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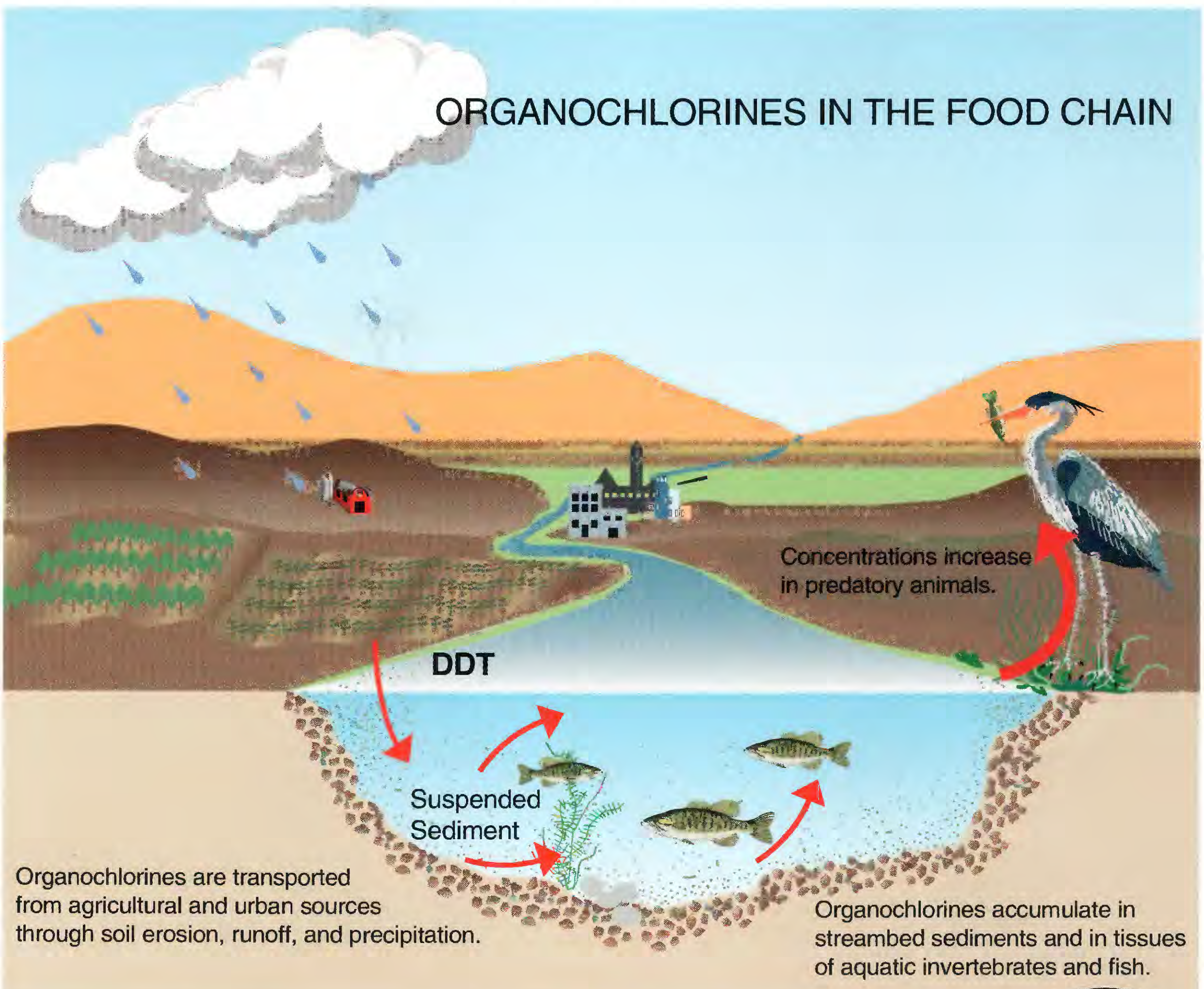
U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 97–4080



NATIONAL WATER - QUALITY ASSESSMENT PROGRAM

Cover: Diagram showing organochlorine bioaccumulation in the food chain.
(Courtesy of Connie Dean, U.S. Geological Survey, Tacoma, Washington)

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By Terry R. Maret *and* Douglas S. Ott

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Water-Resources Investigations Report 97–4080

Boise, Idaho
1997

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

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http://wwwrvares.er.usgs.gov/nawqa/nawqa_home.html

or

http://wwwidaho.wr.usgs.gov/nawqa/usnk_home.html

FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for a specific contamination problem; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequence of new policies.

To address these needs, the Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

•Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.

•Describe how water quality is changing over time.

•Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 60 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 60 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Chief Hydrologist

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
centimeter (cm)	0.3937	inch
gram (g)	0.03527	ounce, avoirdupois
hectare (ha)	2.471	acre
kilometer (km)	0.6214	mile
liter (L)	0.2642	gallon
meter (m)	3.281	foot
millimeter (mm)	0.0394	inch
square kilometer (km^2)	0.3861	square mile

To convert °C (degrees Celsius) to °F (degrees Fahrenheit), use the following equation:

$$°F = (1.8)(°C) + 32$$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated water-quality units:

µg/kg micrograms per kilogram
mg/L milligrams per liter
mL milliliter

ORGANOCHLORINE COMPOUNDS IN FISH TISSUE AND BED SEDIMENT IN THE UPPER SNAKE RIVER BASIN, IDAHO AND WESTERN WYOMING, 1992–94

By TERRY R. MARET *and* DOUGLAS S. OTT

Abstract

Fish-tissue and bed-sediment samples were collected from 20 sites in the upper Snake River Basin in Idaho and western Wyoming as part of the National Water-Quality Assessment Program to determine the occurrence and distribution of organochlorine compounds. During 1992–94, 41 samples were analyzed for 28 different organochlorine compounds in whole-fish tissue and 32 compounds in bed sediment. Sites sampled were third- through seventh-order streams that represented three environmental settings: reference conditions, agricultural land use, and mixed (agricultural and urban) land use. Fourteen organochlorine compounds were detected in fish tissue and nine in bed sediment. All compounds detected in bed sediment also were detected in fish tissue. Fish-tissue and bed-sediment samples from agricultural and mixed land-use sites contained one or more organochlorine compounds. The most frequently detected compound at all sites was p,p'DDE, which was present in 80 percent of the fish-tissue and 30 percent of the bed-sediment samples. A maximum of three compounds were detected, all in fish-tissue samples from reference (forest and rangeland) sites. The highest number of compounds was detected in fish-tissue (nine) and bed-sediment (eight) samples from mixed land-use sites. No clear relation was apparent between the occurrence of external anomalies and fish-tissue contaminant concentrations or land use.

The distribution of organochlorine compounds in the basin was related to land use. Total DDT was detected at sites in all land uses; total PCB was detected at only agricultural and mixed land-use sites. Total chlordane was detected in fish-tissue samples from primarily mixed land-use sites; samples from six of the eight sites contained detectable concentrations. Median concentrations of p,p'DDE in fish-tissue samples from mixed land-use sites were significantly higher ($p<0.05$) than from reference and agricultural sites. Significant positive relations between percent agricultural land and concentrations of total DDT ($r^2=0.41$) and lipid-normalized total DDT ($r^2=0.48$) were observed.

Concentrations of p,p'DDE, total PCB, total DDT, and toxaphene in fish-tissue samples from three mixed land-use sites equaled or exceeded national guidelines established for protection of fish-eating wildlife: Portneuf River at Pocatello, total PCB; Rock Creek at Twin Falls, p,p'DDE, total DDT, and toxaphene; and Snake River near Buhl, p,p'DDE and total DDT. Concentrations of total DDT and p,p'DDE in 32 and 34 percent of fish-tissue samples, respectively, analyzed during this study exceeded the 1980–81 U.S. Fish and Wildlife Service/National Contaminant Biomonitoring Program (USFWS/NCBP) geometric mean concentrations. Concentrations of total PCB in samples from the Portneuf River at Pocatello and concentrations of toxaphene in samples from Rock Creek at Twin Falls also exceeded the USFWS/NCBP geometric mean concentrations.

Comparisons of 1970–84 USFWS/NCBP concentrations of total DDT and total PCB in fish-tissue samples from the Snake River near Hagerman with concentrations measured during this study indicated a decreasing trend. Concentrations of p,p'DDE in all sediment samples from Rock Creek at Twin Falls exceeded the Canadian Probable Effect Level guideline. Total PCB was detected in sediment from only one site, Portneuf River at Pocatello, which was also the only site where concentrations of total PCB in fish tissue were elevated. Because organochlorine compounds are lipophilic and tend to bioaccumulate in tissue, fish are a better indicator of organochlorine contaminant occurrence and distribution than are bed sediment or water in the upper Snake River Basin.

Some of the highest concentrations of organochlorine contaminants in tissue and sediment in the basin were detected at sites receiving irrigation-return flows. Results of this study support the importance of controlling sediment erosion on irrigated land to reduce the quantity of contaminants entering streams that receive irrigation-return flows.

INTRODUCTION

The 92,700-km^2 upper Snake River Basin (USNK) in eastern Idaho and western Wyoming (fig. 1) was 1 of 60 National Water-Quality Assessment (NAWQA) study units selected for assessment in the Nation (Leahy and others, 1990). The surface-water component of the NAWQA Program requires an integrated approach (physical, chemical, and biological) to aid in interpretation and assessment of changes in stream quality (Gurtz, 1994). One component of this integrated approach is examination of the occurrence and distribution of selected organochlorine compounds and trace elements in bed-sediment and fish-tissue samples from the USNK.

The presence of persistent organochlorine compounds in the environment may be related to past and present land use in a watershed. Organochlorine compounds enter the aquatic environment from a variety of sources, including the atmosphere (Majewski and Capel, 1995), industrial and municipal effluents (U.S. Environmental Protection Agency [USEPA], 1992), and agricultural nonpoint-source runoff (Johnson and others, 1988).

Most organochlorine compounds are not highly water soluble. They commonly adsorb on suspended sediment particles and are deposited along stream bottoms. In turn, bottom-sediment contaminants can be ingested by benthic organisms and can biomagnify through aquatic and terrestrial food chains. Bottom-feeding fish, such as suckers, are particularly vulnerable to the accumulation of organochlorine compounds. Because contaminants can accumulate at higher levels in the tissue of an organism than in surrounding water or sediment, fish are good indicators of contaminants in aquatic habitats.

Many organochlorine compounds, including chlorinated pesticides and polychlorinated biphenyl's (PCB's), are probable carcinogens (Carson, 1962). Most organochlorine pesticides have been replaced by more acutely toxic but ephemeral organophosphate, carbamate, and synthetic pyrethroid pesticides. Studies also have linked the presence of organochlorine compounds to deleterious effects on endocrine development and reproductive viability of fish and wildlife (Fry and Toone, 1981; Colborn and others, 1993). Although use of many organochlorine compounds was largely discontinued during the early 1970's through the 1980's (U.S. Environmental Protection Agency, 1989) and use of PCB was cancelled in 1985, many compounds, particularly DDT, PCB's, and their metabolites, still can be found in fish tissue because of their persistence in the environment. Concentrations of DDT and PCB's in fish tissue were detected at 98 and 90 percent, respectively, of 399 sites sampled throughout the Nation during 1986–89 (U.S. Environmental Protection Agency, 1992). Organochlorine compounds were detected in most tissue samples of fish collected in the USNK from 1970 to 1990 (Maret, 1995), and some concentrations exceeded guidelines for the protection of fish-eating wildlife (National Academy of Sciences and National Academy of Engineering [NAS/NAE], 1973).

Guidelines and standards (summarized by Nowell and Resek, 1994) for pesticides in water, sediment, and tissue have been established for the protection of water quality and health of organisms. Information on contaminant concentrations in fish and sediment can be used as an indicator of potential risk to human health and wildlife. Contaminant concentrations in tissue and sediment also can be used to evaluate national and regional long-term trends in water quality.

