Proposals for Changes to Maine Water Quality Standards Under Triennial Review: A Proposal by Mark Whiting to List Lakes and Streams as Impaired for Acid Rain Impacts

This proposal is for DEP to develop acid rain-based water quality standards, evaluation methods, and to list impaired waters. The purpose is to protect Maine endangered Atlantic salmon and protect aquatic communities in general, communicate the problem to other state and federal agencies, and provide a legal basis for restoration projects.

1. **Citation of Standards** (no changes proposed)

The Clean Water Act Section 305 (b) authorizes states to develop water quality criteria to protect aquatic life. States are expected to list impaired waters and report to Congress specifically on acid rain impaired lakes.

Maine DEP has pH standards. **MRS Title 38 Waters and Navigation, Chapter 3 Article 4-A Water Classification Program, § 464 Classification of Maine Waters, 4. General Provisions (A) (4-5)** which prohibit discharges to state waters:

> (4) Discharge of pollutants to waters of the State that imparts color, taste, turbidity, toxicity, radioactivity or other properties that cause those waters to be unsuitable for the designated uses and characteristics ascribed to their class;
>
> (5) Discharge of pollutants to any water of the State that violates sections 465, 465-A and 465-B, except as provided in section 451; causes the "pH" of fresh waters to fall outside of the 6.0 to 8.5 range; or causes the "pH" of estuarine and marine waters to fall outside of the 7.0 to 8.5 range;

This pH standard is typically not enforced outside of point-source pollution impacts due to ambiguity on what the natural baseline conditions are and the large number of situations in which pH in seemingly natural areas (Acadia National Park, Downeast Unorganized Territories) falls outside this range.

Title 38 § 464.3.A requires the DEP Commissioner to report to the Legislature and identify current water quality status and to identify non-attaining waters and describe State plans for mitigation.

3. Reports to the Legislature. The department shall periodically report to the Legislature as governed by the following provisions.

A. The commissioner shall submit to the first regular session of each Legislature a report on the quality of the State's waters which describes existing water quality, identifies waters that are not attaining their classification and states what measures are necessary for the attainment of the

What do these reports say? The most recent summary of acid rain impairment in Maine is found in the **DEP 2006 Integrated Water Quality Monitoring and Assessment Report (305b report)** says the following:

Approximately 1,150 lakes (797,000 acres - approximately 80% of lake surface area) have been assessed for acidity, predominantly by using measures of pH and ANC. There are about 65 acidic lakes (ANC < 0) comprising a total surface area of approximately 750 acres (1.0% of the lakes and 0.08% of the lake surface area). Approximately 20 of the roughly 65 acidic lakes are ten acres or greater in size and considered 'significant'; the remainder are at least 1 acre in size. Extrapolation of Eastern Lake Survey results predicts that there are probably only a few unidentified acidic lakes greater than ten acres in size. There are likely some (probably less than 50) additional non-dystrophic acidic drainage and seepage lakes in the 1 to 10 acre size range. Table 4-29 provides a summary of acidity assessment efforts in Maine lakes.

The definition of acidified is narrowly defined as lakes where Alkalinity has been completely depleted. Even so, there are 65 acidified lakes, of which 20 are Great Ponds. The **HELM** study was first published in 1988 **(Kahl, JS and M Scott, 1988. Chemistry of Maine's high elevation lakes: results of the HELM project)**. We have known about this problem for 32 years. But details are not available. Which lakes are these? The public has a right to know. What about impairments that are less extreme than no alkalinity at all? The report does not say.

