David R. Young and D. McDermott-Ehrlich

SEDIMENTS AS SOURCES OF DDT AND PCB

In past reports, we have described the relatively high concentrations of DDT and PCB compounds found in bottom sediments and fish from the region of Los Angeles County's Joint Water Pollution Control Plant (JWPCP) discharge off Palos Verdes. During the last 4 years, the mass emissions of these contaminants from this submarine outfall system have been reduced through control of industrial inputs and general use restrictions. However, our studies over the same years have revealed that DDT and PCB concentrations in the tissues of bottom-feeding fish of the region do not reflect these reductions. These findings are summarized here, along with a discussion of the role that contaminated bottom sediments appear to play in this situation.

METHODS

Since 1972, we have conducted chlorinated hydrocarbon analyses by electron-capture gas chromatography on 1-week composites of effluents collected approximately every 6 months from the major wastewater treatment plants discharging into the Southern California Bight. During 1973 and 1974, we conducted intercalibration programs with the laboratories of Dr. Robert Risebrough (University of California, Berkeley) and Dr. Spyros Pavlou (University of Washington); these tests indicated a satisfactory agreement between the DDT and PCB results of the three groups, with typical coefficients of variation of approximately 20 percent for JWPCP wastewater. Corresponding coefficients of variation for our data alone are generally about 5 to 10 percent. In addition, this intercalibration program verified the accuracy of the monitoring data for total DDT concentrations in JWPCP effluent beginning in 1971. Thus, these monthly averages were used to estimate the JWPCP s mass emission rates of these contaminants.

Surveys of the chlorinated hydrocarbon concentrations of bottom sediments on the Palos Verdes shelf were conducted during the summers of 1972 and 1975. In addition, DDT and PCB analyses were made on muscle tissue of Dover sole (Micvostomus pacifious) taken by trawl from this discharge zone during May 1972, December 1973, May 1974, and February 1975. Intercalibration studies for these chlorinated hydrocarbons on these types of samples have yielded coefficients of variation of approximately 25 percent, and typical coefficients of variation for our results alone are 10 to 20 percent.

RESULTS

Los Angeles County's Monitoring Transects 0 to 6, from which the Dover sole we analyzed were obtained, are shown on Figure 1. The specimens were trawled from constant depths of 75 ft (20 m), 200 ft (60 m), or 450 ft (135 m). Therefore, samples from the County's 100, 200, and 500 ft benthic grab stations were selected for comparison of 1972 and 1975 surface sediment (0 to 5 cm) DDT and PCB concentrations. These stations are also shown in Figure 1, and the corresponding 1972 to 1975 sediment concentration comparison is presented in Table 1.

A preliminary examination of our Dover sole data indicated that there was no apparent relationship between DDT or PCB concentrations in the fish tissues and depth of capture. Therefore, we next attempted to determine whether or not these concentrations were strongly dependent on the location of capture along the Peninsula. The May 1972 and May 1974 surveys provided the most data points for this comparison. In Figure 2, we have plotted all of our data from these two surveys on concentrations of DDT and PCB in muscle tissue of Dover sole as a function of distance from the JWPCP outfalls; the figure also gives the median values for each transect. With the exception of a distinct drop between 1972 and 1974 in total DDT concentrations in specimens taken along Transect 5 (nearest the outfalls), the patterns in general are remarkably similar and do not indicate any major changes with distance from the outfalls.

On the basis of these results, we concluded that the February 1975 Dover sole specimens, which were collected in a single trawl made between Transects 3 and 4, could be included in our time-series study. To make the flatfish and sediment data as comparable as possible, we considered only those values for Dover sole specimens taken from Transects 1 through 5. As seen in Figure 1, this selection resulted in a quite close correspondence between the bottom sediment and flatfish sampling sites.

To compare changes between inputs, sediment, and flatfish concentrations, we have summarized the JWPCP monthly effluent data as follows: For each of the four trawling surveys conducted between May 1972 and February 1975, both median and mean (plus or minus standard error) concentrations of total DDT were calculated from JWPCP monitoring values for the 6-month period preceding and including the month of each trawl. As mentioned earlier, these DDT data had been confirmed by numerous intercalibrations. However, because of difficulties with the PCB monitoring data prior to January 1975, we combined our results wherever appropriate with those from the university (intercalibrating) laboratories to obtain our best estimate of representative PCB concentrations during the 6-month period. Therefore, error estimates are not always available for these PCB values.

