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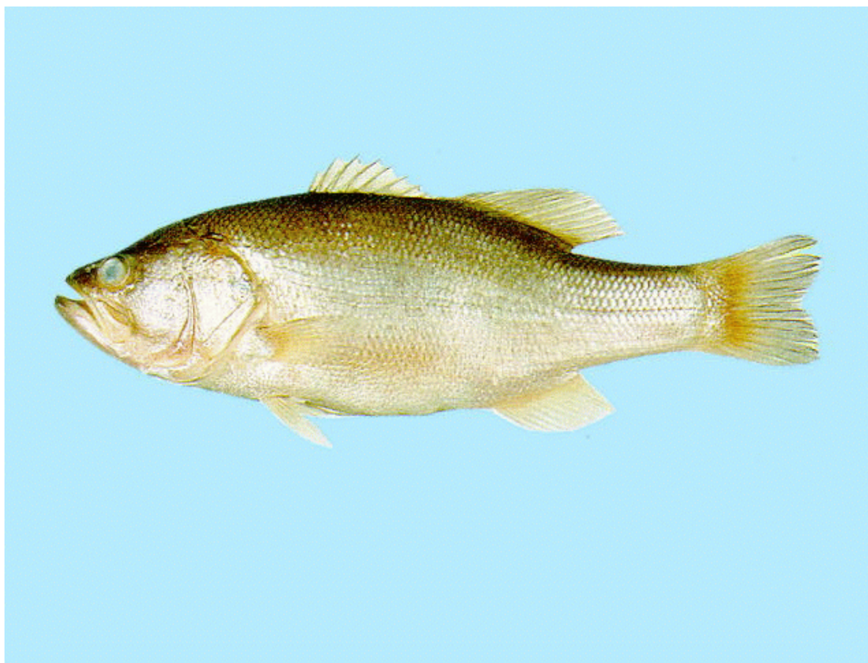
The National Survey of Mercury Concentrations in Fish

Data Base Summary 1990-1995



THE NATIONAL SURVEY OF MERCURY CONCENTRATIONS IN FISH

DATA BASE SUMMARY
1990 - 1995

September 10, 1999

U.S. Environmental Protection Agency
Standards and Applied Science Division
401 M Street, SW
Washington, DC 20460

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INTRODUCTION AND BACKGROUND

1.1 DISCUSSION OF THE ISSUE

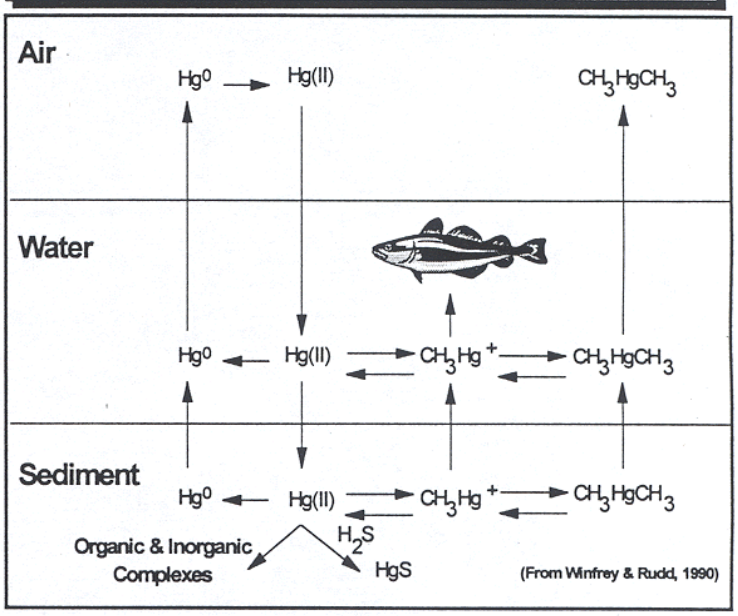
Mercury cycles in the environment as a result of natural and anthropogenic activities. The amount of mercury mobilized and released into the biosphere has increased since the beginning of the industrial age. Most of the mercury in the atmosphere is elemental mercury vapor, which circulates in the atmosphere for up to a year, and hence can be widely dispersed and transported thousands of miles from likely sources of emissions. Most of the mercury in water, soil, sediments, or plants and animals is in the form of inorganic mercury salts and organic forms of mercury (e.g., methylmercury). The inorganic form of mercury, when either bound to airborne particles or in a gaseous form, is readily removed from the atmosphere by precipitation and is also dry deposited. Wet deposition is the primary mechanism for transporting mercury from the atmosphere to surface waters and land. Even after it deposits, mercury commonly is emitted back to the atmosphere either as a gas or associated with particles, to be re-deposited elsewhere. As it cycles between the atmosphere, land, and water, mercury undergoes a series of complex chemical and physical transformations, many of which are not completely understood.

Mercury accumulates most efficiently in the aquatic food web. Predatory organisms at the top of the food web generally have higher mercury concentrations. Numerous studies in lotic and lentic freshwater environments have shown that the vast majority of total mercury in fish tissue is methylmercury, with nearly all total mercury as methylmercury in upper trophic level fish. Inorganic mercury, which is less efficiently absorbed and more readily eliminated from the body than methylmercury, does not tend to bioaccumulate. Fish consumption dominates the pathway for human and wildlife exposure to methylmercury.

1.1.1 Mercury Speciation and Cycling in the Aquatic Ecosystem

Understanding the distribution and cycling of mercury among the abiotic and biotic compartments of aquatic ecosystems is essential to understanding the factors governing this contaminant's biological availability and assimilation in water. Relative to most metals, mercury has a much longer residence time in the atmosphere. As a result, mercury is mobile and readily dispersed through the atmosphere, with the aquatic cycling of mercury strongly affected by exchange processes across the air-water interface. Mercury can be present as a dissolved constituent in water, concentrated in the air-water

Figure 1-1. Mercury Cycling in Surface Water



microlayer interface, attach-ed to plankton and suspended detritus, and present in bottom sediments and benthos (Figure 1-1).

Mercury is biogeochemically active in natural waters, an expected characteristic, given the multiple routes and reactions available for the interconversion of dissolved mercury species (Fitzgerald, 1989; Andren and Nriagu, 1989). The three species, or oxidation states, of mercury prevalent in the aquatic environment are:

- Hg^0 – elemental, or metallic, mercury
- Hg_2^{+2} – mercurous ion, a divalent mercury form
- Hg^{+2} – mercury II, the mercuric ion, a divalent ion

In oxygenated waters supporting living organisms, mercury in the Hg^{+2} form generally dominates and is rapidly removed from solution through adsorption to suspended solid and bottom sediments, by binding to organic detritus, and through biotic assimilation. Mercury species form both organic [i.e., methylmercury—CH_3Hg^+ and dimethylmercury $(CH_3)_2Hg$] and inorganic (mercuric chloride—$HgCl_2$) compounds. Organic forms of mercury, such as methylmercury, exhibit longer biological half-life than inorganic mercury; the half-life of methylmercury ranges from 1.5 years in trout to approximately 2 years in pike (Ruohtula and Miettenen, 1971).

1.1.2 Methylmercury

All forms of mercury can be methylated by natural processes. Much of the methylmercury in the aquatic environment is derived from internal, biologically-mediated synthesis. For example, anaerobic sulfate-reducing bacteria, as well as aerobic bacteria and fungi, are major mediators of methylation in sediment. Most methylation occurs in the sediment, but it can also occur in the water column. Moreover, methylmercury is also produced when dimethylmercury, $(CH_3)_2Hg$, dissociates in neutral or acidic conditions. Fish cannot methylate mercury in vivo, although methylation in the gastrointestinal tract has been documented (Rudd et al., 1980).

Unlike dimethylmercury, methylmercury forms highly stable bonds. With a strong affinity for sulfur-containing organic compounds (e.g., proteins) and ionic properties that facilitate penetration through membranes, methylmercury bioaccumulates in fish and biomagnifies in aquatic ecosystems. While it may comprise less than 30 percent of the total mercury in zooplankton, methylmercury accounts for approximately 90 percent of the total mercury in fish (Huckabee et al., 1979). Excretion of methylmercury is slow relative to the rate of uptake (Wiener, 1987), and no convincing evidence that methylmercury is demethylated in fish exists (Weiner and Spry, 1994).

1.1.3 Methylmercury in the Aquatic Ecosystem

All water bodies in the Northern Hemisphere are probably contaminated with mercury due to long-range transport and deposition from anthropogenic sources (Weiner and Spry, 1994). Predominant exposure to methylmercury for fish is through diet, with direct uptake of methylmercury from water across the gills providing minimal exposure. Exposure and accumulation of methylmercury in aquatic organisms is subtly complex and influenced by numerous biotic and environmentally mediated reactions. For example, piscivorous feeding habits, subsequent biomagnification in food chains, and fish species, size, age, and longevity influence methylmercury concentrations in fish tissues (Birge et al., 1977). Environmental factors, such as anthropogenic discharges, the form and concentration of mercury, water temperature, low acid-neutralizing capacity, atmospheric deposition, pH, dissolved oxygen levels, sedimentation rates in water bodies, proximity to wetlands, and the flooding of new impoundments or reservoirs, are all factors affecting the exposure of fish to methylmercury in the aquatic environment.

1.1.4 The Toxic Effects of Methylmercury

While the rates of bioassimilation of mercury vary due to biotic and abiotic factors, methylmercury imparts the same toxic effects on all species. In fish, methylmercury binds to red blood cells and is rapidly transported to all organs, including the brain, blood, spleen, kidney, and liver. Most methylmercury ultimately accumulates in muscle, bound to sulfhydryl groups in protein (Weiner and Spry, 1994). The route of uptake (e.g., via the gills or diet) has little influence on the bodily distribution of methylmercury. The production of metallothioneins, metal-binding proteins that aid animals by binding metal ions, are not induced by mercury in fish species (Roseijadi, 1992). Thus, the primary detoxification mechanism in fish for methylmercury may be storage in the muscle rather than storage in other sensitive and vulnerable tissues and organs (Weiner and Spry, 1994).

The effects of methylmercury in fish are well characterized and include death, reduced reproductive success, impaired growth and development, behavioral abnormalities, organ and immune response damage, altered blood chemistry, osmoregulation effects, reduced ingestion rates and predatory success, and impacted oxygen exchange (Weiner and Spry, 1994; Zilloux et al., 1993). Prenatal and neonatal life stages exhibit greater sensitivity, and the effects appear to be irreversible (Wiener, 1987). In fact, survival of fish embryos has been shown to be substantially reduced by minute quantities of either inorganic or organic mercury from waterborne exposure (Birge, 1977).

Neurotoxicity is the most likely chronic response of wild adult fishes to dietary methylmercury (Weiner and Spry, 1994), with long-term dietary exposure to methylmercury causing lack of coordination, inability to feed, and diminished responsiveness. Fish exposed to methylmercury in laboratory situations, for example, exhibited several symptoms of methylmercury intoxication, including loss of appetite, reduced activity, darkened skin, loss of equilibrium, reduced growth, and reduced visual activity (Matida et al., 1971). Additional studies on fish from Minamata Bay, Japan, have reported that the neurotoxic effects of methylmercury impede the abilities of wild fish to locate, capture, handle, and ingest prey, and also impair the ability to avoid predation (Takeuchi, 1968).

For humans, epidemics of mercury poisoning following high-dose exposures to methylmercury in Japan and Iraq demonstrated that neurotoxicity is the health effect of greatest concern when methylmercury exposure occurs to the developing fetus. Dietary methylmercury is almost completely absorbed into the blood and distributed to all tissues including the brain; it also readily passes through the placenta to the fetus and fetal brain.

1.2 PURPOSE OF DATA COMPILATION

The potential adverse effects of chemical contaminants in fish is an ongoing Agency concern that is directly related to Clean Water Act responsibilities to ensure that waters of the United States are fishable and swimmable. As a percentage of total mercury, methylmercury is not problematic for short-lived species, because the opportunity to accumulate mercury for periods of many years does not exist. From an ecological perspective, however, mercury can bioaccumulate through the food chain, resulting in body burdens that are higher than the baseline exposure concentrations; species at higher trophic levels (e.g., humans, the bald eagle, and piscivorous fish species) prey on other mercury-concentrating organisms (e.g., forage fish, which in turn feed on smaller forage fish, which feed on zooplankton or benthic invertebrates). Bioaccumulation increases the likelihood that chronic effects of mercury will impact the health and reproduction of organisms at higher trophic levels.

Although the degree of mercury bioaccumulation in fish tissues differs from watershed to watershed, mercury contamination is becoming a national concern. Concern stems from information indicating that methylmercury tends to bioconcentrate in fish tissue up to a million times or more over concentrations found in the water column. In contrast to terrestrial animals, which concentrate mercury in feathers or fur, fish populations concentrate mercury in muscle tissue. This aspect is of particular concern to EPA, because edible tissues of fish and other aquatic organisms may contain mercury concentrations that exceed limits based on EPA risk assessment procedures for certain consumption patterns.

As of July 1999, 40 states had issued a total of 1,931 fish consumption advisories for specific water bodies or for portions of statewide water bodies. Of these 1,931 advisories, 90% were issued by the following 11 states: Minnesota (821), Wisconsin (402), Indiana (126), Florida (97), Georgia (80), Massachusetts (58), Michigan (53), New Jersey (30), New Mexico (26), South Carolina (24), and Montana (22). Ten states (Connecticut, Indiana, Maine, Massachusetts, Michigan, New Hampshire, New Jersey, North Carolina, Ohio, and Vermont) have issued statewide advisories for mercury in their freshwater lakes and rivers. Another five states (Alabama, Florida, Louisiana, Massachusetts, and Texas) have statewide advisories for mercury in their coastal waters.

Regulatory and scientific focus on mercury in the aquatic ecosystem has been motivated largely by the health risks of consuming contaminated fish, primarily because human exposure to methylmercury is almost wholly due to fish (Fitzgerald and Clarkson, 1991; Clarkson, 1992). While mercury contamination poses potentially serious human health and ecological problems, understanding of the problem is still relatively limited. The ability to determine the nature and the extent of mercury concentrations in fish on a regional and national basis, to identify possible sources of contamination, and to link mercury concentrations to sources depends on the availability of data suitable for such analysis.

To help fill this need, EPA began a cooperative effort in 1995 to assemble a nationwide data base on total mercury concentrations in fish tissue. The first objective of this project was to assemble and review data on the mercury contamination in fish tissue. This step included identifying appropriate state and federal agencies and other groups with relevant data on mercury concentrations in fish. The second step in this project involved the development of a fish tissue data base, organizing relevant data to be used for future analyses. EPA focused data compilation efforts on obtaining results of state monitoring efforts during 1990-1995 (See Appendix). These data can be used to derive estimates of tissue concentrations, determine the number and frequency of samples taken and analyzed by state, and calculate descriptive statistics on mercury concentrations in fish tissue. The current data base will facilitate EPA's ability to determine additional and future data needs. In the future, the data base may be used to identify and evaluate factors affecting mercury contamination in fish.

1.3 THIS DOCUMENT

This document describes the national mercury data base compiled and quality assured by EPA's Standards and Applied Science Division within the Office of Water's Office of Science and Technology. In addition to this introduction, this document contains a description of the data base (Section 2.0), including an overview of the data base format, inconsistencies among data sets, and a discussion of the steps taken to standardize and ensure data quality. Section 3 describes the data base in detail and provides a national overview of the types of data contained in the data base and a summary of mercury concentrations in selected fish species. Section 3 also presents state profiles; for each state included in the data base, a four-page graphical and tabular summary is provided. Each summary presents sampling information (e.g., the number of fish and sites sampled); details on the ten most common species and other variables related to fish that are contained in each state data set; sampling sites and range in mercury concentration across each state for those reporting latitude and longitude; and summary statistics on fish mercury content. Section 4 describes issues relevant to analysis of the data, including treatment of nondetects, and provides a brief discussion of the potential future uses of the data base. Section 5 lists the references consulted in preparing this report.

SECTION 2
DATA BASE STRUCTURE AND FORMAT

2.1 OVERVIEW OF THE DATA BASE

Data from 40 states and the District of Columbia comprise the national data base on total mercury concentrations in fish tissue. The data are broadly categorized into three groups, providing location, biological, and mercury concentration information. The principal features of the national data base on mercury concentrations are:

- Fish tissue samples collected from 1990 to 1995, inclusive.

- Location information, with most states providing latitude and longitude.

- Common and scientific names for fish species.

- Total mercury concentrations greater than zero. If the mercury concentration was labeled as “non-detected” or as less than a given value, the detection limit or the given value was used to estimate mercury concentration.

- Weighted mercury concentrations in fish tissues. For composite samples, the number of fish in the composite was used as the weighted value. For samples comprised of a single fish, or samples where composite information was not available, a weight of one (1) was assigned.

States not included in the data base either could not provide information on mercury concentrations in fish (i.e., Alaska, Colorado, Hawaii, Idaho, Nevada, North Dakota, Wyoming, and Utah), or provided data in hard copy reports (i.e., Montana and South Dakota). Mercury data available only in hard copy reports were not included in the data base because the data in hard copy reports frequently did not contain complete information. Furthermore, manually entering the data from hard copy into an appropriate electronic format, obtaining missing information, and performing quality control checks on the data would have been prohibitive, given the schedule and scope of work for this project.

2.2 DATA BASE FORMAT

The compiled data were imported initially into SAS® from various formats. To make the data base more widely accessible, a relational data base was constructed in Microsoft Access 97. The Access data base has been updated with new data from several of the states and has been subjected to additional quality control and assurance and overall standardization. Table 2-1 lists the states that comprise the national data base on mercury concentrations in fish tissue, as well as the primary source of the data (i.e., state or STORET). A list of the data fields in Access 97 and a short explanation of the data contained in the field are provided in Table 2-2.

2.3 INCONSISTENCIES AMONG DATA SETS

After identifying, obtaining, and verifying data from the appropriate sources, discrepancies among state data were identified by visually examining each data set. Consistency in the formatting of data

Table 2-1. The National Survey of Mercury Concentrations in Fish: Data Base Sources[a]

State Name	State Data	STORET Data
AL	Primary	
AZ	Primary	
AR	Primary	
CA	Primary	
CT	Primary	
DE	Primary	
DC	Primary	
FL	Combined data sets	
GA	Combined data sets	
IL		Primary
IN	Primary	
IA		Primary
KS		Primary
KY	Combined data sets	
LA	Primary	
ME	Primary	
MD	Primary	
MA	Primary	
MI	Primary	
MN	Primary	
MS	Primary	
MO	Primary	
NE		Primary
NH	Primary	
NJ	Primary	
NM	Primary	
NY	Primary	
NC	Primary	
OH	Primary	
OK	Combined data sets	
OR	Primary	
PA		Primary
RI[b]	Primary	
SC	Combined data sets	
TN		Primary
TX		Primary
VT	Primary	
VA		Primary
WA	Primary	
WV	Primary	
WI	Primary	

[a] Data not available for AK, CO, HI, ID, MT, ND, NV, SD, UT, and WY.
[b] Rhode Island data are for 1996 through 1998 and are included in the data base, but are not addressed in this report.

Table 2-2. The National Survey of Mercury Concentrations in Fish: Data Base Field Descriptors

Field	Description	Example
State	State name	Alabama
Water Body	Water body name	Tensaw River
County	County name	Berkshire
Location	Description of location where the sample was taken	Mobile River, river mile 27.0
Latitude	Latitude in decimal degrees	39.2521
Longitude	Longitude in decimal degrees	-95.0812
Agency	Federal or state collection agency responsible for sampling	Ohio Department of Health
Collection Date	Date sample was collected	12/21/93 = 931221
Date	Sampling date presented in Access Date/Time format	12/31/93
Common Name	Common name	Largemouth bass
Genus	Genus name	*Micropterus*
Species	Species name	*salmoides*
Sample Type	Indicates whether sample type is composite or specimen	Composite or Specimen
Number in Sample	Total number of fish that comprise a sample	3
Mean Length	Length of individual or mean length for a composite sample (mm)	355.00
Total Length	Total length of sample (mm)	1777.00
Mean Weight	Mean weight for a composite sample (g)	690.00
Total Weight	Total weight for a specimen (g)	910.00
Portion	Identifies the organ or portion of fish analyzed	Fillet, skin off; Whole body, etc.
Standardized Portion	Assigns each portion type into one of four categories	Whole body, Fillet, Other, Unknown
Detection Limit	Detection limit (ppm)	0.001
Mercury Basis	Indicates whether mercury was measured on a wet or dry weight basis	Wet or Dry
Mercury Concentration	Mercury concentration measured in fish tissue (ppm)	0.570
Dry_Wet Conversion	Tissue concentrations on a dry weight basis were converted to wet weight for comparison purposes	Wet Weight = Dry Weight x (1-%moisture)
Fillet Conversion	Some states reported whole body concentrations of mercury rather than fillet concentrations. For comparison purposes, the whole body mercury concentrations were converted to fillet.	$C_r = C_{wb} \div 0.7$ Where, C_r = Fillet Hg concentration C_{wb} = Whole body Hg concentration
Wet_Fillet Concentration	Presents the tissue data (Whole body, Fillet and Unknown) on a wet weight and fillet basis	0.570
Qualifier	Descriptive information accompanying the mercury value	"Less than" or "estimated"

sets from state to state is the most important requirement in establishing a well-structured national data base. Some of the principal inconsistencies and discrepancies encountered are discussed below.

2.3.1 Missing Data or Blank Fields

Very few state data sets submitted initially contained all the requested data fields. Some states could not send the requested data because such data were not collected. Others were able to send the additional information, and in some cases a completely new version of the data set was submitted. If the state could not supply additional data, STORET was searched in an effort to augment the data set. This standardization process resulted in obtaining some additional latitude and longitude data. EPA attempted to standardize the data to make the data base as complete as possible. For example, some states provided only the year, or the year and month of the sample collection date. The month of January and/or the first day of the month (01) were assigned as necessary to form a complete value for the variable *Collection date* in the data base.

2.3.2 Differing Data Structures

In addition to differing software packages, the format or structure of the data sets varied from state to state. For example, field descriptor names differ across states. Furthermore, the same field names may define the same, or different, variables. Empty entries in data sets also vary from state to state. In some state data set formats, empty entries denote missing values. However, in other state data formats, empty entries imply that the values for the empty entry are the same as the prior nonempty value. The disparities among state data structures and field names typically cannot be discerned until the given format for several state data sets is thoroughly examined. Improving the consistency among state data base formats, such as through the use of EPA's modernized STORET data system, would greatly enhance comparability and synthesis of data on a national scale.

2.3.3 Differing Coding Systems

A fairly common discrepancy among the state data sets is that each state has a different coding system. Lack of explanation for the codes hinders the standardization, and additional contact with the state was necessary to interpret codes for several fields, including common name, fish species, portion analyzed, collection agency, county, and qualifier. Some state data sets contain only the common name and do not contain a key that cross references the associated scientific name. Other records that frequently differed:

- fish length, for which different units were given—inches, centimeters, or millimeters;
- fish weight—pounds or grams;
- common name/species/genus—Carp or Common carp/Cyprinus or C./carpio
- mercury concentration—ppm or ppb
- latitude and longitude—degree-minute-second or decimal degrees; and

- length and weight measurements—total length and total weight of fish or composite or mean length and weight of the composite

2.4 STANDARDIZATION OF VARIABLES

Standardizing the variables in each state data set consisted of the following activities:

- Three fields are associated with identifying fish species: common name, genus name, and species name. Most states only provided common names using different coding schemes. In order to standardize the names, genus and species names were assigned to the common names. The first step in this process used a data sheet containing both common names and scientific names as designated by the American Fisheries Society (AFS). All common names were matched electronically to identical common names. In cases where names did not match, taxonomy literature and best professional judgement were used to identify the genus and species. Some states supplied common names that had been coded for their data management system without providing an accompanying key to the coding system. For example, one state may have used "LMB" for largemouth bass or assigned a numeric code to a common name, and a follow-up contact with the state was required to obtain information on the coding system.

- The portion analyzed was standardized from the state data set into the national data base and then again for the analysis presented in this document. The standardized portion code in the data base and the portion code used for mercury concentrations analyses are shown in the following table. Other entries for portions analyzed that were supplied by states included connective tissue, eggs, eyes, gills, gonads, liver, head and viscera, no head or viscera, no skin, and veins. These entries were retained as is in the data base, but they were eliminated for analyses involving whole-body and fillet mercury concentration comparisons.

Table 2-3. Standardized Portion Codes

Portion Code in State Data base	Standardized Portion Code	Portion Code Used in Analyses
Edible portion, edible, edible skin-off	Edible portion	Fillet
F, Filet, FS, PF, SFF, SFFC	Fillet, skin off	Fillet
F, FILSK, Fillet-skin-on, SOF, SOFC	Fillet, skin on	Fillet
86, F, F1, F2, Meat, Fillets	Fillet, skin unknown	Fillet
Headless whole fish	Headless whole fish	Whole body
15, 59, MWBC, WB, WBC, whole fish	Whole body	Whole body
Whole body, skin off	Whole body, skin off	Whole body
Whole body, skin on	Whole body, skin on	Whole body

- Values for latitude and longitude were converted to decimal degrees, such as 39.2522 and 95.3267. This process entailed converting the degree, minute, second or the radian format supplied by most states to decimal degrees by the following equations:

$$Lat\_decimal = Lat\_deg + Lat\_min / 60 + Lat\_sec / 3600$$

$$Long\_decimal = Long\_deg + Long\_min / 60 + Long\_sec / 3600$$

- For some states, the variable water body was provided. In situations were this variable was not provided, it was derived from location information provided by the state. For example, if the location information provided was "Mississippi River at RM 37.0," the water body derived was the Mississippi River.

- Qualifiers are descriptive information accompanying the mercury concentration measurement, such as "ND," "non-detected," and "less than." These qualifiers were standardized across all state data sets. The following table provides some examples of the different values in this field in state data sets assuming the detection limit is 0.02 ppm.

Table 2-4. Examples of Qualifiers for Mercury Concentrations

Mercury Concentration (Provided by the State)	Qualifier (Provided by the State)	Standardized Mercury Concentration	Standardized Qualifier
ND		0.02	Non-detected
0.01	half the detection limit	0.02	Non-detected
0.02	less than, or <	0.02	Less than
-	ND, or not detected, NA	0.02	Non-detected
0.02	estimated	0.02	Estimated

- Units of length, weight, and mercury concentrations were standardized to millimeters, grams, and ppm, respectively. Simple mathematical conversions were performed in this standardization task. Length and weight measurements are given as total and/or mean. Some states did not provide information regarding whether length and weight measurements were total or mean. In instances where this could not be discerned or when these were not supplied, the state was contacted for clarification.

- For some states, fish tissue mercury concentrations were provided on a dry weight basis. An additional column was added to the data base (Dry_Wet Conversion) that converts the concentrations on a dry-weight basis to a wet-weight basis to enable data comparisons. The follow equation was used to perform the conversion calculation:

$$Wet\ weight = Dry\ Weight \times (1 - 0.xxx)$$

where:

Wet weight = mercury concentration by wet weight in mg/kg tissue
Dry weight = mercury concentration by dry weight in mg/kg tissue
0.xxx = percent moisture in fish tissue expressed as a decimal (e.g., 75% = 0.75)

Moisture content varies in fish based on numerous factors such as age and species, and because moisture content is not included as a variable in the data base, all conversions were made with an assumed moisture tissue percentage of 78.5% (0.785). This value was based on the arithmetic mean of the moisture contents of coho salmon (85%), kokanee (74%), lake whitefish (80%), pike (78%), white sturgeon (78%), and sockeye salmon white muscle (fillet, 76%) (B.C. Environment, 1998; McDonald, 1997).

- The fish tissue data consist primarily of analyzes of mercury concentrations in fillets. Some states, however, provided data on the basis of whole body measurements. To facilitate comparisons between tissue and whole-body measurements, the following empirically-derived equations from Bevelheimer *et al.* (1996) were used:

$$C_{wb} = 0.7 \times C_f$$

where:

C_{wb} = whole-body mercury concentration in mg/kg
C_f = fillet mercury concentration in mg/kg

A field (fillet conversion) was added to the data base that contains the results of the calculation above, solved for C_f only for those records where the mercury concentration was measured based on whole body measurements.

2.5 General Quality Assurance/Quality Control

The first step in quality assuring the data was to identify the appropriate data source for each state. States either maintained collected data within the state agency and/or submitted mercury concentrations in fish tissue data directly to STORET, a nationally maintained ambient water quality data base. Data downloaded by the state from the STORET system and sent in an electronic or hard copy format are considered “STORET” data. Data maintained by the state agency in house and not submitted to STORET are considered “state” data. State-collected data on mercury concentrations in fish tissue were available from most states in electronic or hard copy formats, or both.

EPA quality assured STORET data while trying to obtain missing data fields from STORET and BIOS, another national data base containing fish species information that is compatible with STORET maintained on EPA’s mainframe computer. STORET and BIOS were searched on the EPA mainframe, and the resulting data were compared to STORET data sent by the state. When possible, STORET data from the mainframe were used to augment incomplete data sets received from the state. This action resulted in five (5) states with combined data sets from 1990 – 1995, as shown in Table 2-2.

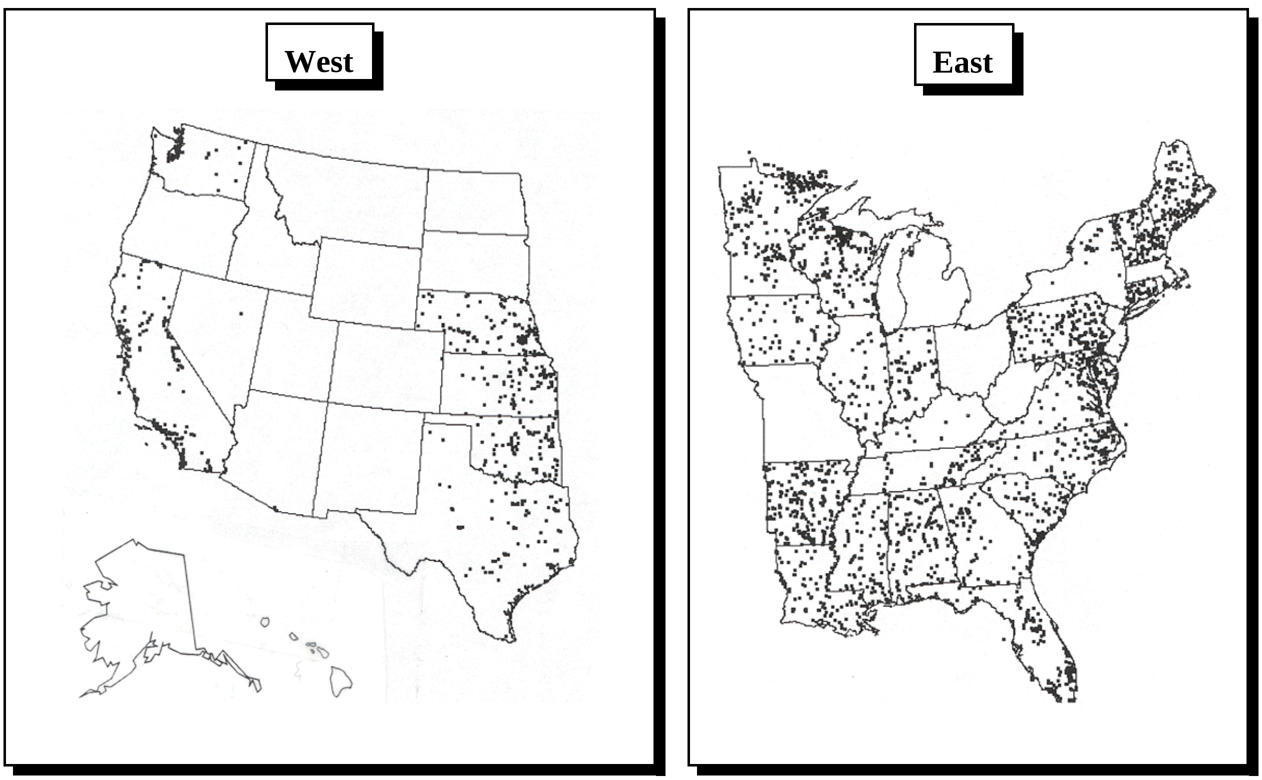
Following completion of the data standardization process, additional quality assurance measures were performed before performing any analysis on the data base. For example, the mercury concentration field was carefully scrutinized. Unreasonably high mercury concentrations (e.g., 140.0 ppm and 220.0 ppm) were identified and subsequently dropped from the data base when scientifically valid explanations could not be identified. Other suspicious mercury concentrations (13.3 ppm, 5.95 ppm, and 5.83 ppm) identified were noted in the data base but were not dropped because reasonable justifications could not be identified. In one instance, values for a chemical other than mercury that had been sent were identified and substitute data were provided by the state. Additional errors in fields such as sampling date, latitude, and longitude also were discovered and corrected, following confirmation with the state contact.

SECTION 3
NATIONAL AND STATE OVERVIEW

3.1 NATIONAL OVERVIEW

The District of Columbia and 40 states are represented in the electronic version of the national mercury data base. The sampling sites in the data base for which latitude and longitude are available are depicted on the national map in Figure 3-1.

Figure 3-1. Sampling Locations with Latitude and Longitude



3.1.1 Availability of Data Variables

Table 3-1 summarizes the variables that are present in, or absent from, the national data base. Varying combinations of data on location, biology, and mercury are available in the electronic data base for 40 of the 50 states plus the District of Columbia. Data are available in hard copy only for Montana and South Dakota, and they have not been incorporated into the electronic data base. For Rhode Island, data records for the years 1996 through 1998 are included in the data base, but are not addressed in this report. Data on mercury concentrations in fish are not available for Alaska, Colorado, Hawaii, Idaho, Nevada, North Dakota, Utah, and Wyoming.

Table 3-1. The National Survey of Mercury Concentrations in Fish: Presence/Absence of Variables in Data Base

	Location Information				Biological Information						Mercury Information	
State[a]	**Site**	**Lat/ Long**	**Water-body**	**Date**	**Taxon**	**Wt.**	**Length**	**Comp. vs. Spec.**	**Portion Analyzed**	**Weight Basis**	**Conc.**	**Units**
AL	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AZ	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
AR	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DC	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓
FL	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
GA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IL	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IN	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IA	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓
KS	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓
KY	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
LA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ME	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MD	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
MA	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MI	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MN	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MS	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
MO	✓			✓	✓	✓		✓	✓	✓	✓	✓
MT			✗		✗		✗	✗	✗	✗	✗	✗
NE	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓
NH	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NJ			✓	✓	✓	✓	✓	✓	✓		✓	✓
NM	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NY	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
OH	✓		✓	✓	✓			✓	✓	✓	✓	✓
OK	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
OR	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PA	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓
SC	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
SD			✗		✗						✗	✗
TN	✓	✓	✓	✓	✓				✓	✓	✓	✓
TX	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
VT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
VA	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
WA	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
WV	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
WI	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

[a] Data not available for AK, CO, HI, ID, ND, UT, and WY; see text for note on RI.
✗ = Data available only in hard copy reports. Not included in data base.
✓ = Data available electronically in data base.

Location data are included in four variables: *site*, *latitude*, *longitude*, and *water body* name; the *sampling date* is also provided in this category of variables in Table 3-1. Most of the location information is included in the electronic data base for 40 of the 50 states and the District of

Columbia, with the level of detail describing location and water body varying among states. Of the four location variables, latitude and longitude for the sampling site are the most frequently missing variables. Latitude/longitude are missing from the electronic data base for Massachusetts, Michigan, Missouri, New Jersey, New Mexico, Ohio, Oregon, and West Virginia.

Biological data are included in the following variables: *taxon*; *weight* and *length* of a specimen (an individual fish) or average weight and length (if the sample is a composite); whether the sample represents a *composite* of more than one fish or a single individual, or *specimen*; what portion of the fish is analyzed (i.e., *whole body, fillet*); and whether the mercury content is expressed on a *wet* weight basis or *dry* weight basis (or both). Of these variables, length is the most commonly missing variable, absent from 12 states. All states and the District of Columbia in the national data base report the portion analyzed, and, with the exception of New Jersey, all report the weight basis of the fish tissue analyzed.

Mercury data are included in four variables: *concentration, units, detection limits,* and *comments* associated with the mercury concentration (e.g., "less than"). These four data variables are included in the electronic data base for the 40 states and the District of Columbia.

3.1.2 Type of Sampling and Analysis

Table 3-2, similar to Table 3-1, presents information on the presence or absence of sample type (i.e., composite or specimen), portion of the fish analyzed, and the basis on which mercury concentrations are reported. Sample type includes: individual, composite, and in the case of composites, whether the number of fish in the composite is reported. With two exceptions (Florida and Tennessee), all states provided data on sample type as well as on the number of fish in the composite. When the number of fish in the composite was not specified, the number was assumed to be one.

The portion analyzed includes whole body, fillet, or "other"; other includes gonads, internal organs, eggs, etc. All states analyzed the fillets of the fish for mercury, while several others elected to analyze whole body portions as well. Mercury concentrations are reported on a dry weight basis or a wet weight basis. The vast majority of states measure and report mercury on a wet weight basis.

3.1.3 Extent of Sampling

The national data base for 1990-1995 includes data for nearly 82,000 individual fish (representing 230 different species) at approximately 5,000 locations in approximately 3,200 water bodies. Table 3-3 summarizes the number of discrete water bodies, stations, number of species analyzed, and total fish analyzed from 1990 through 1995 by state. Most states have data for at least five of these years, many have sampled for all six years, and only a few have sampled for two or fewer years. In many cases, the number of water bodies sampled and the number of sampling station locations are approximated from available data submitted by the state. Minnesota, Michigan, Wisconsin, Florida, Arkansas, and California conducted the most sampling during 1990-1995, as measured by the number of water bodies sampled. Broad comparisons among states are not appropriate, because states differ both in terms of geographic size and total amount of surface water.

Table 3-2. The National Survey of Mercury Concentrations in Fish: Presence/Absence of Fish and Mercury Information in Data Base

	Sample Type			Portion Analyzed			Weight Basis	
State[a]	Specimen	Composite Sample	No. in Composite	Whole Body	Fillet	Other	Wet	Dry
AL	✓	✓	✓		✓		✓	
AZ	✓				✓		✓	
AR	✓	✓	✓		✓		✓	
CA	✓	✓	✓	✓	✓	✓	✓	
CT	✓				✓		✓	
DE	✓	✓	✓	✓	✓	✓	✓	
DC		✓			✓		✓	
FL					✓	✓	✓	
GA	✓	✓	✓	✓	✓	✓	✓	✓
IL	✓	✓	✓	✓	✓		✓	
IN	✓	✓	✓	✓	✓		✓	
IA		✓	✓	✓	✓	✓	✓	
KS	✓	✓	✓	✓	✓	✓	✓	
KY	✓	✓	✓	✓	✓	✓	✓	
LA	✓	✓			✓		✓	
ME		✓	✓	✓	✓		✓	
MD	✓	✓	✓	✓	✓	✓	✓	
MA	✓						✓	
MI	✓	✓	✓	✓	✓	✓	✓	
MN	✓	✓	✓	✓	✓	✓	✓	
MS	✓	✓	✓	✓	✓	✓	✓	
MO	✓	✓	✓	✓	✓	✓	✓	
MT	✗	✗	✗		✗		✗	
NE	✓	✓	✓	✓	✓	✓	✓	
NH	✓	✓	✓	✓	✓		✓	
NJ	✓				✓		✓	
NM	✓				✓		✓	
NY	✓				✓		✓	
NC	✓	✓	✓	✓	✓	✓	✓	
OH	✓	✓	✓	✓	✓	✓	✓	
OK	✓	✓	✓	✓	✓	✓	✓	
OR	✓	✓	✓	✓	✓	✓	✓	
PA	✓	✓	✓	✓	✓		✓	✓
SC	✓	✓	✓	✓	✓		✓	✓
SD		✗	✗		✗			
TN					✓	✓	✓	
TX	✓	✓	✓	✓	✓	✓	✓	✓
VT	✓	✓	✓		✓		✓	
VA	✓	✓	✓	✓	✓	✓	✓	✓
WA	✓	✓	✓	✓	✓		✓	
WV	✓	✓	✓		✓		✓	
WI	✓	✓	✓	✓	✓	✓		✓

[a] Data not available for the following states: AK, CO, HI, ID, NV, ND, UT, and WY; see text for note on RI.
✗ = Data available only in hard copy reports. Not included in data base.
✓ = Data available electronically in data base.