Maine law requires Class AA salmon rivers to support all aquatic species "that naturally occur." Class A is also supposed to be "natural." Even the lowest quality Class C waters must support all fish species "indigenous to the receiving waters." **MRSA Title 38 §465.4.C** reads (in part):

C. Discharges to Class C waters may cause some changes to aquatic life, except that the receiving waters must be of sufficient quality to support all species of fish indigenous to the receiving waters and maintain the structure and function of the resident biological community. For the purpose of

Details of Proposed Changes

Salmon recovery is apparently failing due to an inability to reach consensus on what the problems are and how to fix them. Poor water quality appears the most important of the unrecognized and unaddressed problems. The proposed water quality thresholds are from the Downeast Salmon Federation (DSF) liming program for pH, alkalinity, calcium and ionic aluminum (Alx). Liming is a test of the hypothesis that aquatic communities are constrained by pH, alkalinity and calcium. We test this by providing more calcium carbonate. It is like putting gas in a car you think is out of gas. Nothing would happen if something else were limiting. These proposed thresholds are still experimental, but they are also the only ones we have. These are as follows:

Analysis	Threshold	Species	Source
pH	≥ 6.5	Atlantic salmon	Staurnes et al 1995
Calcium	> 1.0 mg/L	All fish species	Howells et al 1983
Calcium	> 2.5 mg/L	Brook trout	Danner 2004
Calcium	≥ 4 mg/L	Brook trout	Danner 2004
Alx	< 27 ug/L	All fish species	Driscoll et al 2003
Alkalinity	≥ 10 mg/L	Brook Trout	Petty et al 2005

A calcium level of at least 1 mg/L is needed to support any fish at all. Values of 2.5-3 mg/L are needed to support the lowest level of reproduction, but fish have organ deformities, loose teeth, and other signs of calcium deficiency. A calcium level of 4 mg/L is needed to support healthy self-sustaining populations of brook trout without loss of fry due to poor water quality alone. These are supported by literature. A DEP-DSF partnership is trying to save this endangered species with a new liming project in Richardson Brook. DEP needs to take this seriously.

The citations for this Table are:

Staurnes, M, F Kroglund & BO Rosseland, 1995. Water quality requirement of Atlantic salmon (Salmo salar) in water undergoing acidification or liming in Norway. Water Air Soil Pollution 85: 347-352

Howells, GD, DJA Brown & K Sadler. 1983. Effects of acidity, calcium, and aluminum on fish survival and productivity – a review. Journal of the Science of Food and Agriculture 34: 559-570.

Danner, R, 2004. Improving Brook Trout Egg Quality in Maine: Adding calcium overcomes the effects of an acidic environment. Hatchery International, Nov-Dec: 33-34

Driscoll, CT, M Kimberley MJ Mitchell &DJ Raynal, 2003. Effects of acidic deposition on forest and aquatic ecosystems in New York State. Environmental Pollution 123: 327-336

Petty, JT, P Lamothe & P Mazik, 2005. Spatial and Seasonal Dynamics of Brook Trout Populations Inhabiting a Central Appalachian Watershed. 134 (3): 572-587

2. **Justification and Supporting Documents**

Problem Statement: Maine has no acid rain assessment methods. We have evidence of massive impairments in Downeast Maine and loss of species, but DEP has no way of assessing attainment of water quality classifications – at least not when the impairment is acid rain. Both a wadeable stream Index of Biotic Integrity (IBI) for fisheries and a macroinvertebrate methodology are critically needed.

The pH thresholds:

All of Maine's water quality criteria for protecting aquatic communities (Classes AA, A, B and C) appear to be compressed in the narrow range between pH 6 and 6.5. For instance, from **Baker, JP, DP Bernard, SW Christensen, MJ Sale, J Freda, K Heltcher, D Marmorek, L Rowe, P Scanlon, G Suter, W Warren-Hicks, and P Welbourn. 1990. Biological effects of changes in surface water acid-base chemistry. In: National Acid Precipitation Assessment Program (NAPAP) Integrated Assessment # 13, State of Science and Technology, vol. II**, in their inter-agency report to Congress, we can see a summary of some of their findings. Note that invertebrates are lost below pH 6.5 and fish species are lost below pH 6. Table 3 is reproduced below:

