PROCEEDINGS
4th annual
technical conference:
March 14-15
1974

ESTUARIES
of the
Pacific Northwest

Inputs & Distributions of
Chlorinated Hydrocarbons in

OREGON STATE UNIVERSITY
ENGINEERING EXPERIMENT STATION
CIRCULAR NO. 50
Inputs and Distributions of Chlorinated Hydrocarbons in Three Southern California Harbors

DAVID R. YOUNG, SR. ENVIRONMENTAL SPECIALIST
AND
THEODORE C. HEESON, SR. RESEARCH TECHNICIAN
SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT
EL SEGUNDO, CALIFORNIA

ABSTRACT

Chlorinated hydrocarbons such as the pesticide DDT and industrial polychlorinated biphenyls (PCB) are major contaminants in southern California marine waters. As a result of a predominant DDT input from the large submarine discharge of Los Angeles County municipal wastewater, coastal mussels off Los Angeles contain up to 50 times more p,p'-DDE than those off San Diego. Specimens of a bay mussel collected from San Diego Bay, Newport Harbor, and San Pedro Harbor also show this pattern of increasing DDT concentrations toward Los Angeles.

However, PCB 1254 concentrations are similar in mussels from the three harbors and are several times higher than in specimens collected from the nearby coastal waters. Estimates for total annual inputs of PCB 1254 to these harbors from municipal wastewater, industrial wastewater, surface runoff, aerial fallout, and vessel antifouling paints range from 1 kg/yr in Newport Bay to 150 kg/yr in San Pedro Harbor, with surface runoff and industrial wastewater constituting virtually all of the latter input.

Although antifouling paints presently constitute a completely insignificant mode for PCB input to these harbors, occasional high PCB concentrations in old paint chips and the correlation of mussel PCB concentrations with antifouling paint usage suggest that this may have been the predominant source of PCB to southern California harbors in recent years. It is not yet known how long these harbors will exhibit enhanced PCB contamination levels over those of the adjacent coastal waters.

*This paper is contribution 18 of the Coastal Water Research Project. Investigations into marine input rates of chlorinated hydrocarbons described here were supported by the U.S. Environmental Protection Agency, Grant R801152. The contents do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. Investigations into chlorinated hydrocarbon distributions described here were conducted in connection with State of California Agreement M-11, with the Marine Research Committee, Department of Fish and Game.
INTRODUCTION

Chlorinated hydrocarbons appear to be one of the most important classes of contaminants yet described in the marine ecosystem of southern California. Excessive concentrations of DDT residues have been found in anchovies, sand crabs, byssal mussels, flatfish, and bottom sediments collected near one Los Angeles coastal harbor. The discharged municipal wastewater, and relatively high concentrations of polychlorinated biphenyls (PCB) have also been reported (Risebrough 1969; Burnett 1971; Southern California Coastal Water Research Project 1973; de Lappe et al. 1974). In addition, reproductive failures in the brown pelican at Anacapa Island rookeries off Los Angeles have been associated with the large accumulations of chlorinated hydrocarbons in this fish-eating bird (Risebrough et al. 1971).

The coastal plain of the Southern California Bight extends from Point Conception to northern Baja California, a distance of about 500 km (Figure 1). It is inhabited by more than 11 million persons, and the intense agricultural and industrial activities of this region have constituted an ample source of chlorinated hydrocarbons to the environment. During the past 5 years, the Coastal Water Research Project has been engaged in describing (1) the input rates of DDT and PCB compounds via major routes to the coastal marine waters and (2) the distributions of these materials in several important components of the ecosystem throughout the Bight. Our studies indicate that the numerous harbors located in the Bight may be significant sources of certain trace metals and organic compounds to the adjacent coastal waters (Southern California Coastal Water Research Project 1973).

During 1973, the Project began a detailed investigation of chlorinated hydrocarbon inputs and distributions in three major southern California harbors: San Pedro Harbor in Los Angeles County, Newport Bay in Orange County, and San Diego Bay in San Diego County. Our study focused on San Pedro Harbor, which is the largest of the three harbors and the one with the greatest variety of inputs. Most of the direct industrial discharges into harbor waters in the Bight occur here; San Pedro Harbor is also the only one of the three harbors that receives a major discharge of municipal wastewater (from the Terminal Island Treatment Plant) and a major input of surface storm runoff (from the Los Angeles River channel). All of the large shipyards in the Bight are located in either San Pedro Harbor or San Diego Bay. In contrast, Newport Bay is almost entirely composed of either recreational craft moorings (in Newport Harbor) or relatively undisturbed wetlands (in upper Newport Bay).

