2003 Caged Mussel Biomonitoring Results

Ed Friedman, Friends of Merrymeeting Bay
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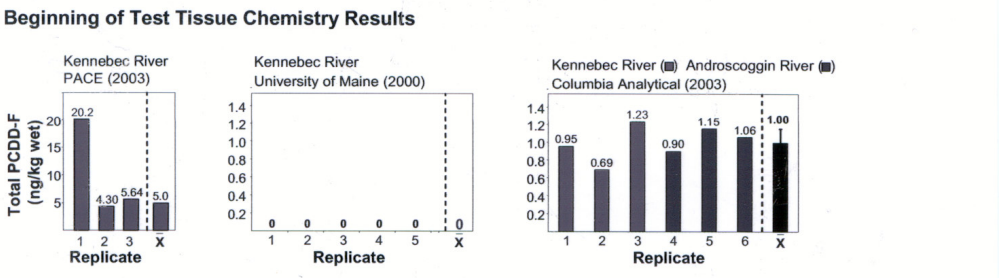
The results from our mussel studies are in and demonstrate that caged bivalves can be an effective surrogate for fish when monitoring dioxins & furans. This is so particularly when they are used to characterize current chemical exposures & possible ecological effects. While the primary goal of the mussel redeployment on the Kennebec, and initial deployment on the Androscoggin, was to evaluate the use of caged mussels as possible biomonitors of dioxin in the state's mandated "above/below" [A/B] test, we also wanted to determine if either the Sappi or International Pulp & Paper [IP] mills were currently discharging dioxins. On the Kennebec we also wanted to evaluate the mussels for possible endocrine system effects from the Sappi discharges.

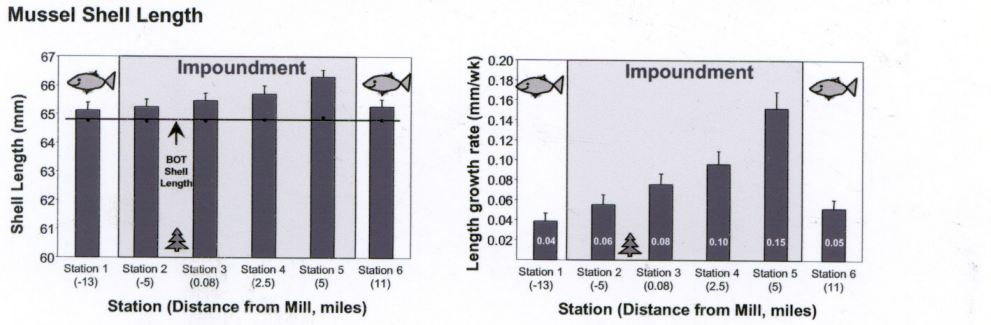
As far as reliably discerning specific contaminant levels detected, there is a huge caveat and this would apply to fish and lipid bags [other monitoring methodologies] as well. In dealing with what appear to be very low contaminant levels, we are flirting with the analytical detection limits of the labs. For instance: In our 2000 study the baseline mussel tissues collected at the beginning of the test from Woolwich had no detectable concentrations of dioxins-furans as analyzed by the University of Maine in Orono [UMO]. In 2003 baseline tissues collected from the same lake as in 2000 were analyzed by two different labs. Columbia Analytical Services [CAS] in Houston [IP's contract lab] found average dioxin/furan concentrations of approximately 1 part per trillion [ppt] while Pace Lab in Minneapolis [low bidder for the DEP contract] detected levels of 5-20 ppt in split samples from the same tissues. In 2000 UMO evaluated end-of-test tissues from the



Kennebec using 150-gram sample sizes and detected 15 of 17 possible dioxin congeners [varieties] tested for, from two mussel cage sites 11 and 13 miles from the mill [stations 1&6]. In 2003 Pace evaluated the end-of-test tissues from six sample sites on the Kennebec [including 3 in the impoundment directly below the mill] using 30-gram samples and only detected 3 congeners. *In light of these confounding factors it seems logical that the DEP would want to have some corroborative testing done using remaining tissue, by the same or third party labs.*

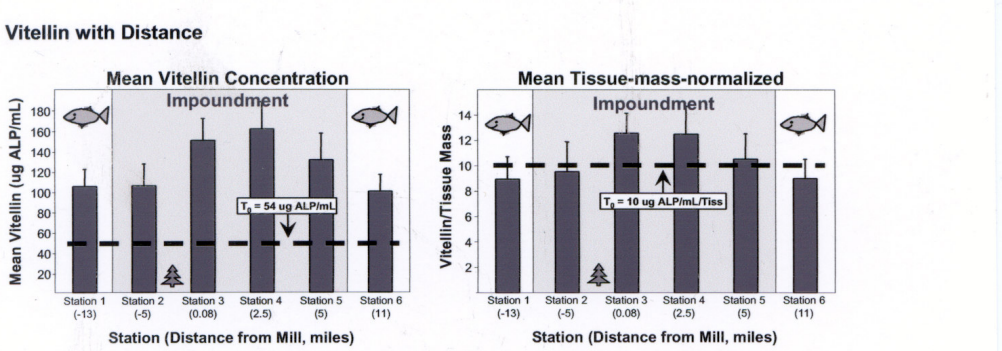
Discussions with analytical chemistry experts from a variety of labs who routinely run these analyses indicate that the more tissue used for analysis, the greater the potential to detect congeners but the greater the likelihood of sample contamination in the lab procedures. One EPA testing standard [1613B] commonly used by a number of labs is somewhat vague on details as well as being somewhat dated [for techniques that are constantly being improved]. Methodologies defined in that standard have now been supplemented or replaced by a number of specialty labs that use more sophisticated procedures. *It seems clear that in the arena of analyses as well as other areas of the DEP monitoring program, that effective and defensible standards need to be decided upon in a transparent process with input from independent peer reviewers and stakeholders. Accountability procedures should probably be put in place before more funds are dispersed.*

