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Metals and PCB Concentrations in Windowpane Flounder from Long Island Sound

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PCBs and metals are pollutants of concern in Long Island Sound. As part of an ongoing study to determine the effects of pollutants on marine animals in the Sound, we have made an attempt to determine the distribution of PCBs and metals at various locations. Analyses of seawater is one way of determining the distribution of these pollutants; however, the analyses for these pollutants are quite complex and the results are often ambiguous because of the dynamic nature of seawater. We, therefore, chose to examine a fish, windowpane flounder (Scophthalmus aquosus), to gain an understanding of the distribution of metals and PCBs in the Sound.

The windowpane flounder was selected because of its availability throughout the year, and because it is relatively non-migratory (BIGELOW & SCHROEDER 1953). Three stations in the Sound were selected based on historical data that showed a pollution gradient for metals in bottom sediments (GREIG et al. 1977) and represented the "best", "worst", and "moderate" conditions (Stations 90, 9, and 54). PCBs and metals were measured in livers, wheras only PCBs were measured in the stomach contents of these fish. The results of these analyses are presented here.

MATERIALS AND METHODS

Windowpane flounder were collected by otter trawl at three locations in Long Island Sound (Fig. 1). Livers were dissected, using stainless steel tools, and placed in either precleaned polyethylene containers for metal analyses or glass jars with a precleaned aluminum foil-lined lids for PCB measurements. Stomachs were also dissected and the contents only placed in clean glass jars and frozen at -20°C for subsequent PCB analyses. The plastic containers were shaken for about one hour before use with 10% nitric acid, rinsed well with deionized water, and oven-dried. The glass containers and aluminum foil were rinsed three successive times with glass-distilled hexane and air-dried.

Metal analyses were conducted using a graphite furnace - atomic absorption method (GREIG et al 1982). PCB analyses were conducted by the saponification procedure described by STOUT & BEEZHOLD (1979), followed by G.L.C. using a packed column of

3% OV 17 on gas chrom WHP (100/120 mesh). A standard of Arochlor 1254 was used for comparison since the chromatograms from these fish closely matched it. Some extracts were also analyzed on a glass capillary SE 54 column and the results confirmed that Arochlor 1254 closely matched the peaks found in the fish.

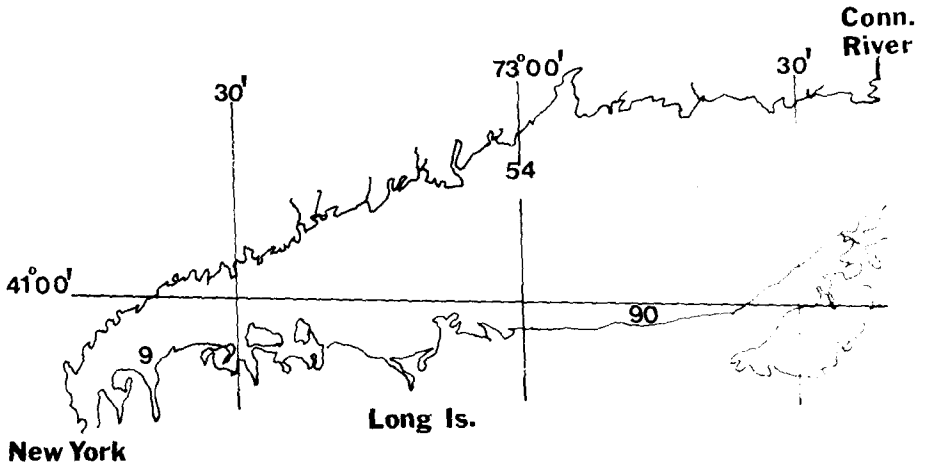

Figure 1. Stations locations for windowpane flounder collected in Long Island Sound. Stations sampled were 9, 54, and 90.

