STATEMENT OF
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BEFORE THE
COMMITTEE ON MERCHANT MARINE AND FISHERIES
HOUSE OF REPRESENTATIVES
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PANEL II

Mr. Chairman, and Members of the Committee, I am Frank G. Wilkes, Chief of the Processes and Effects Branch at the Environmental Protection Agency (EPA) Environmental Research Laboratory, Gulf Breeze, Florida. I have managed research at this Laboratory since 1975 following five years as a Branch Chief in the Office of Research and Development Headquarters in Washington, D.C.

My educational background is as follows: I received a B.A. degree in Biology from the University of Louisville in 1962; a Master of Science degree in Public Health from the University of North Carolina in 1964; and a Ph.D. degree in Environmental Chemistry and Biology from the University of North Carolina in 1968.

I am pleased to be here today to discuss the Environmental Protection Agency's research and understanding of the biomagnification in marine food chains of polychlorinated biphenyls (PCB).

The mission of the Environmental Research Laboratory, Gulf Breeze, is to determine the fate and effects of toxic substances in the estuarine environment. Because our investigations in this important research area involve the impact of dredged material on the estuarine environment, I have acted as EPA Co-Chairman of the Environmental Protection Agency/U.S. Army Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material since its inception in October 1975.

In September 1979 the Gulf Breeze Laboratory received a letter from Ms. Barbara Metzger, Director, Surveillance and Analysis Division, EPA Region II asking for comments on the decision of Region II to grant ocean dumping permits to two applicants for disposal of dredged material containing, among other constituents, polychlorinated biphenyls (PCB). This decision by the Region was based on "the relatively low levels of bioaccumulation shown ... and the fact that the bioaccumulation observed occurred primarily in the polychaete worm, which is of minor significance to the human food web." We were asked for "our written views and comments concerning the tentative determination to concur with the New York District that the test data described herein satisfies the Ocean Dumping Criteria."

In our response, dated 5 September 1979, we stated that research being conducted at the Environmental Research Laboratory, Gulf Breeze, indicated that PCB's are readily bioaccumulated by aquatic organisms. We further stated that polychaetes play a significant role in marine and estuarine food webs and therefore are potential contributors to a potential human health hazard. We documented our comments by attaching a list of eight references which show that polychaetes are, indeed, a significant food source of numerous bottom feeding fishes of commercial importance.

Based on this information, we stated in our letter that "we feel that the potential exists for uptake and biomagnification of PCB's found in the test animals." The concerns which we stated in September are the same concerns that we presently have: if a large-scale ocean dumping of contaminated dredged material occurs, there exists the possibility of transport of these materials up the food chain to humans. Central to these technical issues are the processes of bioaccumulation and biomagnification. However, the exact mechanism of uptake and concentration are less important than the fact that such potential has been repeatedly demonstrated in the permit tests performed on this material.

Let me note at this point that, in discussing our response presenting our views on tha issue of biomagnification and bioaccumulation to Region II, we recognise that permit decisions are in the hand of the Region and they may have available data on other aspects of the disposal operation which are not taken into consideration in our evaluation of the laboratory bioassay data.

I would like now to turn to a discussion of what we mean by "bioaccumulation" and "biomagnification." Bioaccumulation refers to the uptake of chemicals by the organisms directly from water, sediment, and/or food. Biomagnification refers to the increase in toxicant concentration which occurs in successively higher trophic level organisms in an ecosystem.

Biomagnification of PCB's in marine food chains has been reported in the literature. Munson (1972), for example, reported on the movement of PCB's in a food chain in a California estuary. The lowest PCB levels were in the abalone, a strict herbivore; the second lowest levels were in the red sea urchin, a herbivore-scavenger; and the highest levels were in the whelk and the spiny lobster, both scavengers. Munson states that these data "support the idea that higher body burdens are accumulated by organisms at higher trophic levels."

Nisbet and Sarofim (1972) state that aquatic invertebrates and fish can accumulate PCB's to levels between 3×10^3 and 7×10^4 times higher than those in

the ambient water. They also state that PCB levels are clearly magnified within food chains involving birds and mammals by a factor on the order of 10 to 100 at each step.

Finally, the National Academy of Sciences, National Research Council Report on PCB's (1978) stated that "Because PCB concentrations are magnified as the compound moves through food chains, the most pronounced toxic effects are noted in the upper trophic levels."

Thus, since polychaete worms are known to bioaccumulate PCB's, and polychaete worms are known to be a primary food source of bottom feeding fish and, since biomagnification in aquatic food chains has been reported, we feel that the potential for biomagnification of PCB's from polychaetes to higher trophic levels exists.

There have been other studies, however, in which biomagnification of PCB's was not so evident. Bryan (1979), for example, states that "evidence from analyses of polychlorinated biphenyls has suggested that there may be no bioamplification from phytoplankton through food chain to fish." Scura and Theilacker (1977) studied the kinetics of Aroclor 1254 in a food chain consisting of an alga, a rotifer and a fish larvae. Their data suggested that PCB accumulation is not a food chain phenomena but rather the result of direct partitioning of the compounds between

the seawater and the test organism. Mack (1979) studied the relative importance of dietary and aqueous exposure of bluegill sunfish to several organic compounds (not PCB) and concluded that "biomagnification" of chemical residuas in aquatic food chains is not a significant phenomenon in natural systems.

