Pre publication

PCB Absorbed from Sediments by Fiddler Crabs and Pink Shrimp

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Polychlorinated biphenyls (PCB's) are industrial chemicals manufactured in the United States, Europe, and Japan. These compounds are used as plasticizers, flame retardants, insulating and heat exchange fluids and in many other products (1). They are structurally related to DDT, soluble in lipid but relatively insoluble in water, and extremely persistent in the environment (2). PCB's have been reported in many marine and estuarine organisms (3). One PCB, Aroclor® 1254 (4), was reported in water, sediments, and biota from Escambia Bay, Florida (5).

In August 1969, pink, white, and brown shrimp (Penaeus duorarum, P. setiferus, and P. aztecus) from Escambia Bay contained whole body residues of Aroclor 1254 as high as 14.0 parts per million (ppm). Most of the Aroclor was concentrated in the hepatopancreas; residues in seven composite samples of at least five shrimp each ranged from 0.6 to 120.0 ppm. In April 1970, fiddler crabs (Uca minax) collected at three stations along the lower Escambia River and upper Escambia Bay had individual whole body residues of 0.45 to 1.5 ppm.

To determine the distribution of Aroclor 1254 in the estuary the following were taken: 40 samples of water collected in glass bottles, 20 sediments collected with a core or dredge sampler, and many estuarine organisms captured by trawl and dredge. These were then analyzed by gas liquid chromatography (5). Highest residues of the Aroclor were found in the sediments. In one survey (February, 1970), concentrations

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ranged from 0.6 to 61.0 ppm in a sample taken at the discharge of the industrial plant that accidentally released the chemical and at 11 stations extending 16 kilometers below (Figure 1). Aroclor was not detected in sediments collected above the plant but soil samples from the bank near the mouth of the river 6.5 kilometers downstream from the source had 1.4 to 1.7 ppm of this chemical. Subsequent samplings from 3 stations in the Bay showed little change in the amounts of the chemical even after nine months. Therefore, we designed experiments to determine if shrimp and fiddler crabs could accumulate Aroclor 1254 from the sediments.

Seven contaminated sediments (Table 1) were collected with a Petersen dredge from upper Escambia Bay and lower Escambia River at depths of 0.5 to 9 meters for studies on shrimp. Beach sand and additional samples of sediment collected upstream from the contaminated section of the river served as uncontaminated controls. Four kilograms of each of the sediments and 10 adult pink shrimp (P. duorarum) from a population which had previously shown no contamination with Aroclor were placed in each of nine aquaria. Flowing water (12 ℓ/hr, average salinity 27 parts per thousand [ppt], 17° C) covered the substratum to a depth of 10 centimeters.

Fiddler crabs (U. pugilator) were exposed to Aroclor by placing them on five sediment substrates collected as above. Four kilograms of each of the sediments were placed in the upper end of five aquaria inclined

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10 degrees so as to simulate a natural environment. Ten crabs from a population which had no contamination were placed in each aquarium with one serving as a control. Water averaging 27 ppt salinity and 13° C flowed at 5 liters per hour through the lower end. Both shrimp and crabs were fed fish containing <0.03 ppm Aroclor 1254 each day. The experiments were terminated after 30 days. Five crabs were removed from each aquarium, killed and rinsed with a 50% mixture of acetone and water to remove Aroclor 1254 from material adhering to the exoskeleton. To insure enough tissue for analyses, individual crabs and pooled samples of hepatopancreas from shrimp were mixed with anhydrous Na_2SO_4, extracted with petroleum ether in a Soxhlet apparatus, and the extract purified with Florisil (6). Aroclor 1254 was quantitated by gas liquid chromatography (5). The ratio of individual Aroclor isomers maintained integrity in the sediments and tissues of test animals throughout the period of study.

