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A Summary of NWQL Research Concerning the Effects of Polychlorinated Biphenyl on Water Quality and Aquatic Life

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Environmental Protection Agency

National Water Quality Laboratory

Duluth, Minnesota

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Exposure of Brook Trout to Aroclor® 1254

V. M. Snarski and F. A. Puglisi

Brook Trout are being exposed to Aroclor® 1254 to determine the effects of sublethal water concentrations of PCBs on growth, reproduction, hatchability, and survival of fry through absorption of the yolk-sac. The analysis for PCBs in tissue has been included to study the amount concentrated by the fish and its transfer to the eggs. Tissue analysis include measurements in muscle, gonads, and the whole body and during spawning in the eggs. Spawning is expected to occur after 15 months of exposure.

No effect on growth or survival has been observed during the first 9 months of this test. Data were obtained from sacrifices after 14 and 27 weeks of this exposure and after 8 and 14 weeks of a previous exposure terminated before completion.

The residue data from the trout exposed for 27 weeks indicate that approximately 0.55 µg/l of Aroclor® 1254 will result in 5 µg/gm of the PCB mixture in the fish (whole fish basis). The concentration in the fillet of fish exposed to 0.84 µg/l Aroclor® 1254 was 1 µg/gm. The lipid content of the fillet portion of the trout was less than two percent.

Figure 1 shows the relationship between the concentration of PCBs in water and the concentration in the tissue (wet). The linear regression lines suggest the concentration in the tissue to be directly proportional to the concentration in the water. The spread shown by these lines indicates a range of PCBs in various tissues for each water concentration. Note that similar tissues are clustered into narrow

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FIGURE 1 RELATIONSHIP OF PCB'S IN WATER TO PCB'S IN TISSUE

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bands of the entire range.

The concentration of PCBs in the tissue appears to be correlated to the lipid content of the tissue as indicated by Figure 2 which shows the relationship between water concentrations and PCB concentrations calculated on a lipid weight basis. Again, the PCBs in the lipid are directly proportional to the concentration in the water. The variability in concentrations in lipid is much less than the variability in the tissue based on wet weight. This suggests that the PCB level in the tissues result, in part, from the partitioning between the lipid and water.

The concentrations of Aroclor® 1254 in the brook trout lipid ranged from 110,000 to 170,000 times greater than the concentration in the water and was largely independent of the length of exposure after 14 weeks.

