Pleasant River Water Quality Monitoring Plan

A Guide for Coordinated Water Quality Monitoring Efforts in an Atlantic Salmon Watershed in Maine

Photo by Tracey Gamache

April 2007

Pleasant River Water Quality Monitoring Plan

A Guide for Coordinated Water Quality Monitoring Efforts in an Atlantic Salmon Watershed in Maine

April 2007

Prepared by
Barbara S. Arter
BSA Environmental Consulting
PO Box 141
Steuben, Maine 04680
207-546-2018

Barbara Snapp, PhD
Brunswick, Maine

Funded by
National Fish and Wildlife Foundation

Table of Contents

Preface

In an effort to enhance water quality monitoring (WQM) coordination among agencies and conservation organizations, the Project SHARE Research and Management Committee initiated a program whereby river-specific WQM Plans are developed for Maine rivers that currently contain Atlantic salmon populations listed in the Endangered Species Act. The Sheepscot River WQM Plan (http://www.krisweb.com/krissheepscot/krisdb/html/krisweb/biblio/sheepscot_share_arter_2005_wqmpfinal.pdf) was the first plan to be developed under this initiative in 2005 and the Narraguagus Plan was completed in 2006 (http://salmonhabitat.org).

The Pleasant River WQM Plan is the third such plan and like all of the plans was produced by a workgroup comprised of representatives from both state and federal government agencies and several conservation organizations (see Acknowledgments). The purpose of this plan is to characterize current WQM activities, describe current water quality trends, identify the role of each monitoring agency, and make recommendations for future monitoring. The project was funded by the National Fish and Wildlife Foundation.

Since this plan falls on the heels of two previously developed plans, much of the background information on Atlantic salmon and their water quality and habitat requirements have been covered in greater detail in those documents. As such, the reader is encouraged to review the Narraguagus River WQM Plan for detailed descriptions of Atlantic salmon habitat and WQ requirements.

An electronic version of the Pleasant River WQM Plan is available on the Project SHARE website: http://salmonhabitat.org.

Acknowledgments

Linda Bacon	Maine Department of Environmental Protection
Dan Bowker	Cherryfield Foods, Inc
Gregory Burr	Maine Department of Inland Fish and Wildlife
Brad Caswell	Cherryfield Foods, Inc
Dave Courtemanch	Maine Department of Environmental Protection
Richard Dill	Maine Atlantic Salmon Commission
Robert Dudley	US Geological Survey
Adria Elskus	US Geological Survey
John Fendle	Maine Department of Marine Resources
Tracey Gamache	Pleasant River Watershed Council
James Hawkes	NOAA Fisheries Service
Heather Jackson	Maine Board of Pesticides Control
Ken Johnson	University of Maine Senator George Mitchell Center
Ragnar Kamp	Cherryfield Foods, Inc
Dan Kircheis	NOAA Fisheries Service
John Kocik	NOAA Fisheries Service
Steven Koenig	Project SHARE
Marilee Lovit	West Branch Study Committee
Greg Mackey	Maine Atlantic Salmon Commission
Joan McMurray	Pleasant River Watershed Council
Susanne Meidel	Maine Department of Environmental Protection
Steve Mierzykowski	US Fish and Wildlife Service
Dana Murch	Maine Department of Environmental Protection
Nate Pennell	Washington County Soil & Water Conservation District
Rory Saunders	NOAA Fisheries Service
Dwayne Shaw	Downeast Salmon Federation
Barry Southard	Washington County Soil & Water Conservation District
Marcia Spencer-Famous	Maine Land Use Regulation Commission
Greg Stewart	US Geological Survey
Joan Trial	Maine Atlantic Salmon Commission
Leon Tsomides	Maine Department of Environmental Protection
Jacob van de Sande	Downeast Salmon Federation
Mark Whiting	Maine Department of Environmental Protection
Scott Williams	Volunteer Lakes Monitoring Program
Theo Willis	University of Southern Maine

Special Thanks to Craig Snapp, volunteer for the Downeast Rivers Land Trust, for his expertise in GIS Mapping and his donation of the maps. And Project SHARE for hosting this and other water quality projects on their website: http://salmonhabitat.org.

List of Acronyms and Abbreviations

ANC	Acid Neutralizing Capacity
CBNFH	Craig Brook National Fish Hatchery
DE	Down East
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DPS	Distinct Population Segment
EPA	Environmental Protection Agency
E. coli	*Escherichia coli*
KRIS	Klamath Resource Information System
MASC	Maine Atlantic Salmon Commission
MASTF	Maine Atlantic Salmon Task Force
MBPC	Maine Board of Pesticides Control
MDEP	Maine Department of Environmental Protection
MDMR	Maine Department of Marine Resources
MIF&W	(Maine Department) Inland Fish and Wildlife
MS	Mainstem (of the Pleasant River)
NOAA	National Oceanic and Atmospheric Administration
NPS	Nonpoint Source (Pollution)
PR MS	Pleasant River Mainstem
PRL	Pleasant River Lake
PRW	Pleasant River Watershed
PRWC	Pleasant River Watershed Council
PRWQMP	Pleasant River Water Quality Management Plan
OBD	Overboard Discharge (System)
PEARL	Public Educational Access to Environmental Information in Maine
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids
UMGMC	University of Maine Senator George J. Mitchell Center for Environmental and Watershed Research
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
VLMP	Volunteer Lake Monitoring Program
WB	West Branch (of the Pleasant River)
WBSC	West Branch Study Committee
WC	Water Chemistry
WCSWCD	Washington County Soil and Water Conservation District
WQ	Water Quality
WQM	Water Quality Monitoring
WUMP	Water Use Management Plan
YOY	Young of the Year

Executive Summary

This plan was funded by the National Fish and Wildlife Foundation for the purpose of gaining a better understanding of water quality (WQ) trends in Maine's Atlantic salmon rivers and to subsequently make better decisions regarding state and federal recovery plans and activities. To that end, the goal of this plan is to improve coordination of water quality monitoring activities among governmental agencies and conservation organizations within the rivers comprising the Gulf of Maine Distinct Population Segment (DPS) of Atlantic salmon. Information for the development of this plan was gathered during nine workgroup sessions in which WQ indicators were reviewed and recommendations addressing future monitoring were developed. The plan can be used to develop agency-specific and staff workplans, develop proposals for funding, direct future research, and guide conservation and restoration projects.

The Pleasant River Watershed (PRW) is located in western Washington County, drains 85 square miles, and includes 28 ponds and lakes totaling 1,444 acres. Tributaries arise from springs and bogs, running into a network of streams that total 68 mi in length. Highest flows typically occur in early spring and late fall, with much lower flows in summer and early fall. Current land use consists of lowbush blueberry farming, a small amount of timber harvesting, noncommercial landownership (primarily residential or absentee ownership), public lands, and nonprofit conservation easement or landholdings. The mainstem and its tributaries are classified as Class AA, A, and B in accordance with state law and the MDEP Water Classification Program. Atlantic salmon habitat in the PRW is fragmented in four locations: the lower mainstem between head of tide and Saco Falls, the upper mainstem below Pleasant River Lake to Crebo Flats, Eastern Little River, and Western Little River.

The PRW is currently, or has recently been, monitored as part of 13 programs managed by at least 12 different agencies/organizations. Although the term "Water Quality Monitoring" is used loosely throughout this document, review of the various programs reveals that there are generally three types of WQ data collection occurring in the PRW: long-term monitoring, investigative studies, and one-time assessments. Three maps indicate the location of monitoring and NPS restoration sites in the watershed. In general, monitoring in the watershed is primarily focused in the mainstem from Pleasant River Lake to the Great Heath and from below the Great Heath to Narraguagus Bay.

The plan reviews data on ten different WQ indicators, identifies trends, and discusses areas that require further investigation. Parameters reviewed include temperature, pH, nutrients, bacteria, macroinvertebrates, pesticides, metals and other toxins, embeddedness, and streamflow. The three areas of greatest concern in the PRW are pH and related chemistry (aluminum, calcium, etc), pesticides, and the impacts of water withdrawal on aquatic organisms habitat. Based on the review of the WQM history, data, and trends, the plan provides 50 recommendations to refocus and/or support future monitoring and restoration efforts. The recommendations are prioritized, and lead and partnering agencies have been assigned to each.

Chapter 1: Introduction

Project Background, Goals and Objectives, Methodology, and Implementation

Project Origin and Background

Understanding the water quality (WQ) status and trends in Maine's Atlantic salmon rivers is essential to the success of state and federal recovery plans and activities. The Final Recovery Plan for the Gulf of Maine Distinct Population Segment (DPS) of Atlantic Salmon (National Oceanic and Atmospheric Administration and United States Fish and Wildlife Service, 2005) states that "there are a number of water quality issues that have the potential to adversely affect the recovery of the DPS." Specifically, acidified water, aluminum, pesticides, sediment, excess nutrients, pathogens, heavy metals, and toxic chemicals are listed as potential threats.

Currently, WQ data are collected on Maine's DPS rivers by a variety of agencies and organizations with different goals. Within any one watershed, data and information may be collected by as many as ten different agencies or organizations, including:

- Maine Department of Environmental Protection (MDEP Biomonitoring and Atlantic Salmon Programs)
- Maine Atlantic Salmon Commission (MASC)
- Maine Department of Marine Resources (MDMR)
- National Oceanic & Atmospheric Administration (NOAA)
- Maine Inland Fish and Wildlife (MIFW)
- US Fish &Wildlife Service (USFWS)
- University of Maine Senator George J. Mitchell Center for Environmental and Watershed Research (UMGMC)
- US Geological Survey (USGS)
- Pleasant River Watershed Council (PRWC)
- Volunteer Lake Monitoring Program (VLMP)
- Maine Board of Pesticides Control (MBPC)
- Downeast Salmon Federation Wild Salmon Resource Center (WSRC)
- West Branch Study Committee (WBSC)

This plan is an effort to coordinate the collection, storage, review, and distribution of water quality monitoring (WQM) information and data gathered by these agencies and organizations. The plan is a tool that can help agencies and organizations determine WQ trends and conditions in a consistent, credible, and coordinated manner that may be used to further effective restoration efforts. By clearly identifying the role of each monitoring agency and the type of data collected, the plan can be used to:

- gain a better understanding of water quality trends in salmon watersheds
- improve water quality for Atlantic salmon,
- improve communication among agencies,
- identify areas needing NPS restoration,
- evaluate restoration activities,
- assist in making salmon stocking decisions, and
- assist in making land protection and habitat protection decisions.

Project Goal and Objectives

Goal

The goal of this plan is to improve coordination of water quality monitoring activities among governmental agencies and conservation organizations within the rivers comprising the Maine Distinct Population Segment (DPS) of Atlantic salmon.

Objectives

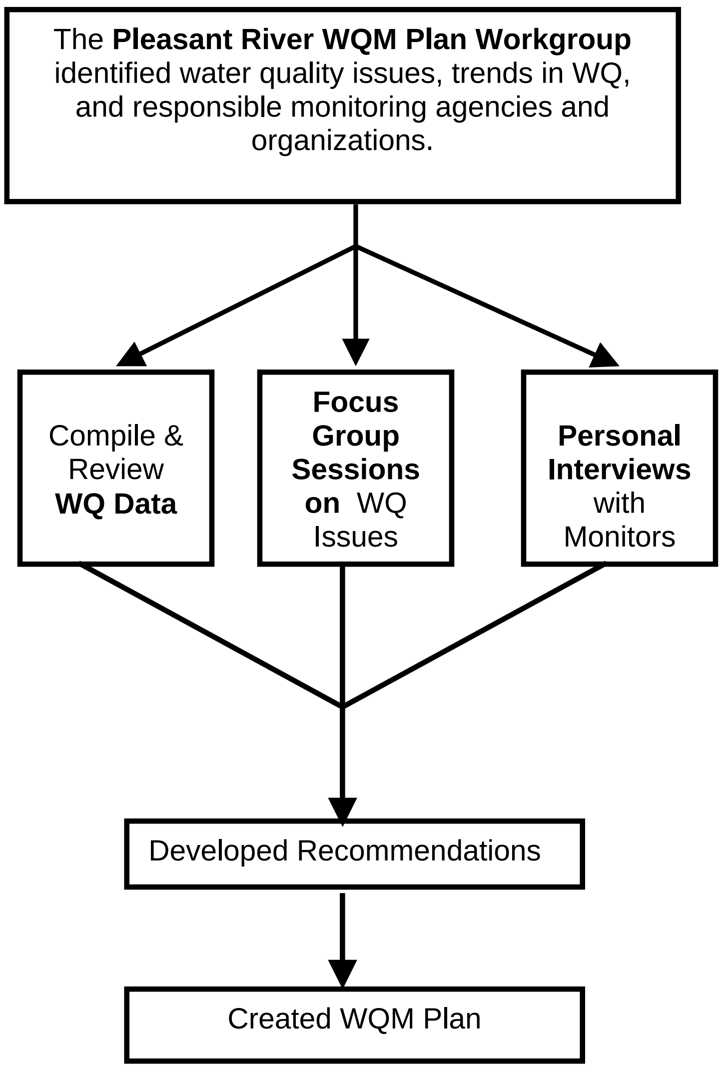
- Summarize current monitoring efforts: collecting agency, parameters, and locations.
- Characterize current water quality trends: DO, temperature, bacteria, pH, nutrients.
- Identify gaps in current monitoring efforts and water quality information.
- Determine the role of each monitoring agency: the type, location, and outcome of monitoring and data.
- Identify those locations and activities that require targeted monitoring, such as priority habitat or restoration sites.
- Make recommendations for future monitoring and data storage and dissemination.
- Create a mechanism for agencies and organizations to agree to specific recommendations by developing a workplan that is signed by each agency.

Although this project is funded by the Maine Atlantic Salmon Conservation Fund of the National Fish and Wildlife Foundation, and the goal addresses Maine's DPS of Atlantic salmon, it should be noted that the WQ trends and standards discussed herein are relevant for all native species in Maine rivers. Overall WQ and the health of all native freshwater species should be considered when making monitoring or management decisions.

Plan Development Methodology

Information for the development of this plan was gathered between February 2006 and January 2007 using the methodology described in Figure 1.1. During that time, several facilitated focus-group sessions were held for the purpose of discussing WQ issues, characterizing trends, identifying agency roles, and establishing recommendations for future monitoring. Data from the various agencies and organizations were compiled, summarized, and reviewed. Lastly, the workgroup reviewed each recommendation and assigned a lead agency and a priority level (Table 5.1), thereby transforming the recommendations into Tasks which may be correlated with Federal Recovery Plan Tasks and which can become part of individual agency workplans.

Figure 1. 1. Pleasant River WQM Plan Development Methodology



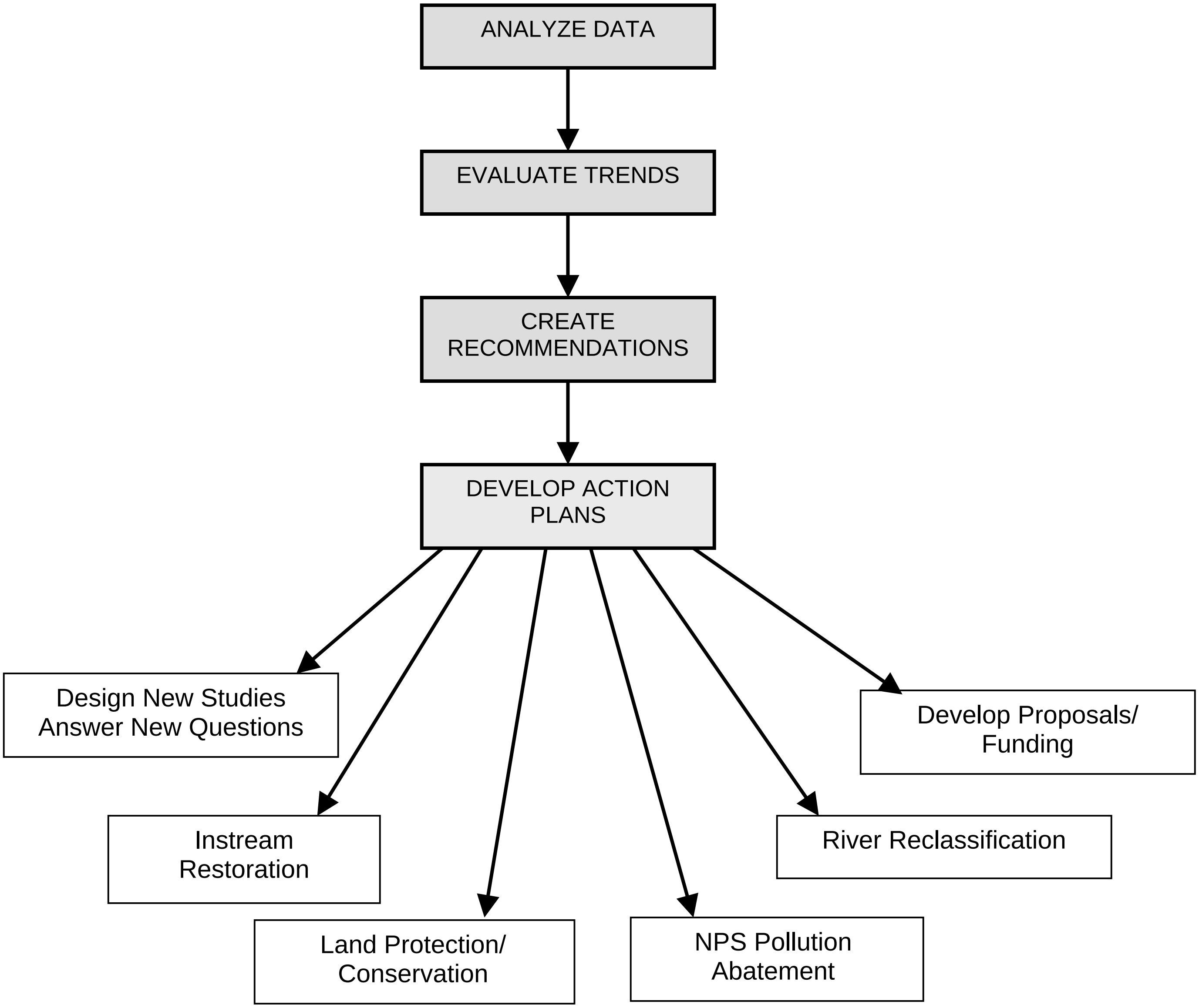
Recommendations for Use of the Plan

The results from a WQM program have the potential to steer, refocus, support, and justify conservation and management initiatives and efforts. The data can facilitate work between agency personnel and landowners. It can make changes in river segment classification and TMDL listings. It can direct land and water conservation, restoration, and protection efforts. Lastly, the data and information can be used to find funding for all of these efforts. Initiatives that may directly benefit from the information and strategies in this plan include:

- Pleasant River Watershed Council Outreach Efforts
- Watershed Council and Project SHARE NPS Pollution Remediation Projects
- Project SHARE Restoration Committee
- Atlantic Salmon Rivers Land Trust Activities
- NOAA/SHARE Research and Liming Committee
- USFWS/NOAA Maine Atlantic Salmon Recovery Plan
- Atlantic Salmon Technical Advisory Committee

The key to effective WQM is not in the collecting, compiling, or storing of data but rather in its use. The ultimate goal in monitoring water quality is to work with other agencies to achieve management goals and ensure better water quality (Figure 1.2). The success of the strategies and recommendations in this plan will depend on all agencies' ability to improve WQM planning and to quickly analyze and utilize results and conclusions for better management decisions.

Figure 1.2. Recommendations for Use of the PR WQM Plan.



Chapter 2: Description of Watershed

Physical Description, Land Use, Stream Classification, and Atlantic Salmon and Other Coldwater Fisheries Habitat

Physical Description

The Pleasant River Watershed has been described in detail in previous publications. The following sections have been drawn primarily from Baum and Jordan (1982).

Location

The Pleasant River Watershed (PRW) is located in western Washington County, Maine and includes portions of five towns (Beddington, Deblois, Columbia, Columbia Falls, and Addison) and four townships (Devereaux, T24MDBPP, T18MDBPP, and T19MDBPP). The mainstem originates at the outlet of Pleasant River Lake in the town of Beddington at an elevation of 317 ft and flows southeast for 28 miles to head of tide in the town of Columbia Falls. See Map 1, Pleasant River Watershed Base Map, Appendix A.

Lakes, Ponds, and Tributaries

The PRW drains an area of 85 square miles and includes 28 ponds and lakes totaling 1,444 acres (Table 2.1). Pleasant River Lake (PRL) is the largest lake in the drainage and accounts for 66% of the total acreage. Other significant ponds include Montegail, Southwest, Otter, Long, Mic Mac, and the Pike Brook ponds. It should be noted that while East and West Pike Brook ponds occur within the boundaries of the watershed they do not have outlets and therefore do not drain into the river or any of its tributaries. Both ponds are kettle hole ponds whose water levels are dependent on ground water levels from spring inflows (G. Burr, MIFW, Personal Communication, March 2007).

Tributaries arise from springs and bogs, running into a network of streams that total 68 mi in length. Extensive peat bogs, and especially the Great Heath, help sustain flow in the lower reaches of the river. The Great Heath makes up approximately 17% of the watershed. Major streams include West Branch, Colonel, Ingersol, Bog, Taylor Branch, Eastern Little River, and Western Little River. Additionally, an unnamed brook comes into the mainstem above Colonel Brook that is considered high quality brook trout habitat.

Table 2.1. Lakes and Ponds in the PRW (MDEP Lakes Database 2006).

MIDAS	LAKE	ACRES	ELEV. (FT)	DRAIN AREA (SqMi)	TOWN	SHORE LENGTH (FT)
1198	TAYLOR BROOK P	7	290	0.21	T18 MD BPP	
1208	SOUTHWEST P	138	368	1.1	BEDDINGTON	
1216	OTTER P	12	290	0.19	T24 MD BPP	3145
4530	HORSESHOE P	12	426	0.18	BEDDINGTON	
7340	UNNAMED P	8	330		DEVEREAUX TWP	
7365	UNNAMED P	5	250		T24 MD BPP	
7367	UNNAMED P	5	250		T24 MD BPP	
7381	UNNAMED P	1	270		T18 MD BPP	
7383	UNNAMED P	1	210		T18 MD BPP	
7387	UNNAMED P	3	250		T18 MD BPP	
7389	UNNAMED P	11	210		T18 MD BPP	
7391	UNNAMED P	5	205		T18 MD BPP	
7461	UNNAMED P	2	210		DEBLOIS	
7465	UNNAMED P	2	250		DEBLOIS	
7467	UNNAMED P	2	250		DEBLOIS	
7501	UNNAMED P	8	365		BEDDINGTON	
7503	UNNAMED P	6	363		BEDDINGTON	
9625	DUCK P (SOUTH)	6	170		COLUMBIA	
9627	DUCK P (NORTH)	7	170		COLUMBIA	
3	PINEO P	7	215	0.18	DEBLOIS	
1196	MONTEGAIL P	170	206	1.49	T19 MD BPP	18485
1200	LONG P	15	230	0.5	T18 MD BPP	
1202	OAK P	12	250	0.38	DEBLOIS	
1210	PLEASANT RIVER L	949	317	14.8	BEDDINGTON	47504
7385	UNNAMED P	3	215		T18 MD BPP	
7463	UNNAMED P	3	210		DEBLOIS	
9667	PIKE BROOK P (W)	32	210	0.58	T18 MD BPP	5912
9819	PIKE BROOK P (E)	12	210	0.1	T18 MD BPP	2359

Topography

Elevation drops 317 ft from PRL to Pleasant Bay. The average gradient is slightly less than 11 ft/mi. The terrain is composed of hills and ridges forested by hardwoods and spruce-fir mixtures. Peak elevations range from Beech Hill at 551 ft to Pleasant Mountain, at 1374 ft the most prominent peak in the watershed. Other peaks include Hall Ridge, North Hill, and Spruce Mountain (second highest at 1078 ft). The lower reaches of the Pleasant River are characterized by drum and kettle topography and contain extensive barrens with low bush blueberries as the major agricultural crop. The final 5 mi of the river flows through terminal moraine with many small hills in a wide valley.

Bedrock formations vary from the headwaters (metamorphosed shale phyllite with shist) to the mid-reaches (granite, diorite, gabro), to the lower regions (slate, quartzite, metasandstone). Most soils originated from glacial till, with some forest podzols occurring in timbered areas. The barrens soils are deep, well drained, sandy and gravelly and show rapid permeability. These soils serve as important aquifers and are capable of producing flows of more than 50 gal/min in springs and wells. Soils closer to the mouth of the Pleasant River are mixed with clayey soils of marine origin.

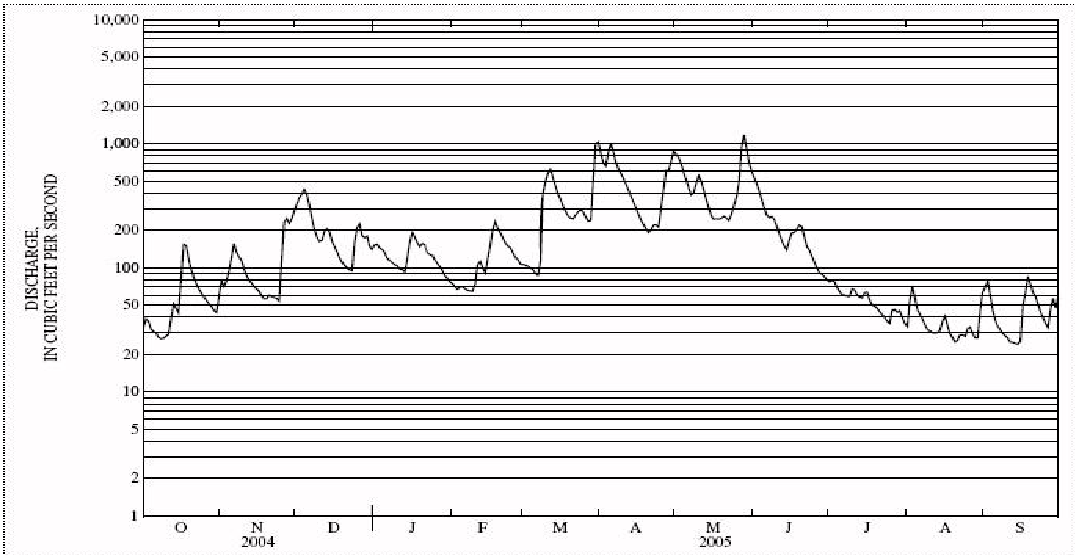
Dams and Obstructions

Several natural and man-made obstructions exist along the Pleasant River mainstem (PR MS). The PRL Dam is the only remaining dam in the watershed. It is owned and maintained by MASC. A Denil fishway has been installed and is maintained jointly by agencies and the PRWC. The Old Hathaway Dam at head of tide in Columbia Falls was removed in 1990, and the Saco Dam was removed in 1982 although pieces of the dams are still visible. Saco Falls is a natural barrier that has a Denil fishway associated with it. Another natural ledge occurs on the Western Little River. No fishway exists there, although there is a small amount of salmon habitat in the stretch of stream above the ledges. Multiple beaver dams also dot the mainstem. These dams may impact spawning and nursery habitats by turning riffles into pools, even though the dams frequently wash out in the spring and probably do not affect smolt migration.

Hydrology

Annual rainfall averages 51 in with runoff estimated at approximately 30 in/sq mi and evapotranspiration estimated at 19 in/yr, thus resulting in an average discharge slightly below 200 cfs. Streamflow in the PR MS is not substantially regulated by any impoundments, and daily and longer averages of measured streamflow are thought to be representative of natural conditions (Slack and Landwehr 1992). Median monthly streamflows, as recorded at the Epping gage, indicate that the largest streamflows (150-260 cfs) occur in the spring (March, April, May) when precipitation on snowpack and saturated soils is high (Dudley and Stewart, 2006). As snowmelt and spring precipitation ends and evapotranspiration increases, flow recedes and continues receding through summer. Lowest streamflows (40-50 cfs) occur during summer (July, August, and September). Summer flows are a function of groundwater discharge and some precipitation runoff. Streamflows often increase in the fall (75-125 cfs) as evapotranspiration decreases and precipitation increases. Figure 2.1 illustrates a hydrograph for water year 2005 at Epping when flow was high in fall and spring and low during summer months.