Table 3-3. The National Survey of Mercury Concentrations in Fish: Number of Records and Years in Data Base

State[a]	Number of: Discrete Water bodies Sampled	Discrete Stations Sampled	Species Analyzed	No. of Fish Analyzed	Year Reported: 1990	1991	1992	1993	1994	1995
AL	89	141	24	2236	✓	✓	✓	✓	✓	✓
AZ	2	2	5	51						✓
AR	161	222	29	2389		✓	✓	✓	✓	✓
CA	176	223	48	4914	✓	✓	✓	✓	✓	
CT	54	54	4	618						✓
DE	19	29	16	190	✓	✓	✓	✓		
DC	2	7	8	75		✓	✓	✓	✓	
FL	194	273	36	2819	✓	✓	✓	✓	✓	✓
GA	94	208	44	3412	✓	✓	✓	✓	✓	✓
IL	3	66	13	458	✓	✓	✓	✓		
IN	49	119	43	1987	✓	✓	✓	✓	✓	✓
IA	53	75	10	549	✓	✓	✓	✓	✓	✓
KS	69	85	15	755	✓	✓	✓	✓	✓	✓
KY	13	45	27	1323	✓	✓	✓	✓	✓	✓
LA	73	97	38	1093	✓	✓	✓	✓	✓	✓
ME	120	125	13	1557				✓	✓	
MD	41	60	22	799	✓	✓	✓	✓	✓	
MA	24	24	5	550					✓	
MI	142	254	36	5063	✓	✓	✓	✓	✓	✓
MN	449	637	41	21537	✓	✓	✓	✓	✓	✓
MS	83	112	23	1127	✓	✓	✓		✓	✓
MO	81	129	29	2077	✓	✓	✓	✓	✓	
NE	85	115	14	1022	✓	✓	✓	✓	✓	✓
NH	63	66	14	199			✓	✓	✓	✓
NJ	58	63	14	373			✓	✓		
NM	37	37	28	467		✓	✓			
NY	36	42	22	993	✓	✓	✓	✓	✓	
NC	103	162	43	4640	✓	✓	✓	✓	✓	✓
OH	106	497	44	4739	✓		✓	✓	✓	✓
OK	59	94	37	2916	✓	✓	✓	✓	✓	✓
OR	36	66	31	935		✓	✓	✓	✓	✓
PA	135	192	28	1127	✓	✓	✓	✓	✓	✓
SC	74	130	26	826	✓	✓	✓	✓	✓	✓
TN	46	69	17	297	✓	✓	✓	✓	✓	✓
TX	65	86	33	673	✓	✓	✓	✓	✓	✓
VT	55	55	16	514	✓	✓		✓	✓	✓
VA	14	48	21	676	✓	✓	✓	✓	✓	✓
WA	12	14	11	164			✓	✓	✓	
WV	18	39	20	428	✓		✓	✓	✓	✓
WI	204	294	39	4659	✓	✓	✓	✓	✓	

[a] Electronic data not available for AK, CO, HI, ID, MT, NV, ND, SD, UT, and WY; see text for note on Rhode Island.

✓ = Data for given year are available in data base.

3.1.4 Mercury Concentrations in Selected Fish Species

Measured by the total number of fish analyzed, the top six species represented in the national data base are largemouth bass, walleye, northern pike, channel catfish, bluegill sunfish, and common carp. Figure 3-2 depicts the weighted mean mercury concentration and selected points on the frequency distribution for each of these species on a national basis. Three features are evident from this analysis in direct relationship to increasing trophic level of species: (1) the weighted mean concentration and overall frequency distribution increases, (2) the spread of concentration values increases, and (3) there is greater separation between the weighted mean and median value of the distribution. This analysis indicates that both the magnitude and variability of mercury concentration values are greater in higher trophic level fish species, as would be expected of the data.

Figure 3-2. Concentration Ranges of Mercury in Tissues of Selected Fish Species.

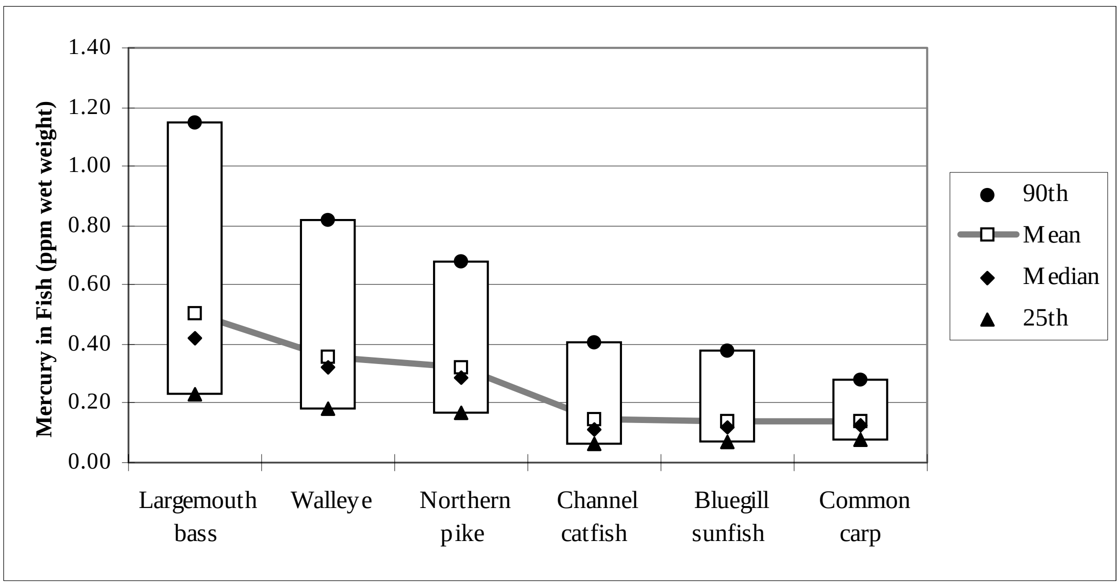


Table 3-4 presents the mean mercury concentrations in parts per million (ppm) in selected species of fish. The ranges in average mercury concentrations (ppm) for these fish are presented in Table 3-5. Comparisons of mercury concentrations within a given fish species across states may not be strictly appropriate for several reasons: sampling strategies (representative versus targeted) may differ; analytical procedures may not be consistent from state to state; mercury concentrations may vary with age of the fish—a variable that may not have been controlled in the sampling; and some mercury analyses may have been performed on either fillets or the entire fish body. Nevertheless, qualitative observations on the ranges of mercury concentrations within a given species are informative.

Table 3-4. The National Survey of Mercury Concentrations in Fish: Mean Mercury Concentrations (ppm) in Major Fish Species [a, b]

State[c]	Largemouth Bass	Smallmouth Bass	Walleye	Northern Pike	Channel Catfish	Bluegill Sunfish	Common Carp	White Sucker	Yellow Perch
AL	0.393				0.214				
AZ	1.369								
AR	0.675	0.257			0.473	0.606			
CA	0.281	0.313			0.143	0.310	0.138		
CT	0.501	0.653				0.057			0.190
DE	0.108				0.050		0.061	0.060	0.049
DC	0.153				0.091		0.082		
FL	0.645					0.350			
GA	0.274		0.371		0.084	0.010	0.136		
IL	0.180	0.094	0.110			0.058			
IN	0.264	0.235			0.183	0.110	0.166	0.137	0.067
IA	0.189				0.104		0.215		
KS					0.125		0.167	0.133	
KY	0.583		0.514		0.147	0.236	0.231		
LA	0.391				0.111	0.147	0.100		
ME	0.634	0.782						0.338	0.333
MD	0.021	0.110	0.132		0.033		0.031	0.049	
MA	0.399	0.391							0.306
MI	0.431	0.292	0.375	0.509	0.047	0.132	0.181	0.117	0.142
MN	0.240	0.232	0.324	0.304	0.266	0.084	0.089	0.103	
MS	0.651				0.274		0.186		
MO	0.257		0.348		0.052		0.128		
NE	0.343		0.168	0.381	0.109		0.167	0.141	
NH	0.573	0.766							0.346
NJ	0.664	0.244			0.228				
NM	0.428		0.875	0.270	0.297	0.347	0.274	0.138	0.488
NY	0.462	0.629		0.477		0.169	0.192	0.456	0.477
NC	0.532	0.550			0.195	0.186	0.200		0.210
OH	0.142	0.173	0.142		0.118	0.097	0.124	0.095	
OK	0.684		0.239		0.193	0.126	0.133		
OR	0.369	0.366				0.359	0.245		
PA	0.293	0.259	0.612		0.284	0.095	0.145	0.107	0.129
SC	0.994				0.345	0.378			
TN	0.255				0.173		0.208		
TX	0.237				0.193	0.050	0.154		
VT	0.802	0.560		0.377					0.332
WA	0.137								
WV		0.226			0.130		0.179		
WI	0.369	0.343	0.440	0.317	0.450	0.131	0.178	0.114	0.150

[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.
[b] Weighted Mean $\bar{x}_w = \sum_i w_i x_i / \sum_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.
[c] Electronic data not available for AK, CO, HI, ID, MT, ND, NV, SD, UT, and WY; see text for note on RI.

Table 3-5. Range of Mean Mercury Concentrations (ppm) for Major Fish Species [a]

Largemouth bass	0.001–8.94
Smallmouth bass	0.008–3.34
Walleye	0.008–3
Northern pike	0.10–4.4
Channel catfish	0.001–2.57
Bluegill sunfish	0.001–1.68
Common carp	0.001–1.8
White sucker	0.002–1.71
Yellow perch	0.01–2.14

[a] These ranges represent fish tissue mercury concentrations on a wet weight and fillet basis.

Although the general pattern of predators having greater weighted mean concentrations than bottom feeders also occurs for state-specific data, substantial variations among states exist for weighted means of representative bottom feeders and especially for predators. State-specific weighted means for bottom feeders (such as channel catfish or common carp) usually fall in the 0.1 to 0.3 ppm range, whereas weighted means for predators (such as largemouth and smallmouth bass) usually fall in the 0.2 to 0.7 ppm range. No clear regional pattern emerges from this particular analysis of the data.

3.2 State Profiles

The decision to compile data for the 1990-1995 time period results in the exclusion of a substantial amount of high-quality data for some states. For example, the number of samples from New York summarized in this report represents only a fraction of the sampling performed from 1970 to the present in that state. An excellent summary of the complete New York data base, as well as other northeastern states, is presented in NESCAUM (1998). For most states, the 1990-1995 time period accurately captures the first years of high-quality mercury sampling and analysis. This report presents state-by-state profiles of detailed information on the data collected by states during a constant period of time.

In compiling these summaries, only the years 1990 through 1995 were included, as stated above. All mercury concentrations were expressed on a wet basis and fillet basis. All non-fish species, such as crayfish, oysters, rock crab, and snapping turtle were excluded. In addition, for the top ten fish species analysis and for the analysis of mercury concentration in the top three species, species identified as “unknown” or “mixed” and mercury concentrations determined on the tissue portion coded as “other” (e.g., gonads, internal organs, eggs, etc.) were excluded.

For each state included in the data base, a separate four-page pictorial and tabular summary describing the data base is presented on the following pages. Each state summary page includes the state name and the source of the data (either a state-maintained data base, STORET, or a combination of both) in the heading spanning the pages.

On the first page of the summary, the total number of fish analyzed and the total number of samples taken for each year represented in the data base are presented. To the right of this bar chart is a state map depicting the locations of the sampling sites for those states reporting latitude and longitude data; maps for states that do not report the latitude and longitude data are presented as state boundaries only. On the bottom half of the first page, the number of records of location variables are presented. The number of observations, along with the percentage that each variable represents in the data set for that state, are given. A table of the ten most common fish species sampled in the state is presented on the top of the second page of each state summary. At the bottom of the second page, the fish data variables are presented.

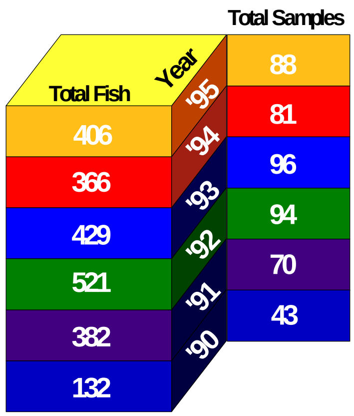
At the top of the third page of each state summary is a map depicting the geographical distribution of mercury concentrations across the state. Maps for states that do not report the latitude and longitude data are presented as state boundaries only. Total mercury concentrations in ppm are categorized as (1) greater than 1.0 ppm, (2) 0.5 to 1.0 ppm, and (3) less than or equal to 0.5 ppm. Closed squares represent mercury concentrations in class 1, shaded circles represent mercury concentrations in class 2, and closed triangles represent mercury concentrations in class 3.

At the bottom of the third page, variables that pertain to mercury are presented. For any one state, the variables that may be contained in the data base include the detection limit of the analytical method, the mercury reporting basis (wet weight or dry weight), the mercury concentration, and any qualifying flags regarding the mercury data value, such as “less than” the detection limit. All measurements in the data base reflect analysis for total mercury.

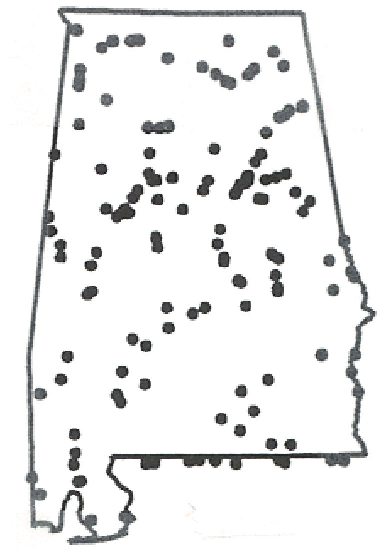
The fourth page of each state summary contains a tabular presentation of mercury concentration for the three most abundant fish species sampled. Mercury concentrations are expressed on a wet basis and a fillet basis. The common name, number of samples, and number of fish are included. For each of the three species, summary statistics that describe the mercury concentrations are given. These statistics include the minimum, maximum, weighted mean, and weighted median concentrations of mercury in ppm. Statistics that describe the variability in the mercury concentrations are also presented: the weighted standard deviation and the coefficient of variation. When the number of fish in a composite sample was omitted from the record, a value of 1 was assumed. The definitions of the statistics and formulas used to derive their values are given at the bottom of the table.

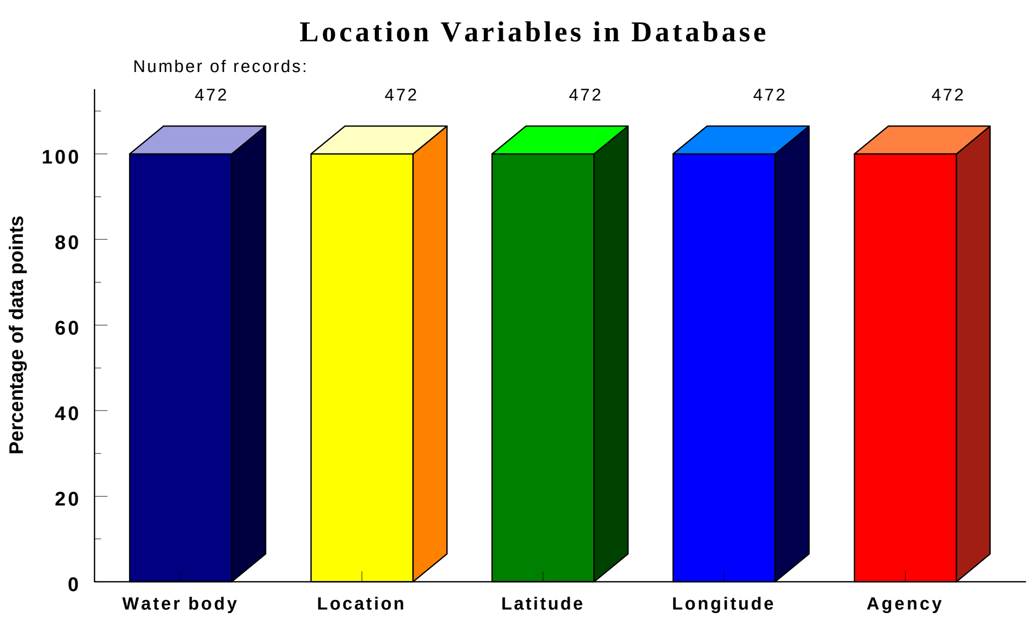
At the bottom of the fourth page of each state summary is a graphic showing the cumulative distribution of mercury concentrations for all fish species, expressed on a wet weight basis and on a fillet basis.

Records Analyzed by Year



Sampling Locations

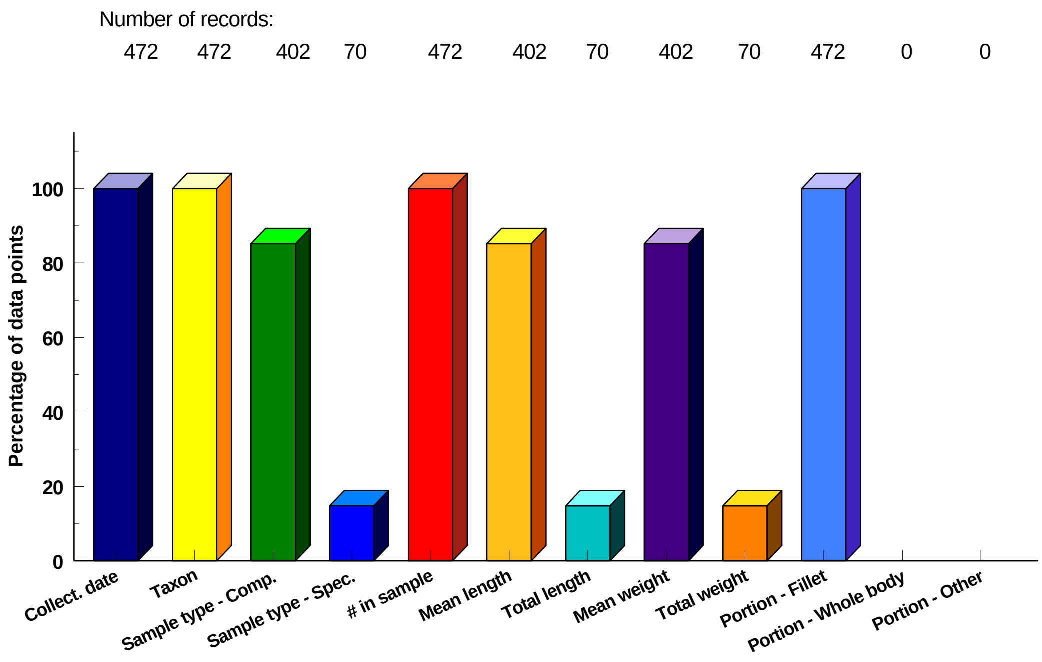




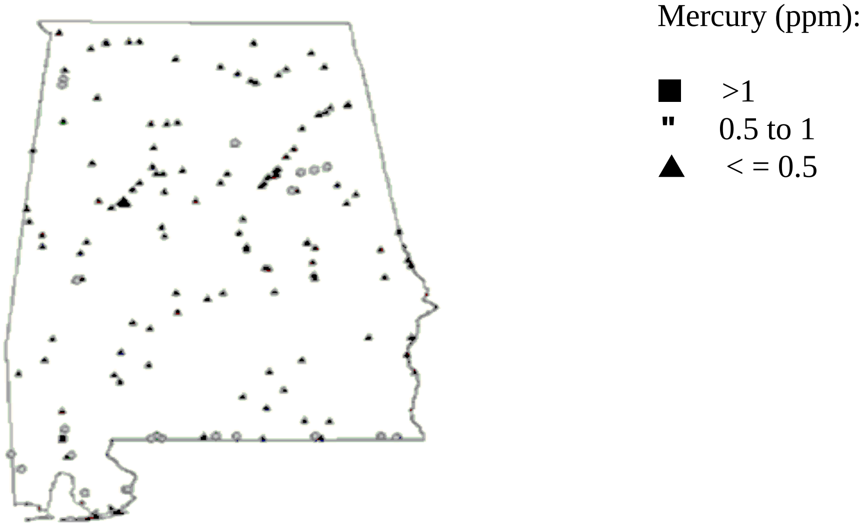
Top Ten Fish Species

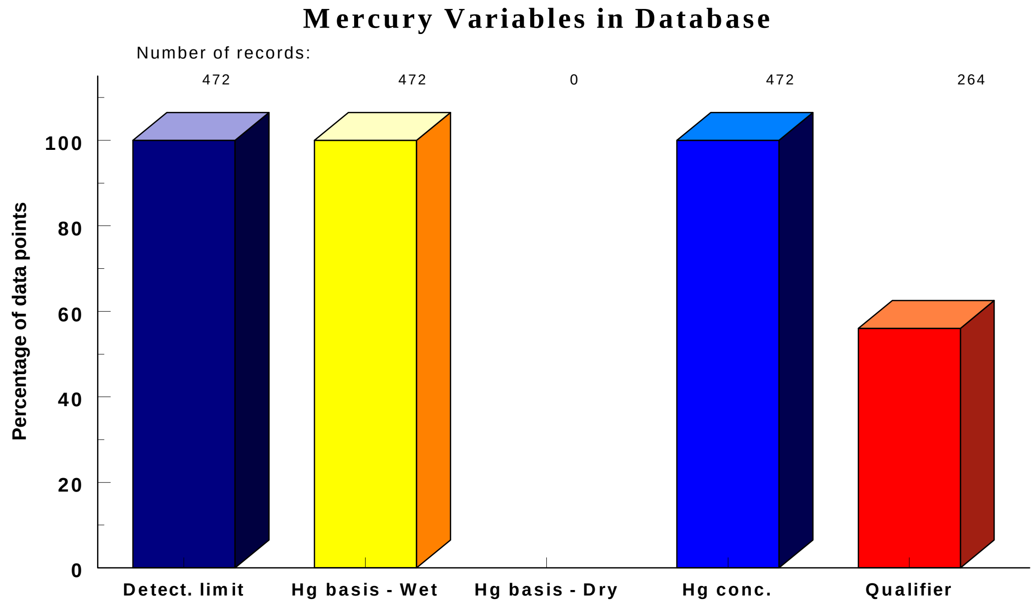
Common Name	Percent	Common Name	Percent
Largemouth bass	41	Flathead catfish	2
Channel catfish	31	Spotted sucker	1
Blue catfish	8	Brown bullhead	1
Black crappie	7	Blacktail redhorse	<1
Spotted bass	5	Redeye bass	<1

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics									
			Mercury Statistics Weighted by No. of Fish in Sample[a]						
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Largemouth bass	180	914	0.100	1.630	0.393	0.380	0.301	76.49
Channel catfish	149	702	0.100	0.660	0.214	0.100	0.165	76.97
Blue catfish	39	178	0.100	0.500	0.189	0.100	0.165	87.69

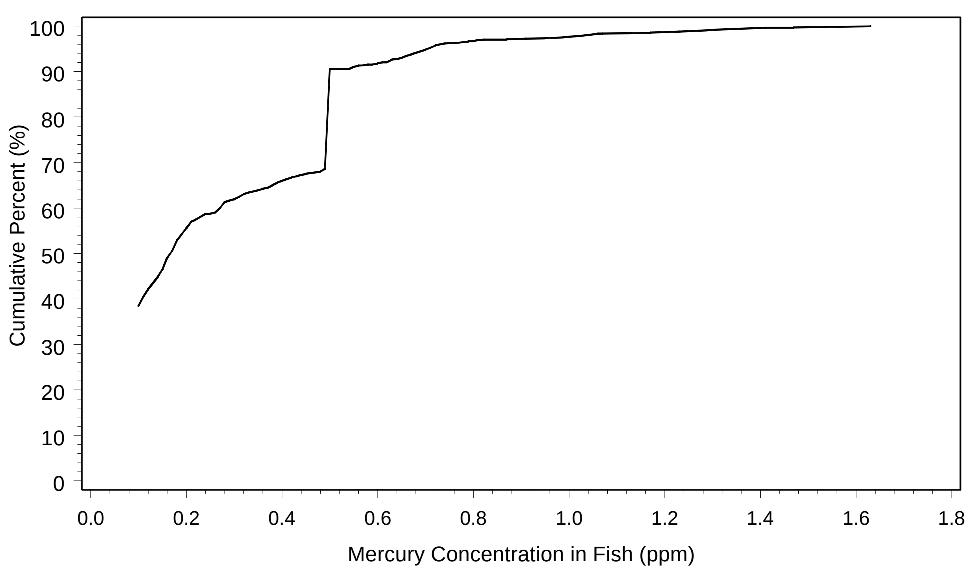
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

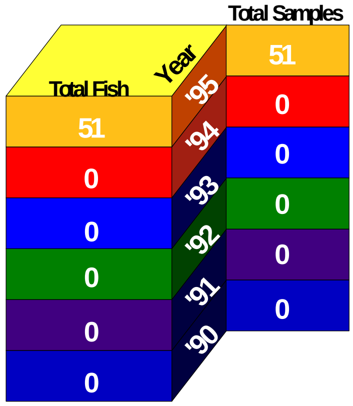
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

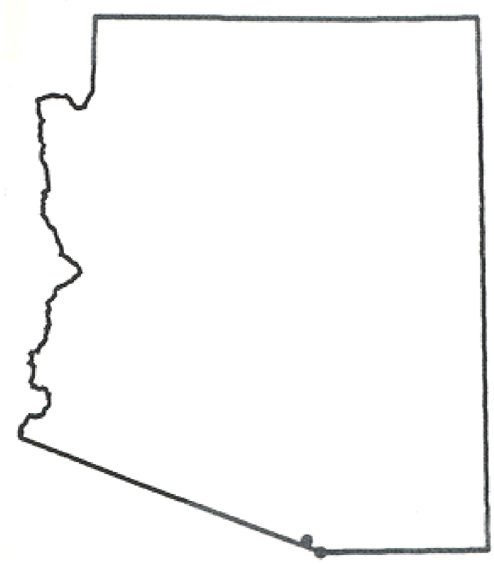
Cumulative Distribution of Mercury Concentrations for All Fish Species in Alabama



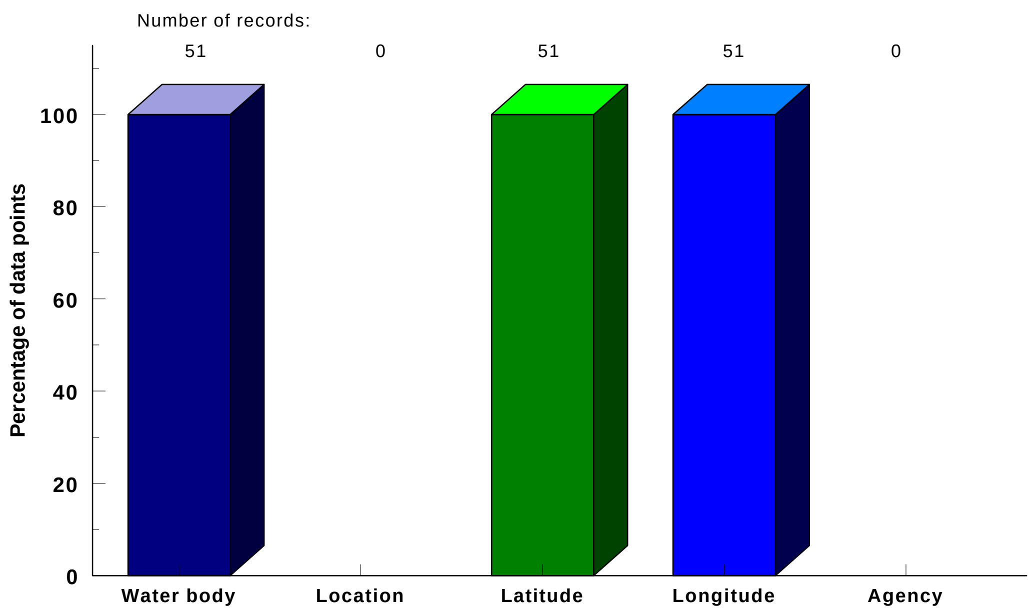
Records Analyzed by Year



Sampling Locations



Location Variables in Database

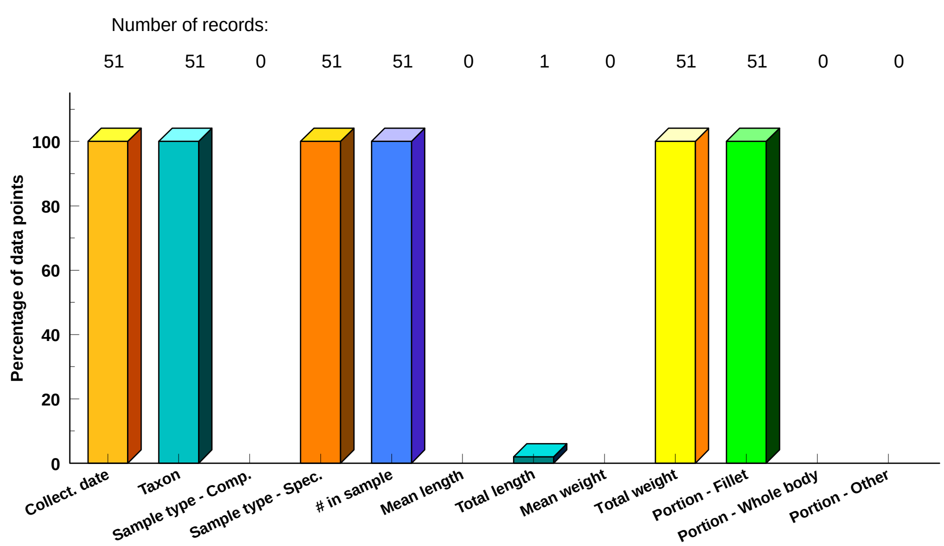


Top Five Fish Species[a]

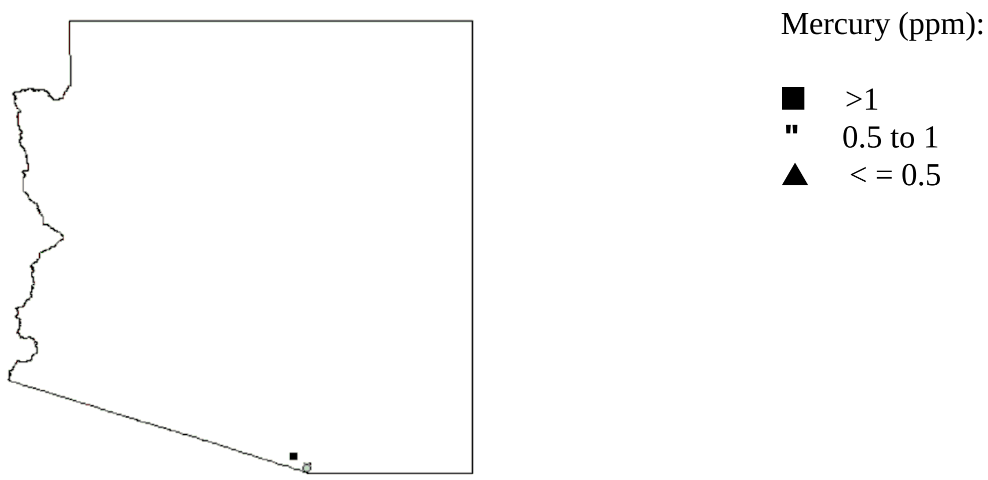
Common Name	Percent
Largemouth bass	69
Yellow bullhead	12
Redear sunfish	10
Bluegill sunfish	6
Black crappie	4

[a] Only five species were identified in the data base.

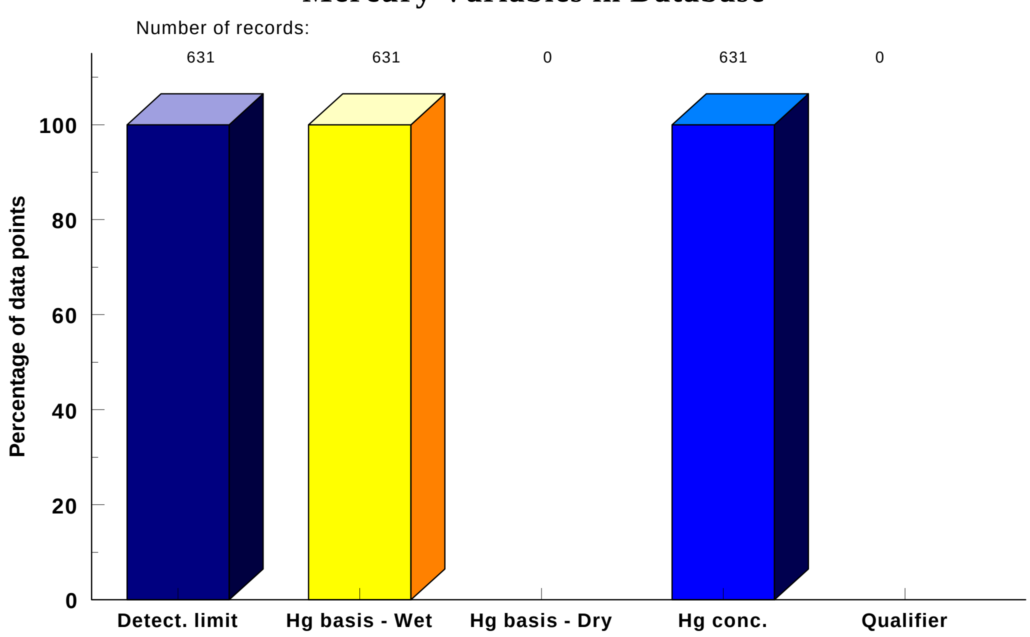
Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis



Mercury Variables in Database



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Largemouth bass	35	35	0.700	2.620	1.369	1.240	0.458	33.46
Yellow bullhead	6	6	0.340	0.890	0.522	0.500	0.204	39.03
Redear sunfish	5	5	0.280	0.690	0.460	0.400	0.177	38.49

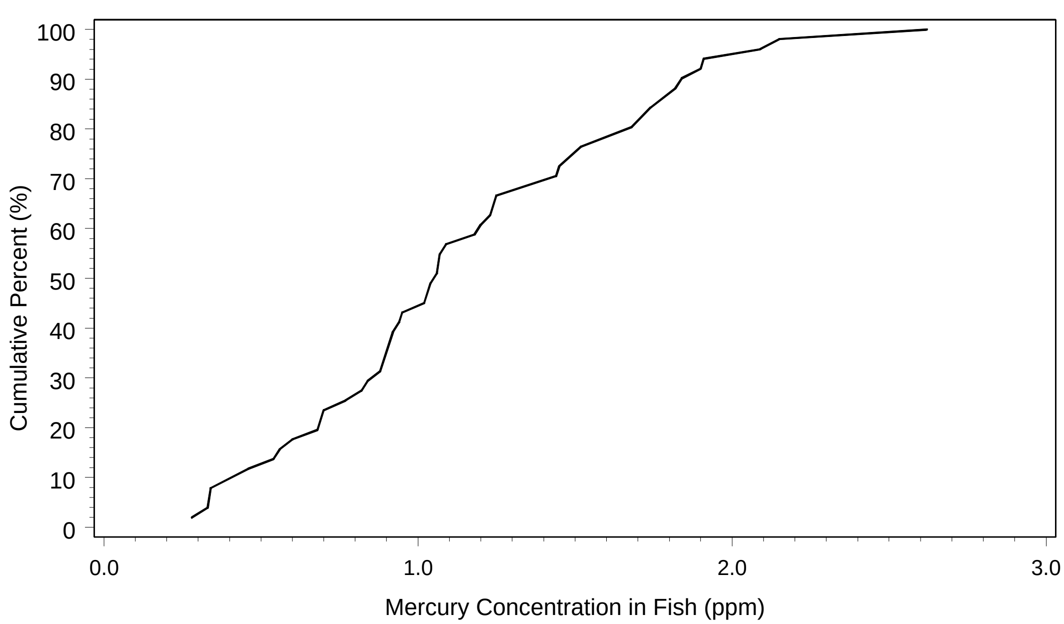
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

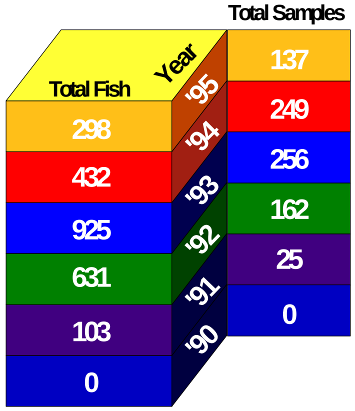
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

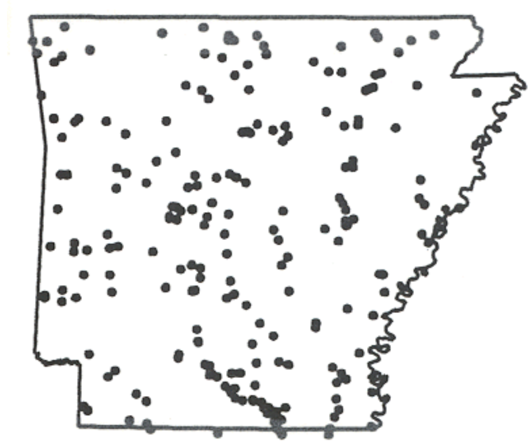
Cumulative Distribution of Mercury Concentrations for All Fish Species in Arizona

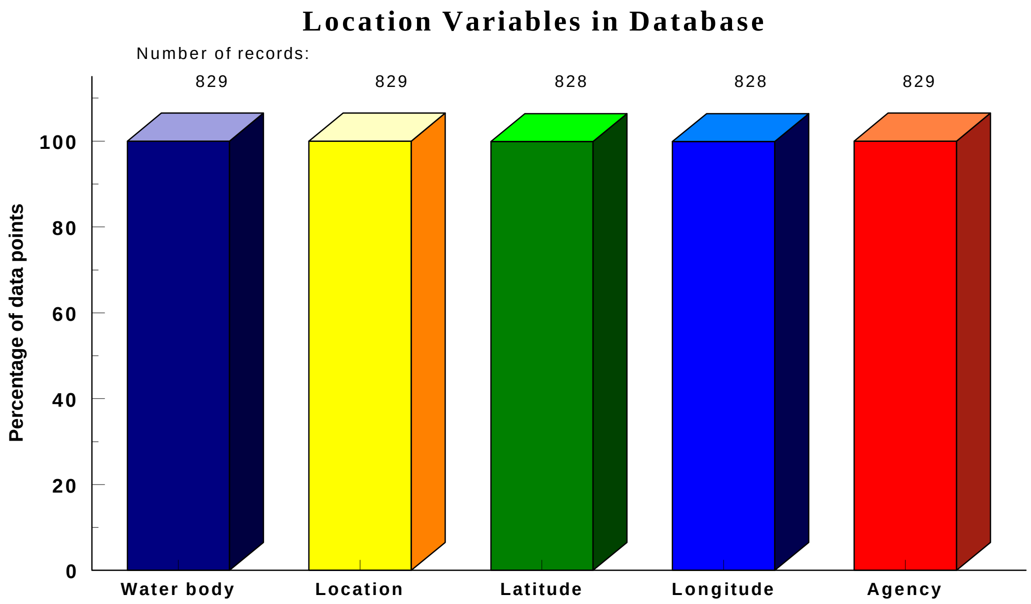


Records Analyzed by Year



Sampling Locations

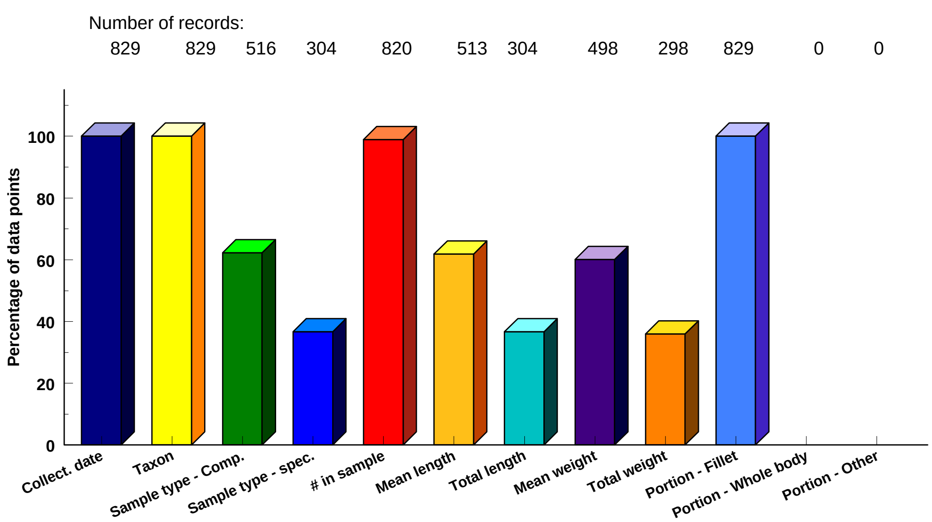




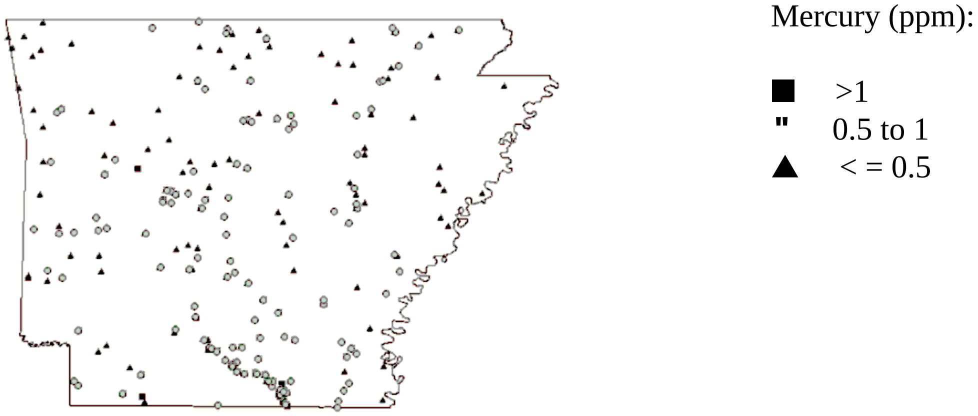
Top Ten Fish Species

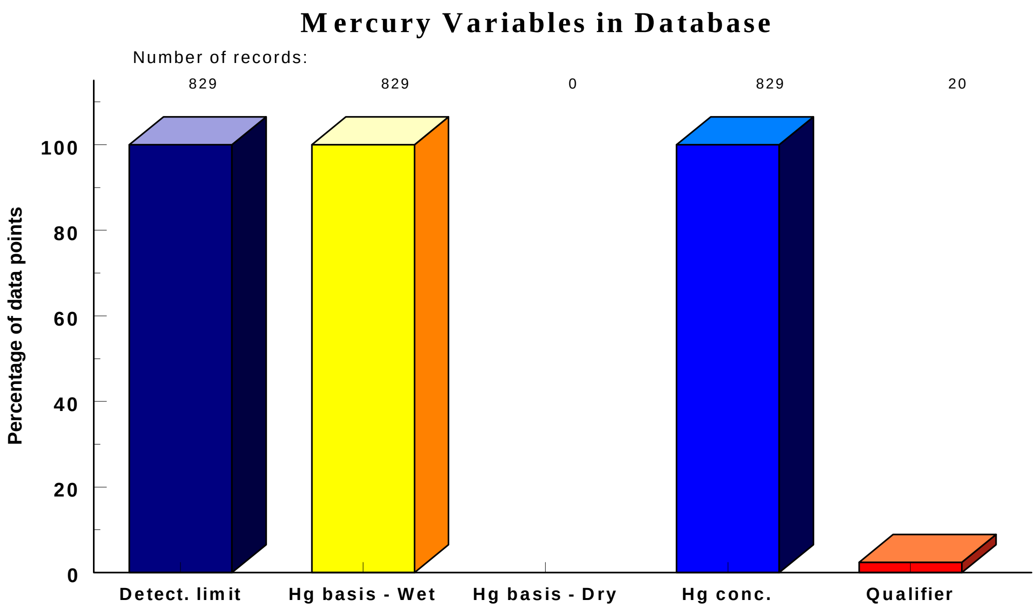
Common Name	Percent		Common Name	Percent
Largemouth bass	50		White crappie	4
Black bass	7		Black crappie	4
Spotted bass	6		Crappie	3
Bluegill sunfish	5		Spotted sucker	2
Channel catfish	5		Flathead catfish	2

