U. S. GEOLOGICAL SURVEY

WATER-QUALITY ASSESSMENT OF THE ALBEMARLE-PAMLICO DRAINAGE BASIN, NORTH CAROLINA AND VIRGINIA— Organochlorine compounds in Asiatic clam (*Corbicula fluminea*) soft tissues and whole redbreast sunfish (*Lepomis auritus*), 1992-93

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INTRODUCTION

The analysis of potential contaminants in biological tissues is an important part of many water-quality assessment programs, including the National Water-Quality Assessment (NAWQA) Program. Tissue analyses often are used to provide information about (1) direct threats to human health and ecosystem integrity, and (2) the occurrence and distribution of potential contaminants in the environment. The use of tissue analyses in the NAWQA Program concentrates on the second objective of providing information about the occurrence and distribution of potential contaminants in the Nation's surface-water resources.

In their guidelines for NAWQA tissue sampling, Crawford and Luoma (1993) recognize four important attributes of tissue analysis. First, tissue analysis can increase the likelihood of detecting small amounts of contaminants because contaminant concentrations can be higher in tissues than in water. Second, tissues can "store" time-averaged measurements or records of the presence of contaminants in the environment. Third, tissue analysis is a direct measurement of the contaminants that accumulate in biological organisms; and finally, integrating tissue analysis with water and sediment analysis produces complementary information about contaminant fate, distribution, and effects.

During 1992-93, Asiatic clam (*Corbicula fluminea*) soft tissues and whole redbreast sunfish (*Lepomis auritus*) samples were collected and analyzed to obtain information about the occurrence and distribution of organochlorine compounds in the Albemarle-Pamlico Drainage Basin of North Carolina and Virginia (fig. 1). This investigation was conducted as part of the NAWQA Program. The purpose of this report is to briefly summarize the results of this investigation.

HIGHLIGHTS

- Relatively few organochlorine compounds were detected and of the compounds detected, all were detected in relatively low concentrations (table 1).
- Organochlorine compounds detected were p,p'-DDD, p,p'-DDE, p,p'-DDT, dieldrin, trans-nonachlor, PCB's, and toxaphene.
- p,p'-DDE was the most common and widespread organochlorine detected.
- Multiple compounds were detected at 6 of 19 sites sampled.
- Compared to the Asiatic clam, redbreast sunfish appear to be better bioindicators of organochlorine contamination in aquatic systems.
- Except for one detection of toxaphene, pesticide concentrations are well below the National Academy of Sciences and National Academy of Engineering (NAS/NAE) guidelines for the protection of fish-eating wildlife.

NATIONAL WATER-QUALITY ASSESSMENT PROGRAM (NAWQA)

The U. S. Geological Survey's NAWQA Program is designed to assess historical, current, and future water-quality conditions in a large, representative part of the Nation's surface- and ground-water resources, and to examine the natural and human factors that affect the quality of these water resources (Leahy and others, 1990). Understanding the major factors that affect water quality at local, regional, and national levels can provide a scientific basis for water-management decisions.

NATIONAL NAWQA STUDY UNITS WITHIN THE CONTERMINOUS UNITED STATES

This map shows the location of the Albemarle-Pamlico study unit in relation to other NAWQA units located within the conterminous United States. Other NAWQA units are located in Alaska and Hawaii.

BASIN DESCRIPTION

The Albemarle-Pamlico Drainage Basin is one of 60 NAWQA study-units nationwide. The study area encompasses about 28,000 square miles (mi^2) in central and eastern North Carolina and southern Virginia and includes four major river basins--the Chowan, Roanoke, Tar, and Neuse. The Albemarle-Pamlico Drainage Basin extends through parts of four physiographic provinces--Valley and Ridge, Blue Ridge, Piedmont, and Coastal Plain. About 50 percent of the land is forested; 30 percent is cropland; 15 percent is wetland, and 5 percent is developed (Woodside and Simerl, 1995). The barrier islands, estuaries, and associated sounds in the drainage basin are not included in the NAWQA study area.

SELECTION OF TAXA FOR ANALYSIS

The NAWQA Program's emphasis on providing information about the occurrence and distribution of potential contaminants influences the selection of targeted species and sampling methods. NAWQA guidelines for studies of contaminants in tissues promote national consistency by recommending the analysis of a specific suite of organisms and tissues. This suite of organisms and tissues is designated on NAWQA's National Target Taxa (NATT) list (Crawford and Luoma, 1993). This list and the guidelines for applying it provided the basis for targeting Asiatic clam soft tissues and whole redbreast sunfish for the Albemarle-Pamlico NAWQA study.

The NATT list places highest priority on the selection of Asiatic clams for analysis because they are widely distributed nationally, remain in one location, and accumulate both inorganic and organic contaminants (Crawford and Luoma, 1993). If Asiatic clams cannot be found at a site, the NATT list recommends targeting appropriate aquatic insects or whole organisms of bottom-feeding fishes. For the Albemarle-Pamlico NAWQA study, redbreast sunfish were targeted if Asiatic clams could not be found because they were the only fish species that could be consistently captured at a majority of the sites. Redbreast sunfish are generalist predators which eat insects, molluscs, arthropods, and even fish (Jenkins and Burkhead, 1993). Sites where neither Asiatic clams nor redbreast sunfish could be found were eliminated from the study.

