Bull. Environ. Contam. Toxicol. (1985) 34:883–889

Bulletin of Environmental Contamination and Toxicology

PCBs in Striped Bass Collected from the Hudson River, New York, during Fall, 1981

Robert J. White,[1] Himi T. Kim, and Jai S. Kim[2]

Department of Atmospheric Science, State University of New York at Albany, 1400 Washington Avenue, Albany, NY 12222

Striped bass (Morone saxatilis), an anadromous species of fish, enter the fresh water reaches of the Hudson River in March and generally prefer to spawn in the river near the mouth of tributary streams from Piermont to Albany. The fish remain in the river during the summer months and migrate to salt water up until late November. Young striped bass feed on microscopic organisms initially and then quickly graduate to feeding on freshwater shrimp and midge larvae. As adults they feed heavily on small fishes (Werner 1980). This diet is the main contributing factor to the contamination of striped bass with polychlorinated biphenyls (PCBs).

PCB contamination in fish flesh from the Hudson River has been investigated throughout the seventies and early eighties (Hullar et al. 1976; Spagnoli and Skinner 1977; Pastel et al. 1980). The concern over the impact of PCBs on human health directed the New York State Department of Environmental Conservation (DEC) to place a ban on commercial fishing from the Hudson River. This ban has been in effect since 1976. The federal limit, set by the Food and Drug Administration, for commercial fisheries was recently reduced from 5 to 2 parts per million maximum concentration of PCBs in fish for human consumption (Federal Register 1979). Past studies have shown concentrations in excess of 5 ppm. Although there has been some decrease in levels of PCBs in striped bass (of some Aroclor mixtures) since 1976, their decrease was not sufficient to justify rescinding the ban on commercial fishing (Hetling et al. 1978). The ban, which only prohibits commercial fishing, has no effect on recreational fishing of the Hudson River. PCBs a persistent aquatic pollutant, are of special interest since they pose a possible hazard to the anglers who consume them.

Previous results, submitted by DEC, have been based on the use of the standard filet (edible portion), and levels of PCBs were determined by pattern matching, which estimates individual Aroclor mixtures. Concentrations are determined by assigning unique PCB congemers to the individual Aroclor mixtures (Spagnoli

[1] Present Address: U.S. Testing, Hoboken, NJ 07030
[2] To whom correspondence should be addressed

and Skinner 1977). Aroclor 1260, for instance, was estimated from 2,3,4,2',3',4',5'-heptachlorobiphenyl. It has been established that many PCBs are not retained by a living organism (less lipophilic) (Cahn 1977); thus, reported levels may be high due to pattern matching. This study reports levels quantified on a peak to peak basis.

The objectives of the present study were to determine the levels of polychlorinated biphenyls in striped bass, to compare these with levels estimated by pattern matching, to determine any association of concentration to length, and to investigate the effects on measured levels of trimming and edible portion.

Fifty striped bass were collected from the Hudson River near Nyack, New York in the fall of 1981. At this time of year the fish reach their highest population near the mouth of the Hudson, returning from migration, and should contain the greatest levels of contaminants. The fish were tagged, weighed and measured in length. Standard and trimmed filets were removed from each specimen. Standard filets have the skin and adipose tissue intact, whereas on trimmed filets these are eliminated. Each filet was homogenized in a Model CFP5 Cruisinart food processor. A 10.0 g subsample from each filet was frozen in liquid nitrogen and lyophilized for 12 hr, then extracted with 100 ml of hexane in a Soxhlet extractor for 6-8 hrs. The extract was quantitatively transferred to a Kuderna-Danish apparatus and concentrated to 5.0 ml, from which 1.0 ml was removed for Florisil cleanup. The remaining 4 ml was quantitatively transferred to a tared vial for hexane extractable lipid (HEL) determination and saved for further use.

