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INTRODUCTION

The only producer of polychlorinated biphenyls (PCB's) in the United States is the Monsanto Industrial Chemicals Company, which has marketed these chlorinated hydrocarbons under the trade name Aroclor for about the last 40 years. The chemicals have been used in industry, primarily as plasticizers and hydraulic and insulating fluids. The dominant PCB's sold in Monsanto's domestic market during the last 10 years have been Aroclor 1242 and Aroclor 1254 (the last two digits signify the average percent chlorine, by weight, in the mixture).

Over the last 4 years, the Southern California Coastal Water Research Project has been studying the inputs of PCB's to the Southern California Bight under a grant from the Environmental Protection Agency. A number of sources of PCB's (most closely resembling Aroclors 1242 and 1254) to the marine environment off southern California have been identified and their inputs quantified (Young et al. 1975a). The greatest known source is the submarine discharge of municipal wastewater; another important route appears to be aerial fallout.

Other workers have studied PCB contamination off California and elsewhere in the U.S. in the past decade. During the summer of 1975, several reports of high PCB levels in fish collected from Lake Michigan and the Hudson River caused public concern about PCB residues in commercial fish and sport fish (Boyle 1975; Severo 1975a, b, and c). Munson's work in California (1972) indicated that, in 1972, concentrations of these chlorinated hydrocarbons were low but widespread in the southern California marine community. However, levels of PCB's in California pelagic birds have been reported to be higher than levels observed in species inhabiting agricultural or urban areas (Risebrough et al. 1968).

The work of Allen and his colleagues (1974) with rhesus monkeys attests to the toxic effects of short-term, low-level (25 ppm) exposures to PCB's on nonhuman primates. Later results of their experiments on the monkeys showed that exposure to PCB's at the 2.5- and 5-ppm levels was related to spontaneous abortions and the birth of undersized infants (Barsotti et al. 1975). The effects and toxicity of PCB's in marine and estuarine organisms have also been studied (Nimmo et al. 1975; Dexter and Pavlou 1972; Wildish 1972; Hansen et al. 1971). De Long et al. (1973) found PCB's to be associated with premature births in the California sea lion.

In conjunction with its studies of PCB sources, the Coastal Wate Project undertook research into the fates and effects of PCB's. The Project's research involved several organisms common locally (a flatfish, a benthic crab, and an open coast and a harbor muss and three distinct programs:

- Regional surveys of PCB levels in the flatfish, the crab, an the mussels. Specimens from stations throughout the Southern California Bight (Figure 1) were analyzed to determine the levels of PCB's present in their tissues and plot the distribution of the substances in the Bight. Changes over time were noted, as were relationships between the concentration levels and man's centers of activity along the coast (wastewater discharge, major harbors). We also sought to identify the dominant PCB present by determining if the PCB's found most closely resembled Aroclor 1242 or Aroclor 1254.* Final we investigated the PCB levels in specimens of the flatfish afflicted with a fin erosion disease prevalent around severa southern California wastewater outfalls.
- A study of the relative amounts of PCB's in the various tissues of the flatfish and the crab.
- The design of a convenient and effective system for continuously monitoring PCB levels in the marine environment.

This report presents the results of these studies.

*Throughout the text, we have used the terms 1242 PCB and 1254 P to distinguish between substances most closely resembling Aroclo 1242 and Aroclor 1254, respectively.

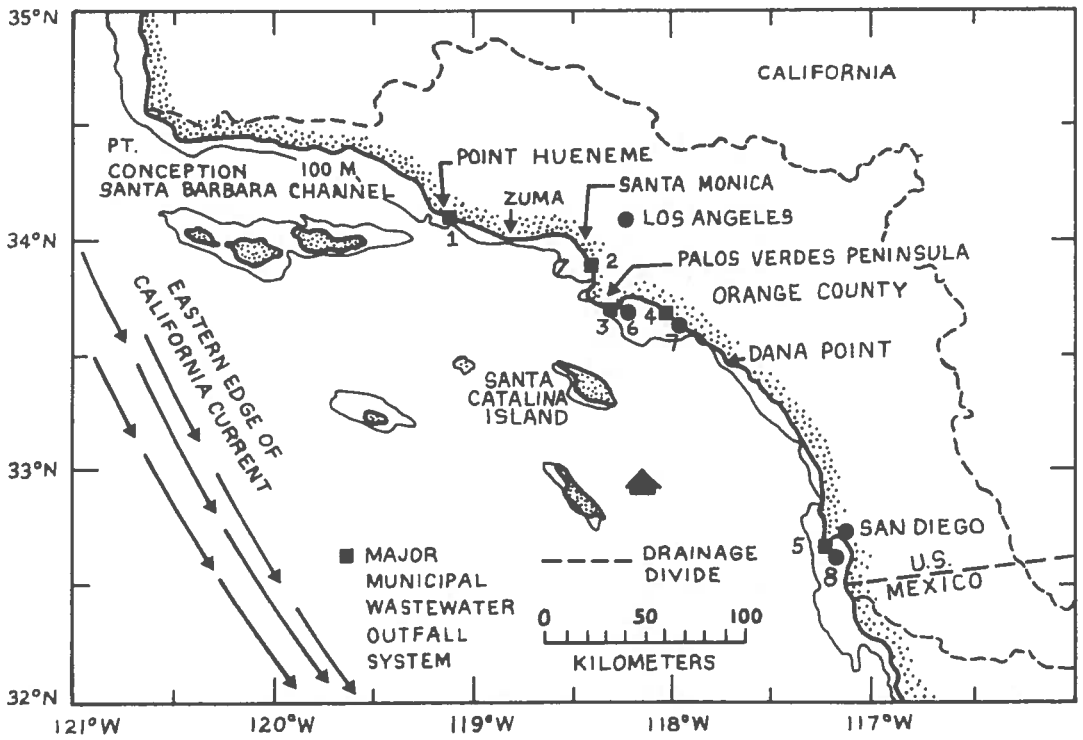

Figure 1. The Southern California Bight. Outfall systems are (1) Oxnard City, (2) Hyperion, Los Angeles City, (3) Whites Point, Los Angeles County, (4) Orange County, and (5) San Diego City. Major harbors are (6) San Pedro, (7) Newport, and (8) San Diego.

SAMPLING AND ANALYSIS

The organisms used in this program were selected on the following considerations:

Dover sole (Microstomus pacificus), a benthic flatfish
- Widely distributed throughout the Bight.
- Easily obtained in relatively large numbers by trawl.
- Closely associated with bottom sediments, which are, in some areas, contaminated with metals and chlorinated hydrocarbons (including PCB's).
- Affected by a fin erosion disease at a high frequency around the largest municipal wastewater discharge system in southern California, the Whites Point outfalls off Palos Verdes Peninsula.

Yellow rock crab (Cancer anthonyi), a benthic crab
- Widely distributed throughout the Bight.
- Easily obtained by trawl, trap, or diver.
- A popular sport crab.
- A scavenger that feeds on bottom material.

Mytilus californianus, an open coast mussel
- Evenly distributed along many coastlines around the world.
- A hardy organism that apparently responds rapidly to changes in environmental levels of trace contaminants.
- Known to concentrate chlorinated hydrocarbons to levels above those in the surrounding seawater.

Mytilus edulis, a harbor mussel
- Distributed in the major harbors of the Bight.
- Comparable to M. californianus in ability to rapidly concentrate chlorinated hydrocarbons.

All four of these organisms were used in the regional surveys of PCB distribution. M. californianus was also used in a series of buoy experiments aimed at devising a system to continuously monitor PCB levels locally.

COLLECTION AND SAMPLE PREPARATION

Benthic Flatfish

During 1971-72, up to four trawl surveys were conducted off each of the following seven regions in the Southern California Bight: Santa Barbara, Point Hueneme, Santa Monica, Palos Verdes Peninsula, Orange County, Dana Point, and Santa Catalina Island (Figure 1). In 1974-75, the survey was repeated with two

variations--the area off Santa Barbara was excluded, and an area off San Diego was added.

Most of the trawls were made with a 7.5-m (25-ft) Marinovich net, which was towed at a speed of 1.3 m/sec (2.5 kn) and remained in contact with the ocean floor for 10 min. When the net was brought aboard ship, Dover sole specimens approximately 200 mm standard length were removed, bagged, labeled, and immediately frozen. The frozen samples were brought to the laboratory and placed in freezers. Muscle tissue subsamples from these specimens were used to obtain the regional data on PCB's in this fish.

Other researchers have found that levels of PCB compounds are considerably lower in muscle tissue of marine organisms that in various other tissues. Thus, in February 1975, special collections of Dover sole were made off Palos Verdes and Orange County for multitissue analyses. Twenty specimens from each region were bagged, labeled, and immediately frozen. In the laboratory, the samples from each region were randomly subsampled into four composites of five fish each. Compositing was necessary to obtain 3 to 5 g (wet weight) of each tissue analyzed. Muscle, liver, gonadal, heart, and kidney tissues were excised from these specimens.

The samples obtained in 1971-72 were dissected on cleaned aluminum foil using stainless steel instruments. The tissue subsamples were placed in acetone-cleaned glass jars with lids lined with aluminum foil and returned to the freezer until analysis by electron-capture gas chromatography. The 1974-75 specimens were dissected on cleaned teflon sheets, using carbon steel implements. The tissue subsamples obtained were placed in glass containers, which had been heated overnight in a kiln at 538°C (1,000°F) to volatilize any interfering compounds from their surfaces. The tissue subsamples were frozen until chemical analyses were performed.

Benthic Crabs

During the 1971-72 trawl surveys off Palos Verdes and Orange County, up to three specimens of Cancer anthonyi were collected from most stations. Traps were placed on the bottom sediments at a number of stations off Santa Monica and outside the San Pedro Harbor during the same period of time.

Upon bringing the trawl nets or traps aboard ship, the specimens were immediately removed, bagged, labeled, and frozen.

In September 1972, three sets of chelae from Cancer crabs (species unknown) were purchased in a fish market in Ensenada, Baja California. According to the fisherman, these crabs had been collected offshore of Ensenada.

All of the crab samples were dissected in the same manner as the 1971-72 fish specimens. The tissues excised from the crabs were the gonads and muscle.

Open Coast Mussels

In the summer of 1971, the survey of levels of PCB in *Mytilus californianus* 4 to 6 cm in length was initiated. Samples were collected from 11 sites between Gaviota Beach (north of Santa Barbara) and Point Loma (near San Diego). Six of the islands in the Bight were surveyed; two northern California stations--Big Sur (south of Monterey) and Bodega Head (north of San Francisco)--were also sampled. In the fall, additional samples were taken at Punta Banda (south of Ensenada, Baja California) and Point Sal and San Simeon (north of Point Conception). This survey was repeated in 1974.

At each sampling site, the mussels were packaged in aluminum foil in groups of ten, labeled, and frozen. The whole soft tissues of these specimens were later analyzed for chlorinated hydrocarbons by electron-capture gas chromatography.

M. californianus was also tested as a biomonitor of PCB contamination. In June 1974, 4- to 6-cm long specimens of the mussel were collected from Point Sal, an area known to be relatively free of PCB contamination. Within 1 day of collection, these mussels were transported to a taut-line buoy anchored off Whites Point, where wastewaters from Los Angeles County's Joint Water Pollution Control Plant are discharged. The mussels were placed in net bags fastened at five levels between the sea surface (0.5 m) and the bottom sediments (35 m), which are highly contaminated with trace metals and chlorinated hydrocarbons at this site (McDermott et al. 1974; Southern California Coastal Water Research Project 1973; Galloway 1972).

For 3 months, the rate and extent of PCB uptake by these mussels was monitored. At 1- or 2-week intervals, 10 specimens from the buoy system were brought to the laboratory, where the whole soft tissues (excluding the byssal fibers) were excised with stainless steel implements. The tissue samples were then analyzed for PCB content, using electron-capture gas chromatography.

Harbor Mussels

During January 1974, we initiated a survey to determine the level of PCB contamination in three of the largest southern California harbors--San Pedro Harbor, Newport Bay, and San Diego Bay (Figure 1). Samples of *Mytilus edulis* 4 to 6 cm in length were collected from ten or more stations in each harbor and also at two or three coastal sites near the mouth of each harbor. (If *M. edulis* were not available at a given site outside the harbors, *M. californianus* were substituted.)

In the field, the specimens were packaged in aluminum foil in groups of ten and labeled. The samples were then brought to the laboratory and frozen. Later, the whole soft tissues (excluding the byssal fibers) were excised and analyzed for their PCB content.

ANALYSIS

The PCB analyses required in this study were performed by two groups. The flatfish, crab, and harbor mussel samples were analyzed by Theadore Heesen of the Project, as were the samples of mussels from the buoy system. The samples of open coast mussels taken throughout the Bight in 1971-72 and 1974-75 were shipped frozen to the Bodega Marine Laboratory (University of California, Berkeley) and analyzed by Brock de Lappe and Dr. Robert Risebrough.

Electron-capture gas chromatography was used in both cases. However, the methods of extracting the samples were different. Intercalibration checks have shown that both procedures produce reliable and comparable results.

Coastal Water Project Analysis, T. Heesen

Approximately 10 g of each tissue sample were weighed into a 150-ml beaker, covered with 20 ml of acetonitrile, and ground with a high-speed blender for 1 min. or until all pieces of the sample were thoroughly ground and mixed with the acetonitrile. The blades of the blender were rinsed twice with 20 ml of acetonitrile, and the rinse was added to the beaker with the sample. The acetonitrile was then decanted and filtered through filter paper into a 500-ml separatory funnel with a ground-glass stopper. The sample was rinsed three times with 20 ml of acetonitrile, and the rinse was decanted and filtered into the separatory funnel with the other acetonitrile fraction. After 50 ml of hexane were added to the separatory funnel with the acetonitrile extract, the funnel was shaken vigorously for 1 min., and the two layers were allowed to separate (the hexane layer is less dense than the acetonitrile layer). The acetonitrile layer was drained through the stopcock into a 400-ml beaker, and the hexane layer was emptied into a 250-ml flask. The acetonitrile fraction was then returned to the separatory funnel and extracted two more times with 50 ml of hexane, after which the hexane extracts were combined in the 250-ml flask and concentrated to about 50 ml with a Rotovapor. The samples were then "cleaned" on a Florisil column.