STUDY DESIGN

During 1992-93, a total of 25 tissue samples were collected from 19 sites in the Albemarle-Pamlico NAWQA study unit (fig. 1; table 2). The sites were selected to include (1) as many of the NAWQA fixed water-quality monitoring sites in the study area as possible, (2) targeted land uses, and (3) sites that improved spatial distribution. Of the 12 NAWQA fixed water-quality stations, 9 were sampled. Fixed stations are locations where physical, chemical, and biological data are collected and assessed. The fixed stations are selected to represent a range of spatial and temporal scales and environmental settings in the study area and are of two types--integrator and indicator.

Integrator sites are established at downstream points in large drainage basins that collect water from hundreds or thousands of square miles. These sites reflect effects from many different kinds of land uses. Indicator sites are located in relatively small drainage areas (generally less than 100 mi^2) that are typically dominated by one or two land uses. These sites are selected to represent certain land uses that could be related to water-quality characteristics (Spruill and others, 1995). For the organic tissue analyses, the majority of the sampling effort was concentrated in integrator and indicator sites in the Coastal Plain.

In 1992, Asiatic clams were collected at 15 sites (table 2). Seven of these sites are integrator stations located in the Coastal Plain. Asiatic clams also were collected at two integrator sites in the Piedmont--Tar River near Tar River (fig. 1, site 8) and Swift Creek near Hilliardston (fig. 1, site 9). The remaining six Asiatic clam samples were collected from indicator sites--four in the Piedmont and two in the Coastal Plain. Of the sites sampled in the Piedmont, two are located in urban settings.

In 1993, redbreast sunfish were collected at eight sites (table 2). Excluding Devils Cradle Creek (fig. 1, site 7), a small Piedmont stream, all redbreast sunfish were collected from sites in the Coastal Plain. Four of the eight sites sampled for redbreast sunfish are mixed-landuse integrator sites. The remaining four sites are fixed indicator stations where the land use is primarily agricultural. Of the eight sites sampled in 1993, four were sites where Asiatic clams had been collected the previous year (table 2).

Organochlorine Compounds Detected

The samples were analyzed at the U.S. Geological Survey's National Water Quality Laboratory (NWQL) for 28 organochlorine compounds targeted by the NAWQA Program (table 1). Seven of the 28 organochlorine compounds analyzed were detected in concentrations above the minimum reporting level (table 1). Organochlorine compounds detected include p,p'-DDD, p,p'-DDE, p,p'-DDT, dieldrin, trans-nonachlor, polychlorinated biphenyls (PCB's), and toxaphene.

One or more organochlorine compounds were detected at 60 percent of the sites. The most common and widespread compound detected was p,p'-DDE. At 5 of the 11 sites where compounds were detected, p,p'-DDE was the only organochlorine detected above the minimum reporting level. Four of the seven organochlorine compounds detected at sampling sites in the Albemarle-Pamlico Drainage Basin also were among the most commonly detected compounds in the U.S. Environmental Protection Agency's (U.S. EPA's) National Study of Chemical Residues in Fish (NSCRF).

In the NSCRF, p,p'-DDE, trans-nonachlor, PCB's, and dieldrin were detected at more than 60 percent of the 362 sites sampled (U.S. Environmental Protection Agency, 1992).

Of the seven organochlorine compounds detected in the study area, all have been banned or restricted in the United States (table 3), yet they still persist in the environment. The well-known chemical stability and persistence of p,p'-DDE, a metabolic breakdown product of DDT, is evident by its presence at 11 of 19 sites sampled. Dieldrin, which is highly toxic to marine and freshwater fish, was detected at three sites even though its production was banned in 1974 (U.S. Environmental Protection Agency, 1993). Trans-nonachlor, a component of chlordane, was detected at three sites. Although chlordane, which is less toxic than dieldrin, has not been shown to biomagnify, it has been shown to bioconcentrate in many aquatic species (Virginia Water Control Board, 1990). One detection of toxaphene was measured at a concentration slightly higher than the minimum reporting level and exceeded the National Academy of Sciences and National Academy of Engineering (NAS/NAE) guidelines (Nowell and Resek, 1994) for the protection of fish-eating wildlife. After the ban on DDT in 1972, toxaphene became one of the most heavily used pesticides in the United States (U.S. Environmental Protection Agency, 1993). This compound is known to accumulate in aquatic organisms and has deleterious effects on nontarget aquatic biota even at extremely low concentrations (Eisler and Jacknow, 1985). PCB's, compounds used primarily by industry, were detected at two large river sites within the study area. PCB's, are a group of 209 different congeners and, therefore, are difficult to analyze and assess. The production of these extremely persistent compounds was banned by the U.S. EPA in 1979 (U.S. Environmental Protection Agency, 1993). All seven of the organochlorine compounds detected in the Albemarle-Pamlico Drainage Basin are recommended by the U.S. EPA to be included as target analytes in fish and shellfish contaminant monitoring programs (U.S. Environmental Protection Agency, 1993).

