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Chlordane Contamination in Selected Freshwater Finfish of New Jersey

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Chlordane (1,2,4,5,6,7,8,8-octachloro-3α,4,7,7α-tetrahydro-4 , 7-methanoindane) , a complex technical mixture of chlorinated organic compounds used in pesticide formulations , tends to bioaccumulate in freshwater and marine food chains because of its great stability and persistence, its lipophilic properties, and its history of being poorly metabolized by biological systems . This contaminant poses a toxic threat to aquatic organisms in acute exposures, directly impacting the central nervous system. Chronic exposures produce a variety of sublethal effects as well, most notably related to altered blood chemistry and enzymatic activity. Nevertheless, many questions remain unanswered regarding the behavior and sublethal effects of chlordane in many aquatic organisms . Chlordane is a known carcinogen in test animals, and a suspected human carcinogen (Shigenaka 1990) . Due to the potential dangers of chlordane on human health and its bioaccumulation in susceptible aquatic organisms , monitoring surveys undertaken in New Jersey waters during the past decade have focused on the uptake of the contaminant by finfish and shellfish suitable for human consumption.

The objective of this work is to examine chlordane contamination in three freshwater finfish species (brown bullhead, *Ictalurus nebulosus;* carp, *Cyprinus carpio;* and largemouth bass, *Micropterus salmoides)* collected in the Camden, Delaware, and northeast regions of the state during two survey periods (1986-1987 and 1988-1991). Temporal and spatial trends of chlordane contamination in these species are based on analysis of the entire database. Recommendations are also presented to consumers of the edible finfish species for minimizing their intake of chlordane.

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MATERIALS AND METHODS

Since 1975, the New Jersey Department of Environmental Protection (NJDEP) has conducted comprehensive monitoring surveys of PCBs, DDT, and chlordane in freshwater, estuarine, and coastal marine systems of New Jersey. Under direction of the Office of Toxic Substances Research - later known as the Office of Science and Research and currently the Division of Science and Research - the Division of Fish, Game and Wildlife, and the Bureau of Water Monitoring, the surveys have concentrated on organochlorine contamination of finfish and shellfish of recreational or commercial importance. The principal goals of these surveys are to determine the level of contamination of PCBs, DDT, and chlordane in selected finfish and shellfish species, to delineate the variations of these compounds in fish and geography, and to assess the suitability of fish for human consumption. Results of the monitoring surveys on PCBs and DDT are treated elsewhere (Kennish et al. 1992; Kennish and Ruppel 1996a, b). This work reviews the findings of monitoring surveys conducted on chlordane contamination in New Jersey freshwater finfish.

NJDEP sampling locations for assessing organochlorine contaminants in aquatic biota of the state are grouped into six geographic regions: (1) northeast (sites within the Hudson, Raritan, Hackensack, and Passaic River drainages) ; (2) north coast (all ocean sites and estuarine sites between Sandy Hook and Seaside Park) ; (3) south coast (all ocean sites and estuarine sites between Sandy Hook and Seaside Park); (4) Atlantic (site 46 off Barnegat Inlet); (5) Delaware (sites on the main stem of the Delaware River, tributaries to the river excluding the Camden area, and tributaries to Delaware Bay) ; and (6) Camden (sites within Stewart Lake, Cooper River, Pennsauken Creek, and Newton Creek drainages) . Figure 1 shows the location of all NJDEP sampling sites. In this study, finfish samples were collected only from sites in the northeast, Delaware, and Camden regions. Hauge et al. (1990) and Hauge (1993) provide additional information on the sampling regions.

Finfish samples were collected by seine and hook and line. The general condition and occurrence of physical abnormalities in the finfish were noted at the time of sampling. All samples were identified to species level, weighed, measured, and frozen at approximately -29.4°C until processed in the laboratory.