Our results are presented in Table 2. Also shown are both median and mean (plus or minus standard error) values for the 17 to 19 available surface sediment concentrations and the 9 to 21 Dover sole muscle tissue concentrations from the various surveys. Because trace analyses occasionally yield extreme values that can strongly bias a mean, we have elected to use the median as the most representative value of a given data set for this comparison.

DISCUSSION

With the exception of the PCB input data, whose limited values provide only trends, we have analyzed the data summarized in Table 2 by means of the Mann-Whitney U test (a nonparametric procedure that tests differences between data sets with unequal numbers of samples). Our objective was to determine which of the changes over time shown in Table 2 are statistically significant. Ratios of the 1972/1975 median concentrations for wastewater, sediment, and muscle tissue, and the probability that the differences reflected in the ratios could have occurred by chance, are listed in Table 3. It should be noted that any probability value of 5 percent or less ($p \leq 0.05$) is generally considered to be statistically significant.

These results show that between 1972 and 1975, there was a significant decrease in the level of total DDT in the JWPCP effluent, and that the median concentration fell by a factor of 5.5 over the time period separating the 1972 and 1975 trawls. Further, the average annual effluent flow rate decreased by approximately 10 percent during this interval (from 370 to about 330 mgd), so that the DDT mass emission rate actually decreased by about a factor of 6. In contrast, there was no statistically significant decrease in concentrations of total DDT in muscle tissue of Dover sole trawled from Transects 1 through 5 in the discharge zone over this time interval, and the median concentration fell by a factor of only 1.5. This was close to the ratio (1.3) of the median total DDT concentrations in surface sediments from this region for 1972 and 1975, which we call the decrease factor.

The available PCB information, although less complete, follows a remarkably similar pattern. Between 1972 and 1975, the input rate of 1242 PCB apparently fell by approximately a factor of 20, which was an order of magnitude above the corresponding decrease factor (2.6) for the median flatfish concentration. A comparison of the total PCB estimates leads to the same conclusion. In contrast, the 1254 PCB values, which are the only such data available for both the sediment and flatfish samples, indicate similar PCB decrease factors for these two benthic categories over the study interval (1.2 and 1.3, respectively).

Scientists from the County Sanitation Districts of Los Angeles County also have observed that average levels of total DDT in Dover sole from the JWPCP monitoring zone have not decreased measurably in the last 3 to 4 years. By combining the Sanitation Districts' results and our measurements made on 144 samples collected during 1971-72, they calculated a mean concentration of 15.8 ppm total DDT. In comparison, mean concentrations measured by the Sanitation Districts in 22 samples collected during fall 1974 and 34 samples collected during spring 1975 were 13.8 ppm and 16.7 ppm, respectively. The FDA guideline for DDT in seafood is 5 ppm; however, in southern California the Dover sole is neither a sportfish nor of commercial importance..

The Sanitation Districts monitoring program also has included occasional samples of two bottom-feeding sportfish, the kelp bass (.Paralabrax ctafhratus) and the black perch (*Embiotoca* jacksoni). For the kelp bass, no difference was observed between the mean levels of total DDT found in the fall 1971 collections (6.3 ppm) and the spring 1975 collections (6.4 ppm), although the data are quite variable. In the case of the black perch, the mean value fell by a factor of 3.3, from 18.3 ppm to 5.6 ppm. Over the same period, the mean concentration of total DDT in JWPCP effluent fell by a factor of 8.0, from 20.0 ppb (July to December 1971) to 2.5 ppb (January to June 1975)

CONCLUSIONS

These findings indicate that contamination of bottom sediments by chlorinated hydrocarbons such as DDT and PCB can cause these synthetic compounds to persist in bottom-feeding fishes long after major reductions have been made in the dominant inputs. This conclusion is consistent with that of a laboratory study performed at the Project (Page 149), which showed that Dover sole maintained in clean, flowing seawater and fed clean food nevertheless accumulated high levels of DDT and PCB when exposed to outfall zone sediments contaminated with these compounds.

It therefore appears that the relatively high levels of DDT now found in bottom-feeding fishes around the JWPCP sub-marine outfalls will decrease only as rapidly as do corresponding levels in the bottom sediments of this region. Based on studies reported in this and past reports, we estimate that approximately 150 tons of total DDT are still contained in the upper 30 cm of these sediments in a 50-sq-km area off Palos Verdes Peninsula. Thus, despite the recent major reductions in JWPCP inputs, these highly-contaminated sediments may cause excessive DDT levels to persist for many years in benthic fishes of the region.