Table 1. Organochlorine compounds analyzed

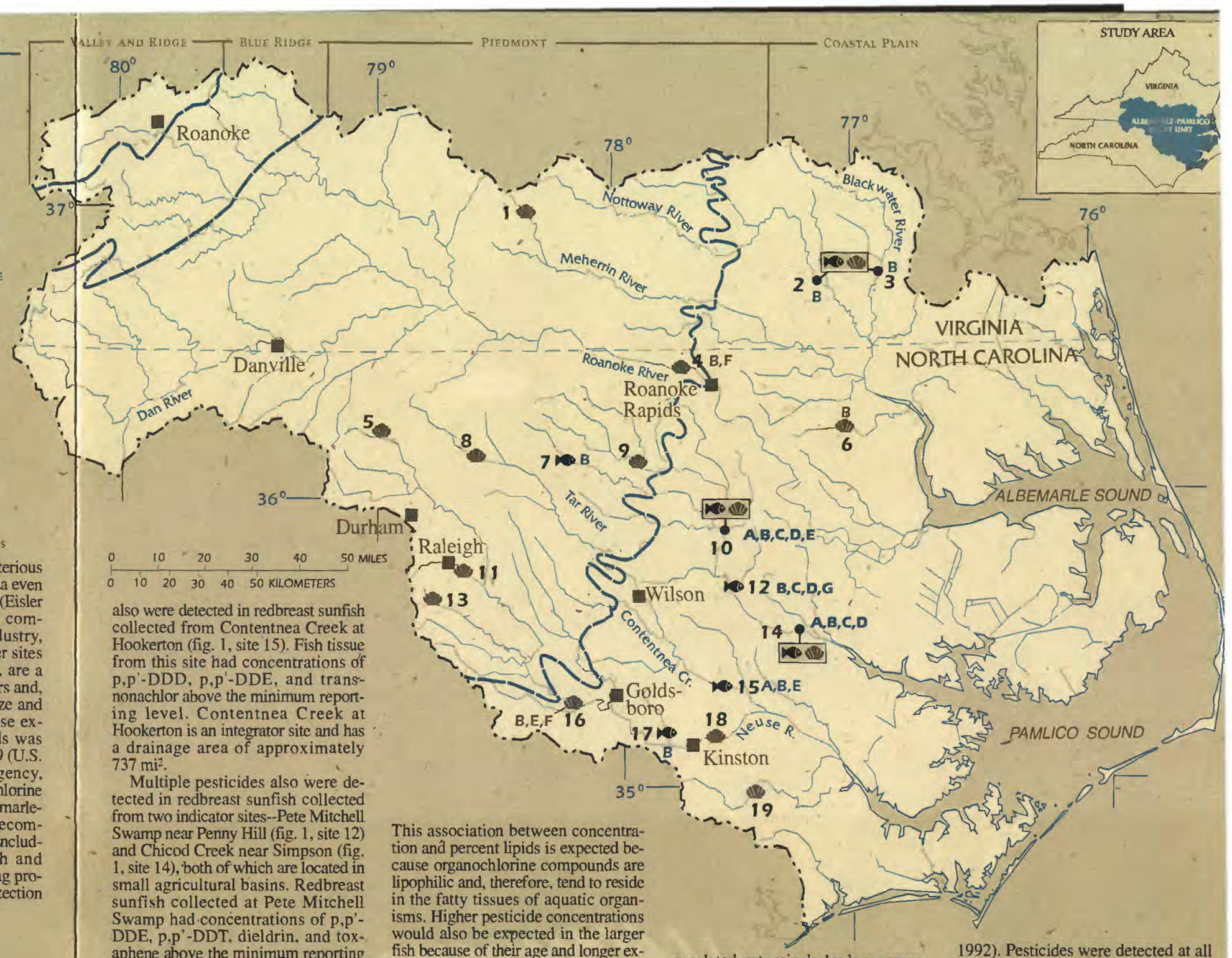
(NAS/NAE, National Academy of Sciences and National Academy of Engineering; MRL, minimum reporting level; µg/kg, microgram per kilogram; nsg, no standard or guideline reported for this compound in the cited reference; -, no detections)