The Project studied the principal input modes—antifouling paint application, direct industrial discharge, municipal wastewater discharge, surface runoff, and aerial fallout. Previous studies had demonstrated the usefulness of the coastal intertidal mussel Mytilus californianus in describing the extent and degree of nearshore contamination by chlorinated hydrocarbons (Southern California Coastal Water Research Project 1973; de Lappe et al. 1974). Therefore, we selected the bay mussel Mytilus edulis to describe the distributions of DDT and PCB compounds within these harbors. The use of Mytilus allowed us to compare concentrations in harbor mussels to those found in coastal specimens, which are more directly exposed to other sources of chlorinated hydrocarbons, such as the large submarine discharges of municipal wastewater.

SAMPLING

We obtained information on typical kinds and amounts of antifouling paints applied annually to recreational, commercial, and naval vessels in the Bight during 1973 by surveying both haulout yards and paint retailers in the vicinity of the harbors under investigation. Samples of principal paint brands currently being applied and paint scrapings from drydock areas were obtained for analysis of chlorinated hydrocarbon content. The survey results were used to estimate the average annual application rate of antifouling paint per recreational craft in the marinas of the Bight; quantities of antifouling paint used annually on commercial and naval vessels were determined directly from surveys of the major shipyards in the Bight.

Industrial discharges into San Pedro Harbor were grouped into several general categories. In the summary and fall of 1973, we collected approximately 20 composites of industrial effluents, each composed of four hourly grab samples from a variety of industries in each category. Replicate 7-day samples of Terminal Island municipal wastewater were obtained in early 1974 by compos- ing (according to flow) three grab samples per day. These samples were refrigerated soon after collection and preserved in pesticide-grade hexane until analyzed.

Samples of surface runoff were collected a few kilometers from the mouth of the Los Angeles River during four storms of Water Year 1973–74; we usually collected about ten samples per storm. The samples were taken at the center of the channel: An all-metal, depth-integrating sampler (patterned after a U.S.G.S. suspended sediment sampling device) was raised and lowered between the surface and the bottom of the stream at a steady rate until it was nearly full. Four-liter samples were preserved with hexane until analyzed.

San Pedro Harbor is comprised of the Los Angeles and Long Beach Harbors.
In addition to the storm runoff collections from the Los Angeles River, we also sampled dry-weather flows in several southern California channels during the spring and summer of 1973.

Aerial fallout was sampled at two stations inside San Pedro Harbor, one on a beach lifeguard tower and the other on the roof of a boat barge anchored near the central breakwater. The Newport Bay station was located at an ocean pier just outside Newport Harbor, and San Diego stations were located at La Jolla and Imperial Beaches, a few kilometers north and south of San Diego Bay, respectively. Replicate week-long collections were made at the stations throughout the summer of 1973 according to a technique developed by McClure (personal communication).* Cleaned glass plates 0.1 sq. m. in area were sprayed with a light coat of mineral oil and placed on unpainted surfaces approximately 4 m. above the ground. Once a week, the plates were scraped and re-sprayed three times in succession; this provided high recovery of the sample and left a cleaned plate for the next collection.

Intertidal mussels 4 to 6 cm. long were collected during January 1974 at ten or more stations in each harbor and also at two or more coastal sites near the mouth of each harbor. The whole soft tissues were removed and analyzed for chlorinated hydrocarbons.

LABORATORY ANALYSIS

Paint samples were extracted using two different methods. Wet paint samples were extracted with diethyl ether-hexane solutions in a separatory funnel. Dry paint samples were hexane-extracted in a Soxhlet extraction apparatus. Both wet and dry paint extracts were cleaned using Florisil columns.

All water samples (municipal wastewater, direct industrial discharge, and surface runoff) were processed using one technique: The samples were extracted with diethyl ether-hexane solutions in separatory funnels, and the extracts were then cleaned, using Florisil columns.

The aerial fallout samples were passed through a silica gel column to separate the chlorinated hydrocarbons from the rest of the sample, according to a technique developed by McClure (personal communication).

The mussel samples were extracted by covering the tissue with acetonitrile and using a high-speed blender to homogenize the sample. The homogenate was filtered into a separatory funnel, and the sample was partitioned with hexane. The hexane fraction was cleaned, using a Florisil column.

*Dr. Vance McClure, National Marine Fisheries Service, Tiburon, Ca.

The instrument used for analysis was a Tracer MT 220 gas chromatograph equipped with two 6 Ni electron capture detectors. The carrier gas was purified nitrogen flowing at a rate of 80 ml/min. The injector, column, and detector temperatures were 225, 190, and 265 degrees C, respectively. The column was a 1/4-x-6-in. tube packed with 3 percent OV-1 on Chromosorb W, AK, DMCS, 60/80 mesh.

RESULTS

The survey of antifouling paint application in several marinas of the Bay indicated that about 75 percent of the boats in each marina were painted once a year and that, on the average, approximately 1 gal.* of paint was used per boat.** On the basis of this relationship and small craft inventories obtained from harbor masters, we estimated the use of antifouling paints in Newport Harbor and in several marinas of San Pedro Harbor and San Diego Bay (Table 1; the table also gives estimated quantities of antifouling paint applied annually to commercial and naval vessels in these anchorages).