RESULTS AND DISCUSSION

PCB concentrations found in windowpane flounder livers are shown in Table 1 and PCBs in the stomach contents are shown in Table 2. No relationship was found between PCB concentrations in the livers of flounders and the assumed pollution gradient, referred to earlier, in the Sound. Flounder collected in 1980 were sampled seasonally and PCB concentrations in their livers did not vary greatly relative to the season. The variability of PCB concentrations was great, as seen by the standard deviations in Table 1. The relative standard deviations for these data ranged from 22.5% to 114.4%, with an average of 62.2%. To test the contribution of analytical variability to these data, a composite was made of several livers and five replicate analyses were conducted. The PCB concentrations ranged from 0.83 to 1.23 ppm, with a relative standard deviation of 18.2%. Thus, the analytical variability could contribute greatly to the variability seen in Table 1, but the variation due to natural, individual differences was greater.

Table 1. PCB concentrations (ppm, wet weight) in livers of windowpane flounder collected from Long Island Sound

Collection Date	Station 9[a]	Station 54	Station 90
	Mean (Standard Deviation)		
May, 1980	1.2(0.309) N=6 b,c	1.2(0.777) N=5	0.6(-) N=3
July, 1980	1.2(0.606) N=6	1.5(0.455) N=6	1.5(0.813) N=6
September, 1980	1.9(1.230) N=6	1.7(0.382) N=6	1.5(-) N=3
November, 1980	1.6(1.830) N=10	1.1(0.734) N=10	2.0(1.870) N=10
July, 1981	1.8(1.380) N=9	None Obtained	2.3(1.740) N=8
July, 1982	1.4(0.988) N=10	None Obtained	0.88(0.484) N=14

a - Stations are: 9 Hempstead Harbor, New York; 54 off Milford, Connecticut; 90 off Roanoke Point, Long Island, New York (see Fig. 1)

b - N = Number of samples analyzed. May, July, September 1980 samples were pools of livers from three fish; all other samples were individual fish livers.

c - All fish in this study were in a size range of 18-35 cm in length. However, 70% of the fish were in a size range of 24-28 cm.

The stomach contents of windowpane flounder were also analyzed for PCB concentrations to determine whether food could be a source of PCB contamination to the flounder. Similar to the liver data, the results were quite variable (Table 2). The two stations where stomach contents were obtained represented the "worst" and "best" conditions relative to pollution (Stations 9 and 90, respectively).

Table 2. PCB concentrations (ppm, wet weight) in stomach contents of windowpane flounder collected from Long Island Sound

Station 9			Station 90		
Collection Date	N[a]	PCBs (mean)	Collection Date	N[a]	PCBs (mean)
7/1981	5	0.12	6/1981	3	0.14
9/1981	4	0.03	9/1981	2	0.03
12/1981	11	0.14	12/1981	14	0.05
3/1982	2	0.044	3/1982	5	0.076
6/1982	5	0.21	6/1982	5	0.45
7/1982	4	0.32	7/1982	5	0.06

a - N = Number of samples analyzed; these were either from individual fish or composited from 2-4 fish.

We expected the PCB levels in the stomach contents to be lower at Station 90 than at Station 9 because of the apparent differences in pollution at these two stations. We analyzed sediment samples from these two stations and found about 1 to 20 µg/kg at Station 90 and 90 to 100 µg/kg at Station 9. However, the mean levels shown in Table 2 suggest that there is little difference in PCB levels in the stomach contents of windowpane flounder at these stations. The mean PCB concentrations ranged

from 0.03 to 0.45 ppm, which is a significant amount to be consumed by the flounder.

When stomachs were full, about 10-20 g of material were present. Assuming that 10 g of food are consumed each day by flounder for at least 70% of the time over a 1-year period, this indicates that 2,655 g of food are consumed in a year. The over-all mean of PCB levels presented in Table 2 is 0.14 ppm. Using a conservative estimate of 0.05 ppm as the average 133 micrograms of PCBs are ingested by a flounder in one year. The livers of windowpane flounder in our study generally weighted about 2-10 g. Thus, if all the PCB consumed by the flounder from the food source accumulated in the liver, it could have levels as high as 13-66 ppm in one year. Perhaps a great deal of the PCBs is never absorbed by the flounder but, rather, eliminated through fecal production. Of course, the PCBs could also be accumulated in other tissues or even in bone. PETERS & O'CONNOR (1982) reported that when striped bass accumulated PCB through either food or only water, the highest concentrations of PCB occurred in the liver as compared to their analyses of gill, gut, flesh, and carcass samples. Although windowpane flounder is a different species than striped bass, it is reasonable to assume that it would behave similarly. The potentially large amount of PCBs available to flounder suggests that the liver may not bioaccumulate a good share of the PCBs that are presented to it. The liver probably is metabolizing or successfully clearing much of the PCB.

