Northeast Salmon Team (NEST) Fact Sheet Collection

Aquatic Macroinvertebrates:
bioindicators of water quality

The chemistry of water is influenced by many things and, in turn, influences many things, including Atlantic salmon.

In Eastern Maine, landscape features cause rivers to be naturally acidic. Additionally, human activities, such as fossil-fuel combustion, metal smelting and industrial processes, deliver acidic compounds (e.g. sulfuric and nitric aerosols) to the Earth's atmosphere. These are eventually returned to Earth via precipitation. Consequently, spring flood events from snowmelt and heavy rains result in episodically low surface water pHs in this region.

What is so special about pH? A low pH, particularly levels below 6.0, has been shown to impair osmoregulation and seawater tolerance of Atlantic salmon smolts. What's worse is that the leaching of base cations from soils that results from acidic deposition can also increase the level of aluminum in the water (in addition to decreasing the acid neutralizing capacity of the system).

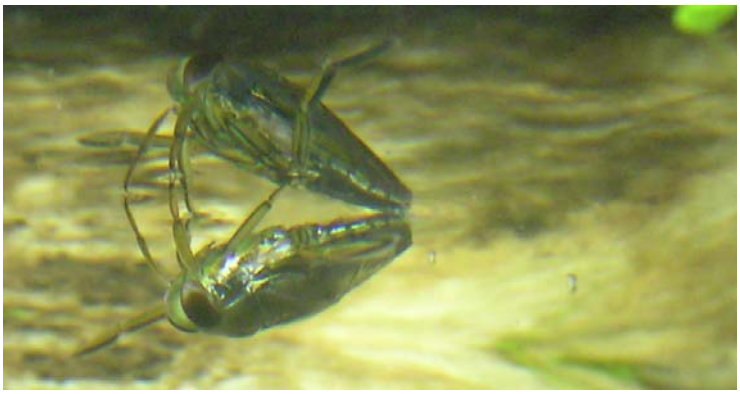
Aluminum, which is the third most abundant element in the earth's crust, is known to produce toxic effects in aquatic ecosystems. Soluble inorganic forms are one of the principle toxicants suspected to affect fish in acidified waters.

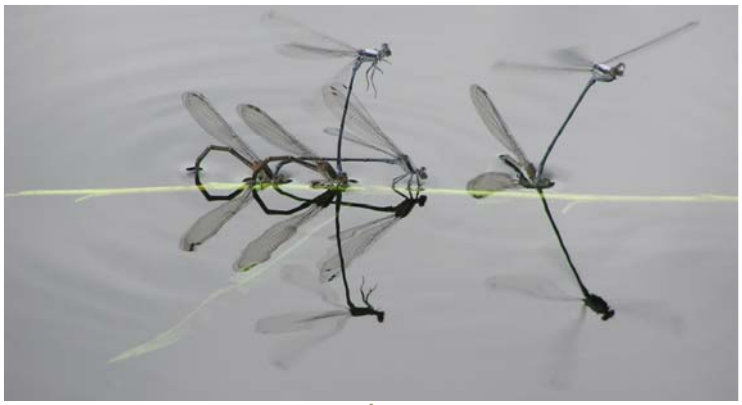
Atlantic salmon undergo dramatic physiological changes prior to transitioning from freshwater into saltwater. Recent studies suggest that Atlantic salmon smolts are especially sensitive to the combined effects of low pH and high aluminum during this transitional life phase. This is the case even in rivers that are not chronically acidic and not normally considered as being in danger of acidification.