Chemical Name	[1]NAS/NAE recommended maximum tissue concentrations (µg/kg) (wet weight)	MRL (µg/kg) (wet weight)	Number of samples greater than MRL/total number of samples		Maximum value (µg/kg) (wet weight)
			Asiatic clam	Redbreast sunfish	
Aldrin	[2]100	5	-	-	-
Chlordane, cis	[2]100	5	-	-	-
Chlordane, trans	[2]100	5	-	-	-
Dacthal(DCPA)	nsg	5	-	-	-
o,p'-DDD	nsg	5	-	-	-
o,p'-DDE	nsg	5	-	-	-
o,p'-DDT	nsg	5	-	-	-
p,p'-DDD	[3]1000	5	-	5/10	36
p,p'-DDE	[3]1000	5	3/15	10/10	130
p,p'-DDT	[3]1000	5	-	5/10	44
Dieldrin	[2]100	5	-	3/10	22
Endrin	[2]100	5	-	-	-
Heptachlor	[2]100	5	-	-	-
Heptachlor epoxide	[2]100	5	-	-	-
Hexachlorgbenzene(HCB)	nsg	5	-	-	-
Hexachlorocyclohexane(HCH), alpha	nsg	5	-	-	-
Hexachlorocyclohexane(HCH), beta	nsg	5	-	-	-
Hexachlorocyclohexane(HCH), delta	nsg	5	-	-	-
Lindane	[2]100	5	-	-	-
o,p'-Methoxychlor	nsg	5	-	-	-
p,p'-Methoxychlor	nsg	5	-	-	-
Mirex	nsg	5	-	-	-
Nonachlor, cis	nsg	5	-	-	-
Nonachlor, trans	**nsg**	5	1/15	4/10	8.8
Oxychlordane	nsg	5	-	-	-
PCB's	**nsg**	50	2/15	-	130
Pentachloroanisole	nsg	5	-	-	-
Toxaphene	[2]100	200	-	1/10	210

[1] Nowell and Resek, 1994.

[2] Applies to total residues for aldrin, BHC, chlordane, dieldrin, endosulfan, endrin heptachlor, heptachlor epoxide, lindane, and toxaphene, either singly or in combination.

[3] Applies to total DDT residues, including DDE and DDD.



Sampling Sites with Multiple Detections

Multiple detections of the organochlorine compounds analyzed in tissue were found at 6 of 19 sites sampled. Four of these sites are on large streams, and two sites are on small Coastal Plain streams. More than one pesticide was detected in redbreast sunfish tissue samples from the Tar River, Contentnea Creek, Pete Mitchell Swamp, and Chicod Creek. Multiple compounds were detected in Asiatic clam tissue samples from the Roanoke and Neuse Rivers.

Redbreast Sunfish

Redbreast sunfish collected from Tar River at Tarboro (fig. 1, site 10), an integrator site, had concentrations of p,p'-DDD, p,p'-DDE, p,p'-DDT, dieldrin, and trans-nonachlor above the minimum reporting level. The Tar-Pamlico River Basin is the third largest in the Albemarle-Pamlico study area (McMahon and Lloyd, 1995), and the drainage area at this site is approximately 2,220 mi^2. Multiple pesticides also were detected in redbreast sunfish collected from Contentnea Creek at Hookerton (fig. 1, site 15). Fish tissue from this site had concentrations of p,p'-DDD, p,p'-DDE, and trans-nonachlor above the minimum reporting level. Contentnea Creek at Hookerton is an integrator site and has a drainage area of approximately 737 mi^2.

Multiple pesticides also were detected in redbreast sunfish collected from two indicator sites--Pete Mitchell Swamp near Penny Hill (fig. 1, site 12) and Chicod Creek near Simpson (fig. 1, site 14), both of which are located in small agricultural basins. Redbreast sunfish collected at Pete Mitchell Swamp had concentrations of p,p'-DDE, p,p'-DDT, dieldrin, and toxaphene above the minimum reporting level. This basin has a drainage area of 17 mi^2 and is predominantly rural, and 59 percent of the land is dedicated to agriculture. Narrow vegetated buffer strips characterize this channelized Coastal Plain stream. Unlike Pete Mitchell Swamp, Chicod Creek is bounded by broad cypress and tupelo wetlands. Redbreast sunfish collected from this stream had concentrations of p,p'-DDD, p,p'-DDE, p,p'-DDT, and dieldrin above the minimum reporting level. This basin has a drainage area of 42 mi^2, and approximately 47 percent of the land is in agricultural use. Redbreast sunfish analyses from Pete Mitchell Swamp and Chicod Creek suggest a relation between lipid content and pesticide concentrations. Redbreast sunfish collected from these two indicator streams have the highest levels of p,p'-DDE as well as the highest percentage of lipids (fig. 2). Concentrations of dieldrin also were the highest in samples from these two sites. In addition, the only fish tissue sample with a concentration of toxaphene above the minimum reporting level was from Pete Mitchell Swamp. This association between concentration and percent lipids is expected because organochlorine compounds are lipophilic and, therefore, tend to reside in the fatty tissues of aquatic organisms. Higher pesticide concentrations would also be expected in the larger fish because of their age and longer exposure times; however, data in this study do not indicate a strong relation between average fish size and detected pesticide concentrations.

Asiatic Clam

Multiple organochlorine compounds were detected in Asiatic clam samples collected at two integrator sites--Neuse River near Cox Mill (fig. 1, site 16) and Roanoke River at Roanoke Rapids (fig. 1, site 4). Asiatic clam samples collected from Neuse River near Cox Mill had concentrations of p,p'-DDE, trans-nonachlor, and PCB's above the minimum reporting level. The Neuse River Basin is the fourth largest river basin in the study area, and the sampling site near Cox Mill has a drainage area of approximately 1,675 mi^2.