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Largemouth bass	440	1190	0.030	3.170	0.675	0.560	0.486	72.03
Black bass	32	157	0.100	1.360	0.640	0.580	0.308	48.11
Spotted bass	50	132	0.170	1.720	0.622	0.600	0.261	42.04

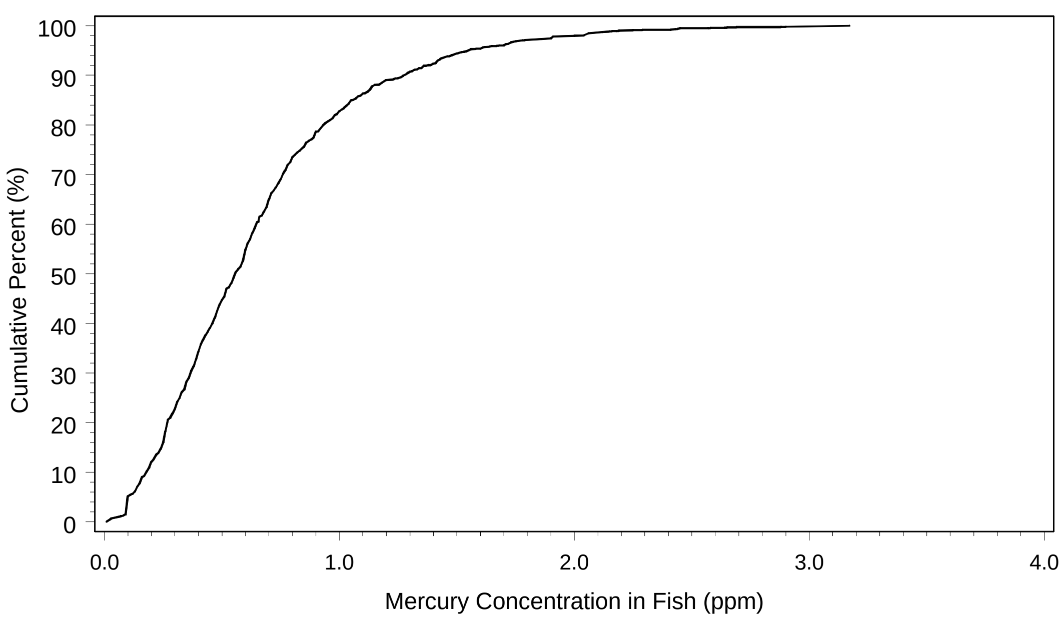
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

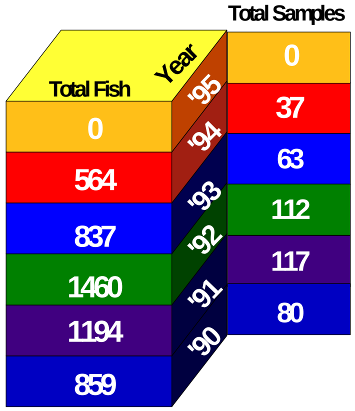
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \; / \; (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

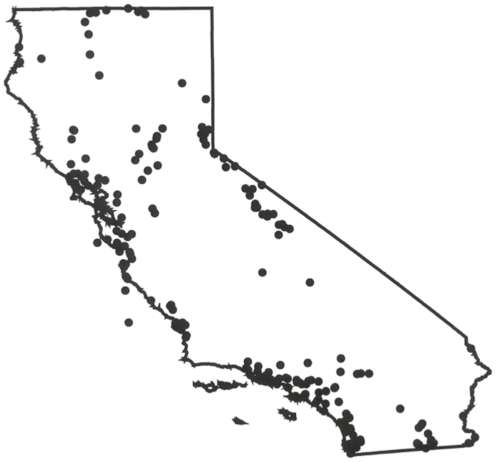
Cumulative Distribution of Mercury Concentrations for All Fish Species in Arkansas

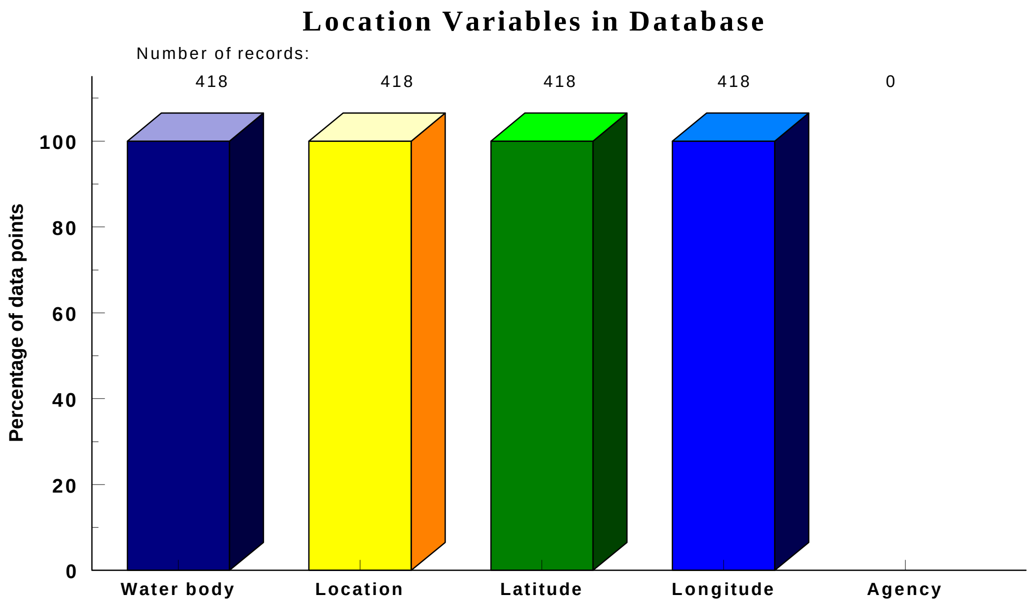


Records Analyzed by Year



Sampling Locations

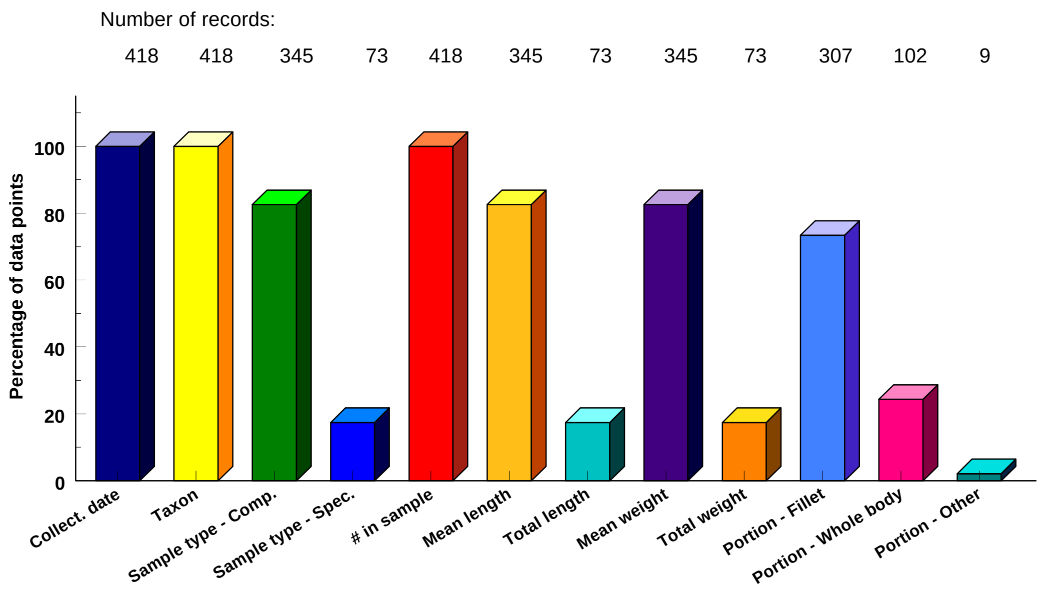




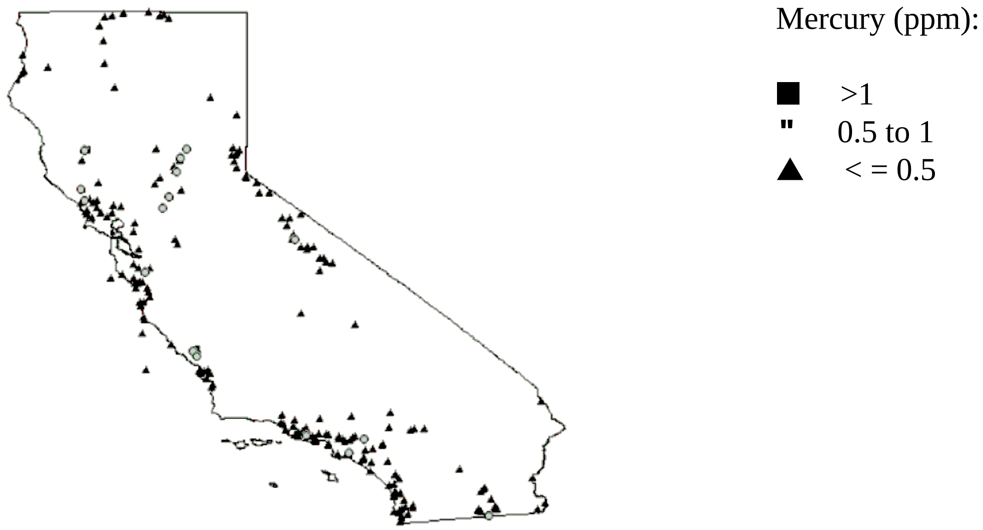
Top Ten Fish Species

Common Name	Percent		Common Name	Percent
Red shiner	12		Santa Ana sucker	5
Largemouth bass	11		Rainbow trout	5
Threespine stickleback	10		Tui chub	5
Fathead minnow	10		Brown trout	3
Arroyo chub	6		Longjaw mudsucker	3

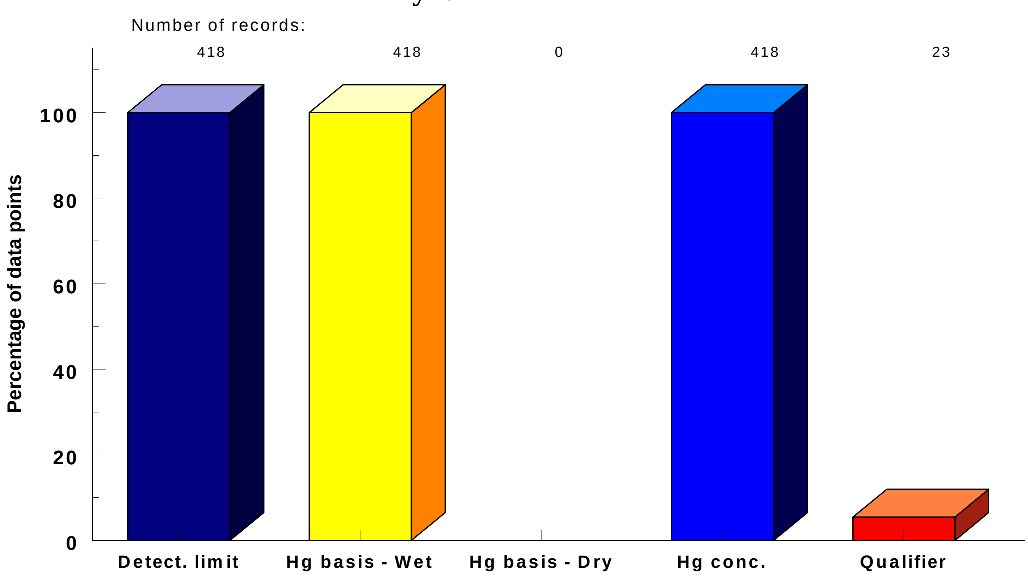
Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis



Mercury Variables in Database



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Red shiner	19	587	0.029	0.157	0.061	0.057	0.034	54.88
Largemouth bass	86	517	0.030	1.800	0.291	0.190	0.304	104.60
Threespine stickleback	12	491	0.057	0.329	0.156	0.114	0.098	62.58

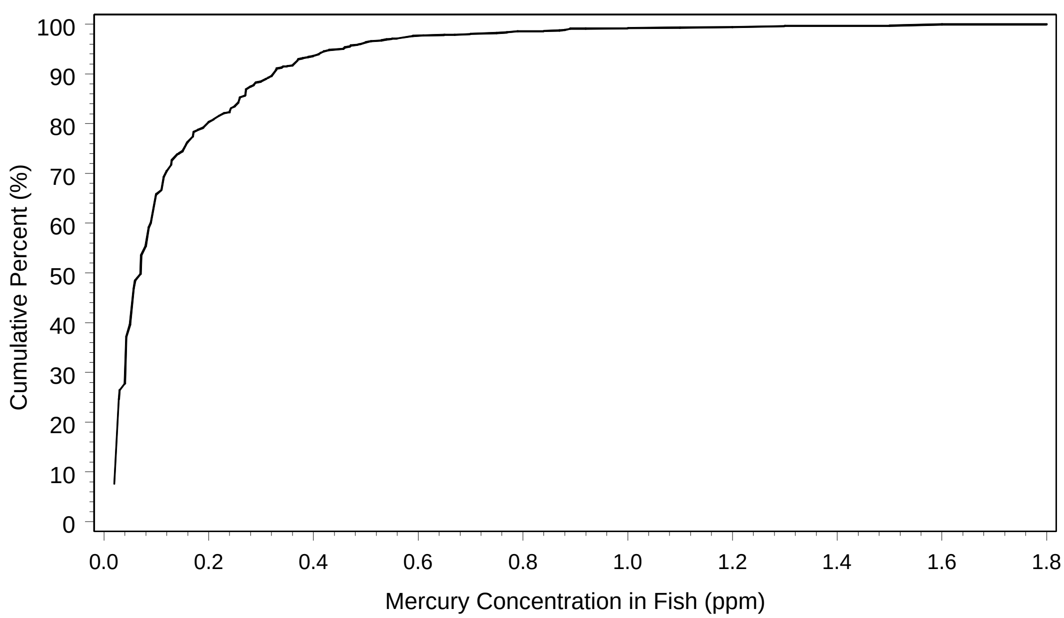
a Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

b Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

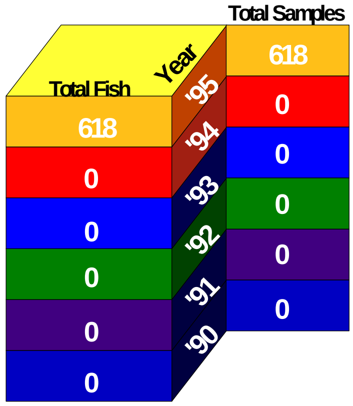
c Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

d CV = $(SD_w / \bar{x}_w) * 100$

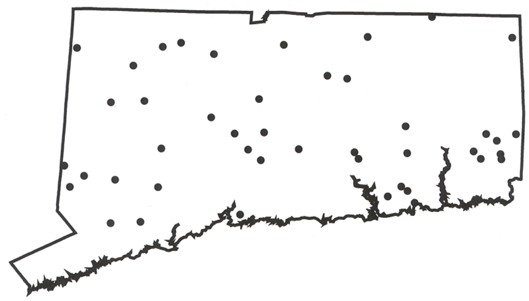
Cumulative Distribution of Mercury Concentrations
for All Fish Species in California



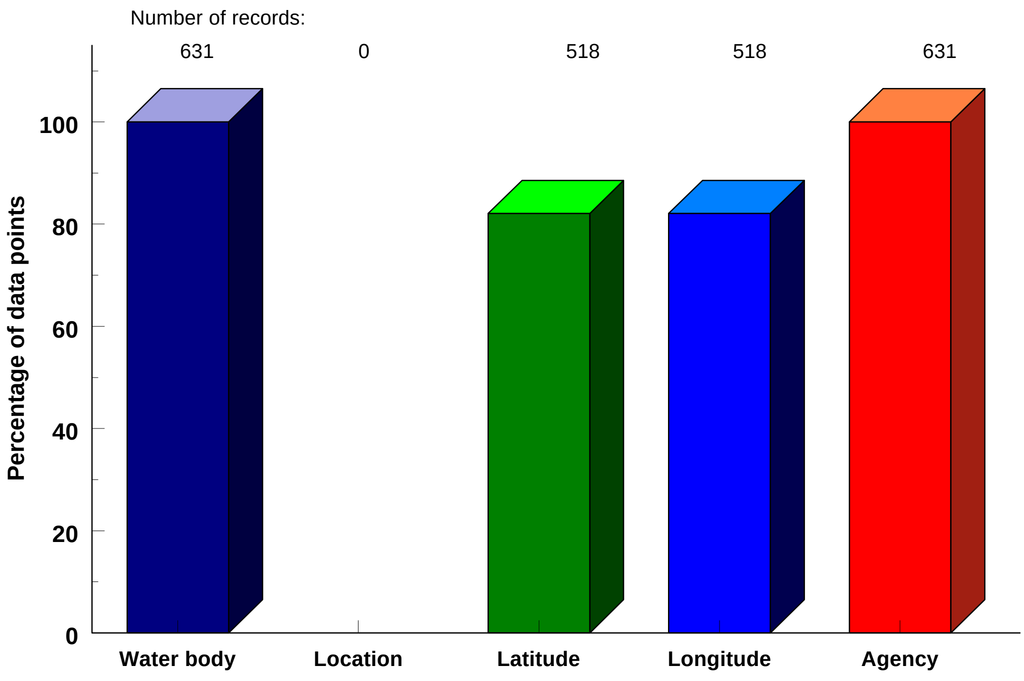
Records Analyzed by Year



Sampling Locations



Location Variables in Database

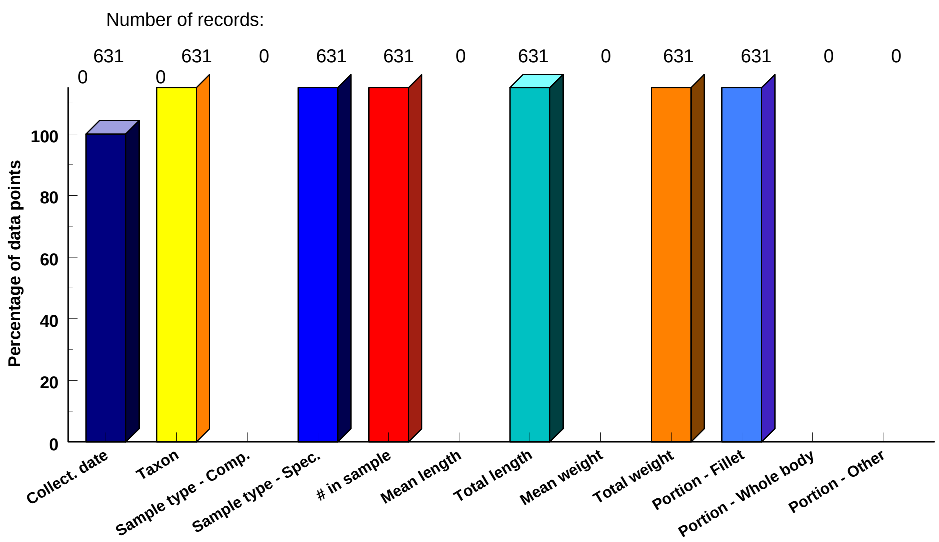


Top Four Fish Species[a]

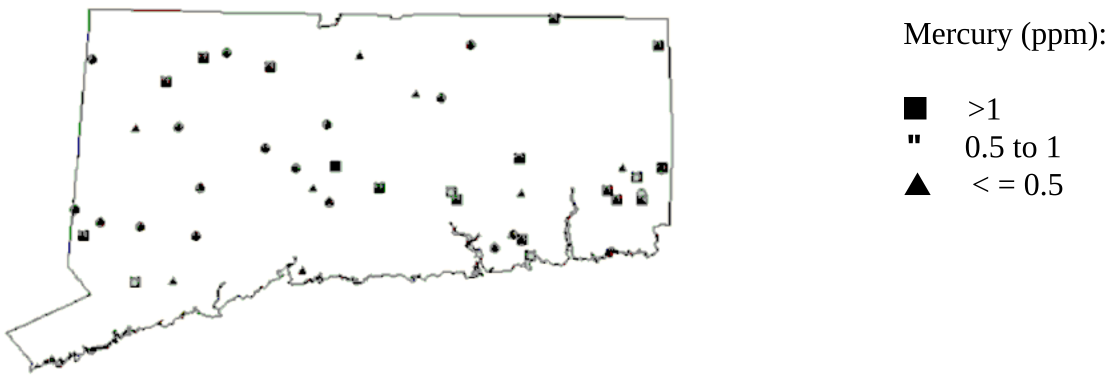
Common Name	Percent
Largemouth bass	82
Yellow perch	12
Smallmouth bass	4
Bluegill sunfish	2

[a] Only four species were identified in the data base.

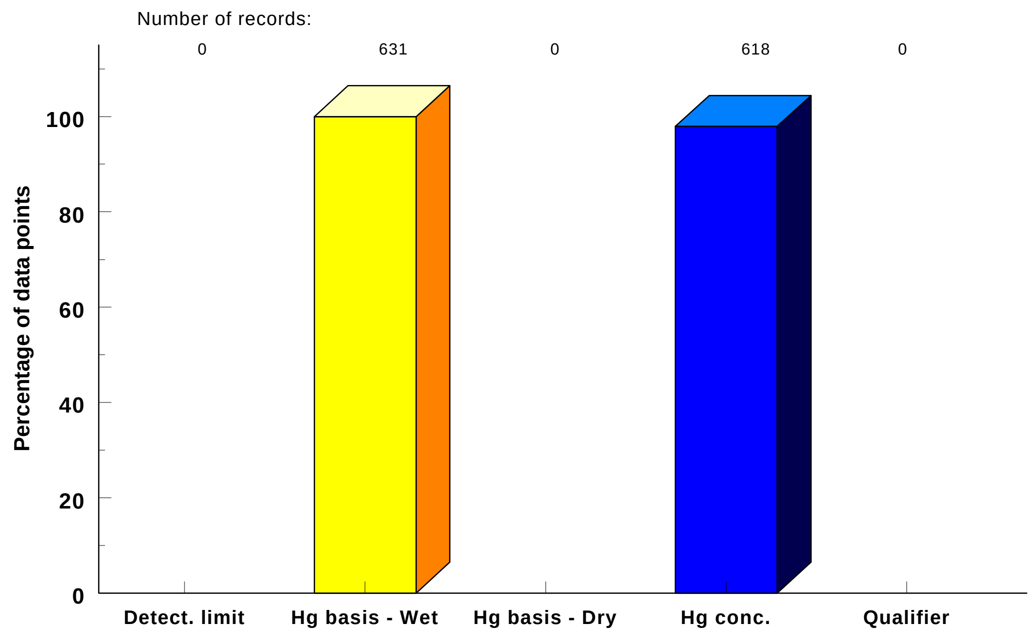
Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis



Mercury Variables in Database



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Largemouth bass	507	507	0.032	2.645	0.505	0.430	0.316	62.55
Yellow perch	77	77	0.033	0.569	0.193	0.174	0.115	59.72
Smallmouth bass	22	22	0.234	2.319	0.653	0.523	0.466	71.41

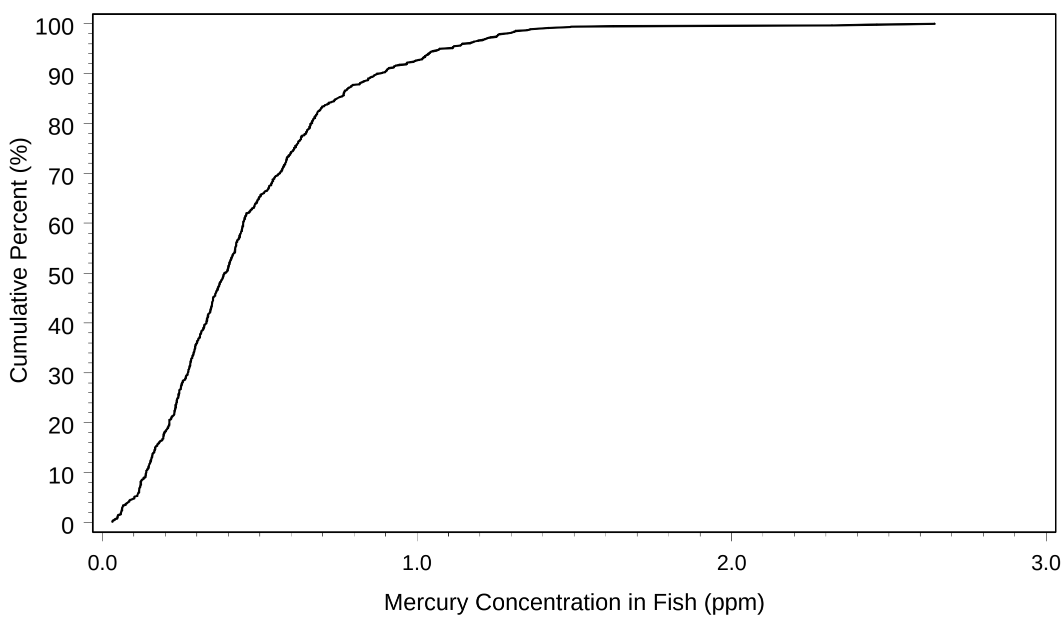
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

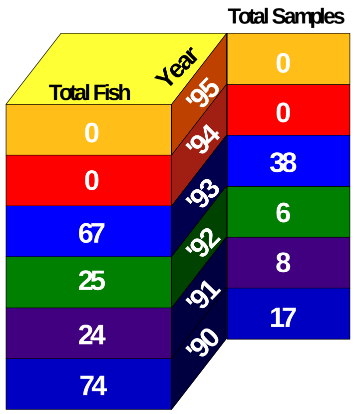
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

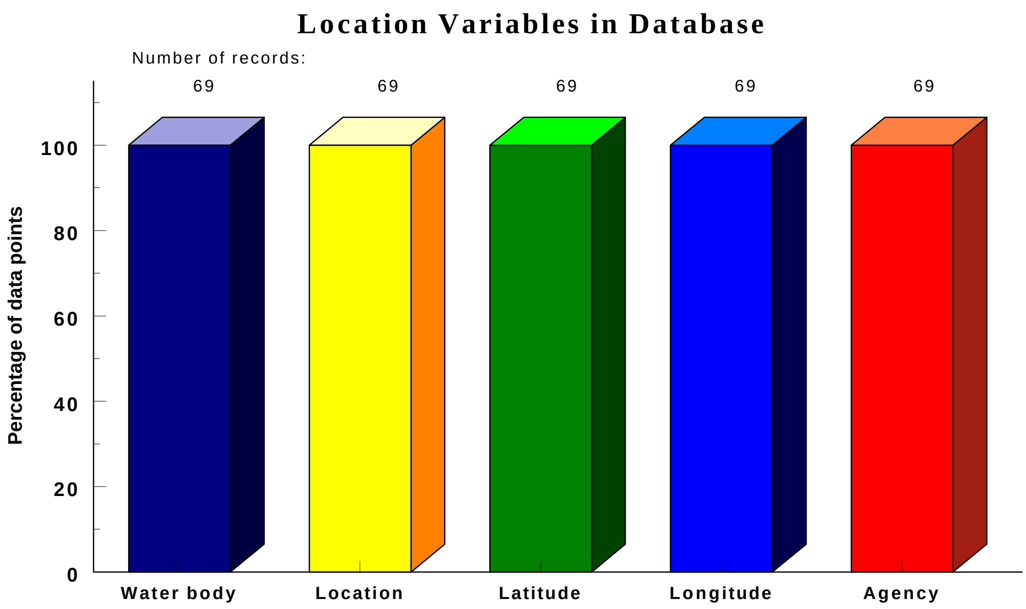
Cumulative Distribution of Mercury Concentrations for All Fish Species in Connecticut



Records Analyzed by Year



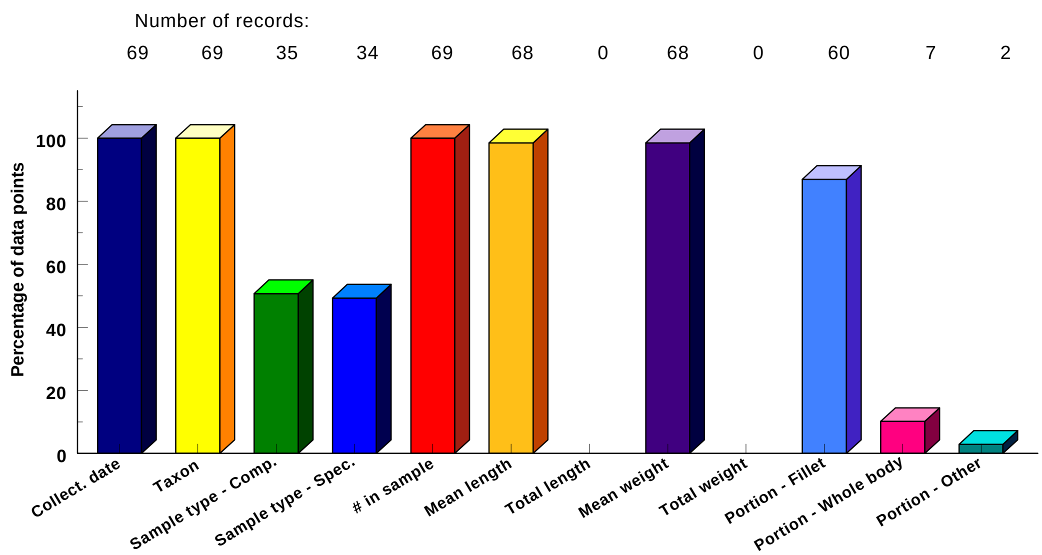
Sampling Locations



Top Ten Fish Species

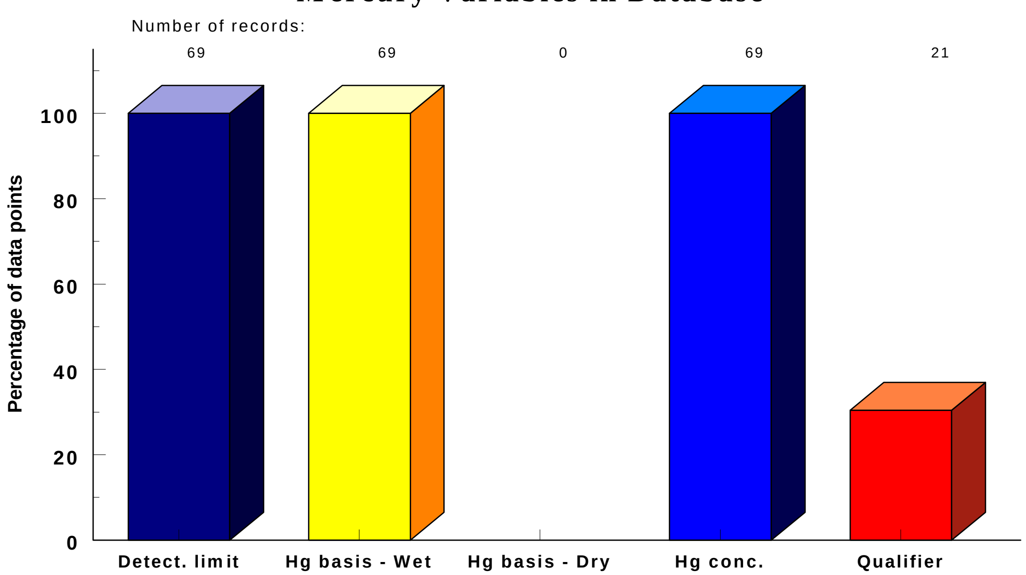
Common Name	Percent	Common Name	Percent
White sucker	27	White perch	6
Channel catfish	10	American eel	5
Yellow perch	9	Common carp	5
Bluefish	7	Brown bullhead	4
Largemouth bass	7	Spot	4

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis

Mercury Variables in Database



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
White sucker	27	51	0.020	0.264	0.060	0.050	0.050	83.11
Channel catfish	13	19	0.029	0.133	0.050	0.042	0.033	66.44
Yellow perch	3	17	0.029	0.086	0.049	0.040	0.025	49.90

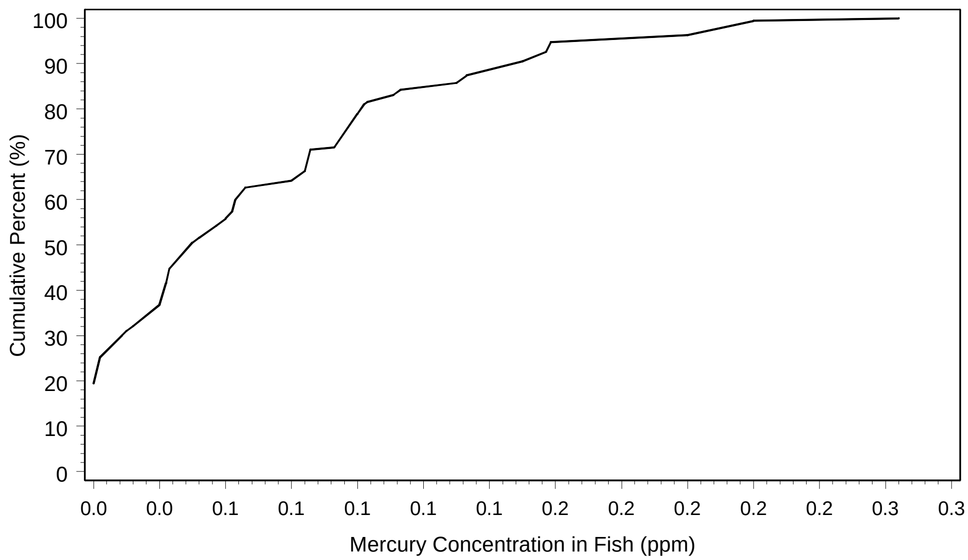
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

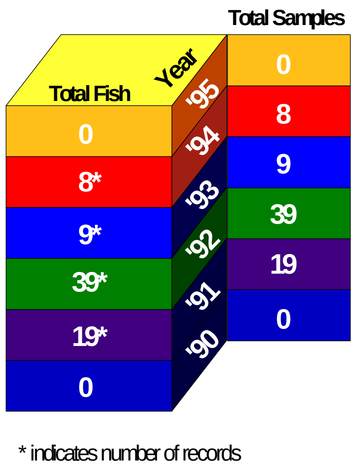
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

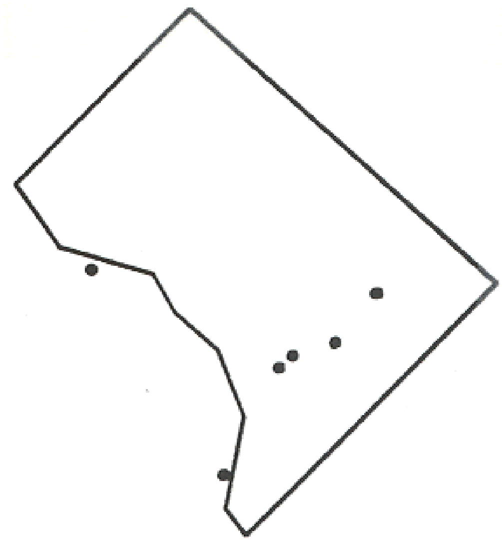
Cumulative Distribution of Mercury Concentrations for All Fish Species in Delaware



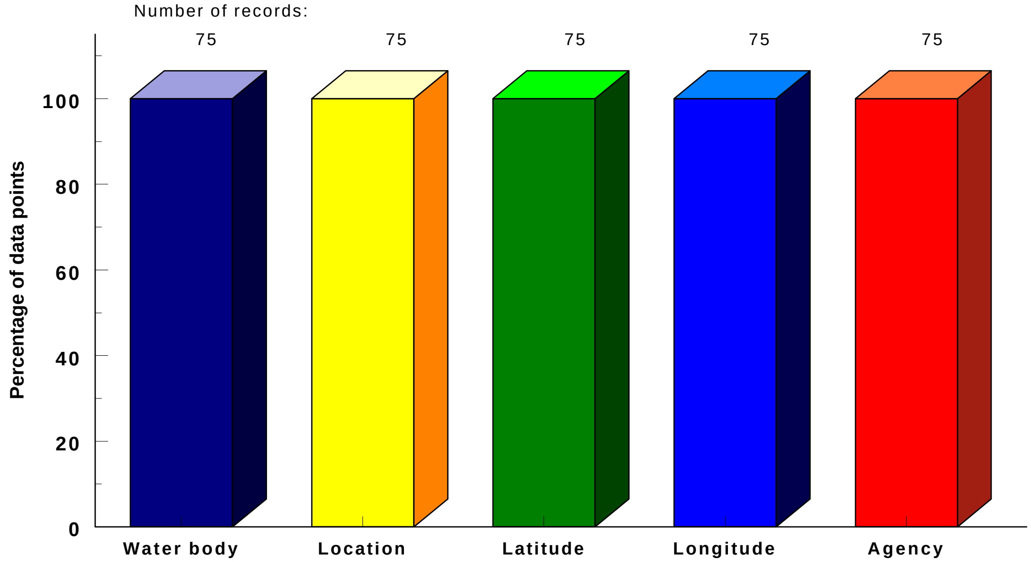
Records Analyzed by Year



Sampling Locations



Location Variables in Database

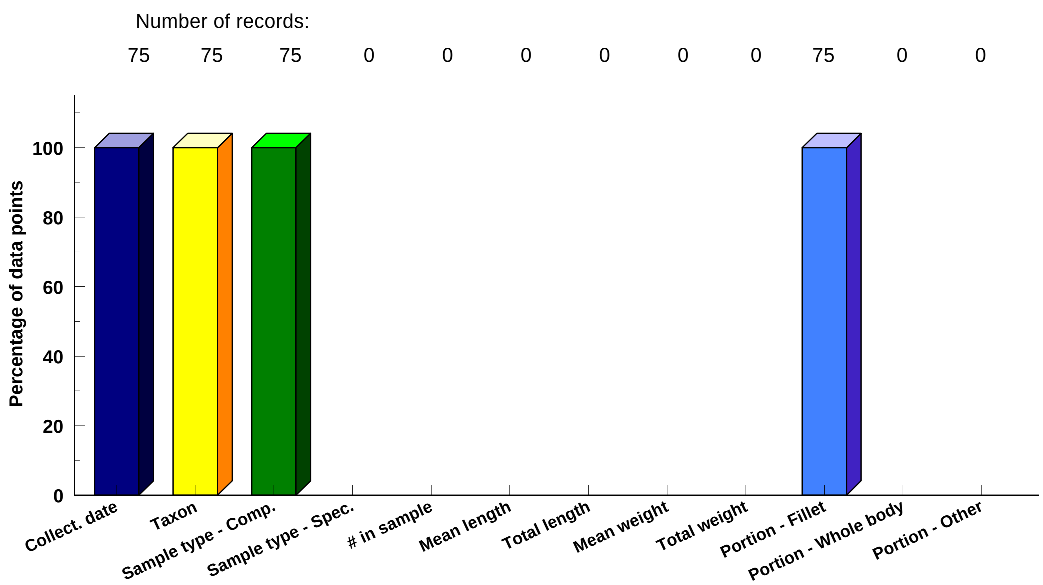


Top Eight Fish Species[a]

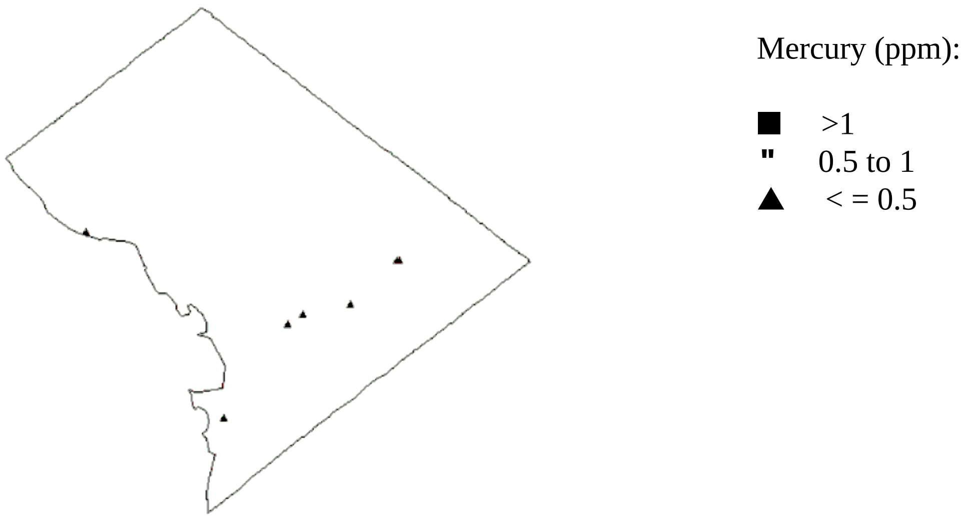
Common Name	Percent		Common Name	Percent
Common carp	29		American eel	8
Channel catfish	23		Bluegill sunfish	8
Largemouth bass	15		Sunfish	3
Brown bullhead	13		Pumpkinseed sunfish	1

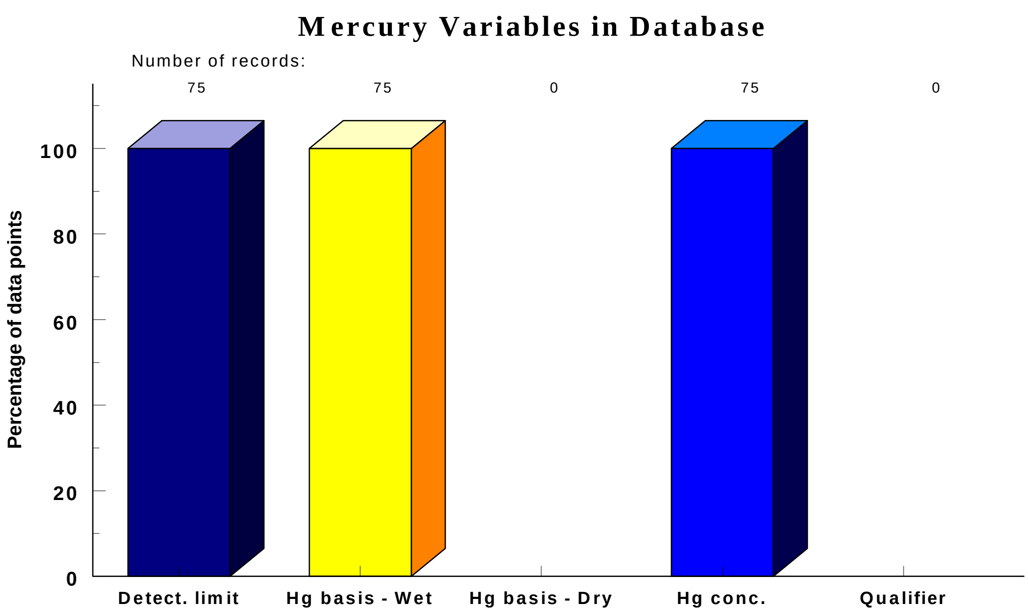
[a] Only eight species were identified in the database.