Table 3
Biological effects of surface water acidification (after Baker et al., 1990)

pH decrease	General biological effects
6.5–6.0	Small decrease in species richness of phytoplankton, zooplankton, and benthic invertebrate communities resulting from the loss of a few highly acid-sensitive species, but no measurable change in total community abundance or production. Some adverse effects (decreased reproductive success) may occur for highly acid-sensitive species (e.g., fathead minnow, striped bass)
6.0–5.5	Loss of sensitive species of minnow and dace, such as blacknose dace and fathead minnow; in some waters decreased reproductive success of lake trout and walleye, which are important sport fish species in some areas. Visual accumulations of filamentous green algae in the littoral zone of many lakes, in some streams. Distinct decrease in the species richness and change in species composition of the phytoplankton, zooplankton, and benthic invertebrate communities, although little if any change in total community biomass or production
5.5–5.0	Loss of several important sport fish species, including lake trout, walleye, rainbow trout, and smallmouth bass; as well as additional nongame species such as creek chub. Further increase in the extent and abundance of filamentous green algae in lake littoral areas and streams. Continued shift in the species composition and decline in species richness of the phytoplankton, periphyton, zooplankton, and benthic invertebrate communities; decrease in the total abundance and biomass of benthic invertebrates and zooplankton may occur in some waters. Loss of several additional invertebrate species common in oligotrophic waters, including *Daphnia galeata mendotae, Diaphanosoma leuchtenbergianum, Asplanchna priodonta*; all snails, most species of clams, and many species of mayflies, stoneflies, and other benthic invertebrates. Inhibition of nitrification
5.0–4.5	Loss of most fish species, including most important sport fish species such as brook trout and Atlantic salmon; few fish species able to survive and reproduce below pH 4.5 (e.g., central mudminnow, yellow perch, and in some waters, largemouth bass). Measurable decline in the whole-system rates of decomposition of some forms of organic matter, potentially resulting in decreased rates of nutrient cycling. Substantial decrease in the number of species of zooplankton and benthic invertebrates and further decline in the species richness of the phytoplankton and periphyton communities; measurable decrease in the total community biomass of zooplankton and benthic invertebrates in most waters. Loss of zooplankton species such as *Tropocyclops prasinus mexicanus, Leptodora kindtii,* and *Conochilis unicornis*; and benthic invertebrate species, including all clams and many insects and crustaceans. Reproductive failure of some acid-sensitive species of amphibians such as spotted salamanders Jefferson salamanders, and the leopard frog.

Note that even at pH 6.5, some organisms are stressed and can be eliminated below that value. Maine's Class AA water quality criteria demand that salmon waters support all species "that naturally occur." If species were present that are now gone, those waters do not attain Class AA or Class A. If indigenous fish species are lost those waters do not attain Class C. A study by Wisconsin DNR, **Eilers, JM, GJ Lien & RG Berg. 1984. Aquatic organisms in acidic environments: a literature review. Department of Natural Resources, Wisconsin, Technical Bulletin #150 pp 24** says (among other things) that "the greatest losses in species diversity are expected to occur between pH 5-6" and "at pH 6, about 50% of leaches, mollusks, sponges and insects are lost." Is that true? If so, these waters with relatively moderate pH would not attain Maine Class AA or A water quality.

From **Driscoll, CT, KM Driscoll, MJ Mitchell & DJ Raynal. 2003. The effects of acid deposition on forest and aquatic ecosystems in New York state. Environmental Pollution 123: 327-336** we find a relationship between pH and fish species diversity in the Adirondack State Park (below). Notice that maximum species diversity is above pH 6.51. Below that, species are lost. In an EPA review of water quality in Northeastern USA lakes, landlocked Atlantic salmon do not persist in lakes when pH is below 6.5 (**Halliwell, DB, TR Whittier & NH Ringler. 2001. Distributions of lake fishes of the Northeastern United States -**

III. Salmonidae and associated coldwater species. Northeast Naturalist 2: 189-206) nor do runs of sea-run Atlantic salmon persist below pH 6.4 in the Catskills (**Baldigo, BP & GB Lawrence. 2000. Communities relative to stream acidification and habitat in the Neversink River, New York. Transactions of the American Fisheries Society 129 (1):60-76).**