Table 1. Chlorinated hydrocarbon concentrations (mg/dry/kg) in the top 5cm of surface sediments collected during summer, 1972 and 1975, Palos Verdes shelf.

	Total DDT			1254 PCB			
Station*	1972	1975	Ratio, 1972 to 1975	1972	1975	Ratio, 1972 to 1975	1242 PCB, 1975
1B	4.7	12.3	0.38	—*	0.71	—	0.18
1C	27.6	45.6	0.61	—	2.74	—	0.69
1D	13.6	3.93	3.46	0.08	0.21	0.38	0.11
3B	14.2	12.4	1.15	1.00	0.81	1.23	0.18
3C	132	74.8	1.76	3.73	1.11	3.36	0.16
3D	13.3	5.98	2.22	0.80	0.41	1.95	0.21
5B	132	129	1.02	8.11	7.42	1.09	2.81
5C	123	76.2	1.61	4.66	5.46	0.85	2.12
5D	19.0	10.3	1.84	0.95	0.41	2.32	0.23
6B	206	65.7	3.14	12.8	4.12	3.11	2.20
6C	180	87.9	2.05	13.0	8.50	1.53	4.44
6D	9.56	9.73	0.98	0.64	0.56	1.14	0.29
8C	164	66.8	2.46	6.65	3.98	1.67	2.15
9B	94.6	124	0.76	4.74	6.89	0.69	1.95
9C	67.6	28.7	2.36	7.26	0.94	7.72	0.19
9D	18.5	7.47	2.48	1.01	0.40	2.52	0.24
10B	9.8	5.66	1.73	0.43	0.38	1.13	0.15
10C	13.2	6.06	2.18	0.80	0.45	1.78	0.08
10D	8.52	6.02	1.42	0.86	0.44	1.95	0.24

*Shown on Figure 1.

*Blank indicates no data.

Table 2. Time-series comparison of chlorinated hydrocarbon concentrations in JWPCP effluent (mg/liter), surface sediments (0 to 5 cm, mg/dry kg), and Dover sole muscle tissue (mg/wet kg).*

Trawl Period	Wastewater** Median	Wastewater** Mean and Std. Error	Wastewater** No. of Samples	Sediments Median	Sediments Mean and Std. Error	Sediments No. of Samples	Flatfish Median	Flatfish Mean and Std. Error	Flatfish No. of Samples
Total DDT									
May 1972	16	16 ± 1.9	6	19	66 ± 16	19	17	26 ± 5.3	21
Dec 1973	6.8	7.2 ± 1.6	6				18	16 ± 2.4	9
May 1974	3.2	3.1 ± 0.34	6				13	15 ± 2.4	20
Feb 1975	2.9	2.9 ± 0.29	6	12	41 ± 9.6	19	11	25 ± 10	10
1242 PCB									
May 1972	24	24 ± 2.5	2	–	–	–	0.80	0.99 ± 0.15	21
Dec 1973	3.9	3.8 ± 0.15	6				0.61	0.66 ± 0.10	9
May 1974	2.5	2.6 ± 0.38	4				0.54	0.51 ± 0.07	20
Feb 1975	1.1	1.2 ± 0.13	5	0.24	0.98 ± 0.29	19	0.31	0.39 ± 0.11	10
1254 PCB									
May 1972	–	–	–	1.0	4.0 ± 1.0	17	1.0	1.3 ± 0.22	21
Dec 1973	1.6	1.6 ± 0.09	8				1.3	1.3 ± 0.15	9
May 1974	1.0	1.0 ± 0.17	4				0.93	0.97 ± 0.13	20
Feb 1975	0.62	0.65 ± 0.04	5	0.81	2.4 ± 0.64	19	0.76	1.5 ± 0.56	10
Total PCB									
May 1972	≥ 24	≥ 24	–	–	–	–	2.1	2.3 ± 0.36	21
Dec 1973	5.5	5.4	–				1.9	2.0 ± 0.23	9
May 1974	3.5	3.6 ± 0.21	4				1.5	1.5 ± 0.19	20
Feb 1975	1.7	1.9 ± 0.16	5	0.99	3.4 ± 0.92	19	1.1	1.9 ± 0.67	10

*Dash indicates sample not analyzed; blank indicates sample not taken.
**Estimated typical concentrations during 6 months preceding trawl.