Figure 2.1. Annual Hydrograph for Water Year 2005 for Epping Station on the Pleasant River (USGS 2006).



Land Use

Current land use consists of lowbush blueberry farming, a small amount of timber harvesting, noncommercial landownership (primarily residential or absentee ownership), public lands, and nonprofit conservation easement or landholdings. It is estimated that approximately 3,550 acres are currently under blueberry cultivation in the watershed. It is unknown how many acres are in timber management. It is estimated, however, that approximately 2000 acres are under conservation easement (or potential easement). This is in addition to the 5,681 acres in the Maine Department of Conservation's Great Heath Unit.

Water Classification and Attainment Criteria

The PR MS and its tributaries are classified as Class AA, A, and B in accordance with state law and the MDEP Water Classification Program. Table 2.2 summarizes the dissolved oxygen, bacteria, habitat, and biological criteria for Class AA, A, and B waters. Table 2.3 lists the classes for various reaches and tributaries in the watershed. Details regarding class water chemistry and attainment of class are discussed in Chapter 4.

Table 2.2. Water Chemistry and Biological Criteria for Class Waters (MDEP 2002)

Class	DO	Bacteria (g.m. = Geomean; inst = Instantaneous)	Habitat	Aquatic Life (Biological) Narrative Criteria
Class AA	as naturally occurs	as naturally occurs	free flowing and natural	No direct discharge of pollutants; as naturally occurs
Class A	7 ppm; 75% saturation	as naturally occurs	natural	As naturally occurs
Class B	7 ppm; 75% saturation	64/100 ml (g.m.*) or 427/100 ml (inst)	unimpaired	Discharges shall NOT cause adverse impact to aquatic life
Class C	5 ppm; 60% saturation	142/100 ml (g.m.*) or 949/100 ml (inst.)	habitat for fish and other aquatic life	Discharges MAY cause some changes to aquatic life

Table 2.3. Classification of the Mainstem and Tributaries in the Pleasant River Watershed (Maine State Title 38 - §467. 2006).

Class	Reach and Tributaries
Class AA	Mainstem from the outlet of Pleasant River Lake to the Maine Central Railroad bridge in Columbia Falls; Eastern Little River in Columbia Falls; Western Little River from its confluence with Montegail Stream to the Pleasant River in Columbia, Township 18 Middle Division and Township 19 Middle Division
Class A	All other reaches and tributaries not classed AA or B
Class B	Mainstem from the Maine Central Railroad bridge to tidewater; all tributaries entering below the Maine Central Railroad bridge; Bog Stream (Deblois); Beaver Meadow Brook (Deblois); and Western Little River from its confluence with Montegail Stream to the Pleasant River in Columbia, Township 18 Middle Division and Township 19 Middle Division

Atlantic Salmon Habitat

General Habitat Requirements

For a river to serve as good salmon habitat, it must have deep holding pools for adult salmon, adequate spawning habitat, nursery areas suitable for rearing juvenile salmon, and be free flowing for migration. Spawning habitat requires a substrate of loose rubble (2-10 cm in diameter) that is permeable to water flow to exchange dissolved gasses and remove metabolic wastes from the redd. Water depth should be between 25 cm and 75 cm with water flows from 27 to 80 cm/s (Heggenes 1990).

Juvenile salmon habitat is quantitatively assessed in terms of juvenile salmon rearing habitat units. One rearing habitat unit is the equivalent of 100 m^2 of habitat possessing at least some of the following features (Heggenes 1990):

- 1-1.5% gradient,
- substrate of cobbles and small boulders (7-50 cm in diameter),
- temperatures that do not exceed 27 ^oC for extended periods of time and are generally less than 22 ^oC,
- depths that range from 20-70 cm,
- water velocities ranging from 10-60 cm/s, and
- overhead cover.

Each salmon rearing unit can support 20-50 parr through the end of the first summer post-hatch and approximately 20 parr at 15 months. Young-of-the-year (YOY) salmon (less than one year old) tend to occupy habitats in the shallower and slower parts of the habitat range, moving to deeper and faster waters with larger cobble as they increase in size (Heggenes 1990). Juveniles also move from shallower riffles in the summer to deeper pools and possibly lakes in the winter to avoid exposure to anchor ice.

Atlantic Salmon Habitat and Population Studies in the PRW

Graphics and related information contained in the following section were obtained from a presentation by Greg Mackey, MASC, to the Workgroup, February 2006.

Habitat

Habitat in the PRW is fragmented in four locations: the lower mainstem between head of tide and Saco Falls, the upper mainstem below Pleasant River Lake to Crebo Flats, Eastern Little River, and Western Little River (see Map 1, Pleasant River Watershed Base Map). The Great Heath separates the lower and upper mainstem. It is unclear if the Great Heath and several reaches of dead water, which occur between the upper and lower portions of mainstem habitat, pose a barrier to passage in terms of temperature or water chemistry. The reach with the greatest amount of habitat (732 rearing units and 54 spawning units) is the lower mainstem between head of tide and Saco Falls (Table 2.4). Some areas of the watershed, such as Bog Stream and upper Eastern Little River, have not been surveyed or mapped so it is unknown if those areas contain habitat.

Table 2.4. Atlantic Salmon Habitat in the Pleasant River.

River Section	Rearing Units (100 m^2)	Spawning Units (100 m^2)
Main Stem Above Great Heath (Priority Habitat 2)	407	75
Mainstem Below Great Heath (Priority Habitat 1)	732	54
Eastern Little River	82	1
Western Little River	57	0
TOTAL	1278	130
Compared to Narraguagus WS	6014	266

In 2002, the MASC developed a subwatershed prioritization mapping system that divides each watershed into subwatersheds based on the quality and quantity of available habitat and access to that habitat. The purpose of the prioritization scheme is to provide guidance for the prioritization of salmon restoration projects. In the Pleasant River, the region of highest priority is the lower mainstem from head of tide in Columbia Falls to Saco Falls in Columbia. Also included in this subbasin is Eastern Little River. Table 2.5 lists the priority drainages.

Table 2.5. Priority Salmon Habitat.

Subwatershed Location	Priority
Head of Tide to Saco Falls including Eastern Little River	1
Saco Falls to the Pleasant River L. Outlet including Western Little River	2
Pleasant River Lake and inlets to the North (excludes Southwest Pond)	3
Estuary including the West Branch	4

Historic Rod Catch

Historic rod catch records from 1956-1981 indicate that rod catch during that time varied from one adult in 1971, 1972, and 1976 to 153 adults in 1961 (Dube and Jordan 1982). In recent years, however, far fewer adults have returned to the Pleasant River. The MASC maintains a trap that non-lethally captures adults returning from sea. The record of returning adults between 1997 and 2004 is listed in Table 2.6. The number of adults has declined dramatically with the highest number of adults returning in 2001 (11 adults) and the fewest returning in 1997, 1999, and 2002 (0-1 adults). Furthermore, the number of redds observed in the system has declined from 44 in 1991 to zero in 1999, 2002, and 2004 (Table 2.7). There are no data for 2005 since there was no trapping and no redd counts conducted during that year. The Pleasant River weir operation was suspended in 2006 since MASC has not detected any aquaculture escapees in the Pleasant River and wild returns are exceedingly low; therefore, operation of the weir is not cost or time effective. Traps continue to be operated on the Narraguagus and Dennys Rivers, and these traps, combined with redd counts, provide an index of adult returns for other Downeast salmon rivers.

Table 2.6. Pleasant River Adult Salmon Returns by Year and Origin (1997-2004).

Year	Wild Origin				Hatchery Origin				Hatchery and Wild Total	Suspected Aquaculture Escapees		Grand Total
	1SW	(%)	MSW	(%)	1SW	(%)	MSW	(%)		Count	(%)	
1997	0	0	1	100	0	0	0	0	**1**	0	0	1
1998												
1999*	0	0	0	0	0	0	0	0	**0**	0	0	0
2000	1	33.3	2	66.7	0	0	0	0	**3**	0	0	3
2001	0	0	11	100	0	0	0	0	**11**	0	0	11
2002	0	0	0	0	0	0	0	0	**0**	0	0	0
2003	1	50	1	50	0	0	0	0	**2**	0	0	2
2004	0	0	1	50	1	50	0	0	**2**	0	0	2

* Trap operated from 15 October, 1999 to 31 October, 1999.

Table 2.7. Number of Redds Observed is the PRW (1991-2005). NC = Not Counted.

Year	Number of Redds Observed
1991	44
1992	17
1993	22
1994	0
1995	8
1996	41
1997	1
1998	9
1999	0
2000	1
2001	3
2002	0
2003	NC
2004	0
2005	NC

Stocking

Unlike the Narraguagus River, the PRW does not currently support a large number of wild, or non-stocked, salmon. Therefore, the number and age class of fish in the system at any given time is a function of stocking history. There was no restoration stocking of hatchery fish prior to 2002. In fall 2002, however, 13,500 parr were stocked into the system. In 2003, 2004, and 2005, significant numbers of both fry and smolts were stocked (Table 2.8). In 2006, only fry were stocked into the system; smolt stocking has been halted temporarily due to the decision to maintain a captive line of Pleasant River broodstock resulting in space limitations at Craig Brook National Fish Hatchery (CBNFH). Furthermore, CBNFH was not capable of rearing a demographically robust number of smolts for the Pleasant River

Table 2.8. Pleasant River Stocking History (2000-2005).

Year	Fry	Parr	Smolts	Fall Smolts
2000	0	0	0	0
2001	0	0	0	0
2002	0	13,500	0	0
2003	48,570	0	2,817	0
2004	46,336	0	8,797	0
2005	42,050	0	3,385	2,548*

Juvenile Population Studies

Each year the MASC conducts electrofishing sampling in the PRW in order to establish population estimates of juvenile salmon (young-of-the-year and parr). Tables 2.9 and 2.10 illustrate the sampling effort (n) that has taken place in the PRW between 1981 and 2005. Due to variation in staff numbers over the years as well as annual fluctuations in weather conditions, sampling effort varies from year to year with eight sites sampled in 1997 and 2003 but less than four sites sampled in all other years. Both parr and young-of-the-year (YOY) densities vary greatly among sites in the watershed. For instance in 1997, parr density varied from 63.6 to 0.2 parr/unit (n=8). Variability is generally attributed to the productivity of individual sites and the characteristics of those sites (e.g., temperature, nutrients, edge effect, etc). In general, higher densities are found in Eastern Little River and on the mainstem at Crebo Flats. The lower mainstem generally has lower parr and YOY density.

In 2004, fry from the Pleasant River Hatchery were placed in Eastern Little River while fry from the Craig Brook Hatchery were placed in the mainstem at Crebo Crossing. Electrofishing sampling data conducted later that season indicate that Eastern Little River is highly productive and significantly more productive than the MS at Crebo. Both YOY and parr densities and YOY and parr mean length were significantly higher at Eastern Little River than at the MS at Crebo (Table 2.11). The data also indicate that while YOY growth rates do not appear to be affected by densities, parr growth rates may be limited by density. Although data are limited, fry reared at Pleasant River Hatchery appear to perform no worse than

Craig Brook Hatchery fry. However, it should be noted that analysis is limited by lack of directly comparable stocking areas and sample size.

Salmon Smolt Production and Migration

The following was presented to the workgroup by James Hawkes, NOAA, in February 2006.

Smolt Studies

Atlantic salmon smolts make the transition from freshwater to saltwater during the spring of each year. In recent years, NOAA has monitored smolt production, smolt migration, and post-smolt assessment on many of Maine's listed (Endangered Species Act, Distinct Population Segment) rivers, estuaries, and nearshore marine environments. Smolt-production monitoring using rotary screw traps (RST) took place in the PRW starting in 1999 and continued through 2004. The PRW RST was located beneath the Main Street Bridge in Columbia Falls near the Wild Salmon Resource Center.

Smolt trapping starts in early April and ends in late May, or early June. The trap is tended and emigrating fish are counted 1-2 times daily. Scales and physiological (biopsies) and genetic (tissue samples) samples are collected from a subset of the smolts. Additionally, biological (length and weight) and observational (fin condition, smolt score – measure of silvering, deformity, and injury) data are collected. These data aid in providing information regarding timing, size, age, and origin of trapped smolts.

The RST studies indicate that smolt emigration generally occurs between mid-April and mid-May with the peak occurring between late April and early May (Figure 2.2). Smolts migrate in response to warming water temperatures and the longer photoperiod of spring. If waters are slow to warm due to cold winter temperatures and ice/snow melt, migration may be delayed, as was the case in 2003. If there is little snow, cold, or ice, waters may warm quickly and emigration may occur earlier, as in 2000.

It is estimated that the number of smolts captured at the RST represents approximately 10-15% of the total population of outmigrating smolts. Between 1999 and 2004 the number of smolts captured varied greatly as a function of the number of fish released during fry and fall parr stocking activities in previous years. In 1999, 592 smolts were captured (Figure 2.3). These fish represented a strong age class of naturally reared fish in the system. Because hatchery brood stock was not available between the years of 1999 and 2002, there were fewer numbers of outmigrating smolts in the Pleasant, a system supported by hatchery fish. In the fall of 2002, approximately 13,000 fall parr were stocked into the system, which accounted for the 8 smolts trapped the following spring (2003), and 241 captured in 2004.

Table 2.9. Parr Densities (Parr / 100m^2) of the PRW (1981-2005).

Year	Median	Max	Min	n
1981	19.8	19.8	19.8	1
1982	17.2	17.2	17.2	1
1984	4.2	6.6	1.8	2
1989	4.6	9.0	0.0	3
1990	14.5	27.4	9.1	3
1991	40.8	69.3	29.6	3
1994	3.4	6.6	0.3	2
1996	15.3	15.3	15.3	1
1997	10.9	94.7	1.1	8
1998	3.8	7.6	0.0	2
2001	1.6	3.2	0.0	2
2003	3.4	65.4	0.0	8
2004	33.5	45.9	0.0	3
2005	24.8	29.6	1.5	3

Table 2.10. Young-of-the-Year Densities (YOY/100m^2) in the PRW (1981-2005).

Year	Median	Max	Min	n
1981	14.7	14.7	14.7	1
1982	15.7	15.7	15.7	1
1984	8.5	9.5	7.6	2
1989	6.6	11.3	3.8	3
1990	10.0	10.2	4.3	3
1991	10.0	26.7	4.1	3
1994	7.1	8.4	5.8	2
1996	0.8	0.8	0.8	1
1997	4.2	63.6	0.2	8
1998	11.0	12.9	9.0	2
2001	4.3	8.4	0.3	2
2003	2.2	6.4	0.0	8
2004	5.5	22.7	0.5	3
2005	5.0	18.6	0.7	3

Table 2.11. Parr and YOY Densities and Mean Length from Two Sites in the PRW (2004). (* significantly different t-test between sites within year classes)

		Density (fish/100m^2)		Mean Length (mm)	
Site	**Fish Type**	**YOY**	**Parr**	**YOY***	**Parr***
Eastern Little River	Pleasant River Hatchery	45.9	22.7	64.3	116.2
Crebo Crossing	CBNFH	20.8	5.53	61.5	124.7

Figure 2.2. Pleasant R Cumulative Timing of RST Smolt Capture (1999-2004).

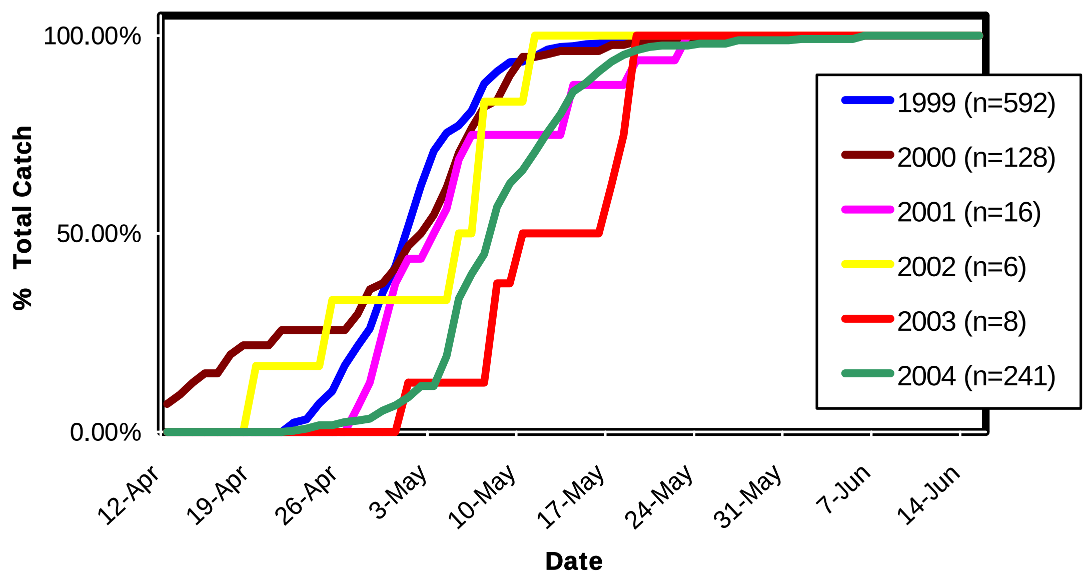
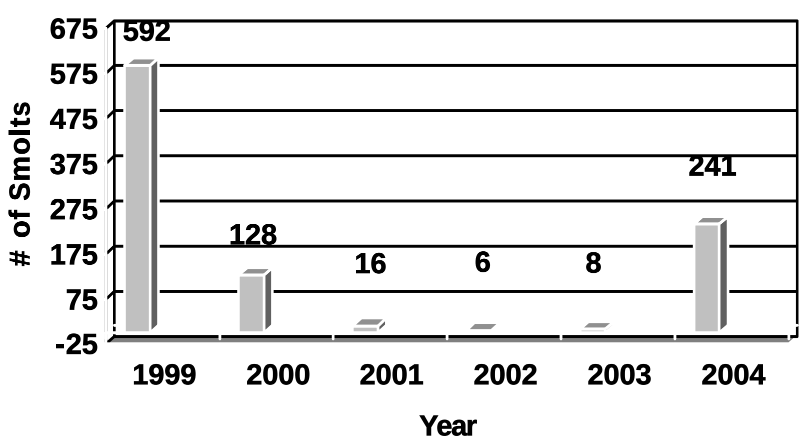


Figure 2.3. Number of Naturally Reared Smolts Recovered in RST (1999-2004).



Data collected at the RST indicate that the naturally reared 2+ smolts leaving the system between 1999-2002 and in 2004 were consistent in size. Fork length measurements ranged between 160.1 and 175.8 mm (Figure 2.4). However, 2003/2004 data indicate that hatchery-reared smolts released into the system in 2003 and 2004 were significantly larger than naturally reared smolts of the same age class (Figure 2.5). For example, in 2004 the hatchery-reared smolts had an average fork length of 223.9 mm compared to naturally reared fork length of 163.0 mm. The difference is attributed to enhanced hatchery conditions and food availability, not experienced by fish reared in a river setting. It is unclear if the larger hatchery-reared fish have a greater advantage over the naturally reared fish in the saltwater environment.

The 2004 scale sample data taken at the RST indicate the age class range and origin of smolts going to sea. All 2004 smolts (n = 218) captured in the RST were naturally reared as a result of the 2002 fall parr stocking. Four smolts (2%) were one year old, 214 smolts (98%) were two years old, and no fish were three years old.

Figure 2.4. Average Fork Length of Naturally Reared Outmigrating Smolts (1999-2004).

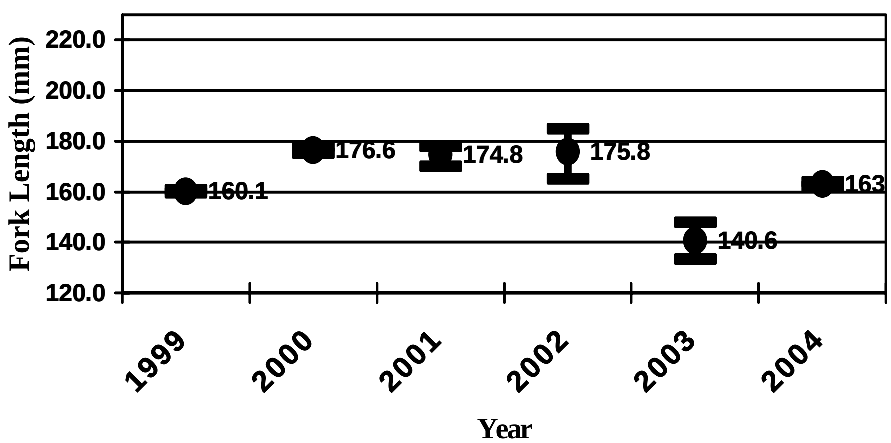
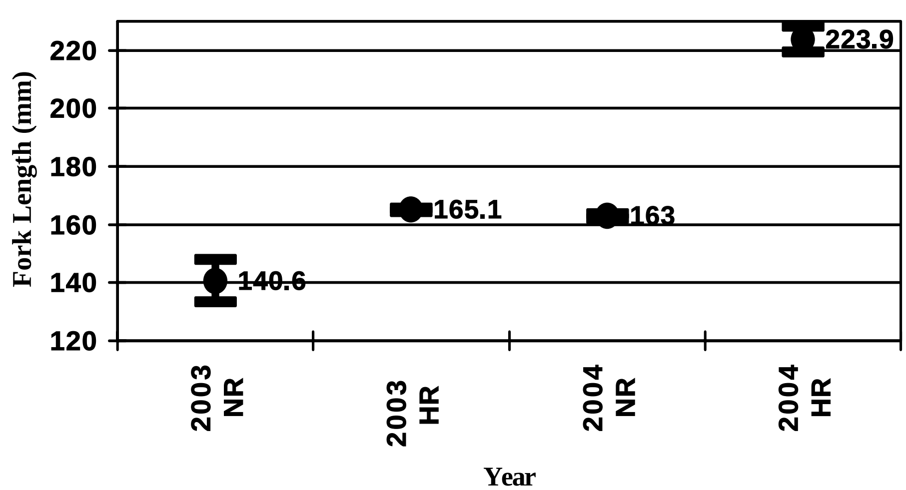


Figure 2.5. Comparion of Fork Length Between Naturally Reared (NR) and Hatchery Reared (HR) Smolts Captured in the RST in 2003 and 2004.

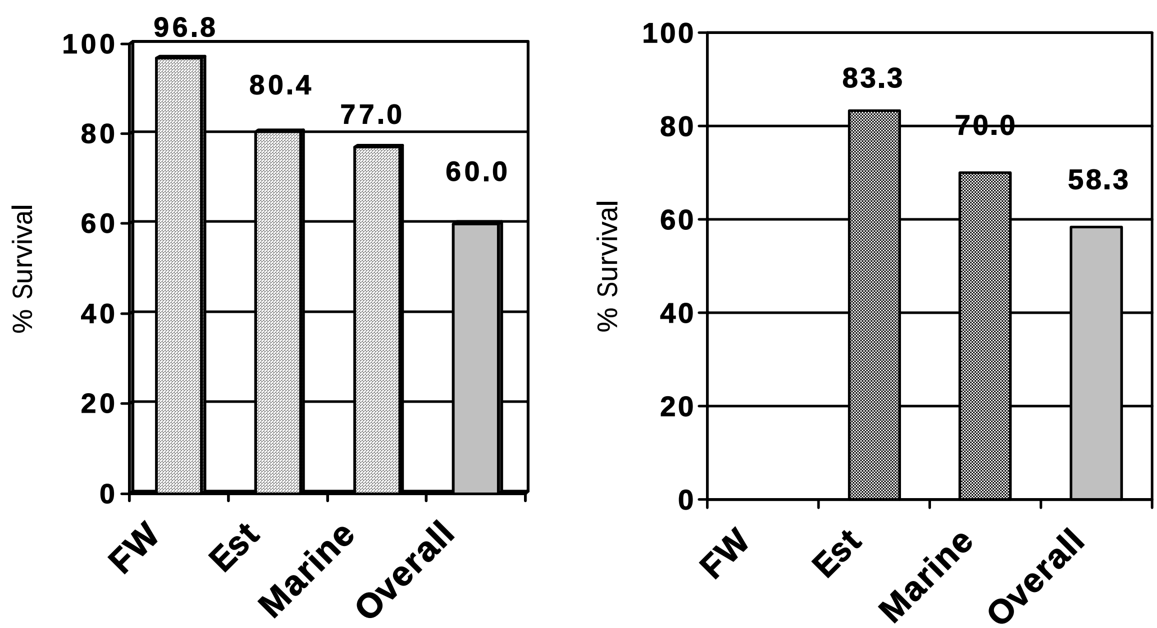


Telemetry Studies

In addition to capturing and sampling smolts, NOAA also conducted ultrasonic telemetry studies on the PRW in 2004. In these studies, smolts are surgically implanted with an ultrasonic serial-coded tag (pinger) that is detected by fixed-location automated fish receivers (VR2) throughout the riverine and estuarine system and the in Narraguagus Bay nearshore marine environment (Figure 2.6). Through these studies, NOAA researchers are able to determine emigration timing, behavior, and survivorship (where and when mortalities may occur), as well as the success rate of smolts with varying rearing histories.

Data from the 2004 telemetry study indicate that smolt survivorship through the riverine, estuarine, and nearshore marine environments (Narraguagus Bay) is approximately 60%. Losses through these environments may be attributed to the smolts' inability to successfully transition from freshwater to the marine environment thereby resulting in a greater risk of predation, or delayed mortality. The data also indicate that both hatchery-reared and naturally reared smolts have similar rates of survival both in the PRW estuary and nearshore environment. Each group appears to make the transition to salt water at the same rate (60%), which suggests that rearing type may not be an indication of survivorship and physiological condition.

Figure 2.6. Survivorship of Tagged Smolts through the Pleasant River and Narraguagus Bay Telemetry Arrays (2004).



Other Diadromous Fisheries

In addition to Atlantic salmon, Maine's rivers have historically hosted numerous other diadromous species including alewife, American eel, American shad, Atlantic sturgeon, Atlantic tomcod, blueback herring, brook trout rainbow smelt, sea lamprey, shortnose sturgeon, and striped bass (Sanders et al. 2006).

Diadromous species collected in the PRW RST trap between 1999 and 2004 include eels, lampreys, alewives, and smelts (Fig 2.7). This process tells researchers which species and the number of individuals entering or leaving the system and information on migratory timing (J. Hawkes, NOAA, Personal Communication, June 2006). The data indicate that smelt and eel numbers have decreased from 1999 to 2004, alewives may be experiencing a slight rise, and lamprey data is too variable to determine a trend. These data do not necessarily reflect the total number of diadromous fish entering the system for a number of reasons. The migratory timing of each of these species differs and the RST collection period may not reflect their peak migration. For some species peak migration may have occurred after the RST was removed. Furthermore, because the RST is designed to capture fish traveling downstream, or leaving the system, it is less effective at capturing fish traveling upstream, or entering the system. High flow may also cause fish to be pushed into the trap more than once.

Alewives

The following graphics and information were presented to the workgroup by Tom Squiers, MDMR, June 2006.

Alewives enter Maine lakes to spawn in May and June at 4-5 years of age and primarily feed on crustaceans. Juveniles stay in lakes 2-5 months eating zooplankton and insect larvae before emigrating to the ocean. Alewives are important forage fish for osprey, striped bass, and smallmouth bass. While 60-70% of spawning alewives leave the system, the remaining 30-40% die and provide a source of marine-derived nutrients to the system.

Alewives are harvested in many Maine rivers and used as bait primarily in the lobster industry. MDMR data indicate that statewide landings were strong from 1950-1958 and from 1973-1981 (Figure 2.8). There was a steady decline starting in 1981 with record lows occurring from 1993-1997. At this time many towns imposed commercial harvesting moratoria in response to the dwindling landings. Landings began to increase in 2002-2004 but have not yet returned to the high levels of the 1950s and 1970s. MDMR has determined landings potential for each of the Washington County watersheds based on lake acreage and river length. East Machias and Dennys rivers have the greatest potential for alewife landings (Figure 2.9). The Narraguagus and Pleasant rivers have less potential but are currently closer to meeting their potential.