*Some common freshwater aquatic macroinvertebrates include crayfish, mussels, aquatic snails and insects (like the waterboatman pictured top right), and the larvae of insects such as damselflies (pictured here laying eggs on a piece of grass in a river). In addition to providing an important food source for juvenile fishes, the sensitivity of certain species of aquatic macroinvertebrates to environmental conditions makes them a particularly good indicator, or **bioindicator**, of water quality.*

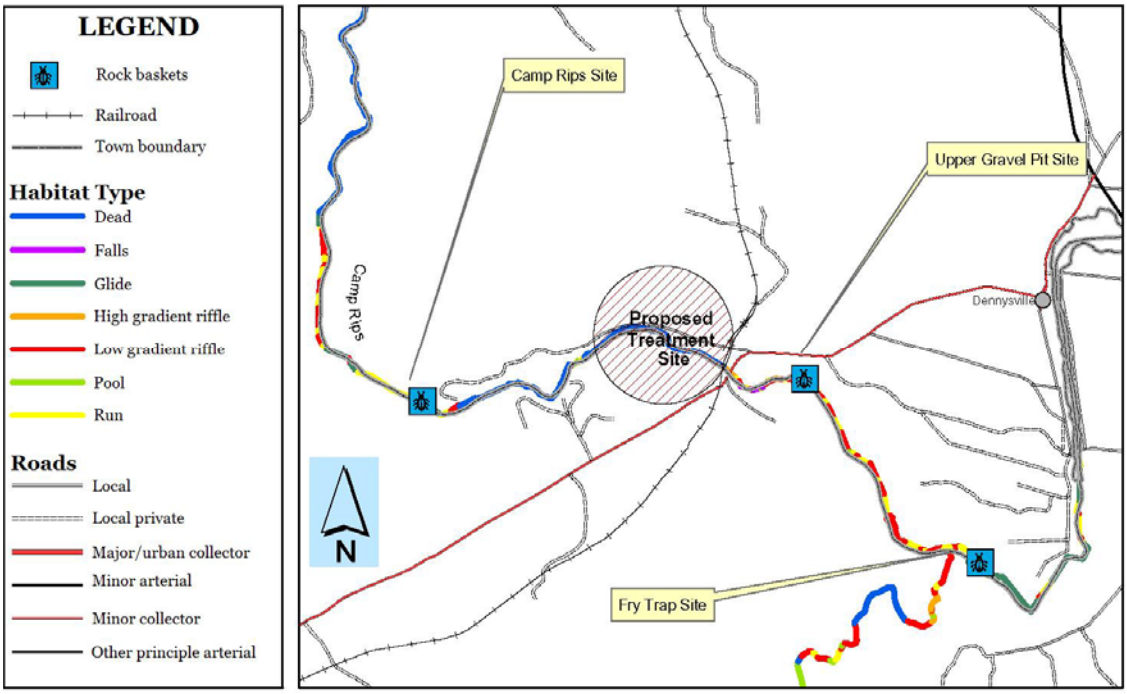
In 2003, an inter-agency and stakeholder committee was organized to determine if river liming would be an appropriate and logistically feasible means by which to buffer against anthropogenic acidification in Eastern Maine. A first step, however, was to identify if water quality did indeed threaten the recovery of Maine's unique population of Atlantic salmon and warrant liming as a mitigation technique.

To inform their decision in regards to liming, NEST conducted two studies: the streamside rearing study (which investigated the effects of episodic acid/aluminum fluxes on Atlantic salmon smolts and fry) and a survey of the aquatic macroinvertebrate community in the Dennys River (the proposed liming site). The latter (which this factsheet highlights) was done in partnership with the Maine Atlantic Salmon Commission, the University of Maine (Machias) and the Maine Department of Environmental Protection.





One of the advantages of using aquatic macroinvertebrates as a water quality bioindicator is their relative ease of collection. *Benthic* macroinvertebrates (those associated with the bottom) are particularly popular as protocols for their collection, identification and use as a bioindicator are well developed. Minimal equipment is necessary for their collection, and the process grants a cost-effective approach for assessing water quality. Monitoring and collecting benthic macroinvertebrates in the Dennys River occurred during 2003-2005. The survey was conducted upstream and downstream of the proposed liming site at the Rt. 86 bridge (see map) and employed the quantitative and qualitative sampling techniques described below.



Surber. A surber (left) was used to quantitatively sample benthic macroinvertebrates in riffle habitat. After placing the surber on the streambed, the sampler uses their hand to disturb the substrate within the boundaries of the frame. Macroinvertebrates residing in the substrate are dislodged and caught in the surber net as they drift downstream.