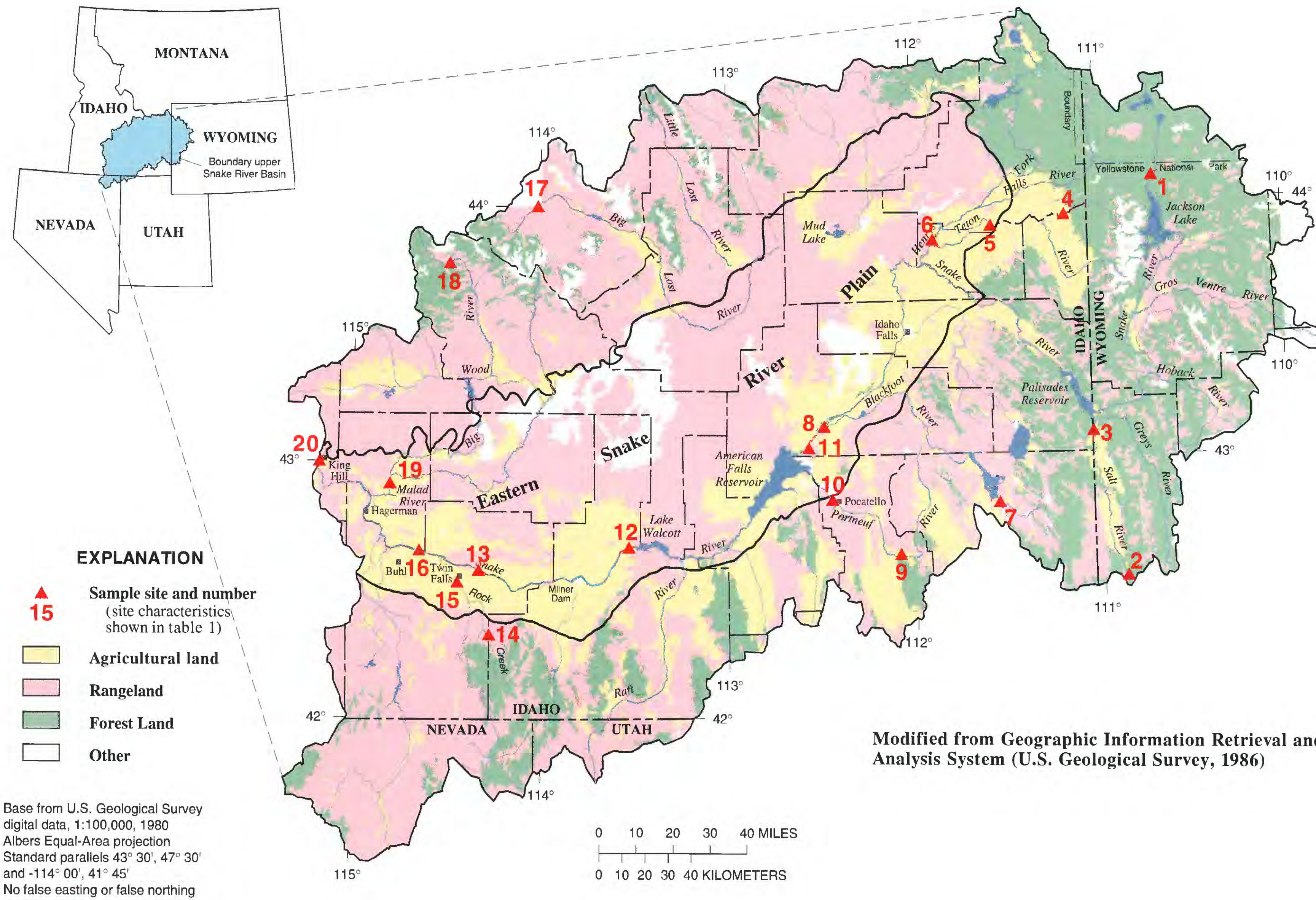

Figure 1. Major land uses and sample sites in the upper Snake River Basin.

The U.S. Fish and Wildlife Service (USFWS) (Schmitt and others, 1990) and the USEPA (1992) have sampled fish tissue at sites throughout the United States. Their sample designs did not include concurrent bed-sediment sampling and did not specifically relate land uses within river basins to contaminant concentrations. Information about how land use influences the occurrence of organochlorine compounds in the environment will provide resource managers a better understanding of the sources and fate of these contaminants in streams.

Purpose and Scope

This report summarizes the results of a study of organochlorine compounds in whole-fish tissue and bed sediment in major environmental settings in the USNK during 1992–94. In addition to basinwide sampling, selected sites also were sampled to characterize temporal (multiple year) and spatial (multiple reach) variability.

Specifically, this report (1) describes the occurrence and distribution of organochlorine compounds in whole-fish tissue and bed sediment from streams in the basin, (2) presents comparisons of detected concentrations with those reported in previous studies and with guidelines established for the protection of wildlife and aquatic biota, and (3) describes the relation of selected organochlorine compounds in whole-fish tissue and bed sediment to major land uses in the USNK.

Previous Studies

Contaminant data on aquatic flora and fauna in the USNK are generally lacking except for a few site-specific studies of fish tissue. Maret (1995) summarized the major studies and ranges of organochlorine concentrations in fish-tissue samples collected during 1970–90. The USFWS has assessed concentrations of contaminants in whole-fish samples collected since 1967 as part of the National Contaminant Biomonitoring Program (NCBP) (Schmitt and others, 1990). The NCBP database contains the most complete long-term information on fish-tissue contaminants in the basin, but samples were collected from only one site, the Snake River near Hagerman. Selected contaminants in whole-fish tissue from the Snake River at King Hill were analyzed on a one-time basis as part of the National Study of Chemical Residues in Fish (U.S. Environmental Protection Agency, 1992). Kent (1976) reported DDT and its metabolites, dieldrin, and PCB's in fish-tissue samples from American Falls Reservoir. The U.S. Department of the Interior collected site-specific contaminant data in 1988 as part of the Irrigation Drainage Program. Water, bed sediment, fish, and water birds from American Falls Reservoir, Portneuf River, and Spring Creek (immediately upstream from American Falls Reservoir) were analyzed for organochlorine compounds (Low and Mullins, 1990). Metabolites of DDT, chlordane, trans-nonachlor, and total PCB were present in fish-tissue samples from these locations. Between 1982 and 1988, the Idaho Division of Environmental Quality (IDEQ; formerly the Idaho Department of Health and Welfare, Division of Environmental Quality) collected contaminant data on fish tissue from specific areas affected by irrigation-return flows (Clark, 1989; Clark and Litke, 1991). A number of organochlorine compounds were detected; concentrations were highest in fish collected downstream from areas affected by irrigation-return flows (see report by Maret, 1995, for a summary of compounds detected). Some samples of fish tissue from Rock Creek near Twin Falls contained unusually high concentrations of toxaphene, an insecticide used to control pests on crops and livestock (Clark, 1989).

Most organochlorine concentrations in fish tissue from the USNK during 1970–90 generally were below the 1980–81 NCBP baseline concentrations (Maret, 1995). However, DDT and PCB's were present in most fish-tissue samples. Selected long-term (1970–84) data for the Snake River near Hagerman suggest that total DDT and PCB's in fish tissue have declined (Lowe and others, 1985).

Information on organochlorine compounds in USNK bed sediment is limited to a few site-specific studies. Low and Mullins (1990) reported low concentrations of DDT and DDE in sediment from the Portneuf River immediately upstream from American Falls Reservoir. Kent (1976) detected DDT and its metabolites and PCB's in sediment from American Falls Reservoir.

Acknowledgments

Numerous individuals assisted in collecting and processing data during the course of the study, including Michael A. Beckwith, Gregory M. Clark, Steven L. Goodbred, Stephanie J. Eisenbarth, Michael G. Rupert, Terry M. Short, Kenneth D. Skinner, Marc A. Sylvester, Ian R. Waite, and Catherine A. Wolf, all from the U.S.

Geological Survey (USGS). Molly A. Maupin (USGS) provided valuable assistance with summarizing the geographic information system data. Marc S. Gamblin, Fred E. Partridge, Richard Scully, and Charles D. Warren (Idaho Department of Fish and Game) provided valuable advice and field assistance. John W. Kiefling (Wyoming Game and Fish Department) also provided valuable assistance with the collection of field data. Colleague reviews by Steven L. Goodbred, Gerald F. Lindholm, William H. Mullins, and Mark D. Munn (USGS) improved the quality of the manuscript.

ENVIRONMENTAL SETTING

The USNK extends about 724 river km from its headwaters in southern Yellowstone National Park, Wyoming, to King Hill in south-central Idaho (fig. 1). Maupin (1995) provided a detailed discussion of the geology, climate, land use, and hydrology in the basin.

Geology of the basin is characterized by basalt that underlies the eastern Snake River Plain (fig. 1); igneous, sedimentary, and metamorphic rocks predominate in surrounding uplands and mountains (Maupin, 1995). Permeable basalt intercepts northern streams, such as the Big Lost and Little Lost Rivers, near the boundary of the plain.

Climate in most of the basin is semiarid and annual precipitation is 25 to 50 cm; at higher elevations in the eastern part of the basin, annual precipitation averages more than 50 cm. Precipitation occurs primarily as snow, and peak flows in streams result from spring snowmelt.

Land use in the basin (fig. 1) is 50 percent rangeland, 23 percent forest land, and 21 percent agricultural land; the remaining area, classified as "other," includes barren soil or rock with little vegetation, urban areas, water bodies, wetlands, lava flows, and tundra (Maupin, 1995). Most agricultural lands are adjacent to the Snake River, a major source of irrigation water. Livestock grazing is common throughout the basin. Logging, mining, and recreation are important land-use activities, particularly at higher elevations.

Four ecoregions constitute more than 99 percent of the basin: Snake River Basin/High Desert, 50 percent; Middle Rockies, 23 percent; Northern Basin and Range, 18 percent; and Northern Rockies, 9 percent. The Wyoming Basin and Montana Valley and Foothill Prairies ecoregions constitute less than 1 percent of the basin (Omernik and Gallant, 1986).

About 13,700 km of streams flow through the USNK, as determined from USGS 1:100,000-scale maps (Maret, 1995). Land surface ranges from about 4,200 m above sea level in the headwaters of the Snake River to 800 m at King Hill. Most streams originate in foothill or montane regions 1,800 to 3,000 m above sea level. Springs along the Snake River between Milner Dam and King Hill provide more than 50 percent of the Snake River discharge measured at King Hill. Reference streams in upland forest and low-elevation rangeland areas are characterized by coarse-grained substrates (gravel and cobble), high gradients (>1.0 percent), well-defined riffle-pool habitats, and sparse macrophyte growth. Large rivers and streams in low-elevation agricultural areas are characterized by finer substrates, lower gradients, and abundant aquatic macrophytes.

Streamflow in the Snake River and major tributaries is highly regulated by dams and diversions, primarily for agricultural use and hydroelectric-power generation. Clark (1994a) described surface-water quality and hydrology of the USNK. Nonpoint-source pollution and water diversions are identified as major factors affecting surface-water quality. Interbasin transfer of water for irrigation use is common practice. Ecological consequences of interbasin transfer of water include changes in streamflow, introduction of exotic species, and alteration of habitat (Meador, 1992). Irrigation projects have resulted in about 9,200 km of canals and 2,100 km of drains in the USNK (U.S. Water and Power Resources Service, 1981).

Surface water in the USNK is generally alkaline (greater than 150 mg/L as calcium carbonate) and is generally productive for aquatic life (Thurow and others, 1988). Coldwater aquatic life, defined as assemblages of aquatic organisms whose optimal growing temperature is below 18°C, is a designated beneficial use of most streams in the basin (Idaho Department of Health and Welfare, 1990).

Nutrients, sediment, bacteria, organic waste, and increased water temperatures are water-quality issues of greatest concern in the USNK (Idaho Department of Health and Welfare, 1989). Coldwater biota, salmonid spawning, and water-contact recreation are primary beneficial uses identified as impaired (Maret, 1995).

Water quality of the middle Snake (Milner Dam to King Hill) is affected by irrigation drainage, aquaculture effluent, municipal effluent, hydrologic modification, and dams (Brockway and Robinson, 1992). Because of these activities, segments of the middle

Snake were listed as "water-quality limited" in 1990 because nuisance macrophyte growth exceeded narrative water-quality criteria, and parts of the river violated standards established for the protection of designated beneficial uses, including coldwater biota and salmonid spawning (Idaho Department of Health and Welfare, 1995).