PCB's and p,p'-DDE also were detected in Asiatic clam samples from Roanoke River at Roanoke Rapids. This site has a drainage area of 8,434 mi^2, the largest of the sites sampled. The Roanoke River Basin is also the largest basin in the study area and is regulated extensively by large reservoirs (McMahon and Lloyd, 1995).

Field data indicate that Asiatic clam samples collected from these two integrator sites had the longest average length compared to other clam samples analyzed. These analyses suggest that the presence of pesticides is more pronounced in the larger clams. It is noted that PCB's were detected only in the Asiatic clam samples.

Comparison of Species as Bioindicators

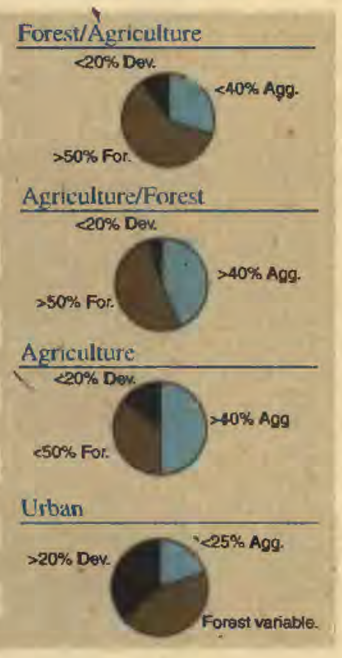
Data from this study indicate that when compared to the Asiatic clam, redbreast sunfish appear to be better bioindicators of organochlorine contamination in aquatic systems. Of the seven compounds detected, all but PCB's were detected in the redbreast sunfish samples; only three compounds--p,p'-DDE, trans-nonachlor, and PCB's--were detected in Asiatic clam samples. This supports other studies which have shown that Asiatic clams are good bioindicators of PCB contamination (Peterson and others, 1992). Pesticides were detected at all eight sites sampled for redbreast sunfish, whereas only 3 of the 15 sites sampled for Asiatic clams had detections above the minimum reporting level. In every fish analysis, p,p'-DDE was detected. In comparison, only three Asiatic clam samples had levels of p,p'-DDE above the minimum reporting level. Of the four sites where both species were collected, only the redbreast sunfish had concentrations above the minimum reporting level. In general, there was a greater occurrence of organochlorine compounds in redbreast sunfish samples than in Asiatic clam samples.

Toxicity

Institutions such as Federal and State agencies have determined standards and guidelines which can be used to indicate tissue concentrations that may have toxic effects on human health, aquatic organisms, or wildlife. These standards and guidelines are commonly applied by comparing them to measured concentrations of individual compounds.

TABLE 2. STATIONS IN THE ALBEMARLE-PAMLICO BASIN WHERE ASIATIC CLAMS AND REDBREAST SUNFISH WERE COLLECTED FOR ORGANIC ANALYSES, 1992-93

Map number	Station name and number (Indicator sites in black; Integrator sites in brown)	Species collected	Drainage area (in square miles)	Physiographic province	Land-use type
1	North Meherrin River near Lunenburg, Va. (02051000)	clam	56	Piedmont	Forest/Agriculture
2	[1] Nottoway River near Sebrell, Va. (02047000)	fish, clam	1,433	Coastal Plain	Forest/Agriculture
3	[1] Blackwater River near Franklin, Va. (02049500)	fish, clam	602	Coastal Plain	Forest/Agriculture
4	Roanoke River at Roanoke Rapids, N.C. (02080500)	clam	8,434	Coastal Plain	Forest/Agriculture
5	North Flat River at Timberlake, N.C. (02085390)	clam	33	Piedmont	Agriculture
6	Ahoskie Creek near Poor Town, N.C. (02053490)	clam	54	Coastal Plain	Forest/Agriculture
7	[1] Devils Cradle Creek near Alert, N.C. (02082731)	fish	13	Piedmont	Agriculture
8	Tar River near Tar River, N.C. (02081500)	clam	165	Piedmont	Agriculture/Forest
9	Swift Creek at Hilliardston, N.C. (02082770)	clam	172	Piedmont	Agriculture/Forest
10	[1] Tar River at Tarboro, N.C. (02083500)	fish, clam	2,220	Coastal Plain	Forest/Agriculture
11	Crabtree Creek at US 1 at Raleigh, N.C. (02087324)	clam	122	Piedmont	Urban
12	[1] Pete Mitchell Swamp near Penny Hill at SR 1409, N.C. (02083833)	fish	17	Coastal Plain	Agriculture
13	Swift Creek near Apex, N.C. (02087580)	clam	20	Piedmont	Urban
14	[1] Chicod Creek at SR 1760 near Simpson, N.C. (02084160)	fish, clam	42	Coastal Plain	Agriculture
15	[1] Contentnea Creek at Hookerton, N.C. (02091500)	fish	737	Coastal Plain	Agriculture
16	Neuse River near Cox Mill, N.C. (02089500)	clam	1,675	Coastal Plain	Forest/Agriculture
17	[1] Bear Creek at Mays Store, N.C. (0208925200)	fish	59	Coastal Plain	Agriculture
18	[1] Neuse River at Kinston, N.C. (02089500)	clam	2,700	Coastal Plain	Forest/Agriculture
19	Trent River near Trenton, N.C. (02092500)	clam	172	Coastal Plain	Forest/Agriculture