Finally, Nisbet and Sarafim (1972), while stating that food chain biomagnification of PCB's can be implicit in food chains leading to birds and mammals, also conclude that "it is not yet clear whether concentrations of PCB's are consistently increased as they pass up food chains from invertebrates to fish and from fish to fish."

Conflicting data also exist on the relative significance of PCB uptake from food and from water. While Macek (1979) concluded that dietary uptake was significantly less than that from aqueous exposure, Bryan (1979) stated that "certainly in fish and crustaceans all the evidence points to food as being the main source or organochlorine residues such as DDT and PCB's." Also Thomann (unpublished manuscript), who developed a steady state model on the fate of chemicals in diverse aquatic food chains, stated that "this model indicates that for PCB, the observed concentration in the top predator fish is almost entirely due to food chain transfer and not uptake directly from the water."

Thus, it appears that biomagnification can occur in some food chains and may not occur in others and that many factors influence our perception of this fact. In organisms like birds and mammals, for example, which receive little exposure from water, diet must play an important role in PCB uptake. In organisms where uptake from water may be most significant, bioaccumulation rather than biomagnification is the primary source of the tissue burden. The lipid content of the organism may be a factor also, as PCB's are partitioned from water to the organism's lipid pool. Thus, an organism's size, age, food habits, lipid content, distribution patterns relative to PCB sources, and exposure variations in time and space, all may affect its propensity for biomagnification. We may not know enough about the New York Bight area to know or predict the concentration that will be attained by a specific species at a specific trophic level given the considerations cited above.

What we do know, however, is that organisms will bioaccumulate PCB's from water and food. I have presented two tables which compare the bioconcentration of PCB's by aquatic organisms with the bioconcentration of other compounds. Table I compares the toxicity and bioconcentration factors (concentation in tissue/concentration in water)

of PCB's and other organic chemicals for the sheepshead minnow, an estuarine fish. This table shows that, generally speaking, the acute toxicity of PCB's to the sheepshead minnow is lower than many of the other compounds listed in the table, particularly the chlorinated hydrocarbon pesticides. However, the chronic toxicity of PCB's, particularly 1254, appears to be greater than for most of the compounds listed in Table I. The Bioconcentration Factor (BCF) for PCB's is very much higher in the sheepshead minnow than for any other compound listed.

Table II compares the BCF values for PCB's and other chemicals for a number of estuarine organisms. It can be seen that the BCF values for PCB's are higher in every organism for almost all compounds.

Thus, we know that by whatever mechanism PCB's get to the higher trophic level organisms, i.e., from water or sediment or food, high concentrations of PCB's can be expected to be found in the tissue of fish of commercial value. Whether these tissue levels result from bioaccumulation or biomagnification is not the significant point; they are nonetheless present and could present a potential health hazard to man. To underline this concern, we need only point to the FDA proposal to reduce the action

level for PCB's in fish from 5 ppm to 2 ppm. We assume that these values were derived based on a knowledge of human health affects of PCB's.

Mr. Cheirmen, this concludes my prepared statemsnt.

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TABLE I

RELATIVE TOXICITY AND BIOCONCENTRATION FACTOR - SHEEPSHEAD MINNOW

Organism \ Compound	PCB	DDT	Kepone	Endrin	Heptachlor	Toxaphene	Lindane	Chlordane	Diazinon	EPN	Trifluralin
Acute Toxicity (LC50-µg/ℓ)	>100	2.0	69.5	0.36	3.68	1.1	103.9	12.5	1,400	188.9	190
Chronic Toxicity (µg/ℓ)	3.6(1016) 0.049(1254)	-	<0.08	.12-.31	2.2	2.5	-	1.7	0.98	4.1-7.9	4.8
Bioconcentration Factor (BCF)	30,000	18,800	7,200	6,400	3,700-4,600	6,100-14,400	337-727	9,000-16,800	169	707	-
References	3, 4, 9	7, 15	5, 13	6	1, 10	1, 12	11	1, 8	2	14	8

TABLE II

BIOCONCENTRATION FACTORS

Organism \ Compound	PCB	DDT	Kepone	Heptachlor	Toxaphene	Endrin	Lindane	Dieldrin
Eastern Oyster Crassostrea virginica	101,000	42,200-76,300	9,354	3,900-8,500	9,000-15,200	2,780	-	5,100-5,500
Grass Shrimp Palaemonetes pugio	27,000	-	11,425 5,127 698	500-700	800-1,200	-	25-80	-
Blue Crab Callinectes sapidus	230,000	-	8.1	-	-	-	-	-
Spot Leiostomus xanthurus	37,000	-	1,221	-	-	-	-	-
Sheepshead Minnow Cyprinodon variegatus	30,000	-	7,200 1,548	7,400-21,300	3,100-20,000	6,400	337-727	-
Pinfish Lagodon rhomboides	17,000	11,000-40,000	-	2,800-7,700	3,800-3,900	-	-	-
References	2, 5, 6, 7 11, 13, 14	4, 10	1, 9, 17	15	16	8, 12	17	3

TABLE I

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