Many springs along the Snake River between Twin Falls and Hagerman (fig. 1) are used for commercial trout production; more than 80 percent of the Nation's commercial supply is produced in this area (Brockway and Robinson, 1992).

Most people live in the cities of Idaho Falls, Pocatello, and Twin Falls; population of the basin in 1990 was about 435,000.

DATA COLLECTION AND LABORATORY METHODS

Fish-tissue and bed-sediment samples were collected from 20 sites during 1992–94 (fig. 1, table 1). A few additional sites were sampled for fish tissue or bed sediment but are not included in this report. Ott (1997) summarized data for all sites sampled. Sample sites were selected by stratifying basin streams by predominant land use, stream type, and spatial coverage. Streams sampled were third through seventh order (Strahler, 1957). Definition of land use was modified from 1:250,000-scale digital data (U.S. Geological Survey, 1986) classified at Anderson levels I and II with a 16-ha mapping resolution (Anderson and others, 1976). Land use was classified as agricultural (including row crops and pasture land), rangeland, forest land, and other (barren rock, urban areas, water bodies, wetlands, lava flows, and tundra). Watershed boundaries were delineated using hydrography and hydrologic unit boundary data layers (U.S. Geological Survey, 1975) and 1:24,000-scale topographic maps.

Sample sites represented eight least-disturbed reference (R) sites, which are streams draining primarily forest land and (or) rangeland upstream from most agricultural and (or) urban land-use areas; four agricultural (A) sites, which are streams draining primarily irrigated agricultural land with row crop production and livestock grazing (15 to 42 percent of each watershed) and no urban land use; and eight mixed (M) sites, which are streams draining agricultural land (20 to 37 percent of each watershed) and receiving municipal sewage effluent and (or) runoff from upstream urban areas. Five of the eight mixed land-use sites are main-stem Snake River sites that integrate many land-use classes.

Fish-tissue and bed-sediment sampling was conducted during base-flow conditions in the summer and fall, 1992–94. Sample sites also were selected to evaluate temporal and (or) spatial variability in major environmental settings. Forty-one fish-tissue and bed-sediment samples were analyzed (tables 2 and 3).

Field Collection

Fish were collected by electrofishing following procedures outlined by Meador and others (1993). Bottom-feeding fish (carp and suckers) were the taxa targeted for evaluation in this study. These taxa were not present at some high-elevation sites, so other species were substituted. The nine fish species collected for analysis were common carp (*Cyprinus carpio*), bridgelip sucker (*Catostomus columbianus*), largescale sucker (*Catostomus marocheilus*), mountain sucker (*Catostomus platyrhynchus*), Utah sucker (*Catostomus ardens*), mottled sculpin (*Cottus bairdi*), Paiute sculpin (*Cottus beldingi*), Wood River sculpin (*Cottus leiopomus*), and mountain whitefish (*Prosopium williamsoni*) (table 2). Bottom-feeding fish were collected at 15 of the 20 sample sites.

At each site, 5 to 10 adult fish of the same species and similar size were composited for analysis. Fish were held in clean, stainless-steel or plastic buckets to avoid contamination during processing in a mobile laboratory. The collected fish were identified to species and sexed (when possible), measured for total and standard length and weight, and examined for anomalies. External anomalies included deformities, eroded fins, lesions, tumors, and parasites. Blackspot disease, caused by a parasitic trematode (Neascus sp.), was detected on fish from several sites, including reference sites, and, therefore, was not considered an anomaly. Fish were wrapped in aluminum foil, placed in plastic bags, labeled, frozen on dry ice, and shipped to the USGS National Water Quality Lab (NWQL) in Arvada, Colorado, for analysis. Further details on tissue-sampling methods used in this study are included in a report by Crawford and Luoma (1993).

Bed-sediment samples were collected along a 90- to 270-m reach at each site and composited for analysis according to guidelines established by Shelton and Capel (1994). A Teflon spoon was used to collect

Table 1. Predominant land use, collection years, and site characteristics for selected sample sites in the upper Snake River Basin, 1992–94

[Sample site No.: Locations shown in figure 1. Predominant land use: R, reference; A, agricultural; M, mixed. Latitude and longitude are in degrees, minutes, and seconds. Regulated refers to structures such as dams and diversions constructed upstream from sites that alter natural river discharge and (or) obstruct fish movement. km^2, square kilometers. WY, Wyoming. Sites are in Idaho unless otherwise indicated. <, less than]

Sample site No.	Predominant land use	Gaging-station name	Gaging-station No.	Latitude	Longitude	Year(s) sample collected	Regulated (yes or no)	Watershed size (km^2)	Percent land use: Agricultural land	Percent land use: Rangeland	Percent land use: Forest land	Percent land use: Urban	Percent land use: Other
1	R	Snake River at Flagg Ranch, WY	13010065	440521	1104138	1992-94	N	1,323	0	4	89	0	7
2	R	Salt River near Smoot, WY	13023700	423132	1105258	1993	N	52	0	30	70	0	0
3	A	Salt River near Etna, WY	13027500	430447	1110212	1992-94	Y	2,207	18	29	52	0	1
4	R	Bitch Creek near Lamont	13054300	435623	1111024	1993	N	215	7	6	81	0	6
5	A	Teton River near St. Anthony	13055000	435538	1113655	1993	Y	2,295	42	12	40	0	6
6	M	Henrys Fork near Rexburg	13056500	434934	1115415	1992-93	Y	8,335	27	17	52	<1	4
7	R	Blackfoot River near Henry	13063000	424900	1113035	1992	N	883	3	43	50	0	4
8	M	Snake River near Blackfoot	13069500	430731	1123106	1992-93	Y	31,560	20	28	47	<1	5
9	A	Portneuf River at Topaz	13073000	423730	1120520	1992-94	Y	1,523	35	54	10	0	1
10	M	Portneuf River at Pocatello	13075500	425220	1122805	1992	Y	3,354	37	52	9	<1	1
11	R	Spring Creek near Fort Hall	13075983	430236	1123315	1993	N	10	14	86	0	0	0
12	M	Snake River near Minidoka Dam	13081500	424023	1132958	1992-93	Y	48,830	23	38	34	<1	5
13	M	Snake River near Kimberly	13090000	423528	1142134	1992	Y	58,650	24	39	30	<1	6
14	R	Rock Creek near Rock Creek	13091995	421929	1141620	1993	N	135	0	27	73	0	0
15	M	Rock Creek[1] at Twin Falls	13092747	423347	1142942	1992-94	Y	624	24	52	24	<1	0
16	M	Snake River near Buhl	13094000	423958	1144241	1992-93	Y	76,105	22	46	26	<1	6
17	R	Big Lost River near Chilly	13120500	435954	1140112	1993-94	N	1,140	0	53	29	0	18
18	R	Big Wood River below Boulder Creek	13135350	434647	1142943	1993	N	324	0	13	72	0	15
19	A	Malad River near Gooding	13152500	425312	1144808	1992-93	Y	8,607	15	66	12	0	7
20	M	Snake River at King Hill	13154500	430008	1151206	1992-94	Y	92,940	21	51	23	<1	5

[1] Includes multiple sites sampled upstream and downstream from this location in 1994.

Table 2. Concentrations of selected organochlorine compounds in composite samples of whole fish collected in the upper Snake River Basin, 1992–94

[No., number; mm, millimeters; g, grams; µg/kg, micrograms per kilogram (wet weight); <, less than; ND, not detected; NA, not available]

Sample site No.–year of collection	Species	No. of fish	Total length (mm)	Mean length (mm)	Weight (g)	Mean weight (g)	Percentage of fish with anomalies	Percent lipid	cis-Chlordane (µg/kg)	trans-Chlordane (µg/kg)	cis-Nonachlor (µg/kg)
1–92	Utah sucker	8	397–462	430	746–1,016	889	0	5.7	<5.0	<5.0	<5.0
1–93	Mottled sculpin	10	66–87	74	2–6	4	0	3.9	<5.0	<5.0	<5.0
1–94	Paiute sculpin	10	72–90	82	5–10	7	0	1.4	<5.0	<5.0	<5.0
2–93	Paiute sculpin	10	86–96	90	7–15	10	0	2.9	<5.0	<5.0	<5.0
3–92	Utah sucker	8	435–515	465	848–1,325	1,071	0	3.6	<5.0	<5.0	<5.0
3–93	Utah sucker	8	428–522	486	850–1,500	1,225	12.5	7.1	<5.0	<5.0	<5.0
3–94	Utah sucker	9	423–527	472	877–1,588	1,121	33.3	6.6	<5.0	<5.0	<5.0
4–93	Mountain whitefish	6	330–400	380	368–734	574	0	7.9	<5.0	<5.0	<5.0
5–93	Paiute sculpin	10	77–150	114	8–58	25	0	2.6	<5.0	<5.0	<5.0
6–92	Utah sucker	8	425–496	458	736–1,225	1,019	12.5	5.5	<5.0	<5.0	<5.0
6–93	Utah sucker	8	415–485	450	750–1,200	988	0	9.5	<5.0	<5.0	<5.0
7–92	Common carp	5	685–705	692	3,750–4,400	4,075	0	14.0	<5.0	<5.0	<5.0
8–92	Utah sucker	7	525–655	562	1,225–2,650	1,725	14.3	14.9	<5.0	<5.0	<5.0
8–93	Common carp	7	589–718	652	2,900–7,700	654	14.3	9.8	<5.0	<5.0	<5.0
9–92	Utah sucker	10	70–171	98	4–59	14	0	10.2	<5.0	<5.0	<5.0
9–93	Common carp	6	495–560	528	1,900–2,750	2,425	33.3	5.3	<5.0	<5.0	<5.0
9–94	Common carp	5	540–585	561	2,272–2,661	2,431	0	10.9	<5.0	<5.0	<5.0
10–92	Utah sucker	8	332–419	378	304–646	490	0	4.4	5.4	<5.0	<5.0
[3]10–92	Utah sucker	8	312–408	360	286–670	414	0	3.6	5.0	<5.0	<5.0
11–93	Utah sucker	8	499–562	531	1,450–2,050	1,713	25.0	6.0	<5.0	<5.0	<5.0
12–92	Utah sucker	8	460–515	487	1,300–1,675	1,459	0	11.0	<5.0	<5.0	<5.0
12–93	Utah sucker	8	425–510	470	1,000–1,500	1,274	12.5	11.0	<5.0	<5.0	<5.0
13–92	Utah sucker	7	455–500	471	856–1,275	1,123	0	6.6	<5.0	<5.0	<5.0
14–93	Mountain sucker	8	104–225	143	9–102	34	25.0	6.0	<5.0	<5.0	<5.0
15–92	Bridgelip sucker	8	180–274	221	50–208	110	0	5.1	<5.0	<5.0	<5.0
15–93	Largescale sucker	8	226–515	341	144–1,675	579	0	8.3	<5.0	<5.0	<5.0
[4]15–94a	Bridgelip sucker	5	241–314	277	149–307	231	0	7.7	<5.0	<5.0	<5.0
15–94	Bridgelip sucker	8	238–345	288	148–377	256	0	7.2	<5.0	<5.0	<5.0
[4]15–94b	Bridgelip sucker	7	268–354	306	204–493	307	0	6.2	<5.0	<5.0	<5.0
16–92	Largescale sucker	8	465–512	492	1,200–1,650	1,409	12.5	5.8	<5.0	<5.0	<5.0
16–93	Largescale sucker	7	430–530	486	850–1,700	1,343	14.3	10.0	<5.0	<5.0	<5.0
[3]16–93	Common carp	6	385–639	530	1,150–4,850	3,125	0	23.0	12	6.9	7.4
17–93	Paiute sculpin	10	60–114	85	2–18	9	0	2.4	<5.0	<5.0	<5.0
17–94	Paiute sculpin	10	83–112	102	6–20	13	0	3.3	<5.0	<5.0	<5.0
18–93	Wood River sculpin	10	73–115	94	5–18	11	0	5.7	<5.0	<5.0	<5.0
19–92	Largescale sucker	8	450–530	484	964–1,500	1,246	87.5	14.1	<5.0	<5.0	<5.0
19–93	Largescale sucker	8	253–540	452	210–1,850	1,239	37.5	9.8	<5.0	<5.0	<5.0
20–92	Largescale sucker	8	381–503	443	555–1,200	887	0	15.0	<5.0	<5.0	<5.0
[3]20–92	Largescale sucker	8	397–470	430	578–1,050	800	0	9.3	<5.0	<5.0	<5.0
20–93	Largescale sucker	8	433–493	461	800–1,150	1,000	0	9.0	<5.0	<5.0	<5.0
20–94	Largescale sucker	8	460–525	492	960–1,375	1,170	0	6.1	<5.0	<5.0	<5.0