Concentrations of PCB 1242 and 1254 observed in the major branches of antifouling paint currently in use in southern California are listed in Table 2; data on levels found in paint scrapings at haulout yards are listed in Table 3. The upper-limit values for total DOT generally were an order of magnitude lower than those for the sum of PCB 1242 and 1254.

Tables 4 and 5 present the concentrations of PCB and DOT compounds observed in effluent composites from the major representatives of direct industrial dischargers to Los Angeles Harbor and Dominguez Channel of Long Beach Harbor. PCB concentrations were highest in effluents from several shipyards, but the discharge rates of these effluents were relatively low. Significant concentrations of both PCB and DOT compounds were found in the canning wastes, which were discharged at the rate of several million gallons per day.

The lowest concentrations were found in cooling water discharges from a power plant in the Los Angeles Harbor area; effluents of this type account for approximately 80 percent of the 1,290 mgd of industrial discharges to San Pedro Harbor. The results of the replicate analyses of Terminal Island municipal wastewater released into the outer portion of San Pedro Harbor (Table 6) revealed higher concentrations of the chlorinated hydrocarbons in this effluent than in most of the direct industrial discharges.

*One gallon equals 3.78 liters.

**Inventory records generally apply to small craft between 16 and 66 ft (about 5 to 20 m) in length.
Figure 2 gives an example of the relationship between estimated discharge rate and concentrations of suspended sediment, total DDT, and PCB 1254 in Los Angeles River storm runoff. Although there were relatively large variations in the chlorinated hydrocarbon concentrations, these values appeared to fluctuate with concentration of suspended sediment and discharge rate. Such a relationship implies that most of the runoff transport of these trace organics occurs during periods of peak discharge. Flow-weighted mean concentrations of these chlorinated hydrocarbons for four individual storms during Water Year 1972-73 are listed, in Table 7, as are the overall storm flow-weighted means for the year. For comparison, corresponding values based on analyses by Risebrough and de Lappe* for Water Year 1971-72 are also listed. These overall means are in remarkably good agreement. Table 8 presents the results of the two seasonal collections of dry weather flow in channels discharging into or nearby the three harbors under investigation.

Figures 3 and 4 illustrate weekly values for flux via dry aerial fallout of PCB 1254 and p,p'-DDT** measured from July to September 1973 at or near the three harbors. During the sampling period, winds were predominantly from the west. Investigations are now in progress to determine if higher fallout values occur during the winter when the sea breezes are less persistent and occasional strong winds from the east carry dust and other materials out over the Bay.

From these data, we have attempted to estimate typical annual inputs of measurable DDT and PCB compounds to the three harbors via the five routes investigated. As seen from Table 2, PCBs were detected in only 7 of the 28 wet paint samples analyzed. With the exception of the two samples with total PCB concentrations of approximately 40 mg/l each, levels generally were the order of 1 mg/l or below; neglecting inequality signatures in Table 2, median values for PCB 1242 and 1254 were 0.3 mg/l and 0.7 mg/l, respectively. Total DDT upper limits generally were an order-of-magnitude lower. We combined these values with the estimated quantities of antifouling paint applied annually to recreational, commercial, and naval vessels in the harbors (Table 1) and obtained estimated upper limits for this annual use of PCB and DDT in these harbors.

The estimates for industrial inputs to San Pedro Harbor were obtained by calculating flow-weighted concentrations of PCB 1254 and total DDT in three classes: power plant cooling water, fish cannery wastes, and "other industrial" discharges. These categories were initially selected because of the relatively high flows of the power plant discharges and the relatively high DDT emissions from canneries. The weighted concentrations were then multiplied by the reported total present flows for the three classes of industrial wastewaters into San Pedro Harbor;** these values are summarized below:

<table>
<thead>
<tr>
<th>Class</th>
<th>Mean Flow Weighted (mg/l)</th>
<th>Mean Conc. (ug/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Plant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling</td>
<td>1,021</td>
<td>0.01</td>
</tr>
<tr>
<td>Cannery Wastes</td>
<td>16</td>
<td>0.09</td>
</tr>
<tr>
<td>Other Industrial</td>
<td>254</td>
<td>0.10</td>
</tr>
<tr>
<td>Blank</td>
<td>0.004</td>
<td></td>
</tr>
</tbody>
</table>

There does not appear to be any significant discharge of industrial waste into Newport Bay;* in San Diego Bay, some power plant cooling waters and cannery wastes are discharged,** but these inputs have not yet been studied.

Estimates of annual PCB and DDT inputs to San Pedro Harbor via the discharge from the Terminal Island Municipal Wastewater Treatment Plant were calculated from the average concentrations listed in Table 6 and the mean discharge rate of approximately 10 mgd.

