The Penobscot River is the largest river wholly contained in Maine and the second largest river basin in New England, following the Connecticut River. The basin encompasses 8,595 square miles and drains approximately one quarter of the state.

Introduction

Geography

The East Branch of the Penobscot originates in East Branch Pond, above Grand Lake Matagamon. The West Branch originates in Seboomook Lake, the confluence of the North and South Branches of the Penobscot, in northern Piscataquis and Somerset Counties. The confluence of the East and West Branches is in Medway, forming the mainstem. The mainstem flows through a series of small developed and industrial towns and cities including Lincoln, Old Town and Orono, before passing through the cities of Bangor and Brewer, then becoming saline at Hampden from the tidal influence of Penobscot Bay. The total length of mainstem, to the mouth at Bucksport, is approximately 98 miles. The Piscataquis and Mattawamkeag Rivers are major tributaries to the Penobscot, discussed in Basin Chapter 2.

Basin Summary Statistics

Biomonitoring Activities in the Basin	**Period of Record**: *Mainstem*: 1974-1997; *Other Stations*: 1984-1997 **Waterbodies Sampled**: 18 **Established Stations**: 47 **Number of Sampling Events**: 82

Wastewater Discharges

The West Branch and mainstem receive wastewater discharges from 5 pulp and paper mills, 10 municipal or combined municipal and industrial treatment plants. The 1995 estimated combined population of Piscataquis and Penobscot Counties is 164,000.

Other Sources

Contaminated woolen mill site; fish hatcheries; miscellaneous industrial waste discharges; timber harvesting; combined sewer overflows (CSO's);

Flow Regulation

84 dams control flows throughout the basin; 18 are licensed by FERC for storage or generation of hydroelectric power.

Quality

Although the Penobscot receives a relatively large volume of wastewater, overall water quality in the basin is good to outstanding, even on the mainstem. This is due to both the large available dilution volume and the remote nature of much of the basin.

Drainage Area (at Eddington)	Average Annual Discharge (at Eddington)	Wastewater Flow Volume (Major Industrials and all Municipal Discharges)	Mainstem Average Dilution
7,764 mi^2	14,110 cfs	163.9 mgd (254 cfs)	56:1

Overview of Biological Monitoring Activities

Forty-seven biomonitoring stations are established in the Penobscot River Basin, excluding the Piscataquis and Mattawamkeag sub-basins (described in Basin Chapter 2). The majority of monitoring effort has been devoted to the mainstem and tributaries affected by pulp and paper mills, with 57% of stations occurring on the mainstem, the East and West Branches and Millinocket Stream (Basin Table 3, p. 138; Basin Map 3, p. 163). The basin was intensively sampled in 1996, in

accord with the National Pollutant Discharge Elimination System rotation licensing schedule (Table 5).

The Penobscot River mainstem is one of the State's most comprehensively monitored rivers for aquatic life, due to research projects in the 1970s and 1980s (see below) and to the efforts of the Penobscot Indian Nation (PIN). The Penobscot Tribe has established an extensive monitoring program on the mainstem and tributaries. In 1991 the Water Resources Program of the Nation requested to meet with Department of Environmental Protection staff to develop a water quality monitoring workplan which would provide data acceptable for use by the Department. Their interest was to contribute to water quality information on sections of the Penobscot and tributaries flowing through tribal lands. They had applied for and received a grant from the US EPA to initiate a monitoring program and they began field data collections in 1992.

A network of stations has been established for basic chemical monitoring, including dissolved oxygen, temperature, bacteria, and biochemical oxygen demand, among other parameters. In 1993, biologists from MDEP accompanied PIN technical staff in the field to train them in biological sampling methods and to set up monitoring stations in the same locations as earlier, MDEP-sponsored, studies (Rabeni 1974; Davies 1987). Since that time PIN has added to its monitoring network to bring their total number of mainstem stations up to 50 for basic physical/chemical assessments. An additional 25 tributary stations are sampled as well. Benthic macroinvertebrate monitoring by PIN staff has occurred at about 15 stations. PIN contracts with the same taxonomist as MDEP to insure comparability of the taxonomic record. Data is submitted to MDEP for editing, coding and data entry into the Biomonitoring Program database. Of the Department's stations on the mainstem, PIN has provided about 75% of the biological data collected since 1992.

