

PENOBSCOT RIVER MERCURY STUDY

FINAL REPORT

**Mercury Contamination of the Penobscot River Estuary:
Current Situation, Remediation Targets
and Possible Remediation Procedures**

**Submitted to Judge John Woodcock
United States District Court (District of Maine)**

April 2013

By: The Penobscot River Mercury Study Panel

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By John W.M. Rudd, R.A. Bodaly, Nicholas S. Fisher, C.A. Kelly, A.D. Kopec and C.G. Whipple

The Penobscot system is contaminated with legacy mercury (Hg) from the HoltraChem site, and this results in continued elevated levels of methyl mercury in biota. Current inputs to the system are small and are not contributing substantially to the problem of high Hg in biota. Recovery of the system has been slow and therefore active remediation is needed to speed recovery.

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By R.A. Bodaly, A.D. Kopec, J.W.M. Rudd, N.S. Fisher and C.G. Whipple

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By Ralph R. Turner.

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By C.C. Gilmour, T. Bell, A. Bullock, A. Graham, A. Maizel, G. Riedel, G. Riedel, and A.D. Kopec.

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By R.A. Bodaly, C.A. Kelly, and A.D. Kopec.

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By R.A. Bodaly and A.D. Kopec.

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By A.D. Kopec and R.A. Bodaly

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By R.A. Bodaly and A.D. Kopec.

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By A.D. Kopec and R.A. Bodaly.

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By R.R. Turner and A.D. Kopec.

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By John W. M. Rudd, Nicholas S. Fisher and Chris G. Whipple.

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By C.G. Whipple

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By John W.M. Rudd, R.A. Bodaly, Nicholas S. Fisher, C.A. Kelly, A.D. Kopec and Chris G. Whipple.

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1 EXECUTIVE SUMMARY

Between 1967 and early 1970's, 6-12 tonnes of mercury (Hg) were discharged from the HoltraChem plant at Orrington, Maine (ME), to the Penobscot River, with smaller amounts being released since that time. At least 9 tonnes are found today in the sediments of the upper and lower Penobscot estuary. Much of this Hg is now buried beneath the surface layer of the sediments, but enough is still present in surface sediments to make the concentrations 10-20 times as high as regional background concentrations. These high concentrations are now widely dispersed throughout the upper estuary, which includes the main stem of the river below Veazie Dam, Mendall Marsh, and the lower Orland River. Hg has also been dispersed into Fort Point Cove, and further south in Penobscot Bay as far as Vinalhaven Island at lower surface concentrations, but still elevated above regional background levels. The geographic pattern of distribution of mercury, both in deep sediments (dated ca. 1967) and in surface sediments, and in biota, is consistent with the HoltraChem site being the major source to the estuary.

Present-day elevated Hg concentrations in biota are due primarily to legacy Hg that still elevates surface sediment Hg concentrations. For some bird and fish species, Hg concentrations are at remarkably high levels, exceeding known toxicity thresholds for these animals. Present-day elevated biota concentrations are not due to ongoing inputs from the HoltraChem site, or from other point sources in the upper estuary.

The form of Hg released from chlor-alkali plants is inorganic Hg, but the form of Hg that is most toxic to biota and humans is methyl Hg. Inorganic Hg is transformed to methyl Hg by bacteria that reside in sediments and wetland soils. Production of methyl Hg in the Penobscot estuary, especially in some wetlands, is more efficient than at most other studied locations. Methyl Hg concentrations are positively related to the total Hg concentrations (the total concentration of all forms of Hg present) in the surface sediments and wetlands. Some habitats in the Penobscot estuary, such as Mendall Marsh, have much higher concentrations of methyl Hg than others, relative to total Hg, but within each habitat, it is clear that sites with higher total Hg concentrations have higher methyl Hg concentrations. In addition, studies of biota showed that there is a link between sediment Hg and biota Hg. Thus, remediation approaches that lower total Hg concentrations in sediments will also lower methyl Hg concentrations in biota.

Methyl Hg biomagnifies in food chains, and certain biota have methyl Hg levels that are either toxic to themselves or to their consumers. In particular, some bird species living in Mendall Marsh and other contaminated marshes in the Penobscot estuary (sites of high Hg methylation rates) are at risk due to the very high levels of Hg in their tissues. In some cases, aquatic prey species were found to be at methyl Hg concentrations that cause toxicity to predatory fish or birds. There is also concern for humans that consume ducks and eels from the upper Penobscot estuary, and lobster in Fort Point Cove.

Hg concentrations in surface sediments and wetlands have been declining since the peak discharge years just following 1967. However, the rate of decline has been slow, as evidenced by the decline of Hg concentrations in dated sediment cores, and the fact that these surface sediment concentrations are still 10-20 times background, 46 years

since discharges began, and still high enough to be hazardous to biota and to human consumers. At current rates of decline, it is estimated that it will take about 33 years for Hg concentrations to be low enough in the main stem of the river to not cause problem levels in biota. In Mendall Marsh it will take longer (about 60 years), because of the high efficiency of methylation in that marsh.

The slow rate of recovery is due to the presence of a large pool of Hg contaminated mobile sediments (estimated at 320,000 tonnes) that has been trapped in the upper estuary. These mobile sediments are efficiently retained in the upper estuary by hydrodynamic processes, which slow the loss of Hg contaminated particles to Fort Point Cove and Penobscot Bay.

Because of this slow rate of recovery, and the continuing risk to biota and human consumers, the Study Panel recommends the establishment of a Remediation Program. This Program involves three types of active remediation procedures that we specifically recommend, including a description of information needed to resolve some scientific and engineering uncertainties that remain before full scale remediation is undertaken. These remediation treatments could be applied separately or in combination. Two of these remediation treatments involve the removal of contaminated mobile sediments either in the entire upper estuary or from Mendall Marsh, and replacement with clean sediments. These treatments would lower the total Hg concentrations in the mobile sediment pool and in the surface sediments where methyl Hg is produced. In turn, methyl Hg concentrations would be lowered in the food chain and in prey species. This would also reduce the risk to human consumers. A third proposed remediation treatment would specifically address the serious situation in Mendall Marsh. For this treatment a Hg binding agent, SediMite™, would be added to the surface soils of the marsh where methyl Hg is produced. This material reduced methyl Hg concentrations in the sediment pore water, and so retards the movement of methyl Hg into the food chain and birds, which are most at risk in Mendall Marsh.

The Study Panel has set targets for total Hg concentrations in certain key aquatic and marsh species and for surface sediments in the upper estuary and Mendall Marsh (450 ng/g dry wt. and 100 ng/g dry wt., respectively). These targets are based on the percentage reduction of methyl Hg in biota that is needed to achieve non-toxic levels in biota. If the remaining uncertainties for the treatments we recommend are satisfied, our studies indicate that recovery times to target levels in the biota would be reduced from several decades to about 5 years.