Bull. Environ. Contam. Toxicol. (1995) 54:919-923

Environmental Contamination and Toxicology

Comparative Analyses of Contaminant Levels in Bottom Feeding and Predatory Fish Using the National Contaminant Biomonitoring Program Data

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Received: 1 May 1994/Accepted: 2 November 1994

Both bottom feeding and predatory fish accumulate chemical contaminants found in water. Bottom feeders are readily exposed to the greater quantities of chlorinated hydrocarbons and metals that accumulate in sediments (Guthrie and Perry 1980). Predators, on the other hand, may bioaccumulate organochlorine pesticides, PCBs, and metals from the surrounding water or from feeding on other fish, including bottom feeders, which may result in the biomagnification of these compounds in their tissues (Guthrie and Perry 1980). This study used National Contaminant Biomonitoring Program data produced by the Fish and Wildlife Service to test the hypothesis that differences exist between bottom feeders and predators in tissue levels of organochlorine pesticides, PCBs, and metals.

MATERIALS AND METHODS

Data from the National Contaminant Biomonitoring Program (NCBP) collected in 1984-1985 were used to test for differences in residue levels between bottom feeders and predators (Schmitt and Brumbaugh 1990; Schmitt et al. 1990). The NCBP, maintained by the United States Fish and Wildlife Service (FWS), documents temporal and geographic trends in concentrations of various environmental contaminants that are a threat to fish and wildlife resources (Schmitt et al. 1985). Freshwater fish tissue samples were collected from a network of sampling stations which were set up across the United States between 1969 and 1984 (Schmitt et al. 1985). The samples were analyzed for organochlorine pesticides, PCBs, and metals (Schmitt et al. 1985).

The 1984-1985 data were used for this project because these data are the most recent and comprehensive that have been published. Fish for the NCBP were collected from 112 stations in the United States at key points in major rivers and

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the Great Lakes (Schmitt et al. 1990). A total of 321 composite samples were collected in the fall and winter of 1984 and early spring 1985 (Schmitt et al. 1990). Two of a representative bottom species (e.g., common carp [*Cyprinus carpio*], white sucker [*Catostomus commersoni*] or other catostomid, or channel catfish [*Ictalurus punctatus*] or other ictalurid) and one of a representative predatory species (e.g., rainbow trout [*Oncorhynchus mykiss*], brown trout [*Salmo trutta*], brook trout [*Salvelinus fontinalis*], lake trout [*Salvelinus namaycush*], largemouth bass [*Micropterus salmoides*] or other centrarchid, or walleye [*Stizostedion vitreum vitreum*]) were sampled. Laboratory analyses of samples were standardized and performed in five laboratories. Therefore, sampling biases and/or variability due to different laboratories performing analyses should be minimized. This project used the wet weight ppm concentrations of the analyzed toxics reported by the NCBP.

To test this hypothesis using NCBP data, the 25 toxics analyzed were grouped into two categories: 1) organochlorine pesticides and PCBs, and 2) metals (Tables 1 and 2). Organochlorine pesticides and PCBs were combined due to the low number of toxics in the PCB category. Also, PCBs are structurally similar to organochlorine pesticides and are lipid soluble. For both categories, the fish tissue residue data were then sorted into bottom feeders and predators. Exploratory data analyses indicated distributions which were skewed toward high values for each contaminant. Using Minitab statistical software, a comparison of means of bottom feeders and predators was performed for each toxic in both groups using a Two Sample-t Test (Welch's V). Although the distributions were skewed, a parametric test (Two Sample-t test) was chosen for the majority of contaminants because of unequal variances and large sample sizes which make the parametric test more reliable. (A Mann-Whitney test was used where appropriate, i.e. equal variances). A p-value of $\leq$0.05 level was used.

RESULTS AND DISCUSSION

Results of the Two Sample-t (Welch's V) tests indicated there were no significant differences in mean residue levels between bottom feeders and predators for 16 of the 18 pesticides and PCBs analyzed (Table 1). Significant differences in tissue residue levels between bottom feeders and predators were only found for *trans*-chlordane and Aroclor 1260.

Results of the Two Sample-t (Welch's V) tests for the metals category showed significant differences in tissue levels for 3 of the 7 metals surveyed (Table 2). The metals found to be statistically different were mercury, cadmium, and zinc.