In 1991, three stations were established on Kenduskeag Stream to evaluate impacts of agricultural activities and urbanization on this stream. The stream and tributaries in it's watershed were revisited in 1997, in a cooperative study between the Biological Monitoring Program, the MDEP Division of Watershed Management and Dr. Alexander Huryn of the Department of Biological Sciences at the University of Maine in Orono. MDEP has sampled the stream and tributaries using the qualitative multihabitat method developed to screen for non-point source biological impacts (Part I, Ch. 2)**,** as well as using the traditional, quantitative, introduced substrate methods of the Biological Monitoring Program. Dr. Huryn has applied methods developed to examine differences in leaf litter processing rates in streams of differing nutrient content.

Historical Perspective

Milestone Events in the Basin

YEAR	WATERBODY	AFFECTED STATIONS	EVENT
1970-1985	Mainstem and West Branch	Mainstem stations above Orono	West Branch assigned **Class D**; Mainstem assigned **Class C** but much of the river failed to attain water quality standards and was federally listed as **"Water Quality Limited"**
1974	Mainstem	124, 125, 126, 127, 128, 129, 130, 131, 132, 133	Rabeni samples above and below paper mills with primary wastewater treatment, finding severe aquatic life impacts from poor water quality
1976-1979	Mainstem	All mainstem stations	Millinocket mills (2), Lincoln mill and Town of Millinocket convert to secondary treatment
1981	Mainstem	124, 125, 126, 127, 128, 129, 130, 131, 132, 133	Davies repeats Rabeni study; finds dramatic improvement in condition of aquatic life downstream of improved treatment plants

YEAR	WATERBODY	AFFECTED STATIONS	EVENT
1986	Statewide	East and West Branches	Water Quality Standards revised: elimination of Class D; merger of Class B-1 and B-2 into new Class B and creation of new Class AA
1986	East Branch		Upgraded to Class AA
1990	Mainstem	47 miles or 59% of mainstem length in segments	Statutory water quality classification upgrade from **Class C** to **Class B** for mainstem segments with improved water quality
1993	Mainstem and selected tributaries		Penobscot Indian Nation initiates water quality monitoring program
1999	Mainstem		Upgrade of entire mainstem to **Class B,** from the Mattawamkeag to tidewater (excluding a 1 mile segment in the Enfield impoundment to remain Class C)

As noted in the above table, water quality in the Penobscot River has improved to the extent that the statutory classification was upgraded in 1990 to Class B for 59% of the length of the mainstem. In the 1999 Legislative session, the entire mainstem (excepted a 1 mile impounded segment) was upgraded to Class B. The Biological Monitoring Program has an unusually extensive record of the changes in the biological communities of the Penobscot mainstem, in relation to changes in water quality, dating back to 1974. At that time the river was listed as a Federal Water Quality Limited Segment from Millinocket, on the West Branch, to the Weldon Dam near Mattawamkeag, because it was not attaining minimum federal water quality standards.

Water quality downstream of the Lincoln pulp and paper mill was also severely degraded. The period from 1974 through 1977 was marked by aggressive treatment plant construction activities on the Penobscot, with the result that by 1977 total suspended solids and biochemical oxygen demand loads to the river were reduced by about 80%. Gradual improvement in discharger performance and implementation of secondary treatment for smaller dischargers has continued to the present.

Case Study 4

Long-Term Monitoring of Water Quality Improvement, Penobscot River Mainstem

Between 1974 and 1981, an estimated 33 million dollars was spent by industry, state and federal sources to implement primary and secondary wastewater treatment technology on facilities discharging into a 100 km section of the Penobscot River between Millinocket and Costigan, Maine. These expenditures resulted in an 80% reduction in the load of biochemical oxygen demand and total suspended solids discharged from the kraft and sulfite pulp and paper mills in the study area. The benthic macroinvertebrate community in the river in 1974 was determined to be highly degraded at three stations in closest proximity to pulp and paper effluents (Stas.129, 131, 133). An additional two sites, somewhat downstream of pollution outfalls (Stas. 125, 126) were determined to be degraded (Rabeni 1977). The benthic community of the study area has been re-evaluated several times following the major water quality changes of the 1970s, with the conclusion that the investments have resulted in dramatic improvements in the river's ability to support aquatic life.

