NATIONAL BIOLOGICAL SERVICE
U.S. DEPARTMENT OF THE INTERIOR

NBS INFORMATION BULLETIN

No. 34 1995

A Simulation Model Looks Back at PCB Concentrations in Alewife

A lakewide survey of polychlorinated biphenyl (PCB) concentration in Lake Ontario alewife (*Alosa pseudoharengus*) was not conducted until 1986, even though alewife is the principal prey fish of adult lake trout (*Salvelinus namaycush*) in Lake Ontario. We applied an individual-based model (IBM) to the lake trout population in Lake Ontario in 1986 to back-calculate PCB concentrations in alewife. Results from the model indicated that the PCB concentration in adult alewife from 1979 through 1985 was, on the average, almost 4 times higher than the PCB concentration in alewife observed in 1986.

In the mid-1980's, PCB concentrations in lake trout from Lake Ontario exceeded the PCB concentrations in lake trout of similar age from Lake Michigan. Furthermore, PCB concentrations in rainbow smelt (*Osmerus mordax*) and slimy sculpin (*Cottus cognatus*), two prey fish favored by juvenile lake trout in both lakes, were substantially higher in the 1980's in fish from Lake Ontario than in fish from Lake Michigan. The alewife was the predominant prey species for adult lake trout in both lakes. An exponential decline in alewife PCB concentrations has been documented in Lake Michigan; however, the temporal trend in PCB concentrations of alewife from Lake Ontario is unknown because the first reported contaminant analysis of alewife from Lake Ontario was conducted on fish caught during 1986. In 1986, the mean PCB concentration in adult alewife from Lake Michigan was roughly twice as high as that measured in alewife from Lake Ontario. During the 1980's, PCB levels in lake trout, slimy sculpin, and smelt were higher in Lake Ontario, but we questioned whether PCB levels in alewife were higher in Lake Michigan.

Simulation Model Tracks Lake Trout Growth and PCB Uptake

In an earlier study, a computer simulation model was presented with data on lake trout populations from Lake Michigan to analyze factors contributing to the variation in concentrations of PCBs in lake trout. The model tracked the growth and PCB uptake for a set of individual lake trout. The model comprised three submodels: predator–prey encounter, bioenergetics, and contaminant accumulation.

In the present study, we fitted the simulation model to the 1986 data for the Lake Ontario lake trout populations to estimate the average PCB concentration in alewife in Lake Ontario from 1979 to 1985. This estimation was accomplished by adjusting the average PCB concentration of adult alewife until the simulated PCB concentrations of the lake trout matched the concentrations observed in lake trout. The adult alewife PCB concentration in 1986 was set equal to the observed value of 0.5 mg/kg in the simulation trials.

The PCB concentrations predicted in lake trout agreed with the observed concentrations when the value of 1.8 mg/kg was assigned to adult alewife from 1979 through 1985 (Figure). In contrast, when the alewife PCB concentration was assumed to remain constant at 0.5 mg/kg from 1979 through 1986, the predicted concentrations in lake trout were substantially lower than the observed concentrations (Figure). Thus, the modeling results indicated that the average alewife PCB concentration between years 1979 and 1985 was nearly

4 times the concentration observed in 1986. Why would PCB concentration change so drastically between 1979–85 and 1986?

A plausible explanation for the apparent decrease in PCB concentrations in adult alewife in Lake Ontario between 1979–85 and 1986 is that adult alewife PCB concentration is dependent on alewife population dynamics. From 1976 to 1986, the alewife population in Lake Ontario underwent sharp interannual changes in abundance that generated correspondingly large changes in growth and in age and size composition. These changes should have caused sharp interannual shifts in contaminant concentrations. The proportion of older (age 4 and older) alewives within the population decreased dramatically between 1984 and 1986. Older alewives contain higher PCB concentrations than younger alewives due to longer exposure to the contaminant. Furthermore, the growth rate of adult alewife was slow in the early 1980's. In general, it has been shown that faster growth rate is associated with lower PCB accumulation rate, because of biomass dilution.

Value to Management

Whether contaminants in Lake Ontario fish species have declined over time is still in question. Observations of PCB concentration in alewife from 1986 to the present can be compared with the estimate from the early 1980's to determine if PCB concentration in alewife decreased from the early 1980s. The age distribution within the alewife population would need to be considered in interpreting temporal trends in alewife PCB concentration.

Our modeling exercise has indicated that PCB concentrations in lake trout in Lake Ontario are dependent on the population dynamics of alewife. We expect that PCB concentrations in the other salmonines will show a similar dependency because the alewife is the predominant prey fi for all salmonines in the lake. Consequently, the status of t alewife population dynamics can be used as an indicator of PCB concentrations in salmonines.

For further information contact

Charles P. Madenjian
Great Lakes Science Center
1451 Green Road
Ann Arbor, Michigan 48105
(313)994-3331

or

D. Michael Whittle
Great Lakes Laboratory for Fisheries and Aquatic Sciences
Department of Fisheries and Oceans
Burlington, Ontario L7R 4A6
(905)336-4565

or

Joseph H. Elrod, Robert O'Gorman, or Randall W. Owens
Great Lakes Science Center
Lake Ontario Biological Station
17 Lake Street
Oswego, New York 13126
(315)343-3951

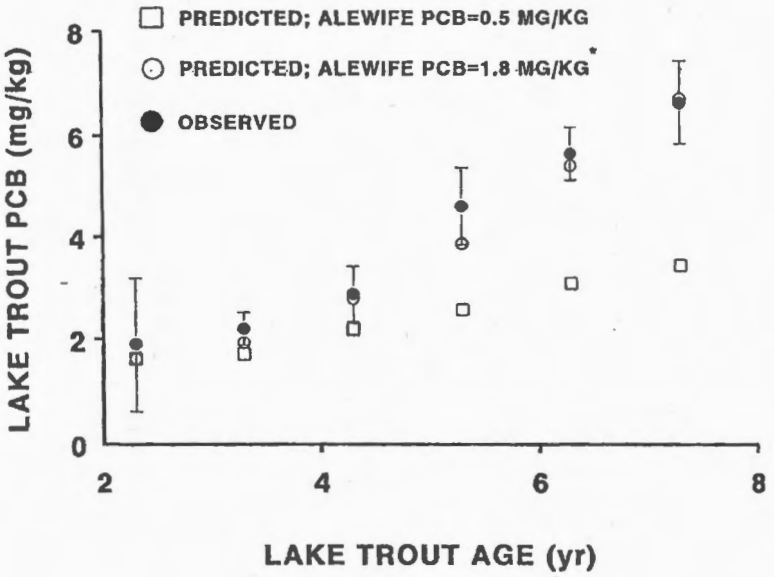

Figure. Observed and predicted average PCB concentrations in whole lake trout (*Salvelinus namaycush*) at ages 2 through 7 from Lake Ontario in 1986. Bars around the observed means represent ±2 SE. Predictions were based on an individual-based model (IBM) for PCB accumulation in lake trout. Predicted averages from the two sets of IBM simulations are shown; in one the PCB concentration in adult alewife (*Alosa pseudoharengus*) was held constant at 0.5 mg/kg, and in the other the PCB concentration in adult alewife was assigned a value of 1.8 mg/kg for years 1979–1985 and a value of 0.5 mg/kg for 1986.