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Common Carp	22	22	0.042	0.210	0.082	0.070	0.040	48.54
Channel catfish	17	17	0.055	0.240	0.091	0.078	0.043	47.52
Largemouth bass	11	11	0.037	0.458	0.153	0.126	0.119	77.65

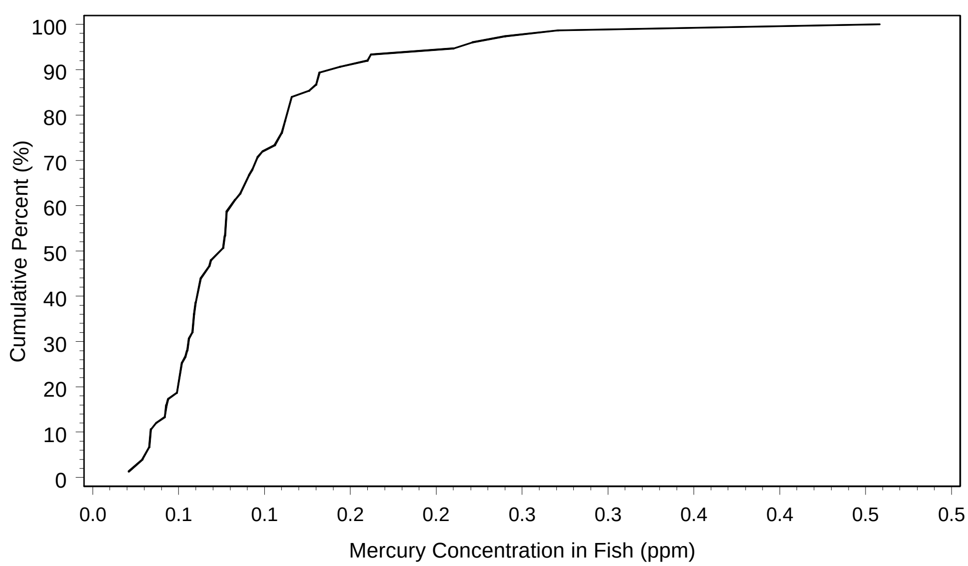
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

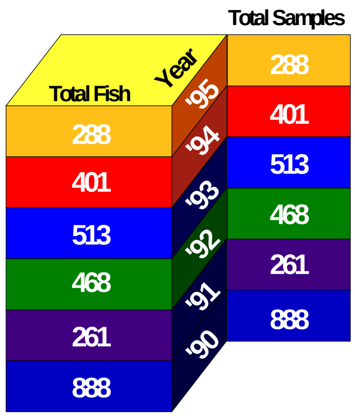
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

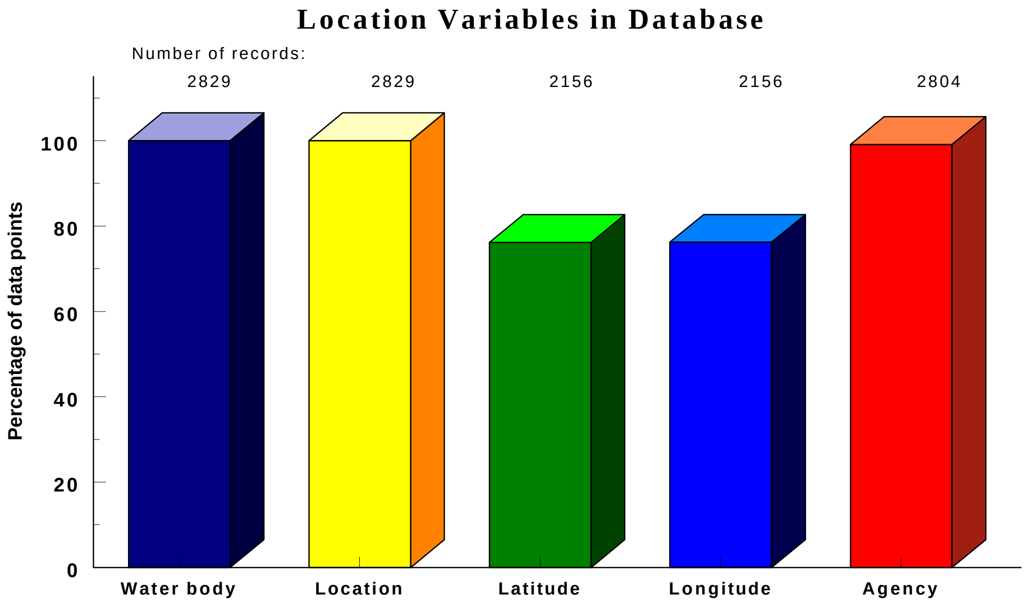
Cumulative Distribution of Mercury Concentrations for All Fish Species in District of Columbia



Records Analyzed by Year



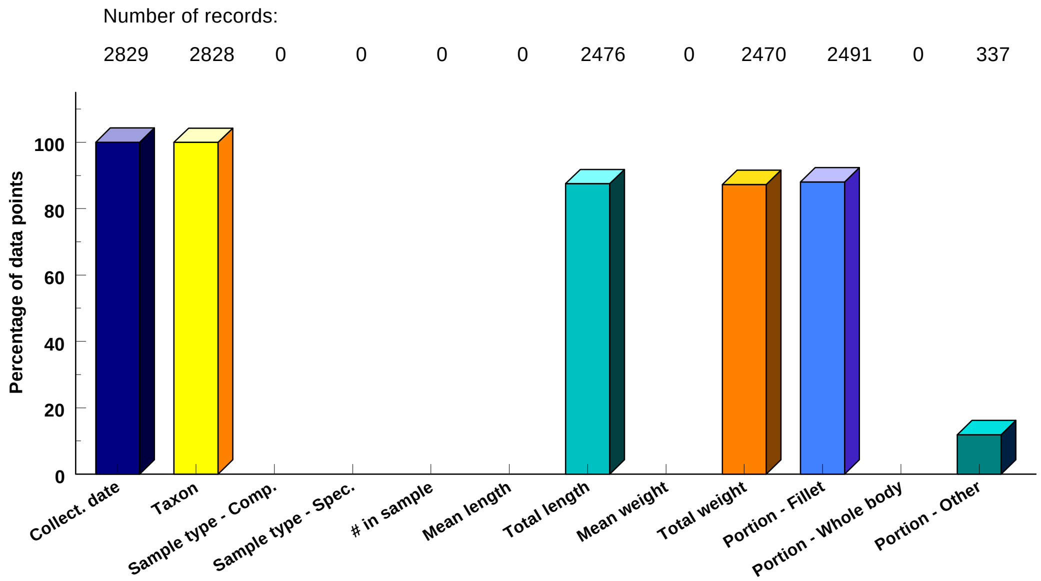
Sampling Locations



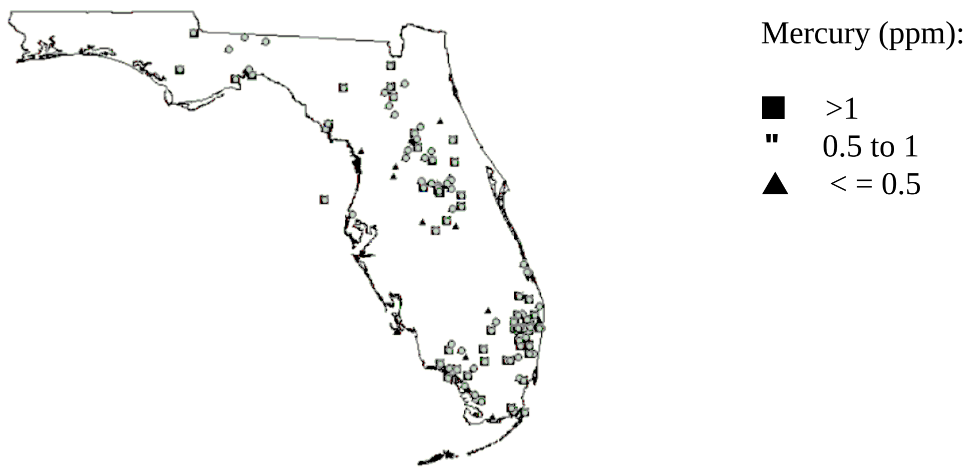
Top Ten Fish Species

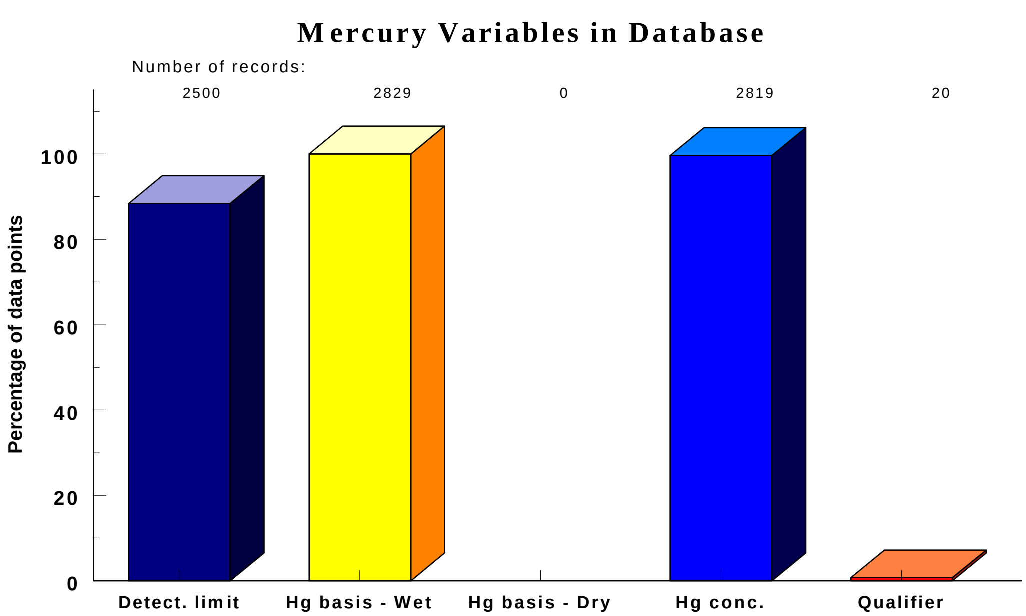
Common Name	Percent		Common Name	Percent
Largemouth bass	71		Florida gar	3
Spotted sea trout	3		Crevalle jack	2
Warmouth	3		Bluegill sunfish	2
Gray snapper	3		Redear sunfish	1
Common snook	3		Yellow bullhead	1

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Largemouth bass	2000	2000	0.020	4.360	0.645	0.550	0.466	72.28
Spotted sea trout	92	92	0.073	1.800	0.677	0.695	0.381	56.32
Warmouth	84	84	0.190	1.700	0.778	0.700	0.356	45.78

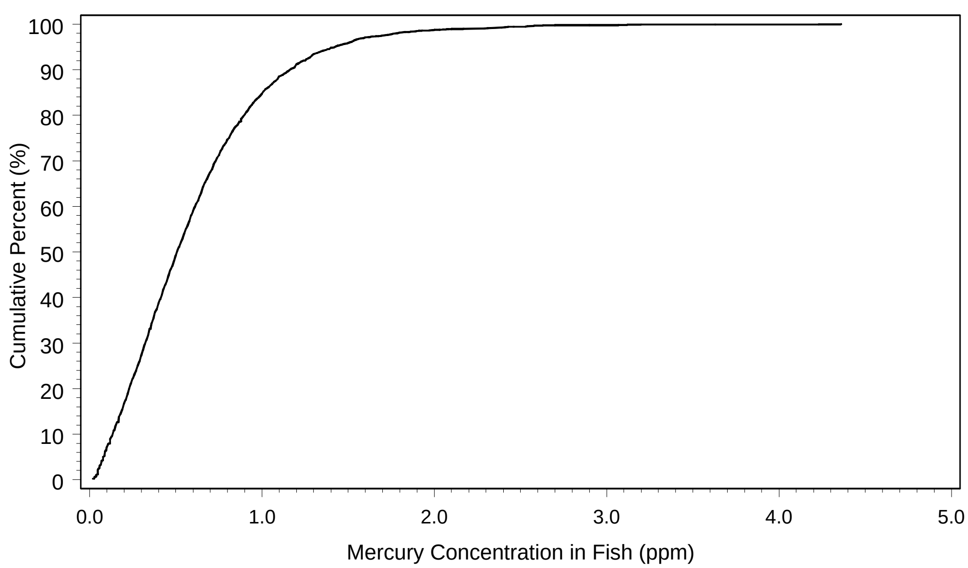
a Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

b Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

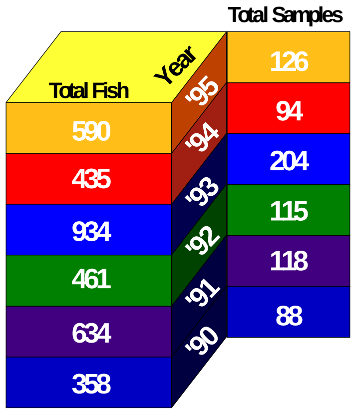
c Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

d $CV = (SD_w / \bar{x}_w) * 100$

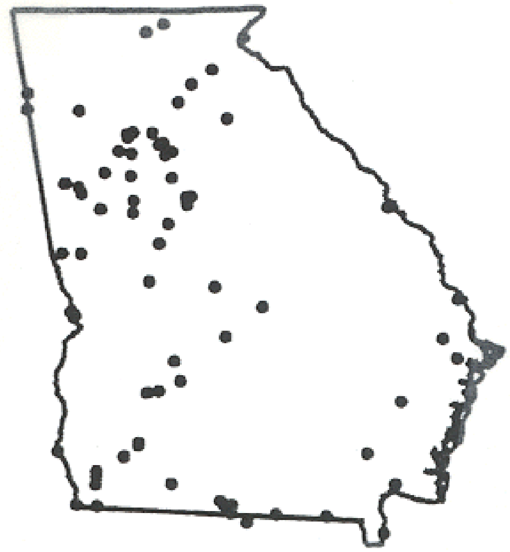
Cumulative Distribution of Mercury Concentrations for All Fish Species in Florida

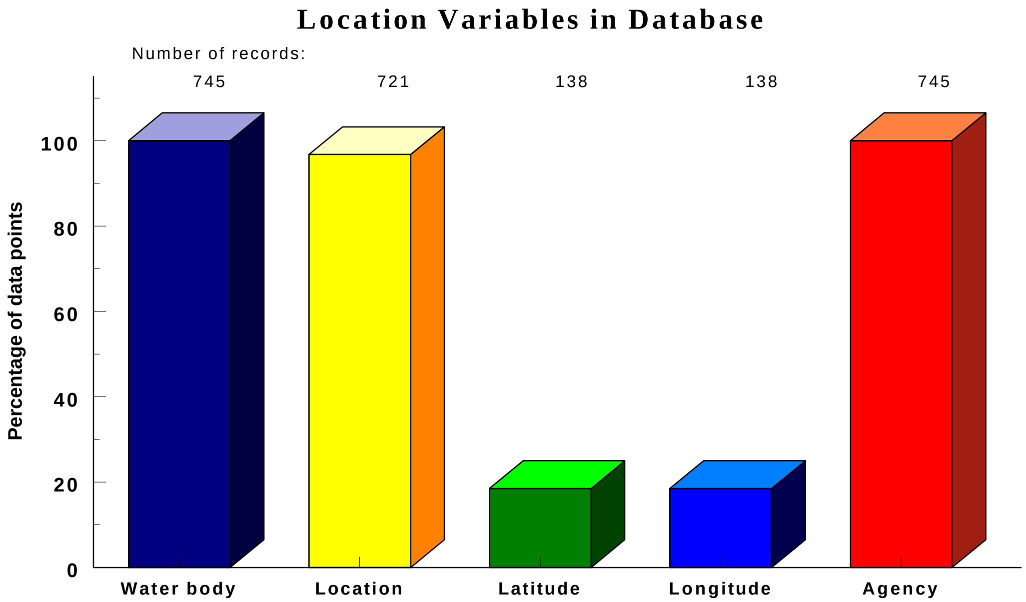


Records Analyzed by Year



Sampling Locations

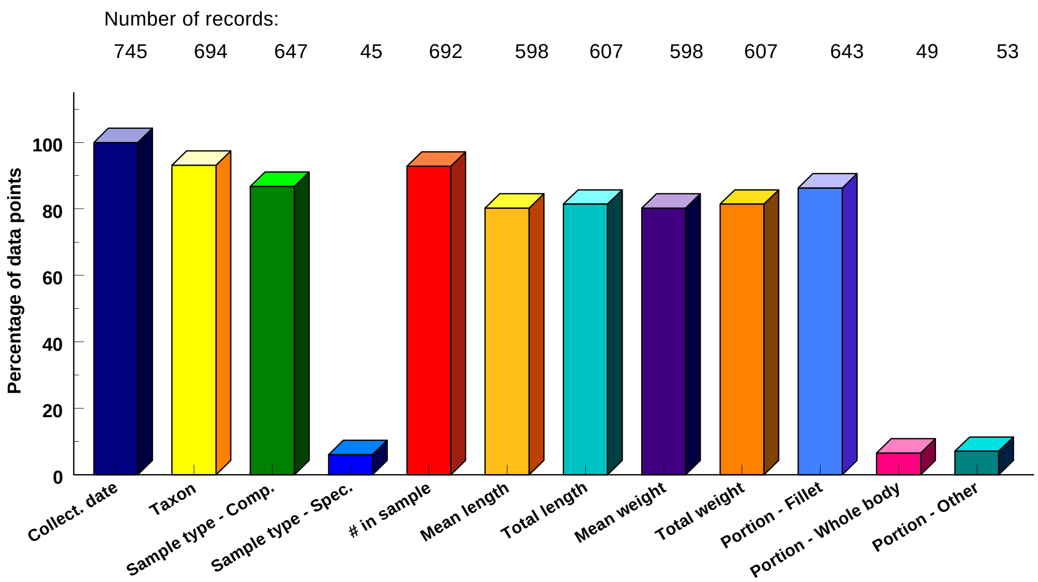




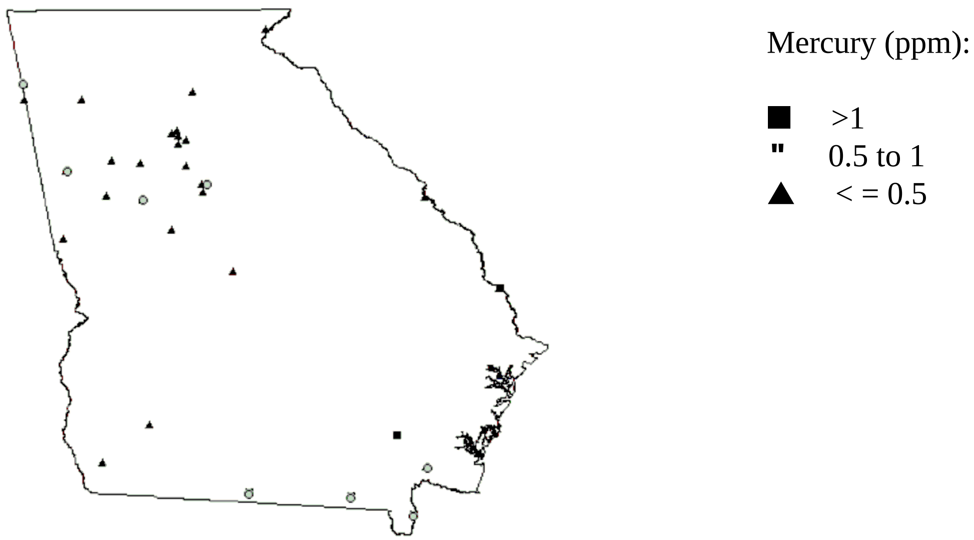
Top Ten Fish Species

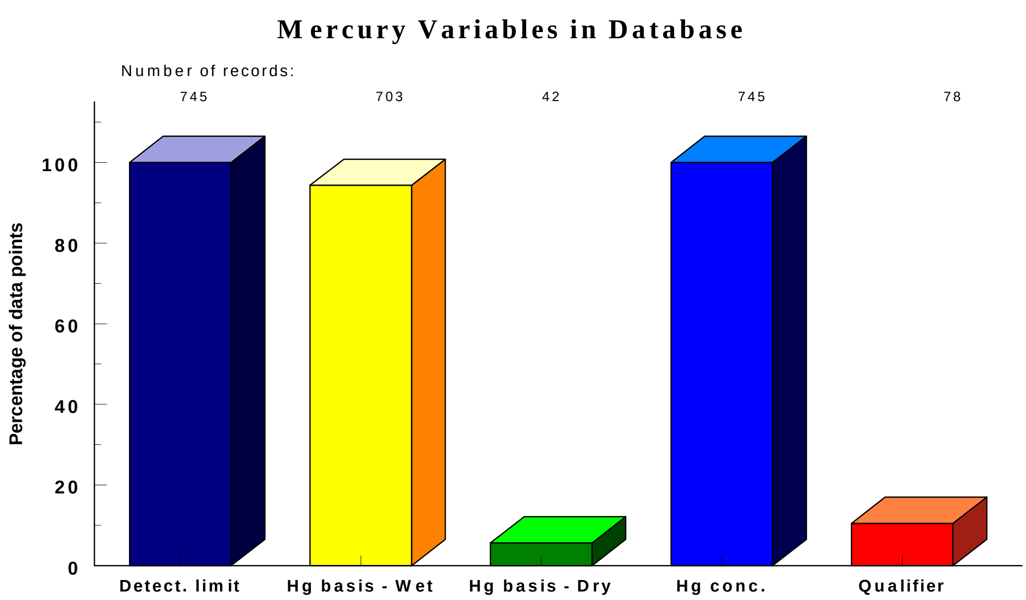
Common Name	Percent	Common Name	Percent
Largemouth bass	29	Flathead catfish	4
Channel catfish	20	Spotted sucker	3
Black crappie	6	Bluegill sunfish	3
Hybrid bass	5	Redbreast sunfish	2
Common carp	4	Redear sunfish	2

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Largemouth bass	206	968	0.010	2.286	0.274	0.199	0.306	111.88
Channel catfish	136	658	0.010	1.143	0.084	0.060	0.140	166.62
Black crappie	43	210	0.010	0.300	0.029	0.020	0.040	134.46

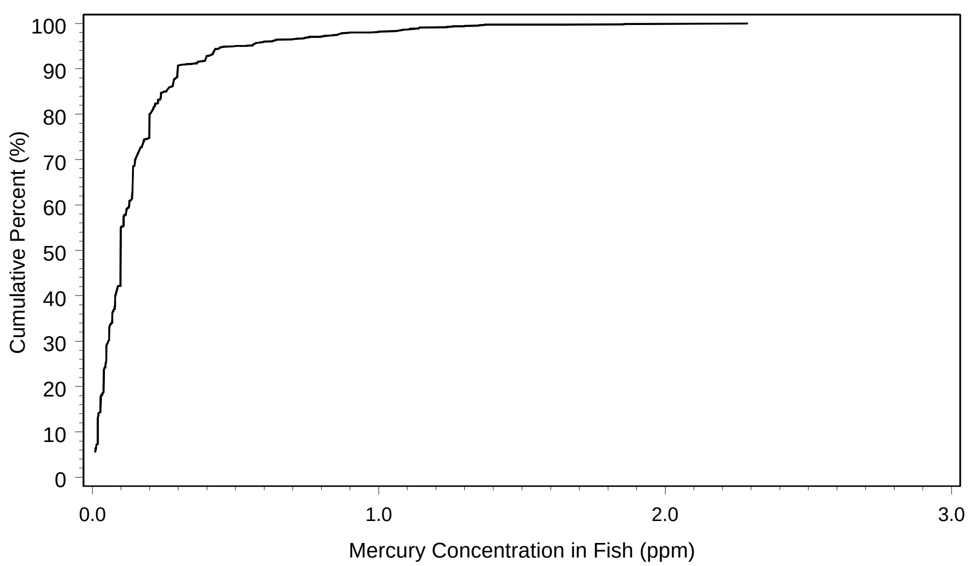
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

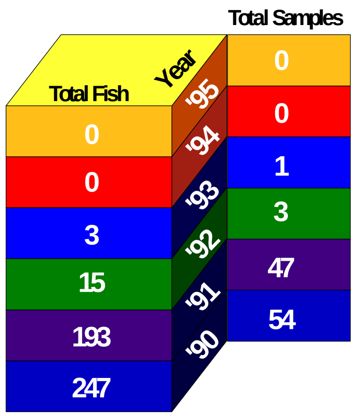
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

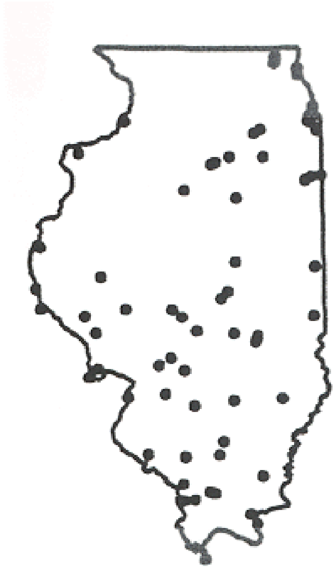
Cumulative Distribution of Mercury Concentrations for All Fish Species in Georgia

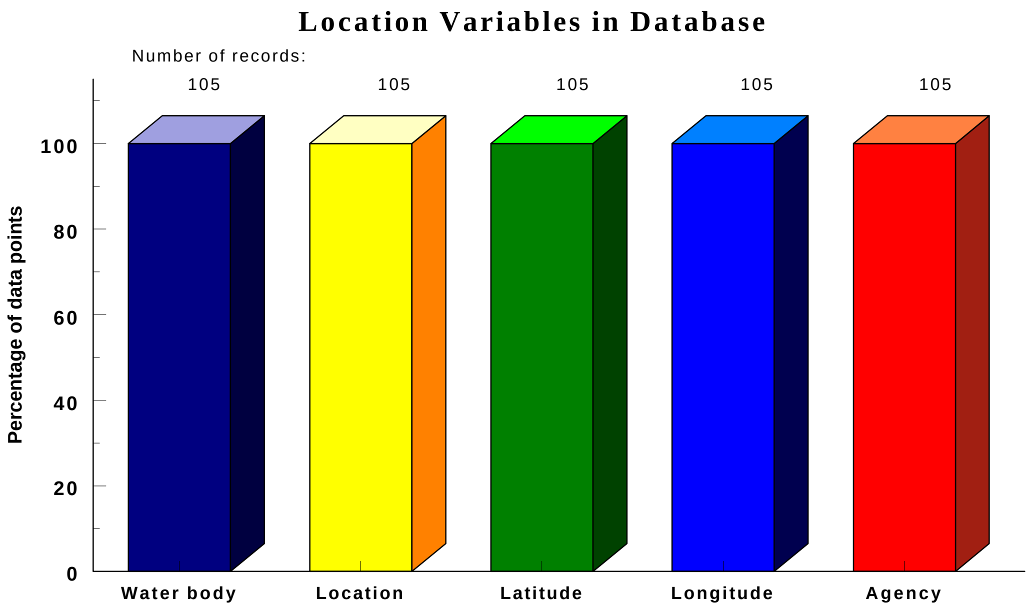


Records Analyzed by Year



Sampling Locations

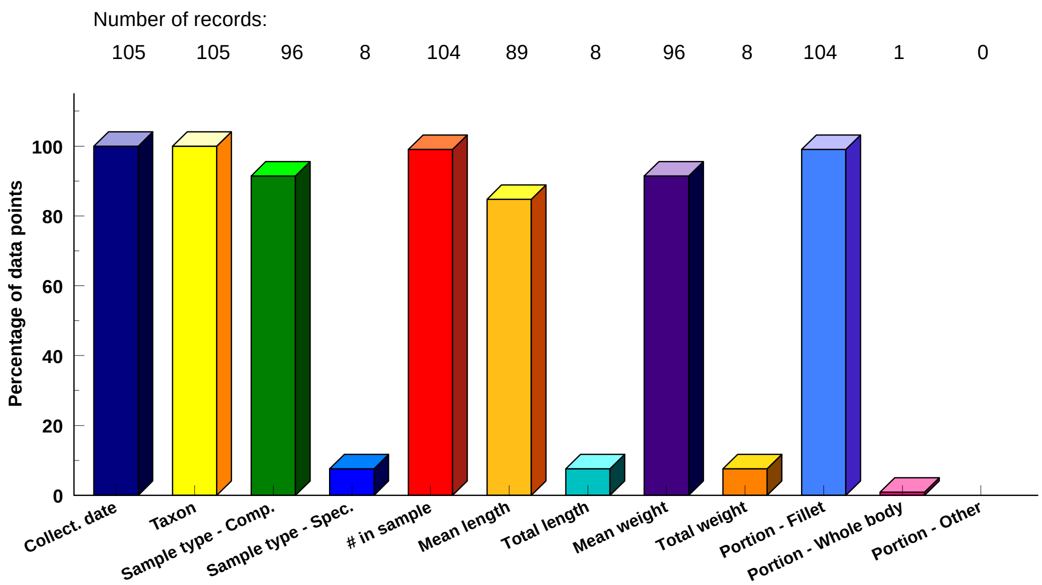




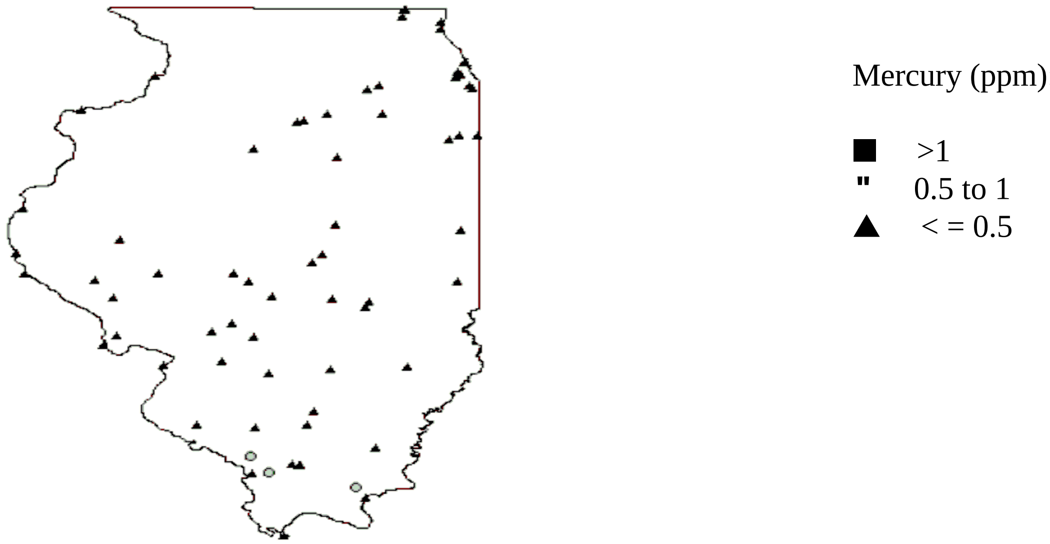
Top Ten Fish Species

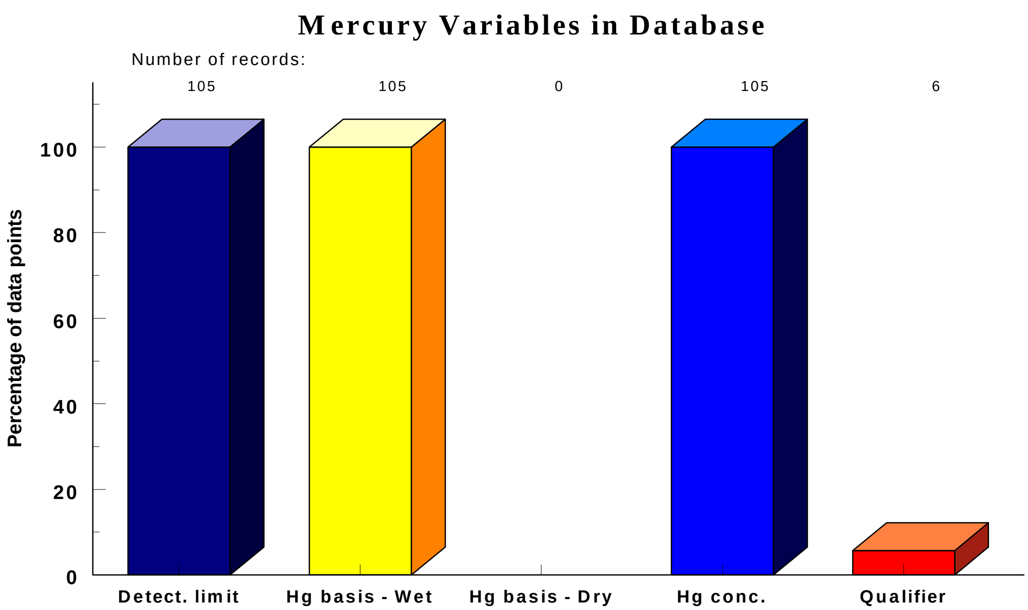
Common Name	Percent	Common Name	Percent
Largemouth bass	67	White bass	3
Bluegill sunfish	7	Lake trout	2
White crappie	5	Brown trout	2
Smallmouth bass	5	Channel catfish	1
Walleye	5	Chinook salmon	1

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Largemouth bass	71	305	0.010	0.880	0.180	0.120	0.163	90.61
Bluegill sunfish	6	30	0.010	0.100	0.058	0.060	0.043	72.88
White crappie	5	24	0.040	0.150	0.075	0.060	0.041	54.20

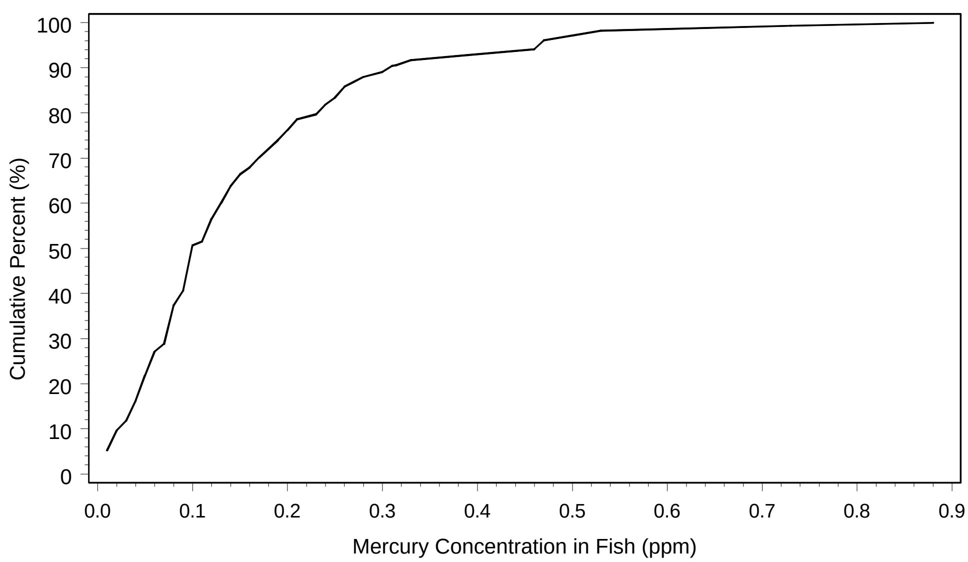
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

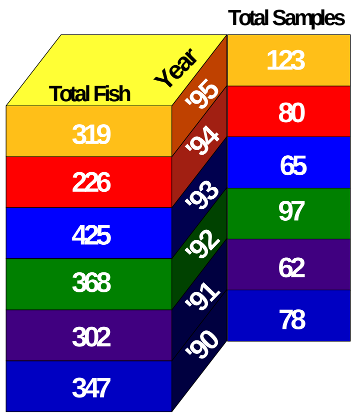
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