The Florisil (MCB, FX284) was activated using a pottery kiln. The temperature was set at 705°C (1,300°F)-- this setting is one at which the kiln melts aluminum foil (melting point: 659°C) and appears satisfactory for the activation of Florisil. The Florisil was placed in covered 250-ml crucibles in the kiln and baked for 4 hours after the kiln reached equilibrium temperature. Once activated, the Florisil was stored under hexane until use.

When a sample was to be cleaned, 7.6 cm (3 in.) of the slurried activated Florisil were added to the cleanup chromatographic columns (25 mm OD, 22 mm ID, and 400 mm long, with a sealed-in, coarse porosity fritted disc; Kontes Glass Co., Vineland, N.J.),

and 1.3 cm (0.5 in.) of anhydrous sodium sulfate was added over the Florisil. The 50-ml sample was added to the Florisil column, after which the column was eluted with 45 ml of 6 percent diethyl ether in hexane.

The cleaned sample was concentrated and injected into a Tracor MT-220 gas chromatograph equipped with a ^{63}Ni detector. The glass column used was 1.8 m (6 ft) long, 6 mm OD, and 4 mm ID and packed with 11 percent mixed-phase OV-17 and QF-1 on 80/100-mesh Gas-Chrom Q (prepared by Applied Science Labs, Inc., State College, Penn.). The carrier gas was prepurified nitrogen with a flow rate of 80 ml/min. The injector, column, and detector temperatures were 225, 205, and 285°C, respectively. The components were identified by retention time; values were derived by comparing the peak heights of the samples with peak heights of Aroclor standards.

Bodega Marine Laboratory Analysis,
B. de Lappe and R. Risebrough

After the frozen mussels were thawed and the excess liquid poured off, the entire contents, with the exception of the byssal fibers, were removed from the shell and homogenized in a Servall Blender; 8- to 10-g portions of the homogenate were placed in clean petri dishes, and the wet weight recorded. The samples were then freeze-dried to produce a crisp wafer. After dry weight was recorded, the samples were ground to a powder with mortar and pestle and mixed with approximately 50 g of anhydrous sodium sulfate. The samples were extracted with hexane or a 2:1 hexane/acetone mixture (the mixture was used on samples from Bodega Bay, Big Sur, San Nicolas Island, San Miguel Island, Punta Banda, and Point Loma) in a Soxhlet apparatus for at least 12 hours. The volume of the lipid/solvent extract was reduced to approximately 25 ml over steam, using a 3-balled Snyder column. This portion was then poured from the round-bottom flask to a 150-ml beaker; the flask was rinsed three times with 10 ml of redistilled petroleum ether and the rinses added to the beaker. The samples were allowed to evaporate to dryness and the lipid weight recorded. The samples were then redissolved in petroleum ether and passed through a 4-cm Davidow column packed in a fritted-glass funnel. The beaker was rinsed with three 50-ml portions of petroleum ether, which were also passed through the column.

The samples were analyzed on an MT-220 gas chromatograph. The two major columns used for analysis were 3 percent OV-1 on 100/120-mesh Gas-Chrom Q and 5 percent QF-1 on 80/100-mesh Chromosorb W. Oven temperature was maintained at 180°C, and the ^{63}Ni detectors were operated at 350°C. Nitrogen was used as the carrier gas.

RESULTS AND DISCUSSION

REGIONAL SURVEY OF PCB'S IN A BENTHIC FLATFISH

One-hundred-ten composite samples of muscle tissue from Dover sole collected throughout the Bight during 1971-72 were analyzed for their PCB content. The median concentrations of total PCB in specimens taken from each sampling station are shown in Figure 2; data for each region are presented in Table 1. The highest PCB values were found in specimens collected around the major municipal wastewater discharges off Palos Verdes (median: 1.9 mg/wet kg), Santa Monica (median: 1.5 mg/wet kg), and Orange County (median: 0.7 mg/wet kg). These values were significantly higher than the PCB levels in specimens collected in areas with little or no municipal wastewater discharge: Santa Barbara Channel (median: 0.06 mg/wet kg), Point Hueneme (median: 0.1 mg/wet kg), Zuma Beach (median: 0.1 mg/wet kg), Dana Point (median: 0.06 mg/wet kg), and Santa Catalina Island (median: 0.04 mg/wet kg).

The range of PCB concentrations in the 1971-72 Palos Verdes Dover sole (0.6 to 8.3 mg/wet kg) was similar to the ranges found by the County Sanitation Districts of Los Angeles County in black perch (Embiotica jacksoni; 0.35 to 43 mg/wet kg) and kelp bass (Paralabrax clathratus; 0.1 to 6.0 mg/wet kg) caught off Palos Verdes during the same period (Southern California Coastal Water Research Project 1973).

Figure 3 shows the results of PCB analyses of 165 individual samples of muscle tissue from Dover sole collected throughout the Bight during 1974-75. Table 2 presents the data for the stations by region. As in 1971-72, the highest PCB values found in 1974-75 were in specimens collected off the three major discharge sites.

The Federal Food and Drug Administration's tolerance limit for PCB in the edible portion of fish intended for interstate commerce is 5 mg/wet kg: Less than 2 percent of the 275 Dover sole collected in the 1971-72 and 1974-75 surveys had levels of total PCB in muscle tissue that exceeded this limit. One fish collected off Palos Verdes during 1971-72 had a muscle tissue concentration of 8.3 mg/wet kg total PCB, and four fish collected off Orange County during 1974-75 had muscle tissue concentrations of total PCB ranging from 5.2 to 6.6 mg/wet kg.

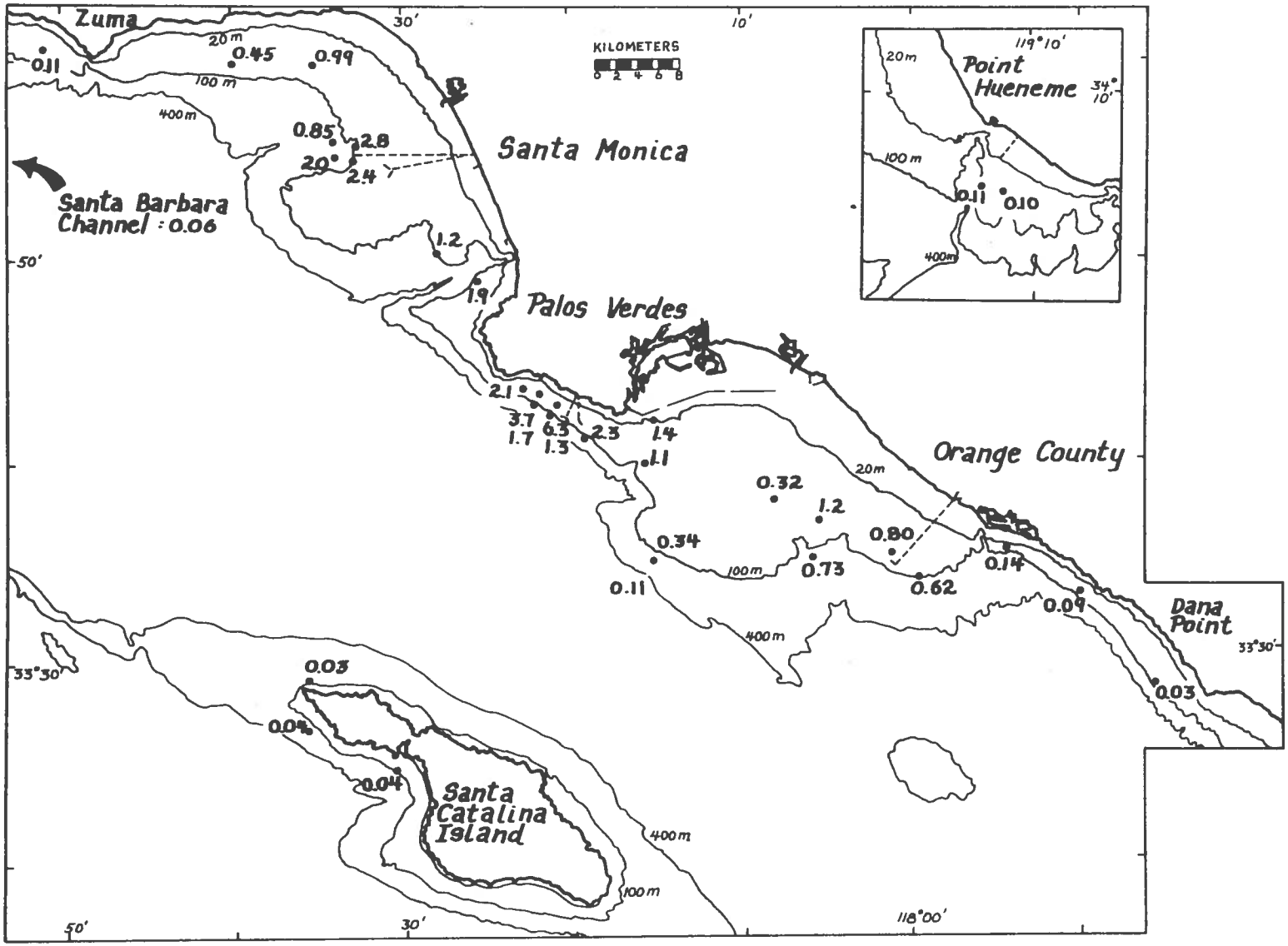

Figure 2. Median concentrations of total PCB (mg/wet kg) in the muscle tissue of Dover sole, 1971-72.

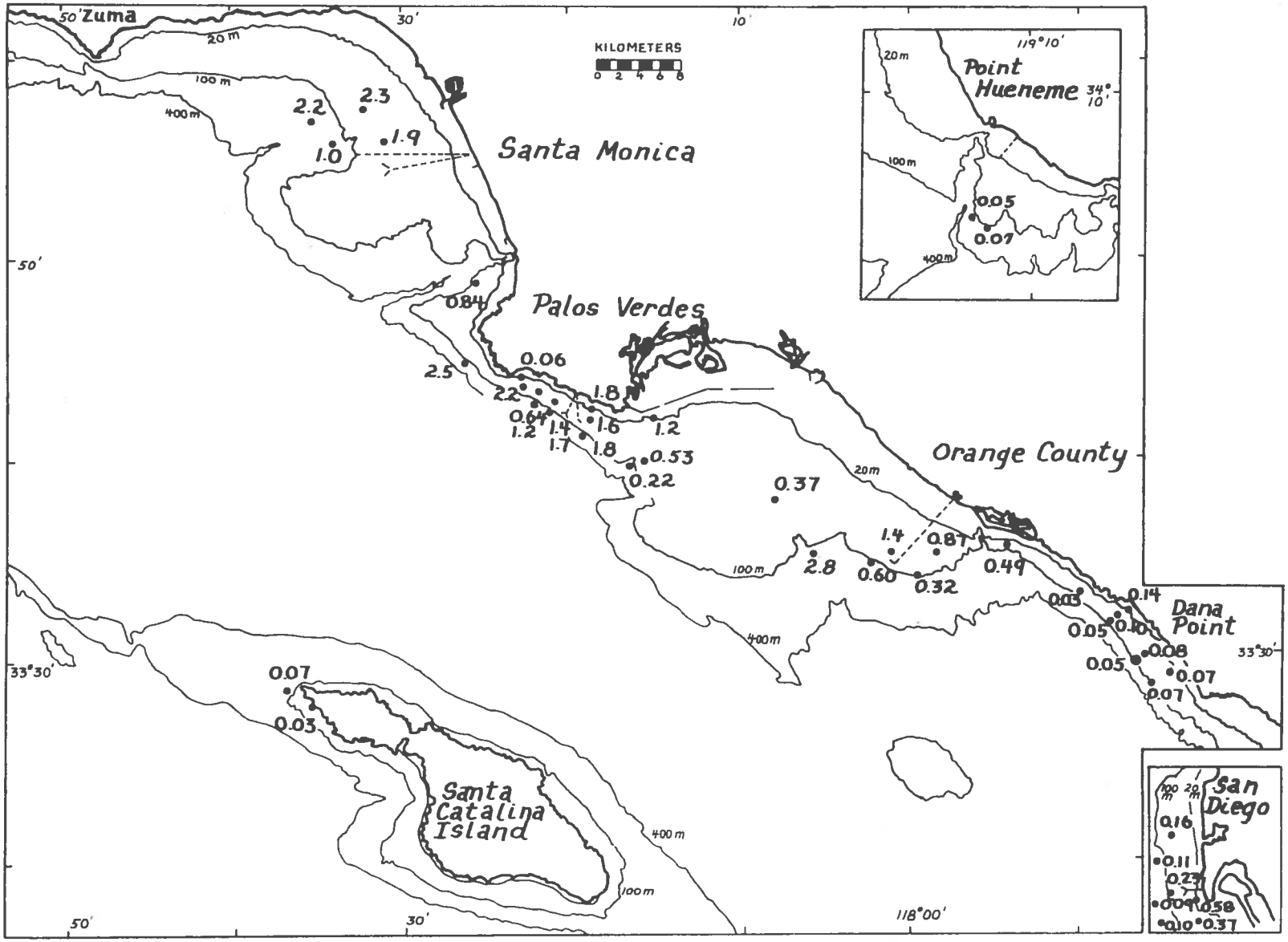

Figure 3. Median concentrations of total PCB (mg/wet kg) in the muscle tissue of Dover sole, 1974-75.

Table 1. Regional surveys of total PCB concentrations (mg/wet kg) in composite samples of muscle tissue of Dover sole, 1971-72.