Finfish sample processing in the laboratory involved excising scaled fillets with the skin intact. The

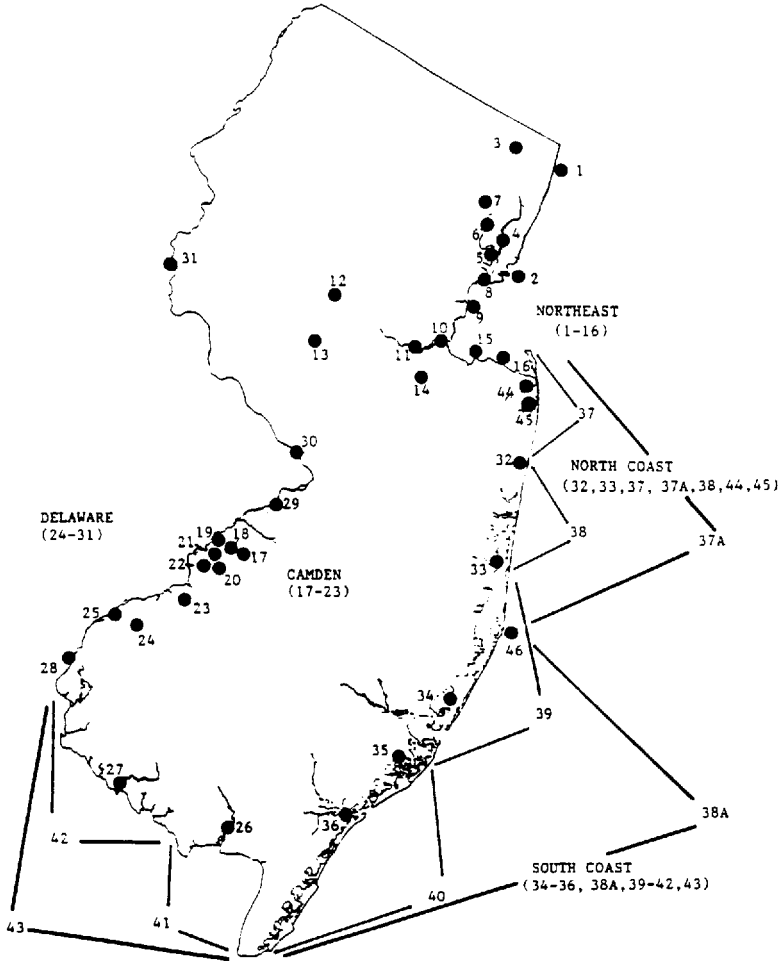

Figure 1. Biotic sampling sites for the chlordane monitoring program in New Jersey during 1986–1987 and 1988-1991 (From Hauge 1993)

standard fillet employed in this investigation was defined as the portion of the fish bounded anteriorly by the pectoral fin and posteriorly by the caudal fin, and from the mid-dorsal line to the mid-ventral line, including the rib cage and belly flap. The standard fillet was used as an individual sample from a single fish or combined with other individuals of the same species and size to form a composite sample usually consisting of five fish. A total of 100 g of tissue was removed from each fish by cutting from the anterior section of the fillet and proceeding posteriorly until 100 g in weight were obtained. For extremely large fish, three cross sections of the fillet - one from behind the pectoral fins, one from halfway between the

first slice and the vent, and one from behind the vent – were taken and combined to yield the 100–g portion. Each five-fish composite sample weighed 500 g and, prior to laboratory analysis, was thoroughly homogenized, packaged in aluminum foil, labeled, and stored frozen at approximately –29.4°C.

Finfish samples were analyzed according to established government guidelines. Homogenized tissue samples were extracted and quantified by gas chromatography at the New Jersey Department of Health laboratory employing a Tracer model 222 gas chromatograph with an electron capture detector. Methods of the U.S. Environmental Protection Agency (1980) for pesticide analysis were applied with slight modification in the initial tissue preparation and extraction sections. Ten grams of tissue were Soxhlet–extracted for 6 hours in a 3:1 hexane-acetone mixture. The extract was then isolated and cleaned up using gel permeation chromatography. The final extract was concentrated, characterized by gas chromatography, and quantified by comparison with standards of chlordane.

Quality control followed U.S. Environmental Protection Agency guidelines (U.S. Environmental Protection Agency, 1976) . A component of the quality control procedures included spiking muscle tissue of one sample with appropriate standards, as well as analyzing replicates of one of the samples in a set. These recoveries were calculated using the 95% confidence interval (± 2 standard deviations) for the mean of the spiked component in the control sample.

RESULTS AND DISCUSSION

Table 1 lists the mean concentrations of chlordane found in each target species by region during the 1986–1987 and 1988–1991 sampling periods. Chlordane typically occurs in highest concentrations in finfish samples collected from the northeast and Camden regions. For example, during the 1986-1987 sampling period the mean concentration of chlordane in carp from the northeast region amounted to 334 µg/kg wet wt, which exceeded the FDA action level of 300 µg/kg wet wt for this contaminant . Chlordane levels in brown bullhead and largemouth bass samples were highest in the Camden region, with mean concentrations being 124 and 21.2 µg/kg wet wt, respectively. The Delaware region exhibited the lowest mean chlordane concentrations during this sampling period, as demonstrated by carp (51.4 µg/kg wet wt) and brown bullhead (5.83 µg/kg wet wt) measurements.