The concentration of PCBs found in livers of windowpane flounder were nearly an order of magnitude greater than those found by BUTLER & SCHUTZMANN (1979) in livers of yellowtail flounder (0.13 ppm) and fourspot flounder (0.28 ppm) collected off the coast of the eatern U.S. and Canada. The authors did not give any specific locations, they only state ". . . 80 stations irregularly scattered in an area from 50 to 200 miles off the coast and extending from New Jersey to Nova Scotia." It is possible that PCB concentrations in fish from offshore areas, as in the BUTLER & SCHUTZMANN study, are lower than in fish from such a coastal area as Long Island Sound. Further work is needed to confirm this conjecture. BUTLER & SCHUTZMANN (1979) also examined other fish species and found PCB concentrations on the order of 1.0 - 2.0 ppm in livers of skate, hake, cod and pollock. These levels were about the same order of magnitude as those found in this study. Recently, GADBOIS (personal communication, National Marine Fisheries Service, Gloucester Laboratory, Massachusetts) reported that the livers of windowpane flounder, collected at 9 stations in the area off the New Jersey and Long Island, New York coasts, had PCB concentrations in the range of 1.0 - 2.2 ppm, wet weight basis. These levels are in the same range as found in the present study.

Concentrations of silver, cadmium, copper and lead were also measured in livers of windowpane flounder (Table 3). There were differences in mean levels of these metals among fish from

the three stations; however, the individual variation in fish from a single station was too great to allow firm conclusions. The problem of individual variability also clouded the picture in regard to seasonal differences in metal concentrations. In general, however, there did not appear to be any seasonal difference. There was no general trend of the metal concentrations in livers in relation to the levels in the sediments. The concentrations of these metals in sediments were: Ag=3.0 <0.5, <0.5; Cd=1.4, <1.0, 1.1; Cu=175, 43, 4,; Pb=110, 19, <5.0, for Stations 9, 54, and 90, respectively (GREIG et al. 1977).

The metal concentrations found in livers of windowpane flounder evidently are typical for finfish. HALL et al. (1978) reported concentrations of a number of metals in livers of 82 species of finfish from all coasts of the U.S. Seventy-five of these species had silver levels in the 0.1 - 0.2 ppm range. Half the species had cadmium concentrations of 0.1 - 0.2 ppm, while the copper content of livers was in the 2 - 10 ppm range for 58 of the species. Lead concentrations were below 1.0 ppm for 73 species. All of these concentrations were within the range found for windowpane flounder livers in the present study.

Table 3. Metal concentrations in livers of windowpane flounder collected from Long Island Sound

Station[a]	Catch Date	N[b]	Ag	Cd	Cu	Pb
			Mean Concentrations (ppm, wet wt.)			
54	June, 1978	6	0.06	0.08	2.8	c
9	July, 1979	12	0.14	0.30	7.5	c
54	July, 1979	16	0.07	0.54	5.2	c
90	July, 1979	14	0.09	0.68	7.4	c
9	May, 1980	6	0.06	0.20	4.5	c
54	May, 1980	6	0.16	0.23	6.3	c
90	May, 1980	4	0.05	0.10	3.2	c
9	July, 1980	10	0.07	0.19	4.1	c
54	July, 1980	10	0.03	0.18	3.3	c
90	July, 1980	10	0.02	0.19	5.0	c
9	Oct., 1980	9	0.06	0.40	6.2	c
54	Oct., 1980	9	0.13	0.35	9.1	c
90	Oct., 1980	10	0.05	0.36	4.8	c

a - Stations - see Table 1

b - N = Number of individual fish livers analyzed

c - Lead levels were below detection limits of the method, about 0.4 to 0.8 ppm

Note: The variability of metal concentrations was great among individual fish livers for one station and one time period. Relative standard deviation of metal concentrations for these individual liver samples ranged from 25% to 140%; however, the majority were in the range of 30% to 70%.

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