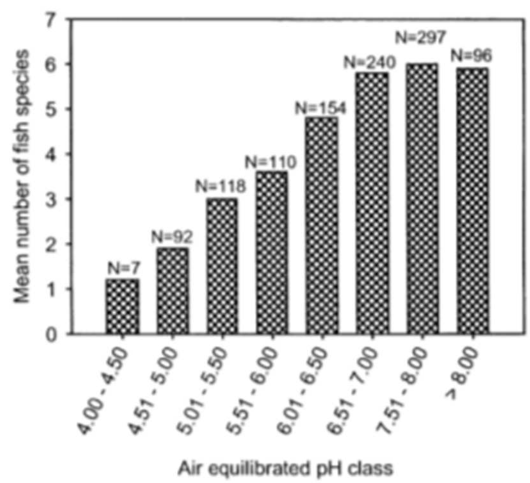


Fig. 3. The mean number of fish species for pH classes from 4.0 to 8.0 in lakes in the Adirondack region of New York. N represents the number of lakes in each pH class (modified from Kretser et al., 1989; Driscoll et al., 2001).

Halliwell et al 2001, goes on to point out that the reference condition for Maine cold water fish communities, namely salmon, slimy sculpin and burbot (cusk) are the species that are most vulnerable to acid rain pollution.

What species are missing in Downeast Maine? Atlantic salmon, burbot, slimy sculpin, are seen in some Downeast lakes but are almost absent in rivers and streams. Due to the volume of water in lakes, lakes have more stable pH than streams do. Streams are flow-through systems that are strongly influenced by each passing rainstorm. It is expected that episodic acidification will be more extreme, and more biologically limiting in streams (**Baker et al. 1990**). Atlantic salmon are stocked in 5 Downeast salmon rivers, but the wild self-sustaining populations are gone, and the stocked fish have extremely poor survival. Twenty years of stocking has not been able to restore salmon. In 2020 we have lower freshwater survival than when we started a state-federal recovery plan in 2000. Class C criteria demand that water quality be adequate to support all indigenous species of fish. If salmon, burbot and sculpin are gone, these waters do not attain even Class C. What does DEP's fish IBI and the invertebrate methods say about individual streams? Do they attain their water classification? There is no way of knowing since DEP has not developed acid rain assessment methods.

From **Haines, TA & JJ Akielaszek, 1983. A regional survey of chemistry of headwater lakes and streams in New England: vulnerability to acidification. USFWS Air Pollution and Acid Rain Report #15, US Dept. of Interior** we learn that in New England among those lakes with good historical data on water quality, **all of the low alkalinity lakes** have been acidified (are more acidic than they used to be) and a large percentage of lakes overall (64% based on pH or 79% based on alkalinity) have become more acidic. So even **the "average" lake is five-times as acidic as it was**, has lost 60% of its alkalinity, and we have known this since the early 1980s! Here are the authors in their own words:

> Historical pH and alkalinity data indicate that waters located in areas where buffering capacity is low have been acidified. Of the 95 lakes with usable historical pH data, 61 (64%) were lower in pH in this survey. Of 56 lakes for which historical alkalinity data were located, 39 (70%) were lower in the present survey. The average lake for which historical data were available increased in hydrogen ion content five-fold and decreased in alkalinity by 60%.

From **Kircheis, D & R Dill, 2006. Effects of low pH and high aluminum on Atlantic salmon smolts eastern Maine and liming project feasibility analysis. US Atlantic Salmon Assessment Committee Working Paper** in a literature review, the authors quote an unpublished George Mitchell Study saying that Tunk Stream lost its ability to support salmon due to acidification. Their findings include 4) below:

> Dennys); 3) tributaries tend to have lower pH than mainstem sites; 4) summer base-flow sampling showed that all of the rivers, except Tunk Stream, had pH values favorable for salmon health for that time of year. The lower ANC and higher DOC make the eastern sites more susceptible to event-driven pH depressions than sites to the west of the Penobscot River.