Station 129 was designated "Highly Polluted" in 1974. It is located 4 km downstream of the Lincoln Pulp and Paper Company outfall. Figure 14 provides a graphical summary (box plot) of changes in significant measures of aquatic community structure for the period of record at Station 129. Appendix 2 provides an explanation of box plot display of data. The nine measures shown are used by DEP in the First Stage linear discriminant model to assign aquatic life classification attainment. In 1974 the substrate at Station 129 was covered with sewage bacteria (*Sphaerotilus*) and the invertebrate community was restricted to worms, leeches and pollution tolerant midge larvae. Numbers of individuals were very high, indicating a "bloom" of tolerant, opportunist organisms. Diversity and richness values were very low and there was a complete absence of pollution-sensitive mayflies and stoneflies (Fig. 14: *283-74*). In terms of aquatic life classification, this station did not meet minimum state or federal standards.

By 1981 dramatic improvements were seen in the benthic macroinvertebrate community (Davies 1987). Total abundance was down, richness and diversity were improved and the proportion of tolerant midge larvae was lower (Fig. 14: *273-81*). Low numbers of stoneflies and mayflies were also present. Overall attainment had improved to Class C standards. The station has been sampled four times since 1981, each time meeting Class B standards and showing continued improvement in community structure, including high diversity and richness and healthy stonefly and mayfly populations. This long-term dataset provides a valuable example of the responsiveness of the biota to water quality improvements. It also highlights the unique usefulness of biological monitoring to document and summarize the real world benefits of responsible stewardship of the State's aquatic resources.