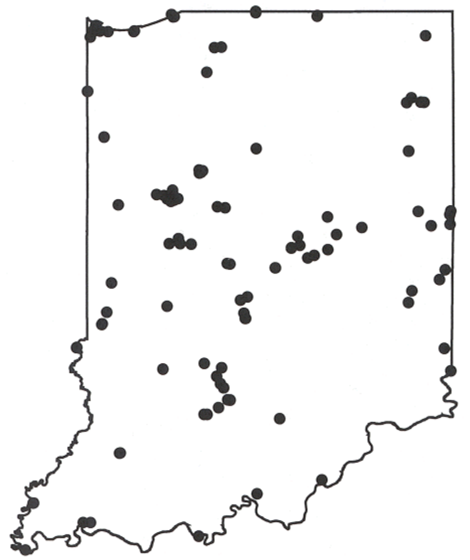
Cumulative Distribution of Mercury Concentrations for All Fish Species in Illinois

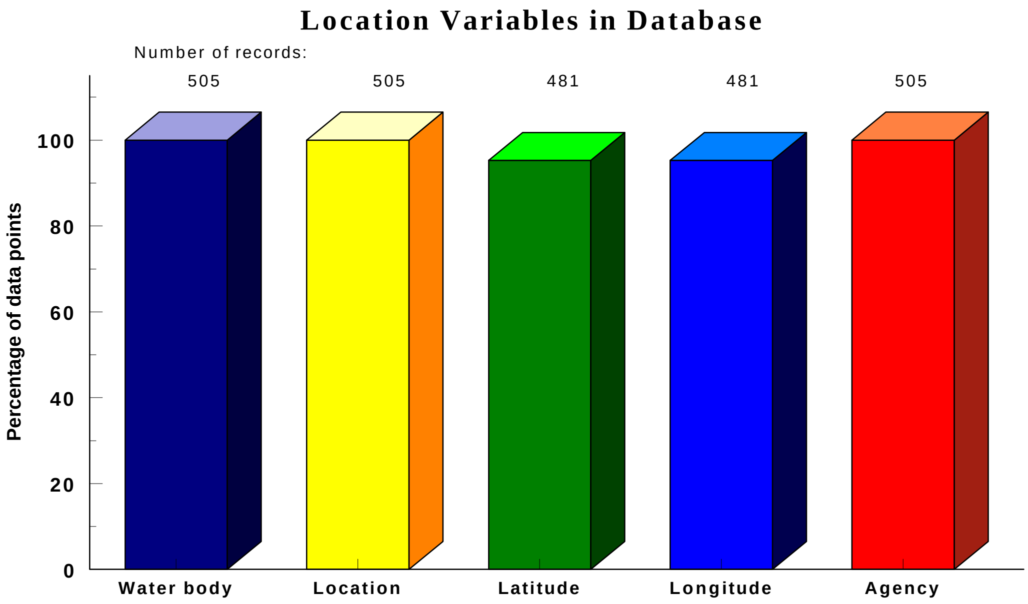


Records Analyzed by Year



Sampling Locations

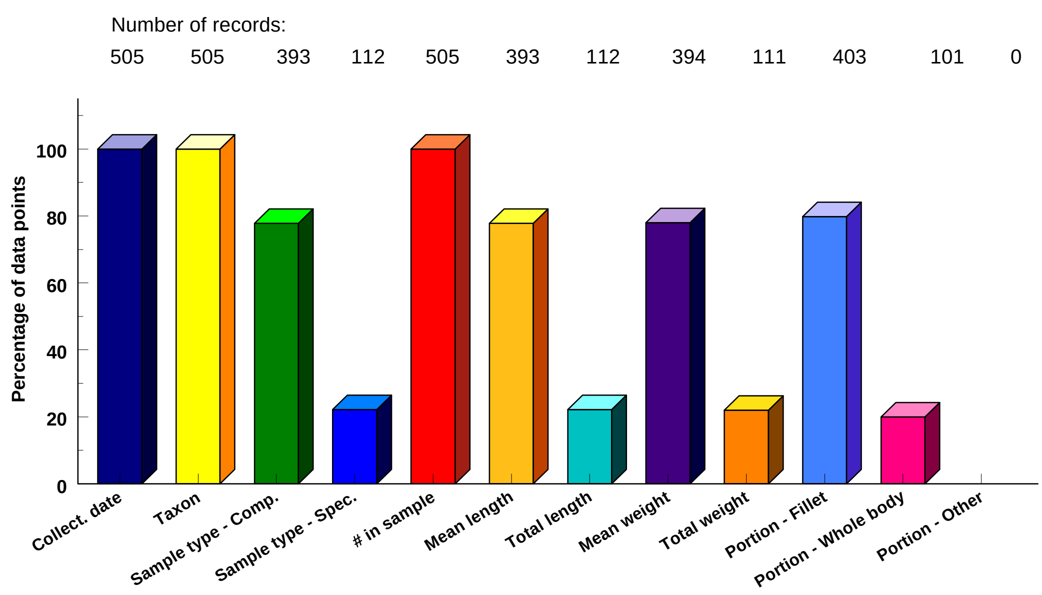




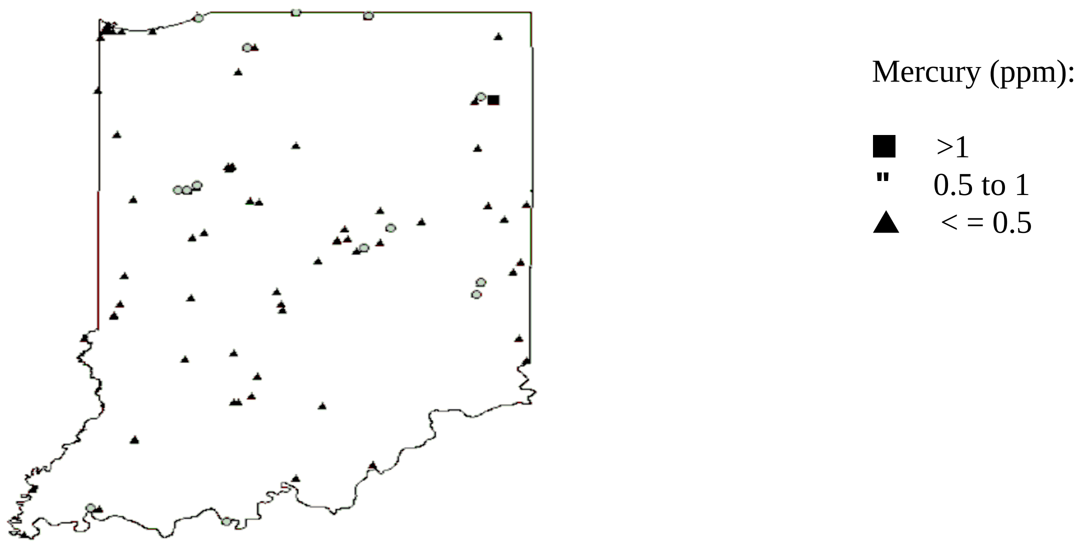
Top Ten Fish Species

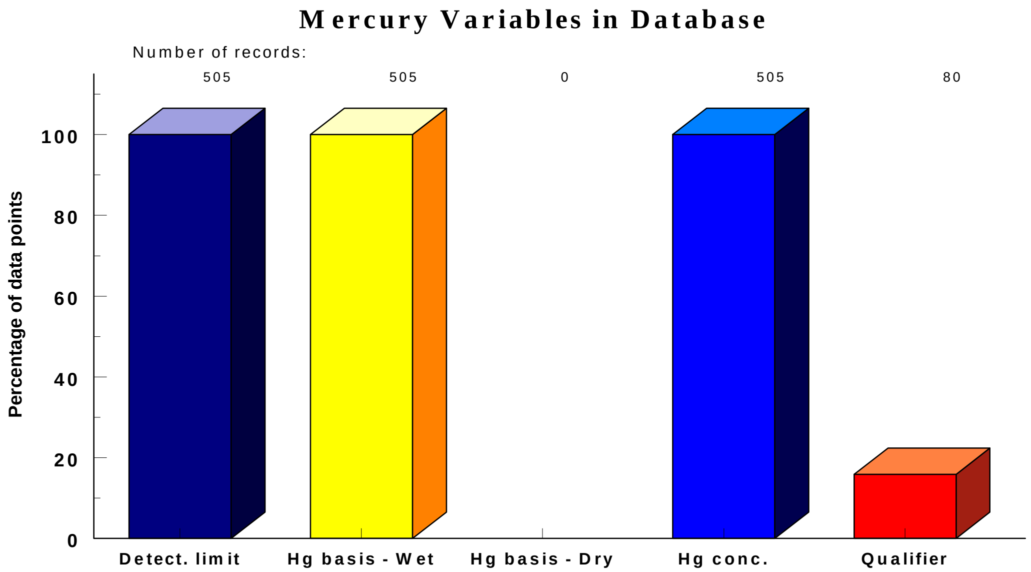
Common Name	Percent		Common Name	Percent
Common carp	25		Longear sunfish	6
Creek chub	7		Channel catfish	6
White sucker	7		Smallmouth bass	5
Black redhorse	7		Largemouth bass	3
Rock bass	7		Spotted bass	2

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Common carp	154	506	0.010	1.000	0.166	0.145	0.125	75.25
Creek chub	15	144	0.029	0.143	0.094	0.100	0.034	36.00
White sucker	25	143	0.030	0.240	0.137	0.120	0.057	41.38

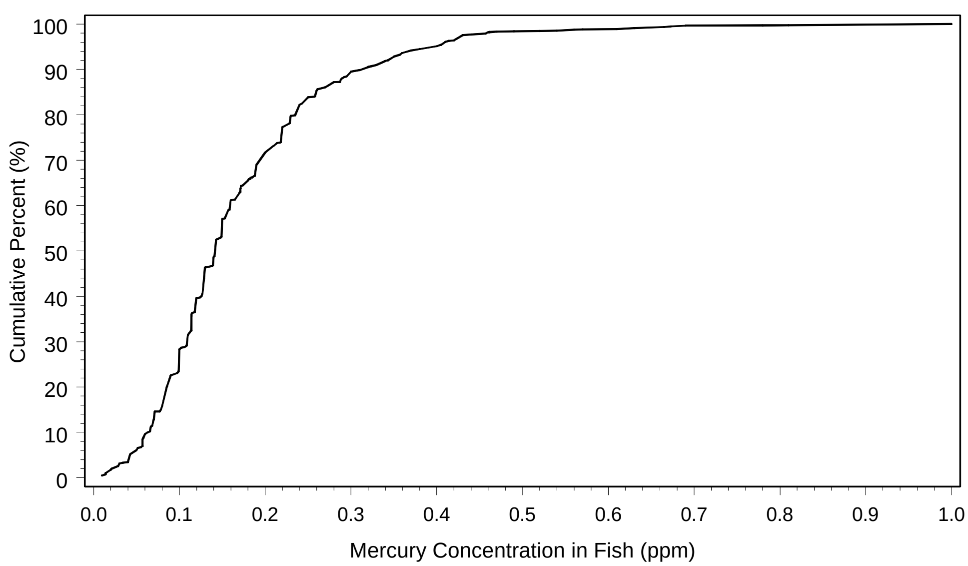
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

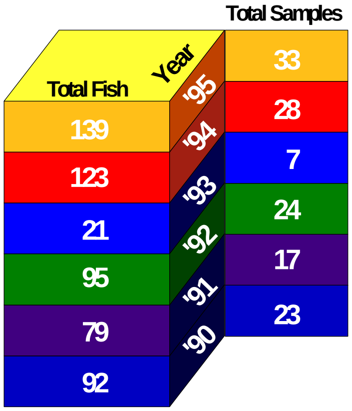
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \; / \; (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

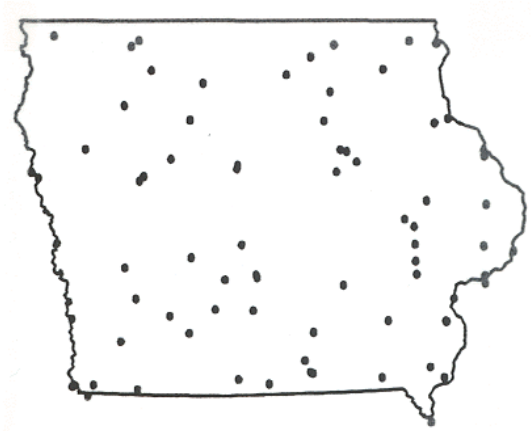
Cumulative Distribution of Mercury Concentrations for All Fish Species in Indiana

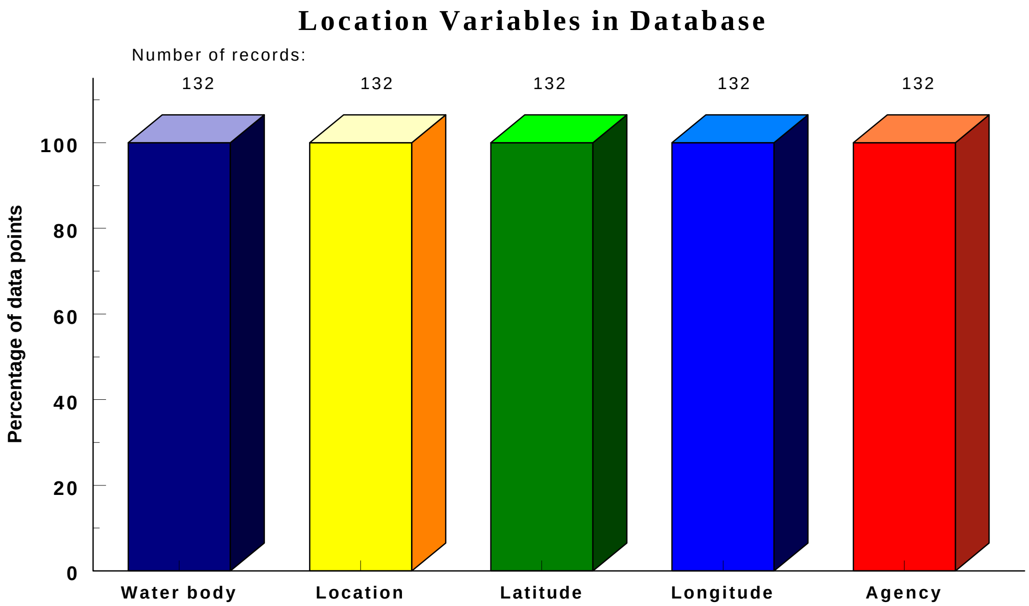


Records Analyzed by Year



Sampling Locations



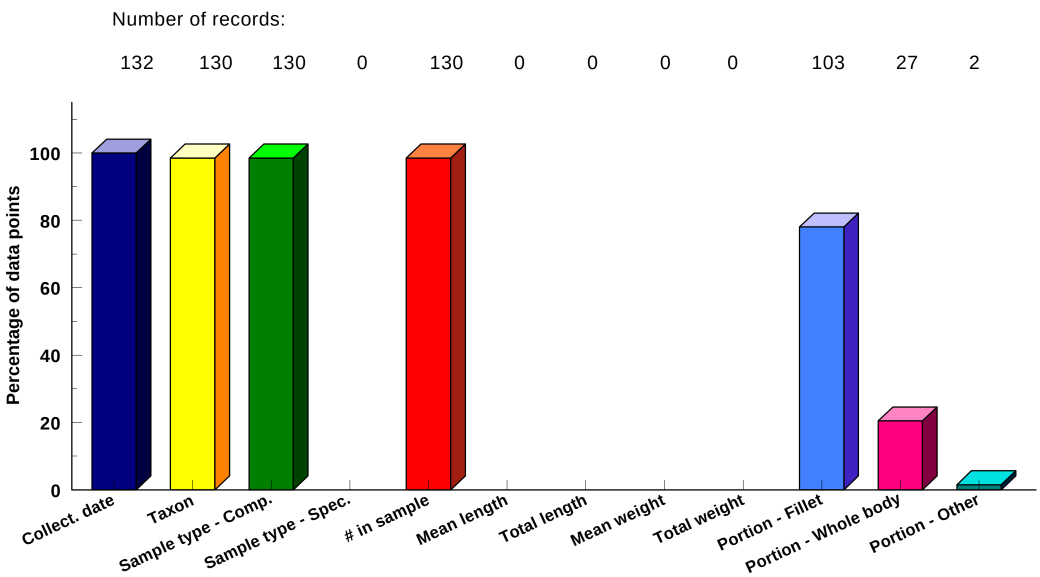


Top Nine Fish Species[a,b]

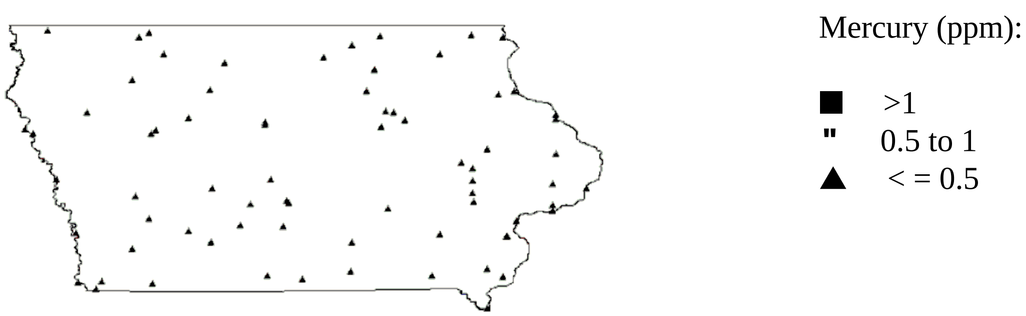
Common Name	Percent	Common Name	Percent
Channel catfish	59	Smallmouth bass	1
Common carp	27	Walleye	1
Largemouth bass	7	Yellow perch	1
White crappie	3	White bass	1
Northern pike	1		

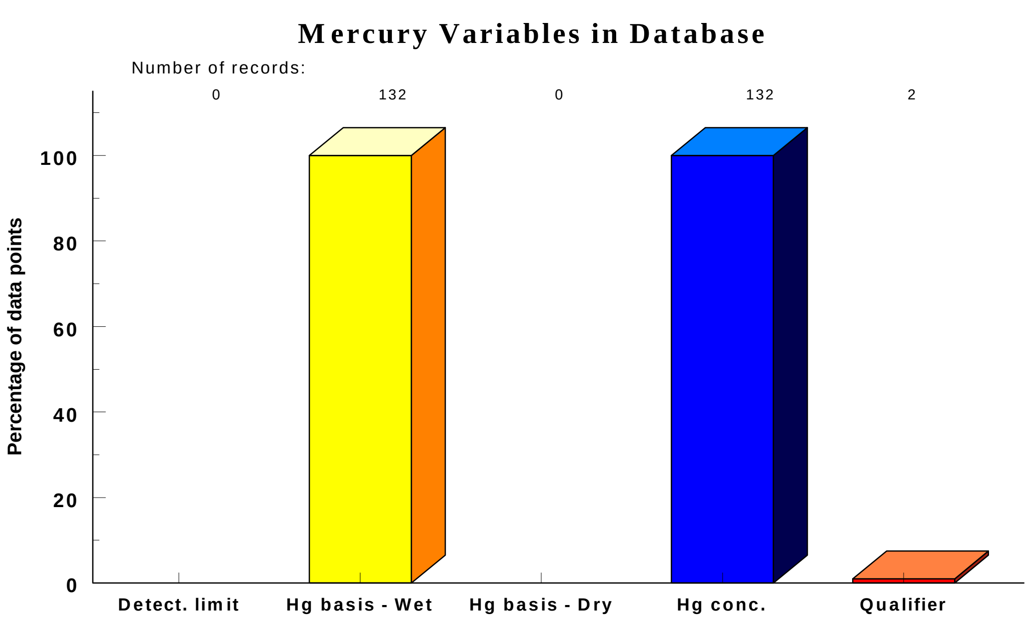
[a] Species identified as "Unknown" were excluded from this analysis.
[b] Only nine species were identified in the database.

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Channel catfish	74	323	0.030	0.410	0.104	0.090	0.063	60.64
Common carp	37	145	0.014	0.486	0.215	0.171	0.132	61.31
Largemouth bass	9	38	0.080	0.480	0.189	0.150	0.116	61.35

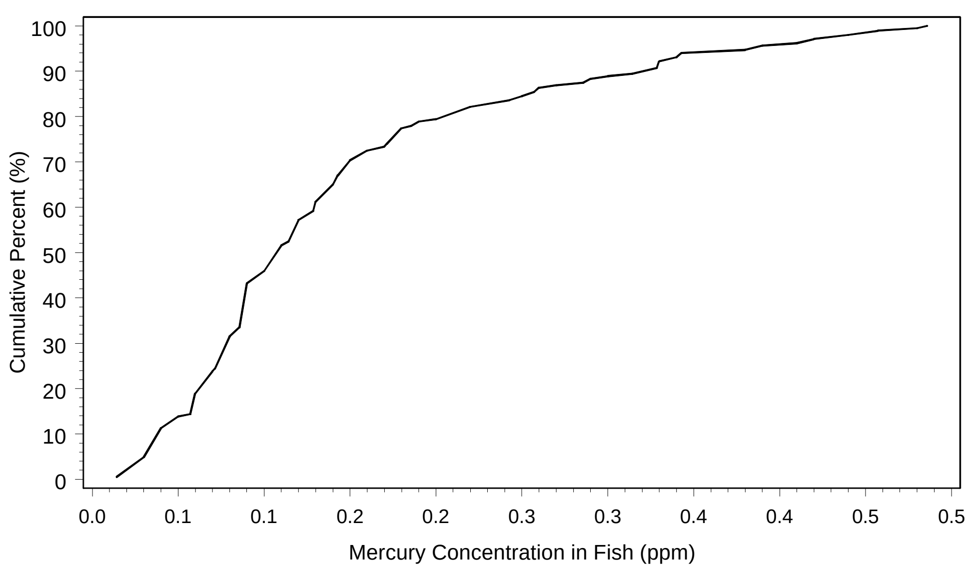
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

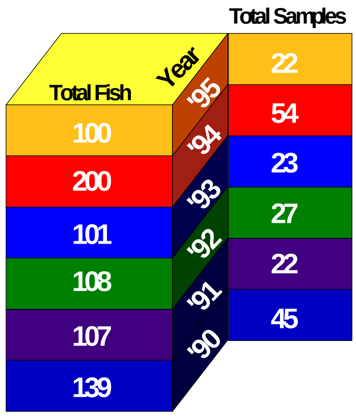
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

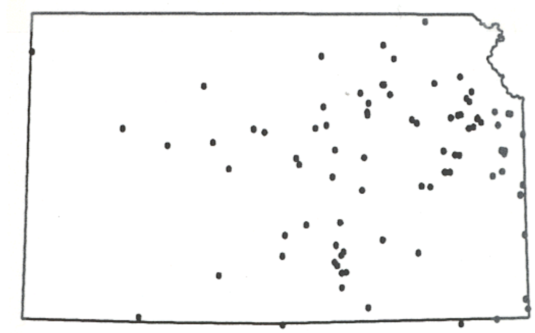
Cumulative Distribution of Mercury Concentrations for All Fish Species in Iowa

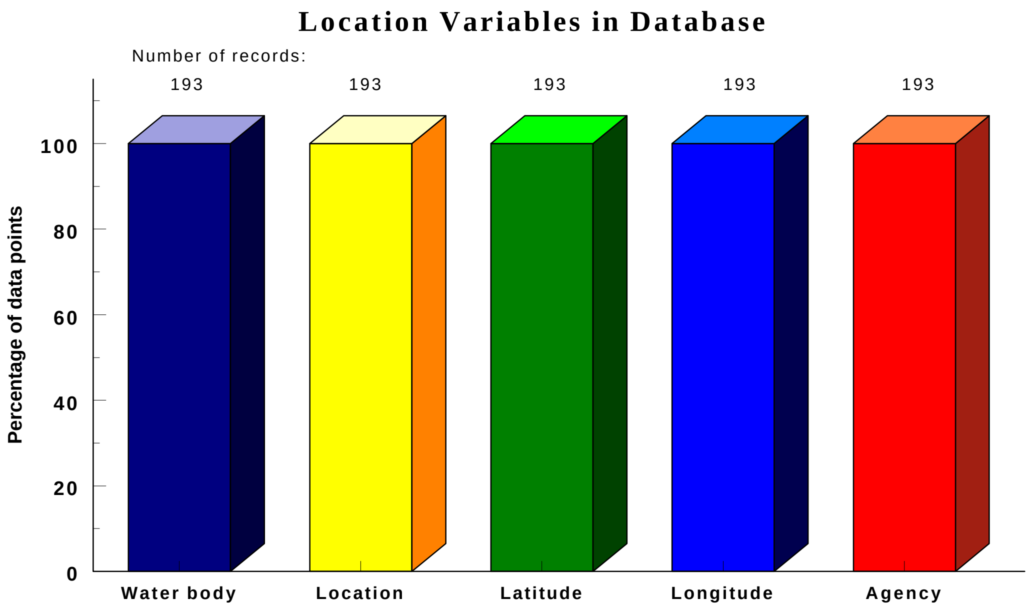


Records Analyzed by Year



Sampling Locations



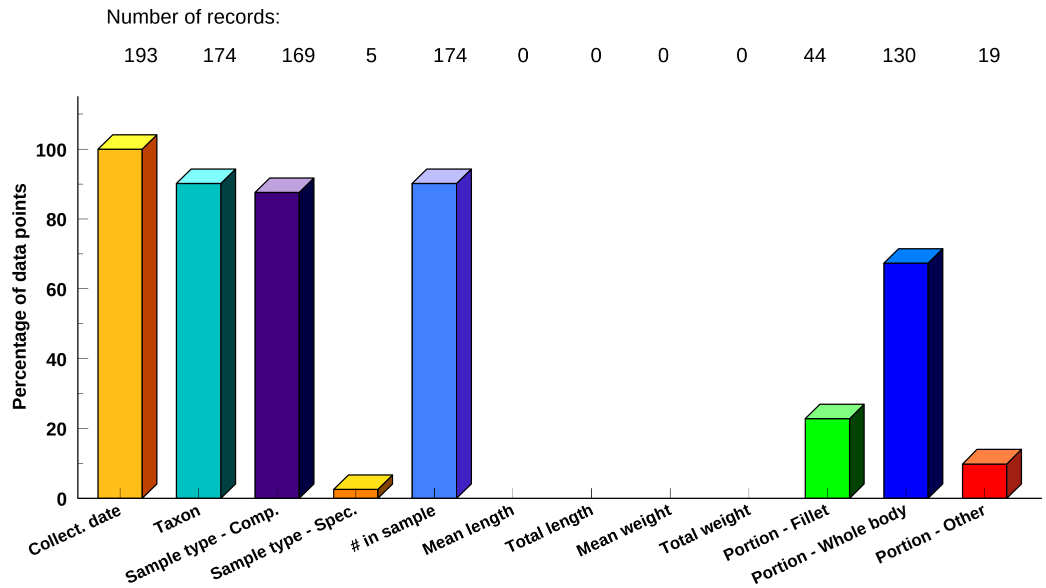


Top Ten Fish Species[a]

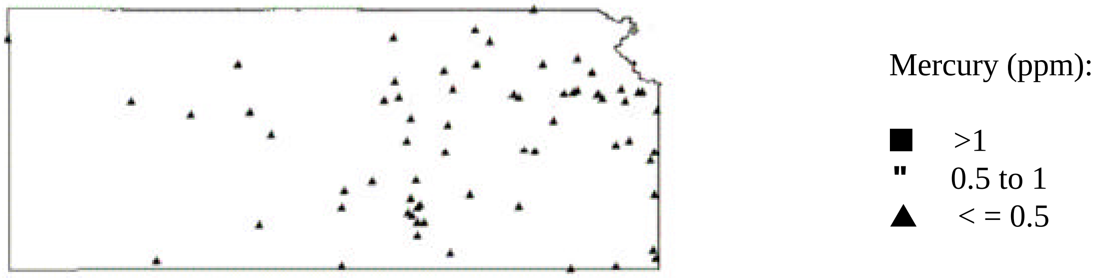
Common Name	Percent	Common Name	Percent
Common carp	76	Smallmouth buffalo	1
Channel catfish	8	Yellow bullhead	1
Black bullhead	4	White bass	1
White sucker	3	White crappie	1
River carpsucker	3	Shorthead redhorse	1

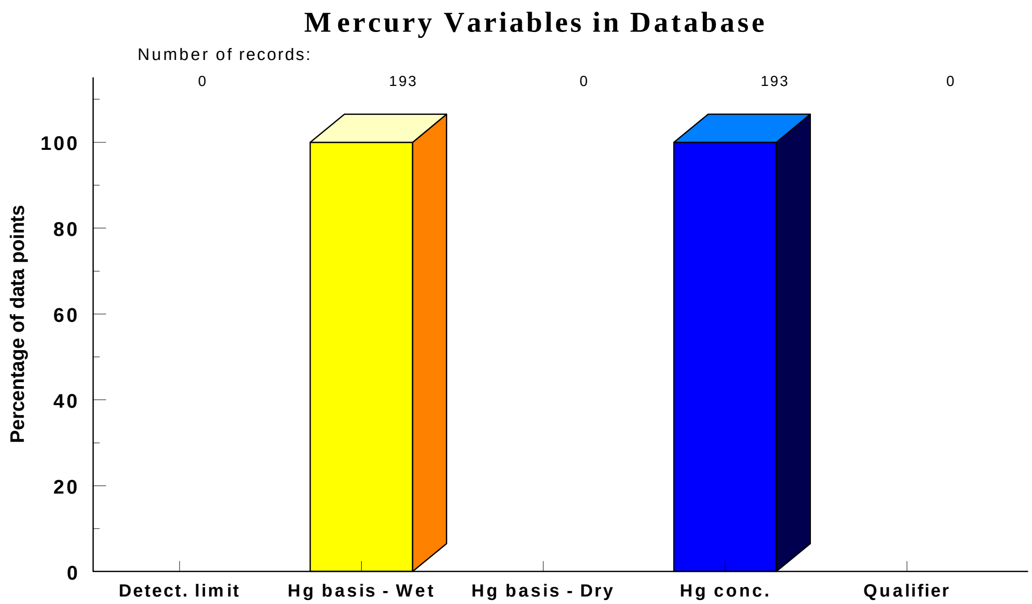
[a] Species identified as “Unknown” and “Mixed species” were excluded from this analysis.

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Common carp	133	556	0.014	0.386	0.167	0.157	0.079	47.06
Channel catfish	12	56	0.029	0.314	0.125	0.140	0.083	66.71
Black bullhead	8	31	0.090	0.271	0.168	0.150	0.061	36.48

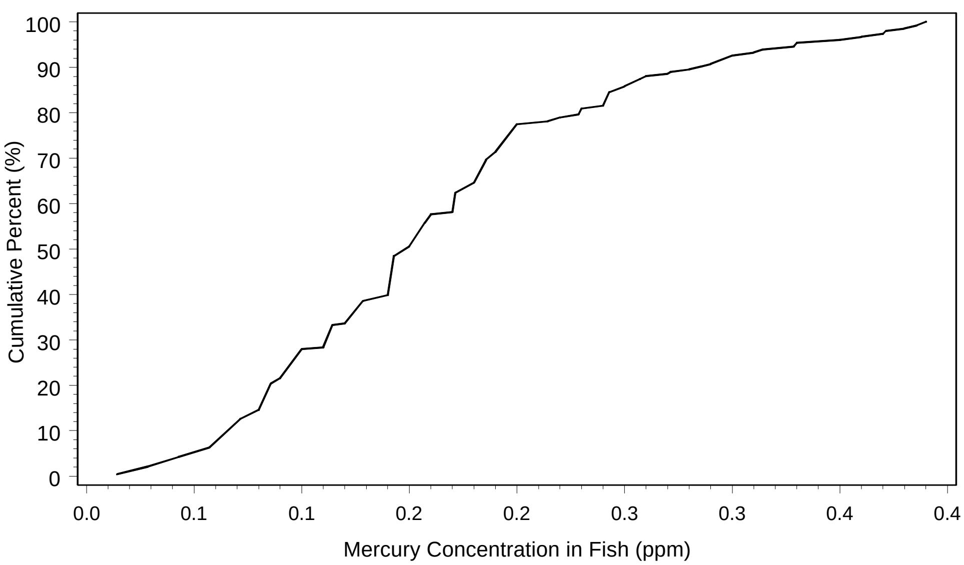
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

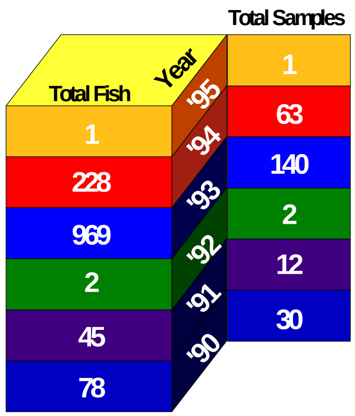
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \;/\; (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

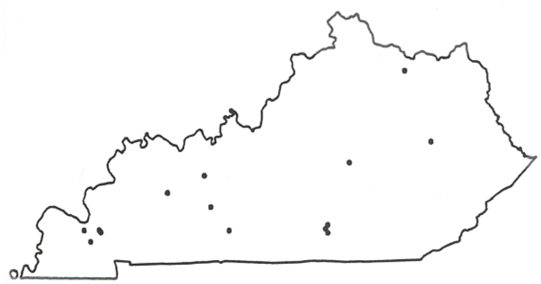
Cumulative Distribution of Mercury Concentrations for All Fish Species in Kansas

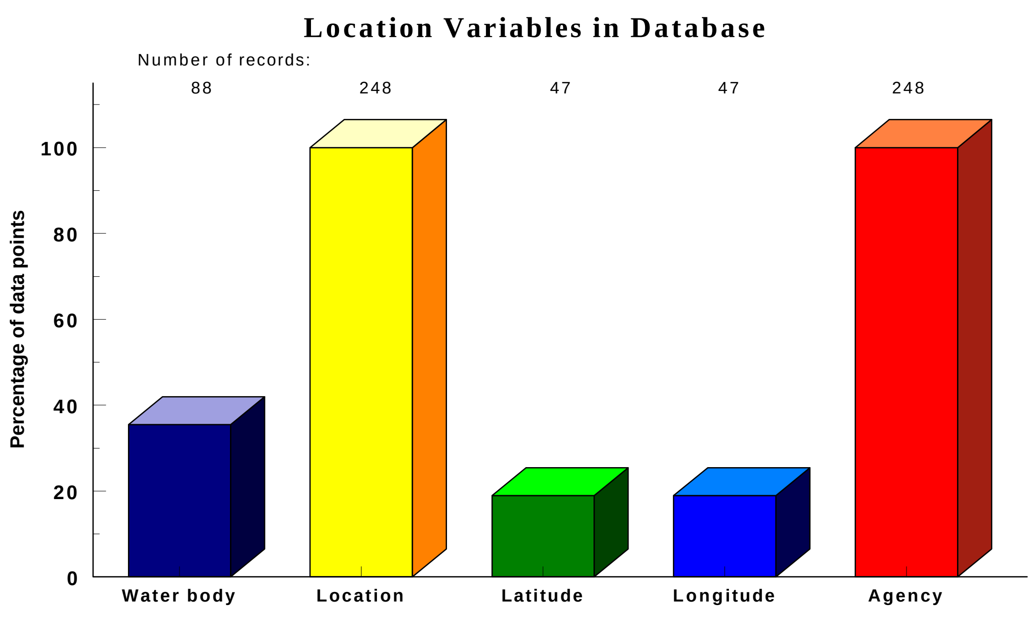


Records Analyzed by Year



Sampling Locations

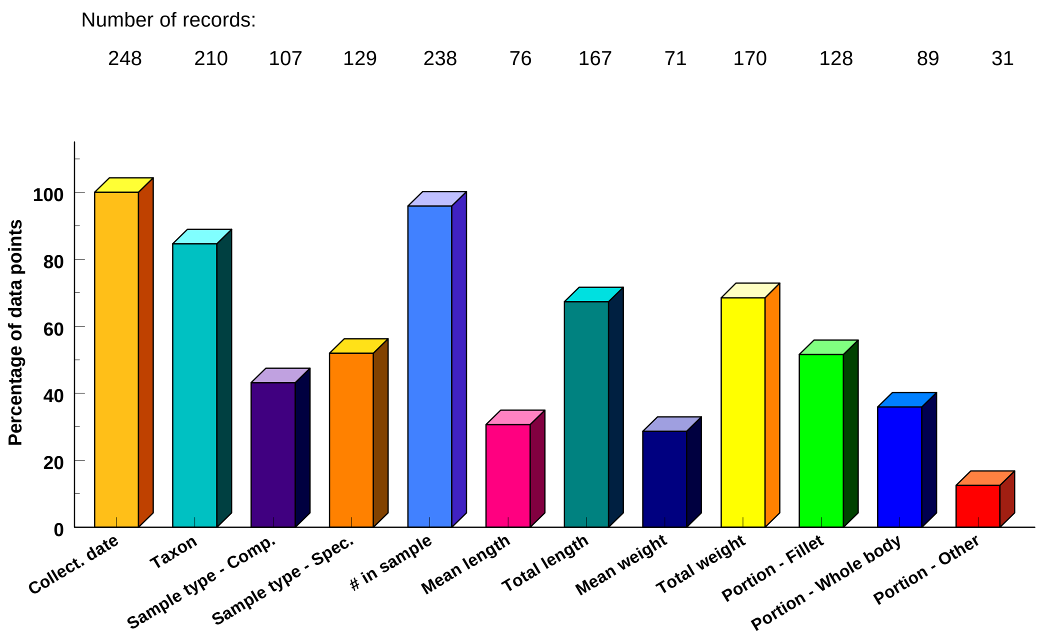




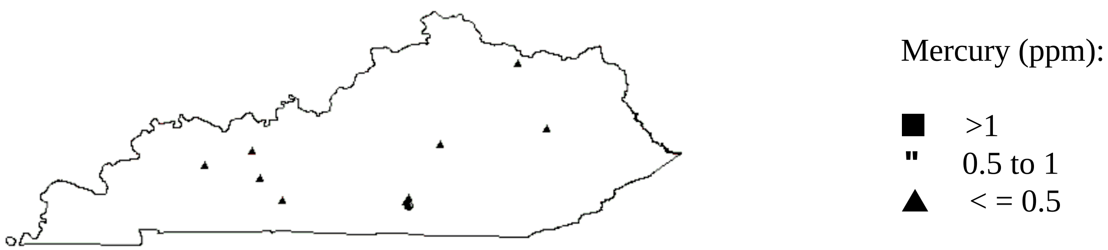
Top Ten Fish Species

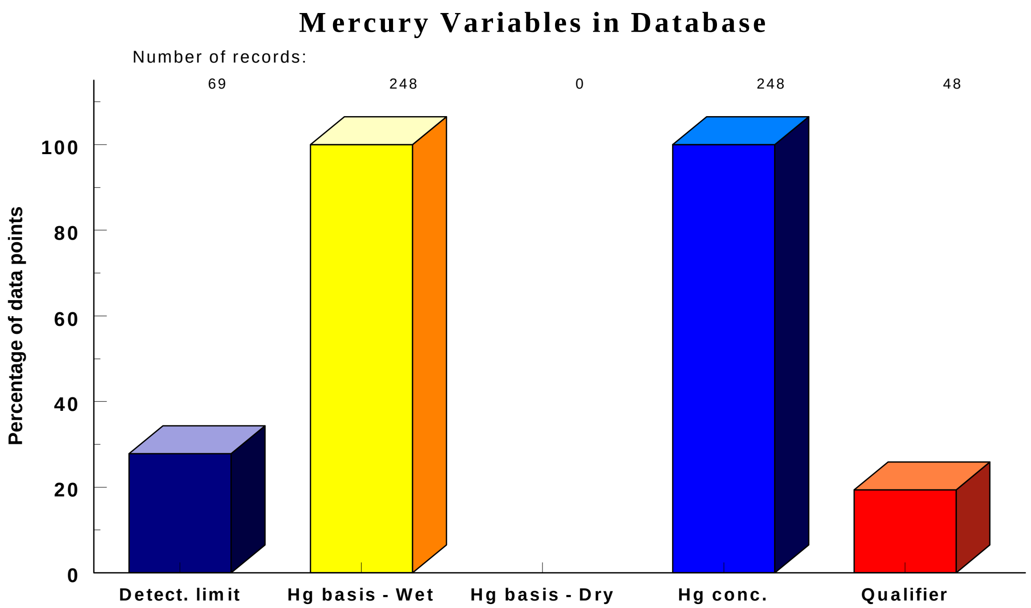
Common Name	Percent	Common Name	Percent
Shad	46	Channel catfish	4
Alewife	14	Walleye	3
Bluegill sunfish	9	Common carp	2
Largemouth bass	9	Catfish	1
Skipjack herring	6	River redhorse	1