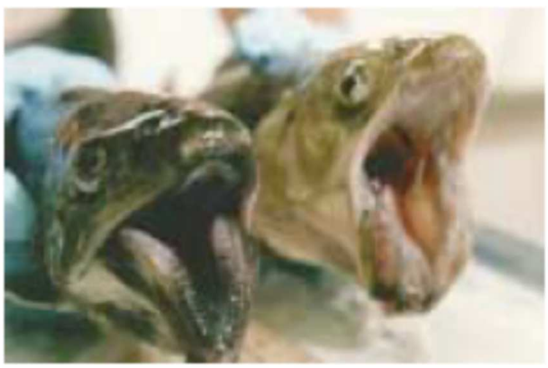
So, in the early 1980s, all of the official Downeast salmon rivers had summertime baseflow pH that was favorable for salmon except for Tunk Stream. Even with marginal pH, Tunk had a small but naturally self-sustaining population of Atlantic salmon. That has been lost due to acid rain. State and federal agencies have a consensus opinion that Tunk Stream is now too acidic to justify being stocked with juvenile salmon since they are not expected to survive.

Listing Tunk Stream as an impaired water will facilitate liming projects that can prove liming as an effective salmon restoration method in Maine. It should also spur DEP to finally develop acid rain assessment methods. DSF believes that we can restore lost Atlantic salmon runs in 10 years based on the experience of liming projects in Nova Scotia, Scandinavia, New York, and Virginia/West Virginia, and based on our own limited liming experience here in Downeast Maine.

The calcium thresholds:

When brook trout are grown in some Maine hatcheries, they can develop fatal deformities after spawning. Necropsies show bone loss, loose teeth, organ deformities, and other evidence of inadequate calcium nutrition. Hatchery fish are given scientifically formulated foods that have all the nutrients that brook trout are supposed to need. So how is it possible they have calcium deficiencies?

Fish lose base cations through their gills and skin. To maintain a positive ion balance in their bodies, fish and other aquatic organisms have to pump ions across membranes using metabolic energy. The gills are the principal organ for this, but dietary cations are also important. An investigation of this problem by DIFW pathologist **Danner, R. 2004. Improving brook trout egg quality in Maine: adding calcium overcomes the effects of an acidic environment. Hatchery International Nov-Dec: 33-34.** showed that dietary calcium was not adequate to maintain body calcium against strong external gradients when ambient Ca (Phillips Hatchery in southern Maine) was 2-2.5 mg/L. There is not enough calcium "to build a health fish" Dr Danner concluded at a Salmon Forum at the U of Maine. Danner thought that "ambient calcium concentrations below 4 mg/L are problematic for many species" and solved the Phillips problem by boosting calcium in the hatchery to 30 mg/L (the standard for aquaculture of salmonids) by adding agricultural lime or calcium chloride.



Brook trout with deformed jaws due to calcium deficiency

The alkalinity thresholds:

Since alkalinity is the best indicator of acid status, an alkalinity standard should be added by law or administrative rules. DEP's own publications have set the acid rain Critical Load at 100 ueq Alk/L specifically to protect salmon (**Miller, EK, 2011. Steady state critical loads and exceedance for terrestrial and aquatic ecosystems in the Northeastern United States. Final technical report to the National Park Service by Ecosystems Research Group**). This should be used until we have something better. The Critical Load model suggests around 43% of Maine soils and waters have exceeded their CL and may be impaired.

The following map is from the EPA's Eastern Lakes Survey. The map shows how subsurface geology interacts with soils to create a mosaic of water quality expressed as Alkalinity. All of Region 1 has surface water alkalinities that are generally below the DEP Critical Load to support Atlantic salmon (100 ueq/L, 5 mg/L). We know that Atlantic salmon are doing poorly in Downeast Maine. This is no mystery; this is cause and effect and we have 40 years of data to prove it.

