Progress Report: A Summary of Water Quality Monitoring Results From Spring 2001, Maine Atlantic Salmon Rivers Project

Project Objectives

In 1999 the DEP and the salmon rivers watershed councils began a water quality monitoring program to provide a baseline characterization of the Atlantic salmon rivers. The purpose of the baseline is to monitor environmental trends and to evaluate environmental stresses that may be effecting salmon. This project began its third field season in 2001. This is a collaborative effort that involves DEP, the salmon river watershed councils, and the University of Maine's George Mitchell Center for Environmental and Watershed Research (formerly the Water Resources Institute).

Two kinds of water samples are collected for analysis at the George Mitchell Center. "Baseflow" conditions are monitored when river conditions are dominated by groundwater (i.e., when there has not been a major rain event in the last 7 days). Stormwater is monitored in the salmon rivers during and after a rain event. Whenever possible, samples are taken before the flood peak, near the peak, and again as the flood waters recede. The water quality parameters that are monitored include pH, alkalinity, temperature, conductivity, major nutrients, turbidity and total suspended solids. Because of its association with acid rain, total dissolved aluminum was measured in baseflow samples beginning in year 2000. In the 2001 field season, total dissolved aluminum was measured in both baseflow and stormwater samples. In addition, if the pH was less than 6.0, total dissolved aluminum was separated into organic and "exchangeable" forms. Exchangeable aluminum is known to bind to the ion-exchange sites on the gills of fish, thereby damaging the fish's ability to osmoregulate. This can lead to neurological and developmental disorders and death.

In 2001, the State Planning Office, Priority Coastal Watersheds Initiative gave us $4,080 to amplify our stormwater monitoring program. Acid rain and suspended sediments have been identified as two pollutants that might effect salmon survival and reproduction. Both of these environmental issues are most extreme during stormwater events.

Progress in Year 2001

In general, the highest stream flows are expected in Maine in March and April with a second peak in the fall. The 2001 field season was the first concentrated effort to sample stormwater during the spring high flow events. This spring was unusual because of the large snowpack that persisted into April. Rain on snow events usually generate the most extreme flood events. However, this spring was characterized by snowstorms in March through mid-April and was then followed by a dry spell that persisted through mid-May. Because we were anticipating a potential rain on snow event, we took individual stormwater samples but did not intensively sample during a single storm. The individual smaller storms provide a perspective for understanding the larger "perfect storm" event.

Basically, we are still waiting for our perfect storm. For the same reason, not all of the money available for stormwater sampling has been spent. Thus, this is a progress report and not a completion report.

Significant Findings

Results from the last two year's baseflow sampling suggest that the eight salmon rivers have moderate pH (range 6-7) and positive alkalinity (ANC range 37-874 ueq/L). Since the sum of the base cations is in excess of SO4 (measured in ueq/L), it is apparent that acid rain is being consumed within the watershed. To date there is no evidence of chronic acidification in any of the salmon rivers. However, since rainwater may dominate streams during storm events, episodic acidification remains a possibility.

Stormwater samples taken this spring (see Table 1) were generally lower in pH and alkalinity than baseflow samples. While the pH ranged from 5.46 (Pleasant R. at Saco Falls) to 8.06 (Cove Brook), these values are still relatively moderate. The alkalinity ranged from 23 ueq/L (Tunk Stream) to 1,580 ueq/L (Cove Brook) indicating that all streams have residual buffering capacity. And while total dissolved aluminum is high, especially in the downeast rivers (range 12-315 ug/L overall), stormwater samples with pH as low as 5.46 have all the aluminum organically bound. In studies of the interaction of low pH with aluminum and fluoride, Hamilton and Haines (1995) suggest that a pH of 5.5 without exchangeable aluminum is not a toxic condition.

Turbidity and suspended sediments found in stormwater samples are also generally moderate, but may exceed 30 mg/L in the Sheepscot and 100 mg/L in Cove Brook. In a review of the effects of suspended sediment on fish health, Newcombe & Jensen (1996) suggest that TSS in excess of 20 mg/L can lead to reduced feeding success for juvenile and adult salmonids. Exposure to TSS in excess of 55 mg/L for extended periods can lead to loss of weight and condition. While not high enough to cause acute respiratory failure or other mortality, the observed values for TSS are enough to harm fish and degrade rocky habitat.

Comparisons with Other Studies

Other studies in the Maine salmon rivers (Haines, 1981) have demonstrated episodic acidification and the potential for fish losses through pH and aluminum interactions. Since these studies, the Clean Air Act has reduced SO4 emissions in the Mid-west and atmospheric precipitation in Maine has become less acidic. Data from the National Atmospheric Deposition Program shows that the volume weighted average pH for wet precipitation was 4.3 in 1980 and 4.7 in 1998. It is possible that reductions in atmospheric pollutants have allowed partial recoveries in the downeast rivers.