Region and Station*	No. of Composites	Mean	Standard Error	Median	Range
Point Hueneme					
VT-27	2	0.097	0.014	0.097	0.083-0.11
VT-47	7	0.099	0.016	0.11	0.042-0.16
Region		0.098		0.10	
Zuma Beach					
F-20	9	0.12	0.009	0.11	0.074-0.16
Santa Monica					
G-20	2	0.99	0.50	0.99	0.49-1.5
M-20	2	0.45	0.090	0.45	0.36-0.54
S-30	1	2.8	-	2.8	-
S-60	2	0.85	0.17	0.85	0.69-1.0
T-30	1	2.4	-	2.4	-
T-60	2	2.0	0.70	2.0	1.3-2.7
Region		1.6		1.5	
Redondo Cyn.					
I-30	2	1.2	0.42	1.2	0.80-1.6
Palos Verdes					
T_0-200	2	1.9	0.28	1.9	1.6-2.1
T_2-200	4	2.3	0.18	2.1	2.1-2.8
T_3-200	1	3.7	-	3.7	-
T_3-450	4	1.6	0.45	1.7	0.56-2.6
T_4-200	2	6.3	1.9	6.3	4.4-8.3
T_4-450	5	1.3	0.10	1.3	0.94-1.6
T_5-450	6	2.2	0.36	2.3	0.78-3.5
T_6-75	2	1.4	0.76	1.4	0.68-2.2
T_6-200	2	1.1	0.54	1.1	0.58-1.7
Region		2.4		1.9	
San Pedro Cyn.					
V-7	3	0.74	0.55	0.34	0.057-1.8
V-11	6	0.44	0.30	0.11	0.033-1.9
Region		0.59		0.22	
Orange County					
T-1	5	0.73	0.093	0.80	0.36-0.87
T-3	1	0.62	-	0.62	-
T-4	5	0.20	0.052	0.14	0.10-0.39
T-5	1	0.73	-	0.73	-
T-6	2	0.32	0.12	0.32	0.20-0.43
VT-3	1	1.2	-	1.2	-
Region		0.63		0.68	
Dana Point					
FU-2	6	0.088	0.022	0.094	0.021-0.15
FU-9	6	0.18	0.13	0.032	0.019-0.84
Region		0.13		0.063	

*Station locations given in Appendix Figure A-1; individual station data for total PCB and the PCB's most closely resembling Aroclors 1242 and 1254 are available from the Project.

Table 1 (continued)

Region and Station*	No. of Composites	Mean	Standard Error	Median	Range
Santa Barbara Channel	10	0.076	0.014	0.058	0.038-0.17
Santa Catalina Island					
SD-3	4	0.044	0.008	0.040	0.030-0.065
SD-9	1	0.041	-	0.041	-
SD-16	1	0.033	-	0.033	-
Region		0.039		0.040	

*Station locations given in Appendix Figure A-1; individual station data for total PCB and the PCB's most closely resembling Aroclors 1242 and 1254 given in Appendix Table A-1.

Table 2. Regional surveys of total PCB concentrations (mg/wet kg) in the muscle tissue of individual Dover sole, 1974-75.

Region and Station*	No. of Samples	Mean	Standard Error	Median	Range
Point Hueneme					
PH-3	2	0.052	0.008	0.052	0.045-0.060
PH-6	3	0.068	0.008	0.067	0.054-0.083
Region		0.060		0.060	
Santa Monica					
C-20	3	1.9	0.67	2.3	0.54-2.7
C-60	3	2.5	0.58	2.2	1.7-3.6
S-20	3	1.9	0.89	1.9	0.37-3.4
S-60	3	1.2	0.18	1.0	1.0-1.6
Region		1.9		2.0	
Palos Verdes					
T_0-200	3	0.80	0.15	0.84	0.53-1.0
T_1-450	3	2.3	0.36	2.5	1.6-2.8
T_2-75	1	0.061	-	0.061	-
T_2-200	3	2.2	0.27	2.2	1.7-2.6
T_3-200	5	1.3	0.55	0.64	0.45-3.4
T_3-450	3	1.2	0.091	1.2	0.98-1.3
T_4-200	5	1.6	0.40	1.4	0.77-3.0
T_4-450	1	1.7	-	1.7	-
T_5-75	2	1.8	0.25	1.8	1.6-2.1
T_5-200	1	1.6	-	1.6	-
T_5-450	6	1.7	0.31	1.8	0.55-2.6
T_6-75	6	1.6	0.44	1.2	0.60-3.3
T_6-200	5	1.8	0.87	0.53	0.23-4.3
T_6-450	2	0.22	0.16	0.22	0.053-0.38
Region		1.4		1.3	

*Station locations given in Figure A-2; individual data for total PCB and PCB's most closely resembling Aroclors 1242 and 1254 are available from the Project.

Table 2 continued

Region and Station*	No. of Samples	Mean	Standard Error	Median	Range
Orange County					
T-1	23	2.2	0.35	1.4	0.37-6.2
T-2	3	0.84	0.44	0.87	0.076-1.6
T-3	3	0.74	0.44	0.32	0.28-1.6
T-4	3	0.53	0.28	0.49	0.068-1.0
T-5	5	3.1	0.95	2.8	0.92-6.6
T-6	3	0.35	0.022	0.37	0.31-0.38
NT-5	6	0.62	0.15	0.60	0.22-1.1
Region		1.2		0.60	
Dana Point					
FU-2	3	0.035	0.010	0.034	0.018-0.053
FU-3	3	0.40	0.32	0.097	0.060-1.0
FU-5	5	0.13	0.058	0.075	0.064-0.36
FU-6	6	0.054	0.006	0.048	0.043-0.079
FU-7	3	0.24	0.18	0.069	0.058-0.60
FU-9	6	0.69	0.63	0.068	0.040-3.8
FU-10	3	0.37	0.27	0.14	0.057-0.90
FU-11	6	0.058	0.012	0.054	0.020-0.096
Region		0.25		0.068	
San Diego					
PL-0	3	0.40	0.21	0.23	0.16-0.82
PL-2	3	0.12	0.030	0.11	0.067-0.17
PL-5	1	0.58	-	0.58	-
PL-6	2	0.086	0.003	0.086	0.083-0.089
PL-7	1	0.37	-	0.37	-
PL-8	3	0.096	0.037	0.10	0.029-0.16
PL-OC	3	0.19	0.039	0.16	0.15-0.27
Region		0.26		0.16	
Santa Catalina Island					
SD-1	2	0.032	0.003	0.032	0.029-0.035
SD-15	3	0.13	0.079	0.066	0.030-0.28
Region		0.081		0.049	

*Station locations given in Appendix Figure A-2; individual station data for total PCB and the PCB's most closely resembling Aroclors 1242 and 1254 are available from the Project.

The dominant PCB observed in both the 1971-72 and 1974-75 samples was 1254 PCB; the other PCB identified was 1242 PCB. The data in Table 3 indicate that the median composition of total PCB in the 1971-72 samples taken around the five major discharge sites was 73 percent 1254 PCB and 27 percent 1242 PCB; in the 1974-75 samples, the median composition was 67 percent 1254 PCB and 33 percent 1242 PCB. In contrast, the median composition of total PCB discharged through the five major wastewater discharge systems in 1974 was 29 percent 1254 PCB and 71 percent 1242 PCB (Young et al. 1975b). The data on total PCB levels in Dover sole, surface sediments, and municipal wastewater discharges during the two survey periods are given in Table 4.

Table 5 presents a comparison of the 1971-72 and 1974-75 regional data. The Wilcoxon signed-rank test (a nonparametric statistical method of determining the differences between two sample sets with data points that can be paired because of a common variable, in this case, station location) has been applied to the data. The results indicate no statistically significant difference ($p > 0.20$) between the 1971-72 and 1974-75 Bight-wide levels of total PCB in the Dover sole.

DISTRIBUTION OF PCB'S IN THE TISSUES OF A BENTHIC FLATFISH

The analyses for the relative amounts of PCB's in the various tissues of the Dover sole were performed on fish taken off Palos Verdes and Orange County; the results (Table 6) indicate differences in the fish from the two areas. The Palos Verdes samples had levels of total PCB in muscle tissue that were lower by a factor of 1.6 than those in the muscle tissue of the Orange County samples, but the levels in the liver, gonad, heart, and kidney tissues of the Palos Verdes specimens were, on the average, two times higher.

The Palos Verdes samples had 20 times more total PCB in liver tissues than in muscle tissue; Orange County specimens had liver values 8 times higher than the muscle values. To determine the liver and muscle tissue burdens in the two sets of fish, we applied the median concentrations of PCB in the specific tissue to the average wet weight of that tissue:

	Liver Burden	Muscle Burden	Ratio, Liver to Muscle
Palos Verdes	0.04 mg	0.02 mg	2
Orange County	0.02 mg	0.03 mg	0.7

FIN EROSION AND PCB LEVELS IN A BENTHIC FLATFISH

The Dover sole collected off Palos Verdes are frequently affected by fin erosion; the disease has recently also become prevalent off Orange County. Data on specimens with eroded fins and those

Table 3. Regional medians of 1254 PCB as a percent of total PCB in the muscle tissue of Dover sole.*

Region	1971-72	1974-75
Santa Barbara Channel	100	-
Point Hueneme**	81	54
Zuma Beach	89	-
Santa Monica**	76	81
Redondo Canyon	84	-
Palos Verdes**	58	67
San Pedro Canyon	79	-
Orange County**	70	71
Dana Point	89	86
San Diego**	-	50
Santa Catalina Island	100	30
Bight-wide median	82	67
Five major discharge regions	73	67

*1254 PCB is the PCB identified that most closely resembled Aroclor 1254 (the only other PCB identified most closely resembled Aroclor 1242).
**Major municipal wastewater discharge site.

Table 4. Comparison of total PCB levels in muscle tissue of Dover sole and bottom surface sediments and PCB mass emission rates in municipal wastewater.

	1971-72			1974-75	
Region	Dover Sole (mg/wet kg)	Sediments* (mg/dry kg)	Municipal Waste** (kg/yr)	Dover Sole (mg/wet kg)	Municipal Waste** (kg/yr)
Palos Verdes	1.9	3.6	11,600	1.3	1,270
Santa Monica	1.5	0.53	1,920	2.0	956
Orange County	0.7	0.02	5,800	0.6	2,100
San Diego	-	0.01	118	0.2	1,050
Point Hueneme	0.1	0.004	3	0.1	5

*Sediments from trawling region only. After Southern California Coastal Water Research Project 1973.
**After Young et al. 1975a.

Table 5. Total PCB concentrations (mg/wet kg) in muscle tissue of Dover sole.*

Region	1971-72 (n = 110) Region Median	1971-72 (n = 110) Station Range	1974-75 (n = 165) Region Median	1974-75 (n = 165) Station Range
Point Hueneme	0.1	0.1	0.06	0.05-0.07
Santa Monica	1.5	0.4-2.8	2.0	1.0-2.3
Palos Verdes	1.9	1.1-6.3	1.3	0.06-2.5
Orange County	0.7	0.1-1.2	0.6	0.3-2.8
Dana Point	0.06	0.03-0.09	0.7	0.03-0.14
San Diego	-	-	0.2	0.09-0.6
Santa Catalina Island	0.04	0.03-0.04	0.05	0.03-0.07

*There is no statistically significant difference between the 1971-72 and the 1974-75 levels.

Table 6. Total PCB concentrations (mg/wet kg) in composite samples of tissues of Dover sole, 1975.*

Tissue	Palos Verdes Median	Palos Verdes Range	Orange County Median	Orange County Range
Muscle	0.7	0.1-1.1	1.1	0.6-1.4
Liver	15	11-18	8.3	4.8-13
Gonads	1.4	0.8-5.2	0.8	0.7-4.6
Heart	1.8	1.5-3.2	0.5	0.4-0.8
Kidney	0.8	0.6-1.1	0.6	0.6-0.8

*For each region, four composite samples of five fish each were analyzed. Individual composite data for total PCB and the PCB's most closely resembling Aroclors 1242 and 1254 are available through the Project.

with healthy fins taken in 1974 in single trawls were paired (Table 7). When the Wilcoxon signed-rank test was applied (the common variable in this case being station location and collection date), the levels of PCB in the muscle tissue of the unaffected fish and the diseased fish were found to be different at the 90 percent confidence level ($p = 0.10$). Although this level is not considered to be statistically significant, it shows a strong tendency for the total PCB levels to be higher in the diseased fish. The median values for the diseased and unaffected groups were 2 and 1 mg/wet kg, respectively (McDermott and Sherwood 1975).

REGIONAL SURVEY OF PCB'S IN A BENTHIC CRAB

We measured the level of PCB contamination in 48 specimens of *Cancer anthonyi* collected throughout the Southern California Bight. These samples provided relatively good coverage of the

Table 7. Total PCB concentrations (mg/wet kg) in muscle tissue of Dover sole with ("diseased") and without ("healthy") fin erosion, 1974.*

Region and Station	No. of Samples	Mean	Standard Error	Median	Range
Palos Verdes					
T_2-200, 17 May 74					
Healthy	1	2.6	-	2.6	-
Diseased	2	2.0	0.25	2.0	1.7-2.2
T_3-200, 17 May 74					
Healthy	3	0.53	0.056	0.50	0.45-0.64
Diseased	2	2.4	0.90	2.4	1.5-3.4
T_4-200, 31 May 74					
Healthy	2	1.5	0.045	1.5	1.4-1.5
Diseased	3	1.6	0.72	0.98	0.77-3.0
T_5-75, 31 May 74					
Healthy	1	1.6	-	1.6	-
Diseased	1	2.1	-	2.1	-
T_5-450, 7 Dec 73**					
Healthy	2	1.2	0.65	1.2	0.55-1.9
Diseased	3	2.7	0.52	2.6	1.8-3.6
T_6-75, 20 Jun 74					
Healthy	3	1.4	0.56	1.0	0.78-2.6
Diseased	3	1.8	0.80	1.5	0.60-3.3
T_6-200, 7 Dec 73**					
Healthy	3	0.35	0.092	0.29	0.23-0.53
Diseased	2	3.8	0.44	3.8	3.4-4.3
Orange County					
T-1, 18 Sep 74					
Healthy	2	4.0	2.2	4.0	1.8-6.2
Diseased	6	3.3	0.65	3.4	1.3-5.2
T-3, 18 Sep 74					
Healthy	2	0.30	0.020	0.30	0.28-0.32
Diseased	1	1.6	-	1.6	-
T-5, 31 May 74					
Healthy	1	0.92	-	0.92	-
Diseased	4	3.6	1.0	3.0	2.1-6.6
NT-5, 18 Sep 74					
Healthy	3	0.29	0.037	0.32	0.22-0.34
Diseased	3	0.96	0.074	0.91	0.86-1.1

*After McDermott et al. 1975.
**Part of the 1974 winter quarter trawl series.

nearshore waters between Zuma Beach and Newport Beach (Orange County). Total PCB concentrations in the muscle tissues of the specimens are illustrated in Figure 4. Station data are presented by region in Table 8. The data indicate that the Food and Drug Administration's tolerance level of 5 mg/wet kg for PCB is not being exceeded in the edible portion of crabs collected in the vicinity of the major wastewater outfalls.