The extract-charged chromatography column, containing 10.0 g of 2% deactivated Florisil (60-100 mesh) topped with 2.0 g anhydrous sodium sulfate, was eluted with 50 ml hexane, and the first 40 ml was collected. This fraction is known to contain PCBs but not more polar compounds, such as organochlorine pesticides and triglycerides (Kim et al. 1984). Each fraction was treated with mercury for the removal of sulfur contamination, concentrated to a final volume of 1.0 ml and transferred to a 1 ml GC vial for analysis by electron-capture gas chromatography (EC-GC).

Gas chromatographic analysis was performed on a Hewlett-Packard Model 5840A digital gas chromatograph, equipped with a ^{63}Ni electron-capture detector and a Model 7617A automatic sampler.

Instrument parameters and operating conditions were as follows: Column: glass, 6 ft x 2 mm I.D., packed with 2% Apiezon L on 100-120 mesh Supelcoport or Chrom W-HP; Injection volume: 4.5 µl; Temperatures: injector- 225°C, detector - 300°C, oven - held 5 min at 200°C then increased 3°C/min to 235°C; Carrier gas: ultra high purity argon-methane (95:5), flowing at 25 ml/min; Total run time: 150 min.

The microprocessor of the EC-GC was calibrated as described in

the previous study using a mixture of 2 ppm (µg/ml) each of Aroclors 1016, 1221, 1254, and 1260 (Pastel et al. 1980). Thirty-nine peaks were resolved in the standard mixture, assigned to their Aroclors of origin by comparison with individual Aroclor chromatograms and information from recent capillary column work (Bush 1980; Bush et al. 1982).

Quality control procedures, detection limits and recovery rates were identical to a previous study (Pastel et al. 1980). The present results are uncorrected for recovery, which ranged from 60-80% for most components.

Positive identification of PCBs was performed on a Finnigan GC/MS/Data System 9500/1015D/6000, equipped with a Grob injection system for capillary column analysis.

RESULTS AND DISCUSSION

The EC-GC quantitative results were filed in a Univac 1100/80 computer, and a program was run which calculated PCB concentration on wet, dry and lipid weight bases and summed the individual PCB peak amounts to give the total PCB concentration. Pattern matching results were obtained using single peaks which were unique to the individual Aroclors. These peaks were 2-chlorobiphenyl for Aroclor 1221; 2,4,4'-, 3,2',4'-, 3,2',3'-, and two other trichlorobiphenyls for Aroclor 1016, 2,4,5,2',4',5'-hexachlorobiphenyl, 3,4,2',3',4'-pentachlorobiphenyl and another hexachlorobiphenyl for Aroclor 1254; and 2,3,4,2',3',4',5'-heptachlorobiphenyl for Aroclor 1260.

Table 1 summarizes and compares the results of peak to peak summation to pattern matching. Those fish with a PCB concentration differing by more than 2 SD (standard deviation) from the mean were excluded, and the mean recalculated. The mean PCB concentrations determined by peak to peak summation and pattern matching were 2.7 ± 1.7 and 2.4 ± 1.7 µg/g wet weight, respectively. Mean PCB concentrations for the two analyses were compared using the student t test, assigning a significant level of 1 percent and without assuming equal variability of the two groups (Natrella 1963). The two were not found to differ significantly. Table 1 also gives a breakdown of PCB concentration by length. No correlation between length and concentration could be made and it was concluded that PCB contamination is more likely a function of location rather than the size of the fish.

Fifteen trimmed filets were randomly selected and analyzed. Their PCB concentrations and hexane extractable lipids (HEL) were compared to the corresponding standard filet. Table 2 lists the quantitative results. The mean PCB concentration for trimmed filets was 1.3 ± 0.6 µg/g wet weight compared to 3.0 ± 1.8 µg/g for the standard filets from the same fish. The application of the t test (α=0.01) showed that the two were found to differ significantly. The mean HEL content for standard filets was 6.9 ± 2.3% of wet weight compared to 3.8 ± 1.2% for trimmed filets.