Figure 2.7. Total Number of Fish Caught in Plasant River NOAA Rotary Screw Trap, 1999-2004 (NOAA, 2006).

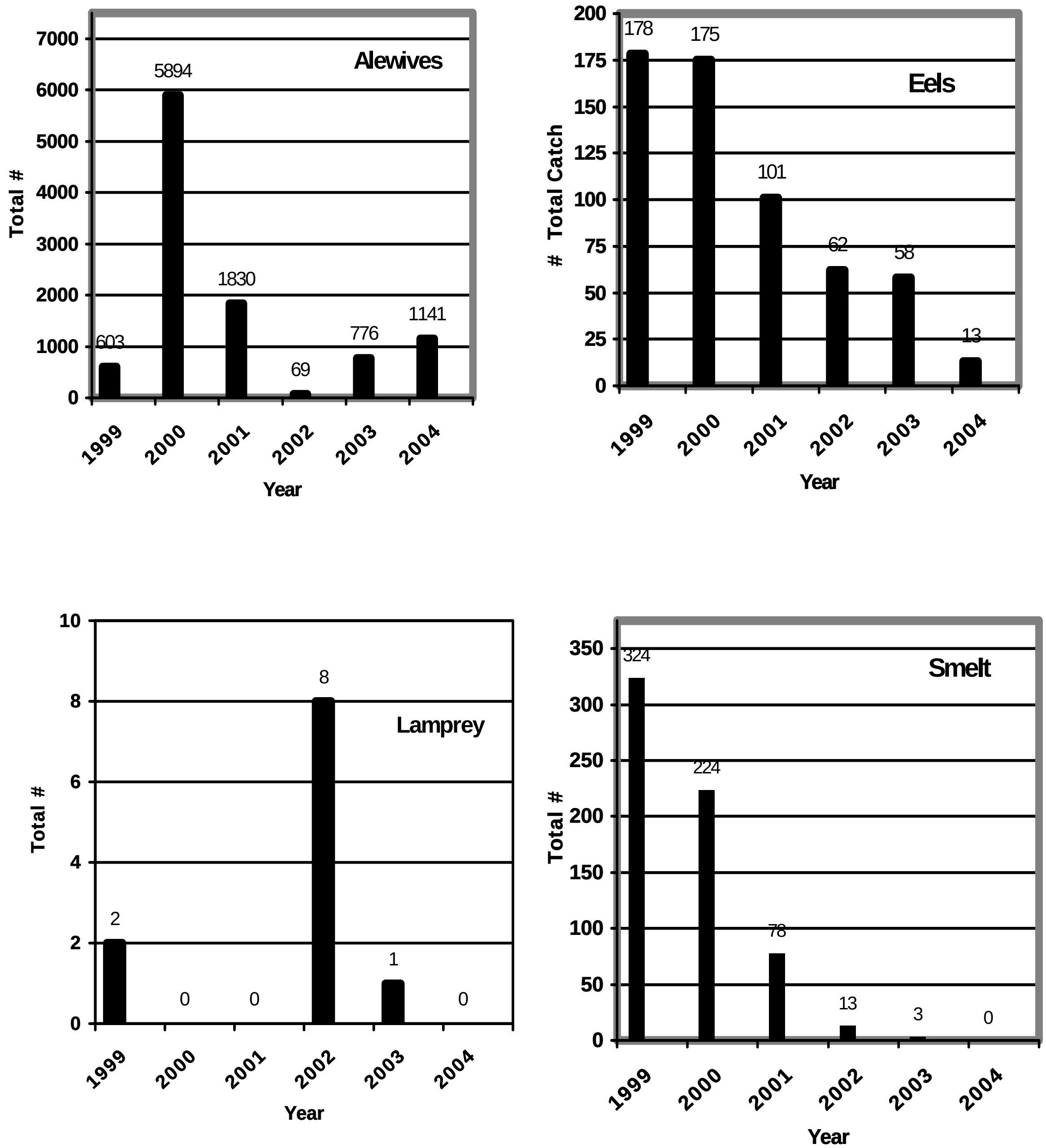


Figure 2.8. Maine State Alewife Landings, 1950-2004.

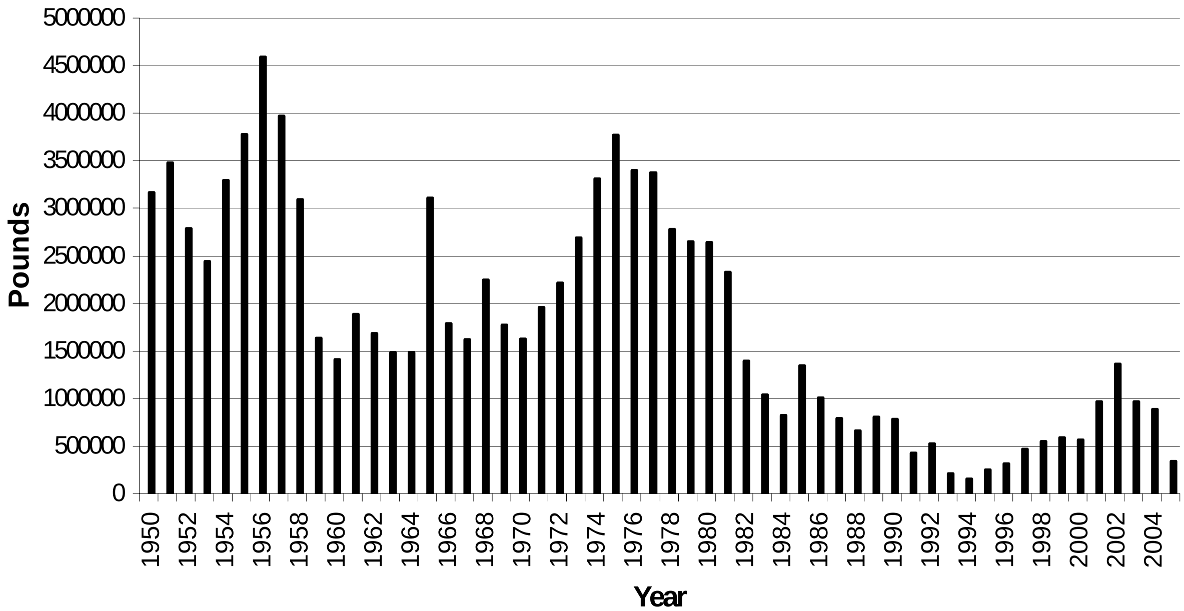
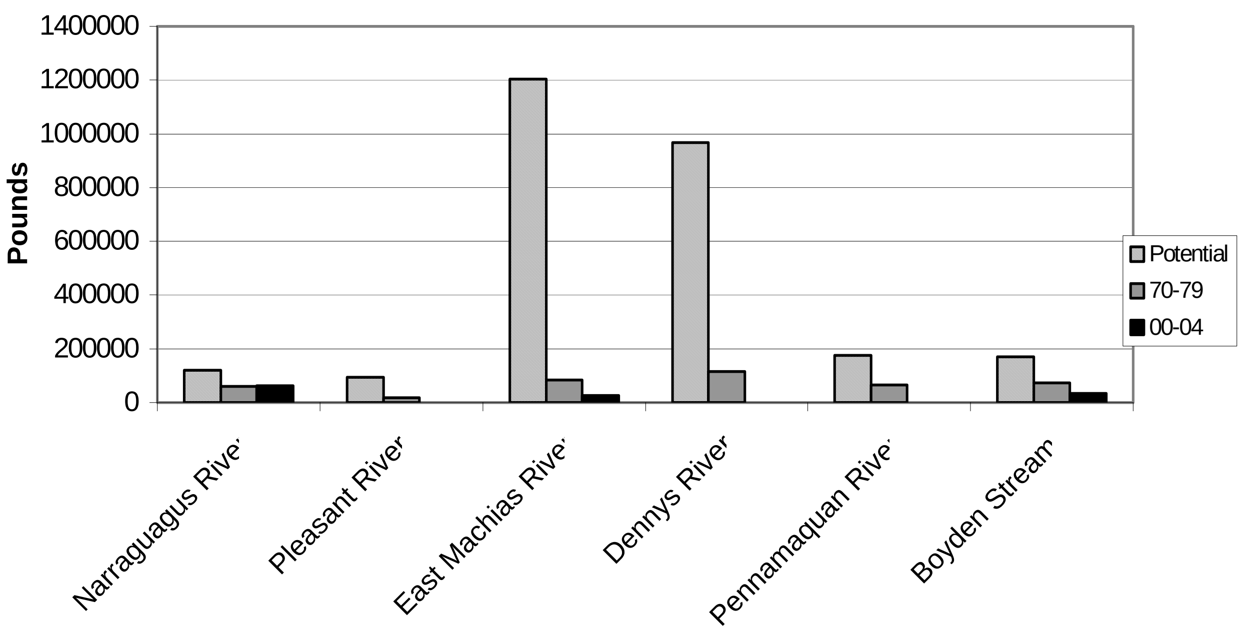


Figure 2.9. Potential and Actual Alewife Landings for Washington County Watersheds, 1970-1979 and 2000-2004.



Nekton Fisheries

The following information was presented by Marilee Lovit, June 2006.

The West Branch of the Pleasant River enters the mainstem below head of tide and is gated at the Addison Rd crossing so that saltwater can not naturally enter the stream above the road. The gate was installed in the 1940s but the purpose of the gate is still unclear. In 2004, volunteers and federal and state agencies began an effort to study the impacts of tidal restriction. The studies have included fish and plant surveys, WQ monitoring, and hydrology and surface elevation evaluations. The following fish were found:

Crangon septemspinosa	*Notropis spp*
Anguilla rostrata	*Fundulus luciae*
Apeltes quadracus	*Menidia menidia*
Brevoortia tyrannus	*Gasterosteus aculeatus*
Fundulus heteroclitus	*Pungitius pungitius*

The study indicates that *Fundulus heteroclitus* was the most abundant species in all marshes studied except for the Upper restricted marsh, where the freshwater genus *Notropis* was most abundant. The upper (restricted) marsh is characterized by low estuarine fish density and richness and a predominantly freshwater fish community. Fish species richness and density in the West Branch at the restricted marsh behind the Post Office is similar to the reference marshes. However, there are no pools or pannes that flood regularly and can support fish in the restricted marsh; fish are restricted to the main channel. Upper marsh does not function similarly to the reference marshes as fish habitat. The predominantly freshwater fish community is limited to the creek and does not contribute to fish production in the Pleasant River Estuary. That is, the fish above the tidal dam likely remain above the dam.

Freshwater Fisheries

Graphics and related information contained in the following section were obtained from a presentation given by Greg Burr, MIFW, to the Workgroup, May 2006.

Brook Trout

The mission of the Maine Department of Inland Fish and Wildlife (MIFW) is to protect, conserve, and enhance inland fish resources of the state of Maine. According to the department, the Pleasant River MS is considered “excellent” brook trout (BT) habitat due to groundwater inputs & large spring flows that keep summer water temperatures cool. A report issued for the Eastern Brook Trout Joint Venture (Trout Unlimited 2006) indicates that BT are threatened throughout its range (all of eastern US) but that Maine is the only state with extensive intact populations of wild, self-producing BT in lakes and ponds. Furthermore Maine has more than twice the number of intact subwatersheds for BT as the other 16 states combined, yet, 65% of the state has no quantitative data on BT status. Although MIFW has not "mapped" specific BT habitat units and currently has no quantitative data for PRW, efforts are being made to gather that information during the 2007 season.

Pleasant River Lake Smelt Management

Pleasant River Lake's smelt population is a donor source of disease free eggs for stocking into regional landlocked salmon lakes. As such, the lake and tributaries are closed to the taking of smelts and there is a verbal agreement with camp owners that the department will only take smelts from one spawning tributary per year: either Pinkham Camp Brook or McGinnis Camp Brook.

Other Fish Species

In addition to native wild brook trout, the PRW is host to numerous other fish species. Table 2.12 lists those fish species that are native, nonnative, and diadromous. In addition to the mainstem, Pleasant River Lake, Montegail Pond, and Southwest Pond are also considered good habitat for several of these species. Table 2.13 describes the habitat and fisheries of these three ponds.

Table 2.12. Fish Species Composition within the PRW.

Native	Nonnative	Diadromous
Brook trout	Smallmouth bass	Atlantic salmon
White perch	Landlocked salmon	American eel
Rainbow smelt	Splake	Alewife
Brown bullhead	Fathead minnow	Sea lamprey
Golden Shiner		American shad
White sucker		Brook trout
Common shiner		Ninespine stickleback
Blacknose dace		Threespine stickleback
Creek chub		
Fallfish		
Banded Killifish		
Finescale dace		
Northern redbelly dace		
Pumpkinseed sunfish		
Redbreast sunfish		
Ninespine stickleback		
Threespine stickleback		
Lake chub		

Table 2.13. Characteristics of PRW Lakes and Ponds.

	Pleasant River L	Southwest Pond	Montegail Pond
Surface Acres	949 acres	139 acres	170 acres
Maximum Depth	52 ft	34 ft	12 ft
Surface Temp	73 F	71 F	78 F
Bottom Temp	52 F	49 F	66-49F
Thermocline	27-29 ft	20-23 ft	NA
DO	5 ppm @35-52 ft	5.0 ppm @ 24-34 ft	5 + ppm to bottom
Surface pH	6.1 (alk = 3.0)	NA	NA
Primary Mgmt Spp	Splake (6.5 splake/splake acre)	White Perch	Brook Trout (Stocked)
Secondary Mgmt Spp	Landlocked Salmon (0.16 salmon/acre)	Brook Trout (Wild)	NA
Other Fisheries	White Perch, SM Bass, Brook Trout	NA	NA
Habitat	Mid -summer Salmonid Habitat – 20 to 35 feet	Usable salmonid habitat 20-24 ft	CW refugia to over-summer trout
Stocking	Splake 350/yr LL Salmon 150/3yr	All wild BT produced in outlet	Stocked 1,200 FF & 300 SY BT

Chapter 3: Water Quality Monitoring History

Monitoring Index, Program Objectives, Indicators, Locations

Overview

The PRW has been monitored as part of 13 programs managed by nine different agencies/organizations. Some agencies monitor the river as part of several different programs or studies (e.g., MDEP monitors for three different studies). Table 3.1 provides an overview of monitoring in the watershed and lists by agency, the project name, sampling dates, sampling frequency, objective, data contact, data storage location, and indicators measured. The reader is encouraged to refer to the table when reviewing the datasets in Chapter 4.

The table is a summary of larger index of sites that includes GPS coordinates and other details and as such is too large for inclusion in the body of this document. The Index, in Excel format, was created to catalogue the details of current and recent WQM efforts and to provide the background information, or metadata, for developing GIS Map 2, Pleasant River WQM Sites (Appendix A). Each map icon corresponds to sites listed in the Index. The Index is arranged by agency and lists each parameter the agency monitors. It is available from the author.

Water Quality Program Objectives

Each of the 13 programs currently collecting WQ/WC data maintains a different objective for data collection based on the mission of the agency. Although the term “Water Quality Monitoring” is used loosely throughout this document, review of the various programs reveals that there are generally three types of data collection occurring:

<u>Monitoring</u>

The term monitoring generally refers to the observance and measuring of specific indicators over a period of time to identify long-range environmental changes. Examples of programs currently using this type of data collection are MDEP/NRWC, MASC Temperature Program, MDMR Shellfish Sanitation Program, WSRC Real Time Chemistry, and USGS Streamflow Gage. After an agency has monitored a specific indicator for many years, staffing and cost often dictate that the program reduce the number of sites and shift to the use of Index Sites, whereby a few sites are monitored in the long term with the results used as a model of response at other sites.

Studies

Water quality/chemistry studies are generally designed to answer very specific questions and are conducted in a defined geographic location over a finite period of time using strictly controlled and replicable protocols. The study often originates from questions raised in response to data gathered from a previously established monitoring program. Examples of agencies/programs currently conducting studies in the PRW include the NOAA Streamside Study and MASC pH Survey.

Assessment.

Data collection in which an agency conducts a one-time sampling and analysis for the presence, absence, and/or level (lethal limits, index of biological indicators, etc) of specific indicators is generally referred to as an assessment. This form of data collection may develop into continued long-term monitoring or a more detailed, specific study. MDEP Biomonitoring Program for Class Attainment and USFWS Contaminant Assessment (primarily metals and organchlorides) are examples of assessment.

Water Quality Indicators

Table 3.1 indicates that there is a wide range of parameters currently or recently monitored in the watershed. Streamflow has been measured by USGS for over 20 years. Continuous temperature (using loggers) has been monitored for the last 10 years by the MASC. MDMR and MDEP Biomonitoring Program currently take one-time field measurements of temperature when monitoring for other indicators. Field pH has been measured using loggers by NOAA (1999-2005), MDEP/PRWC, and Wild Salmon Resource Center (2003-present) and by use of pH pens and loggers by MDEP/PRWC (1999-2005). Lab pH and water chemistry including DOC, ANC, specific conductivity, Ca, Mg, Na, K, Cl, NO_3, SO_4, and Al have been measured by MASC and MDEP/PRWC since 1999. Blueberry pesticides have been monitored by the MBPC since 1997, and biotoxins (i.e., red tide, etc) and *E. coli* have been measured by MDMR since the late 1980s.

Monitoring Locations

Map 2, Pleasant River WQM Sites (Appendix A), illustrates all of the sites that are currently monitored or have been monitored in the past 5 years. Monitoring in the watershed is primarily focused in the mainstem from Pleasant River Lake to the Great Heath and from below the Great Heath to the bay. Due to a lack of access and anthropogenic activity, there are few sites along the river in the Great

Heath area. Different agencies focus their monitoring efforts in different reaches/drainages based on agency objectives. Furthermore some agencies maintain multiple study sites (MASC, MDEP/NRWC, MBPC, and NOAA,) while some agencies maintain only a few index sites (VLMP, USGS, and MDMR).

The MASC focuses their temperature and pH monitoring efforts on Priority Subwatersheds 1 and 2. The MDEP/PRWC monitor sites throughout the drainage. The MBPC monitor sites associated with blueberry cultivation in Priority Subwatersheds 1 and 2. NOAA temperature and chemistry monitoring efforts focus on smolt migration routes in the MS from Saco Falls to the bay. Finally, the VLMP monitors Pleasant River Lake.

The following areas are not currently monitored and should be considered for monitoring:

- most of the lakes and ponds (Montegail, Southwest, etc)
- the Great Heath
- most of the Western Little River

The following areas have some monitoring but should be considered for additional sites:

- West Branch
- Taylor Brook
- Bog Stream
- Colonel Brook

Table 3.1. Overview of Recent WQ Monitoring History in the Pleasant River Watershed.

Investigating Agency	Project Name	Sample Dates	Sample Freq	Objective	Agency Contact	Data Storage	WQ Indicator
Maine Atlantic Salmon Commission	Water Temperature Monitoring	1995-2006	spring, summer, fall	Basin wide temperature monitoring, salmon management	Greg Mackey, MASC	MASC Temperature Database	Digital data loggers
Maine Atlantic Salmon Commission	MASC pH survey	2003-2004	3 times/year, spring, summer, fall	Investigation of pH and related water chemistry in Maine salmon drainages	Richard Dill, MASC	http://pearl.maine.edu	Lab pH and various analytes (ANC, color, DOC, Ca, AL, Mg, NO, SO, etc)
Maine Board of Pesticides Control	Blueberry Pesticides Monitoring	1997-2004	Approx. 2 times per summer	Monitor Pesticide Drift	Henry Jennings, MBPC	Augusta BPC office, Access database	Blueberry pesticides (phosmet, fenbucanzole, hexazinone, etc)
NOAA-Fisheries Service	Telemetry	1999-2004	15 min-hourly	Smolt Migration	Jim Hawkes	NOAA Field Station, Orono	Temperature, pH (YSI data sondes)
NOAA Fisheries Service	NOAA Streamside Study	2004-2006	Periodic Grab Samples	water quality monitoring	Dan Kircheis, NOAA	http://pearl.maine.edu	pH, ANC, DOC, Ca, Mg, Na, K, Al
NOAA Fisheries Service	Calcium Enhancement in Downeast Salmon Rivers (CEDAR)	2003-2004	Periodic Grab Samples	water quality monitoring	Dan Kircheis, NOAA	http://pearl.maine.edu	pH, ANC, DOC, Ca, Mg, Na, K, Al
US Geological Survey	Maine Water Resources	1980-2006	Continuous	Monitor Streamflow	Greg Stewart, USGS	USGS NWIS Database	Streamflow

Maine Department of Environmental Protection	Biomonitoring Program	1996-present	Once per summer in year(s) specified	Aquatic life attainment determination	Leon Tsomides, MDEP	MDEP BioME database	Field Temperature, DO, alga, NO3, NO2, DOC, and macroinvertebrates
Maine Department of Environmental Protection/ Pleasant River Watershed Council	Atlantic Salmon River WQM Program	1999-present	Biweekly-seasonal	Temperature and WQ Monitoring, Salmon Mgmt	Mark Whiting MDEP	MDEP Bangor	Field Temperature, loggers, DO, and pH. Some lab chemistry
Maine Dept of Marine Resources	Public Health Division	1990 to present	6+ samples yearly	Classification of shellfish harvesting areas	John Fendl, MDMR, Lamoine	Central Oracle Database	E. coli, temperature, salinity, biotoxins
Volunteer Lake Monitoring Program	Volunteer Lake Monitoring Program	1982-present	1-2/season	Lake Nutrification	Scott Williams/ VLMP	http://pearl.maine.edu	DO, chl a, transparency, pH, color, TP
US Fish and Wildlife Service	Contaminant Assessment	2003 & 2006	Twice for tissue	Residue analysis	Steve Mierzykowski, USFWS	USFWS Field Office, Old Town	Organochlorines, trace elements
Wild Salmon Resource Center	Real Time Chemistry Online	2003-present	Continuous	Water Chemistry	Jacob van de Sande, DSF	WSRC	Temp, pH, conductivity, Dissolved oxygen with YSI 600XL data sonde

Chapter 4: Water Quality Trends

Temperature, pH, DO, Nutrients, Bacteria, Contaminants, Lake Productivity and Streamflow

Overview of Available Watershed Data

The purpose of this plan is to review existing WQ data and to make recommendations regarding their use in restoration and management decisions and future monitoring plans. This chapter reviews data and makes recommendations regarding the following parameters:

- Temperature
- pH and related analytes (Ca and Al)
- Nutrients
- Marine Derived Nutrients
- Biomonitoring and Macroinvertebrates
- Bacteria
- Pesticides
- Contaminants
- Streamflow
- Lake Productivity
- Nonpoint Source Pollution
- Restoration

The datasets, graphics, and information discussed in the following sections were presented to the workgroup between February and November 2006. **The reader is encouraged to contact agencies directly if there are further questions regarding the data presented herein.**

Water Quality Requirements and Limits of Atlantic Salmon

In order to understand water quality data results, the reader must first understand the water quality requirements of aquatic organisms and overall ecosystem integrity. The Narraguagus River Water Quality Monitoring Plan (Arter and Snapp 2006) (http://salmonhabitat.org/nrwqmp.html) and the KRIS Sheepscot On-line Database provide an extensive review of the water quality requirements and limits for Atlantic salmon. Tables 4.1 and 4.2 summarize some of the limits data as well as provide the data source. Table 4.1 summarizes contaminants and Table 4.2 summarizes physical and chemical characteristics. Tolerances vary at different stages in the life cycle, so data are provided in a stage-specific manner where possible.

Extreme temperatures have profound effects on all life stages. The range for spawning is narrow (4-12 ^{o}C), while parr are more tolerant (0-32 ^{o}C). Transition from parr to smolt is triggered by increasing daylength and spring water temperatures of 5 ^{o}C, with emigration peaking at 8-9 ^{o}C. High summer temperatures can be particularly problematic in streams with low flow rates and/or shallow stretches. The high temperatures can restrict salmon movement and feeding and reduce spawning in the autumn. Activities for all stages are impaired to some extent above about 12 ^{o}C and below about 7 ^{o}C, with substantial impairment occurring above 20 ^{o}C and below 4 ^{o}C.

Optimal pH ranges from 6.5-6.9 with negative effects evident as pH levels drop below 6.0. Several of the salmon streams in Maine (those in eastern coastal Maine) lack good sources of naturally occurring base cations (calcium, magnesium, etc.) leading to very low buffering capacity. Chronic and episodic exposure to low pH affects the ability of smolt to shift from freshwater to saltwater. Low pH may also increase the concentration of heavy metal ions, especially aluminum which can accumulate on and in gill tissues, disrupting ion regulation and impairing gas exchange.

Dissolved oxygen levels must remain above 6 mg/L to ensure survival of all stages in the life cycle. The egg and alevin stages are most vulnerable, and are most successful only if DO is greater than 9 mg/L. Salmon in older stages can protect themselves to some extent by moving out of areas with low DO, but egg and alevin are unable to do so. DO is heavily impacted by water temperature; as temperature increases, the amount of oxygen decreases rapidly.

Stream flow is influenced by slope gradient, breadth of streambed, and volume of inflow from tributaries and ground water. Optimal habitat for salmon spawning and rearing is 1-1.5%, with flows of 10-60 cm/sec. Spawning is most intolerant of low flows; successful spawning beds have flows ranging from 27-80 cm/sec. Shallower gradients and slower flow may lead to deposition of fine particles that interfere with spawning, embryo survival, and emergence of fry. Particle size should be above 2-10 cm to prevent negative effects of siltation.

Optimal water depth for salmon ranges from 20-75 cm. Because depth and flow influence water temperature, variations in depth are important stream features in creating cool-water refugia. Slower portions of a stream can still be navigated and utilized if deeper pools provide cool water in their lower layers. As parr age, they occupy habitats with a wider range of water depth, water velocity, and substrate, reflecting their increased mobility and perhaps varying habitat use in time and space.

Pesticides rarely cause direct lethal effects but often cause sublethal effects such as compromising reproductive success through disruption of hormonal cycles or reducing tolerance to variation in environmental parameters. Even if low levels may not be very toxic to salmon directly, many of these chemicals may affect algal or invertebrate life that supports salmon and other large fish. Chemicals such as chlorine may also cause acute toxicity and sublethal effects at low levels.

Table 4.1. Harmful Levels of Substances That Affect Health of Freshwater Fish.

Substance	**Harmful levels**	**Basis**	**Reference**
Aluminum	> 5µg/L	exchangeable Al	Brocksen et al. 1992
Phosmet (Imidan)	58-37,000 ppb moderate to very high toxicity	96 hour LC50	Pesticide Action Network
Hexazinone (Velpar)	150,000-350,000 ppb low toxicity	96 hour LC50	Pesticide Action Network
Propiconazole (Orbit)	300-100,000 ppb moderate toxicity	96 hour LC50	Pesticide Action Network
Chlorthalonil (Bravo)	24-430 ppb very high toxicity	96 hour LC50	Pesticide Action Network
Chlorine	117 ppb	Acute Toxicity in brook trout	EPA
Suspended solids	> 10 mg/L	> 6 days exposure	Newcomb and Jensen 1996

Table 4.2. Environmental Limits of Tolerance for Atlantic Salmon at Various Stages in Freshwater Summarized from Arter and Snapp, 2006.