The dominant PCB observed in the crabs was 1254 PCB; the other PCB identified was 1242 PCB. The median composition of the total PCB in the muscle tissue was 69 percent 1254 PCB and 31 percent 1242 PCB (Table 9).

The PCB concentrations in the crab (Figure 4) were similar all along the coast; the median values for the different regions agreed within a factor of three. Levels of total PCB found in crabs collected in the vicinity of the wastewater outfalls were generally 10 to 100 times greater than the levels observed in the specimens obtained at Ensenada, Baja California.

DISTRIBUTION OF PCB'S IN THE TISSUES OF A BENTHIC CRAB

A second aspect of the crab survey was to determine the concentrations of PCB's in the reproductive organs. The Bight-wide distribution of PCB compounds in crab gonads was similar to the distribution in muscle tissue: The values showed no distinct pattern.

The composition of total PCB in the crab gonads was also similar to that in the muscle tissue. The dominant PCB identified was 1254 PCB; the other PCB measured was 1242 PCB. The overall composition of total PCB in the gonads was 75 percent 1254 PCB and 25 percent 1242 PCB (Table 9).

Gonad-to-muscle tissue ratios were computed for both female and male specimens (Table 10). The median ratio for total PCB in females was 12; the ratio in males was 5.4. These results indicate that the gonadal tissues generally contain five to ten times more PCB than the muscle tissue. However, in female crabs with an average carapace width of 125 mm, the gonads constitute only 27 percent of the combined weight of muscle and gonad tissues: in males of this size, the gonads are only 7 percent of the combined weight. Table 11 indicates that, despite the relatively smaller mass of gonad tissue, the female gonads carry an absolute tissue burden of total PCB that is 25 percent greater than the muscle tissue burden. In male crabs, however, the gonad tissue burden was one-third that of the muscle tissue. The muscle tissue burden of total PCB was the same for both male and female crabs.

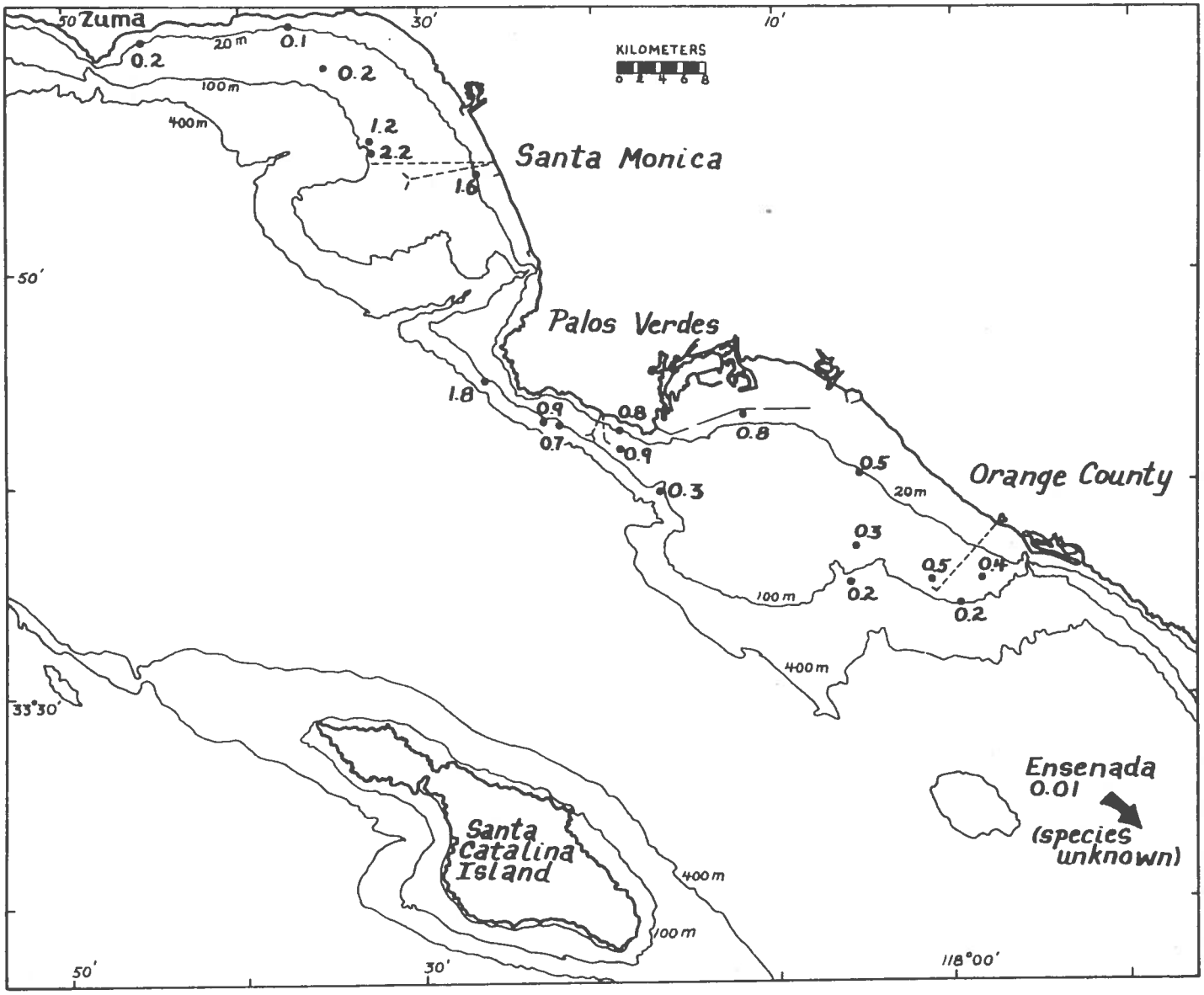

Figure 4. Median concentrations of total PCB (mg/wet kg) in muscle tissue of the yellow rock crab, 1971-72.

Table 8. Regional survey of total PCB concentrations (mg/wet kg) in the muscle tissue of individual yellow rock crabs, 1971-72.

Region and Station*	No. of Samples	Mean	Standard Error	Median	Range
Santa Monica					
3E	2	1.2	0.20	1.2	1.0-1.4
3V	1	0.13	-	0.13	-
5E (1)	2	0.16	0.03	0.16	0.13-0.19
ID	2	1.6	0.50	1.6	1.1-2.1
G-20	2	0.14	0.06	0.14	0.089-0.20
S-30	3	2.9	1.0	2.2	1.6-4.9
Region		1.0		0.68	
Palos Verdes					
T_1-450	3	2.1	0.91	1.8	0.68-3.8
T_2-200	6	0.68	0.17	0.88	0.29-1.5
T_3-450	3	0.94	0.39	0.71	0.40-1.7
T_5-75	3	0.80	0.11	0.79	0.62-1.0
T_5-250	3	0.89	0.05	0.86	0.82-1.0
T_6-450	1	0.30	-	0.30	-
Region		0.95		0.82	
Outside San Pedro Harbor					
3VT	1	0.32	-	0.32	-
4VT	1	0.49	-	0.49	-
5VT	3	0.73	0.11	0.83	0.52-0.85
Region		0.51		0.49	
Orange County					
T-1	6			0.54	0.32-1.4
T-2	1	0.39	-	0.39	-
T-3	1	0.23	-	0.23	-
T-5	1	0.24	-	0.24	-
Region		0.29		0.32	
Ensenada**	3	0.015	0.003	0.014	0.012-0.018

*Station locations are given in Appendix Figure A-3; individual station data for total PCB and PCB's most closely resembling Aroclors 1242 and 1254 are available from the Project.
**Three Baja California chelae (Cancer sp. unknown) purchased in fish market.

Table 9. Regional medians of 1254 PCB as a percent of total PCB in the muscle and gonad tissues of the yellow rock crab, 1971-72.*

Region	Muscle	Gonad
Santa Monica	74	87
Palos Verdes	64	63
San Pedro	77	78
Orange County	62	72
Ensenada**	100	-
Overall†	69	75

*1254 PCB is the PCB identified that most closely resembled Aroclor 1254 (the only other PCB identified most closely resembled Aroclor 1242).
**Cancer sp., chelae only.
†Excluding Ensenada samples.

REGIONAL SURVEY OF PCB'S IN AN OPEN COAST MUSSEL

Composite whole soft tissue samples of ten Mytilus californianus 4 to 6 cm in length collected during 1971 from 6 island and 17 coastal stations in the Bight were analyzed for their PCB content. The results for 1254 PCB are presented in Figure 5. PCB levels in the coastal areas well away from urban centers ranged from 0.014 to 0.026 mg/wet kg. The two highest concentrations, 0.38 and 0.52 mg/wet kg, occurred off Palos Verdes. The highest value observed among the island stations was at Santa Barbara Island (0.069 mg/wet kg). The concentrations of PCB in mussels collected near the outfalls on the Palos Verdes shelf were approximately four times higher than those in specimens taken at Point Loma near the San Diego outfall. The collection points for both of these sets of samples were approximately the same distance (3 km) from the corresponding outfall terminus. However, the mass emission rate of PCB from the outfalls off Palos Verdes in 1971 was estimated to be approximately 100 times greater than the mass emission rate from the San Diego outfall.

During 1974, the Bight-wide survey of PCB's in M. californianus was repeated. Figure 6 illustrates the results for 1254 PCB. Levels of this substance in the Palos Verdes specimens were approximately 10 times greater than the estimated baseline of 0.01 mg/wet kg. Elevated levels of PCB were also found off Point Hueneme and San Diego.

Table 12 compares the 1974 and 1971 concentrations at stations sampled in both surveys. These data show that the degree of contamination by 1254 PCB decreased significantly (54 percent) during the 3-year interval.

Table 10. Total PCB concentrations (mg/wet kg) in gonad and muscle tissue of individual male and female yellow rock crabs and ratios of gonad to muscle tissue total PCB concentrations, 1971-72.

Region and Station*	Specimen No.	Sex	Gonad	Muscle	Ratio, Gonad to Muscle
Santa Monica					
3E	38	F	2.0	1.0	2.0
3V	31	F	3.3	0.13	25
5E (1)	29	M	1.2	0.19	6.3
	30	F	1.2	0.13	9.2
ID	33	F	11	1.1	10
G20	19	F	3.8	0.09	42
	20	F	3.4	0.20	17
S30	35	F	29	2.2	13
	36	F	10	1.6	6.2
Palos Verdes					
T_2-200	13	F	2.3	1.3	1.8
	14	F	1.4	1.5	0.9
T_3-450	16	F	4.3	0.71	6.1
	17	F	4.6	1.7	2.7
T_5-250	10	M	3.7	0.86	4.3
	11	M	7.9	0.82	9.6
	12	F	22	1.0	22
Outside San Pedro Harbor					
3VT	26	F	5.6	0.32	18
4VT	24	F	4.2	0.49	8.6
5VT	48	F	2.2	0.83	2.6
Orange County					
T-1	40	F	11	0.38	29
	41	F	10	0.50	20
	42	F	18	0.58	31
	43	F	4.1	0.32	13
	44	F	3.7	0.90	4.1
	45	F	17	1.4	12
T-2	21	F	3.7	0.39	9.5
T-3	23	F	2.7	0.23	12
T-5	22	M	0.57	0.24	2.4
Median					
Male			2.4	0.53	5.3
Female			2.2	0.64	11

*Station locations given in Appendix Figure A-3; station data for total PCB and the PCB's most closely resembling Aroclors 1242 and 1254 available from the Project.

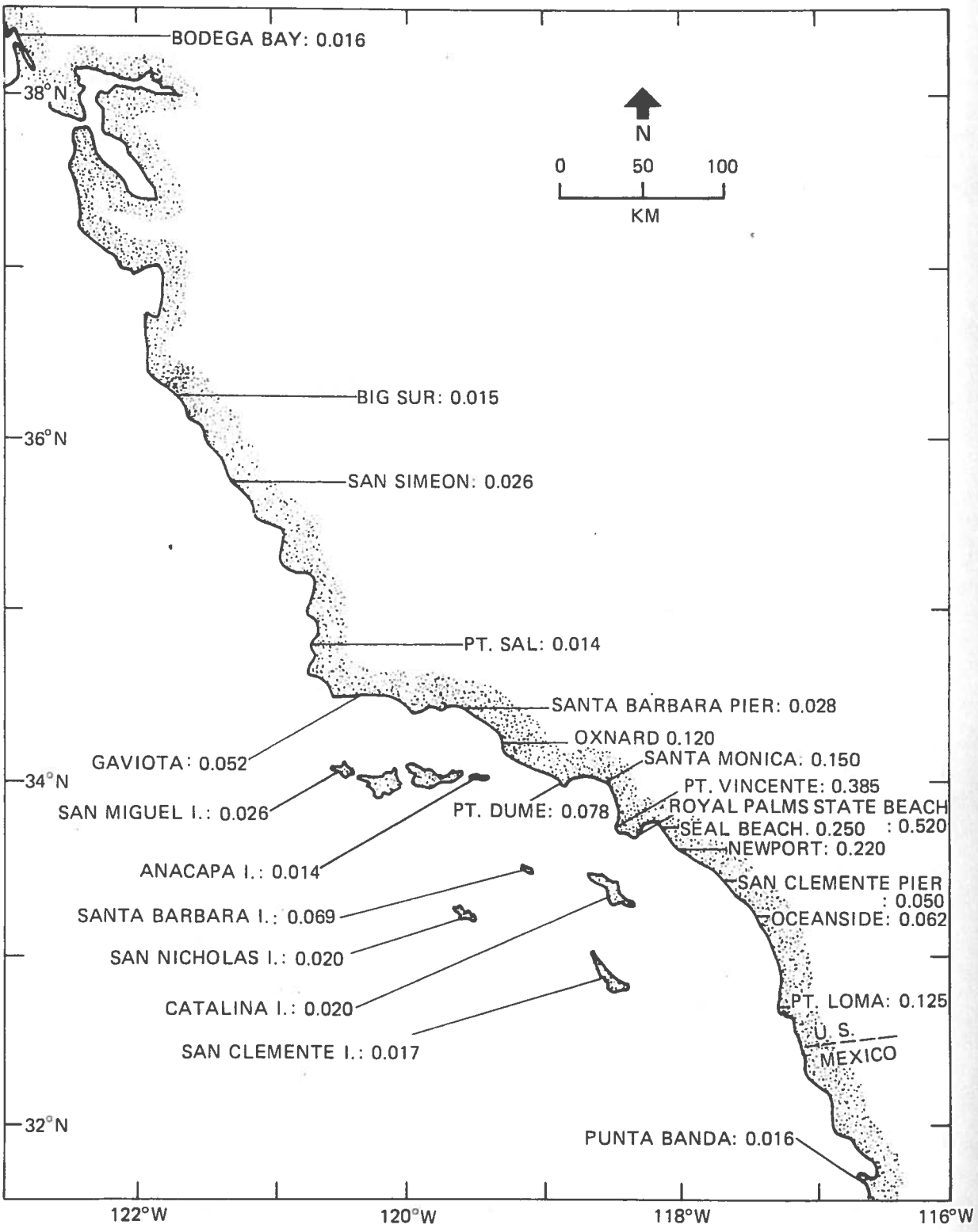

Figure 5. Concentrations (mg/wet kg) of the PCB most closely resembling Aroclor 1254 in whole soft tissue of Mytilus californianus, 1971. From Southern California Coastal Water Research Project 1973, fig. 8-17.