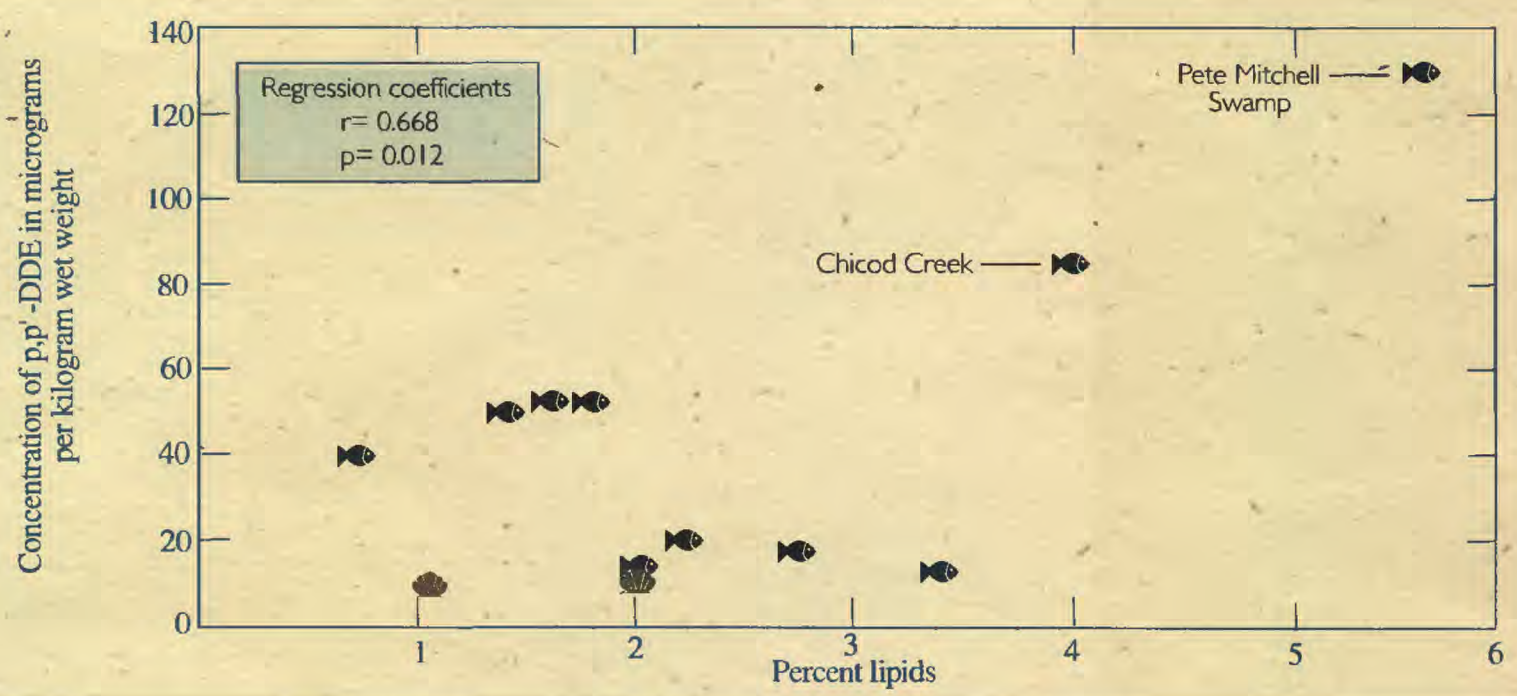
[1] Indicates a NAWQA fixed station.

TABLE 3. GENERAL USE AND REGISTRATION OF CHEMICALS CITED

Chemical name	General use	Registration
Chlordane, total (cis- and trans-chlordane, cis- and trans-nonachlor, oxy-chlordane)	A multipurpose insecticide used in home and agricultural applications to control termites and many other insects.[1]	In 1978, EPA restricted chlordane use to subterranean termite control, nonfood plants, and root dip. In 1987, EPA limited retail sale and use to licensed applicators.[4]
DDT, total (o,p'-DDD, o,p'-DDE, o,p'-DDT, p,p'-DDD, p,p'-DDE, p,p'-DDT)	Prior to 1972, primary uses were in medical entomology (suppressing insect vector populations) and agricultural insect control.[2]	In 1972, EPA restricted the use of DDT only to extreme emergency situations. In 1985, ALL uses of DDT in the U.S. were banned.[2]
Dieldrin	A broad spectrum pesticide primarily used for termite control.[1]	EPA banned the production and most major uses in 1974. In 1987, all used were voluntarily canceled by industry.[1]
PCB's	Compounds mostly used in industrial systems (i.e. plasticizers, lubricants, dielectric fluids in electrical capacitors and transformers); PCB's were not intended to be released directly into the environment.[1]	In 1979, the U.S. banned their production and use.[1]
Toxaphene	A broad spectrum insecticide used mainly on cotton. For many years toxaphene was the most heavily used pesticide in the U.S.[3]	In 1982, the EPA canceled the registration of toxaphene for most uses.[3]