Life stage	**Temperature (°C)** [1]			**pH**			**Dissolved oxygen (mg/L)** [2]		**Water velocity**	**Substrate particles**	**Water depth**
	Survival	**Optimal**	**Feeding**	**Optimal**	**Negative effect**	**Lower lethal**	**Impair-ment**	**Lethal**	**Optimal (cm/sec)**	**Diameter (cm)**	**Optimal (cm)**
Spawning	4-12	5-8	--	--	--	--	--	--	27-80 [10] 52-54 [11]	2-10 [13]	25-75 [13]
Egg and alevin	0.5-12	4-7.2	--	6.6-6.8 [3]	4.0-5.5 [3] 4.5-5.0 [4]	3.1-3.5 [3] 4.0-4.2 [4]	< 9	6	50-65 [10] 10-60 [12]	--	20-70 [13]
Fry	0.5-27.7	8-19	--	--	--	4.0 [5] < 5.0 [4]	< 6	3	50-65 [10] 10-60 [12]	1.6-6.4 [14]	20-70 [13]
Parr	0-32	0.5-20	15-19	> 5.4 [6] 6.5-6.9 [8]	4.7-5.0 [6] 4.4-6.1 [7] 5.8 [8]	4.7 [6]	< 6	3	50-65 [10] 10-60 [12]	> 26 [14]	20-70 [13]
Smolt	5-19	7-14.3	--	--	< 6.2 [9]	4.6-4.7 [4]	< 6	3	--	--	--
Adult	8-23	14-20	--	--	--	--	< 6	3	--	--	--

References

[1] Institute for Fisheries Resources and Sheepscot Valley Conservation Association 2005
[2] USEPA 1986
[3] Peterson et al. 1980
[4] Farmer 2000
[5] Daye and Garside 1977
[6] Watt et al. 1983
[7] Magee et al. 2003
[8] Kroglund and Finstad 2003
[9] Kroglund and Starnes 1999
[10] Baum and Jordan 1882
[11] Beland et al. 1982
[12] Heggenes 1990
[13] Arter and Snapp 2006
[14] Danie et al. 1984

Temperature

The following information and graphics were presented to the workgroup by Mike Loughlin, MASC, Jim Hawkes, NOAA, Mark Whiting, MDEP, and Jacob van de Sande, WSRC, in May 2006.

Summer High Temperatures

Coldwater fish species such as brook trout and salmon require clean cold water as part of their habitat. As mentioned in Chapter 2, the PRW is considered excellent trout habitat because of coldwater inputs in the mainstem and tributaries. Threats to cold temperatures are beaver dams and lack of riparian buffers. MASC, NOAA, MDEP/PRWC, and WSRC monitor summer temperatures in the PRW using loggers or sondes (Table 4.3). There is good coverage of the entire watershed in both the mainstem and tributaries. The data indicate similar findings regarding summer high temperatures:

- with the exception of the PRL Outlet, temperatures in the mainstem and tributaries occasionally exceed 22º C but do not exceed 25º C (Figure 4.1),
- the reach with the highest continuous summer temperatures is the outlet of PRL (22º C to 25º C) (Figure 4.1),
- temperatures at Crebo crossing generally stay well below sublethal limits (22º C) due to the presence of springs and aquifers (Figure 4.1 and Table 4.4),
- temperatures in the lower mainstem (weir and WSRC) are highly variable but generally warmer than Crebo and usually range between 15º C and 25º C (Figure 4.1 and 4.2),
- the tributaries, E Little River and West Little River, are generally cooler than the mainstem (below 22º C) while Canoe Brook often experiences warmer temperatures (above 22ºC) (Figure 4.1 and 4.3).

Table 4.3. Temperature Monitoring in the PRW.

Agency	**Locations**	**Equipment**
MASC	MS and Tributaries	Onset Temperature Pro
NOAA	Crebo Crossing, Col. Falls Village, Telemetry locations	YSI Sonde and Stow Away
MDEP/PRWC	Tributaries	Onset *Tidbit* Loggers
WSRC	MS at Col Falls Village	YSI Sonde

Winter Low Temperatures

Elliot (1991) found 3.8 and 7.0 degrees C to be the lower levels of feeding cessation in juvenile Atlantic salmon at varying acclimation temps. NOAA data indicates that Crebo Crossing experienced temperatures between 3.8ºC and 7.0º C approximately 6000-7000 hours per year between 2000 and 2005.

Figure 4.1. MASC Weekly Average Temperatures for Selected Mainstem and Tributary Sites, 2005.

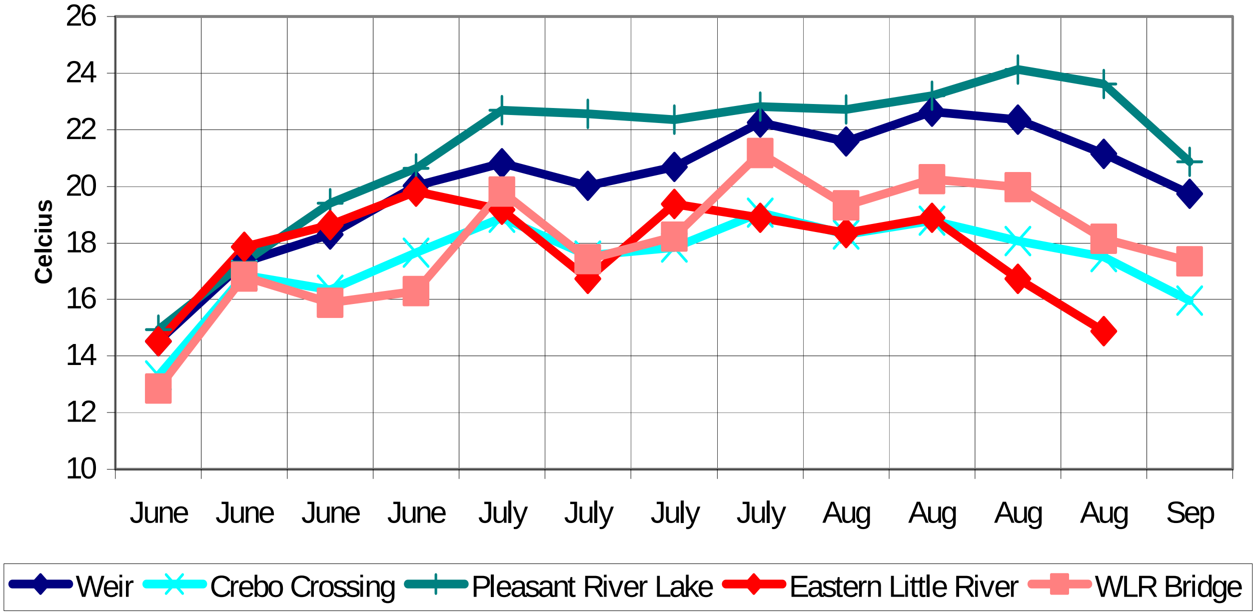


Figure 4.2. WSRC Temperatures of Pleasant River in Downtown Columbia Falls From DSF Data Sonde, 2004 and 2005.

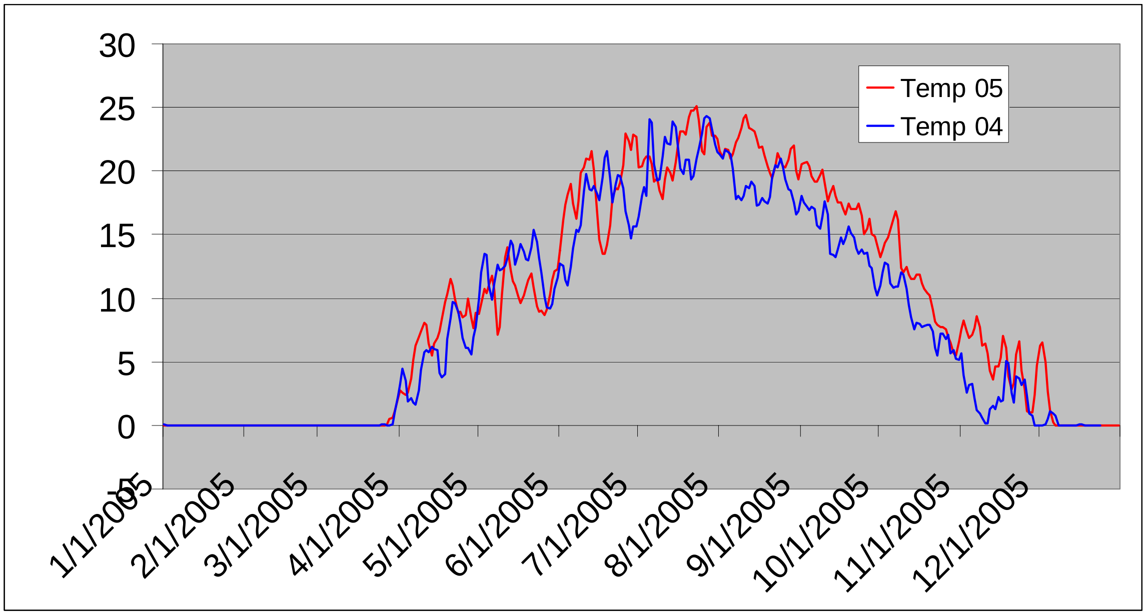


Figure 4.3. MDEP/PRWC Temperature Data for PRW Tributaries, 2005.

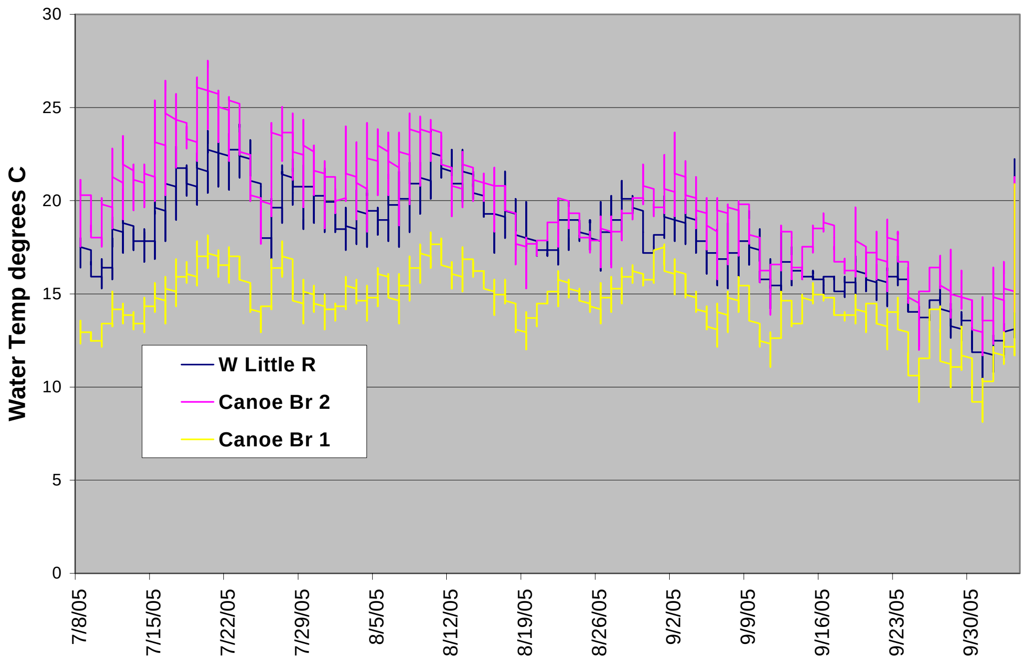


Table 4.4. NOAA Pleasant River Crebo Crossing YSI Temperature Events 2000 – 2005.

Year	# Days Sampled	# Hours Sampled	Hours < 3.8	Hours < 7.0	Hours > 22.5	Hours > 27.0	Hours > 30	Maximum Temp
2000	362	8488	2871	3858	1	0	0	22.66
2001	337	8050	2520	3416	54	0	0	24.60
2002	276	6581	3414	4108	0	0	0	22.31
2003	365	8746	3392	4107	27	0	0	23.81
2004	366	8776	3470	4120	16	0	0	23.51
2005	365	8755	3121	3850	10	0	0	22.94

Recommendations:

4.1 IF&W should focus monitoring and enhancement efforts on river/stream trout habitat including mapping habitat, conducting stream surveys to determine quantitative population status, protecting buffers, and possibly enhancing habitat.

4.2 IF&W should use the results from the Black Brook beaver study to make determinations regarding beaver management in waters with significant trout habitat.

4.3 Since MASC has five years of data, they should continue monitoring index sites (e.g., PRL, Crebo, Saco, Weir, E & W Little R) then develop regression models to predict temperatures depending upon questions related to research.

4.4 MASC should develop a model using recently published data (I.e., Horton) that uses temperature to predict juvenile salmon success rate and growth for various year classes.

4.5 MASC should design and conduct a study to determine if winter ground water and surface water temperatures are warm enough to overwinter juvenile salmon:

a. Establish critical winter temperature thresholds for juvenile and adult salmon (using literature review).
b. Search for existing winter temperature data (data inventory) to investigate if winter temperature thresholds are being exceeded.
c. Determine if the existing data spatially and temporally represents juvenile and adult salmon habitat across the drainage to answer item b?
d. If more data are needed; develop a winter temperature monitoring study, stratified by reach and salmon habitat in order to have sufficient spatial distribution to answer temperature questions related to salmon survival.
e. Establish current winter baseline temperature at multiple sites across the drainage.
f. Compare Pleasant River winter temperature results to researched critical temperature thresholds established in items a and b.

pH and Related Analytes

The following information was presented to the PRWQMP Working Group by Mark Whiting, MDEP, Dan Kircheis NOAA, Steve Norton, UM, April 2006. Additional information comes form 2 articles: A Systematic Survey of Water Chemistry for Downeast Area Rivers *(Johnson and Kahl 2005) and* Effects of low pH and high aluminum on Atlantic salmon smolts in Eastern Maine and liming project feasibility analysis *(Kircheis and Dill 2006).*

pH and Episodic Acidity

Water chemistry and pH are monitored by several agencies for both long-term programs (MDEP, WSRC) and short-term studies (NOAA, UMGMC). The data from these programs indicate that of all of the DPS rivers, the PRW experiences the lowest mean pH (Table 4.5, Johnson and Kahl 2005) and the greatest frequency and most severe documented low pH events (Kircheis and Dill 2006). It is also the only river mainstem that flows through a 5,000-acre peatland (Great Heath). The peatland comprises approximately 17% of the PRW and may be directly impacting the pH via dissolved organic carbon (DOC) and other mechanisms.

Table 4.5. Closed Cell pH (ClpH) Results Separated by Drainage in Ascending Order by Means, 2003-2004 (Johnson and Kahl 2005).

Drainage	Analysis	# of cases	Minimum	Maximum	Median	Mean	Standard Deviation
Tunk	ClpH	18	5.28	6.27	5.95	5.93	0.28
Pleasant	ClpH	34	4.70	7.25	6.05	6.05	0.63
Dennys	ClpH	45	4.84	7.26	6.12	6.09	0.56
Machias	ClpH	69	4.68	7.05	6.17	6.11	0.6
East Machias	ClpH	42	5.17	7.17	6.11	6.13	0.48
Narraguagus	ClpH	53	5.09	7.44	6.28	6.26	0.55
Union	ClpH	47	5.45	7.10	6.36	6.34	0.45
Ducktrap	ClpH	15	5.65	6.77	6.39	6.35	0.32
Sandy River	ClpH	6	6.38	7.03	7.00	6.84	0.27
Sheepscot	ClpH	23	6.32	7.67	6.83	6.87	0.37
Marsh Stream	ClpH	12	6.68	7.45	6.96	7.02	0.24
Cove Brook	ClpH	12	6.49	8.16	7.50	7.40	0.55
Kenduskeag	ClpH	18	7.04	7.88	7.50	7.49	0.25

The MDEP/PRWC collected 92 baseflow and stormwater samples for lab analysis from the MS and tributaries between 1999 and 2002. These lab data indicate that the PRW experiences the lowest pH episodes and has the greatest range in pH (Figure 4.4) of any of the DPS rivers. Baseflow samples had a mean pH of 6.64 and ranged from 5.85 to 7.38 while stormflow samples had a mean of 5.61 and ranged from 4.60 to 7.14 (Table 4.6). Mean acid neutralizing capacity (ANC) of baseflow samples ranged from 70 to 368 µeq/L with a mean of 167 µeq/L. ANC for stormwater samples ranged from 0.2 to 273 µeq/L with a mean of 76 µeq/L (Table 4.7).

Figure 4.4. Baseflow and Stormflow pH of Rivers in the DPS, 1999-2002 (MDEP, 2006).

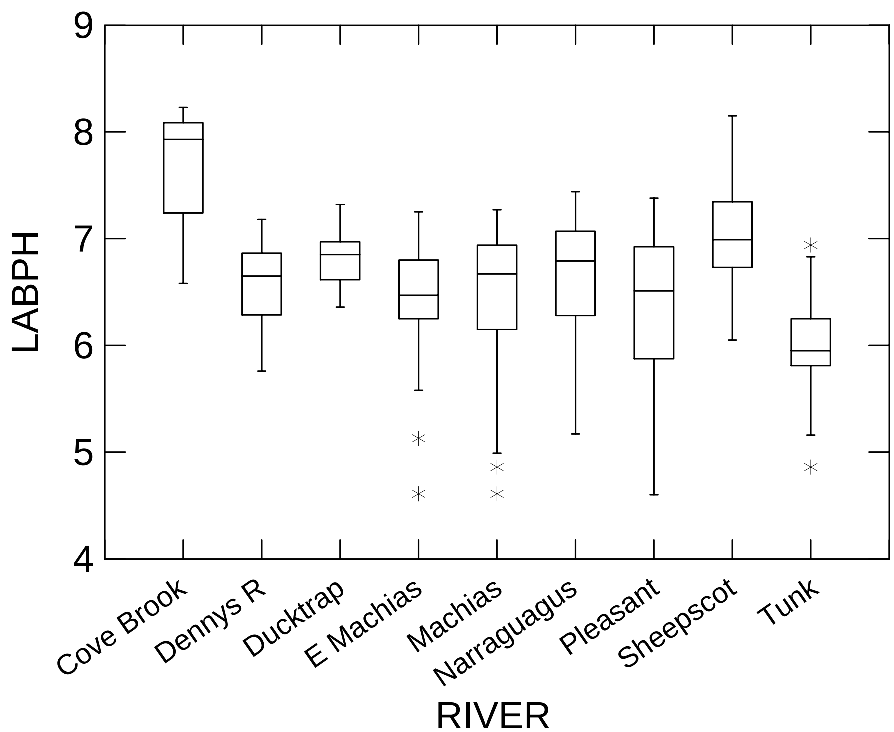


Table 4.6. Comparison of Baseflow and Storm Flow pH Means from Volunteer Grab Samples 1999-2002 (MDEP, 2006).

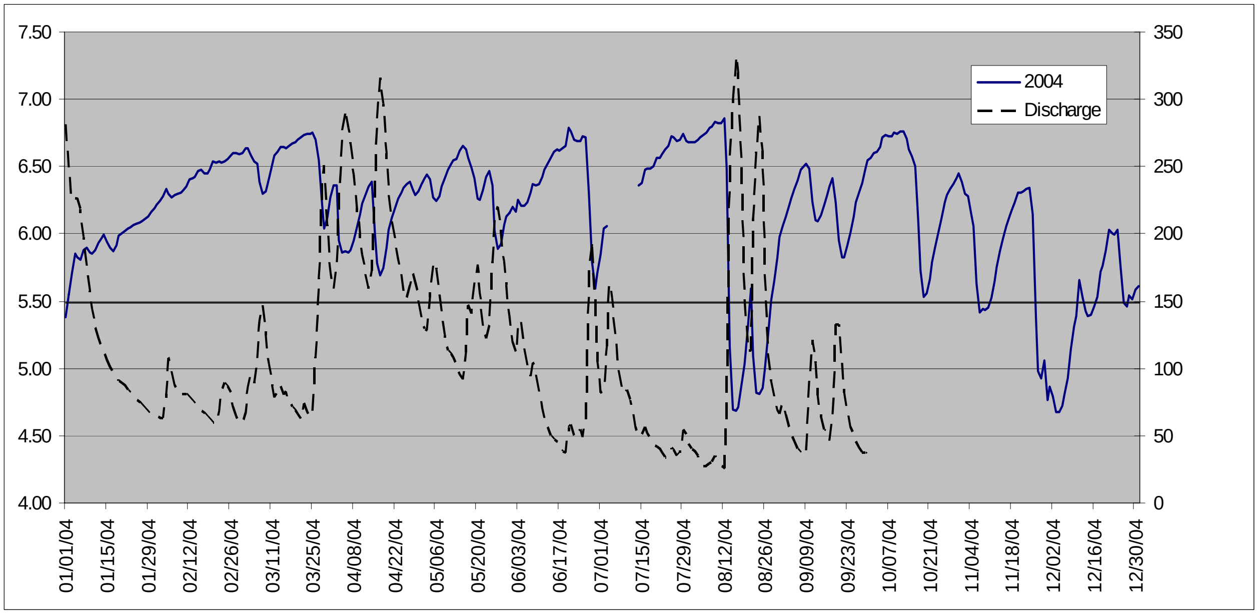
Pleasant River	pH	N	Std Dev	Range
All Baseflow	6.64	43	0.46	5.85-7.38
All Stormwater	5.61	17	0.86	4.60-7.14

Table 4.7. Comparison of Baseflow and Storm Flow ANC means from Volunteer Grab Samples 1999-2002 (MDEP, 2006).

Pleasant River	ANC ueq/L	N	Std Dev	Range
All Baseflow	167	43	56.3	70-368
All Stormwater	76	17	90	0.2-273

Data from the WSRC data sonde (2004) indicate that when discharge (streamflow) levels are elevated, pH drops to levels known to be stressful to salmon (Figure 4.5). For example in August 2004, discharge was above 200 cfs for several days and subsequently pH levels dropped below 5.5 and in some cases below 5.0. A similar pattern can be seen in 2005 data.

Figure 4.5. WSRC 2004 pH and Discharge Data on the PR MS at Columbia Falls



Analysis of the sonde data also suggests that fish and other organisms were subjected to pH levels below 5.0 for extended periods of time. Table 4.8 shows that in 2004 the river experienced 18 days below 5.0 and in 2005 it experienced 76 days below 5.0. Although the number of consecutive days is not provided, the data does suggest that organisms were subjected to stressful pH levels (below 6.0) 55% of the year, and harmful conditions (pH below 5.6) 30% of the year in 2005.

Because the mainstem is affected by these low pH events, it is reasonable to assume that all of the salmon habitat is affected. Fish may not die immediately from these conditions because the pH fluctuates between healthy and non-healthy conditions with each passing storm and conditions are worse in wet years than in drought years. However, the conditions do last long enough (usually about 8 days for a given storm with over 1.0 inches of rain) to harm fish and reduce fitness. Loss of physical condition can lead to higher predation, higher disease mortality, higher winter mortality, and higher smolt migration losses. It should be noted that the Project SHARE Liming Committee recently recommended to proceed with liming experiments to mitigate low pH, low Ca, and high Al conditions (M. Whiting, MDEP, Personal Communication, March 2007).

Table 4.8. Number of Days at Various pH Levels for the Pleasant River at Columbia Falls (DSF, 2006).

	2004 Days	2005 Days
pH < 4.5	0	17
pH < 5.0	18	59
pH < 5.5	39	108
pH < 6.0	105	200

Dissolved Organic Carbon

The MDEP 1999-2002 data also indicate that the PRW has the most darkly colored water and experiences the highest levels of DOC of any of the DPS rivers (Figure 4.6 - values are in mg/L; multiply by 4.0 to convert to ueq/L). Mean stormwater and baseflow DOC was 11 mg/L and a range of 2 to 40 mg/L (Table 4.9). DOC is naturally acidic, but also serves as a buffer (base) at low pH. DOC also moderates toxicity of Al and other metals (Hg, As, etc). Both natural processes and acid deposition influence the frequency and severity of episodic acidification in rivers (Whiting 2006). DOC and sulfate are approximately equal in value when expressed in chemical equivalents (about 40 ueq/L for both chemical species).

Figure 4.6. MDEP Baseflow and Stormwater DOC for the DPS Rivers, 1999-2002 (values are in mg/L, multiply by 4.0 to convert to ueq/L).

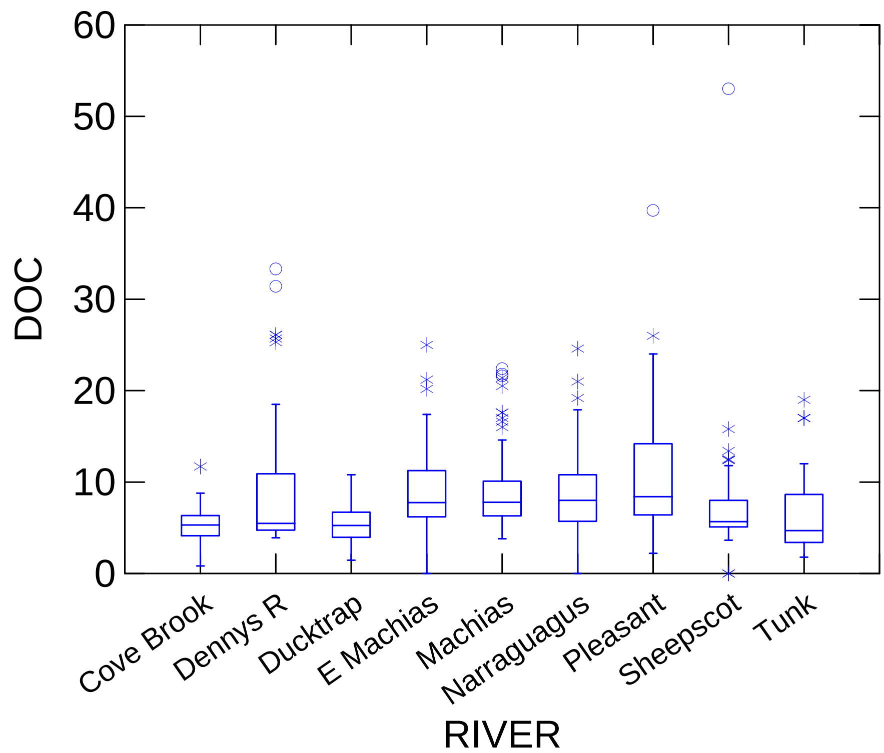


Table 4.9. MDEP DOC Means, Standard Deviations, and Ranges 1999-2002.

Pleasant River	DOC	N	Std Dev	Range
All samples, in mg	11	61	6.6	2-40
All samples, in ueq	44	61	26.4	8-160

<u>Sulfate Chemistry</u>

MDEP and UMGMC data from above and below the Great Heath suggest that the heath contributes some DOC and possibly some sulfate especially in the fall when the water table rises during precipitation events (Figure 4.7 and Table 4.10 all values are in ueq/L except for pH). The heath may also contribute some alkalinity since ANC and pH increase below the heath. This analysis is complicated by the fact that there are seasonal cycles in the ANC production and storage and subsequent release of acidic sulfur. For instance, there may be some sulfate storage in the wetlands in the summer (as reduced sulfur) with some release in the fall and winter as sulfate; this could be a seasonal acidity source.

Sulfates are important because they are primarily from air pollution, and thus are a change for our already acidic rivers. Sulfates have made the Downeast rivers more acidic than they were naturally; and, by reducing the alkalinity (ANC), they make these river more susceptible to acidic episodes. Low pH, high aluminum, and low Ca work synergistically to compromise fish health (M. Whiting, MDEP, Personal Communication, March 2007).

Recent studies by the UMGMC suggest that the low pH episodes that occur in the spring and fall in the Downeast rivers are a function of geology, percentage of wetland in the watersheds, and low base cation content (Kahl & Johnson, 2005). While acidic deposition does occur in the region (Driscoll et al. 2001), the data from Kahl and Johnson suggest that pH is a function of naturally occurring DOC (Table 4.10). High flows in the spring and fall dilute the already low base cation content thus reducing the buffering capacity of the rivers. High flows also mobilize large amounts of dissolved organic carbon (DOC) contributing to high levels of natural organic acidity that appears to be a major contributing factor to low pH events (Figure 4.8) especially in the fall. Data from Kircheis and DIll indicate that sulfate levels may not be influencing low pH events at least in the spring, which is when the experiment was conducted (Figure 4.8).