But, assuming for the moment that the chemistry numbers are in fact reasonably accurate, the data seem to indicate that neither mill is currently discharging the most toxic dioxin congeners. However, Sappi may be the source of some of the least toxic congeners generally associated with combustion [OCDD] and the town of Livermore Falls may be a contributor on the Androscoggin. The mussels deployed in the Kennebec show very clearly effects on growth as likely caused by the mill both in tissue and shell weight and in shell lengths. The mill appears to be an excellent food source though as a blood test



can demonstrate and as our mussels also show, that just because you appear fat, dumb, and happy, all is not necessarily well. When looking at the Kennebec mussels and comparing the old A/B stations [1&6], growth metrics are virtually identical at these sites 25 miles apart yet one can see evidence of very different growth patterns within the impoundment occurring in a gradient downstream of the mill. *This gradient, suggestive of mill effects, illustrates the problem of using above and below sites so far apart [where the DEP fish samples are caught] that can clearly miss possible impacts from the mill.*

Francois Gagne, Christian Blaise, and Chantale Andre, from Environment Canada's St. Lawrence Center performed a vitellin bioassay on our Kennebec mussels. Elevated levels of vitellin have been associated with possible endocrine system disruption and adverse reproductive effects. In a yearlong deployment of caged mussels exposed to wastewater effluent in the St. Lawrence River elevated vitellin levels were associated with sex reversals in mussels while the same effects have been observed in fish showing high levels of vitellogenin [the comparable compound for fish]. *Elevated vitellin levels were very obvious in the impoundment stations below the mill outfall. The lesson here is that*



while dioxin discharges may have become minimal there are likely plenty more chemicals of possibly greater concern still being discharged in mill effluent [26 million gallons per day at Sappi]. This is why FOMB and other groups have continually pushed for closed loop or low flow water systems at the mills, a technology used elsewhere by some of the same companies. Also, as dioxin concentrations have fallen and consequently become more difficult to measure, a number of countries [such as Canada, Sweden, & New Zealand] have switched away from analytical chemistry to effects based monitoring. The DEP may also need to consider at least supplementing their analytical program with effects monitoring to acquire a more complete picture

Caged mussels would seem to be an excellent addition to the DEP monitoring program both for measuring concentrations and showing effects, and for doing so in a controlled way not possible with fish. One could even deploy mussels on the bottom and in the water column to determine differences between historical deposits and current discharges, a question that plagues fish testing but has yet to be resolved. A recently released report by an independent peer review panel noted that smallmouth bass tend to live and feed in the water column [perhaps being more representative of current discharges] while white suckers [nick-named "Hoovers"] spend their lives bottom feeding and are thus more exposed to possible historical accumulations. We arrived at this conclusion independently as we observed both levels of contaminants in white suckers and total possible dioxin "hits" to be substantially higher than with the bass. *While fish may show a tendency to preferentially accumulate the most toxic congener [2,3,7,8-TCDD] mussels seem to do better overall.* Comparing the number of dioxin hits equal to or greater than the detection limit to a total possible from this year's Kennebec data; SPMDs [lipid bags] detected 9.2%, fish [smallmouth bass and white suckers combined] detected 9.4%, and mussels detected 16.3% of total possible hits. On the Androscoggin [with no congener specific data available for SPMDs] combined fish totals were 22.8% to the mussels 23.4%. In 2000 on the Kennebec it was SPMDs 6%, fish 20%, and mussels 38%.

At the lower limits of both possible dioxin discharges and analytical chemistry, regulation based on chemical measurements alone [as the legislation requires] appears to be problematic. If the years of DEP dioxin monitoring since the law went into effect in 1997 have shown one thing it is this. Filled with technical problems not well evaluated when the law was passed, the legitimacy of the A/B test may need to be reevaluated. While these two mills may now be in compliance as far as the dioxin discharges go we believe that the bigger issue to readdress, is that of the millions of gallons of wastewater discharged daily, with their host of unknown constituents, that do in fact show evidence indicative of harmful effects. Moving towards a new paradigm of effects based monitoring combined with analytical chemistry to provide a weight of evidence approach is perhaps the best way to move forward in our quest for cleaner rivers.

Your organization funded this study, dug deep, persisted in lobbying legislators, and has pushed DEP for answers to tough questions that should have been asked years ago. On more than one occasion I found myself exasperated, remarking to a legislator "this is not our job". FOMB has been very fortunate to work with the premier consultants in this field. They developed the ASTM standards for this methodology [requiring a three year peer review process] and their dedication has been unmatched. *Our watchwords have always been: "transparency, scientific & legal defensibility" and the legislators concurred.* Member support is vital to continue this type of work so essential for improving the quality of our rivers and the Bay. More information about this methodology can be found in the "cybrary" section of our web site and a report on the project will be presented at our April 8th Speaker Series event. There is a dedication at the beginning of the 1999 DEP publication *Biomonitoring Retrospective: Fifteen Year Summary for Maine Rivers and Streams* that is apropos, it reads: "This work is dedicated to the smallest creatures, existing at the edges of our awareness. Through them we glimpse intricate realities other than our own, and we are reminded to stay humble."