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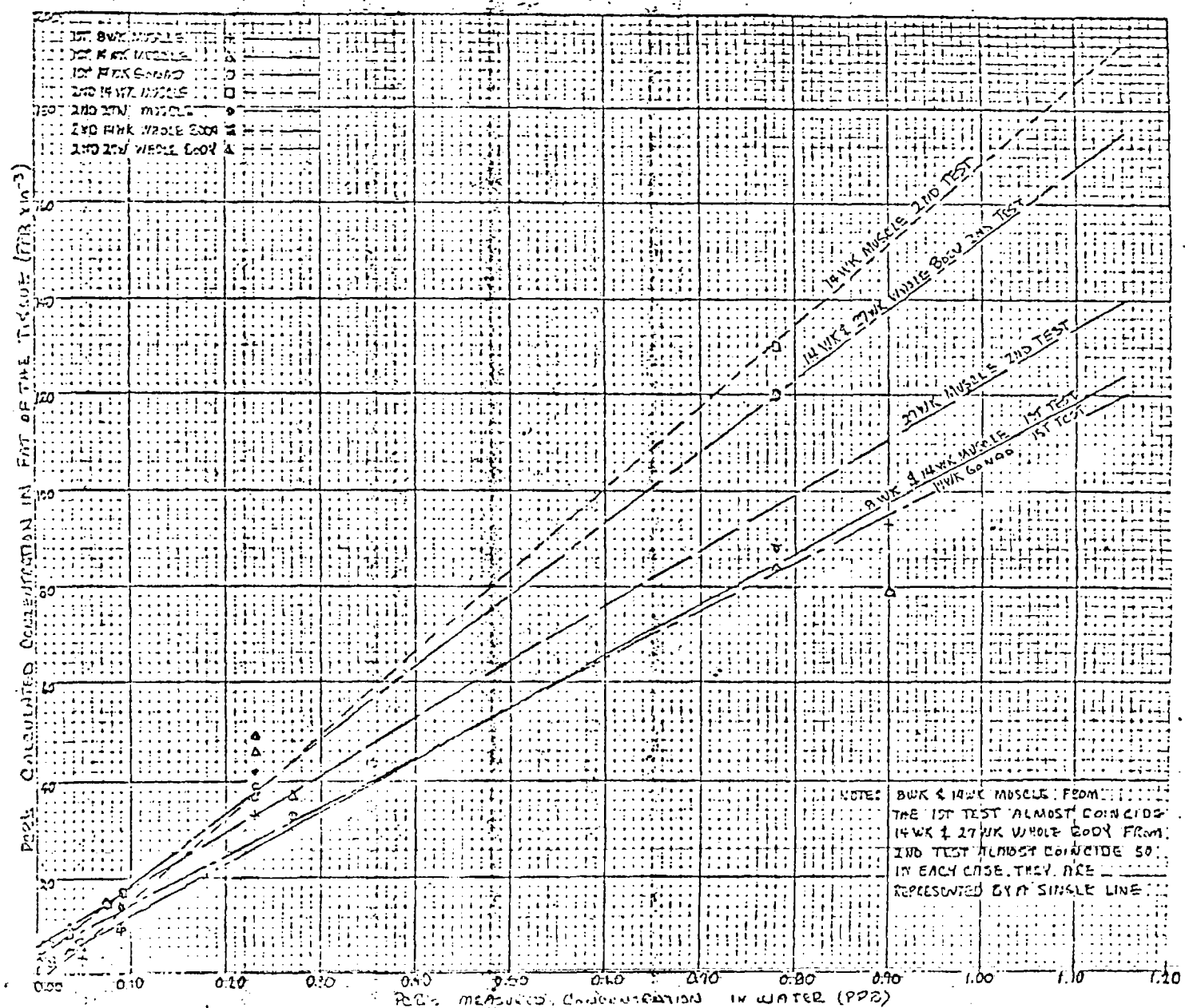

FIGURE 2 RELATIONSHIP OF PCB'S IN WATER TO PCB'S IN FAT

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Exposure of Fathead Minnows to Aroclor® 1248 and 1260

D. L. Defoe, R. W. Carlson and G. D. Veith

Chronic exposures of PCB Aroclors® 1248 and 1260 to the fathead minnow have been completed. The data is being analyzed and prepared for publication.

The data presented herein which represent mean values of duplicate bioassays are normalized to the results obtained with the control fish exposed only to the acetone carrier.

More detailed studies to determine the effect of carriers on the bioassay results are underway.

The 30 day acute exposures using Aroclor® 1248 and fathead minnow fry (less than 12 hours old) has shown that 8 µg/l of A 1248 killed all the fry, 4.5 µg/l killed 50 percent of the fry and caused a 70 percent reduction in the weight of the fry, and 2.2 µg/l caused no mortality but a 20 percent reduction in weight. Similar studies with Aroclor® 1260 demonstrated that 9 µg/l killed all the fry and 4 µg/l caused 70 percent mortality and a 30 percent reduction in fry weight.

The reproduction, measured as the number of eggs spawned per female, in females exposed to 1.1 µg/l Aroclor® 1248 were only 60 percent of that of the controls. Aroclor® 1260 did not affect reproduction at concentrations up to 2.1 µg/l.

The second generation fry from adults previously exposed to the PCB mixtures were exposed to the respective mixtures for 30 days after hatching. Preliminary data analyses indicated that 3 µg/l of Aroclor® 1248

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caused no mortality but a 20 percent reduction in the weight of the fry. Similarly, Aroclor® 1260 caused no mortality when the fry were exposed to 2.1 µg/l; however, the weight of the fry was reduced by 33 percent.

Figure 3 indicates that the concentration of both Aroclor® 1248 and 1260 in the male fathead minnows reached an apparent steady-state after the first 100 days. The concentration of the PCBs in the female fish was more than double that in the male when expressed on a wet weight basis. However, the concentrations expressed on a lipid basis as illustrated in Figure 4 indicate that the females contained slightly less PCB per gram of lipid than did the males. In addition, the PCB concentration in the female on a wet weight basis was much more variable than the male, presumably due to the variable lipid content of the female.