Table 11. Total PCB tissue burdens in yellow rock crab collected throughout the Southern California Bight, 1971-72.

	Male	Female
Percent of combined gonad/muscle tissue weight		
Gonad	7	27
Muscle	93	73
Tissue burden (mg)		
Gonad	0.009	0.031
Muscle	0.025	0.025

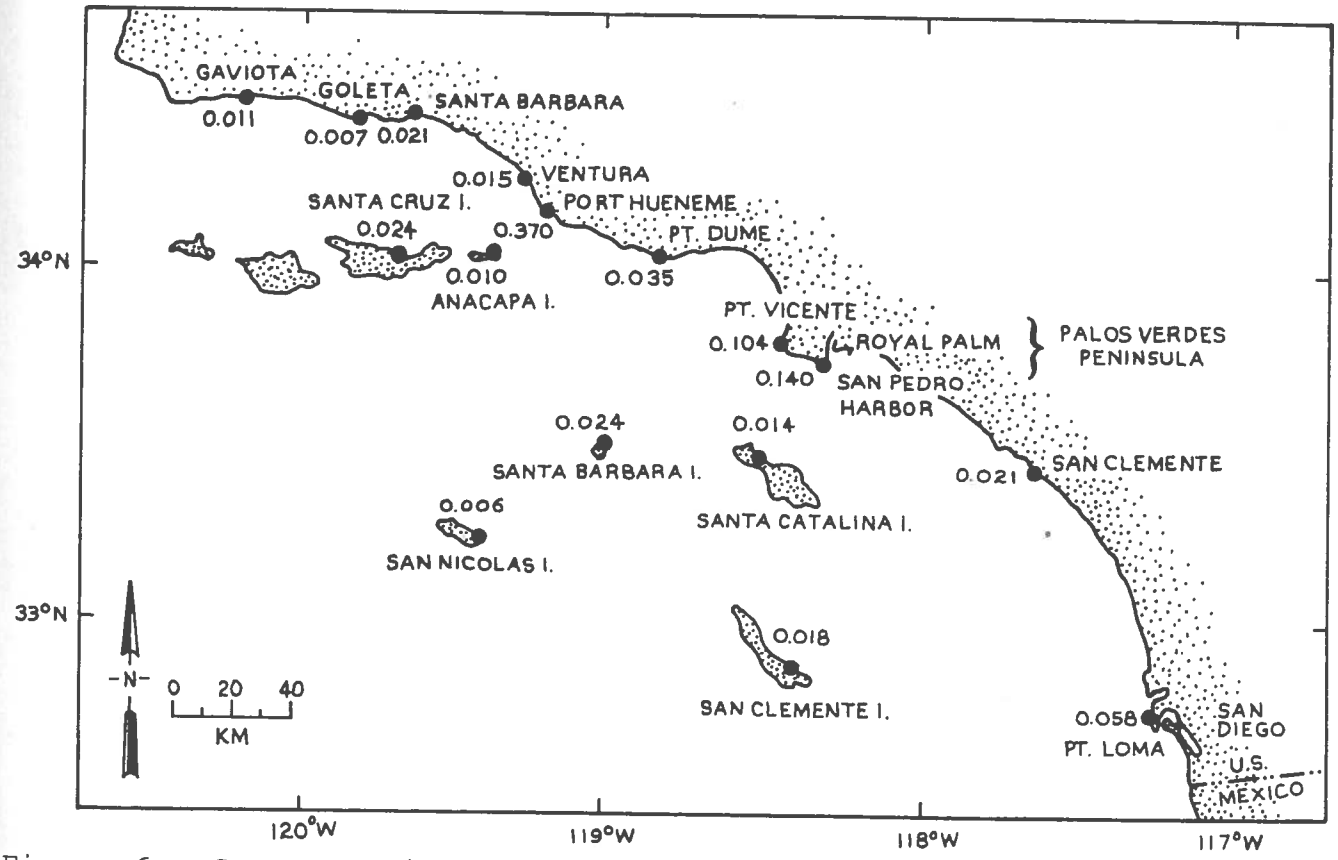

Figure 6. Concentrations (mg/wet kg) of the PCB most closely resembling Aroclor 1254 in the whole soft tissue of Mytilus californianus, 1974. After de Lappe et al. 1975.

SURVEY OF PCB'S IN A HARBOR MUSSEL

Fifty-three composite samples of the whole soft tissues of Mytilus edulis and three samples of M. californianus were collected from three major harbors and from coastal sites adjacent to the harbor mouths and analyzed for PCB (Young et al. 1975b; Young and Heesen 1974). The two PCB's identified were 1242 PCB and 1254 PCB. The median composition of total PCB in the tissues analyzed was 74 percent 1254 PCB (range: 65 to 78 percent) and 26 percent 1242 PCB (range: 22 to 35 percent). The total PCB distributions are presented in Figures 7 through 9.

The survey showed that the harbor mussels had contamination levels up to 20 times those found in specimens of the same species collected from nearby coastal sites. Highest levels were found in mussels taken near regions of heavy vessel activity. Figure 9 shows the data for San Diego Bay, where the range of total PCB values near the commercial docks and navy moorings (0.80 to 1.3 mg/wet kg) is three to four times higher than the values observed at other inner harbor sites, and ten times greater than levels in nearby coastal mussels.

Table 12. Decrease of 1254 PCB in whole soft tissues of Mytilus californianus between 1971 and 1974.*

Station	Decrease Between 1971 and 1974 (%)
Coastal	
Gaviota	79
Santa Barbara	25
Point Hueneme	208**
Palos Verdes Peninsula	
Point Vicente	73
Royal Palm	73
San Clemente	58
Point Loma	54
Island	
Anacapa	29
Santa Barbara	65
Santa Catalina	30
San Nicolas	72
San Clemente	6**
Median Decrease	54

*1254 PCB was the PCB identified that most closely resembled Aroclor 1954.
**Percent increase between 1971 and 1974.

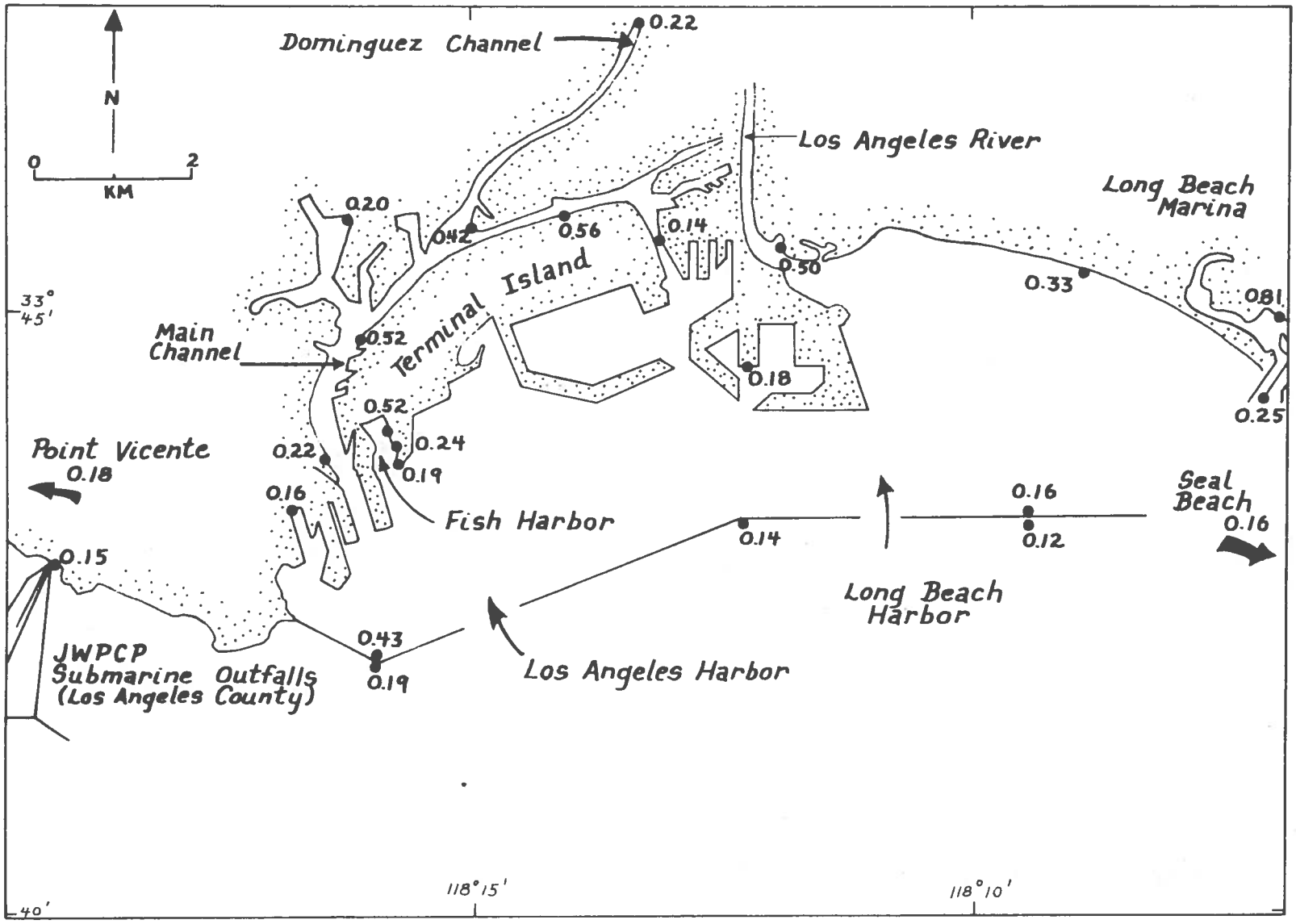

Figure 7. Total PCB concentrations (mg/wet kg) in whole soft tissues of Mytilus edulis in San Pedro Harbor, January 1974. After Young et al. 1975b.

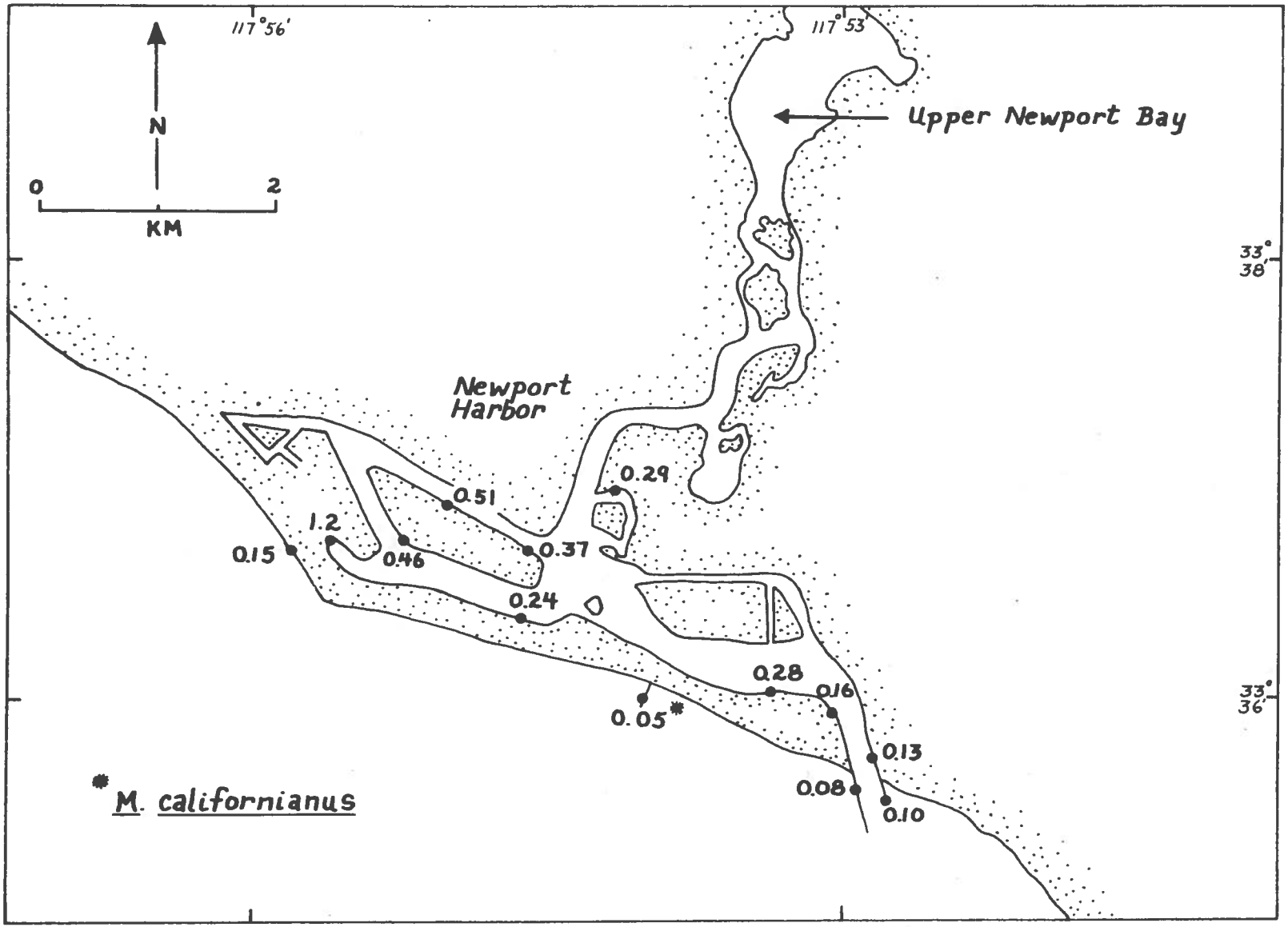

Figure 8. Total PCB concentrations (mg/wet kg) in whole soft tissues of Mytilus edulis from Newport Bay, January 1974. After Young et al. 1975b.

