

# CHLORINATED HYDROCARBONS IN DOVER SOLE, *MICROSTOMUS PACIFICUS*: LOCAL MIGRATIONS AND FIN EROSION

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## ABSTRACT

Dover sole, *Microstomus pacificus*, with and without fin erosion were collected from the municipal wastewater discharge sites of Los Angeles and Orange counties. While there was a significant difference between the total DDT levels in muscle tissue of the unaffected fish from the two regions, there was no significant regional difference between the muscle DDT levels in the diseased fish. This is consistent with the proposed hypothesis that the Orange County diseased fish had originated at the Los Angeles County discharge site. Comparisons of chlorinated hydrocarbon levels in diseased and unaffected Dover sole from the Palos Verdes discharge site of Los Angeles County indicate: 1) DDT levels were significantly higher ( $P < 0.05$ ) in Dover sole with fin erosion, and 2) polychlorinated biphenyl levels were higher at the 90% confidence level ( $P < 0.10$ ) in diseased Dover sole.

In recent years, fin erosion diseases have been observed in several species of marine fishes collected from areas contaminated by industrial or municipal waste such as the Duwamish River estuary, Wash. (Wellings et al. 1976), the New York Bight (Mahoney et al. 1973; Murchelano 1975), and major municipal wastewater discharge sites in the Southern California Bight (Mearns and Sherwood 1974). In southern California, the disease is most prevalent in the Dover sole, *Microstomus pacificus* Lockington, a marine flatfish.

Dover sole with fin erosion occur most frequently near the Palos Verdes discharge site of the Joint Water Pollution Control Plant (JWPCP) submarine outfalls of the County Sanitation Districts of Los Angeles County. During the period 1972-76, 39% of the 20,854 Dover sole collected in 268 samples off Palos Verdes had fin erosion. Only 3.5% of 894 individuals collected in Santa Monica Bay to the north (109 samples), 2.0% of 5,354 individuals collected in south San Pedro Bay to the south (138 samples), and 0.67% of 889 individuals collected off Dana Point farther south (77 samples) were affected with the disease.

The JWPCP outfalls are the dominant source of DDT residues (total DDT) and most trace metals introduced via municipal wastewaters to the Southern California Bight (Galloway 1972; Young et al. 1973; Young et al. 1976b). Although

in 1974 Orange County's discharge of polychlorinated biphenyl (PCB) was twice that of any other discharger (Young et al. 1976a), the sediments off the Palos Verdes Peninsula, as a result of past discharges, have the highest levels of total PCB and total DDT found in marine sediments of the Bight (Young et al. 1976a, b).

The Dover sole is one of the most abundant and most frequently encountered species in trawl catches taken in the vicinity of the southern California submarine municipal wastewater outfalls (Southern California Coastal Water Research Project 1973). In southern California, as in northern California where it is the focus of a major bottom fishery (Hagerman 1952), Dover sole undergo seasonal onshore-offshore migrations (Mearns and Sherwood 1974). Individuals move offshore in the winter and onshore in the summer and have been collected off southern California at depths generally greater than 25 m.

In May and August 1972, trawl catches taken in the vicinity of the Orange County outfall system in south San Pedro Bay contained higher numbers of Dover sole with fin erosion than did previous catches (6 of 684 individuals and 34 of 611 individuals, respectively). This increase was associated with a large influx of Dover sole into the area. Only 273 individuals had been collected in February 1972. Orange County trawls were taken at a standard set of eight stations with the same gear and vessel combination. Only larger individuals (generally > 120 mm standard length, SL) were affected with the disease; this contrasted with the situation off Palos Verdes, where Dover

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sole <120 mm SL also had eroded fins. These observations suggested that Dover sole with fin erosion caught in the vicinity of the Orange County outfall could have migrated from the Palos Verdes shelf (Mearns and Sherwood 1974). Since the increase had occurred 13 mo after the depth of discharge off Orange County had been changed from 20 to 60 m, within the range of the Dover sole, one objective of this study was to test the hypothesis that the diseased fish collected off Orange County had migrated from the Palos Verdes region and that the disease did not originate in the Orange County area. Since collections on the Palos Verdes shelf contained the highest percentage of Dover sole with fin erosion and the shelf was also the site of highest bottom sediment contamination by total DDT, we attempted to use this contamination as a tag of exposure to the JWPCP discharge area. Reported values for the biological half-life of DDT compounds in fish generally range from about 1 to 5 mo (Buhler et al. 1969; Grzenda et al. 1970; Hansen and Wilson 1970; Macek et al. 1970). Since the Orange County discharge site is about 35 km to the south of the JWPCP discharge area, it is possible that movement over this distance could occur before a significant fraction of the accumulated DDT residues had been depleted.