The fathead minnow accumulated Aroclor® 1260 concentrations (lipid basis) approximately 270,000 times that in the water, whereas Aroclor® 1248 was accumulated to lipid concentrations approximately 120,000 times that in the water.

Data analyses and studies concerning the 60 day growth, delays in spawning, egg hatchability, body burden of PCBs, and the elimination of PCBs from the fish are continuing.

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Figure 3
Accumulation of Aroclor 1248 and 1260
in Fathead Minnows

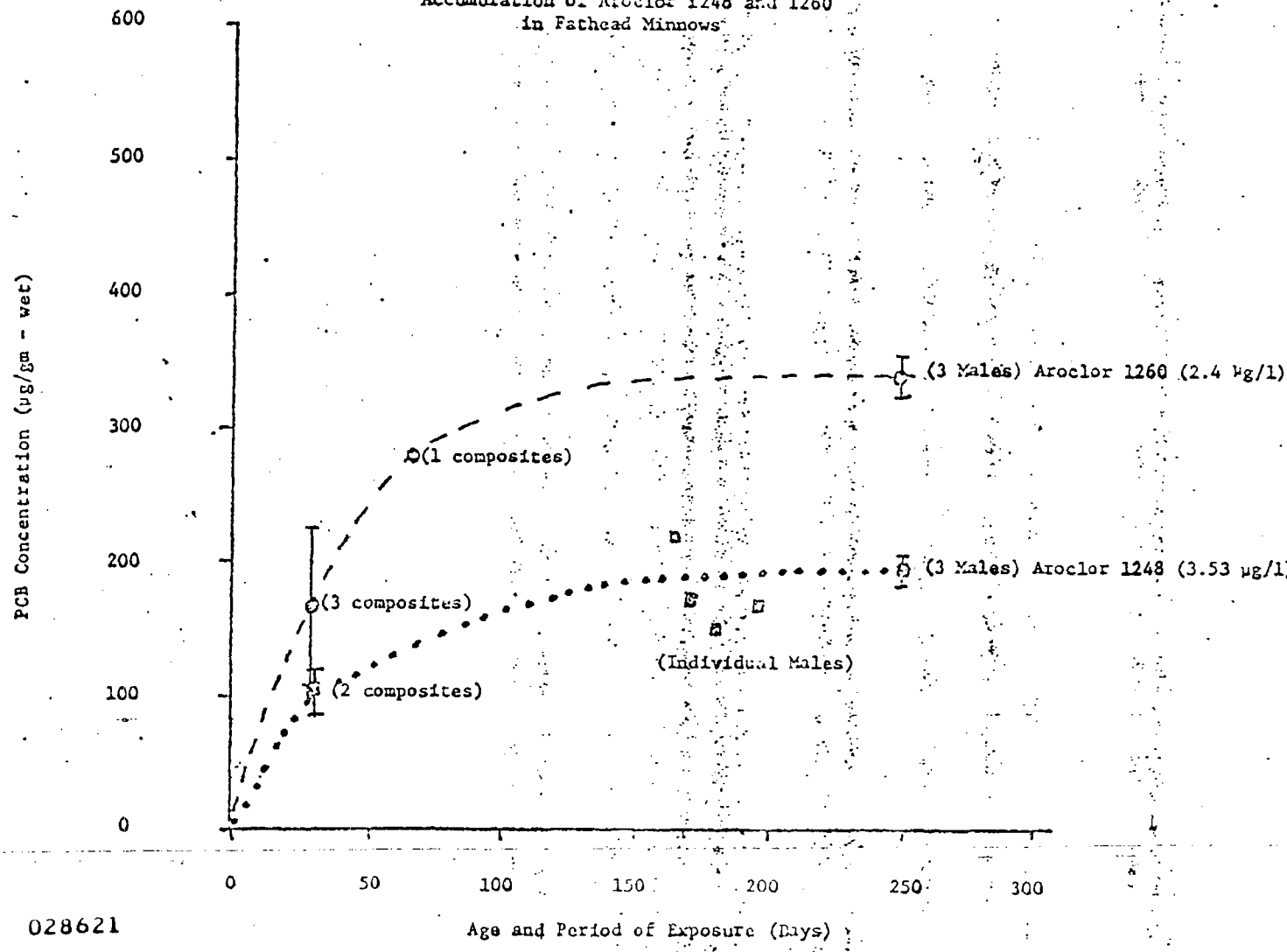

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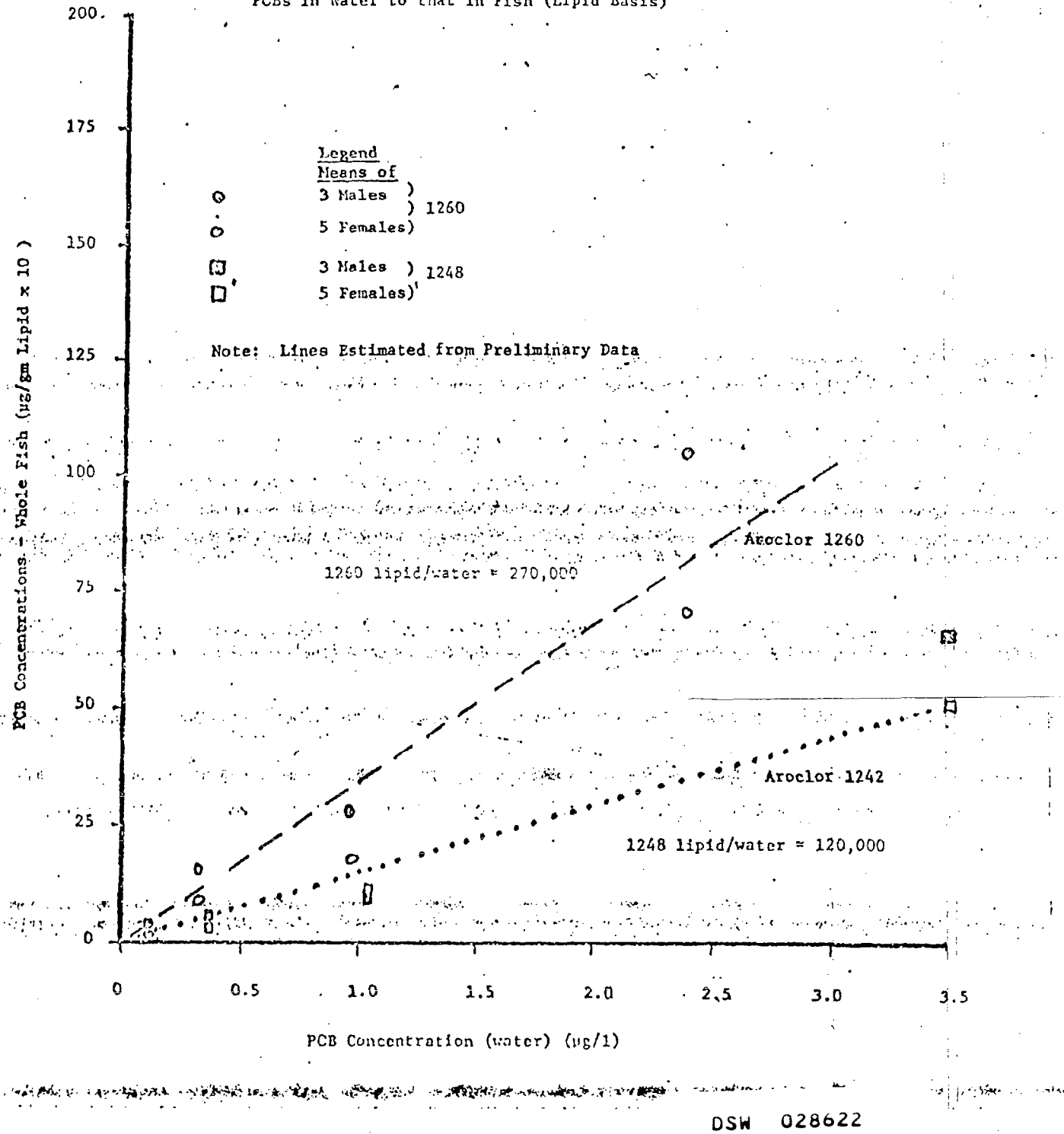
Figure 4
Relationship Between the Concentration of
PCBs in Water to that in Fish (Lipid Basis)



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Summary of Other Exploratory Studies with PCBs

A. V. Nebeker, F. A. Puglisi and D. L. DeFoe

As indicated in Table 1, Aroclor 1248 was the most toxic of the eight aroclors tested to Daphnia magna in static tests, with a 3-week LC50 of 25 µg/liter. Aroclor 1254 was most toxic under continuous-flow conditions with a 3-week LC50 of 1.3 µg/liter. The Aroclors were more toxic under continuous-flow than static conditions, with 16 percent impairment of reproduction caused by 1.0 µg/liter Aroclor 1248.