The long-term annual mean flow of surface runoff to San Pedro Harbor via Los Angeles River is 148 cu m/yr; of this, approximately 29% or 44 cu m/yr is dry-weather flow, and the remainder is attributable to storm flow.† By combining these data with the concentrations given in Tables 7 and 8, we obtain the estimated typical mass emission rates for total

*The industrial wastewater sampling and evaluation program is still in progress.

**Information supplied by Dr. Lewis Schinazi, California State Regional Water Quality Control Board, Los Angeles Region.

*Personal communication, Steven Harrera, California State Regional Water Quality Control Board, Santa Ana Region.

**Personal communication, Joseph Barry, California State Regional Water Quality Control Board, San Diego Region.

*Data provided by the Los Angeles County Flood Control District.
DDT and PCB 1254 (shown in Tables 9 and 10). Of these chlorinated hydrocarbon inputs, only about 2% percent occur via dry weather flow; thus, stormflow does appear to dominate annual runoff transport of these compounds in southern California. Although extensive records for Newport and San Diego Bays are not available, present best estimates for typical surface flow to these two bays are 7 and 12 cu m/yr, respectively. Because stormflow PCB and DDT concentrations were not obtained in these two areas, we have assumed that the dry-weather flow relationships (Table 8) for the Orange County and San Diego County channels, relative to the Los Angeles River dry-weather concentrations, may be used to extrapolate the 1972-73 Los Angeles River stormflow averages (Table 7) to the Newport Bay and San Diego Bay runoff channels.

Finally, the estimates of aerial fallout inputs of PCB 1254 and p,p'-DDT to the waters of the harbors were calculated from the waterway areas and the fluxes measured in the three regions during summer 1973:

<table>
<thead>
<tr>
<th>Harbor</th>
<th>PCB 1254</th>
<th>p,p'-DDT</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Pedro</td>
<td>62</td>
<td>99</td>
</tr>
<tr>
<td>Newport</td>
<td>6</td>
<td>102</td>
</tr>
<tr>
<td>San Diego</td>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>

The resulting estimated annual mass emission rates for the five routes are summarized in Tables 9 and 10. The distributions of total DDT (principally p,p'-DDT) measured in the whole soft tissues of the intertidal byssal mussel Mytilus collected from the vicinities of the three harbors are illustrated in Figures 5 to 7; corresponding distributions for PCB 1254 are illustrated in Figures 8 to 10.

**DISCUSSION AND CONCLUSIONS**

Our investigation shows that negligible quantities of DDT are now entering Newport and San Diego Bays via the five major input modes under study. Because of the large input of stormflow from the Los Angeles River, surface runoff is the dominant source of DDT to San Pedro Bay; however, the estimated total annual input of about 100 kg/yr through runoff is insignificant relative to the 4,000 kg from the Los Angeles County submarine outfalls at Whites Point, just northwest of the harbor) during 1975. (The 1971 DDT input via this municipal wastewater discharge was approximately 19,000 kg, and previous annual inputs may have been considerably higher.)

The distributions of total DDT concentrations in the intertidal mussels, shown in Figures 5 to 7, support the hypothesis that the Whites Point submarine outfall system has been the dominant source of DDT to the coastal and harbor zones investigated. The maximum tissue concentration of 1,500 µg/kg (ppb) occurred on the coast near Whites Point, at the base of the outfalls. With the exception of the surprisingly high concentration (1,300 ppb) within the Long Beach Marina, the levels found inside San Pedro Harbor ranged from 120 to 640 ppb and were similar to (but somewhat lower than) those along the breakwater (range: 360 to 960 ppb).

In general, the DDT values in mussels increased with proximity to the Whites Point outfall system. Values in the coastal specimens outside Newport Harbor, 40 km to the south, were also high (concentrations ranged from 110 to 260 ppb), although inside the harbor, somewhat higher values were observed (200 to 640 ppb). As the present known input rates of DDT to Newport Bay are negligible, these high values in the harbor mussels may be due to recycling of past accumulations of DDT within the restricted waters there.

The San Diego mussels showed the lowest DDT concentrations, with coastal values ranging from 4 to 61 ppb. The median coastal value was 51 ppb compared to the median harbor values of 52 ppb. These levels, which were not significantly different, were approximately 30 times lower than the concentration observed at the base of the Los Angeles County outfalls, 150 km to the north.

The following PCB summary indicates an important difference between the relative distributions of PCB and those of DDT discussed above.

<table>
<thead>
<tr>
<th>Region</th>
<th>Median Range</th>
<th>Median Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Pedro</td>
<td>110-140</td>
<td>160-86-850</td>
</tr>
<tr>
<td>Newport</td>
<td>69-100</td>
<td>210-86-850</td>
</tr>
<tr>
<td>San Diego</td>
<td>47-61</td>
<td>320-19-850</td>
</tr>
</tbody>
</table>

The coastal PCB medians decrease by a factor of two from San Pedro to San Diego, but the harbor medians increase by a factor of two. This pattern indicates that, in contrast to the case for DDT, there appears to be more than one important source of PCB to nearshore waters of the Bight.