Table 2. Concentrations of selected organochlorine compounds in composite samples of whole fish collected in the upper Snake River Basin, 1992–94—Continued

Sample site No.–year of collection	trans-Nonachlor (µg/kg)	o,p'-DDD (µg/kg)	p,p'-DDD (µg/kg)	o,p'-DDE (µg/kg)	p,p'-DDE (µg/kg)	o,p'-DDT (µg/kg)	p,p'-DDT (µg/kg)	Dieldrin (µg/kg)	alpha-HCH (µg/kg)	Toxa-phene (µg/kg)	Total PCB (µg/kg)	Total[1] chlordane (µg/kg)	Total[2] DDT (µg/kg)
1–92	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	ND
1–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	ND
1–94	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	ND
2–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	ND
3–92	<5.0	<5.0	<5.0	<5.0	7.0	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	ND
3–93	<5.0	<5.0	<5.0	<5.0	5.5	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	6
3–94	<5.0	<5.0	<5.0	<5.0	6.7	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	7
4–93	<5.0	<5.0	<5.0	<5.0	10	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	10
5–93	<5.0	<5.0	<5.0	<5.0	28	<5.0	<5.0	<5.0	<5.0	<200	180	ND	28
6–92	<5.0	<5.0	18	<5.0	310	<5.0	17	<5.0	<5.0	<200	91	ND	345
6–93	<5.0	<5.0	22	<5.0	380	<5.0	26	<5.0	<5.0	<200	79	ND	428
7–92	<5.0	<5.0	22	<5.0	31	<5.0	<5.0	11	<5.0	<200	<50	ND	53
8–92	<5.0	10	21	<5.0	290	<5.0	19	<5.0	<5.0	<200	130	ND	340
8–93	8.5	<5.0	NA	<5.0	370	<5.0	<5.0	<5.0	<5.0	<200	190	8.5	370
9–92	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	ND
9–93	<5.0	<5.0	<5.0	<5.0	25	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	25
9–94	<5.0	<5.0	6.6	<5.0	48	<5.0	<5.0	<5.0	<5.0	<200	92	ND	55
10–92	7.6	<5.0	7.7	<5.0	120	<5.0	12	<5.0	<5.0	<200	1,900	13	140
[3]10–92	8.3	<5.0	8.6	<5.0	62	<5.0	6.3	<5.0	<5.0	<200	1,000	13.3	77
11–93	<5.0	<5.0	<5.0	<5.0	20	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	20
12–92	<5.0	<5.0	<5.0	<5.0	69	<5.0	<5.0	<5.0	<5.0	<200	53	ND	69
12–93	<5.0	<5.0	8.5	<5.0	47	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	56
13–92	7.7	<5.0	18	<5.0	520	<5.0	52	<5.0	<5.0	<200	50	7.7	590
14–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	ND
15–92	5.8	<5.0	30	<5.0	500	9.0	<5.0	11	<5.0	<200	<50	5.8	539
15–93	<5.0	<5.0	58	<5.0	1,000	<5.0	90	19	<5.0	540	87	ND	1,148
[4]15–94a	<5.0	<5.0	16	<5.0	520	6.6	46	12	<5.0	<200	<50	ND	589
15–94	<5.0	<5.0	15	<5.0	480	7.0	57	13	<5.0	<200	<50	ND	559
[4]15–94b	<5.0	<5.0	13	<5.0	400	6.3	50	11	<5.0	<200	<50	ND	469
16–92	<5.0	<5.0	7.5	<5.0	260	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	268
16–93	7.8	<5.0	34	<5.0	510	<5.0	24	<5.0	<5.0	<200	81	7.8	568
[3]16–93	25	<5.0	NA	<5.0	1,300	<5.0	7.1	28	<5.0	<200	100	51.3	1,307
17–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	ND
17–94	<5.0	<5.0	<5.0	<5.0	7.9	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	8
18–93	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<200	<50	ND	ND
19–92	<5.0	<5.0	<5.0	<5.0	15	<5.0	<5.0	<5.0	5.4	<200	<50	ND	15
19–93	5.5	<5.0	9.0	<5.0	120	<5.0	<5.0	<5.0	<5.0	<200	54	5.5	129
20–92	5.3	<5.0	<5.0	5.1	160	<5.0	6.0	<5.0	<5.0	<200	51	5.3	171
[3]20–92	7.1	20	<5.0	<5.0	280	<5.0	7.7	<5.0	<5.0	<200	72	7.1	308
20–93	<5.0	<5.0	12	<5.0	160	<5.0	5.3	<5.0	<5.0	<200	<50	ND	177
20–94	<5.0	<5.0	8.2	<5.0	200	<5.0	5.2	<5.0	<5.0	<200	<50	ND	213

[1] Sum of cis- and trans-chlordane, cis- and trans-nonachlor, heptachlor, heptachlor epoxide, and oxychlordane.

[2] Sum of all DDT metabolites.

[3] Field duplicate.

[4] Multiple-reach samples upstream (a) and downstream (b).

Table 3. Concentrations of selected organochlorine compounds, percent total organic carbon, and percent sand and fines in bed-sediment samples collected in the upper Snake River Basin, 1992–94

[µg/kg, micrograms per kilogram (dry weight); %, percent; mm, millimeters; <, less than; ND, not detected; NA, not available]

Sample site No.–year of collection	cis-Chlordane (µg/kg)	trans-Chlordane (µg/kg)	cis-Nonachlor (µg/kg)	trans-Nonachlor (µg/kg)	o,p'-DDD (µg/kg)	p,p'-DDD (µg/kg)	p,p'-DDE (µg/kg)	p,p'-DDT (µg/kg)	Total PCB (µg/kg)	Total[1] chlordane (µg/kg)	Total[2] DDT (µg/kg)	Total organic carbon (%)	Percent sand (particle size 0.062 to 2 mm)	Percent fines (silt and clay, particle size <0.062 mm)
1–92	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	2.3	74	26
1–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.1	74	26
1–94	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	.5	90	10
2–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.8	57	43
3–92	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.5	69	31
3–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.2	39	61
3–94	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.8	49	51
4–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	2.6	59	41
5–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.5	<2.0	<50	ND	3.5	2.8	21	79
6–92	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.1	87	13
6–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.3	69	31
7–92	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.9	72	28
8–92	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	.7	88	12
8–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	.8	79	21
9–92	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.7	49	51
9–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	2.2	47	53
[3]9–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	2.3	40	60
9–94	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.8	48	52
10–92	1.4	2.0	1.2	1.4	1.0	3.7	2.0	<2.0	<50	6.0	6.7	3.0	45	55
[3]10–92	1.5	2.7	1.6	1.9	<1.0	<1.0	2.4	<2.0	101	7.7	2.4	2.8	52	48
11–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.6	64	36
12–92	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	3.0	98	2
12–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.4	<2.0	<50	ND	1.4	5.4	40	60
13–92	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	.3	96	4
14–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	3.5	57	43
15–92	<1.0	<1.0	<1.0	<1.0	<1.0	NA	15	NA	<50	ND	15	.8	37	63
15–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	8.0	34	<50	ND	42	.7	75	25
[4]15–94a	<1.0	<1.0	<1.0	<1.0	<1.0	3.8	29	15	<50	ND	48	1.0	30	70
15–94	<1.0	<1.0	<1.0	<1.0	18	2.6	28	<2.0	<50	ND	49	1.0	25	75
[4]15–94b	<1.0	<1.0	<1.0	<1.0	<1.0	3.5	28	11	<50	ND	43	1.3	24	76
16–92	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.7	<2.0	<50	ND	3.7	3.4	NA	NA
16–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	4.5	<2.0	<50	ND	4.5	1.0	56	44
17–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.4	71	29
17–94	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	2.4	80	20
18–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	.7	91	9
19–92	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.2	20	80
19–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.9	53	47
20–92	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.7	66	34
[3]20–92	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	1.5	NA	NA
20–93	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<50	ND	ND	.7	62	38
20–94	<1.0	<1.0	<1.0	<1.0	<1.0	8.2	<1.0	5.2	<50	ND	13	.7	76	24

[1] Sum of cis- and trans-chlordane, cis- and trans-nonachlor, heptachlor, heptachlor epoxide, and oxychlordane.

[2] Sum of all DDT metabolites.

[3] Field duplicate.

[4] Multiple-reach samples upstream (a) and downstream (b).

sediment from the upper 2.5 cm of the streambed. Five to 10 undisturbed depositional areas were sampled, and samples were composited in a glass bowl until approximately 2 L of fine-grained sediment was collected. Most sediment was collected along shorelines where fine-grained materials were abundant and accessible. Sediments were homogenized, and a subsample of about 500 mL was wet sieved through a 2-mm stainless-steel sieve into a precleaned 1-L glass jar. Excess water was decanted, and samples were frozen for shipment to the NWQL. For particle-size analysis, an additional 200 mL was wet sieved into a 500-mL plastic container.

Care was taken to clean all equipment between each site visit. Cleaning consisted of rinsing with native water, washing with phosphate-free detergent, rinsing in deionized water, and, finally, rinsing with methanol. All equipment was air dried, wrapped in aluminum foil, and stored in plastic containers. Latex or poly-vinyl-chloride gloves were worn during all collection and processing.

Laboratory Preparation and Analysis

Fish-tissue and bed-sediment samples were analyzed for organochlorine compounds by the NWQL. Thirty-three different compounds were analyzed, 28 in fish tissue and 32 in bed sediment (table 4). Compounds were selected for analysis by a screening process that considered such factors as availability of analytical methods, toxicity, bioaccumulation potential, and the capacity of organisms to metabolize the compound (Crawford and Luoma, 1993). Samples were analyzed for pesticides (insecticides, herbicides, and fungicides), breakdown products of pesticides (metabolites), and total PCB, found in dielectric fluid formerly used in capacitors and transformers. Specific information regarding chemical abstract number, use, status, and reagent spike recoveries for each compound is listed in table 4.

Whole-fish composite samples were homogenized using a Hobart grinder. Methods included Soxhlet extraction, gel permeation chromatography, and fractionation using alumina/silica adsorption chromatography with electron-capture detection. Percent lipid in fish tissue was determined using a methylene chloride extract. Methods used for fish-tissue and sediment analyses are described in detail in reports by Leiker and others (1995) and Foreman and others (1995), respectively. Method reporting limits for each compound are listed in table 4.

Percent sand (particle size 0.062- to 2-mm diameter) and percent silt and clay (particle size <0.062-mm diameter) were determined for each bed-sediment sample by standard sieving and weighing of each fraction after drying to a constant temperature of 105°C (Matthes and others, 1992). Percent organic carbon was determined by heating a sample in an inductive furnace and measuring the amount of carbon dioxide by thermal conductivity (Wershaw and others, 1987).

Field and Laboratory Quality Assurance

Field duplicates of fish-tissue and bed-sediment samples were collected from three sites (tables 2 and 3). Samples from stream reaches immediately upstream and downstream (within 1.6 km) from site 15 were collected to evaluate variability of fish-tissue and bed-sediment contaminants within a longer stream segment.

Fish-tissue field duplicates included samples of the same and different species for evaluation of variability in contaminants. The variability is best described using p,p'DDE and total PCB, because these compounds were detected most frequently in samples analyzed. Relative differences in concentrations of p,p'DDE in duplicate samples of the same species ranged from 54 to 64 percent. Differences in p,p'DDE concentrations were highest (87 percent) in samples of different species (common carp and largescale sucker), possibly due to 39 percent higher lipid content in the common carp. Organochlorine compounds are typically lipophilic, which suggests that these compounds accumulate in proportion to tissue lipid content (Hebert and Keenleyside, 1995). Concentrations of p,p'DDE in samples of the same species from multiple-reach sites were similar; differences ranged from 8 to 26 percent. Differences in concentrations of total PCB in samples of the same species ranged from 34 to 62 percent and were highest in samples from site 10, where concentrations of total PCB were 1,000 and 1,900 μg/kg. The difference in concentrations of total PCB in samples of different species from site 16 was 21 percent.