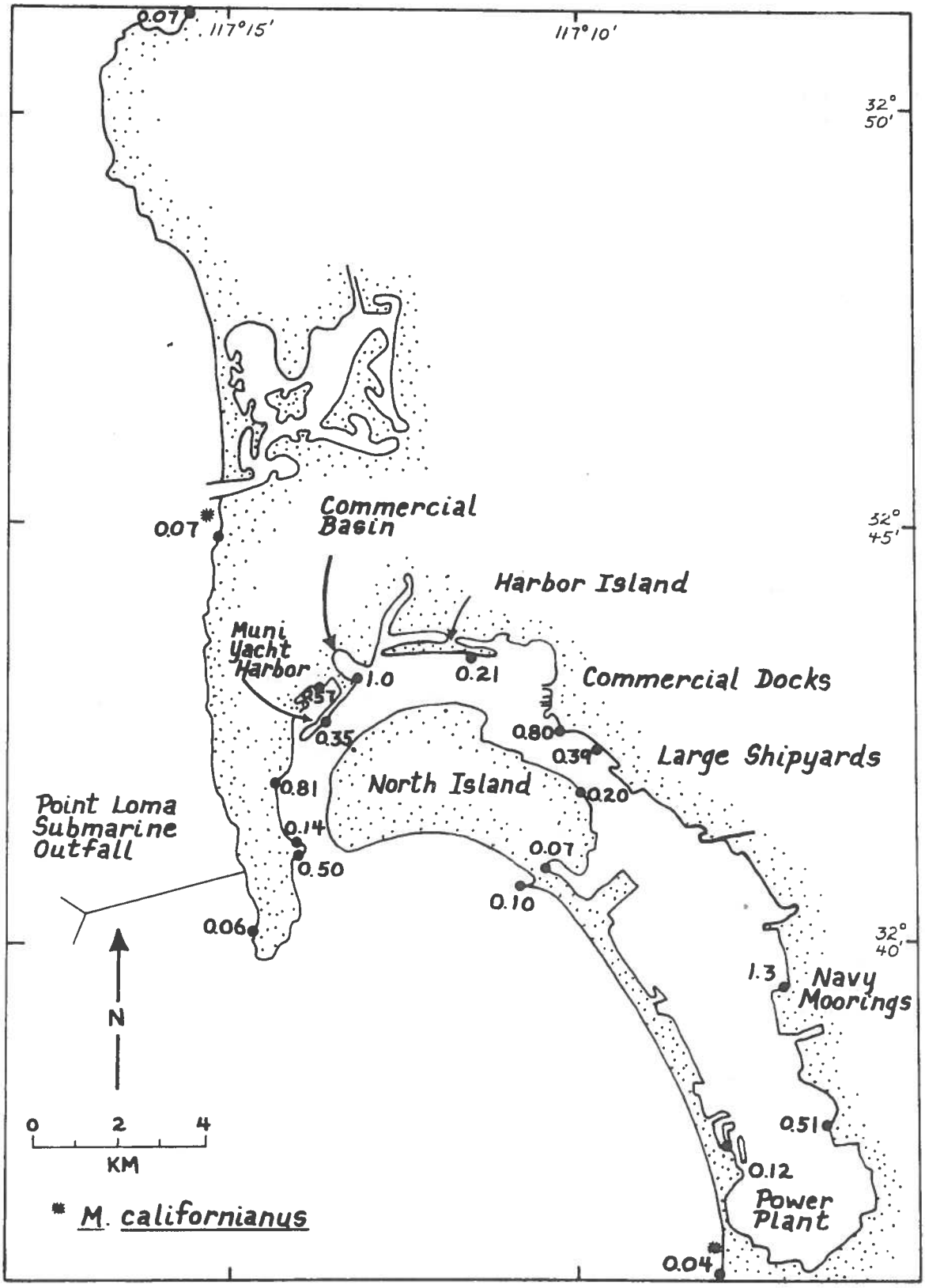

Figure 9. Total PCB concentrations (mg/wet kg) in whole soft tissues of Mytilus edulis in San Diego Bay, January 1974. After Young et al. 1975b.

The levels of 1254 PCB in seawater at the mouths of the harbors were generally on the order of 1 part per trillion (McDermott and Heesen, 1975; Young et al. 1975b). The values of 1254 PCB in the whole soft tissues of the harbor mussels were 100,000 times these seawater levels.

Although most antifouling paints presently applied to vessel bottoms in southern California contain PCB concentrations of less than 1 mg/dry kg, a few samples of pre-1970 paint chips averaged about 10 percent PCB or 100,000 mg/dry kg (Young et al. 1974). Thus it is possible that thousands of kilograms of this synthetic material could have been released annually to the harbor and coastal marine ecosystems, before the widespread use of nonrecoverable PCB's was discontinued in the U.S. in the early 1970's.

BUOY MUSSELS: AN OFFSHORE BIOMONITORING SYSTEM

The mussels transported to the buoy system off Palos Verdes appeared to survive well under the test conditions: Less than 10 percent mortality was observed at any of the five levels (0.5 to 35 m) at which the mussels were suspended during the 3-month study.

On the average, mussels living at Royal Palm Beach, inshore of the buoy, contained 17 times as much PCB as the control specimens at the time of their transfer to the buoy northwest of the outfalls. Thus, exposure of these mussels to PCB was greatly increased upon their transfer to the discharge region.

Application of the Wilcoxon signed-rank test (the common variables in this case being collection date and depth in the water) revealed no significant effect of sex on PCB uptake in the buoy mussels. Therefore, data on males and females were combined; the resultant uptake of total PCB with time is given in Figure 10. These data show that there is a direct relationship between uptake of PCB and proximity of the bioindicator to the contaminated bottom sediments and to the wastewater plume, which is trapped beneath the thermocline. The bottom specimens became approximately 10 times as contaminated as did the surface specimens.

The dominant PCB observed in the specimens was PCB 1254; the other PCB identified was 1242 PCB. The median composition of total PCB in the mussels was 58 percent 1254 PCB and 42 percent 1242 PCB. However, there did appear to be a decrease in the percentage of 1254 PCB as the mussels came into closer contact with the bottom sediments and the wastewater plume.

At the end of the 13-week period, the 1254 PCB concentrations in the whole soft tissues of specimens collected from Level 5 (closest to the bottom sediments) were approaching 0.4 mg/wet kg; those

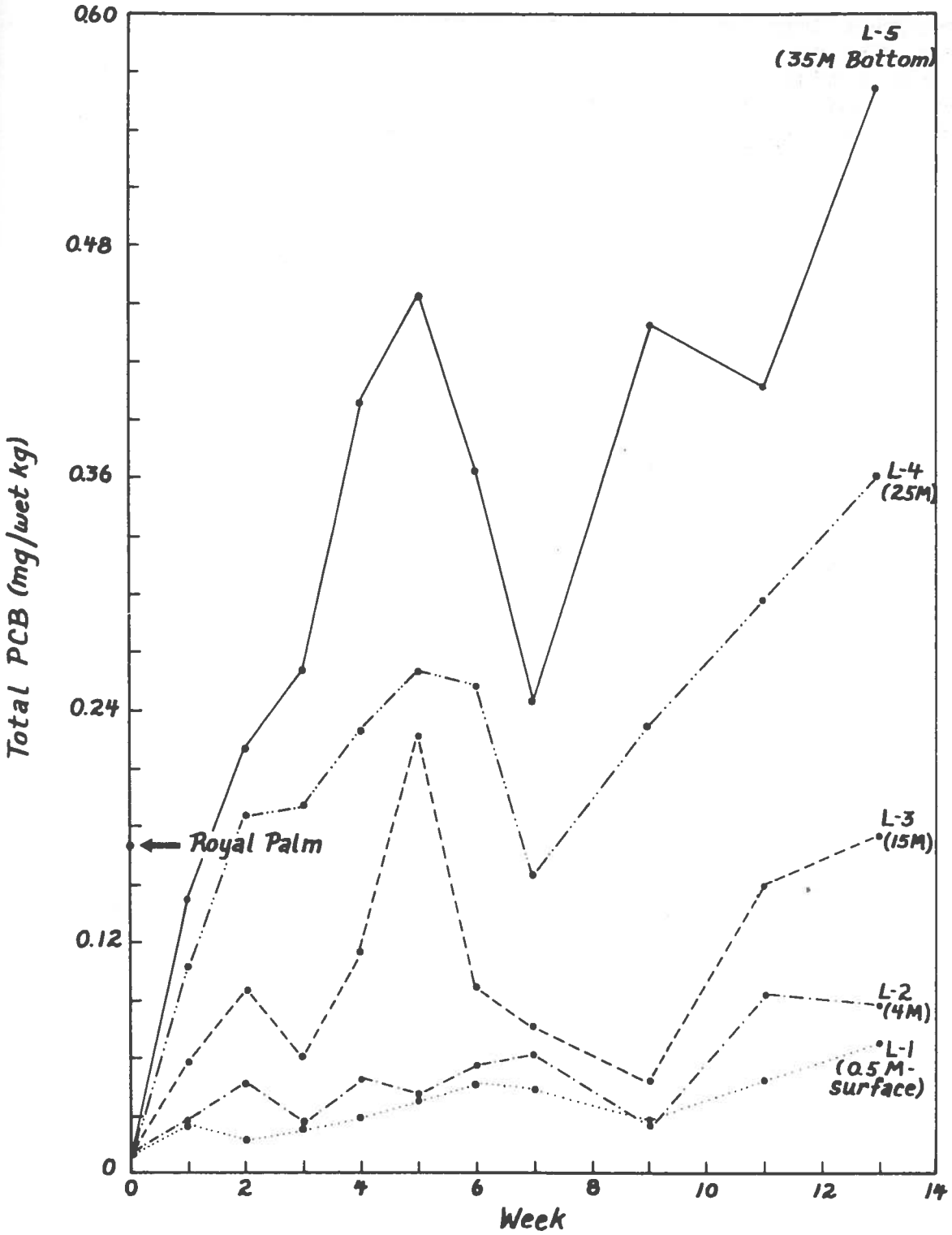

Figure 10. Total PCB concentrations in whole soft tissue composites of Mytilus californianus suspended from a buoy off Palos Verdes, June through September 1974. After Young et al. 1975c.

in specimens from Level 1 (at the surface) were at 0.04 mg/wet kg. To date, the highest 1254 PCB concentration measured in the water above the outfalls is 4 ng/l.* This suggests a concentration factor on the order of 100,000 for 1254 PCB in the whole soft tissues of M. californianus, a number in good agreement with the estimate for M. edulis in the harbors.

*B. de Lappe and R. Risebrough, University of California, Berkeley, personal communication.

SUMMARY AND CONCLUSIONS

The two regional surveys of PCB contamination in Dover sole revealed that levels in specimens taken near the three largest municipal wastewater discharges were significantly higher than levels in specimens from regions with little or no wastewater discharge. Despite the high levels of PCB in the fish from the outfall areas, less than 2 percent of all Dover sole taken in the two surveys had muscle tissue PCB concentrations that exceeded the Federal Food and Drug Adminstration's tolerance of 5 mg/wet kg in the edible portion of fish intended for interstate commerce.

Over the 3-year study period, municipal wastewater emissions of total PCB decreased. Yet we observed no corresponding decrease in the levels of total PCB in the Dover sole. This finding indicates that other factors or inputs of these chlorinated hydrocarbons are involved in maintaining the total PCB levels in this fish.

The Bight-wide surveys of the benthic crab, Cancer anthonyi, and the intertidal mussel, Mytilus californianus, indicated that the PCB contamination levels in these animals are low but widespread. Levels of total PCB in specimens near the major outfall systems were generally 10 to 100 times higher than levels in specimens collected from coastal or island control sites; however, the Federal tolerance level for PCB compounds was not exceeded in the edible portion of any specimens of these two species. The two surveys of M. californianus indicate that the level of PCB contamination in these mussels had decreased significantly over the 3-year interval, 1971-74.

The dominant PCB observed in the three organisms surveyed was 1254 PCB; the other PCB identified was 1242 PCB. The median 1974-75 composition of total PCB in muscle tissue of Dover sole taken near the five major discharge sites was 67 percent 1254 PCB and 33 percent 1242 PCB. This contrasted with the median 1974 composition of municipal wastewater emission of PCB: 29 percent 1254 PCB and 71 percent 1242 PCB. These data, along with a comparison of total PCB levels in Dover sole muscle tissue, surface sediments, and municipal wastewater emissions, indicate that the PCB levels in Dover sole are not dependent only upon the level of PCB discharged in wastewaters and that other factors, such as the volatility of a given PCB, the sediment load of PCB, or the presence of other contaminants (i.e., DDT, hydrogen sulfide,

trace metals) are involved in the biological uptake mechanism for PCB, and the resulting level of PCB in this marine animal.

The composition of the total PCB in the crab and mussel samples taken was similar to that in the Dover sole. However, the mussels translocated to the buoy system and positioned close to the sediments and in the wastewater plume accumulated an increasing percentage of 1242 PCB by the end of the 3-month study.