Figure 1. Trawl transects and sediment collection sites, Palos Verdes shelf.

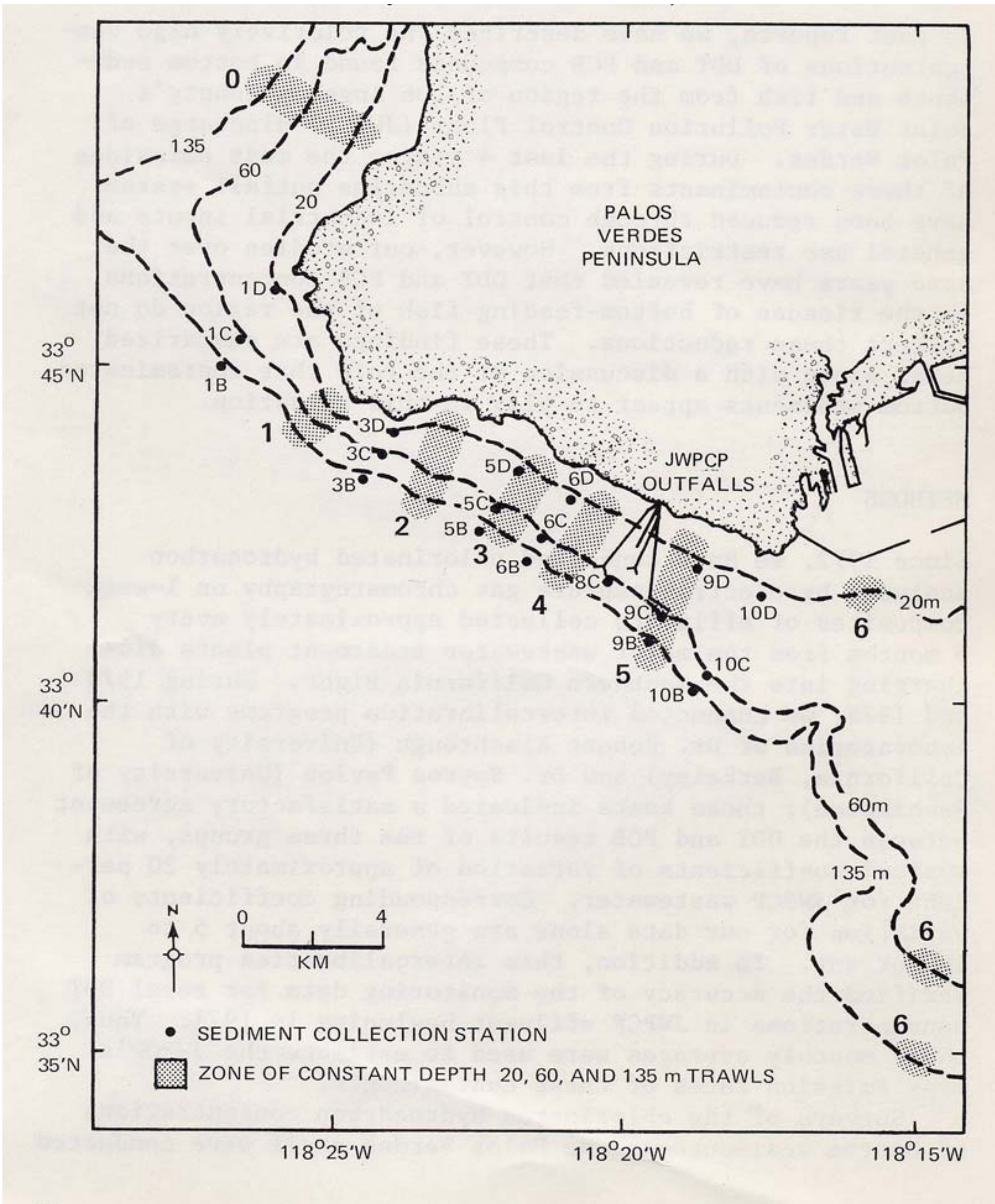

Figure 2. Concentrations of chlorinated hydrocarbons in muscle tissue of Dover sole trawled from transects off Palos Verdes Peninsula during May, 1972 and 1974. Approximate distances of transects from the JWPCP outfalls, which are between Transects 4 and 5, are indicated.