Most organochlorine compound concentrations in bed-sediment field duplicates were not detected. Where compounds were detected, concentrations were near the detection limit and differences were not significant (table 3). One exception was at site 10, where total

Table 4. Chemical and analytical data for selected organochlorine compounds analyzed in fish-tissue and bed-sediment samples, upper Snake River Basin, 1992–94

[Use and status information determined by Meister (1992) and U.S. Environmental Protection Agency (1990 and 1992); µg/kg, micrograms per kilogram; NWQL, National Water Quality Laboratory; SD, standard deviation; <, less than; —, not applicable]

Compound	Chemical abstract No.	Use/status[1]	Fish-tissue samples: Method reporting limit (µg/kg, wet weight)	Fish-tissue samples: NWQL mean recovery, SD, and (sample size)	Bed-sediment samples: Method reporting limit (µg/kg, dry weight)	Bed-sediment samples: NWQL mean recovery, SD, and (sample size)
cis-Chlordane	5103–71–9	insecticide, chlordane component, restricted	<5.0	82, 11 (34)	<1.0	71, 7 (4)
trans-Chlordane	5103–74–2	insecticide, chlordane component, restricted	<5.0	86, 12 (34)	<1.0	71, 7 (4)
Heptachlor	76–44–8	insecticide, chlordane metabolite, restricted	<5.0	77, 11 (34)	<1.0	62, 12 (4)
Heptachlor epoxide	1024–57–3	chlordane and heptachlor metabolite	<5.0	90, 12 (34)	<1.0	72, 8 (4)
cis-Nonachlor	5103–73–1	insecticide, chlordane component, restricted	<5.0	82, 15 (34)	<1.0	68, 11 (4)
trans-Nonachlor	39765–80–5	insecticide, chlordane component, restricted	<5.0	85, 11 (34)	<1.0	72, 8 (4)
Oxychlordane	27304–13–8	chlordane metabolite	<5.0	87, 14 (34)	<1.0	71, 8 (3)
o,p' DDD	53–19–0	DDT metabolite	<5.0	88, 12 (34)	<1.0	74, 6 (4)
p,p' DDD	72–54–8	DDT metabolite	<5.0	92, 23 (22)	<1.0	63, 0 (1)
o,p' DDE	3424–82–6	DDT metabolite	<5.0	81, 14 (34)	<1.0	77, 9 (4)
p,p' DDE	72–55–9	DDT metabolite	<5.0	90, 14 (34)	<1.0	70, 14 (4)
o,p' DDT	789–02–6	insecticide, cancelled 1972	<5.0	89, 13 (33)	<2.0	75, 10 (4)
p,p' DDT	50–29–3	insecticide, cancelled 1972	<5.0	86, 13 (34)	<2.0	71, 5 (4)
Aldrin	309–00–2	insecticide, cancelled 1974	<5.0	78, 11 (34)	<1.0	65, 18 (4)
Dacthal (DCPA)	1861–32–1	pre-emergent herbicide	<5.0	86, 14 (34)	<1.0	75, 8 (4)
Dieldrin	60–57–1	insecticide, aldrin metabolite, cancelled 1985	<5.0	87, 20 (34)	<1.0	70, 11 (4)
Endrin	72–20–8	insecticide, cancelled 1984	<5.0	100, 20 (33)	<1.0	76, 5 (4)
Hexachlorobenzene	118–74–1	fungicide, restricted	<5.0	73, 13 (34)	<1.0	64, 16 (4)
alpha-HCH	319–84–6	lindane component, cancelled 1977	<5.0	70, 11 (34)	<1.0	58, 6 (4)
beta-HCH	319–85–7	lindane component, cancelled 1977	<5.0	88, 12 (34)	<1.0	70, 6 (4)
delta-HCH	319–86–8	lindane component, cancelled 1977	<5.0	82, 17 (34)	—	—
Lindane (gamma-HCH)	58–89–9	insecticide, restricted	<5.0	73, 11 (34)	<1.0	62, 5 (4)
o,p'-Methoxychlor	30667–99–3	insecticide	<5.0	86, 16 (34)	<5.0	74, 6 (4)
p,p'-Methoxychlor	72–43–5	insecticide	<5.0	85, 16 (34)	<5.0	76, 4 (4)
Mirex	2385–85–5	insecticide, restricted 1978	<5.0	90, 11 (34)	<1.0	65, 17 (4)
Pentachloroanisole	1825–21–4	insecticide/fungicide, restricted	<5.0	65, 16 (33)	<1.0	64, 4 (4)
Toxaphene	8001–35–2	insecticide, cancelled 1989	<200	—	<200	—
Total PCB	—	dielectric fluid in capacitors and transformers, cancelled 1985	<50	—	<50	—
Chloroneb	2675–77–6	fungicide	—	—	<5.0	57, 4 (4)
Endosulfan I	959–98–8	insecticide	—	—	<1.0	52, 17 (4)
Isodrin	465–73–6	insecticide, isomer of aldrin, cancelled 1984	—	—	<1.0	65, 15 (4)
cis-Permethrin	61949–76–6	insecticide, restricted	—	—	<5.0	76, 11 (4)
trans-Permethrin	61949–77–7	insecticide, restricted	—	—	<5.0	80, 17 (3)

[1]Restricted means presently in use but only within specific guidelines established by U.S. Environmental Protection Agency; cancelled means no longer legal to manufacture and (or) banned for use in United States.

PCB ranged from undetected to a concentration of 101 µg/kg.

Organochlorine contaminants are highly sorptive and generally accumulate in sediment in proportion to the total organic carbon and associated fine-grained sediment content (Shelton and Capel, 1994). Percent total organic carbon and percent fines (<0.062 mm) in field duplicates and multiple-reach samples were similar and differed by less than 13 percent. Concentrations of p,p'DDE in multiple-reach bed-sediment samples also were similar and ranged from 28 to 29 µg/kg.

Laboratory quality assurance samples were used to estimate the quality of analytical data and to verify and support methods of analyses. Laboratory quality control consisted of laboratory blanks and surrogate and reagent spike recoveries. Laboratory blanks indicated that samples were not contaminated during laboratory processing. Compounds analyzed and means and standard deviations for reagent spike recoveries for fish tissue and bed sediment are shown in table 4. A few DDT isomers, noted as not available in tables 2 and 3, could not be determined because of coelution (analytical problem separating compounds) and (or) degradation during gas chromatographic analysis. Surrogate and reagent spike recoveries were within acceptable levels according to method performance standards outlined in reports by Leiker and others (1995) and Foreman and others (1995). Results were not adjusted to account for percent recovery efficiencies.

The NWQL participated in several fish-tissue interlaboratory studies sponsored by the USFWS and the USEPA (Leiker and others, 1995). Results of these studies validated the fish-tissue methodology used by the NWQL. About 80 percent of all data were within 1 standard deviation and 100 percent were within 2 standard deviations for all compounds analyzed.

DATA ANALYSIS

The low number of detections of many compounds precluded the use of statistical analyses, especially with bed-sediment results. For compounds with a high frequency of detection, such as p,p'DDE, concentrations reported as less than the reporting limit (not detected) were assigned a numerical value of one-half the detection limit. A Pearson's correlation test was used to determine whether tissue concentrations correlated with percent lipid after concentrations were $\log_{10}$ transformed to meet the assumption of normality. Because organochlorine concentrations in tissue can be related to lipid content, data for fish of different species were lipid-normalized to reduce the coefficient of variation. Lipid normalization of organochlorine concentrations in fish tissue did not change the interpretation and demonstrated only slight differences in a few examples. Hebert and Keenleyside (1995) discussed the potential advantages and disadvantages of expressing organochlorine concentrations in tissue using this ratio-based approach. They concluded that lipid normalization is beneficial when contaminant concentrations vary in proportion to lipid content; however, when such a relation does not exist, erroneous conclusions can be made.

Boxplots initially were examined to evaluate relative differences in actual and lipid-normalized p,p'DDE concentrations in fish tissue among land-use groups (reference, agricultural, and mixed). A nonparametric Kruskal-Wallis test using SYSTAT (Wilkinson, 1992) determined statistical differences among land-use groups. This test computes ranks on all data values pooled from all the populations being compared. The ranks are summed for individual populations, and an overall test statistic is computed and compared with tabulated values to determine whether significant differences exist among the populations. The level of confidence in each test is determined by selection of an alpha value. Two-sided tests with an alpha value of 0.05 were used for the comparative tests in this report. If a significant difference was determined, a Tukey's multiple-comparison test was calculated on ranked data to determine which land-use groups were significantly different.

Normalization of organochlorine concentrations in bed sediment to total organic carbon and percent fines (silt and clay) was not performed because so few compounds were detected. Concentrations detected in each sample are listed in table 3. Total chlordane refers to the sum of cis- and trans-chlordane, cis- and trans-nonachlor (major constituents of technical chlordane), and the metabolites of chlordane (heptachlor, heptachlor epoxide, and oxychlordane). Total DDT refers to the sum of the o,p'- and p,p'-isomers of DDD plus DDE and DDT. No distinction was made among the various congeners of PCB.

Concentrations of organochlorine compounds in whole fish are generally higher than in fish fillet samples because muscle tissue typically contains lower concentrations of lipophilic substances (Schmitt and others, 1981). All fish-tissue concentrations reported in this study are from whole-fish tissue samples. The USEPA

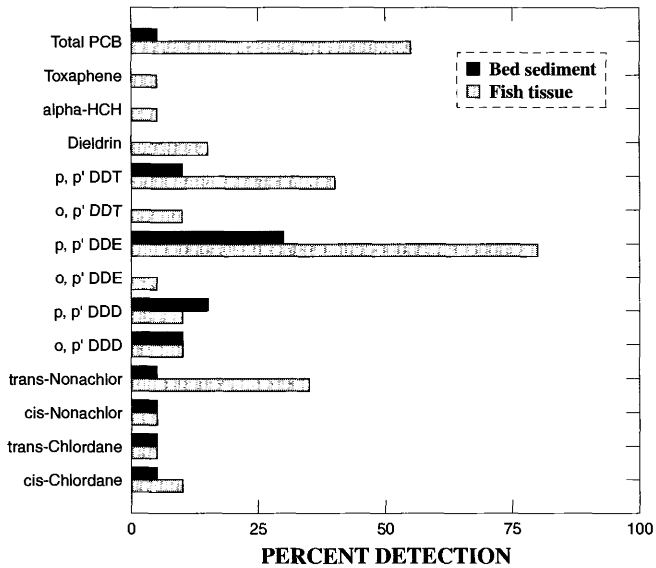

Figure 2. Percent detection of selected organochlorine compounds in fish tissue and bed sediment that exceed reporting limits, upper Snake River Basin,1992–94.

fish consumption advisory guidelines for estimating human health risk are specific to edible parts of fish and shellfish (U.S. Environmental Protection Agency, 1995) and are not directly comparable with concentrations reported in this study.

OCCURRENCE AND DISTRIBUTION OF ORGANOCHLORINE COMPOUNDS

Of the 28 compounds analyzed in fish tissue and 32 in bed sediment, 14 were detected in fish tissue, 9 in bed sediment, and 9 in both (tables 2 and 3, fig. 2). Toxaphene, alpha-HCH, dieldrin, o,p'DDT, and o,p'DDE were present only in fish tissue.

The most frequently detected compound at all sites was p,p'DDE, which was present in 80 percent of the fish-tissue and 30 percent of the bed-sediment samples. This common metabolite of p,p'DDT was the dominant component of total DDT in this study. The next most frequently detected compound was PCB, which was present in 55 percent of the fish-tissue and 5 percent of the bed-sediment samples.

Chlordane components, including cis- and trans-chlordane and cis- and trans-nonachlor, were detected at a few sites in fish tissue and bed sediment. Of the chlordane components, trans-nonachlor was detected most frequently in fish tissue and was present at 35 percent of the sites.

