Trophic Transfer of Atmospheric and Sedimentary Contaminants into Great Lakes Fish: Control on Ecosystem Scale Response Times

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This project was completed in 2001

During the past two decades, inventories of persistent, bioaccumulative organic contaminants have decreased dramatically in the Great Lakes ecosystem. Initial rates of decline of PCBs in the Great Lakes were rapid during the 1970's and early 1980's, but, unfortunately, this rate of decline has apparently slowed since the second half of the 1980s. The most recent data show little or no change in PCB levels in the Great Lakes fishery. This apparent stabilization of PCB levels near the Food and Drug Administration (FDA) advisory level is problematic. The persistence of PCBs in Great Lakes fish has led some to the call for additional regulations, but others argue that the decrease in the rate of recovery of PCBs in the Great Lakes is a natural consequence of internal recycling and continental scale atmospheric exchange and that further regulations are neither cost-effective or warranted.

This project will conduct a field study in Grand Traverse Bay, Lake Michigan to quantify trophic transfer of PCBs through the northern Great Lakes food web, with emphasis on the heretofore unstudied linkage between atmospheric contaminant inputs and benthic food webs via rapidly-settling particles. A quantitative, process-driven model of contaminant transfer in the Great Lakes food web will be developed that distinguishes between 'new' (i.e., regional atmospheric deposition) and 'in-place' (i.e., recycling from contaminated sediments) sources of contaminants that support the slowly-changing contaminant inventories in the highest trophic levels of the Great Lakes.

Our objectives are to quantify the absolute and relative magnitudes of PCB transfers into the northern Great Lakes fisheries from three exposure routes: (1) atmospheric deposition transferred through the pelagic food web, (2) atmospheric deposition transferred via rapidly-settling particles, through the benthic food web, and; (3) transfer from historically-contaminated, in-place sediments through the benthic food web. We hypothesize that each of these routes differ both in their efficiencies of contaminant transfer and in their characteristic response times.

2001 Plans

There are four graduate students involved with this program at MSU and U MD. They have been given the lead on writing the results for publication. We will be involved in at least two manuscripts: one on fluxes of PCB and PAH in the Bay and a second on food web stable isotope fractionation. A final report to EPA also need to be completed during the year and we will contribute a section.

2001 Accomplishments

The final report to EPA and one manuscript were submitted (see products below). This project is now completed.

2000 Plans

A report containing all of the trap data collected over the course of the three-year project will be published. This will serve as a source and reference for the students at MSU and U MD who will be writing manuscripts for the peer-reviewed literature. Presentations will be made at scientific meetings. The PIs and students will meet to make final writing assignments covering the next year.

2000 Accomplishments

Results of trap collections and constituent analyses were discussed at a two day PI and student meeting. An outline of trap and PAH fluxes was developed as a basis for a manuscript. A GLERL Technical Report was completed with all of the project trap data. For the entire duration of the sampling period the average mass flux to GT1 and GT3 were 1.03 ± 1.22 g/m2-day and 0.74 ± .83 g/m2-day respectively. Yearly the mass fluxes at the two sites are not significantly different ($p>0.05$ for the null hypothesis). During the stratified period the average mass flux at GT1 was 0.40 ± 0.20 g/m2-day and at GT3 it was 0.52 ± 0.44 g/m2-day and the two sites are not significantly different from each other ($p>0.05$, null hypothesis). The average mass flux in stratified period at both GT1 and GT3 is slightly less than the average mass flux of 0.65 ± 0.26 g/m2-day observed in southern Lake Michigan (Eadie et al, 1984). GTB mass flux greater than the 0.14 ± 0.06 g/m2-day mass flux observed in the open waters of Lake Superior (Jerimiason et al, 1998)

The average tPAH flux to GT1 was 992 ± 1775 ng/m2-day, while the average tPAH flux to GT3 was 84 ± 128 ng/m2-day. Even though their overall average mass fluxes were similar, the tPAH flux to GT1 significantly greater than tPAH flux to GT3 ($p<0.01$, null hypothesis). Particles settling through the water column at GT3 are less contaminated then at GT1. As with the mass flux there is no significant difference in tPAH flux between GT1 and GT3 ($p>0.01$, null hypothesis) during the stratified period. During the unstratified period tPAH flux was significantly greater at GT1 than at GT3 ($p<0.01$, null hypothesis). The mass fluxes during this time period were also significantly different at the two sites. GT3 had fewer episodic peaks in mass flux than GT1. The elevations in tPAH mass flux at GT1 correspond temporally to peaks in the mass flux at this site These episodic events increase the tPAH flux in the unstratified period at GT1 and tPAH flux is significantly greater during the unstratified period than during the stratified period ($p<0.1$, null hypotheses for paired t-test; $p<0.05$ for independent t-test)

1999 Plans

Deployments of sediment traps in Grand Traverse Bay from Sept. 1998 will be retrieved in July 1999. These are the last field samples being collected, efforts will be focused on data interpretation and writing. Presentations are scheduled for ASLO and IAGLR.

1999 Accomplishments

The final sediment traps deployed for the Grand Traverse Bay program have now been retrieved and all 366 samples have been processed for mass flux calculations and distributed to Co-PIs for constituent analyses. These analyses will be completed over the coming year and manuscripts will follow. Presentations have been made at ASLO and IAGLR.

1998 Accomplishments

The retrieval and redeployment of four trap moorings in Grand Traverse Bay, MI, were successfully completed. Samples were processed internally, then split and distributed to collaborators at Michigan State University and University of Maryland. Initial sample analysis infers intense seiches occurred in September and December 1997, with most sediment transport occurring in these two events.

Other efforts in Traverse Bay by G. Miller includes: Echo intensity (backscatter) data from Acoustic Doppler Current Profilers show persistent diurnal box-wave oscillations. The hypothesis that this is due to zooplankton (Mysis) diel migration behavior. There is considerable interest in determining whether various zooplankton species can be identified using acoustic technology. If so, ADCP backscatter intensities would provide a measure of temporal and spatial zooplankton variability at scales not possible with traditional sampling methods. Analysis or the utility of this approach for high temporal and spatial resolution analysis is continuing.

Products

Baker, J., N. Ostrum, B.J. Eadie, and others. *Trophic transfer of atmospheric and sedimentary contaminants into Great Lakes fish: Controls on ecosystem-scale response times. Report to EPA (FAS# 07-5-25310).* 242 pages.

Schneider, A.R., B.J. Eadie, and J.E. Baker. 2002. Episodic particle transport events controlling PAH and PCB cycling in Grand Traverse Bay, Lake Michigan. *Env. Sci. Tech*. (Submitted)

Eadie, B.J., G.S. Miller, M.B. Lansing, and A.G. Winkelman. 2000. *Settling Particle Fluxes, Current and Temperature Profiles in Grand Traverse Bay. NOAA Technical Memorandum ERL GLERL - 116*. 25 pages.

Cohen, A.R., Stapleton, H.M., Baker, J.E., and Eadie, B.J. *High frequency measurements of PCB and PAH settling fluxes in Grand Traverse Bay, Lake Michigan*. IAGLR, May, 2000