Table 1. PCB Concentrations of Standard Filet (µg/g, Wet Weight) Determined by Peak to Peak Summation and by Pattern Matching, and Grouped by Striped Bass Length (cm)

Group (cm)	log #	length (cm)	P to P (µg/g)	PM (µg/g)
40.0-44.9	SB-102	42.8	1.3	1.0
	SB-104	44.3	1.1	1.0
	SB-114	43.0	3.7	3.2
	SB-116	40.0	2.2	2.5
	SB-119	43.0	1.8	1.3
	SB-120	42.0	1.0	1.1
	SB-127	44.0	1.3	1.0
	SB-128	44.2	5.8	4.0
	SB-132	44.3	1.4	1.0
	SB-133	44.7	1.3	1.4
	SB-134	40.0	2.1	1.5
	SB-138	42.0	1.6	1.5
	SB-139	43.0	5.7	6.1
	Group mean:	42.9	2.3	2.0
		±1.5	±1.6	±1.5
45.0-49.9	SB-101	48.0	7.6	6.8
	SB-103	48.1	4.4	4.1
	SB-105	47.0	1.5	1.5
	SB-106	46.5	1.5	1.3
	SB-108	47.5	4.8	3.9
	SB-110	48.0	2.9	2.2
	SB-111	47.0	1.8	1.5
	SB-112	46.0	3.1	2.2
	SB-113	46.0	2.3	2.1
	SB-118	48.0	2.1	3.1
	SB-123	45.0	2.1	1.8
	SB-126	45.0	1.8	1.1
	SB-129	49.5	1.4	1.1
	SB-131	45.0	1.3	1.3
	SB-135	46.1	8.1	6.4
	SB-136	49.7	2.5	2.0
	SB-137	46.6*	21.3*	20.1*
	SB-140	45.0	2.0	1.9
	Group mean:	46.9	3.0	2.6
		±1.4	±2.0	±1.7
>50.0	SB-107	50.0	2.5	2.7
	SB-109	55.5	2.5	2.1
	SB-115	55.0*	40.3*	34.2*
	SB-117	52.0	2.6	2.0
	SB-121	56.0	2.8	2.0
	SB-122	54.0	2.4	1.5
	SB-124	55.0	2.6	2.0
	SB-125	52.0	7.4	5.4
	SB-130	55.4	1.5	1.5
	SB-141	51.0	1.7	1.3

Table 1 Cont'd

Group (cm)	log #	length (cm)	P to P (µg/g)	PM (µg/g)
	SB-142	54.2	1.5	1.4
	SB-143	54.1	5.6	7.8
	SB-144	54.0	1.5	1.6
	SB-145	53.3	1.4	1.2
	SB-146	54.0	2.9	3.0
	SB-147	51.3	1.2	1.5
	SB-148	55.4	1.6	1.2
	SB-149	54.0	3.3	4.4
	SB-150	54.3	2.0	2.5
	Group Mean:	53.6	2.6	2.5
		±1.6	±1.5	±1.7
	OVERALL MEAN:		2.7 ± 1.7	2.4 ± 1.7

*excluded from mean and standard deviation

Table 2. Comparison of Standard Filets and Trimmed Filets According to PCB Concentration (µg/g Wet Weight) and Hexane Extractable Lipid Content (HEL) (%-Wet Weight)

	Standard Filet		Trimmed Filet	
Log #	PCB (µg/g)	HEL Content (%)	PCB (µg/g)	HEL Content (%)
SB-104	1.1	2.2	.9	2.5
SB-107	2.5	11.0	1.0	6.3
SB-110	2.9	7.1	1.4	3.3
SB-113	2.3	4.2	1.3	2.7
SB-116	2.2	6.5	.7	3.1
SB-119	1.8	6.2	.8	4.0
SB-122	2.4	9.4	1.3	5.0
SB-125	7.4	9.3	2.5	4.3
SB-128	5.8	7.6	2.6	5.0
SB-131	1.3	6.5	.9	3.1
SB-134	2.1	7.3	1.0	4.4
SB-140	2.0	5.7	1.0	1.5
SB-143	5.6	9.4	1.3	4.1
SB-146	2.9	6.8	1.6	4.1
SB-149	3.3	4.4	1.1	3.2
Mean:	3.0	6.9	1.3	3.8
	±1.8	±2.3	±0.6	±1.2

