons depuis les rivières du sud-ouest dans le sens des aiguilles d'une montre vers le nord-est correspond étroitement à l'abaissement des températures océaniques de juin de cette région à l'autre. J'émets l'hypothèse que les stocks de saumons ont adapté leur âge de maturité sexuelle à la longueur et au débit des rivières, au taux de mortalité naturelle durant leur deuxième année en mer et aux températures océaniques moyennes anticipées, reflétant les conditions, pour la croissance et la survie, que rencontrent les smolts. L'âge de la maturité ne semble pas être une réponse directe à aucun de ces facteurs physiques, mais s'expliquerait le mieux en fonction seulement des caractéristiques du cycle de vie entier de chaque stock.

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