Kick nets and D-nets. A kick-net was used to qualitatively sample benthic macroinvertebrate for presence or absence in non-riffle habitat. The sampler places the net downstream and disturbs the streambed's substrate directly upstream. This dislodged macroinvertebrates residing in the substrate were then caught in the net as they drifted downstream. A D-net (below left) was also used to sweep the bank area and sample *micro-habitats*, such as leaf packs and wood debris.

Rock Baskets. Rock baskets provide an artificial substrate on which benthic macroinvertebrates can colonize and are especially useful when wading conditions are poor. Rock baskets were employed at different sites upstream and downstream of the proposed liming site (refer to map) to monitor benthic macroinvertebrates.

As some macroinvertebrates are particularly sensitive and cannot tolerate certain conditions (including acidity), their absence at the proposed liming site would have provided strong support for the river liming. However, this particular survey's results suggest that the composition of the macroinvertebrate community is typical for Downeast Maine (based on what we know from available data): acid intolerant species were found and the assemblage of species appeared to be diverse. Furthermore, following the completion of the streamside rearing study, physiological effects to smolts in response to episodic pH events in the Dennys river were not detected. Thus, plans to conduct an experimental liming project on the Dennys have been suspended.

Data from the macroinvertebrate survey was provided to the Maine Department of Environmental Protection to be used to assist in assessing the water quality of the Dennys River. The collection is currently housed at the University of Maine in Machias to be used for educational purposes and to serve as a reference for future macroinvertebrate surveys in Eastern Maine.

GROUP	FAMILY	GENUS	SPECIES
DIPTERA	Tanypodinae	*Procladius*	
EPHEMEROPTERA	Baetidae		
EPHEMEROPTERA	Baetidae	*Baetis*	
EPHEMEROPTERA	Baetidae	*Baetis*	*flavistriga*
EPHEMEROPTERA	Ephemerellidae		
EPHEMEROPTERA	Ephemerellidae	*Attenella*	
EPHEMEROPTERA	Ephemerellidae	*Serratella*	
EPHEMEROPTERA	Heptageniidae	*Epeorus*	
EPHEMEROPTERA	Heptageniidae	*Leucrocuta*	
EPHEMEROPTERA	Heptageniidae	*Maccaffertium*	
EPHEMEROPTERA	Leptophlebiidae		

A snapshot of the data collected during the Dennys River macroinvertebrate survey is presented above. This particular excerpt identifies a portion of the benthic macroinvertebrates collected on July 1, 2005 with the surber sampler. Full data sets for each site are available on the NEST website under NEST activities (macroinvertebrate survey).

Quick fact: While the presence/absence of sensitive macroinvertebrates can provide a good indication of water quality, macroinvertebrate abundance can likewise provide clues about the productivity of a river system. Although abundance wasn't quantified in this survey, we do know that like other Maine rivers, the Dennys historically had much larger runs of diadromous (sea-run) fishes than today. Inputs of marine derived nutrients from adults returning to spawn are an important food web driver in freshwater systems where significant runs still occur. As juvenile fish must eat, stimulating river productivity (i.e. addressing food web issues from the bottom up) via inputs of key nutrients is a consideration that is currently being explored.

***Clockwise from bottom left**: NEST and University of Maine researchers cluster around a sample of macroinvertebrates collected with a surber sampler at a Dennys river site; a close up of a juvenile stonefly; the stonefly and other specimens preserved in alcohol; the macroinvertebrate collection.*

The NOAA's National Marine Fisheries Service (NMFS) Northeast Salmon Team (NEST) is comprised of managers from the Northeast Regional Office (NER) and scientists from the Northeast Fisheries Science Center (NEC). The NER administers NOAA's programs in the Northeastern United States to manage living marine resources for optimum use. The NEC is the research arm of NOAA Fisheries in the region and plans, develops, and manages a multidisciplinary program of basic and applied research. More Atlantic salmon information is available at www.XXXXXXXXXXXXX.