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Shad	16	608	0.009	0.386	0.104	0.167	0.076	72.75
Alewife	17	182	0.300	3.429	0.522	0.386	0.422	80.85
Bluegill sunfish	41	125	0.029	0.825	0.236	0.190	0.180	76.38

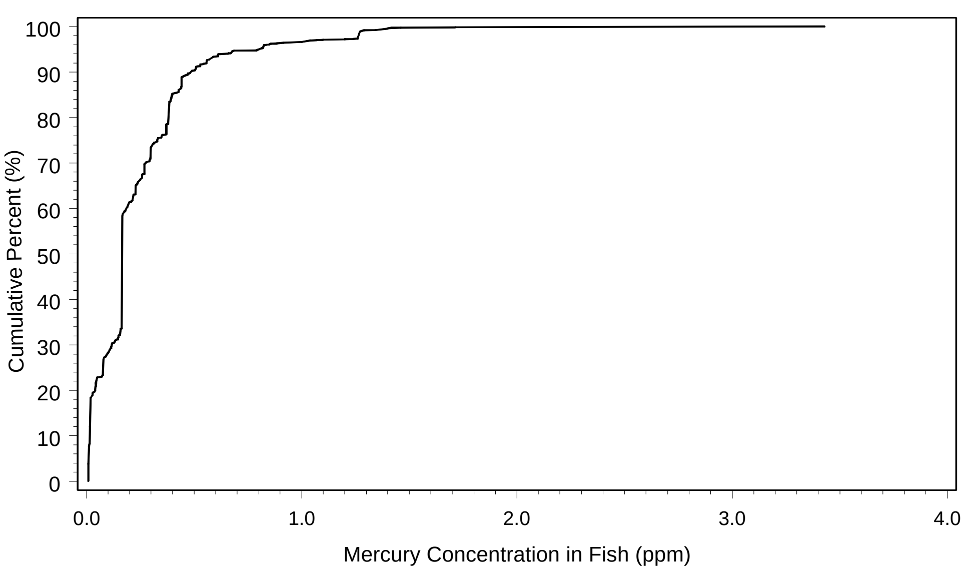
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

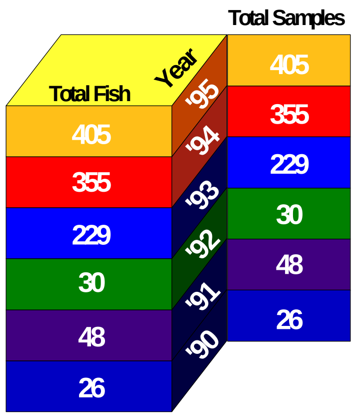
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

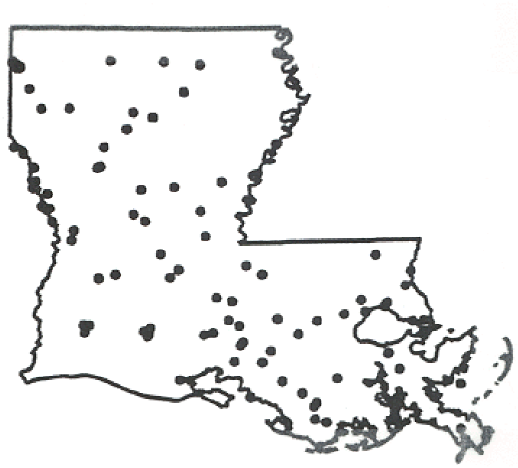
Cumulative Distribution of Mercury Concentrations for All Fish Species in Kentucky

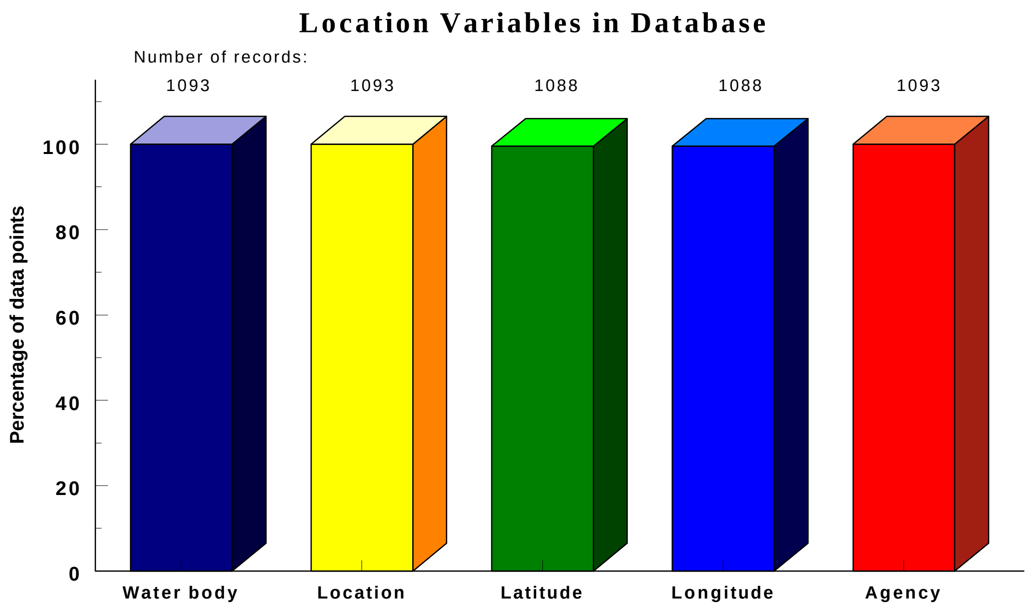


Records Analyzed by Year



Sampling Locations

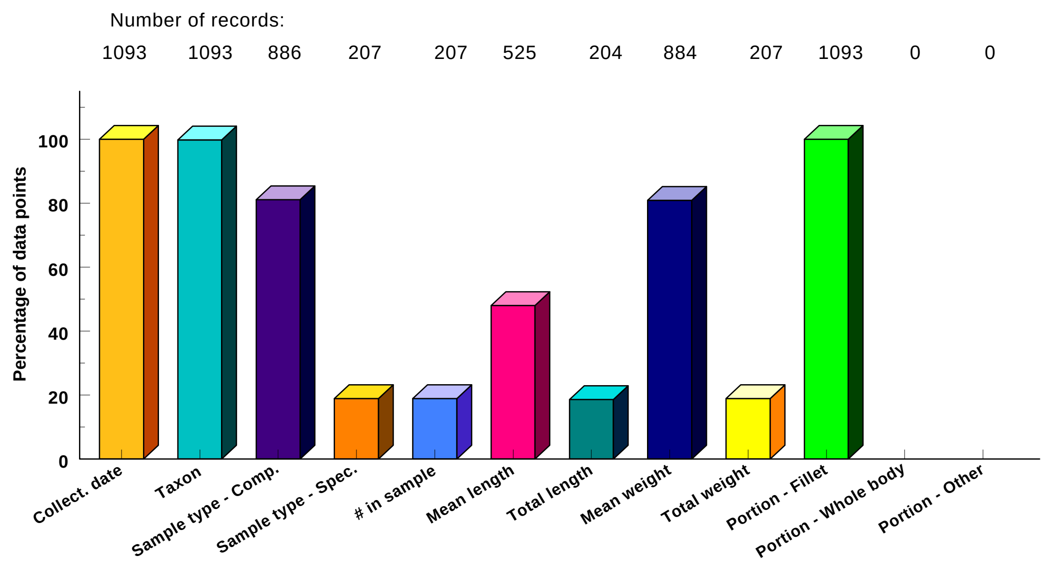




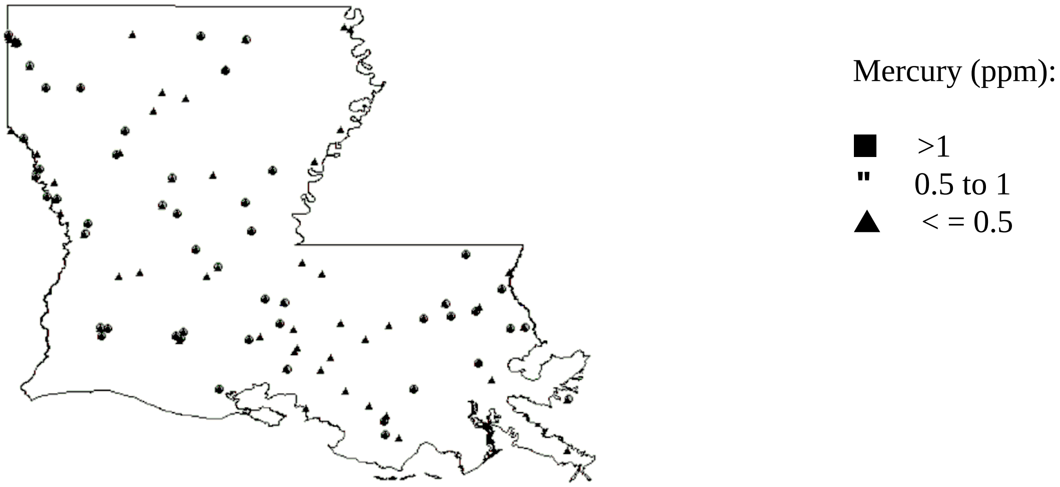
Top Ten Fish Species

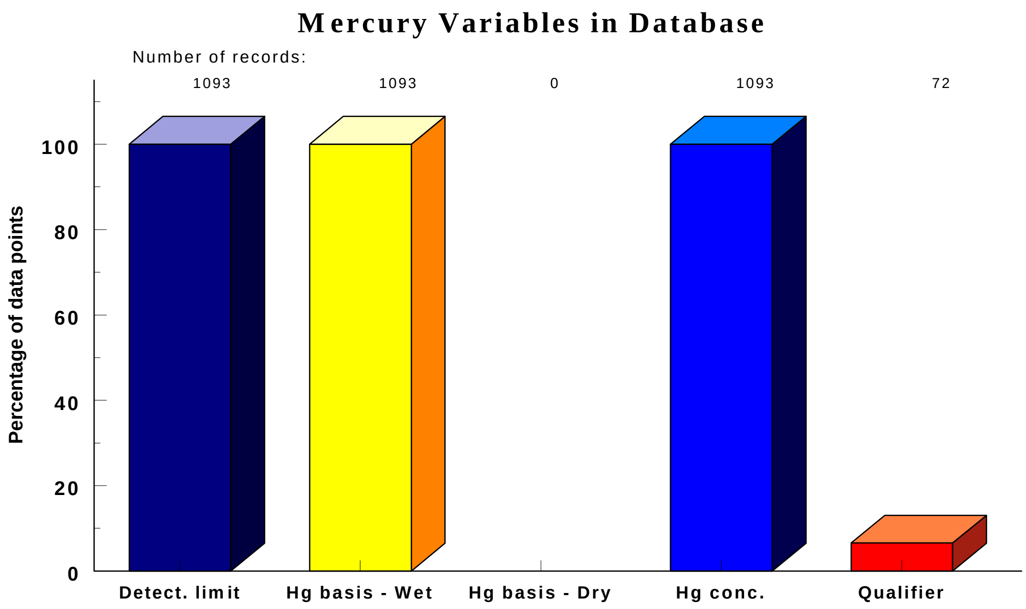
Common Name	Percent	Common Name	Percent
Largemouth bass	41	Redear sunfish	4
Channel catfish	7	Bluegill sunfish	4
White crappie	7	Blue catfish	4
Bowfin	4	Bigmouth buffalo	3
Black crappie	4	Common carp	3

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Largemouth bass	452	452	0.001	1.883	0.391	0.332	0.306	78.32
Channel catfish	76	76	0.001	0.732	0.111	0.060	0.143	128.19
White crappie	76	76	0.001	1.113	0.240	0.165	0.237	98.84

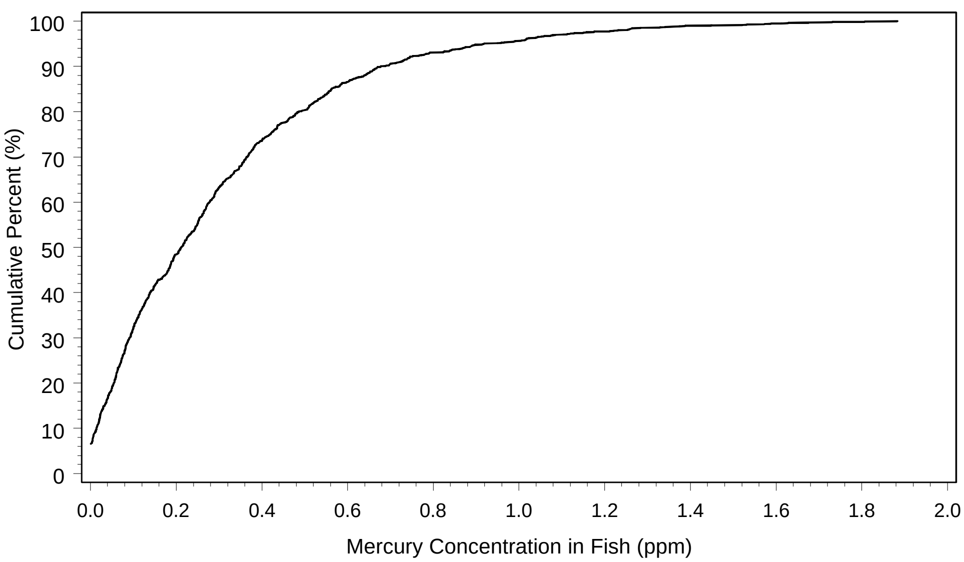
a Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

b Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

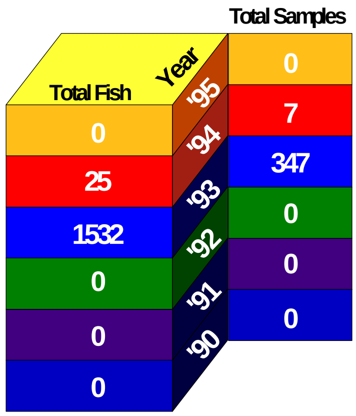
c Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

d $CV = (SD_w / \bar{x}_w) * 100$

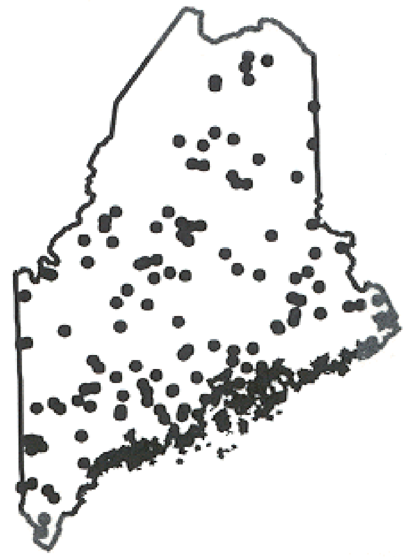
Cumulative Distribution of Mercury Concentrations for All Fish Species in Louisiana

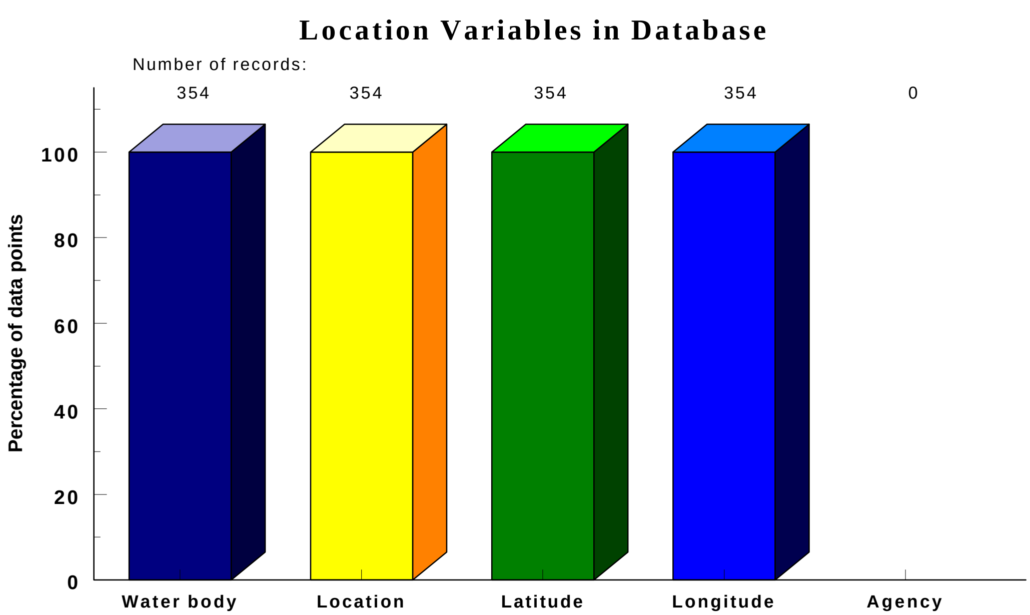


Records Analyzed by Year



Sampling Locations

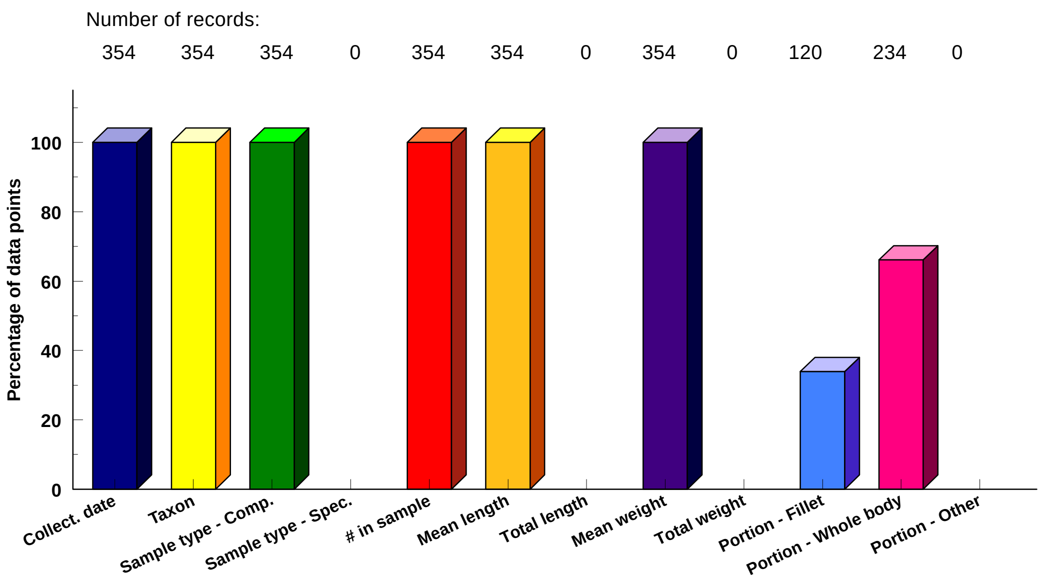




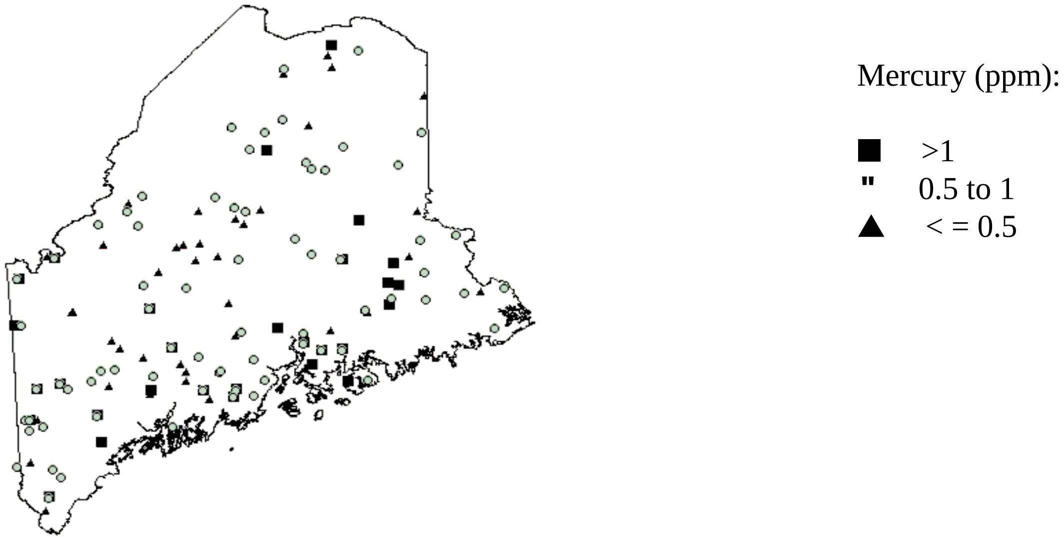
Top Ten Fish Species

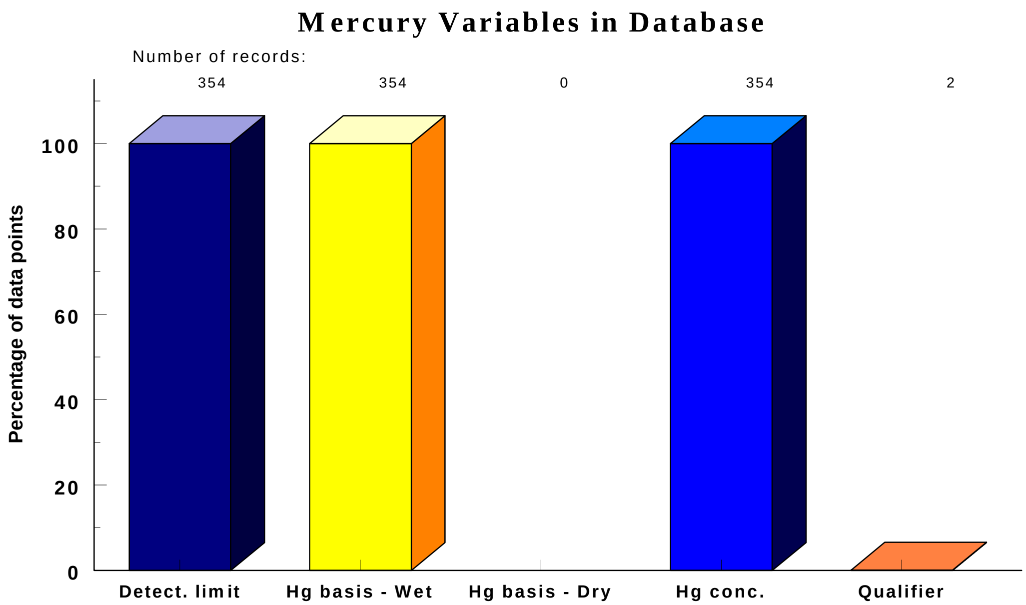
Common Name	Percent		Common Name	Percent
White sucker	34		Yellow perch	7
Brook trout	15		White perch	6
Largemouth bass	9		Chain pickerel	4
Smallmouth bass	9		Brown trout	4
Landlocked Atlantic salmon	7		Lake trout	4

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
White sucker	110	536	0.003	1.714	0.338	0.257	0.272	80.52
Brook trout	59	228	0.025	1.343	0.459	0.410	0.269	58.54
Largemouth bass	30	137	0.071	1.343	0.634	0.600	0.242	38.19

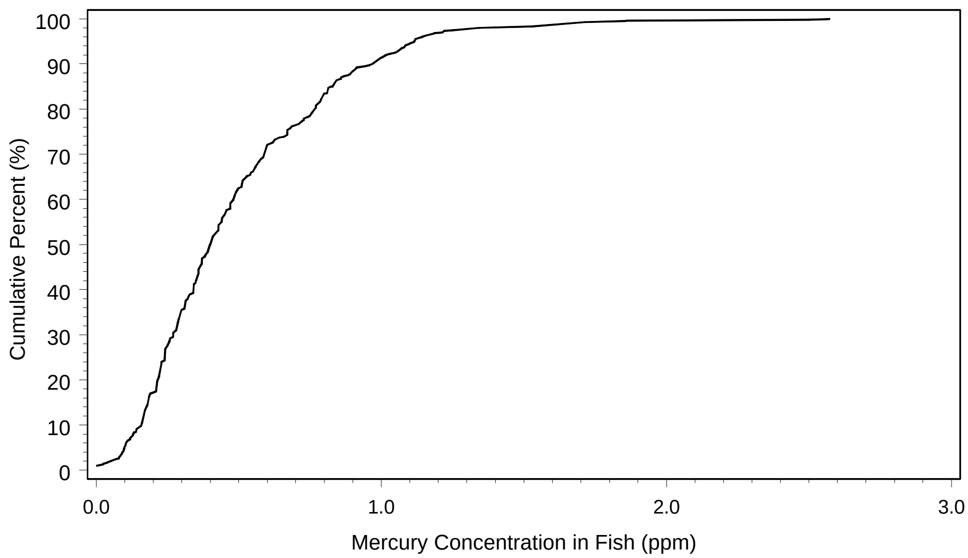
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

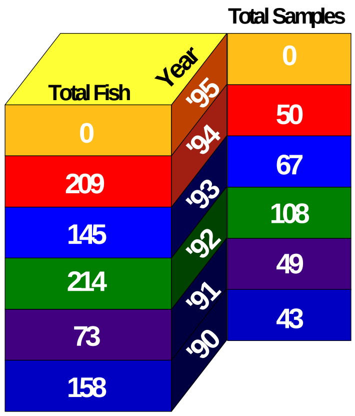
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

Cumulative Distribution of Mercury Concentrations for All Fish Species in Maine

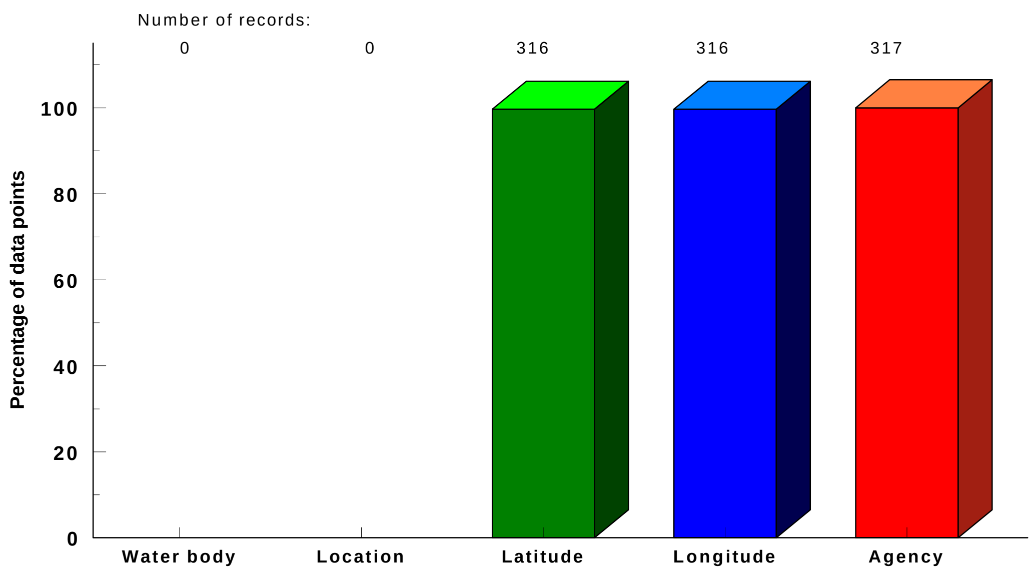


Records Analyzed by Year



Sampling Locations

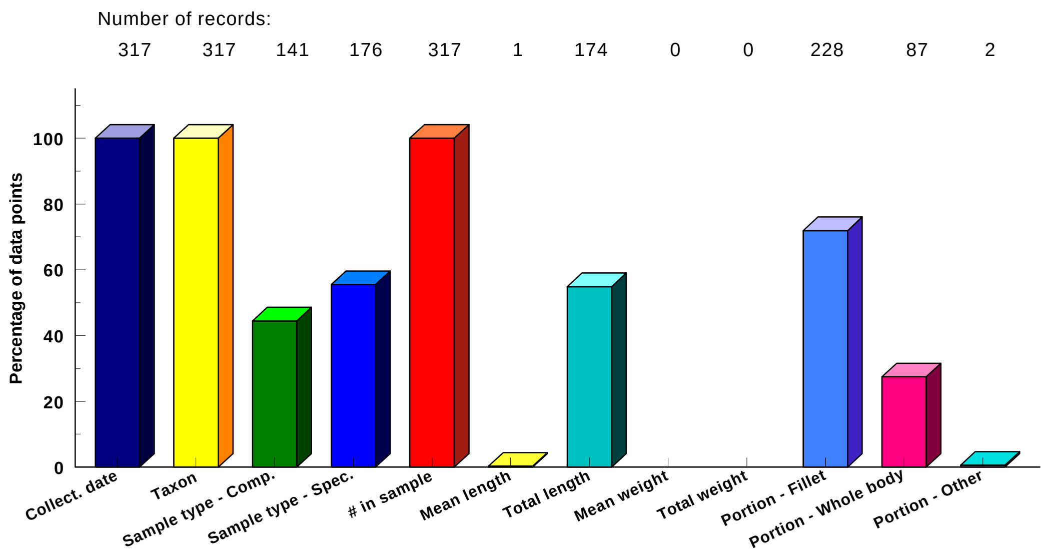
Location Variables in Database



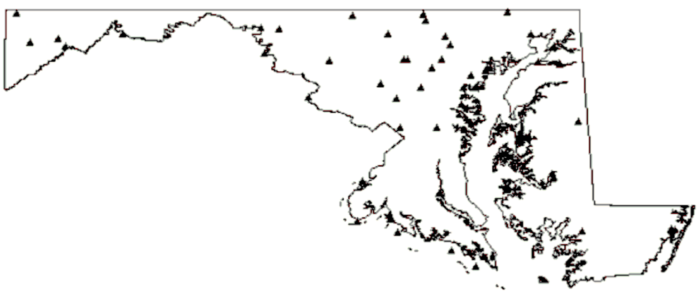
Top Ten Fish Species

Common Name	Percent		Common Name	Percent
Channel catfish	20		Largemouth bass	6
White perch	17		Smallmouth bass	6
Striped bass	12		White catfish	5
White sucker	11		Common carp	4
Brown bullhead	7		Brown trout	3

Fish Variables in Database

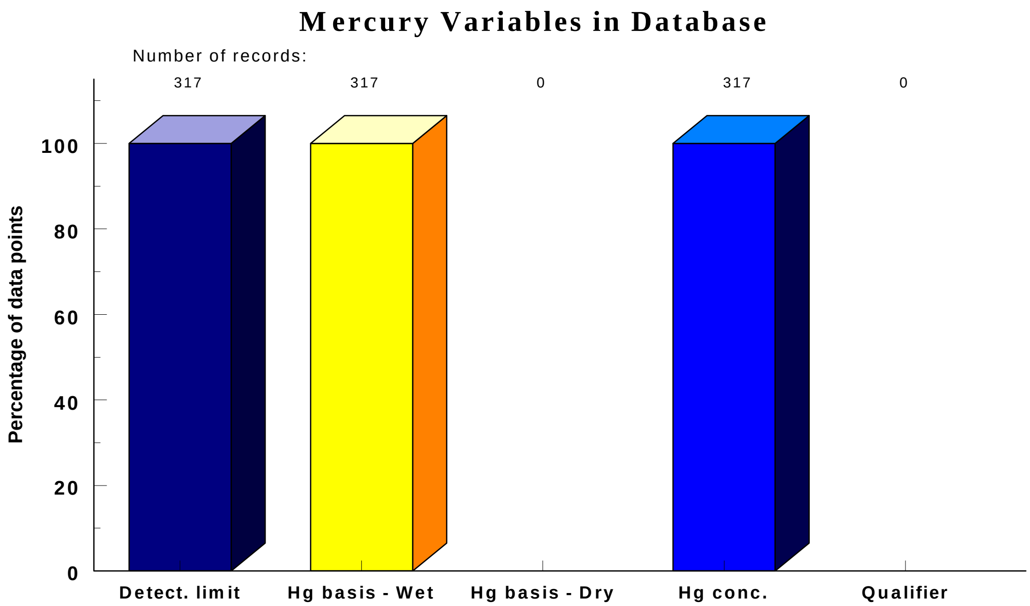


Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis



Mercury (ppm):

- ■ >1
- " 0.5 to 1
- ▲ < = 0.5



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Channel catfish	66	157	0.006	0.256	0.033	0.024	0.031	95.24
White perch	28	135	0.013	0.134	0.038	0.027	0.026	66.91
Striped bass	95	95	0.003	0.177	0.036	0.023	0.035	98.93

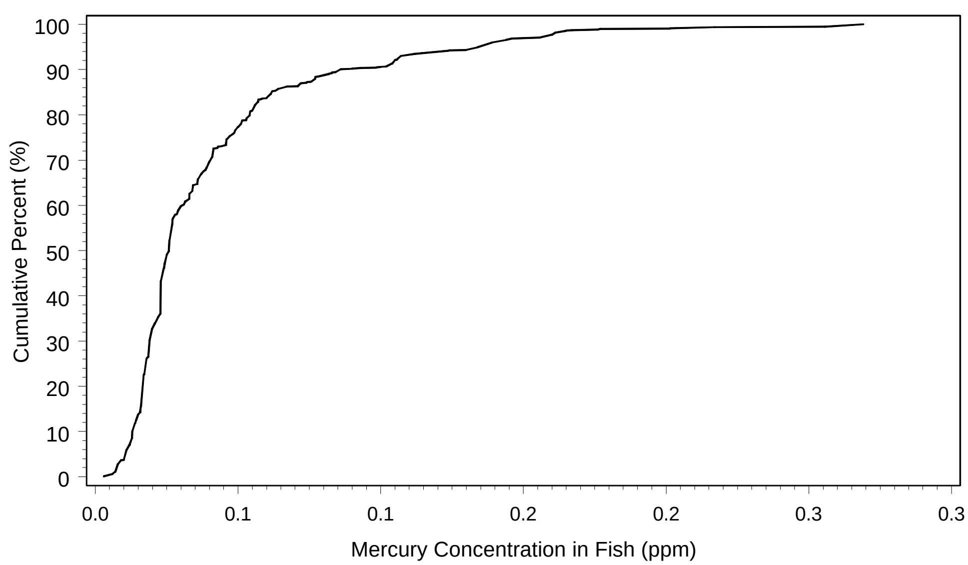
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

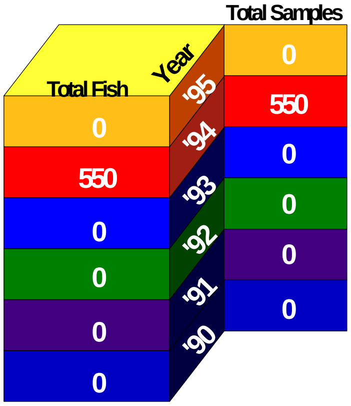
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

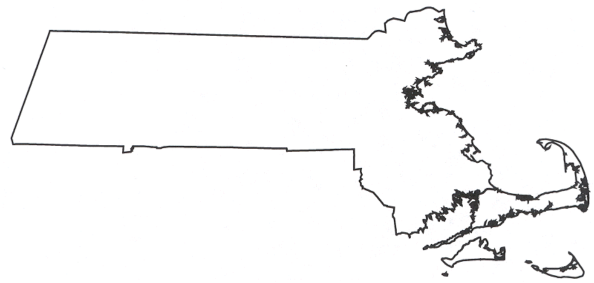
Cumulative Distribution of Mercury Concentrations for All Fish Species in Maryland



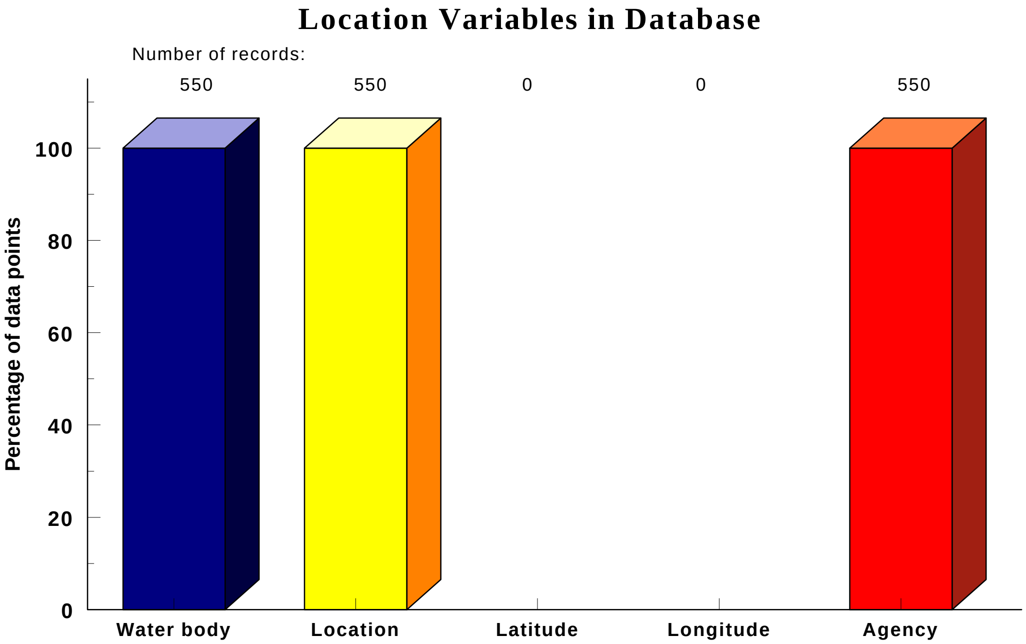
Records Analyzed by Year



Sampling Locations



Latitude and Longitude Data Not Available

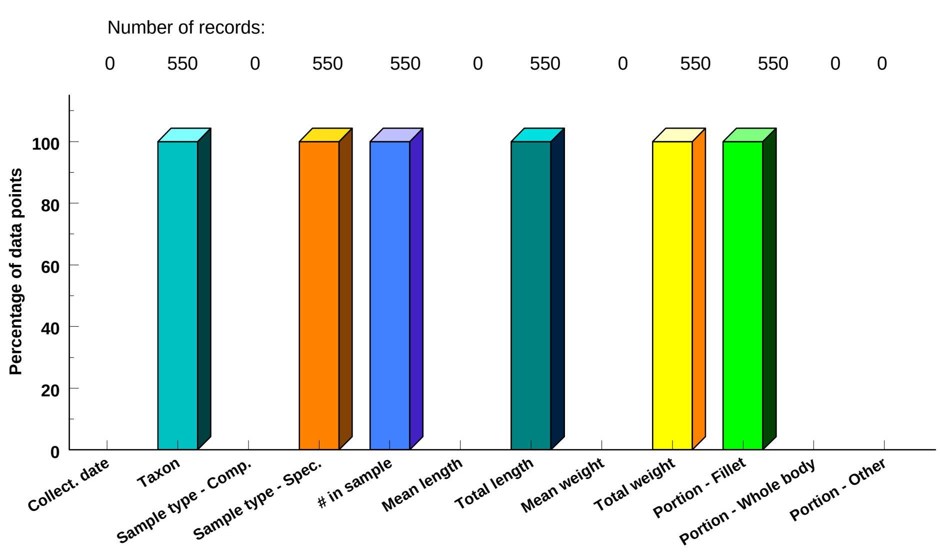


Top Five Fish Species[a]

Common Name	Percent
Yellow perch	36
Brown bullhead	31
Largemouth bass	28
Yellow bullhead	3
Smallmouth bass	3

[a] Only five species were identified in the database.