Generally, fish collected for tissue analysis were in good condition—only 8 percent (26 of 325 fish examined) had external anomalies (table 2). The highest number of fish with external anomalies was from Malad River near Gooding (site 19), where seven of eight largescale suckers had anchor worm (Lernaea sp.). No clear pattern was observed between the occurrence of external anomalies and tissue organochlorine and PCB concentrations or land use. External anomalies were observed on fish collected from reference sites as well as from agricultural and mixed land-use sites throughout the basin.

Organochlorine compounds were identified more often in fish tissue than in bed sediment during this study. A primary reason for this difference is that organochlorine compounds bioaccumulate in animal tissue. One or more compounds were detected in fish-tissue samples from 16 of 20 sites, whereas one or more compounds were detected in bed sediment from only 6 sites (fig. 3). Only at Portneuf River at Pocatello (site 10) were more compounds detected in bed sediment than in fish tissue.

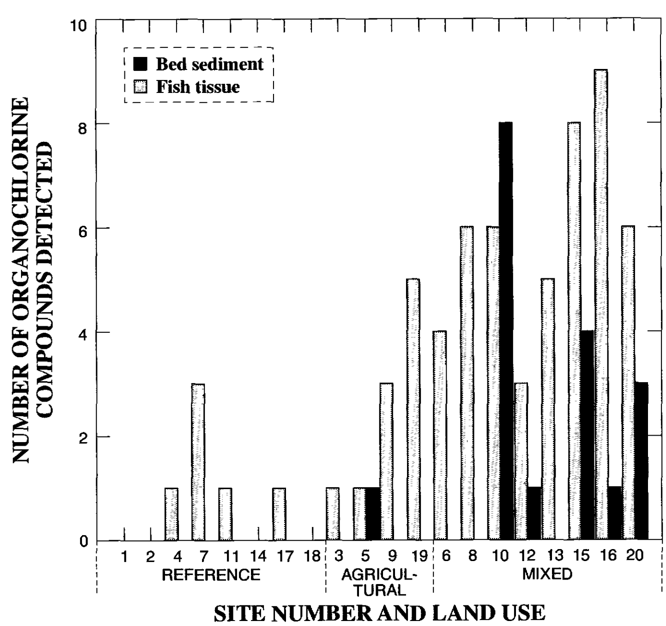

Figure 3. Number of organochlorine compounds detected in fish tissue and bed sediment, upper Snake River Basin, 1992–94.

Land Use and Spatial Distribution

The number of organochlorine compounds detected in fish-tissue and bed-sediment samples from a site is related to land use (fig. 3). A maximum of three compounds, all in fish tissue, were detected at reference sites (located in predominately forest and (or) rangeland watersheds upstream from agricultural and urban influences). Contaminant occurrence at reference sites is likely the result of atmospheric deposition (Majewski and Capel, 1995) and past usage of these compounds by the U.S. Department of Agriculture to control insects on forest lands (Carson, 1962). Organochlorine compounds were detected in fish at only four of the eight reference sites; no compounds were detected in bed sediment at any of the reference sites. Stream gradients at these sites are high (>1.0 percent), and most fine sediment and any associated contaminants likely are transported downstream. Sediment samples from reference sites contained more sand (mean of 72 percent for all samples) than did samples from agricultural and mixed land-use sites (means of 43 and 59 percent, respectively) (table 3).

One or more organochlorine compounds were detected in fish-tissue and (or) bed-sediment samples from all agricultural and mixed land-use sites. The number of organochlorine compounds detected in fish tissue (nine) and bed sediment (eight) was highest in samples from mixed land-use sites (fig. 3). In their study of the South Platte River Basin of Colorado, Nebraska, and Wyoming, Tate and Heiny (1996) determined that the number of organochlorine compounds in fish tissue and bed sediment also was highest in samples from mixed land-use sites. The number of compounds detected in fish tissue and bed sediment in samples from agricultural sites in the USNK ranged from one to five—intermediate between the number of compounds detected in samples from reference and mixed land-use sites.

The distribution of organochlorine compounds in the USNK also was related to land use and is best illustrated by total DDT in fish tissue and bed sediment (fig. 4) and total PCB and total chlordane in fish tissue (fig. 5). Total DDT was the most widely distributed compound in fish tissue and bed sediment, and the most common component was the metabolite p,p'DDE (fig. 4). Of the compounds detected, p,p'DDE was the only compound detected in fish-tissue samples from sites in all land-use groups. DDT metabolites were detected most frequently in fish-tissue and bed-sediment samples from mixed land-use sites. Total PCB was detected at only

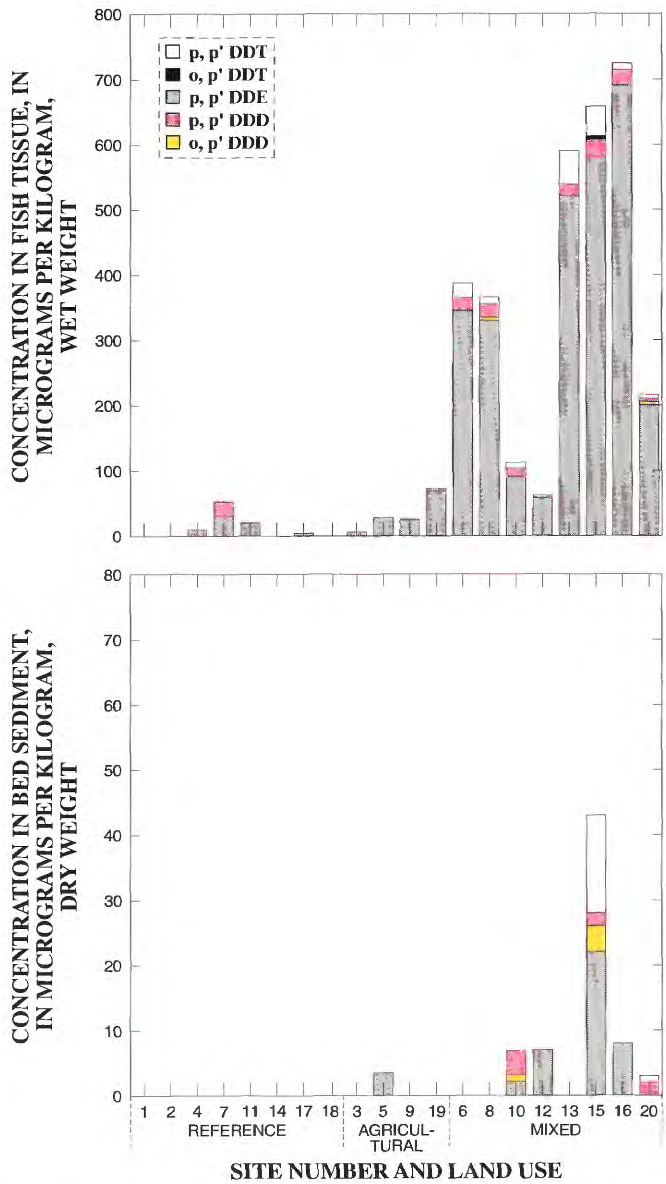

Figure 4. Concentrations of DDT and its metabolites in fish tissue and bed sediment, upper Snake River Basin, 1992–94.

agricultural and mixed land-use sites (fig. 5). Concentrations of total PCB in fish-tissue samples from site 10 (Portneuf River at Pocatello, fig. 1) were particularly high compared with concentrations in samples from other sites (mean of duplicate samples, 1,450 µg/kg). Site 10 is in the city of Pocatello, which may have urban and industrial sources of PCB. Total chlordane was detected in fish-tissue samples from primarily mixed land-use sites; samples from six of the eight sites contained detectable concentrations (fig. 5). Total chlor-

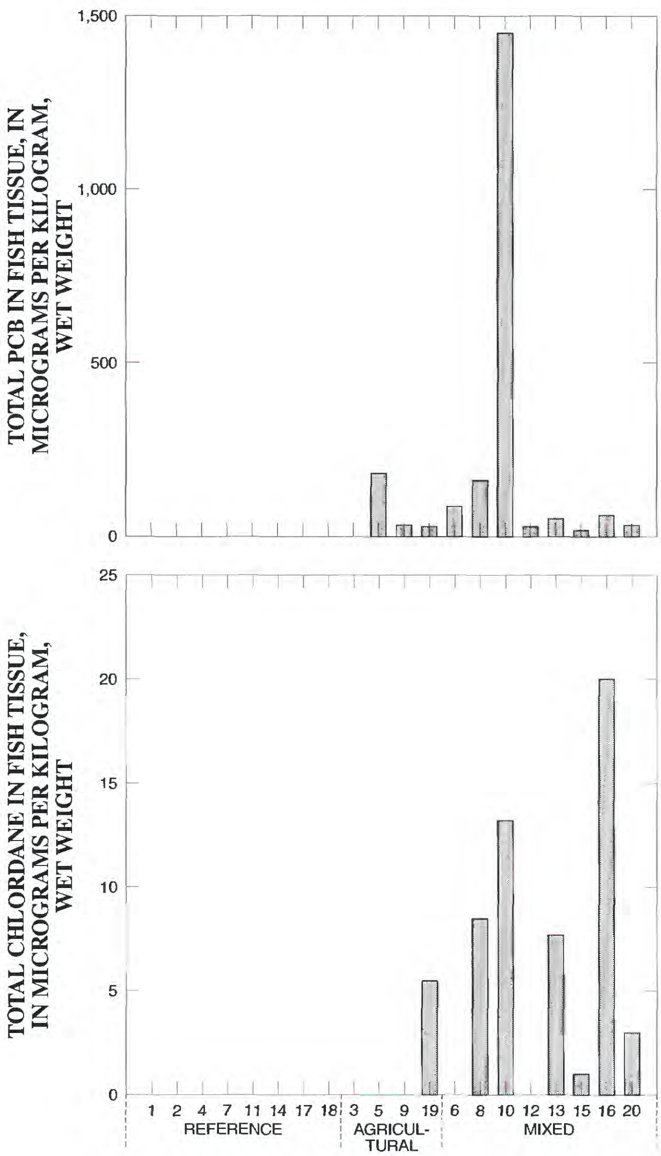

Figure 5. Concentrations of total PCB and total chlordane in fish tissue, upper Snake River Basin, 1992–94.

dane was not detected in fish-tissue samples from any reference sites and was detected in a sample from only one agricultural site.