Also the results from this spring are not extreme storm events. Spring 2001 was remarkable for a lack of a rain in early spring and relatively mediocre rain events in May and June. Also, in order to conserve our resources, the monitoring program this spring focused on the main stems of rivers or major tributaries (like the West Branch of the

Sheepscot and the West Branch of the Narraguagus River). It is likely that acidic episodes are most important in the smaller tributaries and/or are limited to the more extreme weather events (Haines, 1981).

The high pH and alkalinity of Cove Brook suggests a source of carbonate that is not found in the downeast rivers. The pH of water that is in equilibrium with the partial pressure of atmospheric CO2 and in equilibrium with carbonate minerals is 8.2 (Norton, 1982).

Plans for Future Monitoring

We plan to continue both baseflow and stormwater monitoring. In particular, we need to sample the more extreme stormwater events and collect more samples per storm. Since pH, aluminum, and suspended solids vary greatly within a storm as well as between storms, it will clearly take more than one season to completely characterize the less normal events.

We anticipate completion of the SPO funded monitoring program this fall with the return of fall rains.

References Cited

Haines, Terry A. 1981. Effects of acid rain on Atlantic salmon rivers and restoration efforts in the United States. In: Proceedings of a Conference on Acid Rain and the Atlantic Salmon, International Atlantic Salmon Foundation Special Publication #10, 171 p.

Hamilton, Stephen J & Terry A Haines. 1995. Influence of fluoride on aluminum toxicity to Atlantic salmon (Salmo salar).

Newcombe, Charles P & Jorgen OT Jensen. 1996. Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact. No. Amer. J Fish. Man. 16(4): 693-719.

Norton, Stephen A. 1981. The effects of acidification on the chemistry of ground and surface waters. In: Acid Rain/Fisheries, Proceedings of a Symposium of Acidic Precipitation and Fishery Impacts in Northeastern North America. American Fisheries Society, Bethesda, Maryland, pp. 93-102.

This progress report was prepared by Mark Whiting, ME DEP, Bangor Regional Office. 207-941-4566

A: salmonsummary Draft 7/31/2001

Table 1 Summary of baseflow and stormwater data from Spring 2001, Maine salmon rivers project.