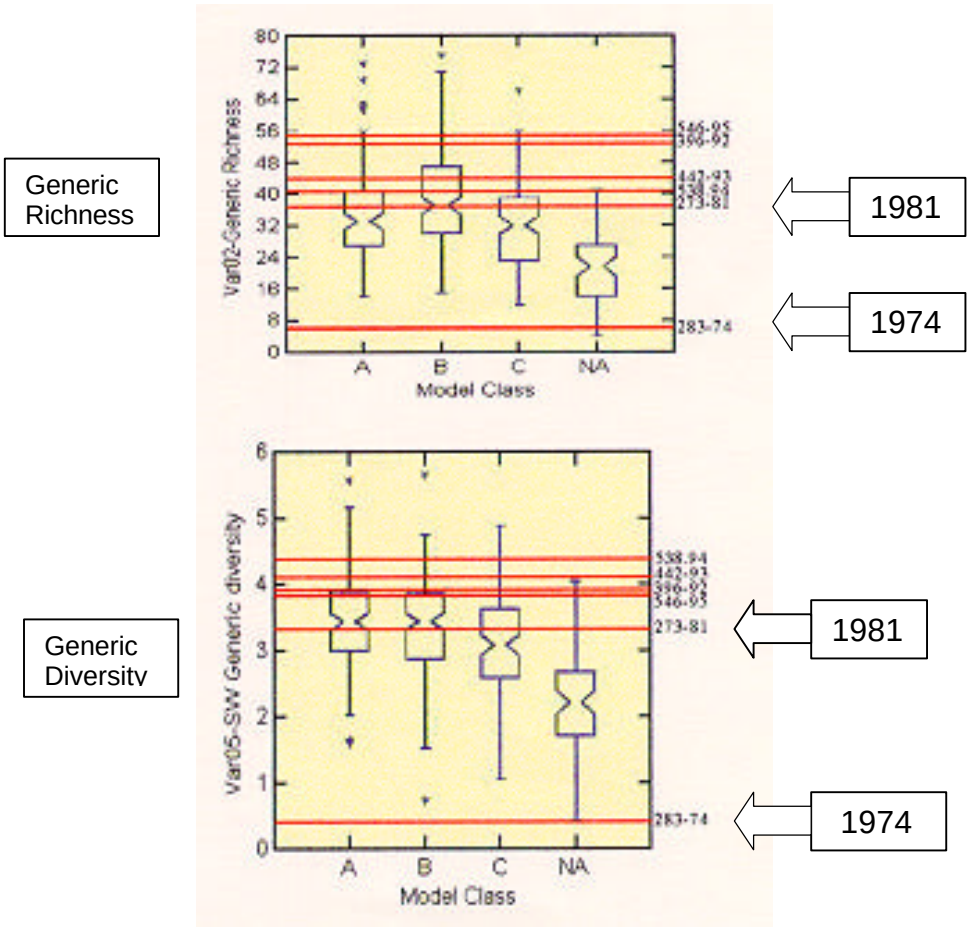

Figure 14 Box plots showing values for 2 biological community variables from Sta. 129, the Penobscot River below Lincoln Pulp and Paper, between 1974 and 1996, as compared to the distribution of all values for all sites within a given class in the MDEP Biological Monitoring Program database

Current Status and Issues

Ten sampled stations in the Penobscot basin are now failing to attain applicable aquatic life standards (Stations 283, 284, 285, 290, 291, 310, 311, 312, 313, and 314 Basin Table 3, p. 138; Basin Map 3, p. 163). Several are new stations on small, non-point source affected streams, sampled during the 1996 and 1997 field seasons. On the mainstem and West Branch, 9 out of 18 stations are exceeding the aquatic life standards of their statutory class. One station (Station 277) on the West Branch below Bowater's Great Northern Pulp and Paper mill and the Millinocket POTW exceeded its assigned Class C standard by two classes in 1996, actually attaining Class A standards. All stations sampled on the West Branch and mainstem since 1986, except two (125 and 173), are attaining at least Class B standards; and three attain Class A standards. The two

stations not attaining at least Class B standards both occur in impoundments. Station 125 is located in the impoundment created by the West Enfield Dam and Station 173 is in the Medway Dam impoundment. Both are attaining Class C standards. Station 176, located in the Veazie impoundment has attained Class B standards since 1992, though it only attained Class C standards in 1985. This demonstrates that with improvements in water quality, attainment of riverine standards is a realistic goal, even in the slow moving waters of impoundments. Evidence supporting this is provided by provisional data obtained from water quality sampling on the Penobscot mainstem during the summers of 1996 and 1997. A marked improvement in dissolved oxygen concentrations in the river, including the impoundments, was noted, as compared to data collected in 1986 and 1988 (Paul Mitnik, MDEP, personal communication).

Station 132 is the only station established on the East Branch of the Penobscot River. It is located just upstream of the confluence of the East and West Branches, in the town of Medway. It has not been sampled for aquatic life since 1981. At that time the station was only attaining Class C standards, though sampling in 1974 showed it attaining current Class B standards. Comparisons of available physical and chemical data from 1974 and 1981 indicated a decline in certain water quality parameters including, dissolved oxygen, conductivity and turbidity. Since there are no significant point sources to the East Branch it is possible that these declines, and the associated condition of aquatic life is a result of non-point source impacts of forestry activities in the watershed. No data is available to indicate the current status of this station.

Future Needs

The very large areal extent and remote nature of much of the Penobscot River Basin has resulted in rather sparse coverage of all but mainstem locations. The basin is not due for intensive NPDES sampling by MDEP until 2001. However, with the exception of the lower East Branch and small streams in the greater Bangor region, all aquatic life sampling in the basin has yielded very favorable results. Streams high in the watershed, in general, are not threatened by point sources, but may be vulnerable to forest harvesting activities. This should be evaluated, as MDEP staff resources allow.

The cooperative study between MDEP and Dr. Huryn at the University of Maine, on the Kenduskeag Stream watershed, is ongoing and should yield valuable information regarding the needs of urban and agriculturally impacted streams. The results will be of statewide value. The East Branch should be sampled prior to the next scheduled NPDES rotation, to determine whether or not it is currently attaining standards.