Figure 4.7. ANC, DOC, Lab pH, and Sulfate of Sites Above and Below the Great Heath, 1999-2002 (MDEP, 2006). The sites are arranged in order from the upper watershed (Worcester Camp) to the lower (Columbia Falls). The Great Heath is located between Crebo Crossing and the Saco Falls sample sites.

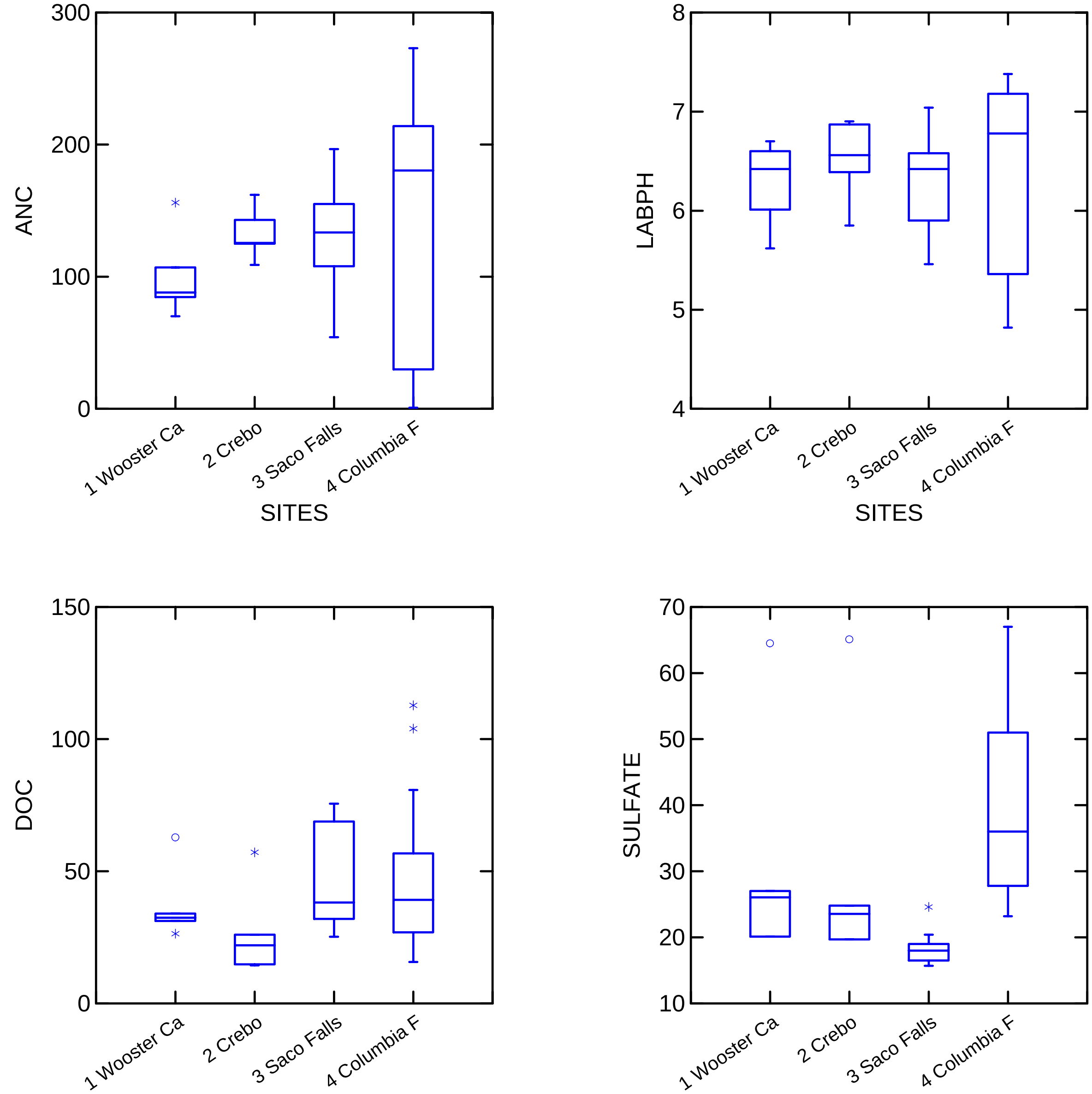
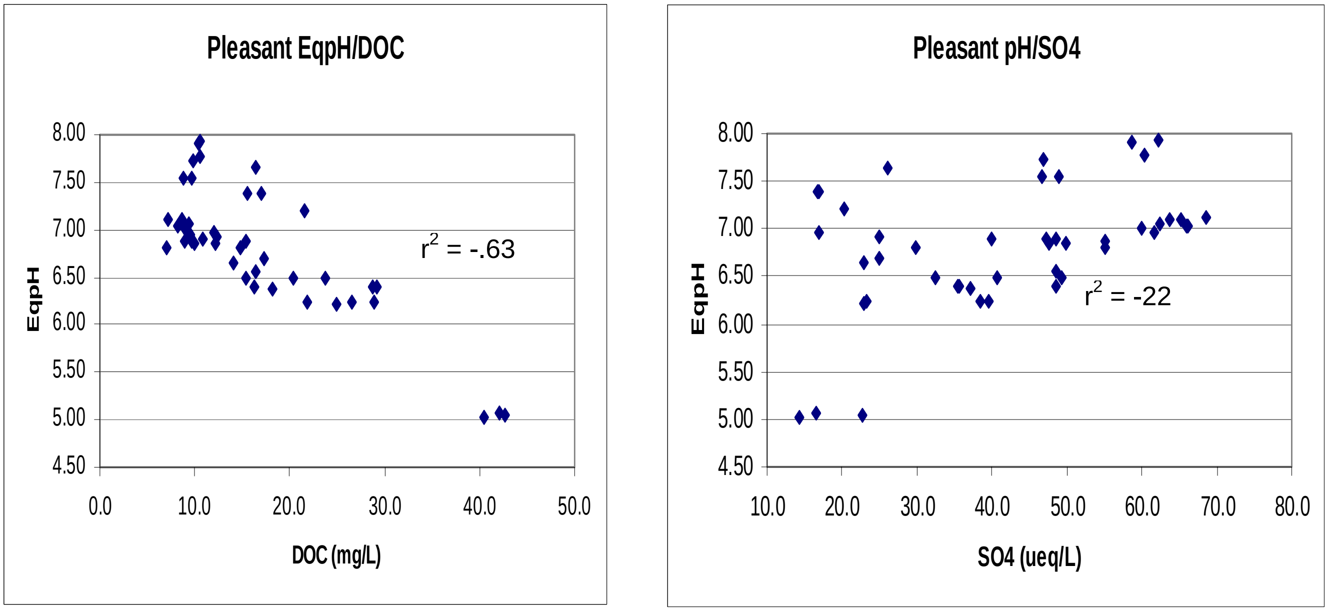


Table 4.10. Selected Sites from the UMGMC Fall 2003 DOC and EqpH results (Johnson and Kahl 2005)

Site	**Drainage**	**DOC (mg/L)**	**EqpH**
Rocky Brook	Narraguagus	27.9	5.13
Sinclair Brook	Narraguagus	22.6	5.25
Baker Brook	Narraguagus	23.4	5.99
Main Stem Rt. 9	Narraguagus	21.0	5.99
31-00-0 Road crossing	Narraguagus	21.9	6.10
Deblois Rt. 193	Narraguagus	17.2	6.76
W. B. Narraguagus (Sprague Falls)	Narraguagus	23.2	5.18
Bowles Brook, 58000 Rd	Machias	45.2	4.83
Holmes Brook on Holmes Falls Rd	Machias	40.6	5.10
Machias Rt. 9	Machias	22.9	5.65
Mopang 2nd Lake Outlet	Machias	6.0	6.78
Mopang above Penman Rips	Machias	27.1	5.00
New Stream, Guptil Road	Machias	37.5	4.73
Old Stream (Rt. 9)	Machias	26.7	6.10
Old Stream, Bear Brook Road	Machias	26.7	5.82
Beaver Dam Stream, Route 9	East Machias	25.0	5.32
East Machias, Gaddis Pool	East Machias	13.0	6.56
East Machias, Rt.9	East Machias	23.9	5.91
Northern Stream on 19000 Rd	East Machias	25.1	5.24
Seavy Stream, 85-00-00 Rd Bridge	East Machias	20.3	5.32
Dennys, Meddybemps Rt.191	Dennys	5.1	6.56
Dennys, Weir	Dennys	24.1	5.68
Cathance Stream, Route 86 crossing	Dennys	20.9	5.53
Cathance Stream, Flume at Dodge Rd	Dennys	17.4	6.19
Venture Brook, Venture Brook Road	Dennys	29.1	4.92
Dead Stream	Dennys	22.0	5.30
Crebo Crossing	Pleasant	13.5	5.87
Little River on Cross Rd	Pleasant	27.7	4.94
Pleasant River, Weir	Pleasant	25.7	5.30
Pleasant River, Pleasant Lake Outlet	Pleasant	8.9	6.36
West Little River	Pleasant	41.0	4.73
Saco Falls	Pleasant	24.5	5.11

Figure 4.8. Relationship between River pH and Dissolved Organic Carbon (DOC) and Sulfates (SO_4) in the Pleasant River, 2003-2004 (Kircheis and Dill 2006).

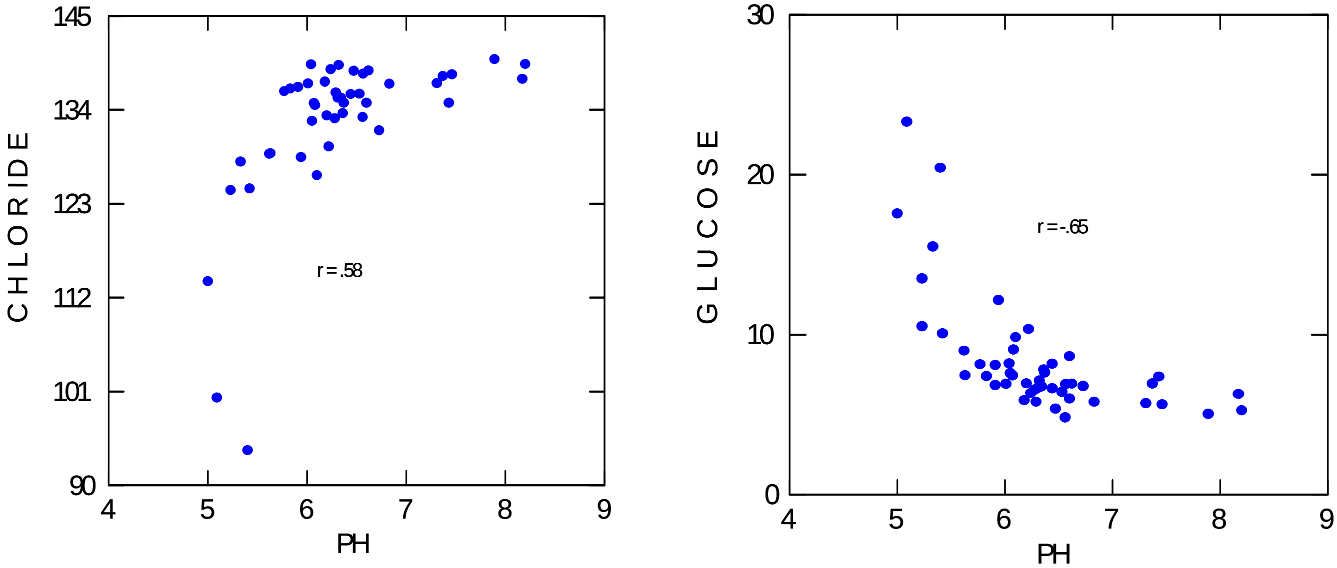


NOAA Streamside Study

A streamside rearing study was conducted on the Dennys and Pleasant rivers (2004-05), Kenduskeag stream (2004), and the West Branch Narraguagus (2005) by NOAA researchers to assess physiological impacts of ambient water chemistry on smolts.

The 2005 study showed no apparent water chemistry-related effect on smolt physiology at either of the two sites in the Dennys watershed. However, water chemistry did affect smolt condition at the two Pleasant River sites and the site on the West Branch Narraguagus. Smolts at both these rivers were exposed to pH levels near or below 5.5, and plasma chloride and plasma glucose levels indicate that these fish were suffering from moderate to severe stress as result of the low pH (Figure 4.9). However, Na+, K+-ATPase levels did not serve as a clear indicator of stress and gill aluminum levels gave no clear indication of aluminum related impacts.

Figure 4.9. Plasma Glucose and Plasma Chloride Levels of Smolts in the PRW. Streamside Study (Kircheis and Dill 2006).



Recommendations:

4.6 Agencies should determine historic water chemistry (pH, nutrient levels, etc) for DPS rivers; this can be accomplished using mussel shell analysis, lake cores, etc.

4.7 Agencies should develop a water chemistry sampling strategy to further identify temporal and spatial patterns of episodic low pH and organic/inorganic aluminum in rivers and tributaries that are identified as having significant Atlantic salmon habitat, and where existing pH data is limited.

4.8 Agencies and researchers should conduct studies designed to determine the direct and cumulative effects of low pH, low calcium, and high aluminum on salmon life stages.

4.9 Agencies and researchers should conduct studies designed to determine the effects of multiple stressors (e.g., low pH, low calcium, high Al, pesticides, high summer temperatures, etc) on various salmon life stages.

4.10 Agencies and NGOs should reconvene the liming committee and explore the possibility of conducting an experimental liming project on a small tributary.

Nutrients

The following information was presented to the PRWQMP Working Group by Mark Whiting, MDEP, March 2006.

MDEP and the PRWC collected baseflow and stormwater samples from 1999 to 2002. They have 47 baseflow and 33 stormwater samples. Compared to the other DE rivers, the Pleasant River has the highest percentage of agricultural land, specifically blueberry land.

Samples were analyzed at the UM Mitchell Center for calcium, alkalinity, DOC, nitrate, TP, sulfate, and pH. During the 4-year monitoring period, mean calcium was 1.9 mg/L and ranged from 0.8 to 4.2 mg/L; mean alkalinity was 6.8 mg/L and ranged from 0 to 18.4 mg/L; mean DOC was 11 mg/L and ranged from 2.2 to 39.7 mg/L; mean nitrate was 0.18 mg/L and ranged from 0 to 0.81 mg/L; and mean TP was 26.5 µg/L and ranged from 0 to 110 µg/L (Table 4.11). These values are consistent with the other DE rivers although nitrates and TP are slightly higher in the Pleasant than in the other DE rivers (Figure 4.10). Recent studies by Reinhardt et al. (2004) show that most of this TP is bound with aluminum and is probably not biologically available in our rivers.

Table 4.11. Mean Nutrient Levels for the Pleasant River (mg/L except TP µg/L) 1999-2002 (MDEP, 2006). *Note that the mode (the most common measurement) for nitrate is zero (these are mostly baseflow values)*

Pleasant R	Ca	Alkalinity	DOC	Nitrate	TP
N	61	58	61	60	57
Mode	1.9	6.5	6.4	0	26
Mean	1.9	6.8	11	0.18	26.5
Std Dev	0.6	3.8	6.6	0.18	20.4
Range	0.8-4.2	0.0-18.4	2.2-39.7	0.00-0.81	0.00-110

Within the Pleasant River watershed, calcium varies very little between sites and ranges from 1 to 3 mg/L (Figure 4.11). Calcium concentrations below 4 mg/L are stressful for many fish species, and concentrations below 2 mg/L are stressful for almost any fish species (Brocksen et al. 1992). Although the current literature states that 2.5 mg/L is the minimum level of calcium for most aquatic organisms, recent studies suggest that salmonids require more calcium for optimum health and reproduction. A recent MIFW report finds that brook trout grown in low ambient dissolved calcium grew significantly larger than treatment groups but had significantly more skeletal deformities, elevated gill Na+/K+ ATPase levels, and significantly poorer egg survival as broodfish (Danner 2007).

Alkalinity, nitrates, and TP, however, show greater variability between sites and in some cases there is great variability at one site. For instance, alkalinity varies from 0 to 18 mg/L at Eastern Little River (ELR). Bog Stream appears to have elevated nitrate and TP levels possibly due to the presence of a fish hatchery. Columbia Falls and ELR both experience elevated turbidity at some times of the year. Elevated levels of turbidity, nitrates, and TP occurred primarily during fall months and are associated with precipitation events (Figure 4.12).

Nitrates

The mean nitrate level for the PRW during 1999-2002 was 0.18 mg/L with the highest levels occurring during high flow. Background total N levels for Maine are approximately 0.15-0.30 mg/L (Smith et al. 2003) to 0.38 mg/L (EPA 2001) for total N (~0.19 mg/L NO3). Atmospheric deposition is approximately 1.0 mg/L nitrate (wet), plus dry deposition (NADP website http://nadp.sws.uiuc.edu) but forest soils are generally nitrogen limited and most nitrate is taken up by the forest. Streamside vegetation also takes up approximately 50% of available nitrogen in surface water (Peterson et al. 2001).

MDEP Biomonitoring Program data (2001) indicate that in the Downeast area total N is 100 times or more than the nitrate concentration (Table 4.12). Total N is made up of organic N, nitrate, nitrite, and ammonia. Nitrite and ammonia are generally low in Downeast streams and in unpolluted waters in general, so most of the total N is in the organic form. Organic and total N were not measured in the 2001 study, but the recommended national background levels are given as total N. So while the nitrate levels are low, if the levels are multiplied by 200 to 400 times (taken from the biomonitoring table), the total N values Downeast are very high in comparison to national and regional standards.

Total Phosphorous

In Maine, background TP levels range from 10-17 µg/L with a mean of approximately 13 µg/L (Smith et al. 2003). Mean TP for the PRW during 1999-2002 was 26.5 µg/L which appears to be considerably higher than state background levels. The TP levels in the PRW are higher than the Kenduskeag tributaries (French and Allen Streams and Burnham Brook) and are similar to the urban Penjajawock Stream (Table 4.12, values are mg/l except TP ug/L).

Although Downeast rivers are generally classified as oligotrophic (low productivity), they are apparently not limited by the amount of nutrients present. For instance, phosphorus is known to be strongly bound by aluminum (which is abundant in these streams due to acidic soils). This may make phosphorus largely unavailable for biological uptake (Rienhardt et al. 2004). TP values in the PRW are strongly correlated with total suspended solids (TSS) and turbidity. High flows with high TSS and turbidity are also high in dissolved and particulate aluminum.

Figure 4.10. MDEP Nutrients Levels for all Rivers in the DPS (mg/L except TP µg/L), 1999-2002.

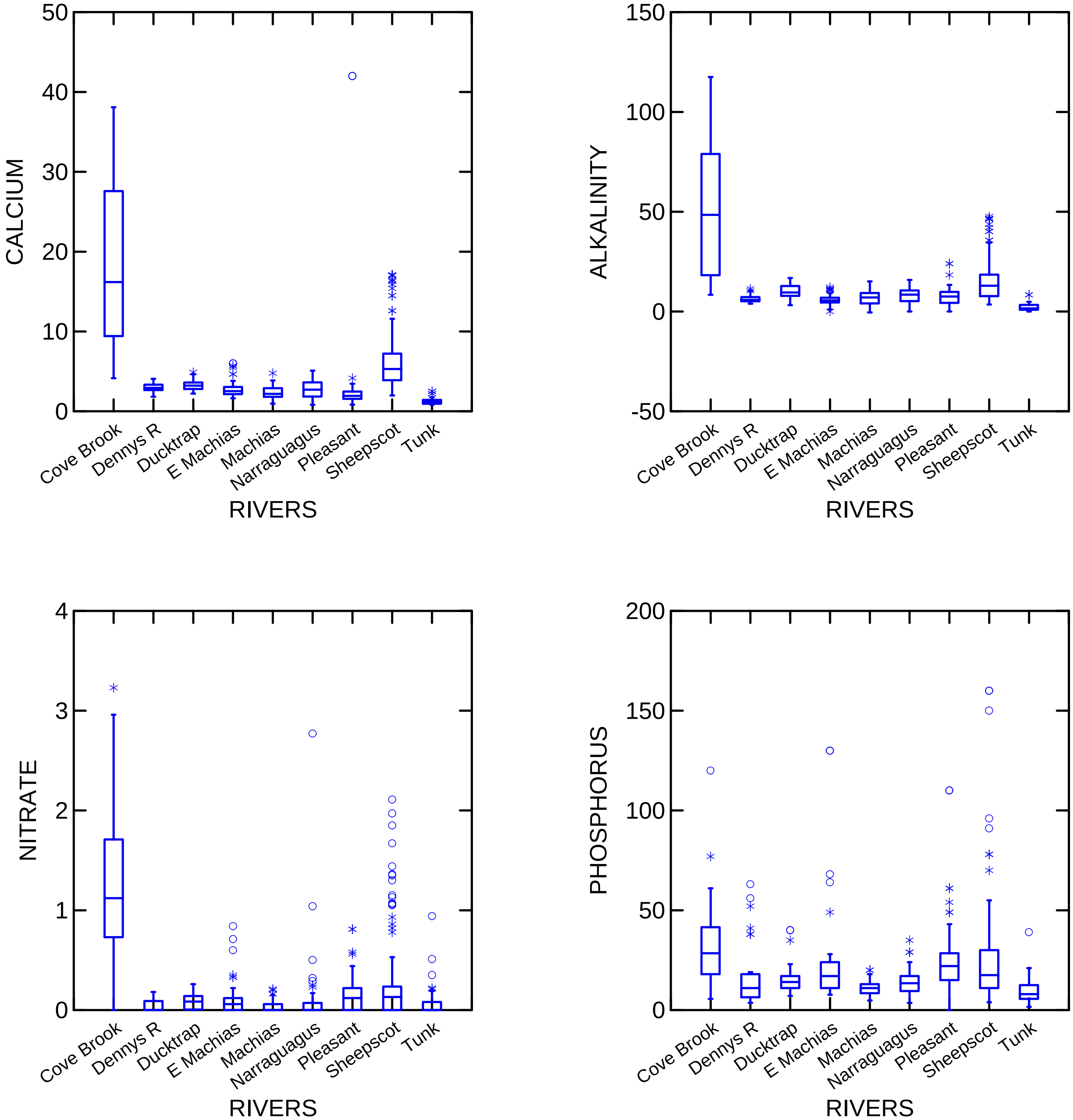


Figure 4.11. MDEP Nutrient Levels in the Pleasant River (mg/L except TP µg/L), 1999-2002.

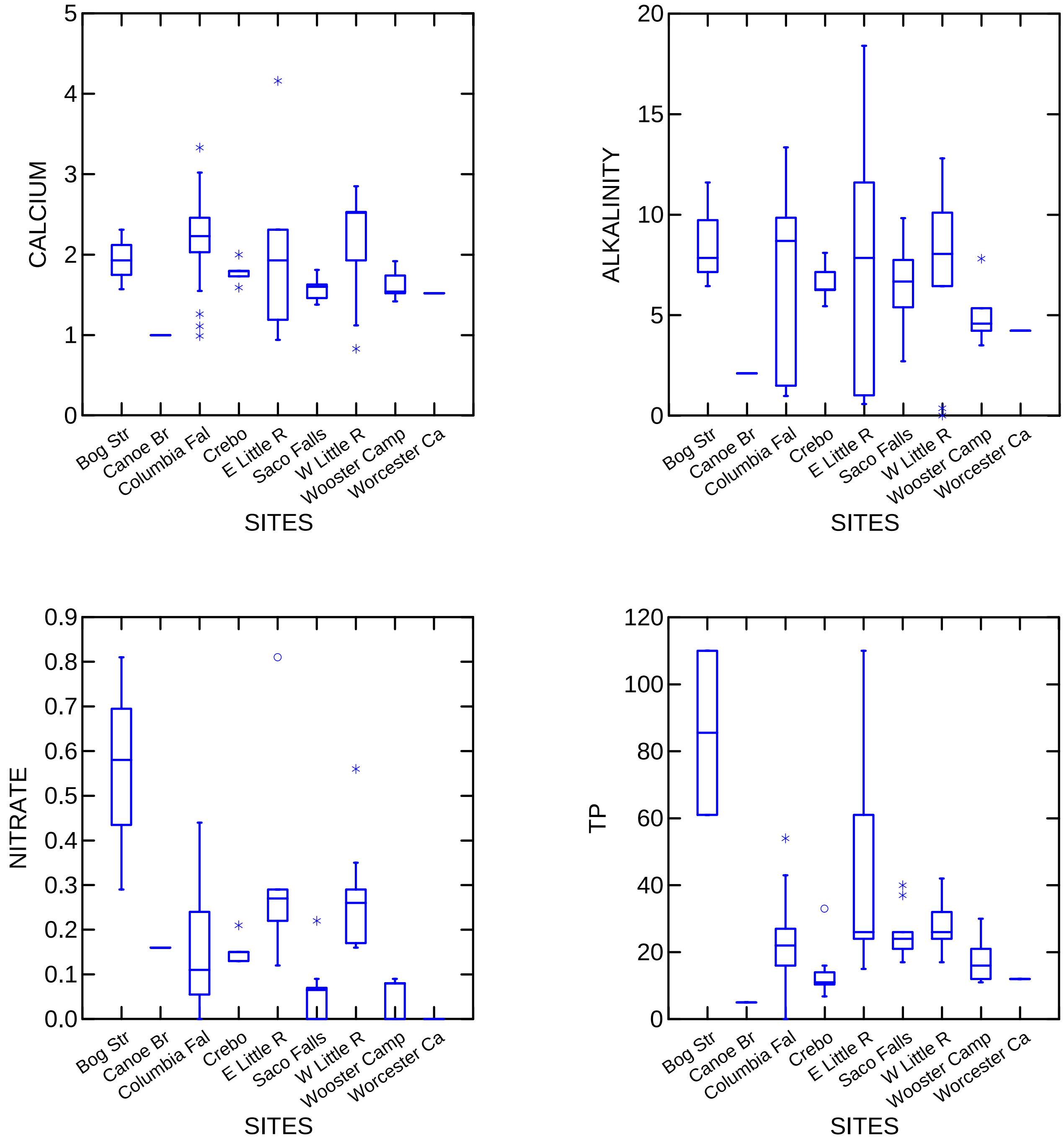


Figure 4.12. Seasonal Nitrate and TP for PRW (mg/L except TP µg/L), 1999-2002.

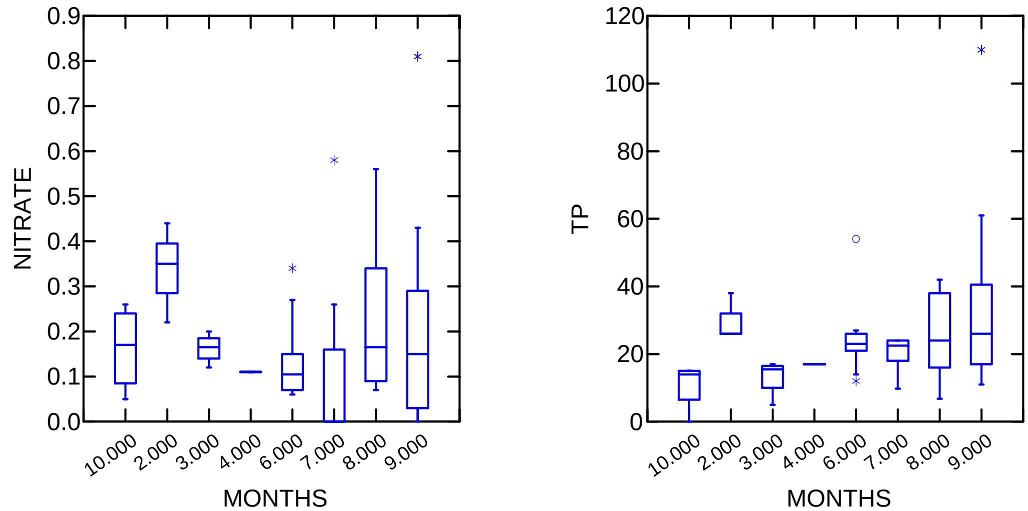


Table 4.12. Nutrients Levels from Bangor and Kenduskeag tributaries and Downeast rivers, 2001 (MDEP Biomonitoring Program, 2001).