Sample ID	sample site	sample type and time taken	amount of pptn	Sample Date	Al ug/L	AlOrg ug/L	Alx ug/L	Ca mg/L	Ca ueq/L	Mg mg/L	Mg ueq/L	Na mg/L
Tunk Stream	Steuben Bridge, Village Rd	stormwater	3" rain and snow in Machias	3/23/01	149	NA	NA	1.29	64.371	0.67	55.1343	4.99
Sheepscot River	Route 126 gauge	stormwater, 927	18" wet snow on 4/10 & meltwater	4/12/01	NA	NA	NA	NA		NA		NA
Sheepscot River	West Branch at Howe Rd	stormwater, 1705	snowmelt	4/11/01	NA	NA	NA	NA		NA		NA
Sheepscot River	West Branch at Howe Rd	stormwater, 906	snowmelt	4/12/01	NA	NA	NA	NA		NA		NA
Sheepscot River	Route 126 gauge	stormwater, 1645	snowmelt	4/11/01	NA	NA	NA	NA		NA		NA
Cove Brook	Baker Brook at Baker Rd	stormwater	0.25 " new rain & ice, snowmelt	4/13/01	NA	NA	NA	NA		NA		NA
Cove Brook	Route 1A	stormwater	0.25" new rain & ice, snowmelt	4/13/01	NA	NA	NA	NA		NA		NA
Cove Brook	Route 1A	baseflow, 1730		5/13/01	33.5	pH > 6	pH > 6	17.2	858.28	2.68	220.5372	7.14
Cove Brook	Baker Brook at Baker Rd	baseflow, 1745		5/13/01	21.6	pH > 6	pH > 6	16.2	808.38	2.11	173.6319	7.77
Cove Brook	Back Winterport Rd	baseflow, 1800		5/13/01	22	pH > 6	pH > 6	19.7	983.03	3	246.87	6.69
Cove Brook	Cove Road	baseflow, 1815		5/13/01	19.5	pH > 6	pH > 6	11.5	573.85	2.35	193.3815	6.78
Cove Brook	Route 1A	stormwater	1.2 " in Stockton Springs	5/19/01	24.6	pH > 6	pH > 6	18.5	923.15	2.86	235.3494	5.92
Cove Brook	Baker Brook at Baker Rd	stormwater	1.2 " in Stockton Springs	5/19/01	13.1	pH > 6	pH > 6	22.7	1132.73	2.87	236.1723	6.15
Cove Brook	Back Winterport Rd	stormwater	1.2 " in Stockton Springs	5/19/01	27.2	pH > 6	pH > 6	16.2	808.38	2.65	218.0685	6.33
Cove Brook	Cove Road	stormwater	1.2 " in Stockton Springs	5/19/01	22.8	pH > 6	pH > 6	10.8	538.92	2.37	195.0273	6.37
Sheepscot River	Route 126 gauge	stormwater	1.2 " in Stockton Springs	5/19/01	55.7	pH > 6	pH > 6	4.65	232.035	0.92	75.7068	3.74
Sheepscot River	West Branch at Howe Rd	stormwater	1.2 " in Stockton Springs	5/19/01	58.2	pH > 6	pH > 6	8.85	441.615	1.35	111.0915	4.47
Machias River	Bad Little Falls, Machias	stormwater, afternoon	1.15" in Machias on 6/3	6/4/01	134	pH > 6	pH > 6	1.99	99.301	0.55	45.2595	3.02
Narraguagus River	Cherryfield, Cable Pool	stormwater, 1600	additional "heavy rain" on 6/5	6/5/01	169	pH > 6	pH > 6	1.76	87.824	0.59	48.5511	3.48
Tunk Stream	Route 182 north side of bridge	stormwater, 1637	additional "heavy rain" on 6/6	6/5/01	62.2			0.94	46.906	0.36	29.6244	3.53
Pleasant River	Saco Falls	stormwater, 1530	additional "heavy rain" on 6/7	6/5/01	214			1.39	69.361	0.47	38.6763	3.11
Narraguagus River	West Branch,.Sprague Falls	stormwater, 1620	additional "heavy rain" on 6/8	6/5/01	229	pH > 6	pH > 6	1.4	69.86	0.52	42.7908	3.02
Tunk Stream	Route 182 north side of bridge	stormwater, 745	additional "heavy rain" on 6/9	6/6/01	81.3			0.95	47.405	0.37	30.4473	3.44
Narraguagus River	Cherryfield, Cable Pool	stormwater, 915	additional "heavy rain" on 6/10	6/6/01	196	pH > 6	pH > 6	1.81	90.319	0.58	47.7282	3.26
Narraguagus River	West Branch, Sprague Falls	stormwater, 800	additional "heavy rain" on 6/11	6/6/01	245	pH > 6	pH > 6	1.39	69.361	0.52	42.7908	2.96
Pleasant River	Saco Falls	stormwater, 840	additional "heavy rain" on 6/12	6/6/01	245			1.38	68.862	0.46	37.8534	2.99
Narraguagus River	Cherryfield, Cable Pool	stormwater, 920	additional "heavy rain" on 6/13	6/7/01	171	pH > 6	pH > 6	1.86	92.814	0.56	46.0824	3.06
Pleasant River	Columbia Falls	stormwater, 1315	additional "heavy rain" on 6/14	6/6/01	301	315	0	1.61	80.339	0.61	50.1969	3.35
Cove Brook	Route 1A	stormwater, 630	1.3 " rain in Stockton Springs	6/18/01	<10	pH > 6	pH > 6	24.8	1237.52	4.2	345.618	7.21
Ducktrap River	Route 52 gauge	stormwater, 1000	1.3 " rain in Stockton Springs	6/18/01	121	pH > 6	pH > 6	2.57	128.243	0.7	57.603	3.38
Tunk Stream	Steuben Bridge, Village Rd	stormwater, 1530	1.5" rain in Machias 6/17	6/18/01	164	pH >6	pH >6	1.42	70.858	0.64	52.6656	4.05
Pleasant River	Columbia Falls	stormwater, 1330	1.5" rain in Machias 6/17	6/18/01	204	pH >6	pH >6	2.23	111.277	0.85	69.9465	4.05
Narraguagus River	Cherryfield, Cable Pool	stormwater, 1500	1.5" rain in Machias 6/18	6/18/01	89.2	pH >6	pH >6	2.25	112.275	0.65	53.4885	3.2
E Machias River	Gaddis Pool, sample 1	stormwater, AM	1.5" rain in Machias 6/19	6/19/01	130	pH >6	pH >6	2.31	115.269	0.68	55.9572	3.01
E Machias River	Gaddis Poo, sample 2	stormwater, PM	1.5" rain in Machias 6/20	6/19/01	128	pH >6	pH >6	2.29	114.271	0.69	56.7801	2.82

Water analysis data from U of Maine, George Mitchell Center for Environmental and Watershed Research