Past studies have shown that in 1971, PCB inputs from Los Angeles and Orange County ocean outfalls each exceeded 1,000 kg/yr, whereas the input from the San Diego Point Loma outfall was an order of magnitude lower (Southern California Coastal Water Research Project 1973). We would therefore expect coastal mussels off San Pedro and Newport

*Excluding *M. californianus* values.
Bays to be more influenced by PCB from the ocean outfalls than are those off San Diego; the median PCB concentrations just presented are consistent with this expectation. However, in all three regions, the values of PCB in harbor mussels exceed those in coastal specimens, implying that a specific harbor-related source may have been a dominant ubiquitous PCB input in recent years.

Although the data of Table 10 does not indicate which or the potential sources investigated is most likely to have been the dominant one, the fact that the high PCB concentrations are found wherever there is intense vessel activity suggests that this may well be the key. In all three harbors, the values are highest in the confined regions where recreational or commercial and naval vessels are present. This conclusion is strengthened particularly by the fact that some of the highest PCB concentrations observed occurred in Newport Harbor, an anchorage with a high density of recreational craft and with no significant discharge of industrial, municipal, or surface runoff wastewater. The occasional very high concentrations of PCB in dried chips of antifouling paint support this hypothesis, although other potential vessel sources, such as loss of hydraulic fluid, might also be the explanation.

Samples of pre-1970 antifouling paints are now being sought to further investigate this possibility. If the tentative conclusions attributing the relatively high PCB concentrations in harbor mussels to past inputs from this source are confirmed, it could mean that the prohibition of "open" use of PCB, such as in paints, has decreased the application of PCB to vessel bottoms by up to 10,000 kg/yr in the largest harbors of the Sight. Nevertheless, the restricted circulation in these harbors, and the proximity of harbor intertidal organisms to potential PCB sources, has resulted in significantly higher contamination levels of PCB than are exhibited by coastal mussels near present major submarine discharges of these chlorinated hydrocarbons.

ACKNOWLEDGMENTS

We thank Larry Miller, Newport Beach Chamber of Commerce, and Ray Berry, California Shipyards, for help in acquiring these data. Personnel of the Flood Control Districts and the California Regional Water Quality Control Board in Los Angeles, Orange and San Diego Counties provided important information on surface runoff and industrial discharges. We also appreciate the cooperation of most of the owners and operators of drydocks and retail paint outlets at the harbors we investigated. Elliott Berkhiser, Joseph Johnson, and Paul Snokler of the Coastal Water Research Project participated in the field collections and laboratory analyses, and Deirdre McDermott and Robin Simpson, also of the Project, assisted in preparation of the manuscript.

BIBLIOGRAPHY


FIGURES

Figure 1. Location of the three harbors studied within the Southern California Bight.

Figure 2. Concentrations of chlorinated hydrocarbons and suspended sediments in Los Angeles River stormwaters, 11-12 March, 1973.

Figure 3. July through September 1973 flux of PCB 1254 at three major harbors in Southern California.

Figure 4. July through September 1973 flux of p, p'-DDT at three major harbors in Southern California.

Figure 5. Concentrations (ug/wet kg) of total DDT in whole soft tissues of Mytilus edulis in San Pedro Harbor, January 1974.

Figure 6. Concentrations (ug/wet kg) of total DDT in whole soft tissues of Mytilus edulis in Newport Bay, January 1974.

Figure 7. Concentrations (ug/wet kg) of total DDT in whole soft tissues of Mytilus edulis in San Diego Bay, January 1974.
Figure 8. Concentrations (ug/wet kg) of PCB 1254 in whole soft tissues of Mytilus edulis in San Pedro Harbor, January 1974.

Figure 9. Concentrations (ug/wet kg) of PCB 1254 in whole soft tissues of Mytilus edulis in Newport Bay, January 1974.