In Dover sole, external signs of the disease were restricted to the fins. The noninflammatory nature of the lesions and the absence of any demonstrable organisms associated with the lesions, as determined by histological examination, suggest that the disease is not the result of an infectious process (Klontz and Bendele<sup>3</sup>). If chemical agents are involved, then it is possible that concentrations of these agents in tissues might reflect their involvement in disease development. A second objective of this study was to explore the role of chlorinated hydrocarbons in the fin erosion disease by determining if there were differences between the levels of total DDT and total PCB in muscle tissue of Dover sole with and without eroded fins.

### SAMPLING AND ANALYSIS

Fish analyzed in this study were subsamples of collections made during routine trawl monitoring

surveys by the County Sanitation Districts of Los Angeles and Orange counties. During 1974, up to four trawl series were conducted off the Palos Verdes Peninsula and Orange County (Figure 1). The trawls off Orange County were conducted with a Marinovich semiballoon otter trawl with a 7.6-m (25-ft) headrope and a 1.3-cm (0.5-in) stretch mesh cod end liner. Hauls off Palos Verdes were made with a net of identical dimensions but of heavier construction and otter boards.<sup>4</sup> The nets were towed at a speed of 1.3 m/s (2.5 knots) and remained in contact with the ocean floor for 10 min. When the net was brought aboard ship, specimens of Dover sole, with eroded fins (diseased) and without eroded fins (unaffected), were removed, bagged, labeled, and immediately frozen. The frozen samples were returned to the laboratory and placed in freezers.

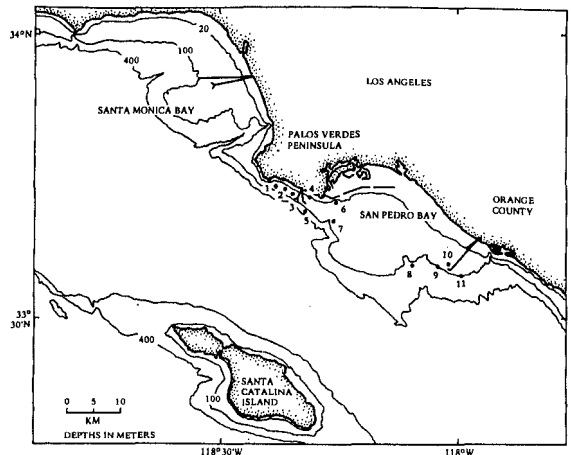


FIGURE 1.—Stations off Palos Verdes and Orange County at which Dover sole were collected.

The following numbers of Dover sole were obtained from each of the 1974 quarterly trawl series: winter (December 1973–February 1974), 10 from off Palos Verdes; spring (March–May 1974), 15 from off Palos Verdes and 5 from off Orange County; summer (June–August 1974), 6 from off Palos Verdes; and fall (September–November 1974), 17 from off Orange County.

The mean and the standard error of the standard lengths for the Palos Verdes samples with ( $n = 16$ ) and without ( $n = 15$ ) eroded fins were

<sup>3</sup>Klontz, G. W., and R. A. Bendele. 1973. Histopathological analysis of fin erosion in southern California marine fishes. South. Calif. Coastal Water Res. Proj., Rep. TM 203.

<sup>4</sup>This net was constructed for the Coastal Water Project by J. Willis, Morro Bay, Calif.

174 ± 3 mm and 193 ± 6 mm, respectively; the respective body weights were 78 ± 5 g and 115 ± 11 g. Measurements for the diseased ( $n = 14$ ) and unaffected ( $n = 8$ ) Orange County specimens were 195 ± 4 mm and 182 ± 7 mm SL, 119 ± 8 g and 98 ± 10 g, respectively. These fish were generally 3 to 4 yr old, though some were younger and some older. The mean standard lengths of several age-classes of over 425 southern California Dover sole collected at coastal locations by small otter trawl were as follows: age-class I, 70 mm; II, 140 mm; III, 170 mm; IV, 190 mm; V, 220 mm (Mearns and Harris<sup>5</sup>).

Muscle tissue subsamples were excised from each of the specimens when they were semi-thawed. The dissections were performed on cleaned Teflon<sup>®</sup> sheets, using carbon steel implements. The tissue samples were placed in glass containers, which had been heated overnight in a kiln at 538°C (1,000°F). The samples were then frozen until chemical analyses were performed.