	Date	DOC	NO3	TN	TP	TSS
Birch Stream	7/20/2001	3	0.413	0.709	27	2.2
Shaw Brook	7/20/2001	6.1	0.069	0.45	16	1
Reeds Brook	7/20/2001	6.4	0.236	0.657	14	4.9
Penjajawock Stream	8/3/2001	2.1	0.957	1.267	26	2.5
Penjajawock Stream	8/3/2001	4.9	0.206	0.662	37	22
Penjajawock Stream	8/3/2001	4.4	0.007	0.359	19	7.8
Penjajawock Stream	8/3/2001	4.4	0.037	0.456	18	2.9
Penjajawock Stream	8/3/2001	3.5	0.046	0.473	11	4.2
French Stream	8/2/2001	8.9	0.064	0.79	24	2.3
Allen Stream	8/1/2001	7.1	0.445	0.911	13	1.3
Footman Brook	8/1/2001	12.4	0.096	0.815	15	12
Burnham Brook	8/1/2001	2.2	0.36	0.829	21	6
W Branch Pleasant R	7/19/2001	3.1	0.001	0.236	9	4.9
E Machias R	7/26/2001	8.1	0.001	0.361	12	0.6
Machias R	7/27/2001	8	0.001	0.296	14	1.8
Machias R	7/26/2001	7.4	0.001	0.399	11	0.2
Narraguagus R	7/26/2001	6.4	0.002	0.307	11	0.2
Chandler R	7/26/2001	10.4	0.008	0.475	28	0.2

Recommendations:

4.11 MDEP nutrient monitoring should continue and should include sampling for Total N.

4.12 Freshwater nutrient data should be linked to marine derived studies (see below).

4.13 A river-specific comprehensive nutrient budget and productivity study that measures overall ecosystem integrity and functionality (nutrient and energy budgets, trophic sources, presence/absence of functional groups, diversity, etc) should be conducted in order to determine if each river has enough nutrients and food sources to support all salmon life stages.

Marine-Derived Nutrients

The following graphics and information was provided by Theo Willis, May 2006.

Anadromous fish may contribute to freshwater systems through a variety of mechanisms. They import marine-derived nutrients (MDN) through death, excretion, and reproduction; they alter habitat via nest construction; and they export nutrients via smoltification. The import of nutrients may increase primary productivity and invertebrate productivity and nest construction may reduce siltation and trigger invertebrate emergence (Moore et al. 2004).

Cultural oligotrophication is the process whereby a suite of anthropogenic influences, such as extensive timber harvesting, loss of diadromous species, and acid precipitation removes nutrients from freshwater systems. Nislow et al. concluded that continuing to stock and produce smolts from a system where adults lack access, and other labile phosphorous inputs are limited, ensures a net loss of P via smolts. If smolt production and P are positively associated, P loss should eventually result in lower smolt production and a smaller yearly loss of P such that the overall production and P flux stabilizes at some lower level. The same study also found that ammonia levels were found to increase substantially in the presence of migrating alewife; a single spawned out alewife carcass yields on average 3.6 g N and 0.6 g P; and a single spawned out alewife produces 1.2 g N and 0.2 g P. A typical freshwater system will need 500-900 alewife carcasses or 1,500-2,700 living alewives to balance losses.
MDEP data from 1969-1970 and 1999-2002 suggest that there has been a general decrease in nutrient status (and subsequent oligotrophication) occurring in the DPS rivers over this time period. The data indicate that average TP (combined baseflow and stormwater) and baseflow nitrates have decreased over time (Table 4.13).

Table 4.13. Average Total Phosphorous and Average Baseflow Nitrate Levels for Several DPS Rivers Using MDEP Data, 1969-1970 and 1999-2002. *Areas highlighted in yellow represent decreases in those nutrients*.

	DPS River Ave TP µg/L (1969-1970)	DPS River Ave TP µg/L (1999-2002)	DPS River Ave Baseflow NO3 mg/L (1969-1970)	DPS River Ave Baseflow NO3 mg/L (1999-2002)
Sheepscot	143	28	0.14	0.18
Ducktrap	N/A	16.5	N/A	0.1
Narraguagus	127	14.0	0.12	0.08
Pleasant	N/A	28.2	N/A	0.16
Machias	139	10.9	0.11	0.02
E. Machias	N/A	24.0	N/A	0.07
Dennys	N/A	18.8	N/A	0.03

Recommendations:

4.14 Design a mark and recapture study designed to capture immigrating and emigrating diadromous species during their peak migrations in order to get a better understanding of their current population structure and potential nutrient contribution. Species of particular interest include American eel, alewife, and anadromous brook trout.

4.15 All fisheries management agencies should adopt ecosystem-based management principles and develop river-specific fisheries management plans to ensure all species are properly managed. Models from other rivers, such as the Penobscot, could be used on all DPS rivers.

4.16 Restoration activities should focus on ensuring passage (maintain fishways), restoring native fish assemblages, and restoring ecological functions (e.g., West Branch restoration).

4.17 Fisheries management agencies should work together to gather accurate data on return rates of diadromous species (e.g., recording the number of fish in smolt traps, etc).

4.18 Design a study to determine if marine derived nutrients have an impact on salmon spawning and rearing habitat and if these nutrients are limited in the salmon watersheds. Experimental results from other rivers could be used on all DPS rivers.

4.19 Fisheries management agencies should investigate what impact if any restored diadromous fisheries will have on existing recreational freshwater fisheries

Biomonitoring and Macroinvertebrates

The following information was presented by Mark Whiting, MDEP to the PRWQMP Working Group, March 2006.

MDEP Biological Monitoring Program

The MDEP Biological Monitoring Program assesses the health of rivers and streams by evaluating the composition of resident biological communities. The program has been sampling locations throughout Maine since 1983, and by late summer 2002 had established more than 650 monitoring stations on approximately 232 rivers and streams. Data collected in accordance with Maine's biocriteria protocol are analyzed using statistical models, whose results estimate the association of a sample to the four water quality classes defined by Maine's Water Classification Program. Findings of the Biological Monitoring Program are used to document existing conditions, identify problems, set water management goals, assess the progress of water resource management measures, and trigger needed remedial actions (MDEP 2002).

The program uses rock baskets or rock bags as artificial substrates, which are colonized for 4 weeks, retrieved and macroinvertebrates are sorted, identified, and counted. Macroinvertebrates are used in this model because they are extremely diverse, have limited mobility, represent a wide range of pollutant tolerances, and the evaluation methods are cost-effective and well established. Pollution sensitive taxa include Ephemeroptera (mayflies), Plecoptera (stonefiles), and Trichoptera (caddisflies). Pollution insensitive taxa include Diptera (true flies). Density, diversity, and metrics are calculated and a statistical predictive model is used to determine if the sites meet water quality criteria for state classifications (see Chapter 2). Results between 1989 and 2001 (Table 4.14) indicate that while the mainstem at Crebo Crossing attained its class status in 1999 and 2001, Bog Stream failed to attain in 1989 and 2001and No Name Stream failed in 1996. Nonattainment is attributed to hatchery effluent and possible agricultural NPS. In 2006, East Little River, West Little River and the MS at Crebo Crossing were monitored but results were not available at the time of this report.

Table 4.14. MDEP Biomonitoring Sites and Attainment Status Within the PRW..

	Site	Class	Attainment	Pollution Source	Year
Pleasant R	Crebo Crossing	AA	Yes	Agriculture NPS	2001
Pleasant R	Crebo Crossing	AA	Yes	Agriculture NPS	1999
Trib	Bog Stream	B	No	Hatchery	1989
Trib	Bog Stream	B	No	Hatchery	1989
Trib	Bog Stream	B	No	Agriculture NPS	2001
Trib	No Name	A	No	Agriculture NPS	1996

Index of Biological Integrity

The following information was presented by Adria Elskus, USGS, to the PRWQMP Working Group, March 2006.

An Index of Biotic Integrity (IBI) measures several metrics of a biological assemblage (e.g. fish or macroinvertebrates) to arrive at a single numerical value for site integrity (e.g., sensitive/resilient species, trophic composition, health/condition). '[IBI] integrates information from individual, population, community, zoogeographic and ecosystem levels into a single ecologically based index of the quality of a water resource' (Karr et al. 1986).

The greatest benefit of the IBI process is that, unlike the benthic macroinvertebrate index currently used by MDEP (Predictive Statistical Model), the IBI relies on several measures of ecosystem integrity. Like the macroinvertebrate index, the IBI is systematic, quantitative and incorporates professional judgment. It is best suited for sites for which there are large data sets on complex communities; it is not suitable for single-species. The IBI generates a total score that categorizes a site as good, fair or poor based on the reference sample that is used.

Determining the IBI for the Pleasant River would tell us if the system is balanced, self-sustaining, and resilient. When used over time, it would also provide an indication of whether the site is improving, degrading, or experiencing no change. It is not recommended that an IBI be conducted in lieu of the MDEP Predictive Statistical Model but rather that it be conducted in addition to the MDEP protocol.

Recommendations:

4.20 A study to determine the IBI should be conducted in order to determine the presence/absence of appropriate taxa (this should be done in addition to the MDEP Predictive Statistical Model).

4.21 MDEP should continue to biomonitor W & E Little rivers, Crebo Crossing, and Saco Falls. They should add Meyers and Coffin ponds and the West Branch to their wetlands monitoring program.

Bacteria

The following graphics and information was provided by John Fendle, MDMR, November 2006.

MDMR maintains 10 bacteria monitoring programs in the estuary and PR Bay as part of the state's Shellfish Sanitation Program. The goal of the program is to protect public health by ensuring that shellfish are harvested from pollution-free areas and are processed and transported under sanitary conditions.

A random sampling method is used in order to obtain an understanding of WQ in varying conditions such as seasonal variation, tides, and weather changes. Sites are sampled a minimum of six times per year to maintain open approved status. Classification of a site is based on the statistical average of the 30 most recent samples, the "90^{th} percentile" (P90), or the number of colonies per 100 ml sample. Table 4.15 summarizes the classification standards of the shellfish sanitation program. Sites may also be closed if they are downstream from known discharges regardless of bacteria levels.

Table 4.15. MDMR Water Quality Classification.

Classification	**P90**	**Geometric Mean (gm)**	**Definition**
Approved	<49	<14 mpn*	Open. No sewage pollution or red tide
Conditionally Approved	<49	<14 mpn	Open unless there is > 1 inch rainfall in 24 hour period. Examples include sewage treatment plant or marina.
Restricted	<300	<88 mpn	Depuration harvest only. Slightly polluted area; harvest under strictly regulated conditions by licensed operation that purifies shellfish before sale.
Prohibited	>49	>14 mpn	Closed. Actual or potential sewage or red tide or lack of sufficient data.

mpn= Most Probable Number

Only one of the ten MDMR sampling sites is closed (prohibited) to shellfish harvesting (Table 4.16). The mainstem from head of tide in Columbia Falls south to Dyer Cove in Addison is closed not because of elevated coliform levels but because of the presence of 10 overboard discharge septic systems (OBDs) in the towns of Columbia Falls and Addison. This type of system must be maintained by its owner and although inspected by MDEP, often release untreated bacteria/sewage into the river.

Table 4.16. Fecal Coliform Levels in the Pleasant River Estuary as of November 2006.

Station	Geometric mean	p90	Approved/prohibited AREA
EM001.00	4.4	18.3	Approved
EM003.00	5.5	26.2	Approved
EM005.00	3.9	7.7	Approved
EM006.00	5.2	26.7	Approved
EM007.00	6.6	46.2	Approved
EM010.00	7.4	27.6	Prohibited
EM011.00	9.4	67.3	Approved
EM012.80	3.9	11.2	Approved
EM013.00	7.0	41.7	Approved
EM014.00	3.8	9.1	Approved

Recommendations:

4.22 Continue current level of bacteria monitoring. No new monitoring is recommended at this time.

4.23 PRWC and towns should work with MDMR , MSPO, and MDEP to replace OBDs and ultimately open shellfish areas which are now closed due to sanitation closures.

Pesticides

The following information was presented by Heather Jackson, MBPC, to the PRWQMP Working Group in March 2006.

The Maine Board of Pesticides Control (MBPC) has been monitoring blueberry pesticides in the Downeast Atlantic salmon rivers since 1997 and in area ground water since 1994. Currently, MBPC monitors for blueberry pesticides in the Pleasant and Narraguagus Rivers most summers, and monitors ground water statewide every four years.

Groundwater Studies

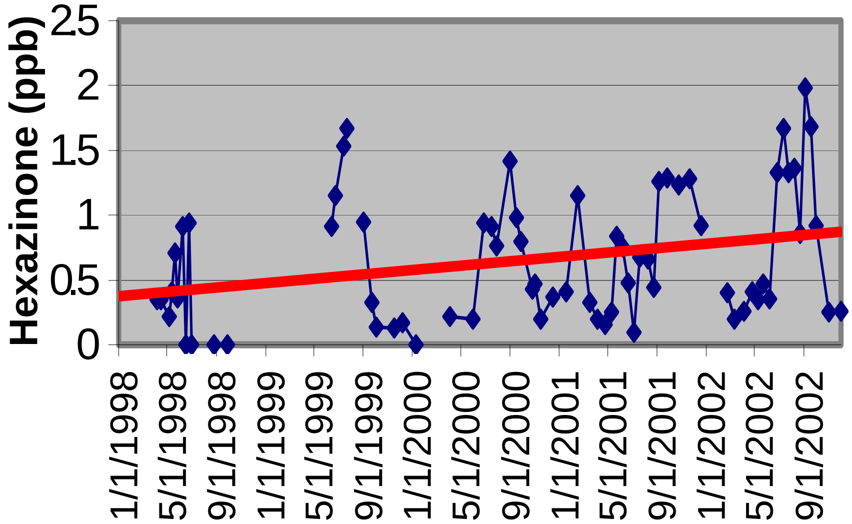
Hexazinone has been the only blueberry pesticide detected in MBPC ground water studies. Between 1994 and 2002, approximately 42-75 % of wells sampled (wells within ¼ mile downgradient of active blueberry fields) contained hexazinone. The concentrations of hexazinone found are almost always below 12 ppb and usually below 2 ppb. The health advisory level (HAL) for hexazinone is 400 ppb, which according to EPA, is neither lethal nor sublethal to humans.

Surface Water Time Series

Between 1998 and 2002, the MBPC conducted a Time Series Study of the Pleasant River. The goal was to determine the amount of hexazinone present at one sampling site during the course of five years as well as the variations in concentration in relation to the times of pesticide applications (usually spring of a non-bearing year).

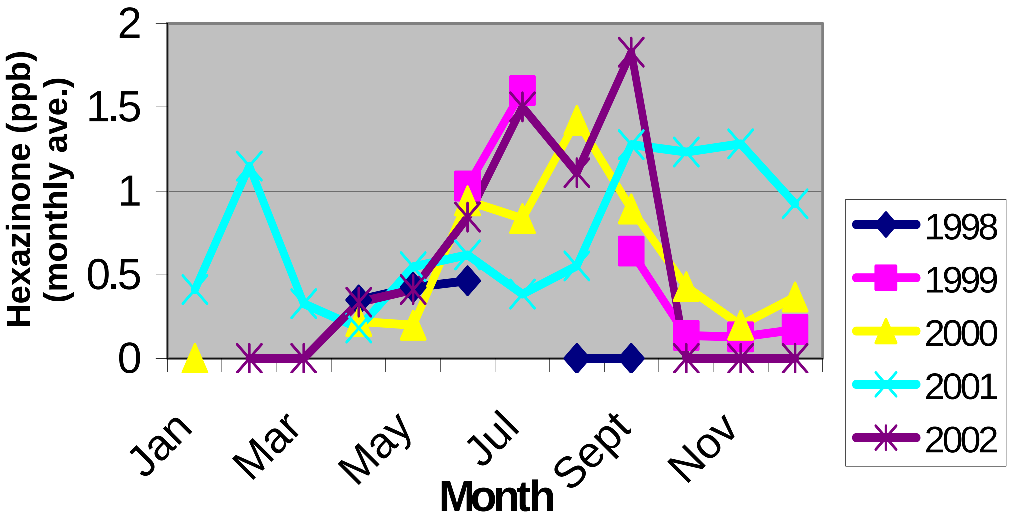
Results from this study show that hexazinone can be present in the Pleasant River every month of the year (Figure 4.13). Concentrations of hexazinone are low (0-2 ppb) compared to EPA's drinking water Health Advisory (400 ppb). There are no established guidelines for surface water.

Figure 4.13. Pleasant River Time Series, 1998-2002.



An annual comparison of the same data (Figure 4.14) indicates that the level of hexazinone in the river varies seasonally suggesting that slightly higher levels in the summer and fall may be the correlated with application and precipitation events. It is unknown if time series levels would be reduced today since hexazinone use is less now than it was during 1998 through 2002.

Figure 4.14. Pleasant River Time Series Comparison by Year, 1998-2002.



Spring Study

In 2000, the MBPC collected samples from seven mapped springs in the MS in an effort to determine which blueberry chemicals were entering the ground water and ultimately entering the river via springs. The spring locations were obtained from the US Fish and Wildlife Service. The samples were analyzed for 11 blueberry chemicals and only hexazinone was found. Eight out of ten samples were positive and levels ranged from 0.17 to 3.08 ppb.

Tributary Study

In 2000, the MBPC collected samples from tributaries in an effort to determine hexazinone concentrations in the smaller bodies of water. The samples were analyzed for hexazinone only and eight of eleven samples were positive ranging from 0.4 to 1.4 ppb.

Drift Studies

Between 1999 and 2004, the MBPC conducted pesticide drift studies in the PRW. Drift cards were placed between the river/stream and blueberry fields during the time of aerial pesticide application to determine the extent to which pesticides enter the waterways. The studies showed some pesticide drift to water resources at 1000' from target areas (low levels) in four of six years. Of all of the pesticides that are aerially applied, phosmet was the most commonly found.

Of the 12 sites monitored between 2000 and 2004, five sites had no detections of phosmet (Table 4.17). Seven sites had detects in the water sample, on the drift card filters, or both. Filter samples ranged from ND to 2.30 µg and the sites with the highest amount of phosmet were the south side of Montegail Pond, which drains to Western Little River. Other sites with phosmet detects on drift cards include Colonel and Longfellow brooks.

Phosmet levels ranging from ND to 3.76 ppb were found in water samples from the mainstem at Crebo Crossing, Colonel Brook, Ingersoll Branch, Bog Stream, and two sites on the south side of Montegail Pond. The site with the highest level in water was Bog Stream. These levels are well below the established LC50 for all organisms (58 to 37,000 ppb) and both major blueberry companies have abandoned aerial spraying of pesticides in 2005.

Blueberry pesticide sampling, in the Pleasant River watershed, was not conducted in 2005 and 2006. In 2005, MBPC focused on rain event residential pesticide sampling, corn herbicide sampling, potato pesticide sampling, and sampling in the Sheepscot River watershed. The legislature has directed MBPC to monitor drift from pesticide applications to control brown tailed moth during the spring of 2006, as these applications may pose a risk to some marine organisms.

Table 4.17. Summary of MBPC Pleasant River Phosmet Sampling, 2000-2004

Site	Years Sampled	Phosmet in Water	Phsomet on Drift Card
14BPCS042 Pleasant R. / boat launch	2002, 2004	ND	NA
14BPCS043* Pleasant R. – Crebo	2000, 2001, 2003	ND - 0.253 ppb	ND
14BPCS051* Colonel Bk.	2000, 2001, 2003	ND – 0.1 ppb	0.731 µg
14BPCS052 Ingersoll B.	2001, 2002	ND - 0.815 ppb	ND
14BPCS053 Taylor Bk	2000	ND	ND
14BPCS057 Longfel Bk./ E Smith P	2000	ND	ND – 0.688 µg
14BPCS058* Bog St	2000, 2001	ND – 3.76 ppb	ND
14BPCS061 West Ingersoll	2001	ND	ND
14BPCS063 Long P	2003	ND	NA
14BPCS064 Montegail Pd. S.	2003, 2004	ND – 1.95 ppb	0.50 – 2.296 µg
14BPCS065 Montegail P.SW	2003, 2004	ND – 0.28 ppb	ND – 1.455 µg
14BPCS066 Pretty P	2003, 2004	ND	NA

* = site received hit(s) of propaconizole, chlorothalonil or fenbuconazole

<u>Recommendations:</u>

4.24 Monitoring and studies should be regularly updated to include new pesticides being introduced on the market.

4.25 MBPC should continue GW & SW long-term monitoring in order to compare new data with past results and to detect trends.

4.26 MBPC should include fungicide monitoring in the PRW.

4.27 All agencies should encourage the use of passive samplers when sampling for pesticides in order to improve sampling timing and save costs

4.28 2010 GW sampling for hexazinone should be reviewed by scientists and other stakeholders and appropriate actions taken.

4.29 A study should be conducted to ascertain if the new ground application of pesticides is reducing the amount of pesticide entering the water.

4.30 Agencies should encourage growers to use Integrated Pest Management

Multiple Stressors

The following information was provided by Adria Elskus, USGS, January 2007.

Maine rivers and lakes feature a broad range of stressors, including acidity, aluminum (Al), endocrine-disrupting chemicals, organochlorines and pesticides. Many of these are present simultaneously. Exposure to a mixture of contaminants could have effects on fish that would not be predicted from exposure to individual stressors alone. For example, co-exposure of amphibians to the insecticide carbaryl in the presence of predator scent increased carbaryl toxicity 2-4 fold relative to carbaryl exposure alone (Relyea et al. 2001). Similar effects have been seen for herbicides (Relyea 2005). Temperature stress can also compound chemical toxicity, with higher temperatures increasing the sensitivity of oysters to cadmium (Sokolova 2004). Even in situations where, individually, the chemicals may be beneficial, such as increased biomass of algae and tadpoles in the presence of insecticide or fertilizer, combining insecticide with fertilizer can be deleterious (Boone et al. 2005).

Of particular concern for fish in Maine's Downeast rivers (Washington County) is the combination of blueberry pesticides, acidic water and elevated levels of Al, each of which has been implicated in hindering salmon recovery (National Research Cnouncil 2004). The MBPC has consistently detected blueberry pesticides, including phosmet and hexazinone, in Downeast rivers (Jackson 2003). During spring and fall rains, these rivers experience dramatic fluctuations in acidity, reaching pH levels as low as 4.6 (Kircheis et al. 2006). Elevated acidity induces the release of sediment-bound aluminum into the overlying water (Gensemer et al. 1999). One result is that fish are developing in the presence of blueberry pesticides (0.2-3 ppb), highly acidic water (pH<5.6) and elevated levels of aluminum (Al;>70 ppb), a multiple-stressor combination that may seriously compromise development, physiological processes and fitness. While acidic conditions toxic to fish (Lydersen er al. 2002) can be exacerbated in the presence of aluminum (Driscoll et al. 1980; Staurnes et al. 1993), how acid/Al conditions and pesticides interact to affect toxic potency is completely unknown.

An additional concern is the need for information on the potential effects of proposed changes, including alterations in pesticide usage and plans to neutralize river acidity. For example, the Maine blueberry industry currently proposes to replace two of the pesticides found consistently in Maine rivers, phosmet and hexazinone, with candidate alternatives, spinosad and mesotrione, for which fish early life stage effects have not been evaluated. Plans by NOAA-Fisheries to neutralize the acidity of Downeast rivers as a mitigation tool have been put on hold until more information is available on the potential beneficial/detrimental effects of this action (Kircheis 2006).

There are known hazards to fish associated with the current-use pesticides (EPA 1988; Nieves-Puigdoller at a. 2004), but little information exists on proposed alternatives. Phosmet is a cholinesterase inhibitor that affects muscle contractions, respiration, is extremely toxic to many fish species (EPA 1988; Orme et al. 2004) and, like other organophosphates, may deleteriously affect fish immune function(Galloway et al. 2003; Harford et al. 2005) and behavior (Levin et al. 2003; Swain et al. 2003). Phosmet pulses have been detected in July in Downeast rivers in every year sampled (2000, 2001, 2003) (Jackson 2003), yet phosmet continues to be used, with caution, because of its low water solubility and short half-life (hours to days). Recent work has shown, however, that even short-term exposure to pesticides that degrade rapidly in the environment can have lasting, deleterious effects to aquatic life (De Guise et al. 2004). Spinosad, the proposed alternative to phosmet, is a bacterial fermentation product. It is considered only slightly toxic to early life stage trout (0.962 ppm lowest observable effects concentration). Its effects on the nervous system of insects (hyperstimulation of muscle contractions) occur through biological receptors present in both vertebrates and invertebrates (Salgado 1998; Salgado et al. 2004), suggesting it could also have sub-lethal, behavioral effects in fish.

The current use herbicide, hexazinone, has a long half-life and can have sub-lethal effects on respiration in early life stage fish (Nieves-Puigdoller et al. 2004). Because of hexazinone's propensity to enter and remain in the groundwater, the herbicide mesotrione has been proposed as an alternative (D. Yarborough, Univ Maine Blueberry Extension, pers comm.). Mesotrione is not persistent in water or soil, but it's degradates are mobile and may contaminate groundwater, particularly in cold climates with low pH soils (EPA 2001), conditions which define the Downeast river watershed. Mesotrione inhibits carotenoid biosynthesis in plants but is considered virtually non-toxic to fish based on acute 96 h exposure studies (EPA 2001); however, the effects of mesotrione on fish early life stages are unknown.

Recommendations:

4.31 Initial multiple stressor studies involving low pH, pesticides, and aluminum have been conducted; further studies should be conducted in order to determine specific interactions and long term effects.

4.32 Conduct study to evaluate the potential effects of candidate pesticides on fish sensitive early-life stages before these pesticides come into use.

4.33 Conduct study to determine whether neutralization of pesticide-contaminated river water is protective.

Contaminants

US Fish and Wildlife Service Contaminant Screening

The following information was presented to the workgroup by Steve Mierzykowski, USFWS in March 2006.

The Pleasant River was included in a USFWS/MASC/USGS screening-level contaminant assessment of the eight DPS Atlantic salmon rivers. In the assessment, composite samples of whole-body white suckers were analyzed for organochlorine compounds (e.g., Total PCBs, DDT metabolites, etc.) and trace elements (e.g., mercury, copper, etc.).

In 2003, white suckers were collected from three locations on the Pleasant River for the residue analysis portion of the study. One composite sample of two fish was collected from Saco Falls, one composite sample of five fish was collected near the Farren Camp, and a single fish was collected below the Pleasant River Lake outlet. In 2006, a single fish was collected in Pleasant River Lake. Tissue was analyzed for 22 organochlorine compounds: HCB (hexachlorobenzene), PCB-Total, alpha BHC (hexachlorocyclohexane), beta BHC, gamma BHC (lindane), delta BHC, alpha chlordane, cis-nonachlor, dieldrin, endrin, gamma chlordane, heptachlor epoxide, mirex, o,p'-DDD, o,p'-DDE, o,p'-DDT, oxychlordane, p,p'-DDD, p,p'-DDE, p,p'-DDT, toxaphene, and trans-nonachlor. Inorganic analysis included Al, As, B, Ba, Be, Cd, Cr, Cu, Fe, Hg, Mg, Mn, Mo, Ni, Pb, Se, Sr, V, and Zn.

Preliminary results of the tissue analyses of the DPS rivers sampled to date revealed that of the 22 organochlorine compounds in the analytical scan, only DDE (a DDT metabolite), was detected and it occurred at low levels (4 ppb). In the National Contaminant Biomonitoring Program geometric mean concentration for DDE was 190 ppb (Schmitt et al. 1990). Metals analysis (Table 4.18) indicates that although there were elevated levels of chromium and selenium in some Narraguagus River sucker samples, the two Pleasant River composite samples had no elevated metal levels. With the exception of chromium, which tends to be higher in omnivorous species than piscivorous species, trace element levels in white suckers from the Downeast salmon rivers do not appear elevated when compared to concentrations reported in state, regional, and national biomonitoring programs.

Once all laboratory work is completed and the data analyzed for the eight DPS Atlantic salmon rivers, a final report will be prepared and posted on the USFWS Maine Field Office contaminants web site (http://mainecontaminants.fws.gov) December 2007.