[1] U.S. Environmental Protection Agency, 1993 [2] Virginia Water Control Board, 1990 [3] Eisler and Jacknow, 1985 [4] Eisler, 1990

FIGURE 2. CONCENTRATION OF P,P'-DDE AGAINST PERCENT LIPID CONTENT OF TISSUE SAMPLES



Data collected for this study cannot be used to assess potential hazards to human health. Standards and guidelines for assessing hazards to human health apply to edible tissues, but the data collected for this study include inedible tissues. Asiatic clams are not considered edible by humans; and although redbreast sunfish are a popular gamefish, the portion analyzed (whole fish) does not represent the edible portion (fillet). This means that Food and Drug Administration action levels, U.S. EPA tolerances, U.S. EPA guidelines for fish tissue concentrations, and recommended screening values are not directly applicable to the results of this study.

For this study, the potential threat of organochlorine compounds to wildlife was assessed by using NAS/NAE guidelines for the protection of fish-eating wildlife. These recommended guidelines apply to whole fish. Of the seven organochlorine compounds detected, NAS/NAE guidelines exist for only five compounds--p,p'-DDD, p,p'-DDE, p,p'-DDT, dieldrin, and toxaphene. Observed concentrations of p,p'-DDD, p,p'-DDE, p,p'-DDT, and dieldrin were well below the NAS/NAE guidelines for the protection of fish-eating wildlife. The only detection of toxaphene exceeded the NAS/NAE guidelines (table 1, fig. 3). The reported concentration of toxaphene (210 micrograms per kilogram) was only slightly above the minimum reporting level. It should be noted that toxaphene is a highly complex mixture of over 200 compounds, making analysis extremely difficult (U.S. Geological Survey, 1995). Whole-fish tissue standards are not available for trans-nonachlor and PCB's. For PCB analysis, multiple congeners make it difficult to assess and establish screening values. Although no comparative guidelines exist for these two compounds, concentrations in tissue samples collected in the study area are relatively close to the minimum reporting level.

Summary and Conclusion

In summary, 7 of the 28 organochlorine compounds analyzed were detected in Asiatic clam and whole redbreast sunfish samples collected from selected streams in the Albemarle Pamlico Drainage Basin. All seven of the compounds detected have been banned or restricted, yet their persistence in the environment is evident by their presence at 11 of 19 sites sampled. Multiple compounds were detected at 6 sites with p,p'-DDE being the most common and widespread compound detected. For whole redbreast sunfish, multiple pesticides were detected at four sites in eastern North Carolina--two integrator sites and two indicator sites. For the Asiatic clam, multiple compounds were detected at two large integrator sites. Overall, when compared to the Asiatic clam, redbreast sunfish seem to provide a more complete characterization of both the occurrence and distribution of organochlorine compounds in the Albemarle-Pamlico NAWQA Drainage Basin.

Of the compounds detected, all but toxaphene were present in concentrations well below the NAS/NAE guidelines for the protection of fish-eating wildlife. In general, this study indicates that relatively few organochlorine compounds were detected and of the compounds detected, all were detected in relatively low concentrations; however, because of the toxic nature of these compounds and their ability to adversely affect nontarget organisms, further investigation and monitoring is still warranted.

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(freshwater Asiatic clam)
Corbicula fluminea

The Asiatic clam was introduced to the west coast of the United States in the late 1930's. Presently this freshwater clam can be found across the country due to rapid reproduction and dispersion. (Lauritsen and Mozley, 1983) Adult clam sizes range from 10 to 50 millimeters long (1/3 to 2 inches) (Pennak, 1989).

(redbreast sunfish)
Lepomis auritus

The redbreast sunfish is a native North American freshwater fish. It is found throughout the Atlantic slope from New Brunswick to central Florida and is a popular gamefish in many waters of North Carolina and Virginia. Total length of an adult redbreast sunfish ranges from 90 to 185 millimeters (3 1/2 to 7 1/3 inches) (Jenkins and Burkhead, 1993).

Sample Collection and Analysis

Samples were collected and field-processed in accordance with national NAWQA guidelines for tissue sampling and analysis (Crawford and Luoma, 1993). Asiatic clams were collected from streambeds with modified rakes. Similar sized clams were selected, where possible, for composite samples of 100 to 500 specimens, depending on the size of the clams. The clams were placed in an acid-rinsed stainless-steel container filled with ambient water. The container was then placed in a cooler over ice for a minimum of 24 hours to allow the clams to depurate. Depuration is purification by the excretion of waste material, and the procedure is an attempt to eliminate material from the gastrointestinal tract of the clams. Midway through the depuration period, the water was replaced. For shipment, each composite sample was wrapped in foil, placed in a plastic bag on dry ice, and shipped frozen to the NWQL for further processing and analysis.