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis

Mercury (ppm):

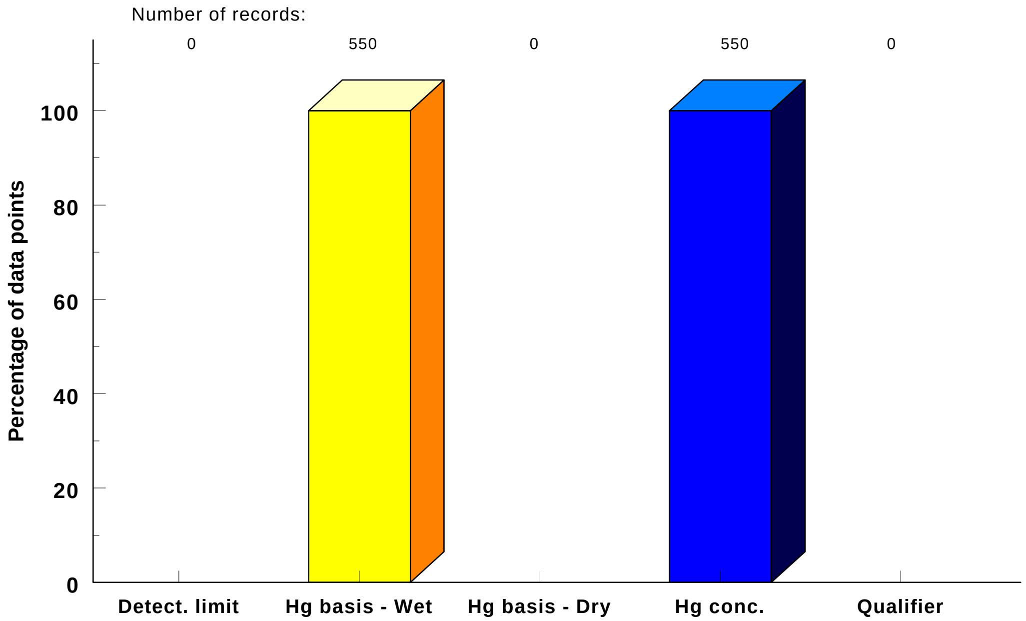
■ >1

" 0.5 to 1

▲ < = 0.5

Latitude and Longitude Data Not Available

Mercury Variables in Database



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Yellow perch	198	198	0.010	0.752	0.306	0.272	0.155	50.62
Brown bullhead	169	169	0.010	0.794	0.141	0.108	0.106	75.55
Largemouth bass	152	152	0.045	1.100	0.399	0.334	0.233	58.38

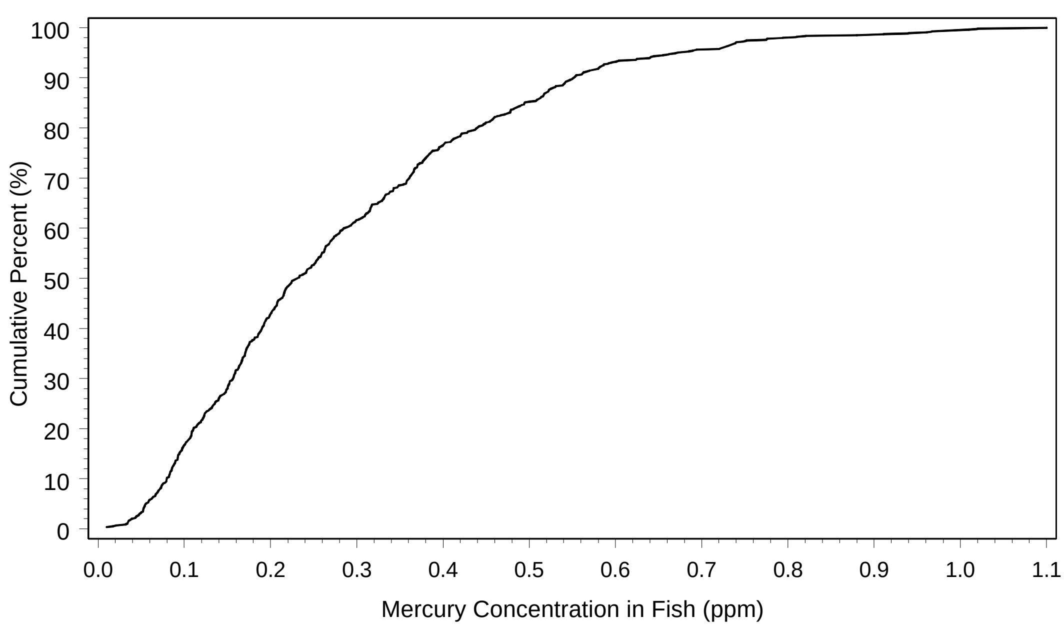
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

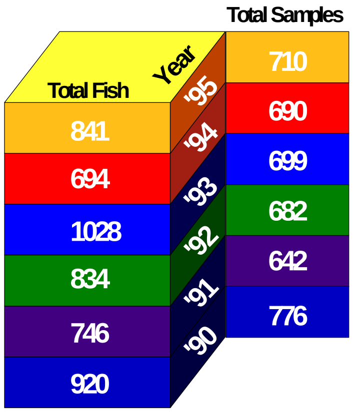
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

Cumulative Distribution of Mercury Concentrations for All Fish Species in Massachusetts



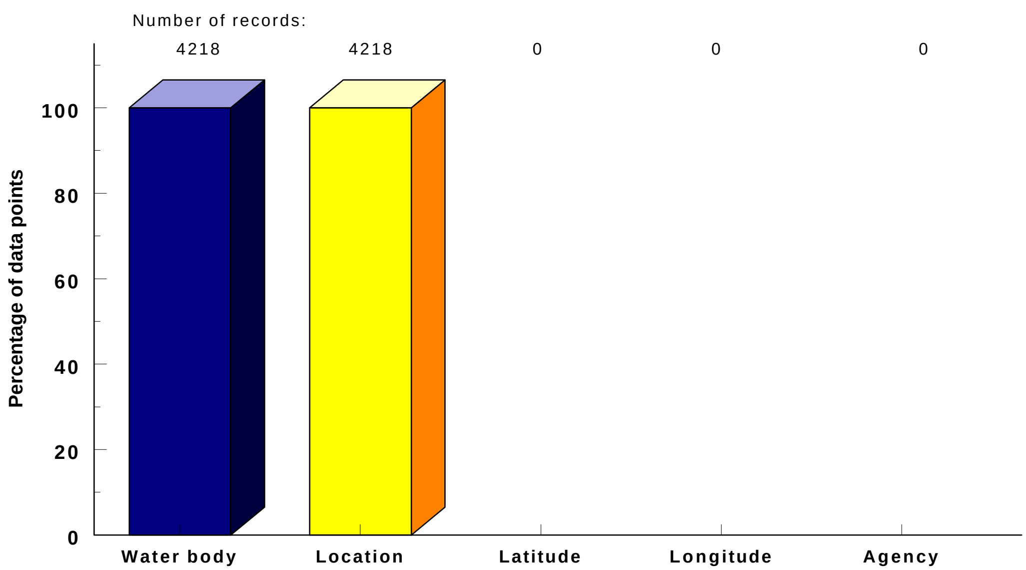
Records Analyzed by Year



Sampling Locations

Latitude and Longitude Data Not Available

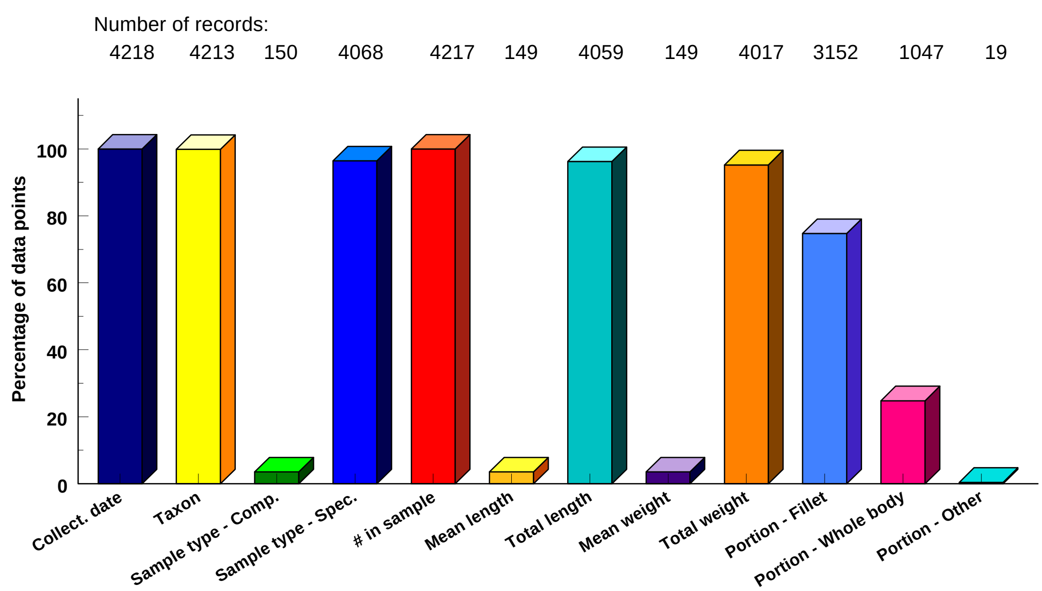
Location Variables in Database



Top Ten Fish Species

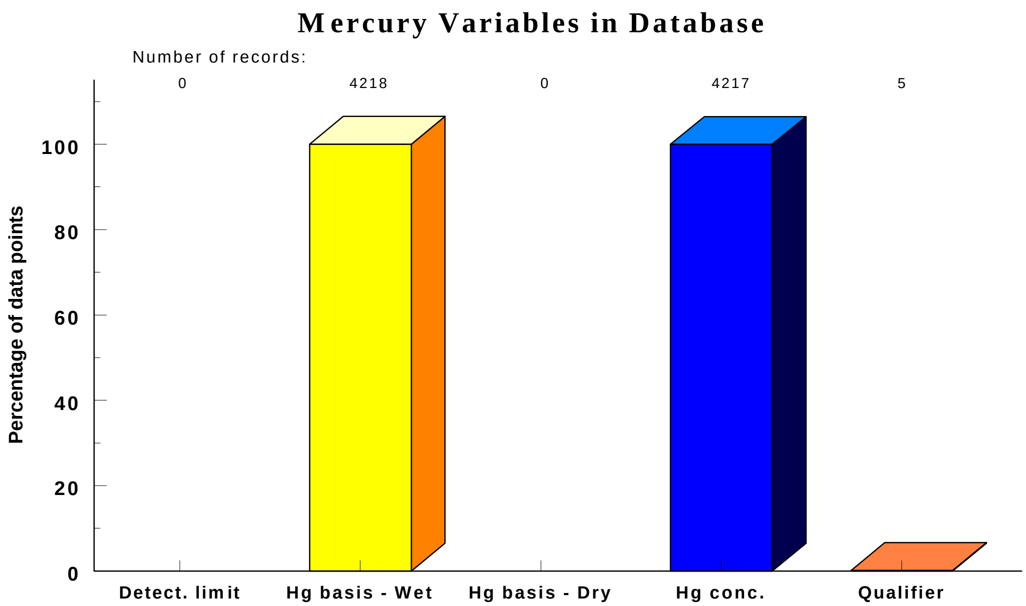
Common Name	Percent		Common Name	Percent
Channel catfish	19		Lake trout	5
Common carp	18		Yellow perch	4
Walleye	15		White sucker	3
Northern pike	8		Smallmouth bass	2
Largemouth bass	7		Lake whitefish	2

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis

Latitude and Longitude Data Not Available



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Channel catfish	190	964	0.014	0.710	0.047	0.029	0.062	131.91
Common carp	908	934	0.010	0.814	0.181	0.160	0.107	59.20
Walleye	723	763	0.030	1.740	0.375	0.290	0.272	72.53

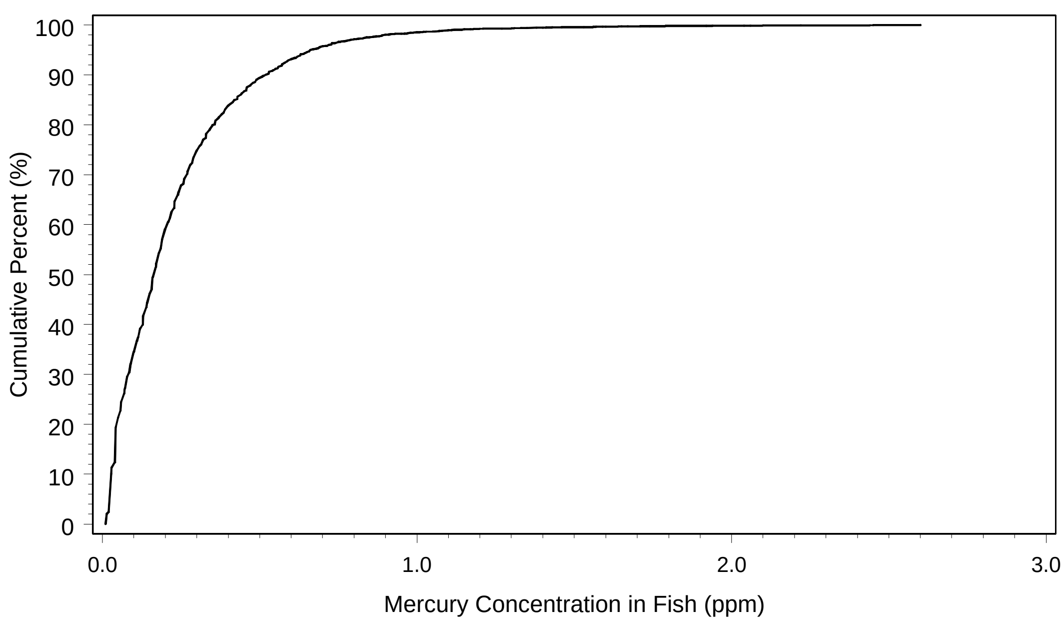
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

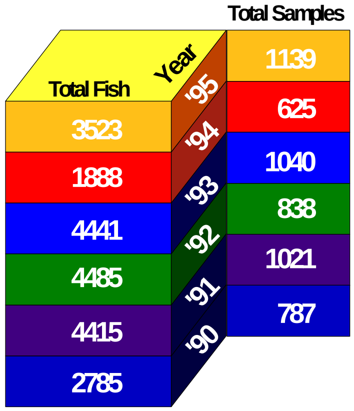
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

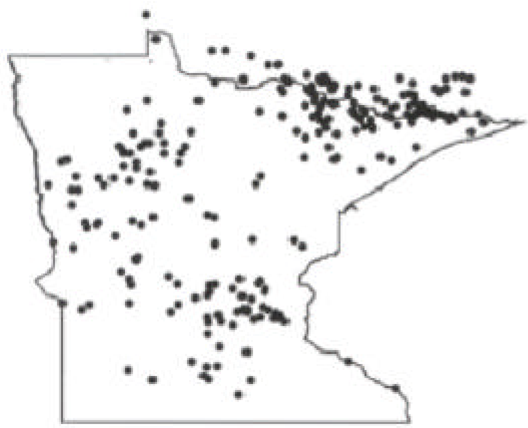
Cumulative Distribution of Mercury Concentrations for All Fish Species in Michigan

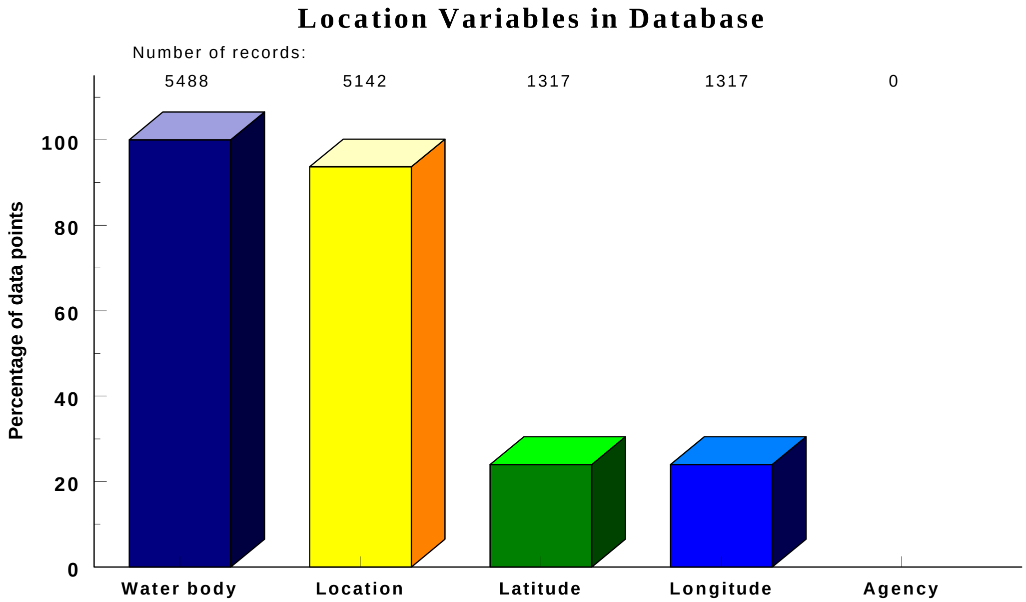


Records Analyzed by Year



Sampling Locations

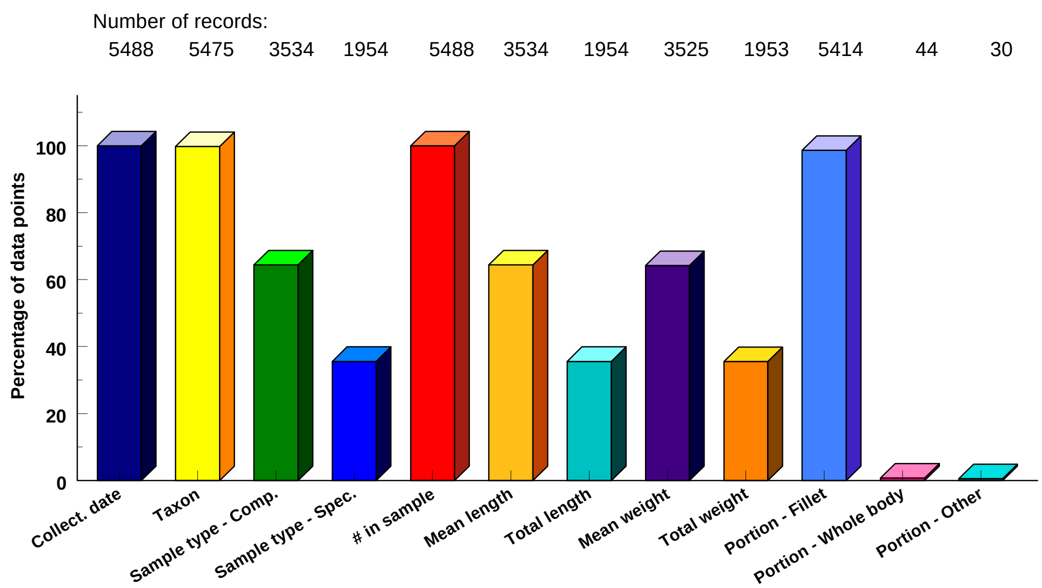




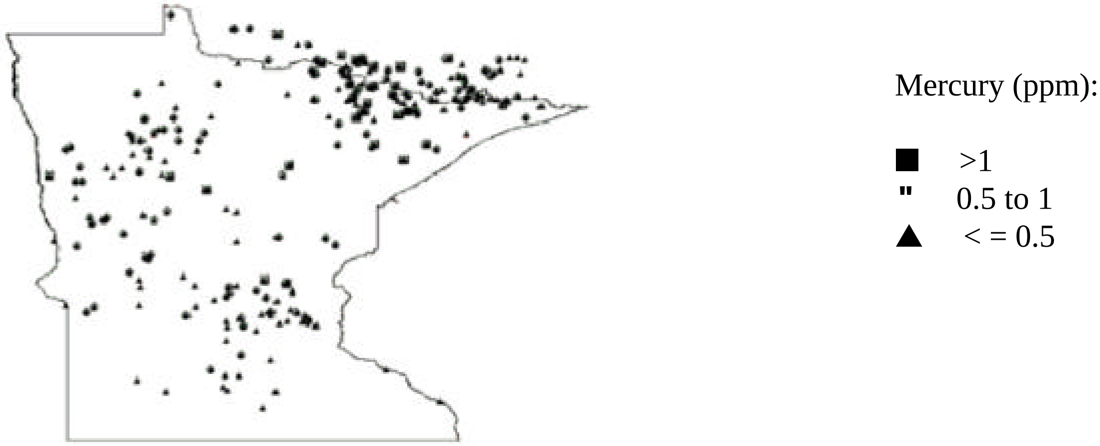
Top Ten Fish Species

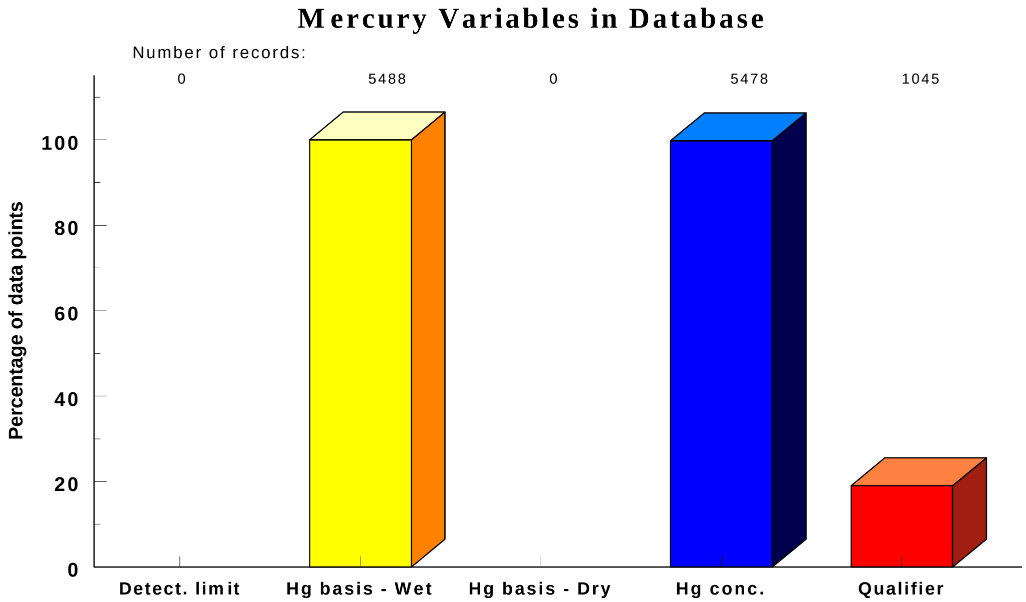
Common Name	Percent		Common Name	Percent
Walleye	26		Common carp	6
Northern pike	23		Black crappie	5
White sucker	9		Lake trout	2
Bluegill sunfish	8		Cisco (lake herring)	2
Yellow perch	7		Smallmouth bass	1

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Walleye	1677	5636	0.010	2.900	0.325	0.260	0.253	77.97
Northern pike	1562	5019	0.010	2.500	0.304	0.250	0.219	71.93
White sucker	427	1987	0.010	0.680	0.103	0.075	0.090	86.99

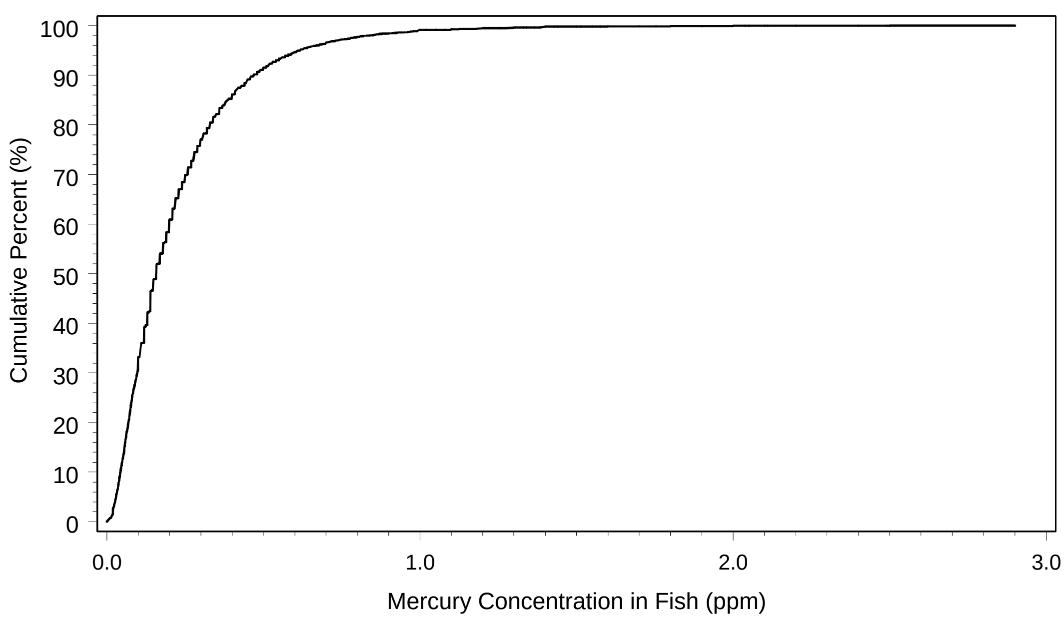
a Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

b Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

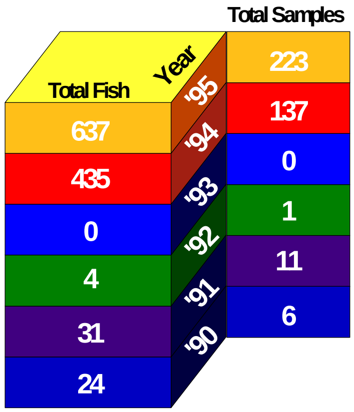
c Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

d $CV = (SD_w / \bar{x}_w) * 100$

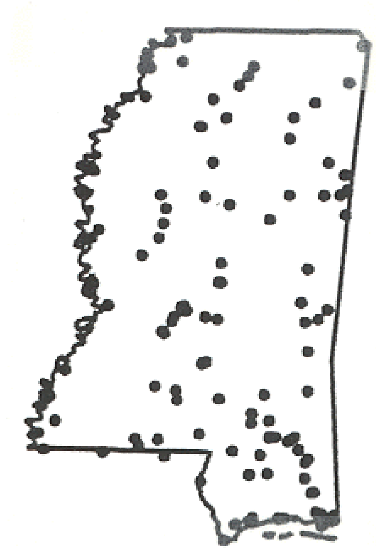
Cumulative Distribution of Mercury Concentrations
for All Fish Species in Minnesota

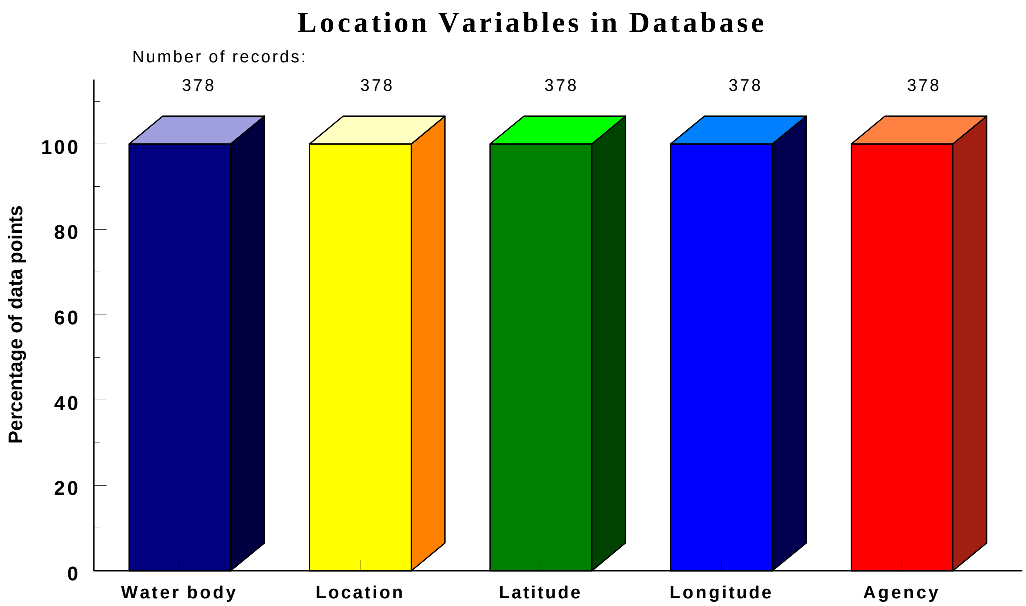


Records Analyzed by Year



Sampling Locations

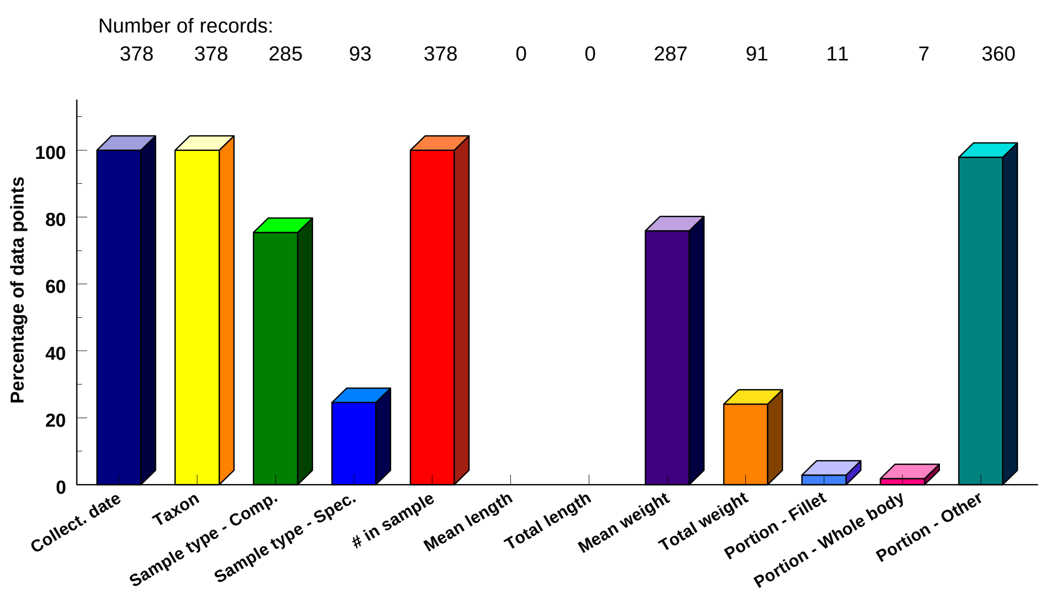




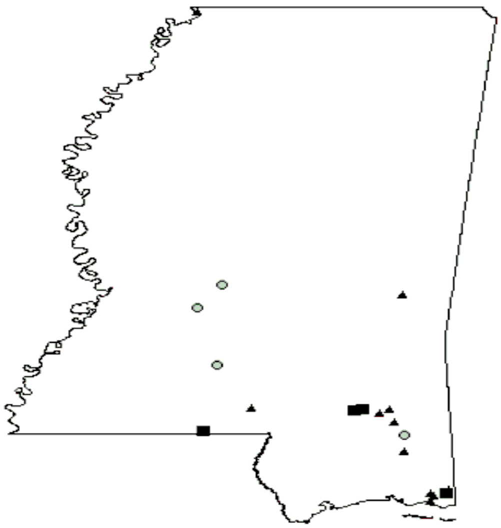
Top Ten Fish Species

Common Name	Percent		Common Name	Percent
Largemouth bass	54		Smallmouth buffalo	3
Channel catfish	14		Buffalo	1
Bass	6		White crappie	1
Flathead catfish	6		Common carp	1
Spotted bass	5		Bigmouth buffalo	1

Fish Variables in Database

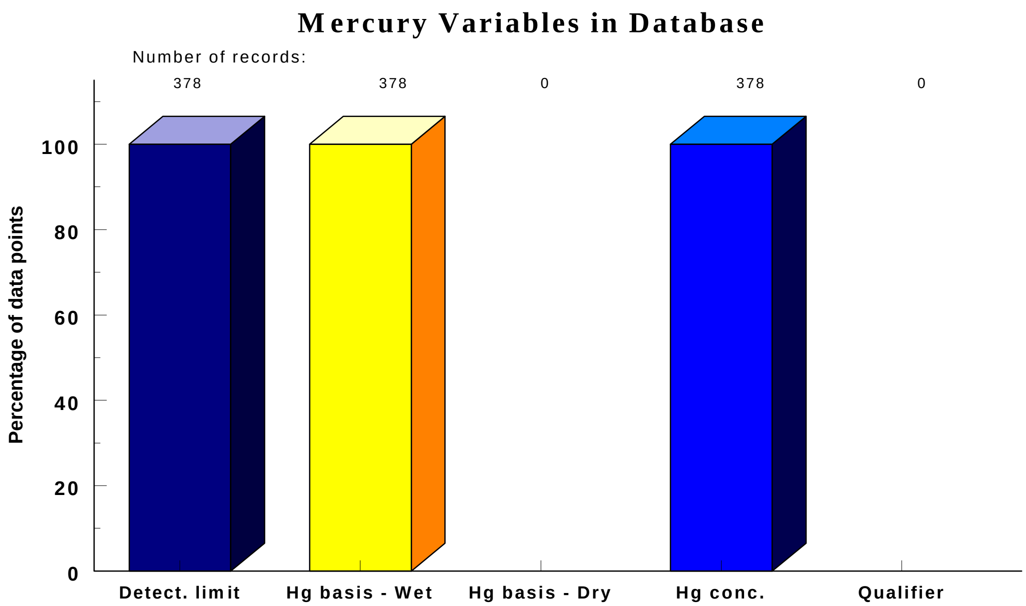


Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis



Mercury (ppm):

■ >1
" 0.5 to 1
▲ < = 0.5



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Largemouth bass	203	606	0.090	2.630	0.651	0.580	0.393	60.31
Channel catfish	43	157	0.040	2.100	0.274	0.210	0.299	109.24
Bass	21	72	0.370	2.400	0.913	0.890	0.417	45.68

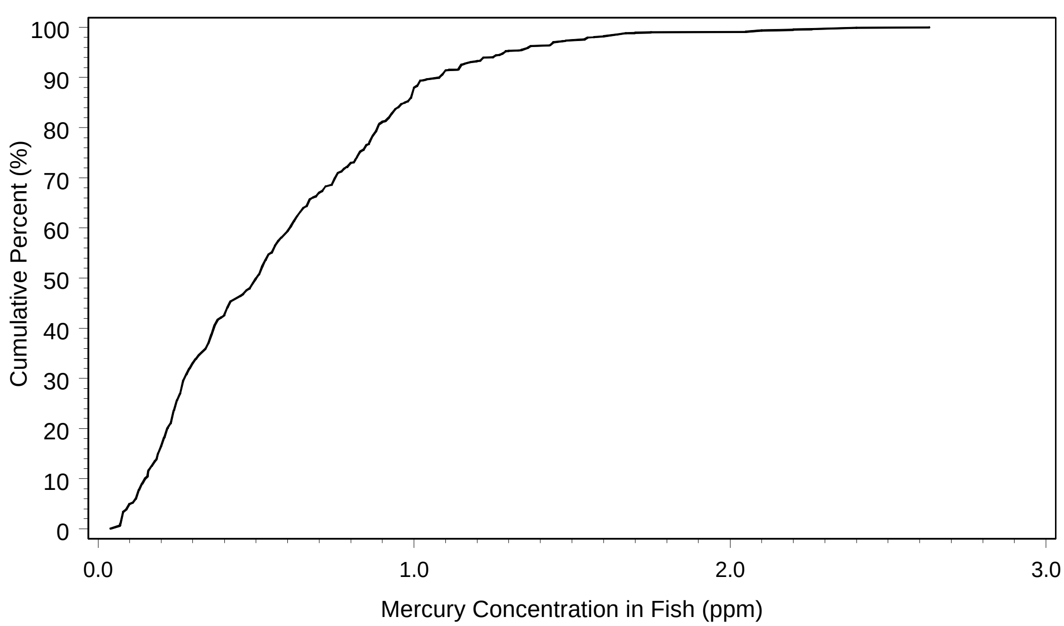
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

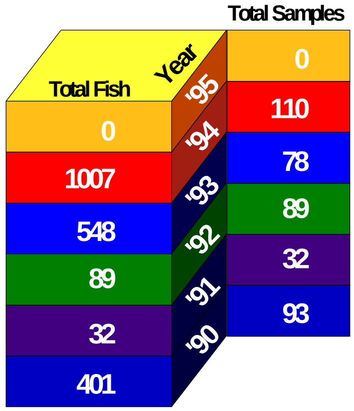
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \; / \; (\Sigma_i w_i - 1)}$

[d] CV = $(SD_w / \bar{x}_w) * 100$

Cumulative Distribution of Mercury Concentrations for All Fish Species in Mississippi

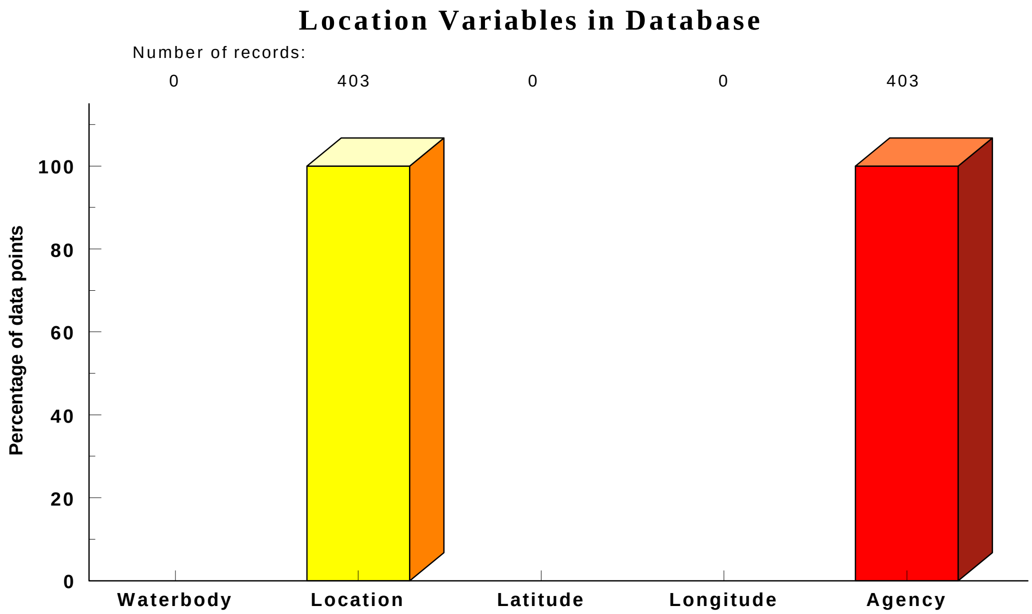


Records Analyzed by Year



Sampling Locations

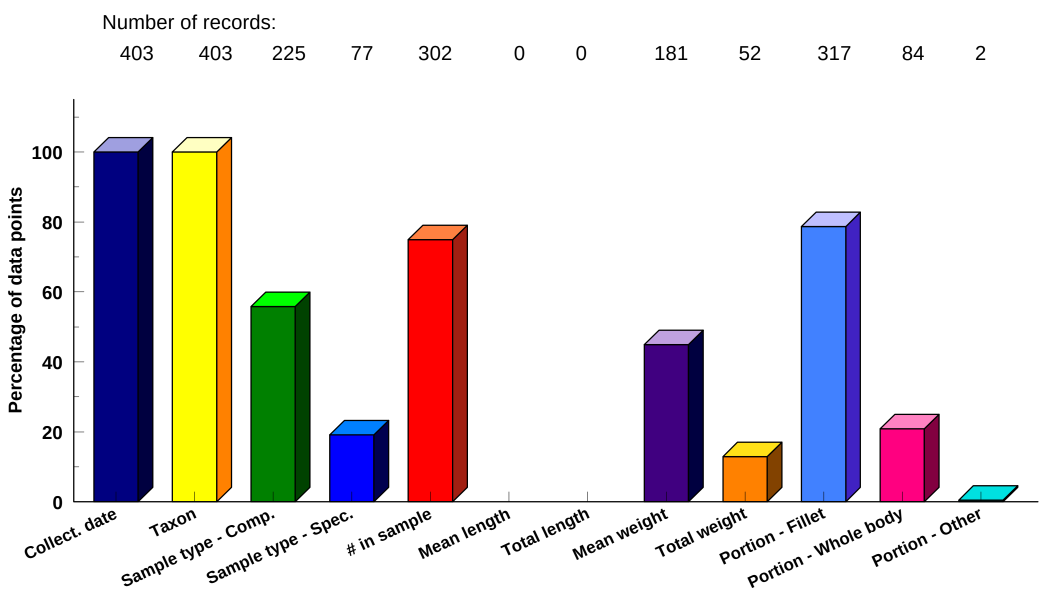
Latitude and Longitude Data Not Available