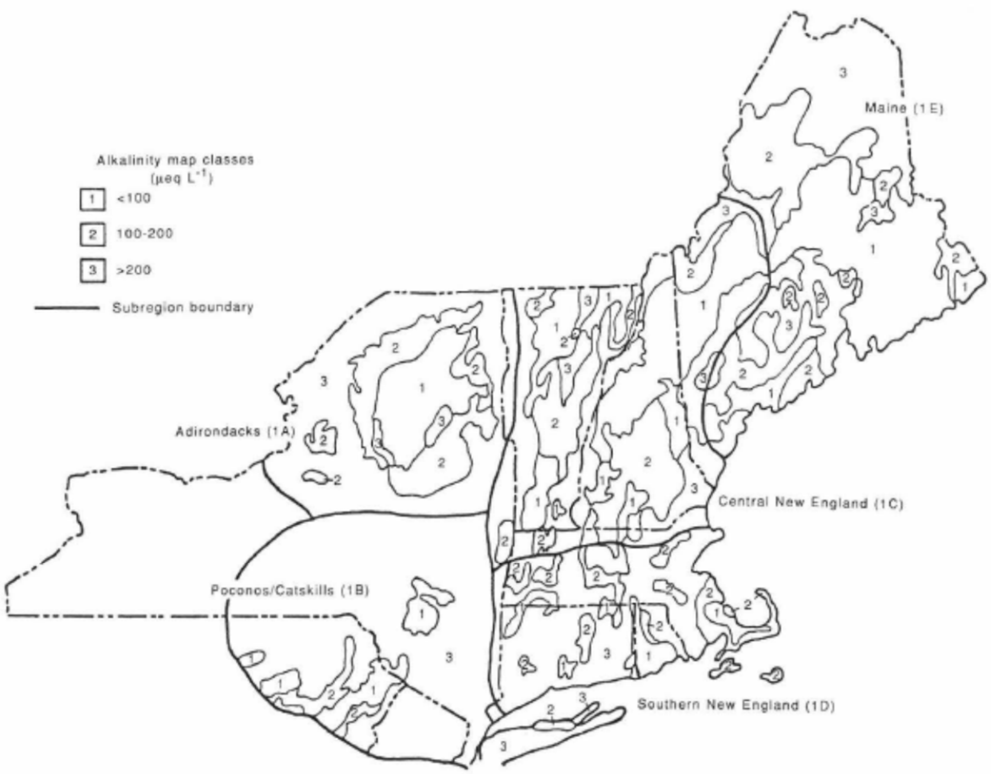


Figure 1. Sub-regions and alkalinity map classes for the Eastern Lake Survey, northeastern region (from Linthurst et al., 1986).

From **Crosby, BJ, JR Webb, JN Galloway and FA Deviney. 2006. Acidic Deposition Impacts on Natural Resources in Shenandoah National Park. US Dept of Interior, National Park Service, Technical Report NPS/NER/NRTR—2006/066** we find the following graph for streams in Shenandoah National Park. We saw something like this with pH and now we see that the relationship with alkalinity (here called Acid Neutralizing Capacity or ANC) is also highly significant. Lakes like the Maine HELM lakes that have lost all of their alkalinity on the bottom left of the graph (0 fish and 0 ANC). They do not support fish. In this paper, streams in SNP need at least 160 ueq of Alkalinity/L to support 10 species of fish. There are 26 common species of fish in the park and 44 species in the Shenandoah River valley that have been seen at some time or other in the park.

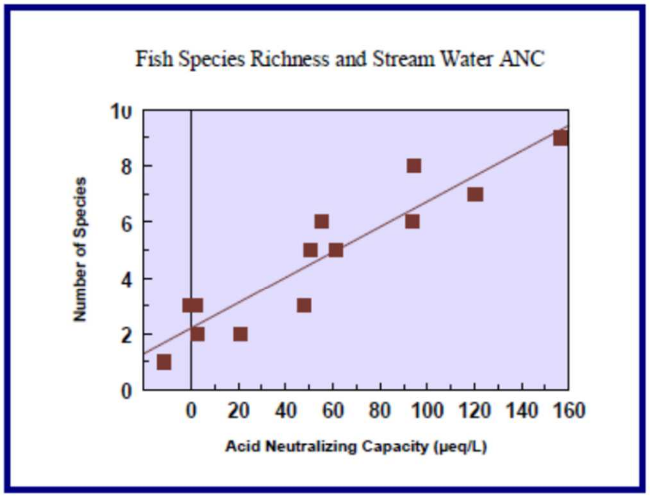


Figure 1.8. Relationship between number of fish species and minimum ANC recorded in Shenandoah National Park streams (from Bulger et al. 1996b).