Levels of total DDT and total PCB were measured in the samples using electron-capture gas chromatography (Young et al. 1976b). The components were identified by retention time; values were derived by comparing the peak heights of the samples with the peak heights of standards.

## RESULTS AND DISCUSSION

### Migration Hypothesis

The hypothesis that the diseased Dover sole collected off Orange County had migrated from the Palos Verdes shelf was tested by measuring the levels of total DDT and total PCB in muscle tissue from specimens with and without eroded fin tips from both locations. To discount possible seasonal variability, all results obtained for each disease category at an individual station were combined on a quarterly basis. To discount possible station variability, only data from those stations for which both diseased and unaffected specimens had been analyzed were used. For comparison, we used the median total DDT and total PCB concentrations for diseased and unaffected fish. Tables 1 and 2 present the results for total DDT and total PCB, respectively.

TABLE 1.—Median concentrations (milligrams per kilogram wet weight) of total DDT in muscle tissue of Dover sole, with and without eroded fins, collected off Palos Verdes Peninsula and Orange County, 1974 quarterly trawl series.

Location Station	Quarter	Diseased (with eroded fins)			Unaffected (without eroded fins)		
		<i>n</i>	Median	Range	<i>n</i>	Median	Range
Palos Verdes:							
5	Winter	3	18	15–29	2	7.0	2.0–12
7	Winter	2	36	29–44	3	1.8	1.3–2.3
1	Spring	2	26	18–34	1	25	—
2	Spring	2	20	16–24	3	5.0	4.3–5.3
3	Spring	3	13	7.2–45	2	11	9.6–13
4	Spring	1	16	—	1	14	—
6	Summer	3	15	8.0–29	3	11	8.8–13
Orange County:							
8	Spring	4	31	19–75	1	7.6	—
10	Fall	6	7.6	4.2–57	2	1.0	0.3–1.7
11	Fall	1	19	—	2	1.2	0.3–2.2
9	Fall	3	4.2	0.9–6.1	3	0.4	0.4–0.5

TABLE 2.—Median concentrations (milligrams per kilogram wet weight) of total PCB in muscle tissue of Dover sole, with and without eroded fins, collected off Palos Verdes Peninsula and Orange County, 1974 quarterly trawl series.

Location Station	Quarter	Diseased (with eroded fins)			Unaffected (without eroded fins)		
		<i>n</i>	Median	Range	<i>n</i>	Median	Range
Palos Verdes:							
5	Winter	3	2.6	1.8–3.6	2	1.2	0.6–1.9
7	Winter	2	3.8	3.4–4.3	3	0.3	0.2–0.5
1	Spring	2	2.0	1.7–2.2	1	2.6	—
2	Spring	2	2.4	1.5–3.4	3	0.5	0.4–0.6
3	Spring	3	1.0	0.8–3.0	2	1.4	1.4–1.5
4	Spring	1	2.1	—	1	1.6	—
6	Summer	3	1.5	0.6–3.3	3	1.0	0.8–2.6
Orange County:							
8	Spring	4	3.0	2.1–6.6	1	0.9	—
10	Fall	6	3.4	1.3–5.2	2	4.0	1.8–6.2
11	Fall	1	1.6	—	2	0.3	0.3
9	Fall	3	0.9	0.9–1.1	3	0.3	0.2–0.3

Using the Mann-Whitney *U*-test, we found no significant difference ( $P > 0.20$ ) between total DDT concentrations in the muscle tissue of diseased fish from the Orange County and Palos Verdes regions. The overall median total DDT concentrations were 13 and 18 mg/kg wet weight, respectively. In contrast, there was a significant difference ( $P < 0.05$ ) between total DDT levels in the unaffected fish from the two regions (overall medians of 1.1 and 11 mg/kg wet weight, respectively).

In this study, the overall median values obtained for total DDT levels in diseased Dover sole from both areas and in the unaffected fish from Palos Verdes were 10 or more times greater than the overall median value obtained for the unaffected Orange County specimens. McDermott and Heesen (1975) had previously found that the

<sup>5</sup>Mearns, A. J., and L. H. Harris. 1975. Age, length, and weight relationships in southern California populations of Dover sole. South. Calif. Coastal Water Res. Proj., Rep. TM 219.

<sup>6</sup>Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

median level of total DDT in muscle tissue from Dover sole collected off Palos Verdes was about 10 times greater than the median level observed for the Orange County specimens (McDermott and Heesen<sup>7</sup>).

These results support the hypothesis that the Dover sole with fin erosion collected off Orange County came from the Palos Verdes population. They also suggest that levels of DDT in tissues may be used as a tag when investigating local migrations of fish from or across a known point source of DDT.