Figure 10. Concentrations (ug/wet kg) of PCB 1254 in whole soft tissues of Mytilus edulis in San Diego Bay, January 1974.
Figure 10.
<table>
<thead>
<tr>
<th>HARBOUR</th>
<th>NUMBER OF BOATS</th>
<th>ANTIFOULING PAINTS (£/YR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAN PEDRO HARBOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOS ANGELES HARBOR</td>
<td>3,600</td>
<td></td>
</tr>
<tr>
<td>LONG BEACH HARBOR</td>
<td>2,700</td>
<td></td>
</tr>
<tr>
<td>LONG BEACH MARINA</td>
<td>2,500</td>
<td></td>
</tr>
<tr>
<td>SUBTOTAL</td>
<td>8,800</td>
<td>25,000</td>
</tr>
<tr>
<td>COMMERCIAL AND NAVAL</td>
<td>-</td>
<td>115,000</td>
</tr>
<tr>
<td>NEWPORT HARBOR</td>
<td>8,600</td>
<td>25,000</td>
</tr>
<tr>
<td>SAN DIEGO BAY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MUNI. YACHT HARBOR</td>
<td>1,900</td>
<td></td>
</tr>
<tr>
<td>COMMERCIAL BASIN</td>
<td>800</td>
<td></td>
</tr>
<tr>
<td>HARBOR ISLAND</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>CORONADO MARINA</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>OTHERS</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>SUBTOTAL</td>
<td>3,600</td>
<td>10,000</td>
</tr>
<tr>
<td>COMMERCIAL AND NAVAL</td>
<td>-</td>
<td>75,000</td>
</tr>
<tr>
<td>TOTAL</td>
<td>21,000</td>
<td>250,000</td>
</tr>
</tbody>
</table>

*Estimates based partially on data from Barry (1972).
Table 2. Polychlorinated biphenyl concentrations in anti-fouling paints used in southern California.

<table>
<thead>
<tr>
<th>Code</th>
<th>Brand and Type</th>
<th>PCB (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1242</td>
</tr>
<tr>
<td></td>
<td><strong>RECREATIONAL</strong></td>
<td></td>
</tr>
<tr>
<td>P23</td>
<td>Brolite Z-Spar 2000</td>
<td>&lt;0.06</td>
</tr>
<tr>
<td>P45</td>
<td>Multitox</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>P34</td>
<td>Colortox</td>
<td>-</td>
</tr>
<tr>
<td>P33</td>
<td>Killer (8-90)</td>
<td>&lt;0.3</td>
</tr>
<tr>
<td>P37</td>
<td>A-1316 (1969)</td>
<td>&lt;0.4</td>
</tr>
<tr>
<td></td>
<td><strong>Woolsey</strong></td>
<td></td>
</tr>
<tr>
<td>P24</td>
<td>Vinelast (blue)</td>
<td>&lt;0.3</td>
</tr>
<tr>
<td>P39</td>
<td>Vinelast (Red)</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td></td>
<td><strong>International</strong></td>
<td></td>
</tr>
<tr>
<td>P28</td>
<td>Interv-lux 62</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>P26</td>
<td>Bottomkote 69</td>
<td>&lt;0.4</td>
</tr>
<tr>
<td>P20</td>
<td>Vinyl-lux</td>
<td>&lt;0.03</td>
</tr>
<tr>
<td>P19</td>
<td>T1-lux</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>P18</td>
<td>Copper-lux</td>
<td>&lt;0.06</td>
</tr>
<tr>
<td></td>
<td><strong>Petit</strong></td>
<td></td>
</tr>
<tr>
<td>P25</td>
<td>Unigrip</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>P51</td>
<td>Trinidad 75 (red)</td>
<td>&lt;0.09</td>
</tr>
<tr>
<td>P31</td>
<td>Pacific Special</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td><strong>Mariner's</strong></td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>1034 Lido</td>
<td>&lt;0.3</td>
</tr>
<tr>
<td></td>
<td><strong>Singapore</strong></td>
<td></td>
</tr>
<tr>
<td>P32</td>
<td>696 Blue</td>
<td>&lt;0.4</td>
</tr>
<tr>
<td></td>
<td><strong>Devco-Reynolds</strong></td>
<td></td>
</tr>
<tr>
<td>P30</td>
<td>Navicote</td>
<td>&lt;0.8</td>
</tr>
<tr>
<td>P63</td>
<td>Triple C</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td><strong>COMMERCIAL</strong></td>
<td></td>
</tr>
<tr>
<td>P54</td>
<td>Devco-Reynolds Super Tropical</td>
<td>18</td>
</tr>
<tr>
<td>P58</td>
<td>3407</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>P59</td>
<td>213</td>
<td>&lt;0.92</td>
</tr>
<tr>
<td>P64</td>
<td>Hot Plastic</td>
<td>1.30</td>
</tr>
<tr>
<td>P55</td>
<td>Cold Plastic 105</td>
<td>&lt;1.6</td>
</tr>
<tr>
<td></td>
<td>Amarcote</td>
<td></td>
</tr>
<tr>
<td>P62</td>
<td>Emeron 67</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td>Proline</td>
<td>&lt;0.17</td>
</tr>
<tr>
<td></td>
<td><strong>NAVY</strong></td>
<td></td>
</tr>
<tr>
<td>P60</td>
<td>Devco-Reynolds 121/63</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>P61</td>
<td>129/63</td>
<td>&lt;0.1</td>
</tr>
</tbody>
</table>

Table 3. Polychlorinated biphenyls in anti-fouling paint scrapings from southern California drydocks.