Na ueq/L	K mg/L	K ueq/L	ANC ueq/L	Cl ueq/L	NO3 ueq/L	SO4 ueq/L	DOC mg/L	DOC ueq/L	pH Field	pH lab	H+ ueq/L	SPCOND us/cm	TotalP ug/L	P ueq/L	TSS mg/L	Turbidity NTU	Temp. C field
217.065	0.34	8.6972	39.3	220	3	61	6.8	27.2	5.6	5.83	1.4791084	39.5	19	0.608	NA	NA	
	NA		NA	NA	NA	NA	NA		7.2	NA		NA	NA		10	2.4	2.1
	NA		NA	NA	NA	NA	NA		7.2	NA		NA	NA		47	4.4	2.1
	NA		NA	NA	NA	NA	NA		7	NA		NA	NA		21	4.9	0.7
	NA		NA	NA	NA	NA	NA		7	NA		NA	NA		19	3.8	0.7
	NA		NA	NA	NA	NA	NA			NA		NA	NA		86	40	
	NA		NA	NA	NA	NA	NA			NA		NA	NA		100	28	
310.59	0.86	21.9988	998	240	11.7	120	4.5	18		7.93	0.011749	132	15	0.48	NA	NA	
337.995	1.05	26.859	910	270	<1.0	100	6.5	26		7.61	0.0245471	127	25	0.8	NA	NA	
291.015	0.77	19.6966	1150	220	21.3	120	4.5	18		7.82	0.0151356	144	16	0.512	NA	NA	
294.93	0.69	17.6502	712	210	<1.0	61	8.8	35.2		7.2	0.0630957	99.1	43	1.376	NA	NA	
257.52	0.81	20.7198	1090	210	13.8	120	4.2	16.8		8.06	0.0087096	139	24	0.768	6.8	3.2	
267.525	0.98	25.0684	1310	210	2.7	140	3.8	15.2		8	0.01	161	31	0.992	7.8	3.9	
275.355	0.69	17.6502	970	240	16	100	5.5	22		7.92	0.0120226	131	43	1.376	8.5	3.5	
277.095	0.48	12.2784	724	200	1.2	61	8.2	32.8		7.46	0.0346737	100	39	1.248	3	1	
162.69	0.92	23.5336	243	140	2.1	87	6.3	25.2		7.21	0.0616595	51.5	14	0.448	2.9	1.9	
194.445	1.5	38.37	484	180	3.2	120	6.3	25.2		7.57	0.0269153	80.9	32	1.024	8.4	1.2	
131.37	0.37	9.4646	110	78	1	40	9.5	38		6.51	0.3090295	25.6	16	0.512	NA	NA	
151.38	0.47	12.0226	110	87	1.4	32	10.4	41.6		6.46	0.3467369	25.9	16	0.512	NA	NA	
153.555	0.25	6.395	29.2	120	0	48	4.5	18		5.95	1.1220185	24.7	6.8	0.2176	NA	NA	
135.285	0.25	6.395	60	63	1.2	18	17.2	68.8		5.61	2.4547089	20.7	21	0.672	NA	NA	
131.37	0.34	8.6972	85.4	53	<1.0	24	12.8	51.2		6.19	0.6456542	20.7	15	0.48	NA	NA	
149.64	0.23	5.8834	34	120	0	45	5.4	21.6		5.82	1.5135612	24.6	8	0.256	NA	NA	
141.81	0.42	10.7436	105	80	<1.0	33	10.8	43.2		6.43	0.3715352	25.6	15	0.48	NA	NA	
128.76	0.33	8.4414	79.4	52	<1.0	25	13.9	55.6		6.1	0.7943282	20.7	15	0.48	NA	NA	
130.065	0.27	6.9066	54.2	57	1.2	18	18.9	75.6		5.46	3.4673685	21	22	0.704	NA	NA	
133.11	0.41	10.4878	109	78	<1.0	34	10.2	40.8		6.5	0.3162278	25.9	13	0.416	NA	NA	
145.725	0.28	7.1624	65.5	77	1.8	26	19.7	78.8		5.74	1.8197009	25	22	0.704	NA	NA	
313.635	1.04	26.6032	1580	220	16.5	120	5.3	21.2		8.1	0.0079433	177	14	0.448	1.1	1.1	
147.03	0.53	13.5574	154	110	1.3	40	10.8	43.2	6.55	6.77	0.1698244	34.1	35	1.12	5.2	0.9	
176.175	0.38	9.7204	67.3	150	<1.0	43	10.7	42.8		6.15	0.7079458	32.3	21	0.672		2.1	
176.175	0.49	12.5342	146	120	5.5	36	11.8	47.2		6.65	0.2238721	36.1	54	1.728		9.3	
139.2	0.6	15.348	159	83	1	34	8.9	35.6		6.9	0.1258925	30.6	18	0.576		0.9	
130.935	0.36	9.2088	96.7	110	3.2	52	9.1	36.4		6.44	0.3630781	31.9	20	0.64		1.2	
122.67	0.32	8.1856	94.6	110	2.2	53	9.3	37.2		6.51	0.3090295	30.5	21	0.672		0.57	
																0.6	

Water analysis data from U of Maine, George Mitchell Center for Environmental and Watershed Research