There were no significant differences ( $P > 0.20$ ) between the total PCB levels in unaffected Dover sole from Orange County and Palos Verdes, nor between the total PCB levels in diseased fish from the two areas. The overall median total PCB concentrations in muscle tissue of unaffected fish from Orange County and Palos Verdes were 0.6 and 1.2 mg/kg wet weight, respectively; from diseased specimens, 2.3 and 2.1 mg/kg wet weight, respectively.

#### Association of Chlorinated Hydrocarbons with Fin Erosion

Since the diseased fish at Orange County appear to have originated from Palos Verdes and the Palos Verdes area is the primary site of total DDT and total PCB sediment contamination, only the results obtained for total chlorinated hydrocarbon measurements in diseased and unaffected Dover sole collected from Palos Verdes were utilized to test for the association of chlorinated hydrocarbons with fin erosion. Using the Mann-Whitney *U*-test we found that the DDT levels in diseased Palos Verdes Dover sole were significantly greater ( $P < 0.05$ ) than the DDT levels measured in unaffected Palos Verdes specimens. The overall median values for diseased and unaffected Dover sole were 18 and 11 mg/kg wet weight, respectively.

Differences in the levels of total PCB in the muscle tissue of diseased and unaffected Dover sole were significant only at the 90% confidence level ( $P < 0.10$ ). Thus there was a tendency for the total PCB levels to be higher in the diseased

fish. The median values for the diseased and unaffected groups were 2.1 and 1.2 mg/kg wet weight, respectively.

These results indicate that there is a significant association between high levels of total DDT and fin erosion, and a possible association between high levels of total PCB and fin erosion in Dover sole collected off Palos Verdes.

There are several possible reasons for these associations. DDT and PCB in combination with each other and/or other constituents present in this region (such as hydrogen sulfide, high levels of trace metals, or abrasive materials) could be involved in the development of the disease. Alternatively, chlorinated hydrocarbon uptake could be enhanced in diseased fish; hence the higher levels might be the result of the disease rather than a cause. A third possibility is that the fish with fin erosion have been present on the Palos Verdes shelf longer than the unaffected fish and have been exposed to the chlorinated hydrocarbons for a longer period of time. These possible explanations are presently under investigation.

It is interesting to note that while the Palos Verdes municipal wastewater discharges of DDT significantly decreased from greater than 20 metric tons in 1971 to 2 metric tons in 1974 (Young et al. 1975), the levels of DDT in the Dover sole have remained unchanged (McDermott and Heesen see footnote 7). Similarly, the level of DDT in the surface sediments off the Palos Verdes Peninsula remained relatively constant over the 3-yr period, 1971-73 (Young et al. 1975; Young et al. 1976b). The situation for PCB is similar. The discharge of PCB decreased from greater than 19 metric tons in 1972 to 5 metric tons in 1974 (Young et al. 1976a) and the levels of PCB in the Dover sole remained unchanged (McDermott et al. 1976). Unfortunately, reliable historical data for PCB's in the Palos Verdes surface sediments are not available. The overall prevalence of fin erosion in Dover sole also remained relatively constant over the same time period (Sherwood and Mearns<sup>8</sup>). These findings point to the potentially significant role that the sediments may have in the uptake of chlorinated hydrocarbons and in the development of fin erosion in Dover sole.

<sup>7</sup>McDermott, D. J., and T. C. Heesen. 1975. DDT and PCB in Dover sole around outfalls. *In* Coastal water research project annual report, p. 117-121. South. Calif. Coastal Water Res. Proj., El Segundo.

<sup>8</sup>Sherwood, M. J., and A. J. Mearns. 1975. Sampling diseased fish populations. *In* Coastal water research project annual report, p. 27-32. South. Calif. Coastal Water Res. Proj., El Segundo.

## SUMMARY

1. Levels of DDT in Dover sole with fin erosion collected off Palos Verdes and Orange County were not significantly different. This is consistent with the hypothesis that the Orange County diseased fish migrated from the Palos Verdes region and that the disease did not originate at Orange County.
2. A dominant point source discharge of a contaminant, such as the municipal wastewater discharge of DDT compounds off Palos Verdes, may provide a useful tag when investigating the migration of fish from or across that point source.
3. Dover sole with fin erosion from Palos Verdes have significantly higher levels of total DDT ( $P < 0.05$ ) than Dover sole without the disease from the same region.
4. There is a tendency for Dover sole with fin erosion from Palos Verdes to have higher levels of PCB ( $P < 0.10$ ) than Dover sole without the disease from the same region.

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