<table>
<thead>
<tr>
<th>ORIGIN</th>
<th>PCB (mg/dry kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1242</td>
</tr>
<tr>
<td>FIBERGLASS HULL</td>
<td>.1</td>
</tr>
<tr>
<td>TRASHCAN</td>
<td>1.3</td>
</tr>
<tr>
<td>TRASHCAN</td>
<td>9.5</td>
</tr>
<tr>
<td>DRAIN 1</td>
<td>28</td>
</tr>
<tr>
<td>DRAIN 2</td>
<td>7.5</td>
</tr>
<tr>
<td>DRAIN 2</td>
<td>110</td>
</tr>
<tr>
<td>WOOD HULL</td>
<td></td>
</tr>
<tr>
<td>WOOD HULL</td>
<td>3,000</td>
</tr>
<tr>
<td>WOOD HULL</td>
<td></td>
</tr>
<tr>
<td>WOOD HULL</td>
<td>2.8</td>
</tr>
<tr>
<td>WOOD HULL</td>
<td>0.9</td>
</tr>
<tr>
<td>WOOD HULL</td>
<td>1.1</td>
</tr>
<tr>
<td>FIBERGLASS HULL</td>
<td>1.0</td>
</tr>
<tr>
<td>WOOD HULL</td>
<td>0.5</td>
</tr>
<tr>
<td>WOOD HULL</td>
<td>3.7</td>
</tr>
<tr>
<td>TYPE DISCHARGE</td>
<td>FLOW (mgd)</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>FISH CANNERY</td>
<td></td>
</tr>
<tr>
<td>WASTE</td>
<td>5.55</td>
</tr>
<tr>
<td>WASTE</td>
<td>3.20</td>
</tr>
<tr>
<td>RETORT DISCHARGE</td>
<td>0.12</td>
</tr>
<tr>
<td>SHIPYARD</td>
<td></td>
</tr>
<tr>
<td>COOLING WATER</td>
<td>0.04</td>
</tr>
<tr>
<td>COOLING WATER</td>
<td>0.43</td>
</tr>
<tr>
<td>OIL TANKER</td>
<td>0.25</td>
</tr>
<tr>
<td>CLEANDOWN</td>
<td></td>
</tr>
<tr>
<td>SHIP BALLAST</td>
<td>0.04</td>
</tr>
<tr>
<td>SHIP BALLAST</td>
<td>0.29</td>
</tr>
<tr>
<td>OIL REFINERY</td>
<td></td>
</tr>
<tr>
<td>COOLING WATER</td>
<td>0.02</td>
</tr>
<tr>
<td>POWER PLANT</td>
<td></td>
</tr>
<tr>
<td>COOLING WATER</td>
<td>257</td>
</tr>
<tr>
<td>CHEMICAL PLANT</td>
<td></td>
</tr>
<tr>
<td>COMB. PROCESSES</td>
<td>5.51</td>
</tr>
<tr>
<td>BLANK</td>
<td>&lt; 0.004</td>
</tr>
</tbody>
</table>

**TABLE 5. CONCENTRATIONS (µg/L) OF CHLORINATED HYDROCARBONS IN INDUSTRIAL DISCHARGE: DORNGUEZ CHANNEL—LONG BEACH HARBOR, 1973**

<table>
<thead>
<tr>
<th>TYPE DISCHARGE</th>
<th>FLOW (mgd)</th>
<th>PCB 1254</th>
<th>TOTAL DDT</th>
</tr>
</thead>
<tbody>
<tr>
<td>OIL REFINERY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COOLING WATER</td>
<td>0.047</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>COOLING WATER</td>
<td>0.204</td>
<td>0.15</td>
<td>0.12</td>
</tr>
<tr>
<td>COOLING WATER</td>
<td>0.319</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>COOLING WATER</td>
<td>0.270</td>
<td>0.04</td>
<td>0.10</td>
</tr>
<tr>
<td>CHEMICAL PLANT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COOLING WATER</td>
<td>0.047</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>COOLING WATER</td>
<td>0.040</td>
<td>0.01</td>
<td>0.13</td>
</tr>
<tr>
<td>COOLING WATER</td>
<td>0.529</td>
<td>0.004</td>
<td>0.004</td>
</tr>
<tr>
<td>MISCELLANEOUS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUTO WASH</td>
<td>0.040</td>
<td>0.01</td>
<td>0.003</td>
</tr>
<tr>
<td>YARD RUNOFF</td>
<td>0.004</td>
<td>0.18</td>
<td>0.09</td>
</tr>
<tr>
<td>COOLING WATER</td>
<td>0.125</td>
<td>0.16</td>
<td>0.13</td>
</tr>
<tr>
<td>BLANK</td>
<td>&lt; 0.004</td>
<td>&lt; 0.004</td>
<td></td>
</tr>
</tbody>
</table>
Table 6. Concentrations (µg/l) of Chlorinated Hydrocarbons in Replicate Composites of Municipal Wastewater from Terminal Island Treatment Plant,* 19-25 February 1974.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>R-1</th>
<th>R-2</th>
<th>Average</th>
<th>Blank</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCB 1254</td>
<td>0.21</td>
<td>0.09</td>
<td>0.15</td>
<td>&lt;0.006</td>
</tr>
<tr>
<td>p,p'-DDT</td>
<td>0.14</td>
<td>0.05</td>
<td>0.10</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>o,p'-DDT</td>
<td>0.03</td>
<td>0.01</td>
<td>0.02</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>p,p'-DDD</td>
<td>0.15</td>
<td>0.09</td>
<td>0.12</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>p,p'-DDE</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Total DDT</strong></td>
<td><strong>0.35</strong></td>
<td><strong>0.19</strong></td>
<td><strong>0.27</strong></td>
<td><strong>&lt;0.004</strong></td>
</tr>
</tbody>
</table>