A linear regression was used to illustrate the influence of land use on concentrations of organochlorine compounds and to evaluate the relation between percent agricultural land and concentrations of total DDT in fish tissue (fig. 6). Because of a significant relation ($r^2 = 0.22$, $p < 0.01$) between percent lipid in fish tissue and total DDT in all samples, both actual (non-normalized) total DDT concentrations (fig. 6A) and lipid-normalized concentrations (fig. 6B) were used to illustrate this relation. In both examples, a significant positive relation was determined between percent agricultural land and concentrations of total DDT ($r^2 = 0.41$, $p < 0.01$) and lipid-normalized total DDT $r^2 = 0.48$, $p < 0.01$). Lipid-normalized concentrations displayed a

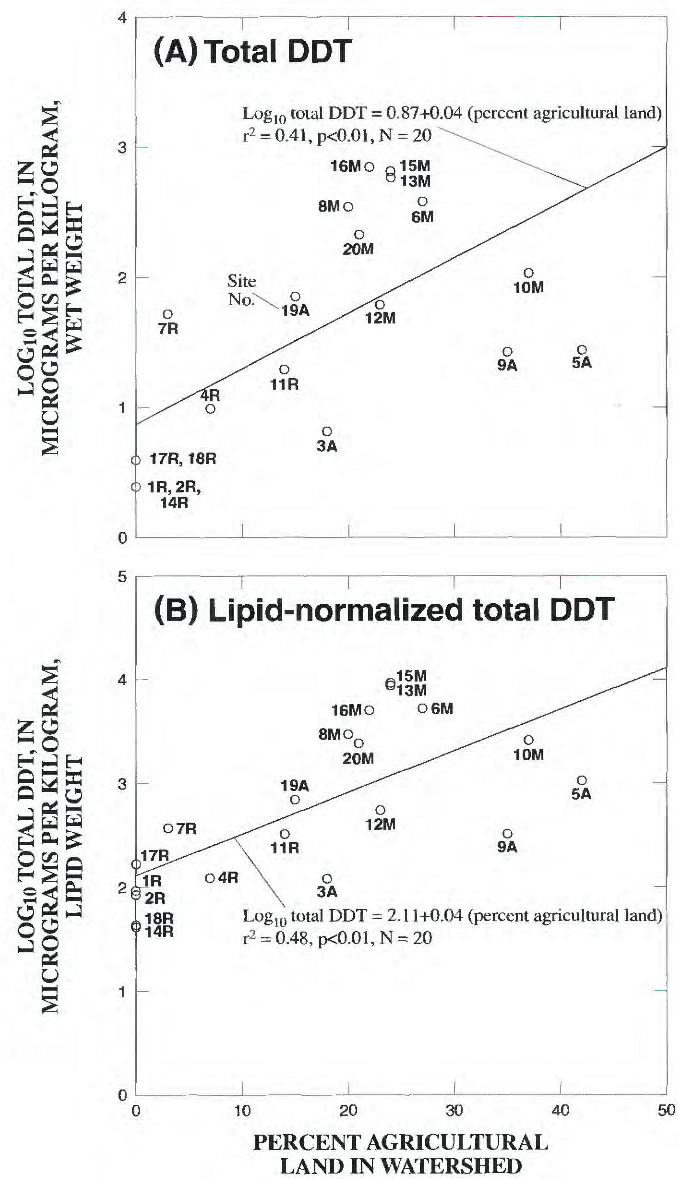

Figure 6. Lines of regression for (A) total DDT and (B) lipid-normalized total DDT concentrations in fish tissue, and percent agricultural land upstream from each site, upper Snake River Basin, 1992–94. [See table 1 for site names corresponding to land-use groups (R, reference; A, agricultural; M, mixed)]

slightly better relation (higher r^2) and the coefficient of variation was reduced by 10 percent, although the overall interpretation did not change with lipid normalization. Tate and Heiny (1996) and Munn and Gruber (in press) determined that lipid normalization may not be necessary when assessing different fish species across large geographic areas. Brown (U.S. Geological Survey, written commun., 1996) determined that total DDT concentrations in tissue of fish from streams in San Joaquin Valley, California, were significantly correlated to elevated specific conductance, pH, and alkalinity, which is indicative of the effects of irrigation-return flows.

Comparisons among concentrations of p,p'DDE, the most commonly detected metabolite of total DDT, and each of the three land-use groups are shown in figure 7. A Kruskal-Wallis test detected a significant difference ($p < 0.05$) in p,p'DDE concentrations among land-use groups. Pairwise comparisons using Tukey's procedure showed that median concentrations of p,p'DDE in fish-tissue samples from mixed land-use sites were significantly ($p < 0.05$) higher than from reference and agricultural sites. Results for lipid-normalized p,p'DDE concentrations were similar.

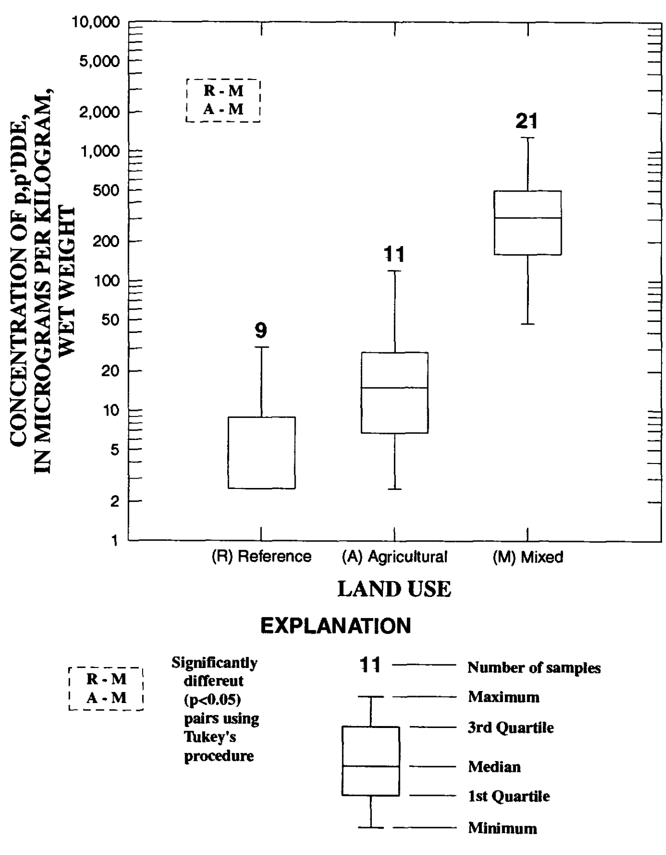

Figure 7. Concentrations of p,p'DDE in fish tissue and significant difference (p<0.05) in median concentrations, upper Snake River Basin, 1992–94.

Table 5. Guidelines for organochlorine concentrations in whole-fish tissue and bed sediment

[NAS/NAE, National Academy of Sciences/National Academy of Engineering; µg/kg, micrograms per kilogram; NA, not available]

Compound	NAS/NAE guidelines[1] for whole-fish tissue (µg/kg, wet weight)	Canadian Interim Sediment Quality Guidelines[2] (µg/kg, dry weight)	
		TEL	PEL
Total chlordane[3]	100	4.50	8.90
Total DDT[4]	1,000	6.98	4,450
p,p' DDD	NA	3.54	8.51
p,p' DDE	NA	1.42	6.75
Dieldrin	100	2.85	6.67
alpha-HCH	100	NA	NA
Total PCB	500	34.1	277
Toxaphene	100	NA	NA

[1]Recommended maximum concentrations in whole-fish tissue for the protection of fish-eating wildlife (NAS/NAE, 1973).

[2]Canadian interim guidelines for threshold effect level (TEL), which represents the concentration below which adverse effects are expected to occur rarely, and probable effect level (PEL), which represents the level above which adverse effects are expected to occur frequently (Environment Canada, 1995).

[3]Applies to the total residues of chlordane and heptachlor epoxide, either singly or in combination.

[4]Total DDT includes all isomers of DDT and metabolites DDE and DDD.

Comparison With Guidelines and Other Studies

To assess the potential for biological impairment caused by organochlorine pesticides and total PCB, concentrations of these compounds were compared with guidelines established for eight compounds (table 5). The whole-fish concentrations were compared with guidelines established by the NAS/NAE (1973). Sediment concentrations were compared with the Canadian Interim Sediment Quality Guidelines for the protection of aquatic life (Environment Canada, 1995), as there are currently no sediment quality criteria for the protection of benthic organisms in the United States (Lisa H. Nowell, U.S. Geological Survey, oral commun., 1996). The Canadian sediment quality guidelines consist of two assessment levels of biological impairment, the threshold effect level (TEL), which represents the concentration below which adverse effects are expected to occur rarely, and the probable effect level (PEL), which represents the level above which adverse effects are expected to occur frequently. All concentrations shown in figure 8 are actual values, not normalized to percent lipid or total organic carbon. Only those sites where concentrations exceeded the NAS/NAE guidelines for fish tissue or the PEL for bed sediment are labeled. The guidelines used for comparison do not address combined effects (additive, synergistic, or antagonistic) or sublethal effects such as reproductive or behavioral problems in organisms.

FISH TISSUE

Concentrations of p,p'DDE, total PCB, total DDT, and toxaphene in fish-tissue samples from three mixed land-use sites equaled or exceeded the NAS/NAE guidelines: Portneuf River at Pocatello (site 10), PCB; Rock Creek at Twin Falls (site 15), p,p'DDE, total DDT, and toxaphene; and Snake River near Buhl (site 16), p,p'DDE and total DDT. Concentrations of these compounds in 7 of 41 tissue samples (17 percent) exceeded the guidelines. According to Schmitt and others (1990), analysis of total PCB in fish tissue, without knowing the specific PCB congeners, is not sufficient to determine the toxicological significance of PCB to organisms. Therefore, it is not known whether the high total PCB concentrations in fish-tissue samples from the Portneuf River at Pocatello (site 10) would be toxic to predators, but the concentrations do indicate a nearby contaminant source(s).

A comparison of fish-tissue contaminant concentrations determined in this study and nationwide geometric mean concentrations determined as part of the 1980–81 USFWS/NCBP study at 107 sites (Schmitt and others, 1990) indicated that some concentrations in the USNK were elevated. For example, the nationwide geometric means for total DDT and p,p'DDE were 290 and 200 µg/kg, wet weight, respectively. Concentrations of total DDT and p,p'DDE in this study exceeded these means in 32 and 34 percent of fish-tissue samples, respectively (table 2). Similarly, concentrations of total PCB in samples from the Portneuf River at Pocatello (site 10) and toxaphene in samples from Rock Creek at Twin Falls (site 15) exceeded nationwide geometric mean concentrations of 530 and 280 µg/kg, wet weight, respectively (table 2). Clark (1989) also reported elevated concentrations of toxaphene (645 to 4,911 µg/kg) in tissue of fish from Rock Creek near Twin Falls in 1982 and 1985. Numerous irrigation-return

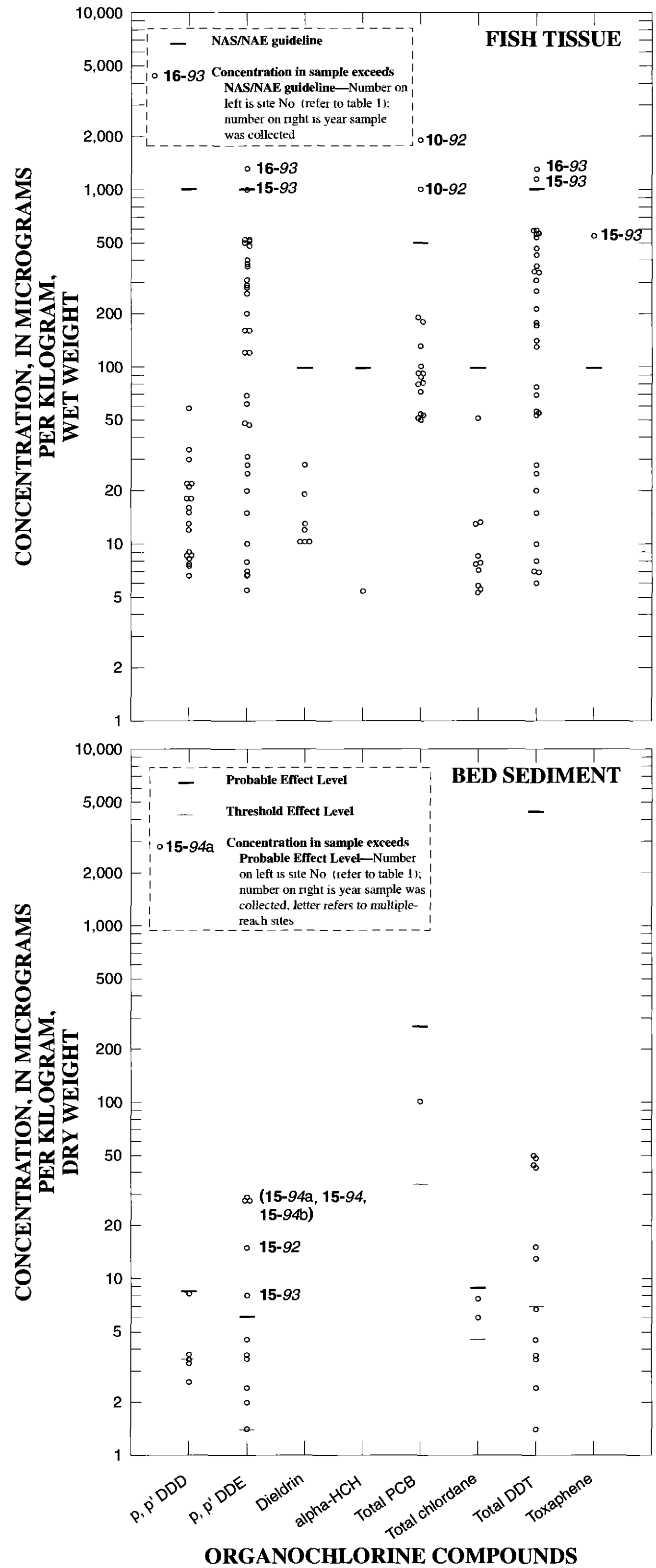

Figure 8. Concentrations of organochlorine compounds in fish tissue and bed sediment in relation to environmental guidelines, upper Snake River Basin, 1992–94. (National Academy of Sciences/National Academy of Engineering [NAS/NAE])

flows along Rock Creek are potential sources of sediment and associated organochlorine contamination (Maret, 1990).