The liver-to-muscle tissue burden ratio for PCB in Palos Verdes Dover sole was 2; for Orange County specimens, the ratio was 0.7. There are two possible explainations for the high liver-to-muscle tissue burden ratio in the Palos Verdes fish. A review of the literature indicates that (1) in metabolic disturbances, the lipid (fat) content in liver tissue may significantly increase, and (2) chlorinated hydrocarbons, which are hepatic poisons, induce fatty livers. As chlorinated hydrocarbons are associated with lipids, if either one or both of these situations had occurred in the Palos Verdes Dover sole, it would have resulted in an increase in the total PCB levels in the liver and a higher liver-to-muscle tissue burden ratio. The lipid content of these tissues is being studied, and further work on the physiological and ecological implications of these tissue burdens is underway.

Analysis of the PCB concentrations in the reproductive organs of C. anthonyi indicate that the gonadal tissues generally contain PCB levels five to ten times higher than the muscle tissue levels. Also, in females, the gonads had an absolute tissue burden of PCB that was 25 percent higher than the muscle tissue burden. As the reproductive organs of this crustacean are exposed to considerably higher levels of this synthetic organic than is the muscle, spawning may represent a significant distribution mechanism of these contaminants in the marine environment, and a significant factor in the elimination of a large percentage of the body burden of these materials from the crab. The long-term effects of PCB concentrations on reproduction or other biological processes in this crustacean are unknown.

There was a strong (although not statistically significant) association between high levels of total PCB and fin erosion in Dover sole taken off Palos Verdes and Orange County. If this association was dependent upon the input level of PCB, one would expect fin erosion to also be prevalent off Santa Monica and San Diego, as the level of PCB input to these regions is comparable to that at Palos Verdes and Orange County. However, this is not the case. There are several possible reasons for the association between high PCB levels and fin erosion. The disease is predominantly found in the Palos Verdes region, where the sediments have the highest PCB levels found in the Bight. Thus, association with contaminated sediments could be the major factor in the initiation of the disease. Also, PCB in combination with other constituents present in this region (DDT, hydrogen sulfide, trace metals) could be involved in the development of the disease. It is also possible that PCB uptake is enhanced in diseased fish; hence the higher

levels could be the result of the disease rather than a cause. These relationships are being further studied.

We found the highest concentrations of PCB in bay mussels, M. edulis, taken near the sites of greatest vessel activity in harbors, such as mooring and bottom repainting facilities. The contamination of harbor organisms may be the result of past use of antifouling paints containing high levels of PCB, although inputs from other vessel-related materials (such as hydraulic fluids) could also be important.

Although the bioindicator, M. californianus, used in the offshore biomonitoring system is an intertidal organism, less than 10 percent mortality was observed, even at a depth of 35 m, over the 3-month study period. Thus, this mussel's hardiness, its ubiquitous distribution along many coastlines around the world, its very high ability for concentrating chlorinated hydrocarbons above seawater values (approximately 100,000-fold for 1254 PCB), and its apparent ability to rapidly respond to changes in environmental levels of such contaminants make it a very useful bioindicator, both in natural intertidal communities and on offshore substrates.

The widespread use of nonrecoverable PCB's was curtailed in the U.S. during the early 1970's. However, the inputs of these persistent substances are still diffuse and difficult to control. There is a need for more knowledge of the effects of these materials in the marine environment; in particular, uptake rates, persistence, and biological effects should be studied.

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APPENDIX

The location of the stations sampled in the programs described in this memorandum are shown in Figures A-1 through A-6.

During 1971-75, the Coastal Water Project conducted studies to determine the amounts of total PCB and the relative amounts of the PCB's most closely resembling Aroclors 1242 and 1254 in the tissues of the marine animals examined in our PCB research. The results of this work are summarized in the body of this memorandum; the detailed data is available from the Project in tables:

Table A-1. Concentrations of total PCB and 1242 PCB and 1254 PCB in composite samples of Dover sole muscle tissue, 1971-72.

Table A-2. Concentrations of total PCB and 1242 PCB and 1254 PCB in individual samples of Dover sole muscle tissue, 1974-75.

Table A-3. Concentrations of total PCB and 1242 PCB and 1254 PCB in composite samples of the various tissues from Palos Verdes and Orange County Dover sole, 1975.

Table A-4. Concentrations of total PCB and 1242 PCB and 1254 PCB in individual samples of yellow rock crab muscle tissue, 1971-72.

Table A-5. Concentrations of total PCB and 1242 PCB and 1254 PCB in individual samples of yellow rock crab gonadal tissue, 1971-72.

Table A-6. Concentrations of total PCB and 1242 PCB and 1254 PCB in composite samples of whole soft tissues from Mytilus edulis from southern California harbors, 1974.

Table A-7. Comcentrations of total PCB and 1242 PCB and 1254 PCB in composite samples of the whole soft tissues of Mytilus californianus suspended from a buoy off Palos Verdes, 1974.

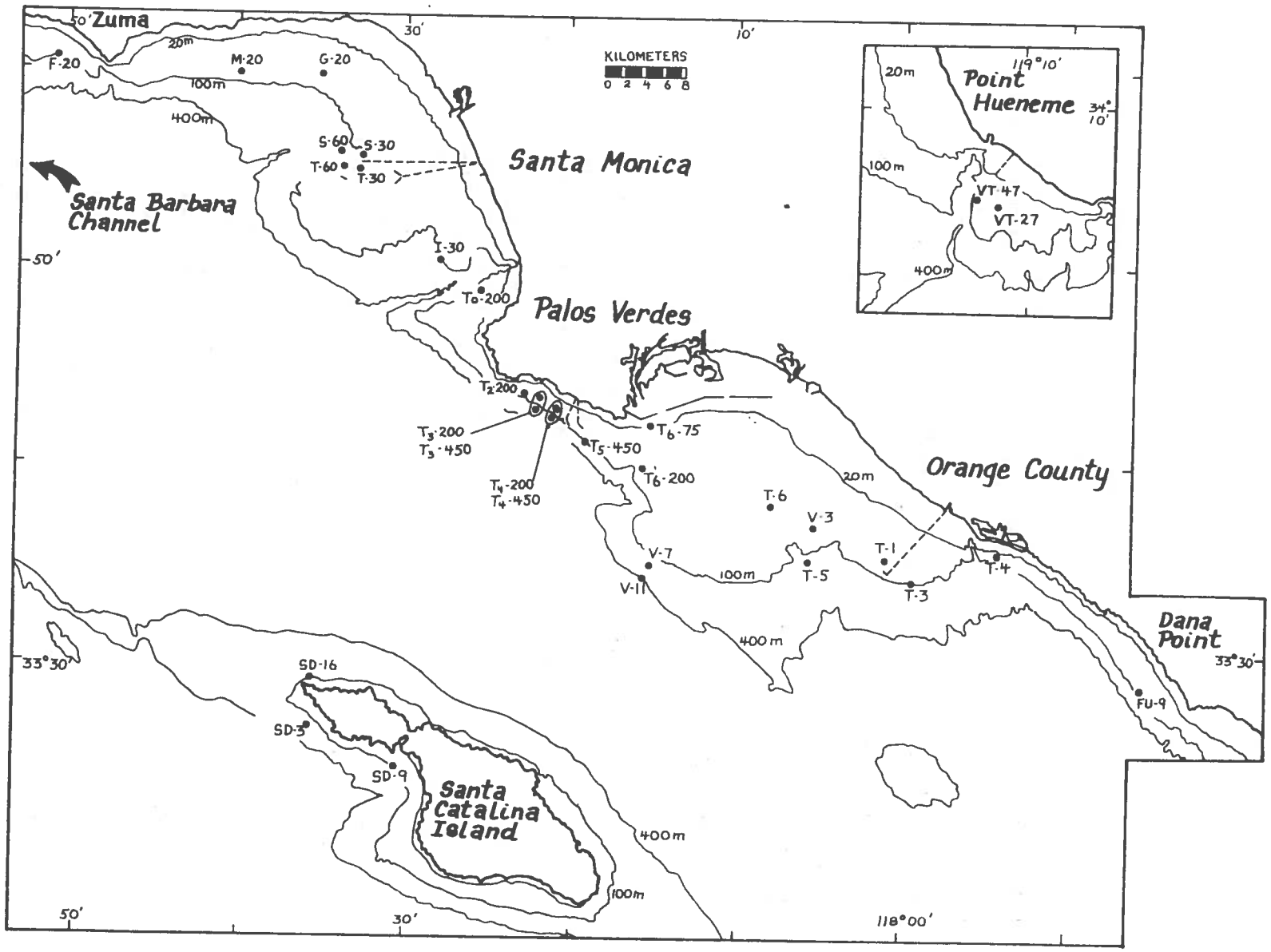

Figure A-1. Station locations, 1971-72 collections of Dover sole.

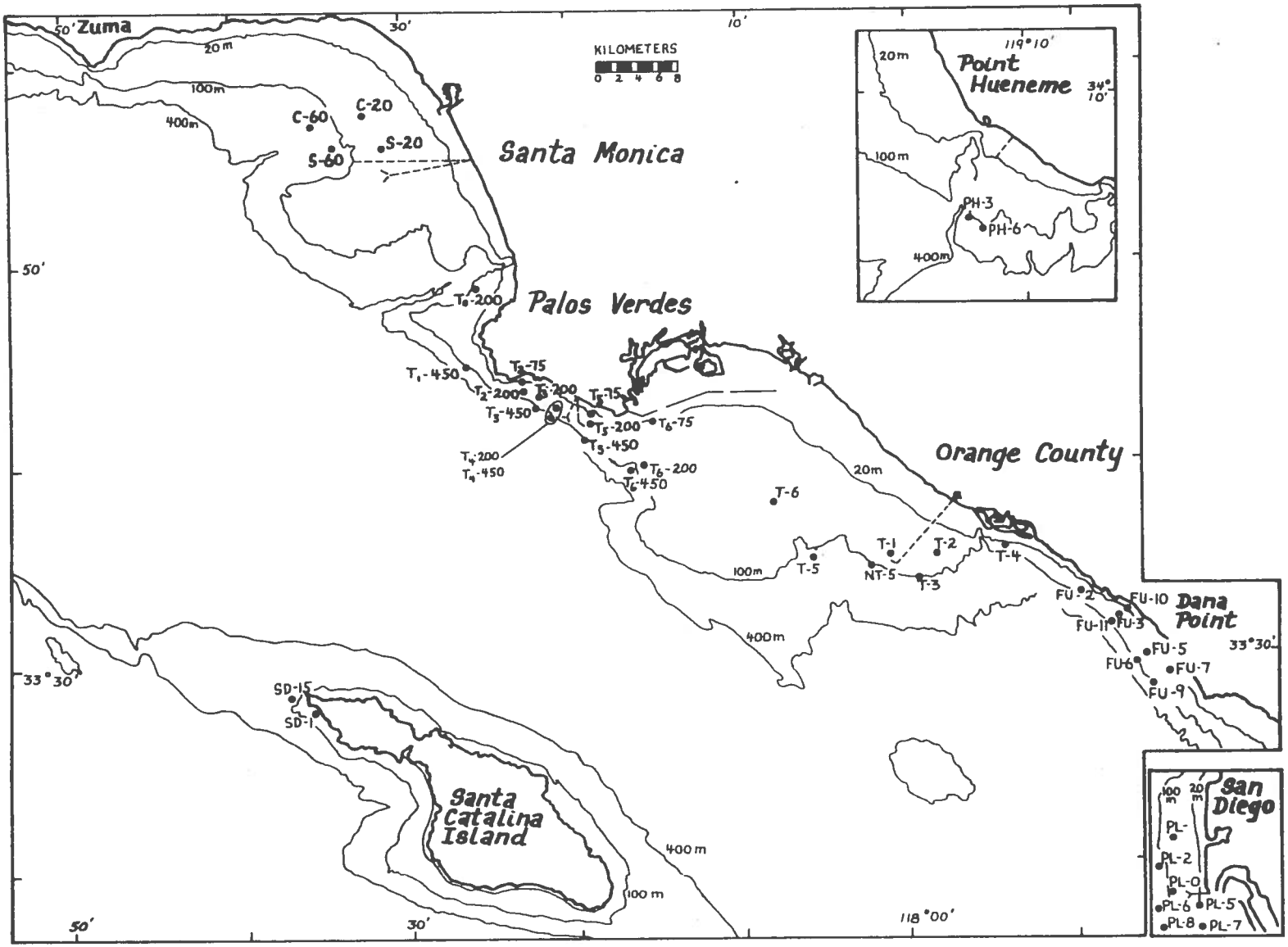

Figure A-2. Station locations, 1974-75 collections of Dover sole.