Redbreast sunfish were collected by electroshocking and then sacrificed in the field by a sharp blow to the base of the head. Each fish was examined for external anomalies, weighed, and measured for total and standard length. Similar to the Asiatic clam samples, redbreast sunfish of approximately the same size were selected for composite samples of 5 to 10 specimens. For shipment, individual fish were wrapped in foil, bagged, labeled appropriately, and then placed in a second bag containing all of the individual fish for that site. The samples were then placed on dry ice and shipped to the NWQL for whole-fish analysis.

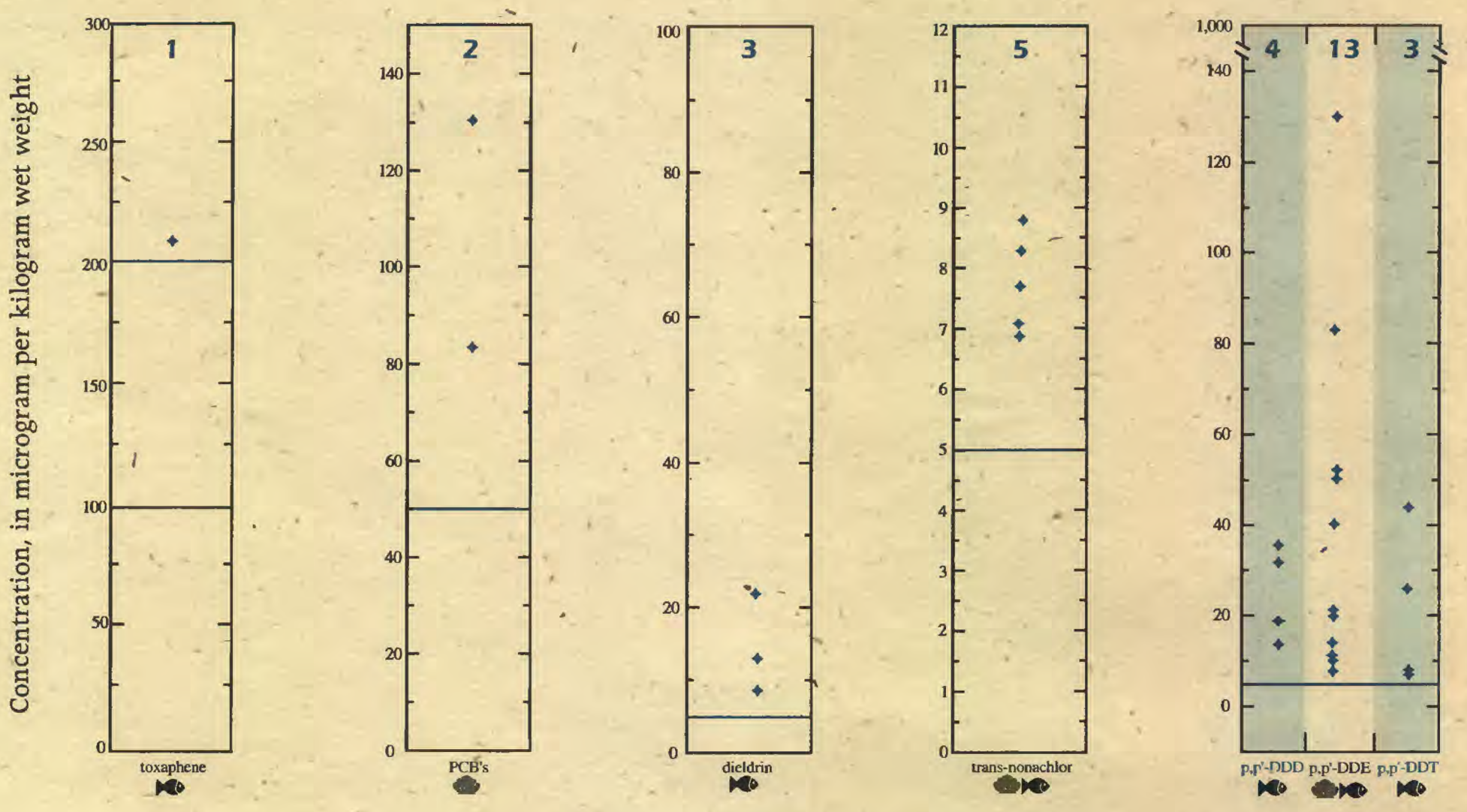
To prevent contamination, all implements used in field processing were carefully washed with phosphate-free detergent and rinsed with methanol. Aluminum foil was used to cover all surfaces on which the fish were placed.

Pesticides and Aquatic Organisms

Pesticides, almost all of which are organic compounds, can be described as "fat loving" and, therefore, will tend to reside in the lipid reservoirs of many aquatic organisms (Ware, 1989).

Many of these organic compounds can bioconcentrate in aquatic organisms, which means chemicals accumulate in tissues at levels greater than the amount in the environment. As pesticides bioconcentrate they also have the ability to increase in concentration at each higher level of the food chain. This is defined as biomagnification. Because humans are often the final consumers and pesticides are toxic by design, their occurrence, distribution, and fate in the environment warrants investigation.

FIGURE 3. CONCENTRATIONS OF ORGANOCHLORINE COMPOUNDS IN ASIATIC CLAMS AND REDBREAST SUNFISH



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