Polychlorinated biphenyls, which are persistent aquatic contaminants, have been monitored in fish flesh for well over a decade. As has been stated earlier, the striped bass analyzed in this study were collected in the fall and should have acquired greater amounts of PCBs than fish collected in the spring. It is difficult to assume that all of the fish migrated to the more contaminated northern reaches of the Hudson River. In their lifetime,

striped bass may spawn several times and those that contained higher than the mean level may have been repeaters (Pastel et al. 1980). The mean reported here was significantly higher than the FDA limit of 2 ppm for fish. Pattern matching results were similar to those based on peak to peak summation and is an adequate technique for the estimation of the individual Aroclor mixtures.

It has been established that PCBs are an extremely lipophilic contaminant. Removal of the skin and adipose tissue significantly decreased the levels of extractable lipid content, ultimately decreasing the levels of PCBs. It is suggested that anglers employ the trimming procedure and limit the number of fish consumed.

Through the production of PCBs, polychlorinated dibenzodioxins and polychlorinated dibenzofurans are produced as by-products (Hutzinger et al. 1974). These compounds are extremely more toxic than polychlorinated biphenyls. The latest studies have shown dioxin levels averaged 19 parts per trillion (ppt), which tends to strain the limit of detection (B. Bush 1982, New York State Health Department, private communication). The FDA advises against unlimited consumption of fish containing more than 25 ppt, whereas for New York State the limit is 10 ppt. Because of the present concern over trace contaminants, the fish should be analyzed periodically to monitor levels and to determine their overall quality.

Acknowledgements. We wish to thank Mr. Grabrielson of Nyack, New York who furnished the fifty striped bass which were analyzed, and Mr. M. Pastel for numerous suggestions to improve the manuscript.

REFERENCES

Bush, B (1980) Report of the determination of PCB by three methods: Disparities in standard materials. New York State Department of Health, Albany, NY

Bush B, Conner S, Snow J (1982) Sensitive and accurate PCB analysis by glass capillary gas chromatography. J Assoc Off Anal Chem 65: 555-568

Cahn PH, Foehrenback J, Guggino W (1977) Physiological responses of marine biota to pollutants. Academic Press, New York

Federal Register (1979) 44(127):38330-38340

Hetling L, Horn E, Tofflemise J (1978) Summary of Hudson River PCB results. Technical Paper #51. New York State Department of Environmental Conservation (PCB Technical Paper)

Hullar T, Mt. Pleasant R, Pagano S, Spagnoli J, Stasiuk W (1976) PCB data in Hudson River fish, sediments, water and wastewater. New York State Department of Environmental Conservation (prepared for PCB Task Force, NYS Health Advisory Council)

Hurtzinger O, Safe S, Zitko V (1974) The Chemistry of PCB's, CRC Press, Cleveland, Ohio

Kim KS, Pastel MJ, Kim JS, Stone WB (1984) Levels of polychlorinated biphenyls, DDE, and mirex in waterfowl collected in New York State, 1979-1980. Arch Environ Contam Toxicol 13:373-381
Natrella M (1963) Experimental Statistics. National Bureau of Standards Handbook 91, US Department of Commerce, US Govt. Printing Office, Washington DC
Pastel M, Bush B, Kim JS (1980) Accumulation of polychlorinated biphenyls in American shad during their migration in the Hudson River, Spring 1977. Pest Monit J 14:11-22
Spagnoli JJ, Skinner LC (1977) PCB's in fish from selected waters of New York State. Pest Monit J 11:69-87
Werner RG (1980) Freshwater Fishes of New York State. Syracuse Press, Syracuse, NY
Received June 25, 1984; accepted July 10, 1984