These results indicate that residue levels for 16 of 18 organochlorine pesticides and PCBs measured in bottom feeders and predators across the entire United States are not statistically different. Significant differences in tissue levels between bottom feeders and predators were found for *trans*-chlordane and

Table 1. Bottom feeders versus predators
(organochlorine pesticides and PCBs)

Pesticides & PCBs	**Mean Fish Tissue Concentration (ppm±s.d.)**		**Significance[a] (p-value)**
	BF (n = 204)	P (n = 116)	
DDE	0.21±0.46	0.24±0.55	NS (p = 0.64)
DDD	0.07±0.21	0.06±0.14	NS (p = 0.65)
DDT	0.03±0.14	0.03±0.06	NS (p = 0.80)
Dieldrin	0.05±0.14	0.04±0.10	NS (p = 0.52)
Endrin	0.00±0.02	0.00±0.01	NS (p = 0.39)
cis-Chlordane	0.03±0.06	0.02±0.04	NS (p = 0.36)
trans-Chlordane	0.02±0.04	0.01±0.02	S (p = 0.016)
cis-Nonachlor	0.02±0.04	0.02±0.03	NS (p = 0.50)
trans-Nonachlor	0.03±0.10	0.03±0.06	NS (p = 0.77)
Oxychlordane	0.01±0.02	0.01±0.01	NS (p = 0.89)
Toxaphene	0.19±0.63	0.17±0.35	NS (p = 0.70)
α-BHC	0.00±0.006	0.00±0.006	NS (p = 0.81)
γ-BHC	0.00±0.003	0.00±0.002	NS (p = 0.085)
HCB	0.00±0.01	0.01±0.04	NS (p = 0.38)
Mirex	0.00±0.04	0.01±0.05	NS (p = 0.36)
Aroclor 1248	0.06±0.32	0.08±0.31	NS (p = 0.63)
Aroclor 1254	0.21±0.39	0.35±0.69	NS (p = 0.063)
Aroclor 1260	0.14±0.24	0.23±0.38	S (p = 0.036)

[a] = Statistically significant at $p \leq 0.05$ (Two Sample-t test)
BF = bottom feeder; n = sample size; NS = not significant;
P = predator; S = significant; s.d. = standard deviation

Table 2: Bottom feeders versus predators (metals)

Metals	**Mean Fish Tissue Concentration (ppm±s.d.)**		**Significance[a] (p-value)**
	BF (n = 202)	**P (n = 112)**	
Mercury (Hg)	0.08±0.06	0.12±0.08	S (p = <0.001)
Lead (Pb)	0.18±0.37	0.15±0.43	NS (p = 0.46)
Selenium (Se)	0.50±0.41	0.50±0.42	NS[b] (p = 0.98)
Arsenic (As)	0.16±0.23	0.16±0.14	NS (p = 0.84)
Copper (Cu)	0.89±0.76	1.18±3.03	NS (p = 0.32)
Cadmium (Cd)	0.04±0.05	0.01±0.02	S (p = <0.001)
Zinc (Zn)	35.96±23.71	17.11±5.67	S (p = <0.001)

[a] = Statistically significant at $p \leq 0.05$ (Two Sample-t test)
[b] = Mann-Whitney test
BF = bottom feeder; n = sample size; NS = not significant;
P = predator; S = significant; s.d. = standard deviation

Aroclor 1260. For *trans*-chlordane, the mean residue level in bottom feeders was greater than the mean residue level in predators. For Aroclor 1260, however, the mean residue level in predators was greater than the mean residue levels in bottom feeders. Overall, the results of the comparative analyses indicate that the majority of the chemicals analyzed accumulate in the fatty tissues of both bottom feeders and predators at about the same rate. These results suggest that for many organochlorine pesticides and PCBs, performing both bottom feeder and predator sampling may not be necessary. Instead, only one trophic guild may need to be collected for analytical purposes. This would result in reductions in field sampling time, laboratory analyses, and a reduction in the monitoring program costs. For the metals category, the results were mixed. Differences in tissue levels were found for mercury, cadmium, and zinc. For mercury, the mean residue level in predators was greater than that of bottom feeders, while for cadmium and zinc, the opposite was true. No differences were detected for selenium, arsenic, lead or copper. Therefore, when conducting analysis for metal contamination in fish, both bottom feeder and predator sampling may be necessary to make reliable estimates of exposure.

Several factors in addition to guild type may have influenced these results. Physiological factors, such as age and fat content of the fish may influence chemical accumulation by fish. Older, fatter fish may accumulate higher levels of a contaminant (EPA 1992). Other factors affecting bioaccumulation include food consumption, growth, reproduction, and metabolic rate (Bruggeman et al. 1984). Other limitations may include the location of sampling stations relative to point and nonpoint sources of pollution, river flow rates, and the fact that water quality may be correlated with the type of fish present such that sampling may be biased toward a certain fish species.

Acknowledgements. My appreciation is extended to J. Andreasen and C. Schmitt, US Fish and Wildlife Service, for their help in carrying out this project. I would like to acknowledge C. Sutton, Operations Research and Applied Statistics Department, George Mason University, for his statistical support.

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