The calculated 96-hour LC50 values for newly-hatched fathead minnows were 7.7 µg/l for Aroclor 1254 and 15 µg/l for 1242. Three-month-old fatheads had a 96-hour LC50 of ca. 300 µg/l for 1242. Reproduction occurred at and below 1.8 µg/l 1254 and at and below 5.4 µg/l 1242. Polychlorinated biphenyls were acutely toxic but exhibited much greater chronic toxicity at very low levels, due to their cumulative nature. Newly hatched young were the most sensitive life stage. Young fathead growth was also affected above 2.2 µg/l 1248 and none survived above 5.1 µg/l after 30 days. Young flagfish, Jordanella floridae, did not survive above 5.1 µg/l 1248 and did not grow well above 2.2 µg/l.

The ninety-six hour LC50 values for Aroclor 1242 and 1248 with Gammarus pseudolimnaeus were 73 and 29 µg/liter. Survival after 30 days was 53 percent at 8.7 µg/l 1242 and 52 percent at 5.1 µg/l 1248. Good reproduction and survival of young occurred at 2.8 µg/l 1242 and 2.2µg/l 1248.

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Table 1. The Comparative Toxicity of Eight Aroclors[a] (in µg/liter) to Daphnia magna in Lake Superior Water as Determined in Static Test Conditions

Aroclor	Three Week LC50	Confidence Limits[b]	Reproductive Impairment 50%	Confidence Limits	16%	Confidence Limits
1221	180	158-205	125	116-135	89	85.6-92.6
1232	72	62.6-82.8	66	60-72.6	53	50.5-55.7
1242	67	55.4-81	63	56.3-70.5	48	45.2-50.9
1248	25	21.4-29.2	24	21.2-27.1	16	13.9-18.4
1254	31	26.8-37.2	28	23.1-33.9	18	14.5-22.3
1260	36	27.7-46.8	33	27.5-39.6	22	17.7-27.3
1262	43	37-49.9	41	33-53.3	24	17.6-32.6
1268	253	222-288	206	185-228	162	146-179

[a]Polychlorinated Biphenyls: Aroclor 1221-1268., Monsanto Chemical Company, St. Louis, Mo.

[b]Ninety-five percent confidence limits.

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Abundant adult emergence of the midge Tanytarsus dissimilis did not occur above 5 µg/l 1248 or 3.5 µg/l 1254. The calculated 3-week LC50 (50 percent reduction based on control as 100 percent) for Aroclor 1254 was 0.65 µg/l for larvae and .45 µg/l for pupae.

Application factors of 0.10 for 1242 and 0.15 for 1248 were calculated for the PCB's and Gammarus. Application factors of 0.2 for 1254 and 0.16 for 1242 were calculated for fathead minnows using newly hatched fish to obtain the 96-hour LC50.

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Survival and Reproduction of Daphnia magna After Three Week Exposure to PCB Mixtures

L. Uhlken, R. W. Carlson

Studies have been initiated to determine the relativity toxicities of individual chlorobiphenyls, simplified mixtures, and Aroclor® 1016 to Daphnia magna. As shown by previous studies, the toxicity of the PCBs increases with increasing chlorine content. For example, Daphnids exposed to 50 µg/l 2,2'-dichlorobiphenyl produced 515 young whereas those exposed to the same weight of a mixture of trichlorobiphenyls produced only 111 young. Daphnids exposed to tetrachlorobiphenyls and Aroclor® 1242 at the 50 µg/l did not survive.

Preliminary data suggests that some mixtures of trichloro-and tetrachlorobiphenyls may be as toxic as Aroclor® 1242. Studies with Aroclor® 1016 are continuing.

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