Table 4.18. Metals in Wholebody White Suckers collected from Five DPS Salmon Rivers, 2005 (USFWS 2006).

	Cove Brook	Ducktrap River	Narraguagus River	Pleasant River	Dennys River	NCBP	SWAT	NE-FMAP
As	0.20	0.15	nd	0.15	0.10	0.14	0.05	0.08
Cd	nd	nd	0.03	nd	0.03	0.03	0.02	0.02
Cr	0.24	0.29	2.20	0.21	0.18		0.05	0.19
Cu	0.67	0.92	1.26	0.58	0.58	0.65	1.73	0.89
Hg	0.15	0.17	0.18	0.16	0.14	0.10	0.17	0.17
Pb	nd	0.10	nd	nd	0.06	0.11	0.30	0.09
Se	0.35	0.44	0.57	0.28	0.62	0.42	0.15	0.37
Zn	18.9	20.2	20.5	17.9	16.1	21.7	15.7	21.1

ppm (ug/g) wet weight
National Contaminant Biomonitoring Program (Schmitt and Brumbaugh 1990)
Surface Water Ambient Toxics Monitoring Program (Mower 2005)
Environmental Monitoring & Assessment Program (Yeardley *et al*. 1998)

<u>MDEP Trace Metals</u>

The following information was presented to the workgroup by Mark Whiting MDEP in March 2006.

Water quality criteria for metals in freshwater systems in Maine are listed in Table 4.19. Trace metal data from MDEP Biomonitoring Program indicate that when compared to other streams in the state, PRW has elevated levels of chromium, iron, and zinc (Table 4.20). Generally these metals are associated with urban pollution, however, in the PRW these levels are most likely due to metal deposits in surrounding bedrock. None of these levels exceeds the state water quality standards.

Table 4.19. Maine Water Quality Criteria for Freshwaters (US EPA 2001)

	Cd	Cr III	Cr VI	Fe	Pb	Zn
Acute	0.4	483	16	1000	10.5	30.6
Chronic	0.08	23.1	11	1000	0.41	30.6

Table 4.20. Trace Metals from Bangor and Kenduskeag tributaries and Downeast rivers, 2001 (MDEP Biomonitoring Program, 2001).

	Cd	Cr	Fe	Pb	Zn
Birch Stream	< 0.05	0.78	510	< 0.05	4.1
Shaw Brook	< 0.05	0.61	473	< 0.05	8.27
Reeds Brook	< 0.05	0.6	460	< 0.05	8.89
Penjajawock Stream	< 0.05	< 0.05	233	< 0.05	< 1.00
Penjajawock Stream	< 0.05	0.74	1422	< 0.05	7.88
Penjajawock Stream	< 0.05	< 0.05	722	< 0.05	5.74
Penjajawock Stream	< 0.05	< 0.05	443	< 0.05	3.02
Penjajawock Stream	< 0.05	< 0.05	180	< 0.05	1.32
French Stream	< 0.05	< 0.05	664	< 0.05	2.39
Allen Stream	< 0.05	< 0.05	229	< 0.05	< 1.00
Footman Brook	0.15	< 0.05	416	< 0.05	1.07
Burnham Brook	< 0.05	< 0.05	945	< 0.05	3.27
W Branch Pleasant R	< 0.05	1.33	519	< 0.05	4.54
E Machias R	< 0.05	1.39	184	< 0.05	2.5
Machias R	< 0.05	< 0.05	333	< 0.05	5.39
Machias R	< 0.05	1.99	233	< 0.05	2.57
Narraguagus R	< 0.05	< 0.05	183	< 0.05	2.82
Chandler R	< 0.05	1.05	1267	< 0.05	3.91

Recommendations:

4.34 USFWS should sample higher trophic-level species and salmon relatives (e.g., small mouth bass and brook trout) for tissue residue analysis and biomarkers (e.g., sex steroids, gonad histology).

4.35 Future contaminant studies should include lake samples so that they can be compared to river samples.

4.36 When sampling, USFWS should include sites which are associated with known blueberry chemical application and MBPC monitoring so that the results can be correlated. Other sites might include El Meadow, Artie's Bridge, and Eastern and Western Little rivers.

4.37 MDEP should incorporate trace metal monitoring into its long-term periodic monitoring program (e.g., every 5-10 years).

Lake Productivity

Information contained in this section was obtained from VLMP, 2006.

Lakes and ponds may influence river WQ in a variety of ways:

- Lakes and ponds in the river watershed may be viewed as pollutant "traps."
- However, as nutrients, sediment, and algae concentrations rise in these waterbodies, there is a proportional export of pollutants to the river downstream. "Lake outlet effect" occurs when poor-quality lake water enters the river and subsequently diminishes river water quality.
- Salmon often pass through in-stream lakes in order to access upstream habitat. Poor lake WQ could act as an obstacle to passage. The use of these lakes by Atlantic salmon is not fully understood.
- Untreated runoff from watershed development is a common threat to both lake and riverine systems

The greatest threat to lake and river WQ is elevated productivity which can reduce clarity/transparency, alter ecosystem balance and stability, reduce dissolved oxygen (DO), reduce coldwater fishery habitat, and lead to the export of algae, nutrients, and sediment to downstream waters. In general all fish will move up to lake layers that have higher DO. In lakes with good DO in deeper layers, adult salmon will hold in the colder, deeper layers. Juvenile salmon will hold in lakes to avoid anchor ice and exposure to extreme cold temperatures in the rivers.

Lakes in Maine are classified into five attainment categories 305(b):

Category 1: Not attaining all standards
Category 2: According to the data, the lake attains some of its standards, and there is no reason to believe that it does not attain others.
Category 3: Possibility of a persistent WQ issue
Category 4: TMDL Complete
Category 5: Regional TMDL Needed. All Maine lakes listed because of statewide fish advisory for mercury.

The MDEP Lakes Program and the Volunteer Lakes Monitoring Program (VLMP) collaborate in the collection of lake data to evaluate water quality, track algal blooms, and determine water quality trends. The VLMP has been collecting WQ data on Maine lakes since the 1970s. The primary focus of their monitoring program is cultural eutrophication, or nutrification, as a result of human activity. Of the 28 ponds and lakes in the PRW, only 3 (PRL and Montegail and Little Horseshoe ponds) have been monitored over the past 13 years (Table 4.21). Although Montegail was monitored for 10 years (19982 to 1992), both it and Horseshoe Pond are no longer part of an active monitoring program. Only PRL is actively monitored as part of the VLMP.

In general all of the ponds have high transparency, low chlorophyll levels, and low TP which indicates overall good water quality. The low transparency and high TP readings at Montegail Pond are due to the fact that the lake is very shallow and that the Secchi disc often hits the bottom. PRL experiences some loss of DO during summer months. This could be a problem for fish using the lake as coldwater refugia during summer months.

None of the lakes is considered at risk for phosphorous loading or for development growth. Montegail is considered moderate and potentially sensitive due to its shallow nature and higher level of TP than other area lakes. It should be noted that Montegail pond is a source of irrigation water for blueberry growers. It is also surrounded by fields that are regularly sprayed with pesticides.

Only one lake has enough data to make a determination regarding EPA/MDEP Attainment Status (Table 4.22). PRL is classed as Category 2: the lake attains some of its standards, and there is no reason to believe that it does not attain others. It should be noted that all lakes in Maine fall into Category 5: TMDL required for mercury.

Table 4.21. Productivity Averages of Three Ponds in the PRW (VLMP 2006).

Lake/Pond (depth)	Years of Data	Secchi (M) Ave = 4.8	TP (ppb) Ave=12	CHL (ppb) Ave=4.7	Color (spu) Ave=27	D.O. Loss?
Montegail (12/7)	5 ('82-'92)	2.9*	12	2.3	15	NO
PRL (52/13)	13 ('93-06)	5.8*	6	1.9	31	Some*
Little Horseshoe Pond	1	8.2	9	N/A	N/A	N/A

*Reading limited by depth of pond – disc hit bottom

Table 4.22. MDEP/VLMP Rating and Attainment Categories.

Lake/ Pond	**WQ Rating for Phosphorus control**	**Most at Risk?**	**Priority Water Body?**	**EPA/DEP Attainment Category**
Montegail	Moderate/ Sensitive	No	No	? =insuff data
PRL	Good	No	No	2 =According to the data, the lake attains some of its standards, and there is no reason to believe that it does not attain others
Little Horse-shoe P	Mod/Sensitive Insufficient Data	No	No	? = insuff data

<u>Recommendations:</u>

4.38 PRWC, VLMP, and lake associations should recruit volunteers for lakes currently not monitored, specifically Montegail Pond (a shallow pond with moderate development, agricultural and irrigation activity) and Southwest pond (contains wild trout habitat).

4.39 The council and lake associations should initiate the MDEP Lake Smart Program, which focuses on managing the home landscape to protect lake water quality.

Streamflow and Water Withdrawal

<u>USGS Streamflow Data</u>

The following information and graphics were presented to the workgroup by Greg Stewart, USGS, November 2006.

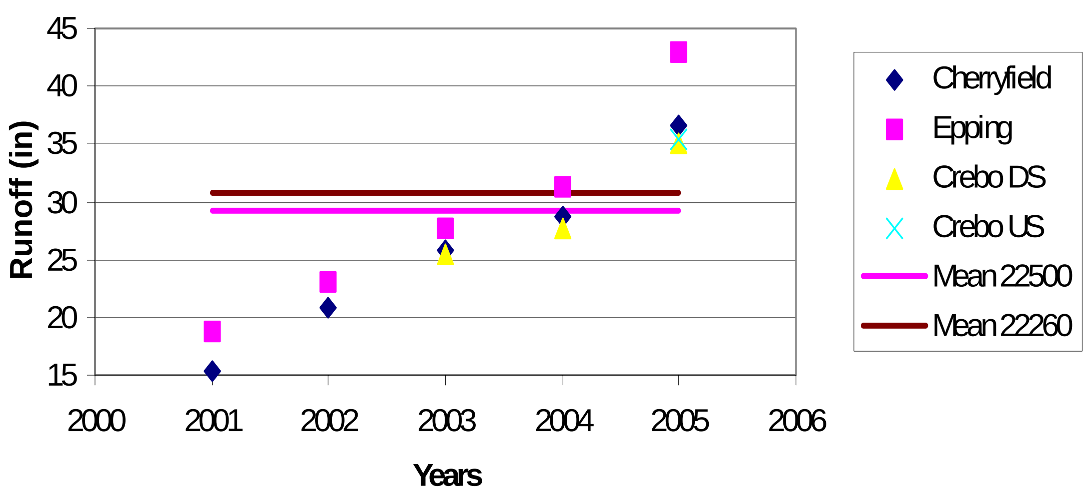
The US Geological Survey maintains gages in rivers in order to determine flow equations, monitor climate change, and develop water budgets and watershed modeling. The data are also used to provide scientists and managers with more information on the hydrology of a particular watershed. USGS has recently maintained three gages on the Pleasant River mainstem (Table 4.23) however as of October 2006, all of the gages have been discontinued due to lack of funding. It is unknown at this time if the gages will be reinstated.

Table 4.23. Station Number, Location, Drainage Size, and Time of Operation for USGS gages in the PRW.

Station Number	Location	Drainage Size	Time of Operation
01022260	Epping (Columbia)	60.6 mi2	1980-91 and 2000-2006
01022220	Crebo Flat (T18 MDBPP)	25.5 mi2	2002-2006
01022210	Upstream Crebo (T24 MDBPP)	22.3 mi2	2004-2006

Extended data records (1980-1991) and recent data collection (2001-2006) indicate that the Pleasant River streamflows are similar to other eastern coastal watersheds in Maine. Annual runoff from four sites between 2001 and 2005 indicates that Epping and both of the Crebo sites behave similarly to the Narraguagus River at the Cherryfield gage station (Figure 4.15). The data indicate that flow at all four sites was below average during 2001-2003 and above average during 2005. Flow statistics indicate that the Narraguagus and Pleasant rivers function similarly in terms of hydrology and stream flow and some predictions can be made about the Pleasant based on data from the Narraguagus (Cherryfield) stream gage. However, the data may be too coarse to predict minor streamflow changes in the Pleasant River, therefore the Pleasant gage should be reinstated.

Figure 4.15. Annual Runoff for Four Sites in the Narraguagus and Pleasant Rivers.



Water Use

The following information and graphics were presented to the group by Brad Caswell, CFI, November 2006.

Many blueberry growers withdraw water for irrigation from naturally occurring ponds, man-made ponds, and/or wells. Table 4.x lists the surface and groundwater withdrawal sites (all in LURC jurisdiction), as well as their withdrawal limits, used by the largest commercial grower, Cherryfield Foods, Inc (CFI). Table 4.24 lists the amount of water withdrawn from the PRW from nine of the CFI withdrawal sites during 2005. The data indicate that 301,346,516 gallons of water were withdrawn in 2005 from 6 wells, 2 ponds, and one reservoir. Table 4.25 indicates that this amount represents less than 1% of typical river discharge and 1.75% of drought year (2001) discharge.

As a function of the LURC permit process, CFI must monitor water withdrawal at each of their sites in order to prove that they are not influencing surface waters and wetlands. In general, they must report how much and how often they withdraw as well as reservoir levels. There is concern among scientists and managers that while there is a large body of information on withdrawal in LURC jurisdiction (due to permitting requirements), there is insufficient information in DEP jurisdictions because there are no permitting requirements.

Table 4.24. Cherryfield Foods, Inc. Surface and Ground Water Withdrawal Sites.

Water Withdrawal Station/Status		**Period of Operation**	**Rate, Pond or Flow Limits**	**Water monitoring stations (required weekly or daily)**
Barren Pond	R	5/1 to 9/30	-1 thru 7/15; -2 thru 9/30	pump site
Crossroads Well	A	5/1 to 9/30	2000 pgm	wells 03-11, 03-13, 03-14, 98-05, 98-01, OW-25-5
				staff gage at Dead Pond (see Table 2)
Duck Pond	R	5/1 to 9/30	-1 thru 7/15; -2 thru 9/30	pump site
East Crebo Well	A	5/1 to 9/30	1600 gpm	wells 00-02, 99-91, 99-93, 98-56, 98-32
East Pike Brk P	R	5/1 to 9/30	-1 thru 7/15; -2 thru 9/30	pump site
Horseshoe Pond	R	5/1 to 9/30	-1 thru 7/15; -2 thru 9/30	pump site
Long Pond	R	5/1 to 9/30	-2 thru 7/15; -4 thru 9/30	pump site
Long Pond (augment.)		5/1 to 9/30	Pond level no higher than MHWM	
Long Pond Well	A	5/1 to 9/30	1000 gpm	wells 05-01, 05-02, 05-03, 03-02, 03-05, 03-19
				LP-1, LP-2, LP-3; staff gage at Long Pond
Montegail North	A	5/1 to 9/15	-0.8 thru 7/15; 1.6 thru 9/15	none
Montegail South	A	5/1 to 9/15	-0.8 thru 7/15; -1.6 thru 9/15	pump site
Montegail West	A	5/1 to 9/15	-0.8 thru 7/15; -1.6 thru 9/15	none

Nature's Bridge Well	A	5/1 to 9/30	3000 gpm	wells 03-16, 03-17
Oak Pond Well	A	5/1 to 9/30	2,500 gpm	wells 03-10, 06-1, 06-2A, 06-5, 06-9; gages SG-18, SG-19
Otter Pond	A	5/1 to 9/30	-0.5 thru 7/15; -1 thru 9/30	pump site
Oxbow Well	A	5/1 to 9/30	2000 gpm	wells 00-06 and 00-10
				staff gages at Spring Hole and Unnamed Pond
				wetland well OX-1; beaver flowage SG-18 (see Table 2)
Pike Brook Well	A	5/1 to 9/30	2100 gpm	wells 00-13, 02-01, 02-02
Pleasant River Well	A	5/1 to 9/30	2000 gpm	wells 02-05, 02-06, 03-05, 03-06, 02-17, 98-22
				wetland well PRW-1; 06-06-A, 06-06-B (see Table 2)
Pretty Barrens Reservoir	A	5/1 to 9/30	2000 gpm	pump site
		10/15 to 11/30	3500 gpm	
Pretty Pond	A	5/1 to 9/30	-1.75 thru 7/15; -3.5 thru 9/30	pump site
Public Lot Well	A	5/1 to 9/30	2000 gpm	staff gage SG-7; wells 00-34 and 99-68 (see Table 2)
Rocky Lake	R	5/1 to 9/30	-0.85 thru 7/15; -1.7 thru 9/15	pump site
Sam Hill Well	A	5/1 to 9/30	2200 gpm	wells 00-S1, 98-08, 98-09, 98-10, 05-04
				staff gage SG-19 (see Table 2)
Schoodic Lake	R	5/1 to 9/15	-1 for season	pump site
Spring Hole P	R	5/1 to 9/30	-1 thru 7/15; -2 thru 9/30	pump site
Unnamed Pond	R	5/1 to 9/30	-0.45 thru 7/15; -0.9 thru 9/30	pump site
West Pike Brk P	R	5/1 to 9/30	-1 thru 7/15; -2 thru 9/30	pump site
Worcester Lot Well	A	5/1 to 9/30	500 gpm	well 98-22 (see Table 2)

A = Active
R = Reserved (unused except if wells are lost)

Table 4.25. Comparison of CFI Irrigation Withdrawal Volume to Annual Discharge in the PRW at Epping.

TYPICAL WATER PUMPED	TYPICAL RIVER DISCHARGE	DROUGHT YEAR (2001) RIVER DISCHARGE
gallons	gallons	gallons
301,346,516	31,972,070,105	17,219,917,440
Percent of Annual River Discharge	0.94%	1.75%

Impacts from Water Withdrawal

The USGS analyzed stream gage data to determine if withdrawal from an irrigation well located near the Pleasant River above Crebo Flats affected streamflow in the mainstem of the river (Dudley and Stewart, 2006). By comparing data from gaging stations above and below the well, USGS was able to determine "that stream stage on days when the well was pumped differ[ed] from stream stage on days with no pumping, indicating that short-term streamflow depletion occurred." The deviation between two linear relations (stream stage during pumping and stream stage with no pumping) was used to estimate how much short-term streamflow depletion was coincident with withdrawals. Estimated short-term streamflow depletion varied with stage and ranged from about 0.3 to 0.8 cfs or 1.7 to 10 percent of total streamflow.

While these ground-water withdrawals clearly affected flow in the Pleasant River, it is unknown to what extent this level of withdrawal and subsequent depletion may impact Atlantic salmon habitat. The data in this report are not comprehensive enough to make that determination. A more comprehensive study that would include a larger data collection effort and geologic and hydrologic information about the stream-aquifer system, ground-water-level data, and modeling is needed to determine short and long-term impacts and to further define the groundwater/surface water relationships at water withdrawal sites.

In addition to the USGS analysis and report, CFI completed a comprehensive evaluation of impacts on the stage (level) of the Pleasant River using USGS stage data for 2005 and 2006 in conjunction with detailed well operation information for the same well. A clear correlation between well operation times and stage of the Pleasant River at the Crebo Flats gage was observed using the 2005 data. Stream flow during this irrigation period reached a low of 6.5 cfs. At the higher low flow of 16 cfs in 2006, a clear correlation was not similarly discernable. This evaluation revealed that the minute-to-minute stage variation at the Crebo Flats gauge is as much as 0.02 feet. Well pumping impact was shown to average 0.011 feet. The duration of any measurable stage impact was found to be 8 hours following one full day of well pumping, and 17.5 hours following three full days of continuous well pumping. The average stage reduction of 0.011 feet results in a flow reduction of 0.33 cfs at a flow of 6 cfs, and 0.55 cfs at a flow of 20 cfs. The report prepared by CFI and submitted to LURC is entitled, *Annual Report of Hydrologic Data for 2006, Cherryfield Foods, Inc., Volume II, Analysis of Pleasant River Stage Data,* dated December 12, 2006 (Brad Caswelll, CFI, Personal Communication, March 2007).

Water Use Management

The following information and graphic were presented to the workgroup by Joan Trial, November 2006.

In 2001, the Downeast Salmon Rivers Water Use Management Plan (WUMP) was created by the MSO and included PRW. The goal of the plan is to ensure that human uses of the water resources in these streams do not adversely affect Atlantic salmon or salmon habitat (MSPO 2001). The two primary objectives of the plan are:

- To protect Atlantic salmon habitat in all river reaches for all life stages through wise water use management, and
- To conserve and use water resources efficiently for human benefit.

The plan was based on river-specific models that can detect large impacts on habitat especially when withdrawals are during periods of low flow. The plan provides a hierarchy of water sources and storage alternatives based on ecological impact on Atlantic salmon and their habitat, availability to grower, ability to be permitted, and affordability (Table 4.26). Although most of the recommendations of the WUMP are being implemented, the process is still challenged by insufficient use reporting and a lack of long-term funding for hydrologic monitoring and further studies on water-use effects on salmon habitat and population dynamics.

In-stream Flow and Water Level Standards

The following information was presented to the workgroup by Dave Courtemanch, MDEP, November 2006.

MDEP is charged with implementing the newly established Instream Flow and Water Level Standard Rule. This rule establishes stream flow and lake water level standards and defines, clarifies and quantifies key elements of 38 M.R.S.A. § 470-H including establishment of flows and water levels protective of all uses, in particular aquatic life use. The rule is based on maintaining natural variation of flow and water level, and provides for variation from the natural condition where water quality, including designated uses and characteristics of each freshwater class, is protected.

Table 4.26. Summary of Water Source Recommendations in the WUMP

Water Source	Withdrawal Limits
Seasonal Groundwater Pumping (wells)	No hydraulic coupling to rivers or streams during the annual period of low flow.
	Hydraulic coupling to rivers and streams, affecting less than 25% of stream discharge, with flow augmentation.
	Hydraulically coupled wells without flow augmentation.
Seasonal Surface Water Pumping (Ponds and Lakes)	Natural lakes and ponds that are hydraulically isolated from surrounding groundwater - maximum drawdown no more than what occurs naturally.
	Natural ponds and lakes that are hydraulically coupled to surrounding groundwater with seasonal outlets - maximum drawdown no more than that which naturally occurs.
	Natural or artificial ponds and lakes that are hydraulically coupled to surrounding groundwater with year round outlets – maintain environmentally protective flow in outlet stream.
Seasonal Surface Water Pumping (Rivers and Streams)	Direct pumping from streams during the annual low-flow period that reduce the flow below a previously established protective environmental flows.
	Skimming high flows during the low-flow season, as long as fish habitat is maintained.
	In late winter and spring during annual period of high flow, as long as fish habitat is maintained.
Storage Alternatives (Assumes water from any acceptable source)	Existing lakes and ponds in which the long-term naturally occurring range of water levels is maintained during the low-flow season.
	Natural depressions, such as kettle holes, that will hold water.
	New constructed ponds filled with precipitation, surface runoff, groundwater seepage alone.
	Existing lakes and ponds, manipulate long-term naturally occurring high or low water level to increase the stored volume..
	Impounded stream with adequate outflows are

Since no one standard will fit all streams in the state, the MDEP will use one, or a combination, of the three following approaches:

Hydrology-based standards:

1. By ‘standard’ flow/level requirements

Habitat-based standards (site-specific):

2. Established within a new or existing* permit
3. Site-specific “alternative” flow/water level designations – through a documented plan

The standards must be based on natural variation of flows and water levels based on six seasons for streams and two for lakes. Seasonal Aquatic Base Flow (ABF) will be based on median flow of the middle month of each season and will be calculated from the flow record, or new USGS equations. Only flows above the ABF can be withdrawn.

Flow/water levels for the various water classes are as follows:Class AA – percent of flow approach

- Class A – seasonal median for no more than two consecutive seasons
- Class B, C – seasonal median
- Class GPA – two incremental 1 foot drawdowns (protection of downstream flows)

The Narraguagus/Pleasant/Mopang WUMP will provide the hydrologic design and flow standards for those streams:

- Use flows identified in WUMP as basis for Water Flow Plan
- Establish alternative early summer (May-June), and late summer (July-August) flows based on WUA predictions of STELLA.
- Use BMPs and conservation to mitigate use
- Assist with storage development, alternative sources
- Follow with flow and resource monitoring
- Use adaptive management as implementation occurs

Recommendations:

4.40 MASC should advocate for funding to reinstate USGS gages in order to monitor withdrawal effects and overall hydrologic functions.

4.41 MASC (and all other fisheries management agencies) should advocate the Dept of Agriculture for more effective water-use reporting using a "Best Management Practices" approach and the WUMP recommendations.

4.42 Develop literature review and/or design study which investigates the effects of water withdrawal on salmon habitat/life stages.

4.43 Based on the results of the recently published report citing short-term streamflow depletion, conduct a study that includes a larger data collection effort and more comprehensive geologic and hydrologic information to determine long-term streamflow effects of water withdrawal.

4.44 All agencies should advocate MDEP to pass more effective water withdrawal permitting and monitoring requirements for MDEP jurisdictions.

4.45 All agencies should advocate MDEP for strong enforcement of new DEP flow standards.

Nonpoint Source Pollution and Buffers

Several embeddedness studies have been conducted by MASC on the Narraguagus and Dennys rivers that suggest that sedimentation is great enough to cause embeddedness and impact habitat. Therefore erosion and other forms of NPS pollution should be considered a serious threat to maintaining healthy aquatic ecosystems.

According to the Project SHARE Nonpoint Source Pollution (NPS) Database, 33 NPS sites have been identified and documented in the PRW during surveys between 1998 and 2005 (Map 3, NPS Sites, Appendix A). The database indicates that the greatest number of NPS problems (Table 4.27) is associated with road erosion (44%), followed by faulty culverts (20%), and beaver activity (13%).

The database also indicates that Columbia Falls, T18 MDBPP, and T24 MDBPP had the greatest number of documented NPS sites (31, 30, and 12%, respectively) most likely due to the high number of road crossings in these three towns/townships. Approximately 24% of the sites have been repaired and no additional work is needed. However, the remaining 76% of the sites are indicated as needing repair. It is unknown at this time if individual landowners have repaired these remaining sites or if repair is still needed.

Table 4.27. Documented NPS Sites in the PRW (Project SHARE , 2006).

NPS Problem	**% of total identified sites**
Road Erosion	46
Faulty Culvert	20
Beaver Activity	13
Inadequate Buffer	6
Algal bloom	3
Bridge	3
Inadequate ditching	3
Point Source	3
Unstable Boat Landing	3

Buffers are important for protecting waterways from sedimentation, NPS pollution, and thermal impacts. A large streamside forested buffer of 300 ft is generally recommended for maintaining water quality and enhancing wildlife habitat for most animals (Connecticut River Joint Commissions 1998). While some organisms require a buffer as small as 50 ft, others require as much as 600 ft (Table 4.28). MIFW also recommends 250 ft buffer for wildlife protection and sensitive areas such as salmon habitat (G. Burr, MIFW, Personal Communication, February 2007). Furthermore, when International Paper was the primary landowner in the area they adopted 300 and 600 ft limited-activity “Protected Zones” on 3rd and 4th order streams respectively as part of their Riparian Zone Management Plan (Arter 2003).

Table 4.28. Recommended Minimum Buffer Widths for Wildlife (Connecticut River Joint Commissions 1998).

Species	**Desired Buffer WIdth (Ft)**
Bald eagle, nesting heron, cavity nesting ducks	600
Pileated woodpecker	450
Beaver, mink, dabbling ducks	300
Bobcat, fox, fisher, otter, muskrat	330
Amphibians and reptiles	100-300
Belted kingfisher	100-200
Scarlet tanager, American redstart, rufous-sided towhee	600
Brown thrasher, hairy woodpecker, red-eyed vireo	130
Blue jay, black capped chickadee, downy woodpecker	50
Cold-water fisheries (brook trout, salmon, etc)	100-300

Recommendations:

4.46 MASC should review existing embeddedness data from Crebo Crossing and compare the data to studies from the Narraguagus and Dennys rivers. The results could be linked to redd and geomorphology data for a better understanding of the impacts from sedimentation.