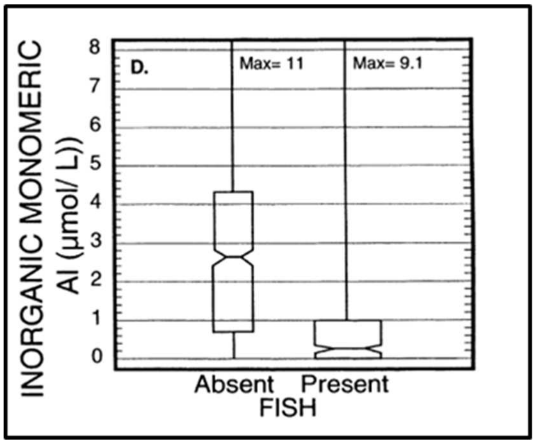
What alkalinity is needed to support them all? The paper does not say. A more recent paper **Sullivan, TJ & TC McDonnell. 2012. Application of critical loads and ecosystem services Principles to assessment of the effects of atmospheric sulfur and nitrogen deposition on acid-sensitive aquatic and terrestrial resources. Pilot Case Study for Central Appalachians, Completion report to EPA** looking at 13 streams in Shenandoah National Park, found that with Alkalinity that ranged from 0-300 ueq/L fish species diversity increased from 1 to 9 in a linear fashion without leveling off (and the relationship is very highly significant $p < 0.0001$). Episodic acidification in the low Alk streams led to mortalities of young brook trout (Salvelinus fontinalis), but not in high-Alk streams. Blacknose dace body condition (K) ranged from poor to very good in the same Alk range. So again, the Alkalinity needs to be high to support natural communities. For lakes, 100 ueq Alk/L might work, but for streams it needs to be at least 200-300 ueq/L (10-15 mg/L).

The DEP **HELM** study, **Kahl and Scott 1988** confirm that vulnerable lakes in western Maine have been affected by acid rain. Some of the findings in the words of the authors are inserted below.

> and 85. The HELM lakes are more dilute, less well buffered, and probably more vulnerable to acidic precipitation than Maine lakes in general. In 1986, six HELM lakes had pH less than 5, and 12 had ANC less than 0. Calculations indicate that as many as one-quarter of the HELM lakes are "acidified," having lost ANC relative to their normal state as a result of acidic precipitation and, to a lesser extent, of organic acidity.

Lakes already documented to have lost all their alkalinity due to acid rain should be listed as impaired waters. Having a list of impaired waters makes money available for Clean Water Act funding, such as 319 projects. Funding in turn facilitates solutions. There are 65 of these lakes, about the same number as the list of lakes currently supporting nuisance and hazardous algal blooms. So, this is a major source of impairment in Maine. It also communicates clearly to other state and federal agencies the importance of the problem and the need for solutions. For the last 35 years, such a consensus among agencies has been elusive, in part because of the lack of action on DEP's part. DEP's contribution to the Atlantic Salmon Recovery Plan is to be the expert on water quality. So, DEP please tell us, what is the status of water quality in the Downeast salmon rivers?

The aluminum threshold:



The aluminum threshold is easy. There is no controversy and there is a solid consensus. The toxic ionic inorganic aluminum, sometimes called exchangeable Al (Alx) has to be less than one u mol/L (27 ug/L). The following graphic is from **Driscoll et al. 2003**, which was cited earlier. Seventy five percent of the lakes with fish in the Adirondacks have Alx below 1 u mol/L. Brook trout are still mainly stocked, so naturally reproducing populations are still rare.