Long-term trend information on organochlorine concentrations in fish tissue is lacking for much of the basin. Maret (1995) noted decreasing concentrations in total DDT and total PCB in fish-tissue samples from the Snake River near Hagerman, sampled as part of the USFWS/NCBP from 1970 to 1984 (Lowe and others, 1985). A comparison of total DDT and total PCB concentrations in fish-tissue samples from the Snake River near Buhl (site 16) and at King Hill (site 20) (this study) with concentrations in samples from the Snake River near Hagerman, reported by Lowe and others (1985), supports similar conclusions. Total DDT concentrations in fish tissue reported by Lowe and others (1985) generally were higher during 1970–84 and exceeded 2,000 µg/kg in most years. Concentrations of total DDT in samples from the Snake River near Buhl and at King Hill collected during this study ranged from 177 to 1,307 µg/kg (table 2). Total PCB concentrations reported by Lowe and others (1985) also were higher during 1970–84 and exceeded 1,000 µg/kg in most years. Concentrations of total PCB in samples from the Snake River near Buhl and at King Hill collected during this study were equal to or less than 100 µg/kg, which is about an order of magnitude less than concentrations reported by Lowe and others (1985).

BED SEDIMENT

Concentrations of p,p'DDE in sediment from Rock Creek at Twin Falls (site 15) ranged from 8 to 29 µg/kg (includes multiple-year and multiple-reach samples) and exceeded the PEL of 6.75 µg/kg (fig. 8). Rock Creek is affected by irrigation-return flows and typically carries a large sediment load. Its streambed and banks are high in silt and clay content (Maret, 1990). Sterling (1983) estimated that 35 to 50 percent of the flow in Rock Creek during the irrigation season consists of return flows, primarily from flood irrigation. Rock Creek also is one of the few sites in the basin where p,p'DDE was detected in multiple water samples (Clark, 1994b). The abundance of fine sediment in irrigation-return flows likely facilitates the transport of contaminants into Rock Creek. Despite the implementation of Best Management Practices and conversion from furrow to sprinkler irrigation in the Rock Creek Basin since 1981 (Yankey and others, 1991), contaminant concentrations remain elevated in Rock Creek. Munn and Gruber (in press) identified a significant positive relation ($r^2=0.80$) between concentrations of total DDT in sediment and percent of land that is gravity irrigated at sites in Washington and Idaho. Johnson and others (1988) routinely detected DDT compounds in Washington streams that receive irrigation runoff. Evidence supports the need to control sediment loads in irrigation-return flows to reduce the quantity of organochlorine contaminants entering streams. It is not surprising, then, that concentrations of p,p'DDE and total DDT in fish-tissue samples from Rock Creek at Twin Falls and the Snake River near Buhl, about 16 km downstream from the Snake River's confluence with Rock Creek, equaled or exceeded the NAS/NAE guidelines (fig. 8).

Total PCB was detected in sediment from only one site, Portneuf River at Pocatello (site 10), which was also the only site where concentrations of total PCB in fish tissue were elevated. Kent (1976) also detected PCB in fish tissue and sediment collected from American Falls Reservoir, about 27 km downstream from site 10. The nearby city of Pocatello and surrounding industrial activity could be potential sources of total PCB, because this compound most often is associated with urban and industrial areas (U.S. Environmental Protection Agency, 1992).

WATER

As part of the USNK NAWQA study, surface water (filtered) was analyzed for dacthal, p,p'DDE, alpha-HCH, gamma-HCH, dieldrin, and cis-permethrin during 1993–94. Thirteen sites coincided with sample sites in this study (sites 1, 3, 5, 6, 8, 9, 12, 13, 15, 16, 17, 19, and 20, table 1). Organochlorine compounds generally were not detected in surface-water samples. Of the 79 water samples from 13 sites, 4 samples from Rock Creek at Twin Falls (site 15) contained dacthal and p,p'DDE, and 1 sample from the Teton River near St. Anthony (site 5) contained p,p'DDE. Compound concentrations were all near their method reporting limits. Kent (1976) also detected organochlorine compounds in fish tissue and sediment but not in water samples from American Falls Reservoir.

SUGGESTIONS FOR FUTURE SAMPLING

On the basis of study results and established guidelines, future testing for organochlorine contaminants in fish-tissue and bed-sediment samples from the

Portneuf River at Pocatello, Rock Creek at Twin Falls, and the Snake River near Buhl seems warranted to facilitate trend analysis. All these sites receive irrigation-return flow and are near urban areas (mixed land use). In addition, analyses of organochlorine compounds in edible fish tissue (fillets of sportfish) and comparison of these analyses with USEPA fish consumption advisory guidelines for estimating human health risk would provide data to evaluate human health concerns (U.S. Environmental Protection Agency, 1995). These sites also might be good candidates to evaluate for endocrine disruption in fish resulting from elevated tissue concentrations of organochlorine compounds. Additional sampling of whole-fish tissue from these sites would provide data to evaluate long-term trends in contaminants and land-use practices.

Results of this study demonstrate that whole-fish tissue is a better medium than bed sediment or surface water for evaluating the occurrence and distribution of organochlorine compounds in USNK streams. Given the expensive laboratory analysis costs of contaminant studies, analyzing fish tissue alone, without also analyzing sediment and water samples, would provide data on the occurrence and distribution of organochlorine contaminants at a reduced cost.

SUMMARY AND CONCLUSIONS

Forty-one fish-tissue and bed-sediment samples were collected from 20 sites in the USNK and were analyzed for organochlorine compounds. Sites sampled were third- through seventh-order streams representing different environmental settings based on land use: reference conditions, agricultural land use, and mixed (agricultural and urban land uses). Thirty-three different compounds were analyzed, 28 in fish tissue and 32 in bed sediment.

Field duplicates of fish-tissue and bed-sediment samples were collected from three sites. Samples were collected from reaches upstream and downstream from one site to evaluate the variability of fish-tissue and bed-sediment contaminants within a longer stream segment. Concentrations of p,p'DDE in fish-tissue field duplicates of the same species differed by 54 to 64 percent; concentrations in different species differed by 87 percent. Concentrations of p,p'DDE in multiple-reach samples of the same species were similar; relative differences ranged from 8 to 26 percent. Total PCB concentrations in duplicates of the same species ranged from 34 to 62 percent.

Most organochlorine compound concentrations in bed-sediment field duplicates were below or near detection limits and differences were not significant. The one exception was for total PCB in sediment from site 10, where concentrations ranged from undetected to 101 μg/kg. Concentrations of p,p'DDE in bed sediment from multiple-reach sites were similar and values ranged from 28 to 29 μg/kg.

Organochlorine compounds were identified more often in fish tissue than in bed sediment during this study, primarily because organochlorine compounds are lipophilic. They tend to accumulate in the fatty tissues of organisms and can biomagnify as a result of various food chain interactions. Fourteen compounds were detected in fish tissue and nine in bed sediment; nine compounds were detected in both fish tissue and bed sediment. All compounds detected in bed sediment also were detected in fish tissue. The most frequently detected compound, p,p'DDE, a common metabolite of p,p'DDT, was the dominant component of total DDT. It was present in 80 percent of the fish-tissue and 30 percent of the bed-sediment samples. The next most frequently detected compound, total PCB, was present in 55 percent of the fish-tissue and 5 percent of the bed-sediment samples.

A maximum of three organochlorine compounds were detected, all in fish-tissue samples from reference sites. No compounds were detected in bed sediment from reference sites. One or more compounds were detected in fish-tissue or bed-sediment samples from all agricultural and mixed land-use sites. The highest number of compounds was detected in fish-tissue (nine) and bed-sediment (eight) samples from mixed land-use sites.

Generally, fish collected for tissue analysis were in good condition; only 8 percent (26 out of 325 fish examined) had external anomalies. No clear relation was determined between the occurrence of external anomalies and fish-tissue contaminant concentrations or land use. External anomalies were noted on fish from reference sites as well as from agricultural and mixed land-use sites throughout the basin.

The distribution of organochlorine compounds in the basin was related to land use. Total DDT was the most widely distributed compound in both fish tissue and bed sediment. Total PCB was detected at only agricultural and mixed land-use sites. Total chlordane was detected in fish-tissue samples from primarily mixed land-use sites; samples from six of the eight sites contained detectable concentrations. Significant positive relations were determined between percent agricultural land and concentrations of total DDT ($r^2 = 0.41$) and lipid-normalized total DDT ($r^2 = 0.48$). Lipid-normalization produced a slightly better relation (higher r^2) but did not change the overall interpretation. Median concentrations of p,p'DDE in fish-tissue samples from mixed land-use sites were significantly higher ($p<0.05$) than from reference or agricultural land-use sites.

Concentrations of p,p'DDE, total PCB, total DDT, and toxaphene in fish-tissue samples from three mixed land-use sites equaled or exceeded the NAS/NAE guidelines: Portneuf River at Pocatello, total PCB; Rock Creek at Twin Falls, p,p'DDE, total DDT, and toxaphene; and Snake River near Buhl, p,p'DDE and total DDT. Concentrations of these compounds in 7 of 41 tissue samples (17 percent) exceeded the NAS/NAE guidelines.

During this study, concentrations of total DDT and p,p'DDE in fish tissue exceeded 1980–81 USFWS/NCBP geometric mean concentrations in 32 and 34 percent of the samples analyzed, respectively. Total PCB in samples from the Portneuf River at Pocatello and toxaphene in samples from Rock Creek at Twin Falls also exceeded nationwide geometric mean concentrations.

Long-term trend information on organochlorine concentrations in fish tissue is lacking for much of the basin. However, comparisons of total DDT and total PCB concentrations in samples from the Snake River near Hagerman (collected during 1970–84 as part of the USFWS/NCBP) with concentrations determined in this study show a decreasing trend. Concentrations of total PCB in fish-tissue samples from Snake River sites collected during this study were generally an order of magnitude less than concentrations reported by the USFWS/NCBP.

Concentrations of p,p'DDE in sediment exceeded the PEL in all samples from Rock Creek at Twin Falls. Rock Creek typically carries heavy sediment loads from irrigation-return flows during the irrigation season, which facilitates instream transport and deposition of organochlorine compounds. Concentrations of p,p'DDE and total DDT in fish-tissue samples from Rock Creek at Twin Falls and the Snake River near Buhl, about 16 km downstream from the Snake River's confluence with Rock Creek, equaled or exceeded the NAS/NAE guidelines. This evidence supports the need to control sediment erosion to reduce the quantity of contaminants entering streams.

Total PCB was detected in sediment from only one site, Portneuf River at Pocatello, which was also the only site where concentrations of total PCB in fish tissue were elevated. Presence of PCB in both sediment and fish tissue suggests local sources.

Organochlorine compounds generally were not detected in surface-water samples. Of the 79 water samples analyzed, 4 samples from Rock Creek at Twin Falls contained dacthal and p,p'DDE, and 1 sample from the Teton River near St. Anthony contained p,p'DDE. Detectable concentrations were all near the method reporting limits for these compounds.

To properly assess contaminant occurrence and distribution in the aquatic environment, it is important that the appropriate environmental medium be tested. Because organochlorine compounds are lipophilic and tend to bioaccumulate in tissue, fish provide a more appropriate sampling matrix than do bed sediment or water.

Some of the highest concentrations of organochlorine contaminants in tissue and sediment in the basin were detected at sites receiving irrigation-return flows. Because some organochlorine contaminants are currently present in these watersheds, land-use practices designed to reduce the amount of contaminated sediment delivered to streams by way of irrigation-return flows could potentially benefit aquatic life and fish-eating wildlife.

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