Fiddler crabs and shrimp exposed to the contaminated sediments accumulated Aroclor 1254 in their tissues by ingesting contaminated sediment particles or by absorbing the leached chemical from water. Test animals were observed to sift the sediments and could have ingested the particles. In most instances, the amount of Aroclor in individual crabs or in shrimp hepatopancreas was directly related to the amount in the sediments. We analyzed the distribution of the chemical in the sediment

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in relation to particle size and found it was evenly distributed. High residues of Aroclor in the hepatopancreas of shrimp exposed to sandy silts, however, could be due to the leaching of the chemical from the sediments and subsequent absorption of the chemical through the gills as well as ingestion of sediment. Three and one-half parts per billion (ppb) was in the effluent water from the aquarium with sandy silt (61.0 ppm Aroclor) and the water from the silt (30.0 ppm) had only 0.5 ppb. Even though fiddler crabs were not continuously covered with water, they could have obtained Aroclor from the water as they wet their gills.

We have demonstrated experimentally that Aroclor 1254 can enter the estuarine food web from sediments. Others (5) have shown this chemical to occur in higher trophic levels such as fish and since PCB's are apparently widespread in the world (3), we should be more alert concerning the presence, movement, and effects of these chemicals in the environment.

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Table 1. Aroclor 1254 (ppm) in individual fiddler crabs (Uca pugilator) and hepatopancreas from pink shrimp (Penaeus duorarum) which were kept for 30 days on naturally occurring sediments containing Aroclor. Mortalities occurred in some experimental groups of shrimp, but could not be attributed to Aroclor 1254.

Sediment	Aroclor 1254 in sediment (ppm, dry weight)	Average and range of Aroclor 1254 in five individual fiddler crabs (ppm, wet weight)	Aroclor 1254 in combined hepato-pancreas from four or more shrimp (ppm, wet weight)
Sandy silt*	61.0	80.0 ± 25.0	240.0
Silt**	30.0	17.0 ± 9.0	6.1
Sandy silt**	5.7	---	9.8
Silt**	4.9	3.6 ± 0.9	1.3
Sandy silt**	4.1	---	6.7
Silt**	2.5	3.2 ± 0.9	1.1
Silt**	1.4	---	0.2
Sand control*	ND	0.3 ± 0.2	< 0.2
Silt control**	ND	---	< 0.2

* Sediment which contained particles of sand >354 microns in diameter.

** Sediment which contained particles of sand 354 microns or less.

--- No sample.

ND = not detectable

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References

1. Reynolds, L. M., Bull. Environ. Contam. and Toxicol., 4, 128 (1969).

2. Risebrough, R. W., and Brodine, V., Environment, 12, 16 (1970).

3. Risebrough, R. W., Rieche, P., Peakall, D. B., Herman, S. G., and Kirven, M. N., Nature, 220, 1098 (1968); Koeman, J. H., Ten Noever De Brauw, M. C., and De Vos, R. H., Nature, 221, 1126 (1969); Jensen, S., Johnels, A. G., Olsson, M., and Otterlind, G., Nature, 224, 247 (1969)