4.47 Project SHARE, MDEP, and the councils should work with landowners/state/towns to repair roads and reduce the number of unremediated NPS sites in the watershed.

4.48 All restoration projects (large woody debris, culvert repair, stream bank stabilization, etc) should include an assessment component that includes before and after geomorphology assessment, sediment budget, WQM, embeddedness analysis, and parr density evaluation.

4.49 In order to protect surface water temperature, water chemistry, control beaver populations, protect wildlife habitat, and maintain ecosystem integrity and nutrient budgets, riparian buffers should be expanded to 250 ft (as recommended by MIFW and International Paper Best Management Practices) and activity within the buffer should be regulated:

a. Work with landowners to voluntarily (or via easement) use 250 ft set back and maintain buffers.
b. Enforce exiting laws (i.e., NRPA) that require set backs for resource protection.
c. Advocate for trout and salmon habitat to be listed under NRPA rules.

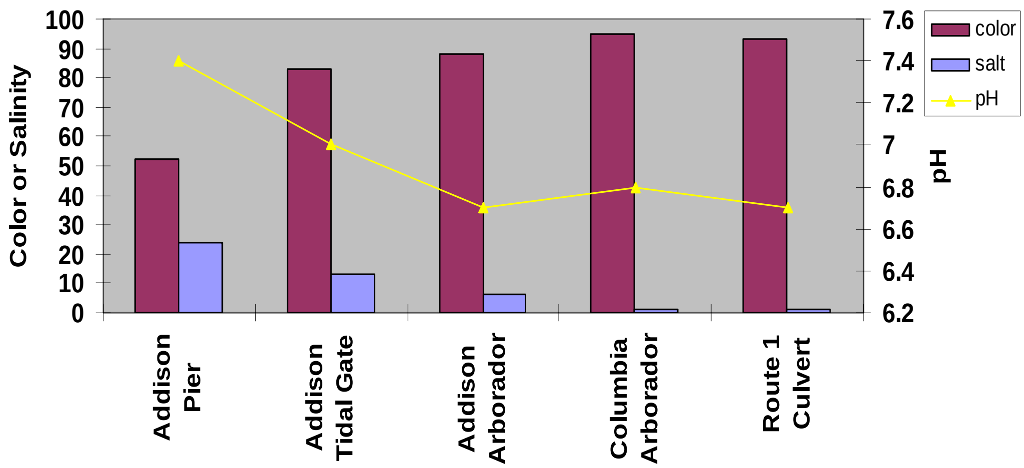
Restoration

West Branch Pleasant River Restoration Project

The following information was presented to the workgroup by Marilee Lovit, and Mark Whiting, MDEP, June 2006.

In addition to the nekton studies mentioned in Chapter 2, the West Branch (WB) Study Committee also conducted WQM above and below the gate in 2005 and 2006 (Figure 4.16). All DO values were above 7 ppm and 70% saturation, and pH ranged from 6.7 to 7.4. Watercolor ranged from 50-90 SPU and freshwater levels were higher than saltwater samples. Trace Metals, Cr, Fe, and Zn, were high as is typical of other DE rivers. High salinity (25 ppt), small tides, and limited marsh vegetation at the restricted Post Office marsh was found to limit habitat for estuarine fish.

Figure 4.16. MDEP WQ Data for the WB PR, 2005.



Recommendations:
4.50 Continue to investigate the impacts of tidal restriction and the possibility of gate removal and the return of natural tidal flow, ecosystem integrity, and nekton populations.

Chapter 5: Summary of Recommendations

Tasks, Lead and Partnering Agencies, and Prioritization

Agency Tasks

Table 5.1 lists all of the recommendations generated from workgroup discussions for future monitoring based on those trends. The Workgroup reviewed and discussed each recommendation and assigned lead and partnering agencies and priority levels thus transforming each recommendation into a task which may be correlated with Federal Recovery Plan Tasks and which can become part of individual agency workplans.

The tasks are prioritized as high, medium, or low based on how soon each agency/organization thought each action could be achieved or at least initiated by the lead agency/organization:

Priority:	High	1-2 years	2007-2008
	Medium	3-4 years	2009-2010
	Low	5-6 years	2011-2012

Lead, Partners:	**Lead**	The lead agency(s) is the agency that will initiate the task and oversee its progress. The lead agency may provide staff/funding or seek outside funding. The lead agency determines priority.
	Partners	Partnering agencies are those agencies that provide input, data, technical assistance, support, etc. Partners may or may not provide financial assistance.

Table 5.1. Summary of Recommendations (Tasks).

	TEMPERATURE	**LEAD/**Partner	**PRIORITY**
4.1	IF&W should focus monitoring and enhancement efforts on river/stream trout habitat including mapping habitat, conducting stream surveys to determine quantitative population status, protecting buffers, and possibly enhancing habitat.	**IF&W**, MASC	High
4.2	IF&W should use the results from the Black Brook beaver study to make determinations regarding beaver management in waters with significant trout habitat.	**IF&W,** MASC	Low
4.3	Since MASC has five years of data, they should continue monitoring index sites (e.g., PR MSL, Crebo, Saco, Weir, E & W Little R) then develop regression models to predict temperatures depending upon questions related to research.	**MASC**	High
4.4	MASC should develop a model using recently published data (i. e., Horton) that uses temperature to predict juvenile salmon success rate and growth for various year classes.	**MASC**	Med
4.5	MASC should design and conduct a study to determine if winter ground water and surface water temperatures are warm enough to overwinter juvenile salmon:	**MASC**	High
	a. Establish critical winter temperature thresholds for juvenile and adult salmon (literature review).		
	b. Search for existing winter temperature data (data inventory) to investigate if winter temperature thresholds are being exceeded.		
	c. Determine if the existing data spatially and temporally represents juvenile and adult salmon habitat across the drainage to answer item b		
	d. If more data are needed; develop a winter temperature monitoring study, stratified by reach and salmon habitat in order to have sufficient spatial distribution to answer temperature questions related to salmon survival.		
	e. Establish current winter baseline temperature at multiple sites across the drainage.		
	f. Compare Pleasant River winter temperature results to researched critical temperature thresholds established in items a and b.		

	pH AND RELATED CHEMISTRY		
4.6	Agencies should determine historic water chemistry (pH, nutrient levels, etc) for DPS rivers; this can be accomplished using mussel shell analysis, lake cores, etc.	**MASC,** NOAA, MDEP, Univ Researchers	Med
4.7	Agencies should develop a water chemistry sampling strategy to further identify temporal and spatial patterns of episodic low pH and organic/inorganic aluminum in rivers and tributaries that are identified as having significant Atlantic salmon habitat, and where existing pH data is limited.	**MASC,** NOAA, MDEP, Univ Researchers	High
4.8	Agencies and researchers should conduct studies designed to determine the direct and cumulative effects of low pH, low calcium, and high aluminum on salmon life stages.	**MASC,** NOAA, MDEP, Univ Researchers	High
4.9	Agencies and researchers should conduct studies designed to determine the effects of multiple stressors (e.g., low pH, low calcium, high Al, pesticides, high summer temperatures, etc) on various salmon life stages.	**Univ Researchers,** USGS, DSF, NOAA, MASC	High
4.10	Agencies and NGOs should reconvene the liming committee and explore the possibility of conducting an experimental liming project on a small tributary.	**DSF,** All Agencies	High
	NUTRIENTS		
4.11	MDEP nutrient monitoring should continue and should include sampling for Total N.	**MDEP,** PRWC	High
4.12	Freshwater nutrient data should be linked to marine derived studies (see below).	**Univ researchers,** MDMR, MASC MDEP, NOAA	High
4.13	A river-specific comprehensive nutrient budget and productivity study that measures overall ecosystem integrity and functionality (nutrient and energy budgets, trophic sources, presence/absence of functional groups, diversity, etc) should be conducted in order to determine if each river has enough nutrients and food sources to support all salmon life stages.	**MASC, Univ researchers,** NOAA, MDEP	Med
	MARINE DERIVED NUTRIENTS		

4.14	Design a mark and recapture study designed to capture immigrating and emigrating diadromous species during their peak migrations in order to get a better understanding of their current population structure and potential nutrient contribution. Species of particular interest include American eel, alewife, and anadromous brook trout.	**Univ researchers,** NOAA, MASC, MDMR	Low
4.15	All fisheries management agencies should adopt ecosystem-based management principles and develop river-specific fisheries management plans to ensure all species are properly managed. Models from other rivers, such as the Penobscot, could be used on all DPS rivers.	**MDMR**, **NOAA, IF&W, MASC**	High
4.16	Restoration activities should focus on ensuring passage (maintain fishways), restoring native fish assemblages, and restoring ecological functions (e.g., West Branch restoration).	**MDMR**, NOAA, USFWS, WBSC, MASC, MIF&W	High
4.17	Fisheries management agencies should work together to gather accurate data on return rates of diadromous species (e.g., recording the number of fish in smolt traps, etc).	**MASC,** NOAA, DMR, MIF&W	High
4.18	Design a study to determine if marine-derived nutrients have an impact on salmon spawning and rearing habitat and if these nutrients are limited in the salmon watersheds. Experimental results from other rivers could be used on all DPS rivers.	**Univ Researchers, MASC,** NOAA,	Low
4.19	Fisheries management agencies should investigate what impact if any restored diadromous fisheries will have on existing recreational freshwater fisheries	**MIFW,** MASC, MDMR	High
	BIOMONITORING MACROINVERTEBRATES		
4.20	A study to determine the IBI should be conducted in order to determine the presence/absence of appropriate taxa (this should be done in addition to the MDEP Predictive Statistical Model).	**Univ Researchers,** MDEP	Med
4.21	MDEP should continue to biomonitor W & E Little rivers, Crebo Crossing, and Saco Falls. They should add Meyers and Coffin ponds and the West Branch to their wetlands monitoring program.	**MDEP,** PRWC	Med
	BACTERIA		
4.22	Continue current level of bacteria monitoring. No new monitoring is recommended at this time.	**MDMR**	High

4.23	PRWC and towns should work with MDMR, MSPO, and MDEP to replace OBDs and ultimately open shellfish areas which are now closed due to sanitation closures.	**PRWC/Towns,** DMR, SPO, and MDEP	High
	PESTICIDES		
4.24	Monitoring and studies should be regularly updated to include new pesticides being introduced on the market.	**MBPC**	Med
4.25	MBPC should continue GW & SW long-term monitoring in order to compare new data with past results and to detect trends.	**MBPC**	Med
4.26	MBPC should include fungicide monitoring in the PRW.	**MBPC**	Med
4.27	All agencies should encourage the use of passive samplers when sampling for pesticides in order to improve sampling timing and save costs	**MBPC**	Med
4.28	2010 GW sampling for hexazinone should be reviewed by scientists and other stakeholders and appropriate actions taken.	**MBPC**	Low
4.29	A study should be conducted to ascertain if the new ground application of pesticides is reducing the amount of pesticide entering the water.	**Univ Researchers, MBPC**	High
4.30	Agencies should encourage growers to use Integrated Pest Management	**All**	High
	MULTIPLE STRESSORS		
4.31	Initial multiple stressor studies involving low pH, pesticides, and aluminum have been conducted; further studies should be conducted in order to determine specific interactions and long term effects.	**Univ Researchers,** USGS, MBPC, DSF	High
4.32	Conduct study to evaluate the potential effects of candidate pesticides on fish sensitive early-life stages before these pesticides come into use.	**Univ Researchers,** USGS, MBPC, DSF	High
4.33	Conduct study to determine whether neutralization of pesticide-contaminated river water is protective.	**Univ Researchers,** MBPC, USFWS	High
	CONTAMINANTS		

4.34	USFWS should sample higher trophic-level species and salmon relatives (e.g., small mouth bass and brook trout) for tissue residue analysis and biomarkers (e.g., sex steroids, gonad histology).	**USFWS**	High
4.35	Future contaminant studies should include lake samples so that they can be compared to river samples.	**USFWS**	High
4.36	When sampling, USFWS should include sites which are associated with known blueberry chemical application and MBPC monitoring so that the results can be correlated. Other sites might include El Meadow, Artie's Bridge, and Eastern and Western Little rivers.	**USFWS,** USGS (Elskus)	High
4.37	MDEP should incorporate trace metal monitoring into its long-term periodic monitoring program (e.g., every 5-10 years).	**MDEP,** MASC	Low
	LAKES		
4.38	PRWC, VLMP, and lake associations should recruit volunteers for lakes currently not monitored, specifically Montegail Pond (a shallow pond with moderate development, agricultural and irrigation activity) and Southwest pond (contains wild trout habitat)	**PRWC, VLMP, Lake Associations, MDEP**	High
4.39	The council and lake associations should initiate the MDEP Lake Smart Program, which focuses on managing the home landscape to protect lake water quality.	**PRWC, VLMP, Lake Associations, MDEP**	Med
	STREAM/WITHDRAWAL		
4.40	MASC should advocate for funding to reinstate USGS gages in order to monitor withdrawal effects and overall hydrologic functions.	**MASC,** USGS	High
4.41	MASC (and all other fisheries management agencies) should advocate the Dept of Agriculture for more effective water-use reporting using a "Best Management Practices" approach and the WUMP recommendations.	**All**	Med
4.42	Develop literature review and/or design study which investigates the effects of water withdrawal on salmon habitat/life stages.	**MASC,** USGS	High
4.43	Based on the results of the recently published report citing short-term streamflow depletion, conduct a study that includes a larger data collection effort and more comprehensive geologic and hydrologic information to determine long-term streamflow effects of water withdrawal.	**MASC,** USGS	High

4.44	All agencies should advocate MDEP to pass more effective water withdrawal permitting and monitoring requirements for MDEP jurisdictions.	**PRWC, DSF**, All Agencies	Med
4.45	All agencies should advocate MDEP for strong enforcement of new MDEP flow standards.	**PRWC, DSF**, All Agencies	High
	NPS		
4.46	MASC should review existing embeddedness data from Crebo Crossing and compare the data to studies from the Narraguagus and Dennys rivers. The results could be linked to redd and geomorphology data for a better understanding of the impacts from sedimentation.	**MASC,** SHARE, MDEP	Low
4.47	Project SHARE and the councils should work with landowners/state/towns to repair roads and reduce the number of unremediated NPS sites in the watershed.	**SHARE, MDEP PRWC,** Landowners	High
4.48	All restoration projects (large woody debris, culvert repair, stream bank stabilization, etc) should include an assessment component that includes before and after geomorphology assessment, sediment budget, WQM, embeddedness analysis, and parr density evaluation.	**SHARE, PRWC, USGS, MASC, MDEP**	High
4.49	In order to protect surface water temperature, water chemistry, control beaver populations, and maintain ecosystem integrity and nutrient budgets, riparian buffers should be expanded to 250 ft and activity within the buffer should be regulated:	**ALL**	High
	a. Work with landowners to voluntarily (or via easement) to use 250 ft set back and maintain buffers.		
	b. Enforce exiting laws (I.e., NRPA) that require set backs for resource protection.		
	c. Advocate for trout and salmon habitat to be listed under NRPA rules.		
	RESTORATION		
4.50	Continue to investigate the impacts of tidal restriction and the possibility of gate removal and the return of natural tidal flow, ecosystem integrity, and nekton populations.	**WBSC,** PRWC, WSRC, USFWS	Med

Literature Cited

Arter, B. S. 2003. Narraguagus River Watershed Nonpoint Source Pollution Management Plan. Project SHARE, Eastport, ME.

Arter, B. S. and B. Snapp. 2006. Narraguagus River Water Quality Monitoring Plan. BSA Environmental Consulting, Steuben, ME.

Baum, E. T. and R. M. Jordan. 1982. The Narraguagus River: an Atlantic Salmon River Management Report. Maine Atlantic Sea Run Salmon Commission, Bangor, ME.

Beland, K. F., R. M. Jordan, and A. L. Meister. 1982. Water depth and velocity preferences of spawning Atlantic salmon in Maine rivers. N. Amer. J. Fish. Man. 2: 11-13.

Boone, M.D., C. M. Bridges, J. F. Fairchild, E. E. Little. 2005. Multiple sublethal chemicals negatively affect tadpoles of the green frog, Rana clamitans. Environmental Toxicology and Chemistry 24, 1267-1272.

Brocksen, R. W., M. D. Marcus, and H. Olem. 1992. Practical Guide to Managing Acidic Surface Waters and their Fisheries, Lewis Publ., Inc.

Danie, D. S., J. G. Trial, J. G. Stanley, L. Shanks, and N. Benson. 1984. Species profiles: life histories and environmental requirements of coastal fish and invertebrates (North Atlantic): Atlantic salmon. USFWS, report FWS/OBS-82/11.22.

Danner G. R. 2007. Investigating the Causes, Diagnosis and Treatment of Brook Trout Nutritional Hyperparathyroidism. In D. McNeish ed. Fisheries Research Report 07-04. Maine Department of Inland Fisheries & Wildlife, Augusta, Maine (draft April 2007).

Daye, P. and E. Garside. 1977. Lower lethal levels of pH for embryos and alevins of Atlantic salmon, *Salmo salar* L. Can. J. Zool. 55: 1504-1508.

De Guise, S., J. Maratea, and C. Perkins. 2004. Malathion immunotoxicity in the American lobster (Homarus americanus) upon experimental exposure. Aquatic Toxicology 66, 419-425.

Driscoll Jr., C., J. Baker, J. Bisgoni Jr, and C. Schofield. 1980. Aluminum speciation and its effect on fish in dilute acidified waters. Nature 284, 161-163.

Dudley, R. W. and G. J. Stewart. 2006, Estimated effects of ground-water withdrawals on streamwater levels of the Pleasant River near Crebo Flats, Maine, July 1 to September 30, 2005: U.S. Geological Survey Scientific Investigations Report 2006-5268, 14 p., online only.

Elliott, J. M. 1991. Tolerance and resistance to thermal stress in juvenile Atlantic salmon, *Salmo salar*. Freshwater Biol. 25: 61-70.

Farmer, G. J. 2000. Effects of low environmental pH on Atlantic salmon (*Salmo salar* L.) in Nova Scotia. Canadian Stock Assessment Secretariat Research Document 2000/050.

Galloway, T. and R. Handy. 2003. Immunotoxicity of organophosphorous pesticides. Ecotoxicology 12, 345-363.

Gensemer, R. and R. Playle. 1999. The bioavailability and toxicity of aluminum in aquatic environments. Critical Reviews in Environmental Science and Technology 29, 315-450.

Harford, A. J., K. O'Halloran, and P. F. A. Wright. 2005. The effects of in vitro pesticide exposures on the phagocytic function of four native Australian freshwater fish. Aquatic Toxicology 75, 330-342.

Heggenes, J. 1990. Habitat utilization and preferences in juvenile Atlantic salmon (Salmo salar) in streams. Regulated Rivers: Research and Management. 5: 341-354.

Institute for Fisheries Resources and Sheepscot Valley Conservation Association. 2005. KRIS Sheepscot On-Line Database. 19 Oct 2005. http://www.krisweb.com/krissheepscot/krisdb/html/krisweb/index.htm

Jackson, H.P. 2003. 2003 Drift study of two aerially applied blueberry pesticides. In: Maine Board of Pesticide Control, Augusta, p. 19pp

Johnson, K. and J. S. Kahl. 2005. A Systematic Survey of Water Chemistry for Downeast Area Rivers. University of Maine Senator George Mitchell Center. http://www.umaine.edu/WaterResearch/research/nfwf_salmon_water_chemistry.htm

Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant, and I. J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Illinois Natural History Survey Special Publication 5, 28 p.

Kircheis, D. and R. Dill. Effects of low pH and high aluminum on Atlantic salmon smolts in Eastern Maine and liming project feasibility analysis January, 2006

U.S. Atlantic Salmon Assessment Committee Working Paper, 2006 NOAA's National Marine Fisheries Service, and Maine Atlantic Salmon Commission, p. 30pp

Kroglund, F. and B. Finstad. 2003. Low concentrations of inorganic monomeric aluminum impair physiological status and marine survival of Atlantic salmon. Aquaculture 1: 119-133.

Kroglund, F. and M. Staurnes. 1999. Water quality requirements of smolting Atlantic salmon (*Salmo salar*) in limed acid rivers. Can. J. Fish. Aquat. Sci. 56: 2078-2086.

Levin, E.D., E. Chrysanthis, K. Yacisin, and E. Linney. 2003. Chlorpyrifos exposure of developing zebrafish: effects on survival and long-term effects on response latency and spatial discrimination. Neurotoxicology and Teratology 25, 51-57.

Lydersen, E., S. Lofgren, and R. T. Arnesen. 2002. Metals in Scandinavian Surface Waters: Effects of Acidification, Liming and Potential Reacidification. Critical Reviews in Environmental Science and Technology 32, 73-295.

Magee, J. A., M. Obedzinski, S. D. McCormick, and J. F. Kocik. 2003. Effects of episodic acidification on Atlantic salmon (*Salmo salar*) smolts. Can. J. Fish. Aquat. Sci. 60: 214-221.

Maine Department of Environmental Protection. 2002. River and Stream Biological Monitoring Program Frequently Asked Questions. Augusta, ME.

Maine Department of Environmental Protection. 2006. MDEP Lakes Database. Augusta, Maine.

Maine State Planning Office. 2001. Downeast Salmon Rivers Water Use Management Plan: Pleasant and Narraguagus Rivers and Mopang Stream. Augusta, Maine.

Maine Title 38: Waters and Navigation Chapter 3: Protection and Improvement of Waters. Subchapter 1: Environmental Protection Board Article 4-A: Water Classification Program §467. Classification of major river basins http://janus.state.me.us/legis/statutes/38/title38sec467.html February 2007.

Moore, J. W. and D. E. Schindler. 2004. Nutrient export from freshwater ecosystems by anadromous sockeye salmon (Oncorhynchus nerka). Canadian Journal of Fisheries and Aquatic Sciences **61**:1582-1589.

Mower B. 2005. Surface water ambient toxic monitoring program. Division of Environmental Assessment. Maine Department of Environmental Protection. Augusta, Maine.

National Research Council, 2004. Atlantic Salmon in Maine. In: National Academies Press, Washington, DC, p. 275 pp

Newcombe, C. P. and J. O. T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. No Amer. Fisheries Man 16 (4):693-719).

Nielsen, J.P. 1999. Record Extension and Streamflow Statistics for the Pleasant River, Maine. US Geological Survey. WRIR 99-4078.

Nieves-Puigdoller, K., and S. D. McCormick. 2004. Effect of hexazinone and atrazine on different life stages of Atlantic salmon. In: Fourth SETAC World Congress and 25th Annual Meeting in North America - Abstracts, Portland, Oregon November 14-18, 2004 pp. 396, Abstract #PW205.

Nislow, K., J. Armstrong, and S. McKelvey. 2004. Phosphorus flux due to Atlantic salmon (Salmo salar) in an oligotrophic upland stream: effects of management and demography. Canadian Journal of Fisheries and Aquatic Sciences 61:2401-2410.

Orme, S. and S. Kegley. 2004. PAN Pesticide Database. Pesticide Action Network, North Amercia. San Francisco, CA. http:www.pesticide.org.

Peterson B. J., W. M. Wollheim, P. J. Mulholland, J. R. Webster, J. L. Meyer, J. L. Tank, E. Marti, W. B. Bowden, H. M. Valett, A. E. Hershey, W. H. McDowell, W. K. Dodds, S. K. Hamilton, S. Gregory, and D. D. Morrall. 2001. Control of nitrogen export from watersheds by headwater streams. Science 292: 86-90.

Randall, A.D. 1996. Mean annual runoff, precipitation, and evapotranspiration in the glaciated northeastern United States, 1951-80, USGS Open-File Report 96-395.

Reinhardt, R. L., S. A. Norton, M. Handley, and A. Amirbahman. 2004. Dynamics of P, Al, and Fe during discharge episodic acidification at the Bear Brook Watershed in Maine, USA. Water Air and Soil Pollution 4:311-323.

Relyea, R. A. 2005. The lethal impacts of roundup and predatory stress on six species of North American tadpoles. Archives Of Environmental Contamination And Toxicology 48, 351-357.

Relyea, R. A. and N. Mills. 2001. Predator-induced stress makes the pesticide carbaryl more deadly to gray treefrog tadpoles (*Hyla versicolor*). Proceedings of the National Academy of Sciences of the United States of America 98, 2491-2496.

Salgado, V. 1998. Studies on the mode of action of spinosad: Insect symptoms and physiological correlates. Pesticide Biochemistry and Physiology 60, 91-102.

Salgado, V. and R. Saar. 2004. Desensitizing and non-desensitizing subtypes of alpha-bungarotoxin-sensitive nicotinic acetylcholine receptors in cockroach neurons. Journal of Insect Pathology 50, 867-879.

Saunders, R. M., A. Hachey, and C. W. Fay. 2006. Maine's Diadromous Fish Community: Past, Present, and Implications for Atlantic Salmon Recovery. Fisheries. Vol 31 No 11.

Schmitt C.J., J.L. Zajicek, and P.H. Peterman. 1990. National contaminant biomonitoring program: residues of organochlorine chemicals in U.S. freshwater fish, 1976 - 1984. Archives Environmental Contamination and Toxicology. 19:748-781.

Schmitt C.J. and W.G. Brumbaugh. 1990. National contaminant biomonitoring program: concentrations of arsenic, cadmium, copper, lead, mercury, selenium, and zinc in U.S. freshwater fish, 1976 - 1984. Archives Environmental Contamination and Toxicology 19:731-747.

Slack, J.R., and J. M. Landwehr. 1992. Hydro-climatic data network (HCDN)—A U.S. Geological Survey streamflow data set for the United States for the study of climate variations, 1874–1988: U.S. Geological Survey Open-File Report 92–129, 193 p.

Sokolova, I.M., 2004. Cadmium effects on mitochondrial function are enhanced by elevated temperatures in a marine poikilotherm, Crassostrea virginica Gmelin (Bivalvia : Ostreidae). Journal Of Experimental Biology 207, 2639-2648.

Staurnes, M., P. Blix, and O. B. Reite. 1993. Effects of acid water and aluminum on parr-smolt transformation and seawater tolerance in Atlantic salmon, Salmo salar. Canadian Journal Of Fisheries And Aquatic Sciences 50, 1816-1827.

Swain, H., S. Donerly, E. Chrysanthis, K. Yacsin, E .Linney, and E.D Levin. 2003. A zebrafish model for studying the neurobehavioral impacts of developmental chlorpyrifos exposure. Toxicological Sciences 72. 129-139

Trout Unlimited for the Eastern Brook Trout Joint Venture. 2006. Eastern Brook Trout: Status and Threats. Trout Unlimited, Arlington Virginia.

U. S. Environmental Protection Agency. 1986. Quality Criteria for Water: Dissolved Oxygen. EPA 440/5-86-001. Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C. 20460.

U. S. Environmental Protection Agency. 1988. Environmental Fate and Effects Division RED Chapter for Phosmet. US EPA, Memorandum. PC Code No. 059201.

U. S. Environmental Protection Agency. 2001. Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria, Rivers and Streams in Nutrient Ecoregion VIII. US EPA Office of Water, publication # EPA 822-B-01-015

U. S. Environmental Protection Agency. 2001. Pesticide Fact Sheet: Mesotrione. US EPA, Office of Prevention, Pesticides and Toxic Substances (7501C).

Watt, W. U., C. U. Scott, and W. J. White. 1983. Evidence of acidification of some Nova Scotia rivers and its impact on Atlantic salmon. Can. J. Fish. Aquat. Sci. 40: 462-473.

Whiting, M. 2006. A Summary of Volunteer Data from Tunk Stream, Little River and West Little River in the Pleasant River Drainage, and the Narraguagus River. An Annual Progress Report for the Downeast Salmon Rivers, 2005 Field Season. Maine Department of Environmental Protection, Bangor, Maine.

Appendix

Maps:

The following maps are PDF files that are electronically separate from the plan text.

1. Pleasant River Watershed Base map
2. Pleasant River WQM Sites
3. NPS Sites in the PRW