Table 1. Concentrations of chlordane by region in selected freshwater finfish of New Jersey during the 1986-1987 and 1988-1991 sampling periods.[1,2]

Sampling Period	Species	Region		
		Camden	Delaware	Northeast
1986-1987	Brown Bullhead	124 ± 89 (8)	5.83 ± 0.8 (2)	72.9 ± 55 (2)
	Carp	260 ± 146 (13)	51.4 ± 19.7 (3)	334 ± 147 (4)
	Largemouth Bass	21.2 ± 11 (5)	No Samples	12.9 ± 0 (1)
1988-1991	Brown Bullhead	102 ± 44.2 (8)	64.8 ± 64.2 (4)	52.8 ± 0 (1)
	Carp	275 ± 0 (1)	No Samples	149 ± 73.7 (1)
	Largemouth Bass	47.6 ± 33.6 (2)	5.0 ± 0 (1)	No Samples

[1]Values in µg/kg wet weight
[2]Number in individuals sampled in parentheses

Chlordane concentrations remained highest in finfish samples from the northeast and Camden regions during the 1988-1991 sampling period. For instance, the highest mean value of chlordane contamination in carp (275 µg/kg wet wt) was recorded in the Camden region; a lower mean value in this species (149 µg/kg wet wt) was registered in the northeast region. Similarly, peak levels of chlordane in the brown bullhead (102 µg/kg wet wt) and largemouth bass (47.6 µg/kg wet wt) were documented in the Camden region. The mean concentration of chlordane in the brown bullhead and largemouth bass from the Delaware region equalled 64.8 µg/kg wet wt and 5.0 µg/kg wet wt, respectively.

Results of the chlordane surveys are consistent with those of DDT and PCB surveys reported elsewhere, which show that finfish in the northeast and Camden regions of the state are the most severely contaminated (Hauge et al. 1990; Hauge 1993; Kennish et al. 1992; Kennish and Ruppel 1996a, b). Although restrictive regulations on the use of chlordane in the U.S. were initially implemented in 1974, this contaminant has persisted in freshwater and marine environments nationwide. Hence, the 1986-1987 bioaccumulation study conducted by the U.S. Environmental Protection Agency indicated variable levels of chlordane contamination in finfish and shellfish from about 60 estuarine and coastal marine sites in the U.S. In addition, NOAA's National Status and Trends Program between 1984 and 1988 uncovered chlordane contamination, albeit to a relatively minor degree, in estuarine and coastal marine systems along much of the nation's coastline (Shigenaka 1990). Because chlordane resists degradation and persists in aquatic environments, it will likely be found for many years by environmental monitoring and assessment programs in New Jersey and nationwide.

This study revealed the widespread occurrence of chlordane in the tissues of freshwater finfish in New Jersey, including recreationally important species. Lipid-rich finfish species tend to accumulate the greatest concentrations of organochlorine compounds (Kennish 1992; Kennish et al. 1992; Kennish and Ruppel 1996a, b). The existing framework of state consumption advisories, prohibitions, and sales bans provides an effective strategy for protecting the public from excessive exposure and biomagnification effects of the organochlorine contaminants in edible finfish species. This framework may also protect the finfish-consuming public from exposure to other contaminants in the organisms as well.

Several recommendations can be advanced to further reduce the public's risk to chlordane contamination.

First, regular monitoring of contaminant levels in finfish and shellfish should continue. A more intense sampling program is also needed to accurately characterize the variation in biotic contamination in future years. Sound management decisions concerning the issue of seafood contamination depend on adequate and reliable data. Second, the aforementioned protective measures (i.e., consumption advisories, prohibitions , and sales bans) for seafood consumers should be continually re–evaluated in light of new information as it becomes available, either through direct monitoring programs or other sources. Third, consumers can take a more active role in reducing their intake of the contaminants by properly preparing edible finfish for cooking and by using cooking techniques that minimize chlordane exposure. Included in these techniques are fat stripping (e.g., skin, belly flap, and lateral line) of lipid–rich species and the draining away of fats during the cooking process.

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