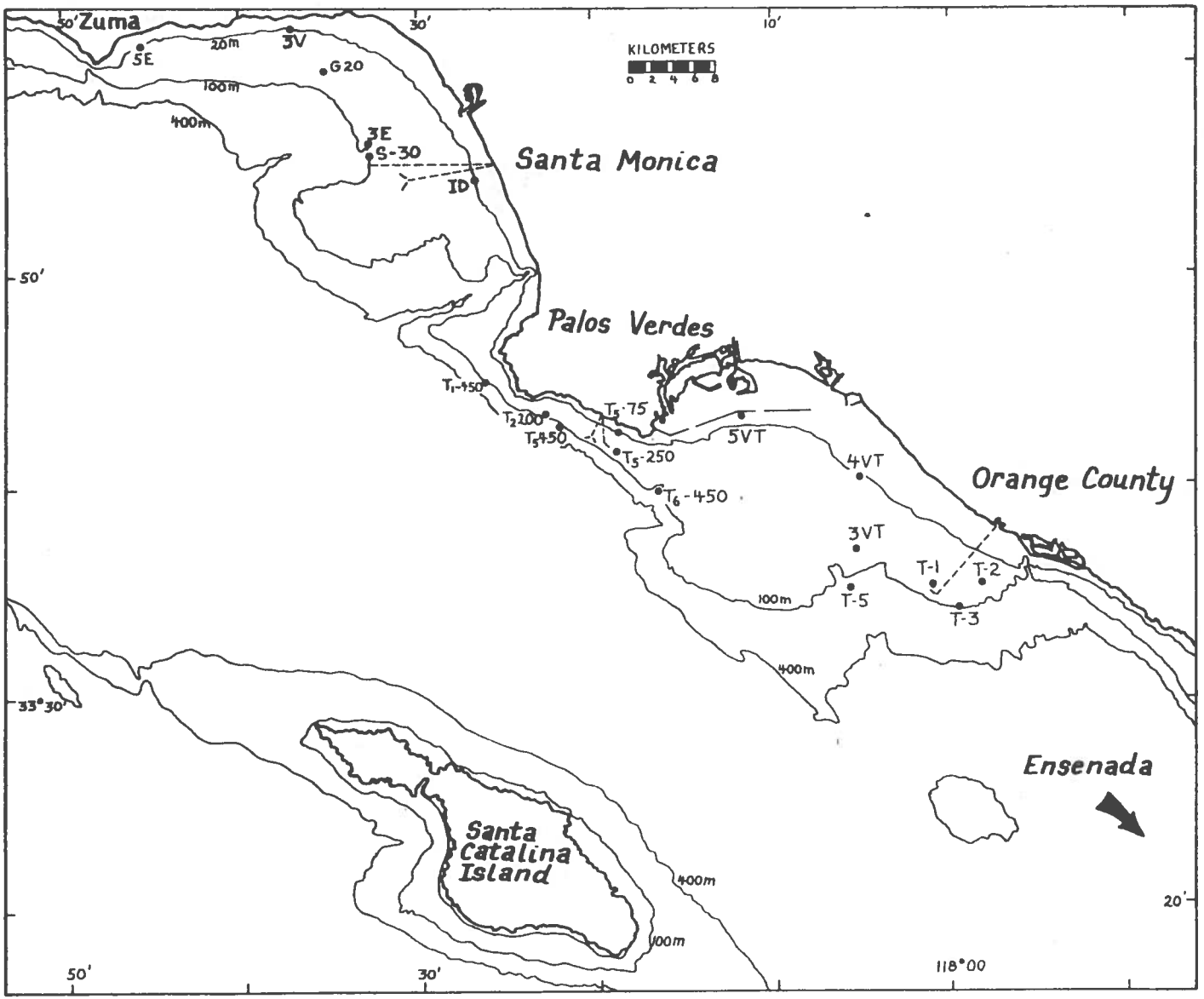

Figure A-3. Station locations, 1971-72 collections of yellow rock crab.

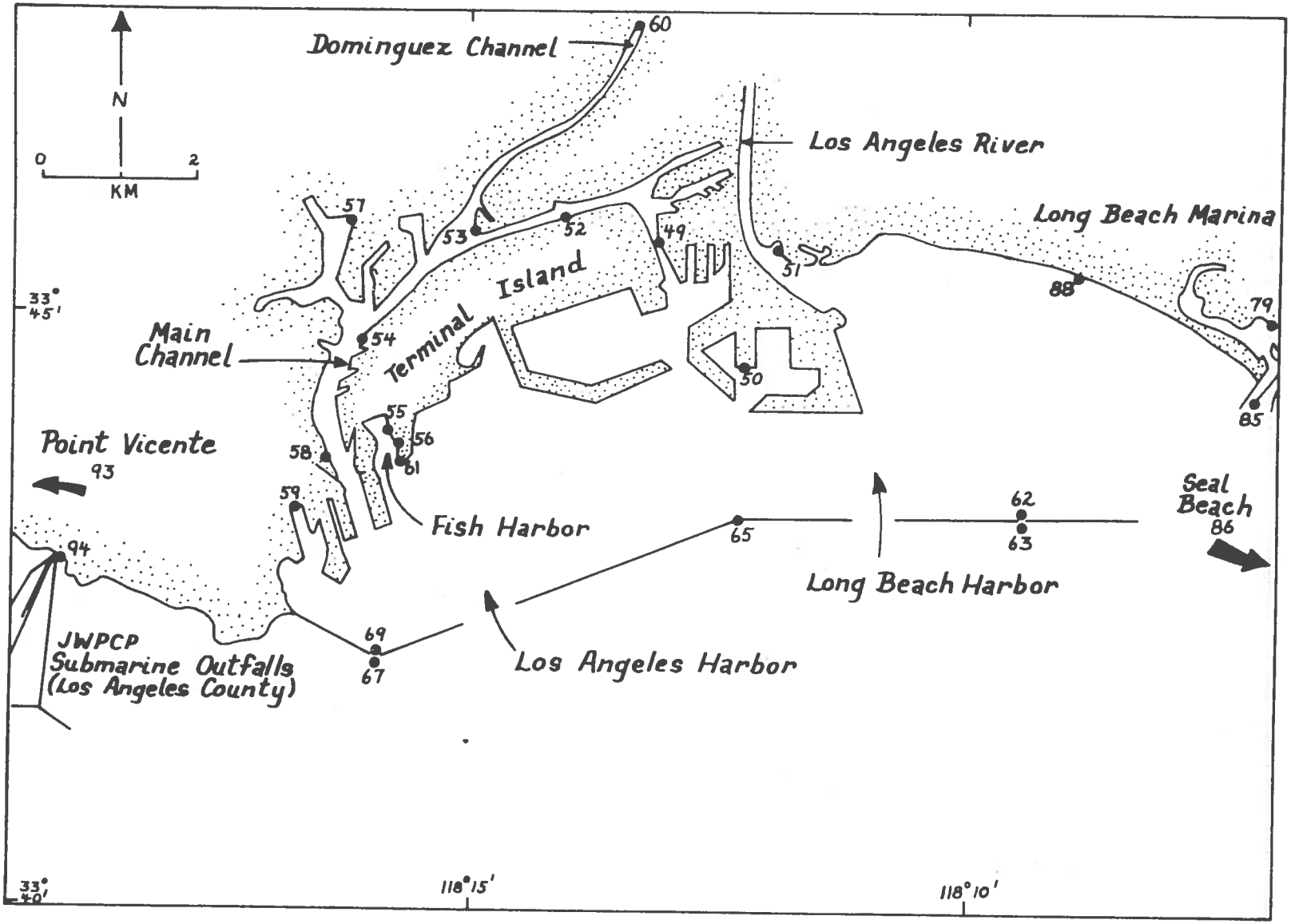

Figure A-4. Station locations, San Pedro Harbor collections of yellow rock crab, 1971-72.

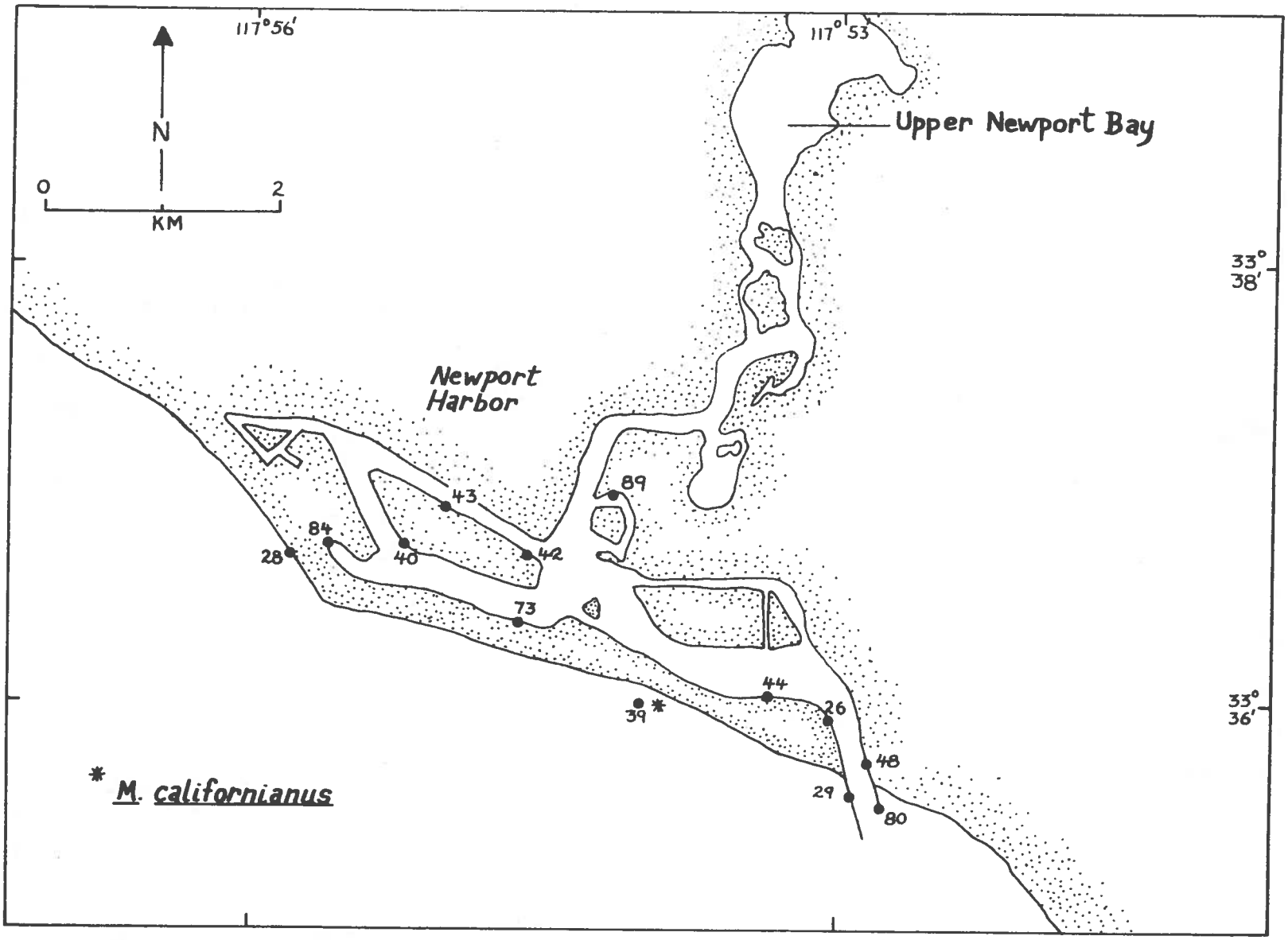

Figure A-5. Station locations, Newport Harbor collections of Mytilus edulis, 1974.

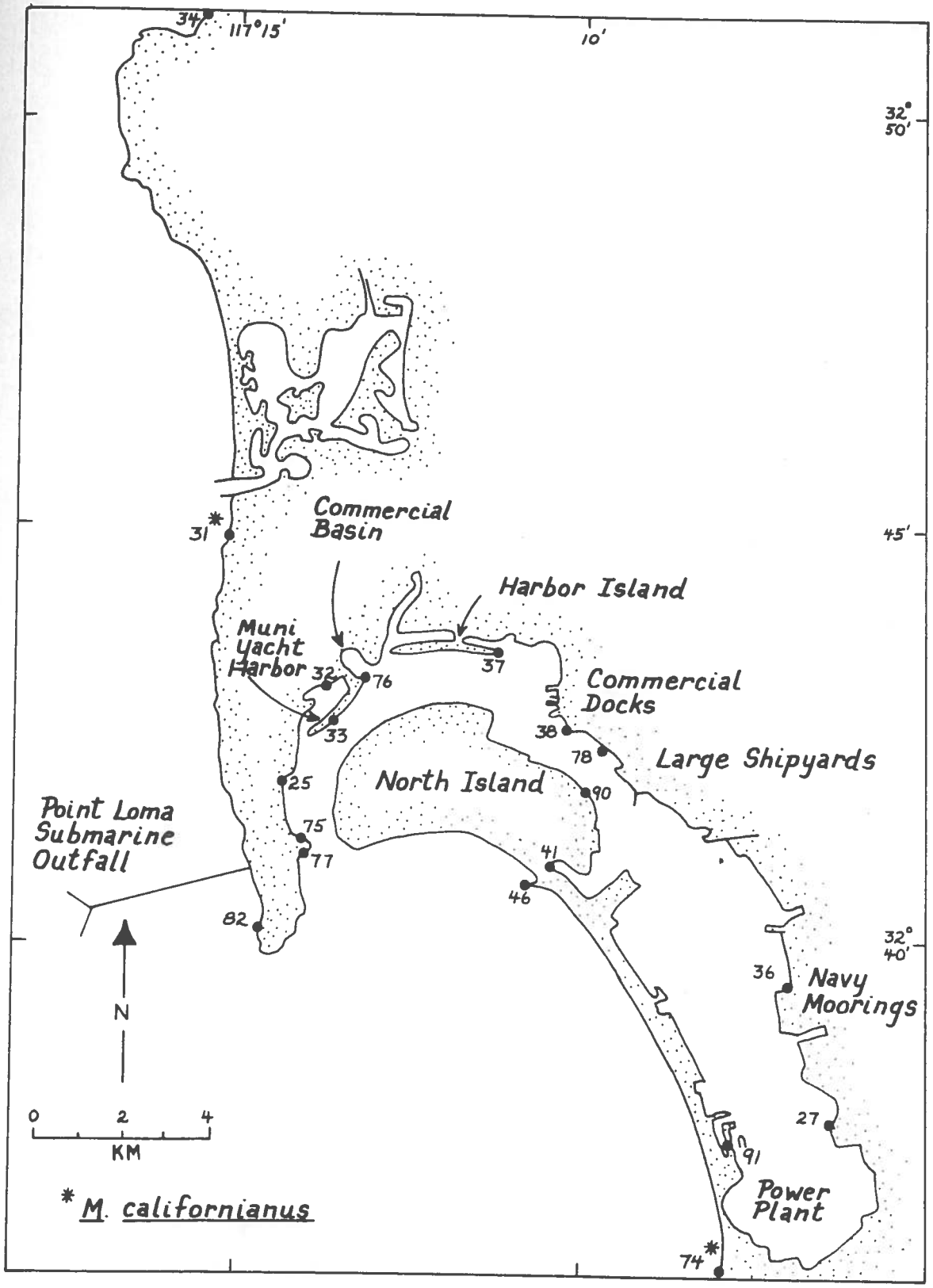

Figure A-6. Station locations, San Diego Harbor collections of Mytilus edulis, 1974.