*Mean annual discharge approximately 10 mgd.

Table 7. Flow-Weighted Mean Concentrations (µg/l) of Chlorinated Hydrocarbons in Los Angeles River Storm Runoff

<table>
<thead>
<tr>
<th>Date</th>
<th>PCB 1254</th>
<th>Total DDT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971-72 Average</td>
<td>1.03</td>
<td>0.88</td>
</tr>
<tr>
<td>1972-73 Average</td>
<td>0.77</td>
<td>0.78</td>
</tr>
<tr>
<td>4-7 Dec 1972</td>
<td>0.52</td>
<td>0.67</td>
</tr>
<tr>
<td>27 Feb-1 Mar 1973</td>
<td>0.85</td>
<td>0.99</td>
</tr>
<tr>
<td>6-9 Mar 1973</td>
<td>0.91</td>
<td>0.73</td>
</tr>
<tr>
<td>11-12 Mar 1973</td>
<td>0.73</td>
<td>0.60</td>
</tr>
<tr>
<td>Average Blank</td>
<td>&lt;0.003</td>
<td>&lt;0.004</td>
</tr>
</tbody>
</table>

Table 8. Concentrations (µg/l) of Chlorinated Hydrocarbons in 1973 Collections of Dry Weather Flow.

<table>
<thead>
<tr>
<th>Channel</th>
<th>County</th>
<th>PCB 1254</th>
<th>Total DDT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles R.</td>
<td>L.A.</td>
<td>0.10</td>
<td>0.15</td>
</tr>
<tr>
<td>San Juan Cr.</td>
<td>Orange</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>San Luis Rey R.</td>
<td>S. Diego</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>San Diego R.</td>
<td>S. Diego</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Blanks</td>
<td></td>
<td>&lt;0.002</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

66
TABLE 9. ESTIMATED TYPICAL ANNUAL MASS EMISSION RATES OF TOTAL DDT (KG/yr) TO THREE SOUTHERN CALIFORNIA HARBORS.

<table>
<thead>
<tr>
<th></th>
<th>SAN PEDRO HARBOR</th>
<th>NEWPORT BAY</th>
<th>SAN DIEGO BAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUNICIPAL WASTEWATER</td>
<td>4</td>
<td>~ 0</td>
<td>~ 0</td>
</tr>
<tr>
<td>DIRECT INDUSTRIAL</td>
<td>17</td>
<td>~ 0</td>
<td>-</td>
</tr>
<tr>
<td>SURFACE RUNOFF</td>
<td>95</td>
<td>0.7</td>
<td>2</td>
</tr>
<tr>
<td>AERIAL FALLOUT*</td>
<td>7</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td>ANTIFOULING PAINTS</td>
<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>124</td>
<td>1.1</td>
<td>2.7</td>
</tr>
</tbody>
</table>

*P,P'-DDT ONLY

TABLE 10. ESTIMATED TYPICAL ANNUAL MASS EMISSION RATES OF PC3 1254 (KG/yr) TO THREE SOUTHERN CALIFORNIA HARBORS

<table>
<thead>
<tr>
<th></th>
<th>SAN PEDRO HARBOR</th>
<th>NEWPORT BAY</th>
<th>SAN DIEGO BAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUNICIPAL WASTEWATER</td>
<td>2</td>
<td>~ 0</td>
<td>~ 0</td>
</tr>
<tr>
<td>DIRECT INDUSTRIAL</td>
<td>51</td>
<td>~ 0</td>
<td>-</td>
</tr>
<tr>
<td>SURFACE RUNOFF</td>
<td>96</td>
<td>0.4</td>
<td>3</td>
</tr>
<tr>
<td>AERIAL FALLOUT</td>
<td>2</td>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td>ANTIFOULING PAINTS</td>
<td>0.1</td>
<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>151</td>
<td>0.7</td>
<td>3.9</td>
</tr>
</tbody>
</table>