3. Bodies of Water Proposed to be Listed

The lakes from the HELM study found to be "acidified" (ANC < 0 ueq/L) should be listed. These 65 lakes have apparently already been reported to EPA as impaired waters. Lakes and streams of Acadia National Park are all impacted by acid rain, and many or possibly all of them should be listed. To begin with, all those lakes and streams in ANP that fail to meet DEP pH and Alkalinity standards (pH < 6 and ANC < 100 ueq/L) and are already known to have poor biological conditions should be listed. Paleolimnological data from Speck Pond (Grafton TWP), Mud Pond, and Little Long Pond (T10 SD) shows that they have become chronically acidified. Mud Pond and Anderson Pond (T10 SD) originally had a pH around 7 and have become more acidic. These ponds should be listed. East Bear Brook the control site at the U of Maine long-term environmental study site on Lead Mountain has continued to acidify through 2009 and should be listed. Tunk Stream and Dead Stream (sometimes called Bowles Str) used to sustain natural populations Atlantic salmon and now do not. Since they do not meet even Class C criteria, and because water quality is below known survival thresholds for salmon, these should be listed. Dead Stream is now chronically acidified by 1 pH unit compared to 1983 and suffers from acidic episodes. Dead Stream was the first stream to have been limed in DEPs Liming Pilot Study. Partial biological recovery with liming and rapid degeneration after the liming study was terminated clearly shows cause and effect. The impairment is due to loss of alkalinity and calcium and shows that calcium carbonate additions can restore endangered Atlantic salmon.

The five Downeast salmon rivers with endangered Atlantic salmon, namely the Narraguagus, Pleasant, Machias, East Machias, and the Dennys Rivers should be listed. These rivers used to have naturally self-sustaining salmon and now do not. The Narraguagus R had a commercial freshwater mussel fishery (a biological supply company) in the 1960s that was abandoned and is now found only in lakes. Other species are reduced almost to the point of being missing, including slimy sculpin, cusk, crayfish and snails. Many species are present but rare, including stickleback, blacknose dace, and other minnows.

There are many more bodies of water than need to be listed, but this is a good beginning. In order to do a better and more complete job, we need the basic tools to evaluate aquatic systems for acid rain impairment. We need the fishery and macroinvertebrate assessment models as soon as possible.

Locations and Water Quality Data:

Only DEP knows the names of the HELM lakes and what towns there are located in. Some of these lakes might be naturally acidic and might not be included (but it is important to note that even naturally acidic lakes that do not become more acidic with acid rain can still be affected – natural acidity is replaced by mineral acids and water toxicity increases, indigenous species can be lost, pH alone is not a good measure of impacts). Only DEP knows which lakes are thought to be acidified. We also want to know the names of the **Haines, TA & JJ Akielaszek, 1983** lakes and where they are. These lakes also have good baseline and more recent data needed to evaluate trends. How many of these 60 lakes are different from the 65 HELM lakes? How many are in Maine? Where are the data? And even more importantly why are we so focused on lakes, when the streams are clearly more vulnerable?

The National Park Service has 40 years of water quality data from lakes and streams in the park. Park Service publications and other peer-reviewed papers are available.

Speck Pond and the smaller Tunk lakes, Anderson, Mud and Little Long Pond have good historical data or paleolimnological reconstructions that show they have become chronically acidified. These are documented in peer-reviewed papers.

Tunk Stream is in T10 SD, Cherryfield and Steuben. The whole stream should be listed. DEP has the water quality data available from the Salmon Rivers Program, including lab chemistry and sonde recordings. For every place DEP has a sonde recording from Downeast salmon rivers, we have documented episodic acidification. There are fishery surveys from the 1980s (including Tunk) and these are available as reprints. There is some logging and blueberry fields. Acid rain is the main reason fishery restoration (salmon and alewives) has been impossible.

Dead Stream is in T37 MD BPP and Day Block Township. The whole stream should be listed. DEP has the water chemistry and sonde records from the Salmon Rivers Program and the Liming Pilot Project. Summary data and reports from the Trial and Stanley studies in the early 1980s are available as reprints. All of the watershed is industrial timberland. The liming project demonstrated the cause and effect relationships between water quality and stream biology. Dead Stream/Bowles has better than average for water quality among the Downeast salmon rivers. The brook trout-only and fishless streams should be listed.

4. Impacts on Stakeholders

Atlantic salmon are already federally listed as an endangered species. Salmon and their critical habitats are already protected. The main impact of the proposed changes is that by tying salmon recovery to water quality, we can identify and fix the problems.

No permit owners or municipal discharges are thought to be affected. Land use permits are also not anticipated to be impacted.