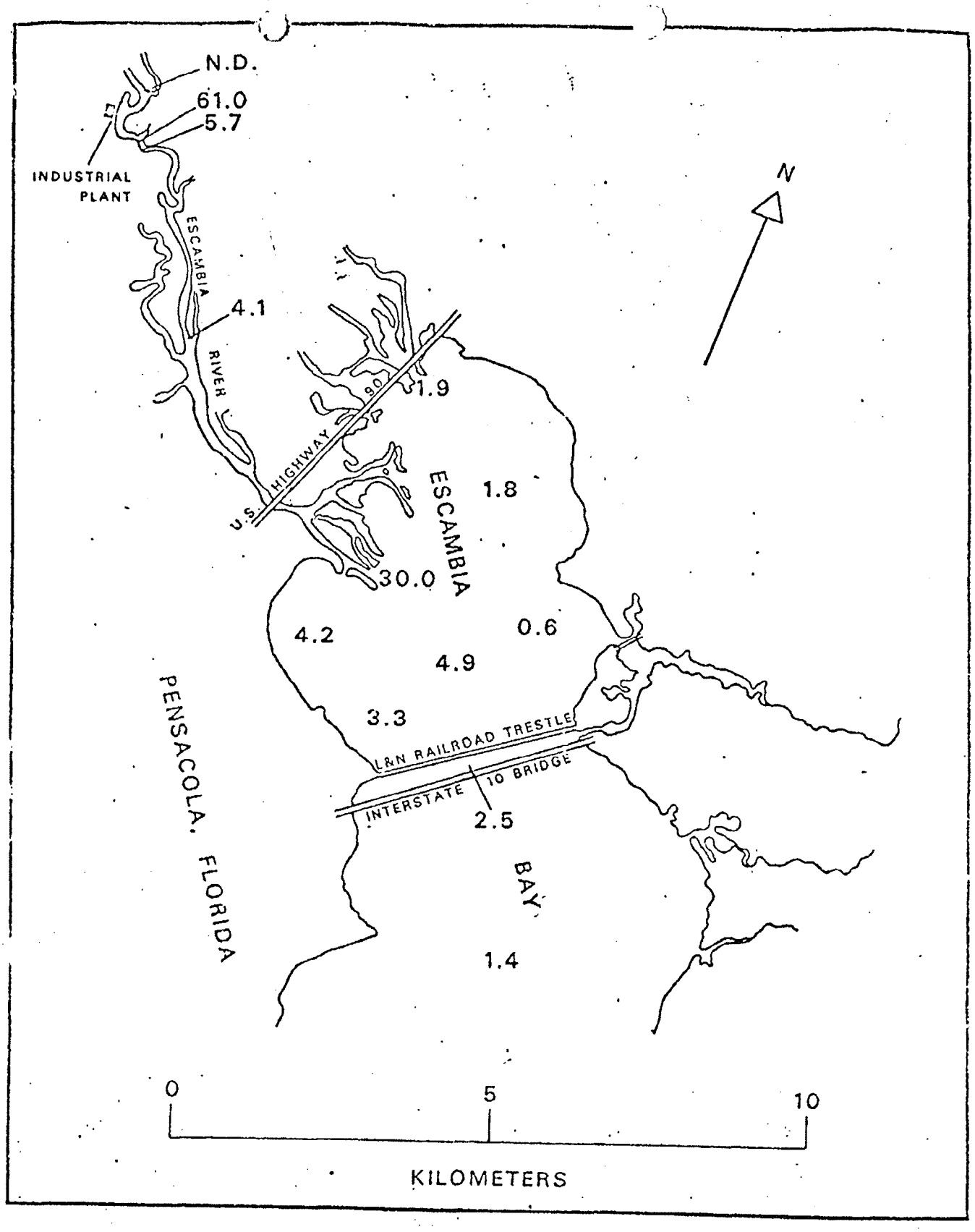
4. Registered trademark, Monsanto Co., 800 N. Lindberg Blvd., St. Louis, Mo. 63166.

5. Duke, T. W., Lowe, J. I., and Wilson, Jr., A. J., Bull. Environ. Contam. and Toxicol., 5, 171 (1970).

6. Mills, P. A., Onley, J. H., and Gaither, R. A., J. Assoc. Offic. Agr. Chem., 46, 186 (1963).

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N.D.
61.0
5.7
INDUSTRIAL PLANT
ESCAMBIA RIVER
4.1
N
1.9
U.S. HIGHWAY 90
1.8
ESCAMBIA BAY
30.0
4.2
0.6
4.9
3.3
L&N RAILROAD TRESTLE
INTERSTATE 10 BRIDGE
2.5
1.4
PENSACOLA, FLORIDA
0
5
10
KILOMETERS

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Figure Legend

Figure 1. Study area showing lower Escambia River, upper Escambia Bay and stations where sediment was collected on 24 February 1970. The amount of Aroclor 1254® found at each station is given in parts per million (ppm). N. D. = not detected.

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