Top Ten Fish Species

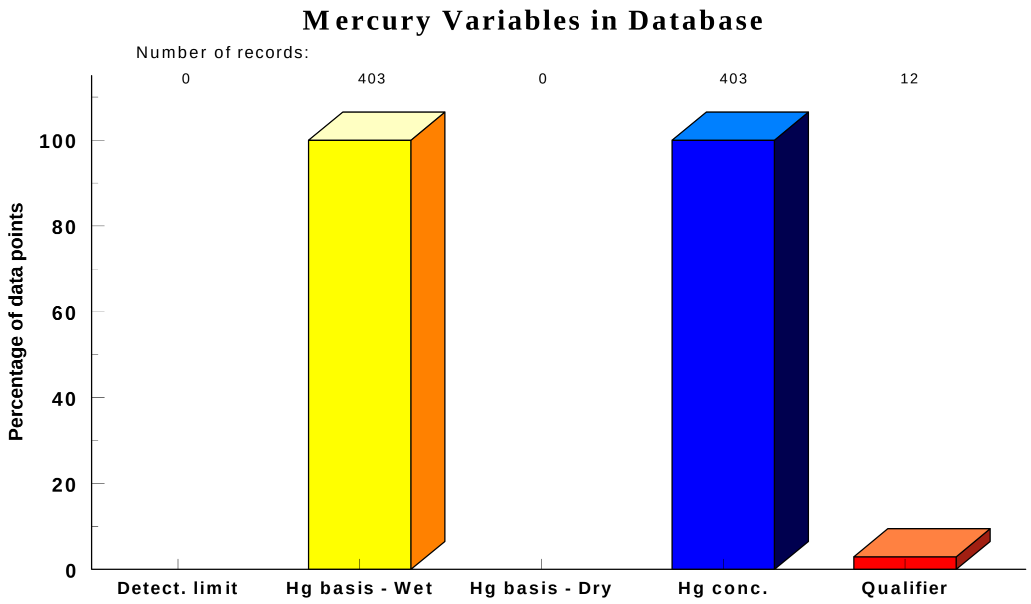
Common Name	Percent		Common Name	Percent
Common carp	59		Black redhorse	3
Channel catfish	10		Golden redhorse	3
Largemouth bass	5		Paddlefish	3
Shorthead redhorse	4		Sucker	2
Sunfish	3		Walleye	1

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis

Latitude and Longitude Data Not Available



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Common carp	184	1224	0.002	0.454	0.128	0.125	0.061	47.54
Channel catfish	50	198	0.002	0.350	0.052	0.040	0.055	106.63
Largemouth bass	24	106	0.002	0.608	0.257	0.230	0.151	58.73

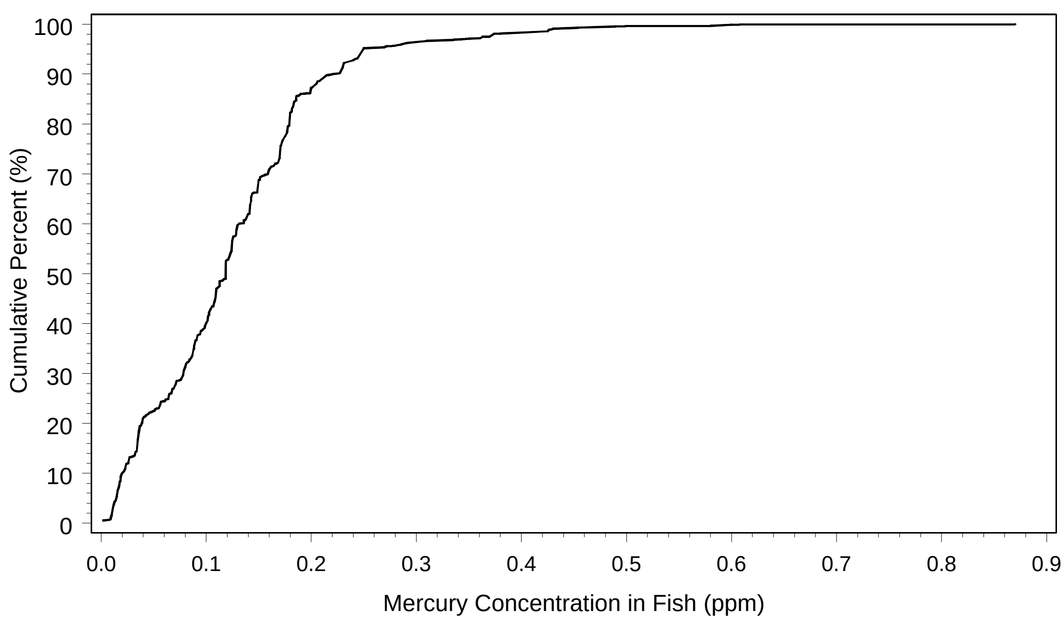
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

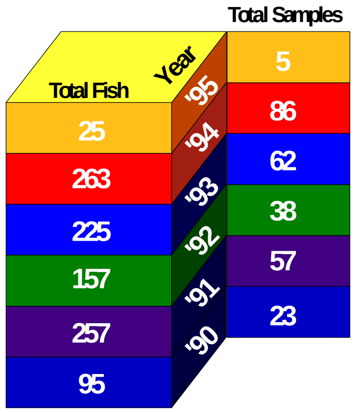
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

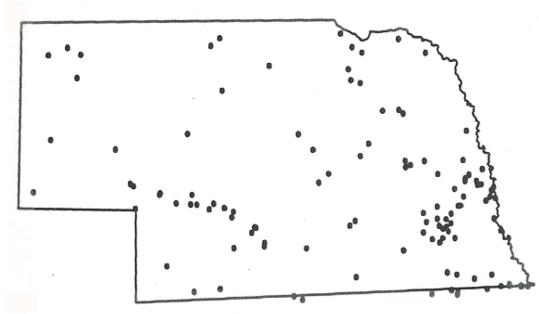
Cumulative Distribution of Mercury Concentrations for All Fish Species in Missouri

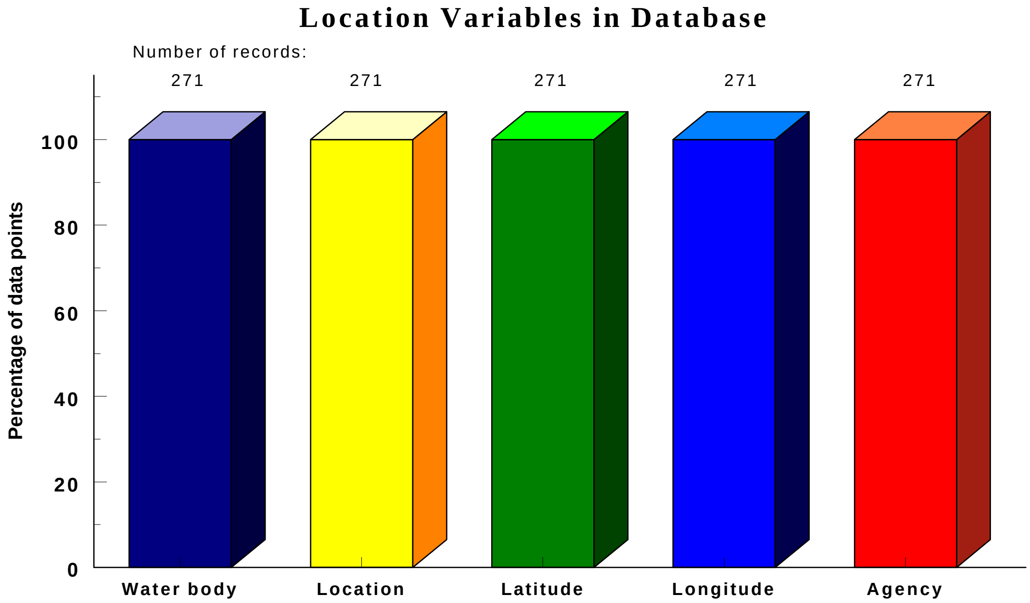


Records Analyzed by Year



Sampling Locations

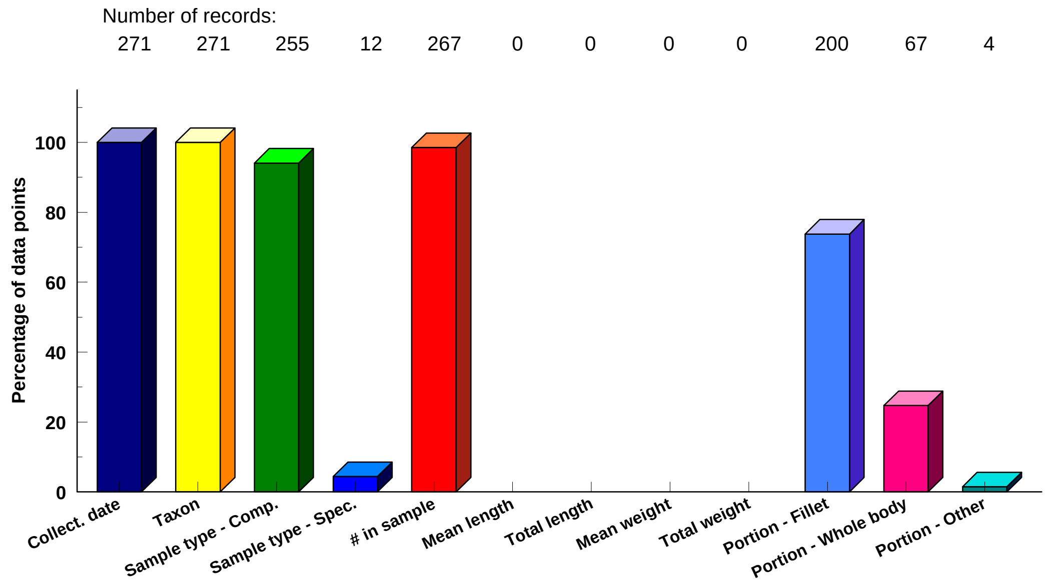




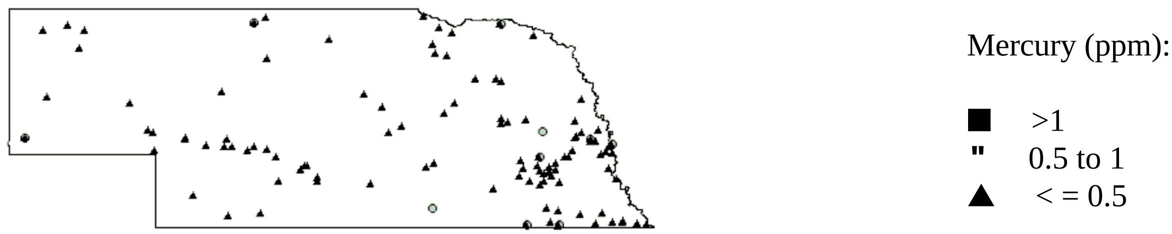
Top Ten Fish Species

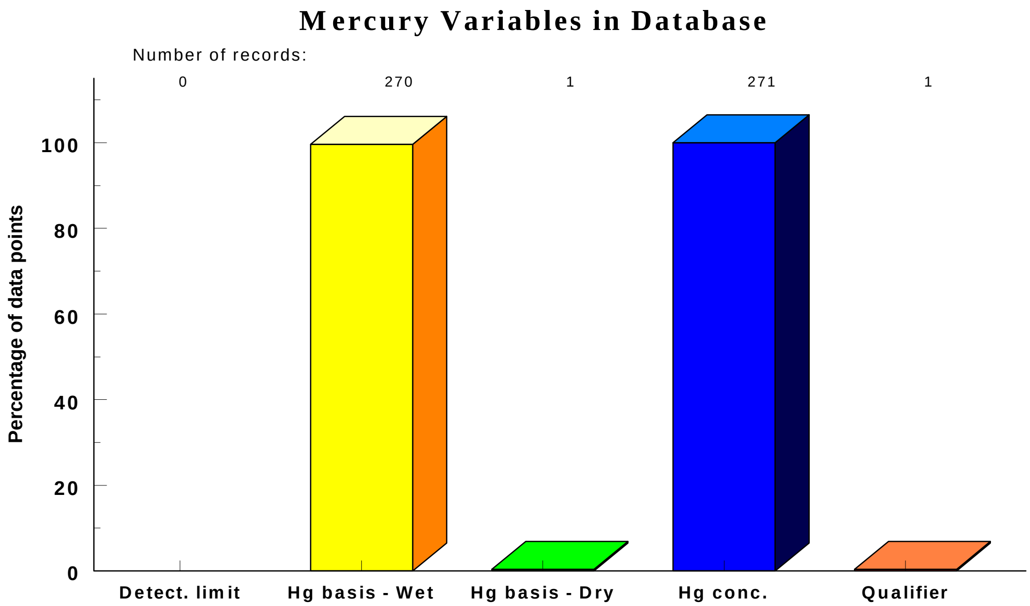
Common Name	Percent		Common Name	Percent
Common carp	44		Black bullhead	2
Channel catfish	23		Northern pike	1
Largemouth bass	18		River carpsucker	1
Walleye	5		Hybrid bass	1
White sucker	3		Flathead catfish	1

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Common carp	121	449	0.030	0.600	0.168	0.143	0.095	57.24
Channel catfish	59	238	0.001	0.643	0.109	0.080	0.102	93.58
Largemouth bass	44	182	0.080	0.920	0.343	0.310	0.203	59.12

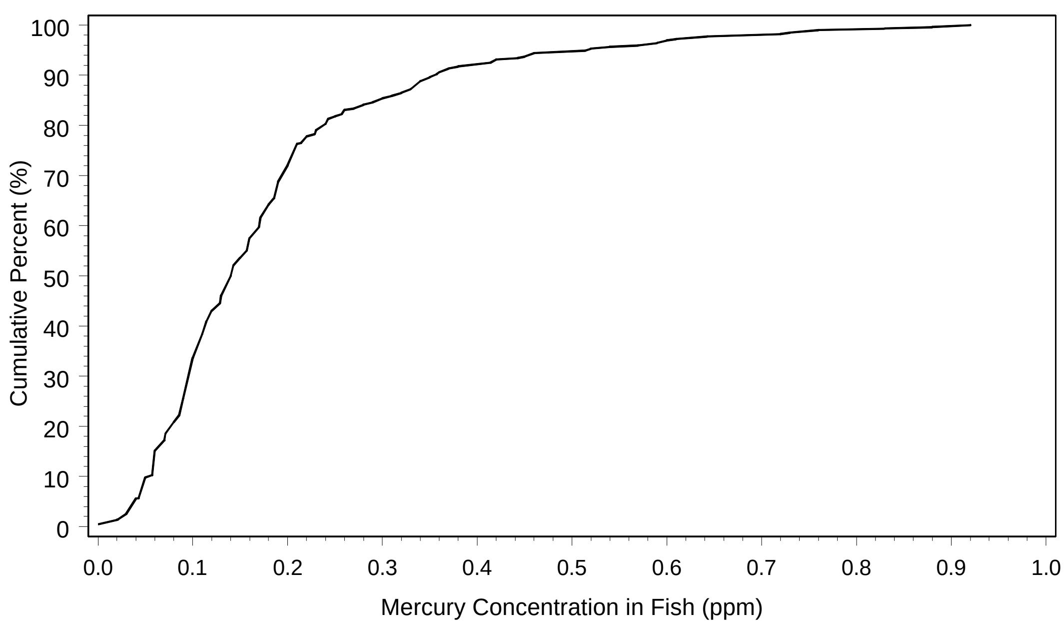
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

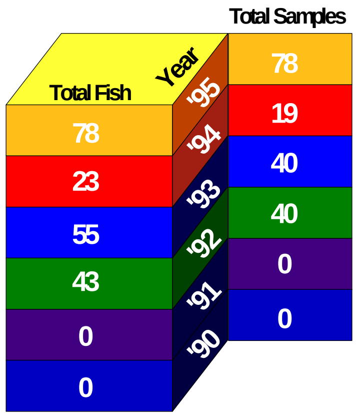
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

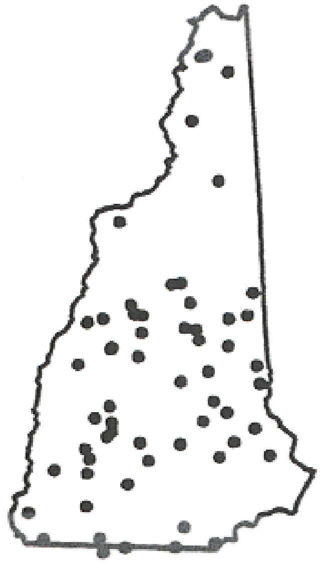
Cumulative Distribution of Mercury Concentrations for All Fish Species in Nebraska

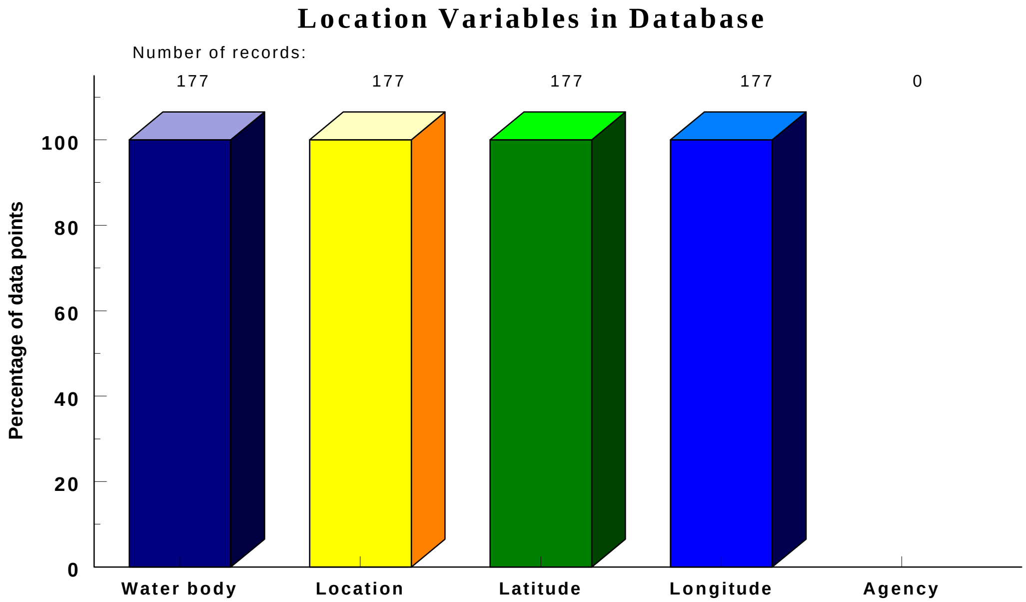


Records Analyzed by Year



Sampling Locations

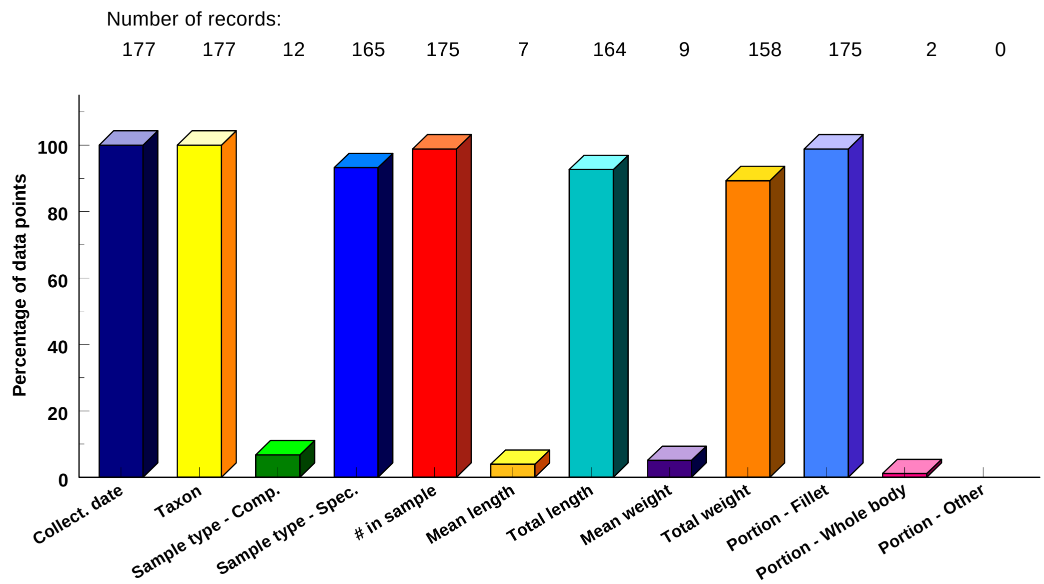




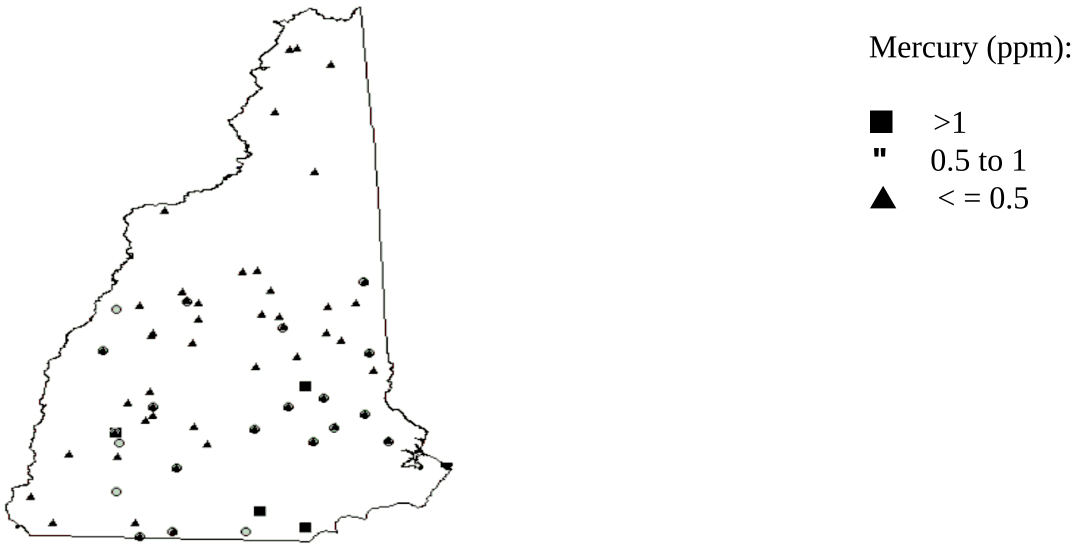
Top Ten Fish Species

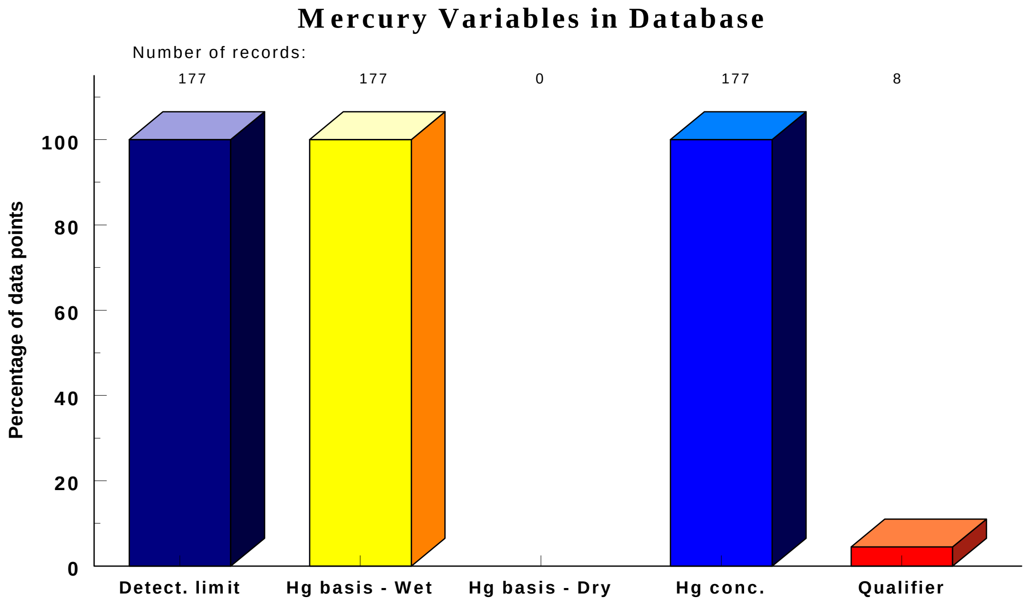
Common Name	Percent	Common Name	Percent
Largemouth bass	18	Smallmouth bass	7
Yellow perch	18	Lake trout	5
Brook trout	14	White perch	4
Chain pickerel	12	Brown trout	3
Brown bullhead	11	Landlocked Atlantic salmon	3

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics									
			Mercury Statistics Weighted by No. of Fish in Sample[a]						
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Largemouth bass	35	35	0.210	1.400	0.573	0.460	0.321	56.02
Yellow perch	29	35	0.110	0.640	0.346	0.350	0.136	39.32
Brook trout	15	28	0.100	0.610	0.160	0.130	0.125	78.04

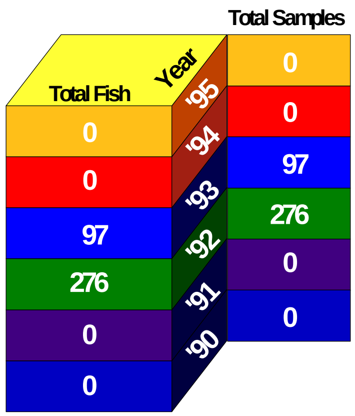
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean Θ_w = $'_i w_i x_i$ / $'_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

[c] Weighted Standard Deviation: $SD_w \;'\; \sqrt{'_i w_i (x_i \& \bar{x}_w)^2 \;/\; ('_i w_i \& 1)}$

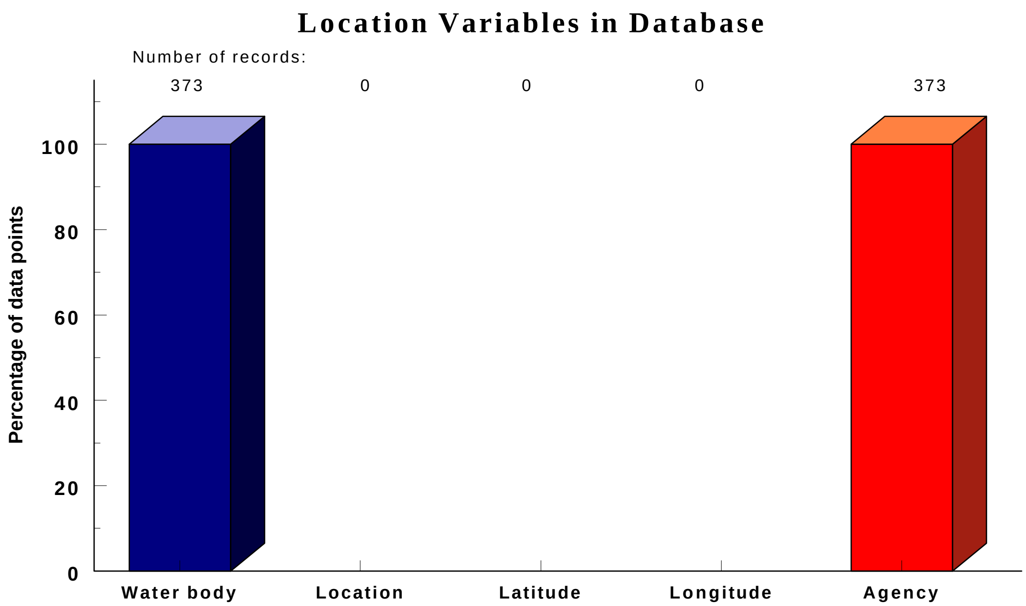
[d] CV = (SD_w / Θ_w) * 100

Records Analyzed by Year



Sampling Locations

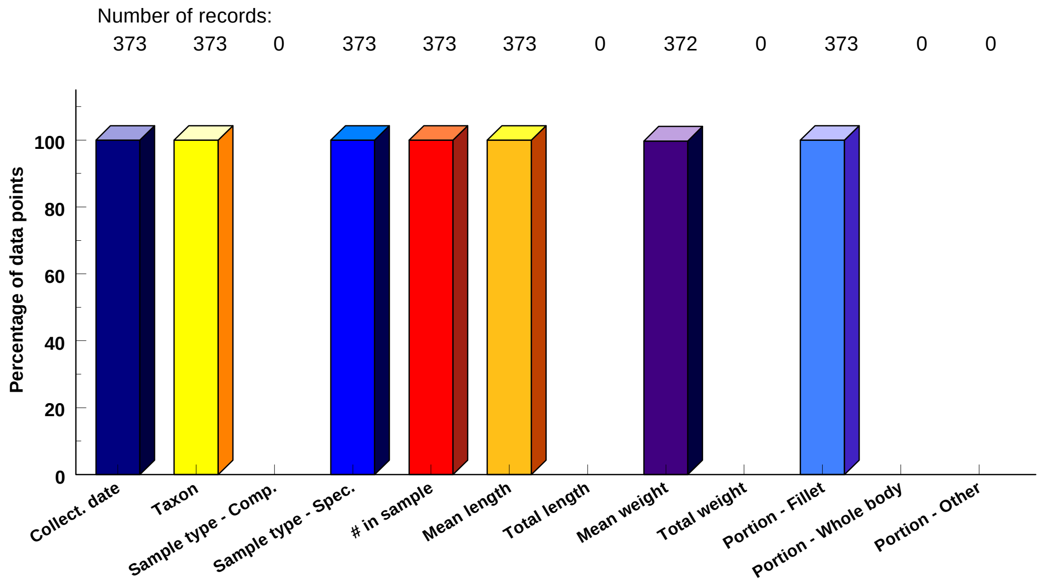
Latitude and Longitude Data Not Available



Top Ten Fish Species

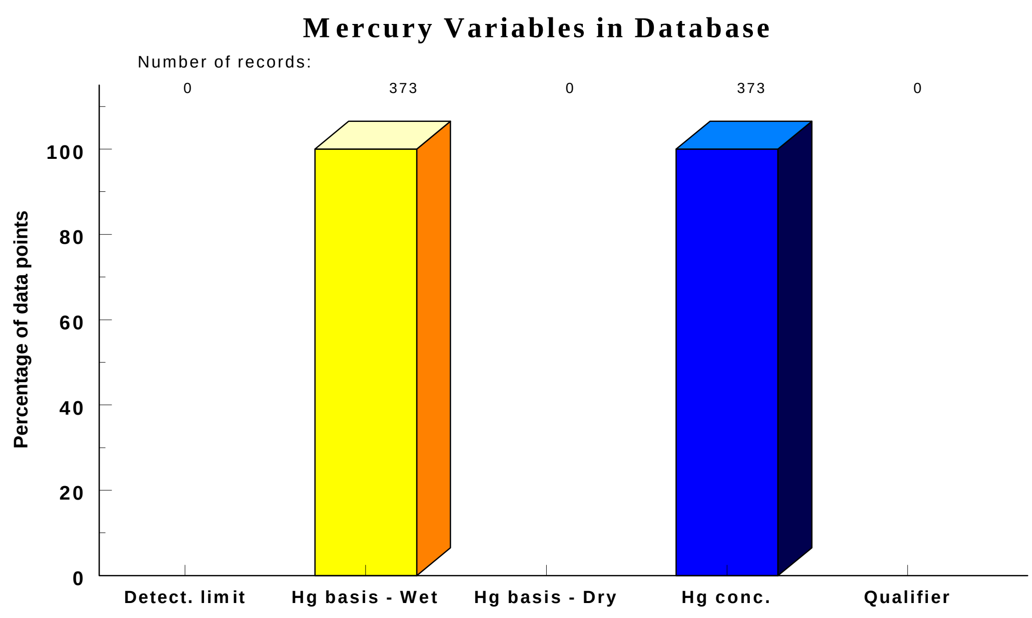
Common Name	Percent		Common Name	Percent
Largemouth bass	46		Channel catfish	4
Chain pickerel	19		White catfish	3
Brown bullhead	7		Yellow bullhead	2
Smallmouth bass	6		Hybrid bass	2
Black crappie	5		Lake trout	2

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis

Latitude and Longitude Data Not Available



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Largemouth bass	173	173	0.030	8.940	0.664	0.370	1.003	150.95
Chain pickerel	72	72	0.090	2.810	0.743	0.505	0.621	83.68
Brown bullhead	26	26	0.020	0.470	0.105	0.060	0.106	101.60

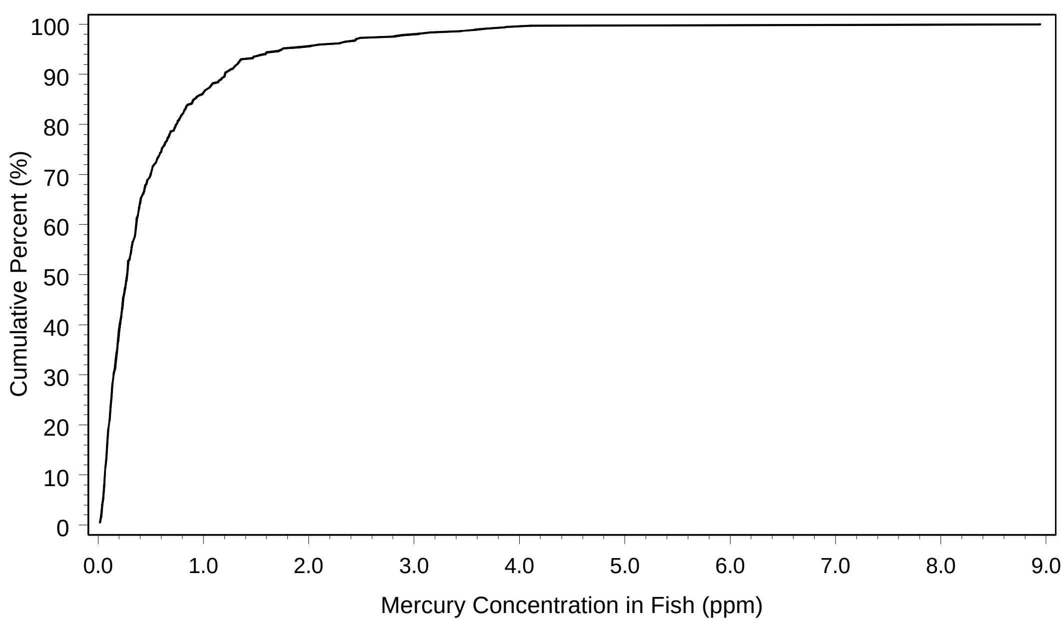
a Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

b Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

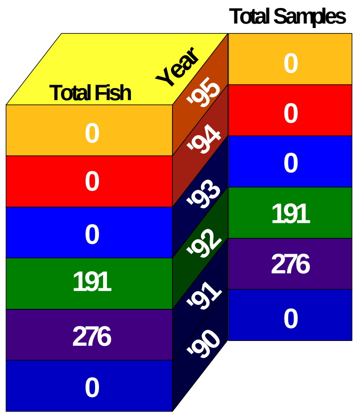
c Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

d $CV = (SD_w / \bar{x}_w) * 100$

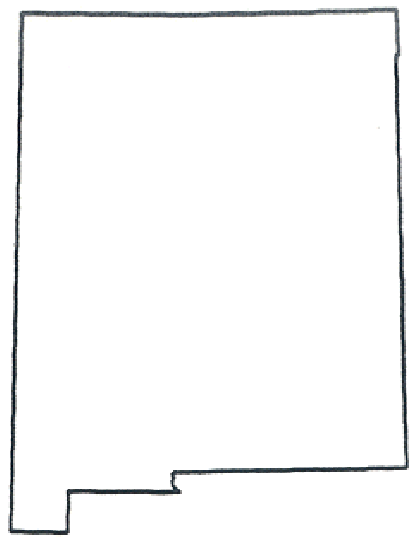
Cumulative Distribution of Mercury Concentrations
for All Fish Species in New Jersey



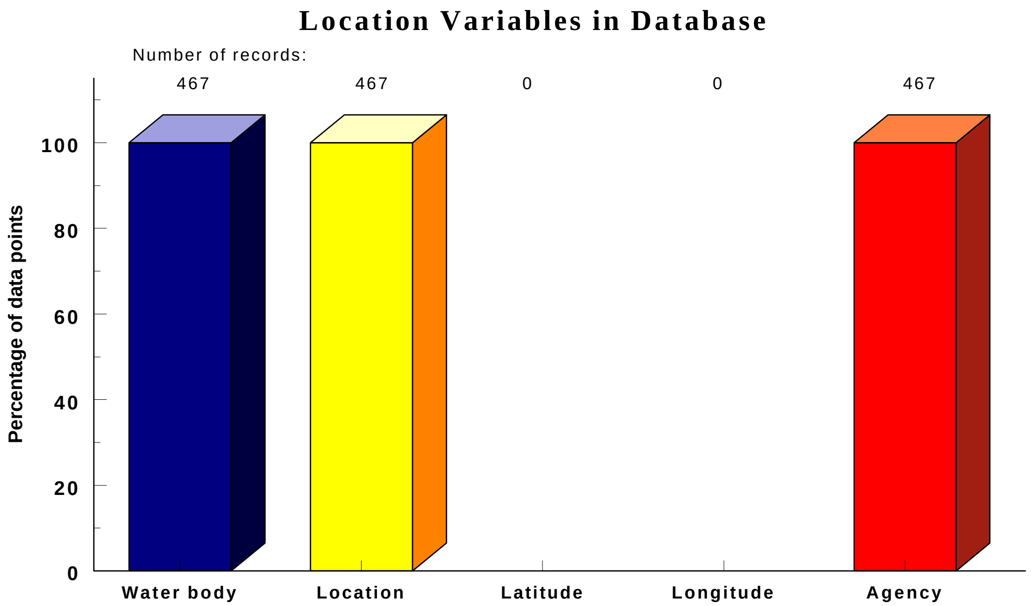
Records Analyzed by Year



Sampling Locations



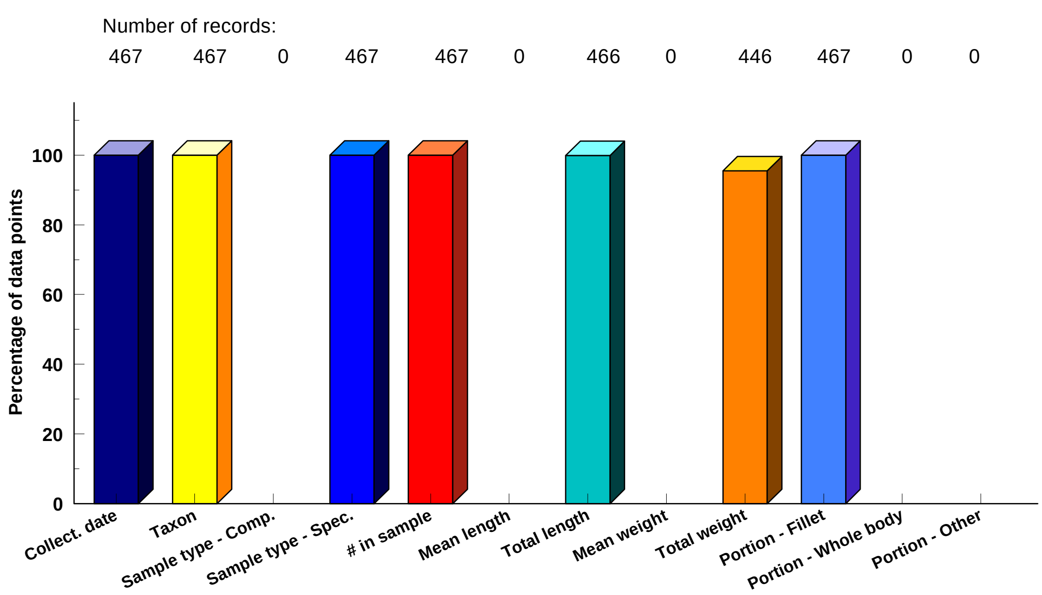
Latitude and Longitude Data Not Available



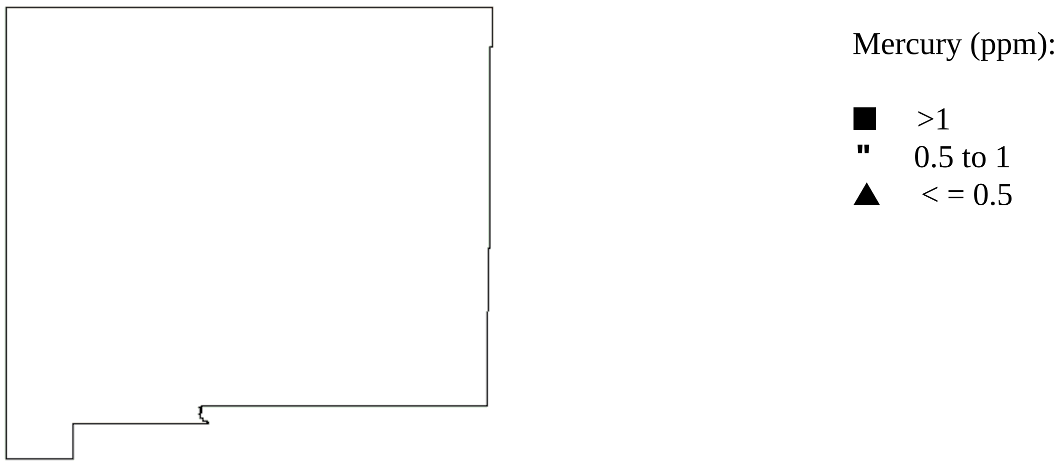
Top Ten Fish Species

Common Name	Percent		Common Name	Percent
Channel catfish	17		White bass	7
Walleye	14		Brook trout	4
Rainbow trout	10		Kokanee salmon	4
White sucker	9		Black bullhead	4
Largemouth bass	7		Bluegill sunfish	3

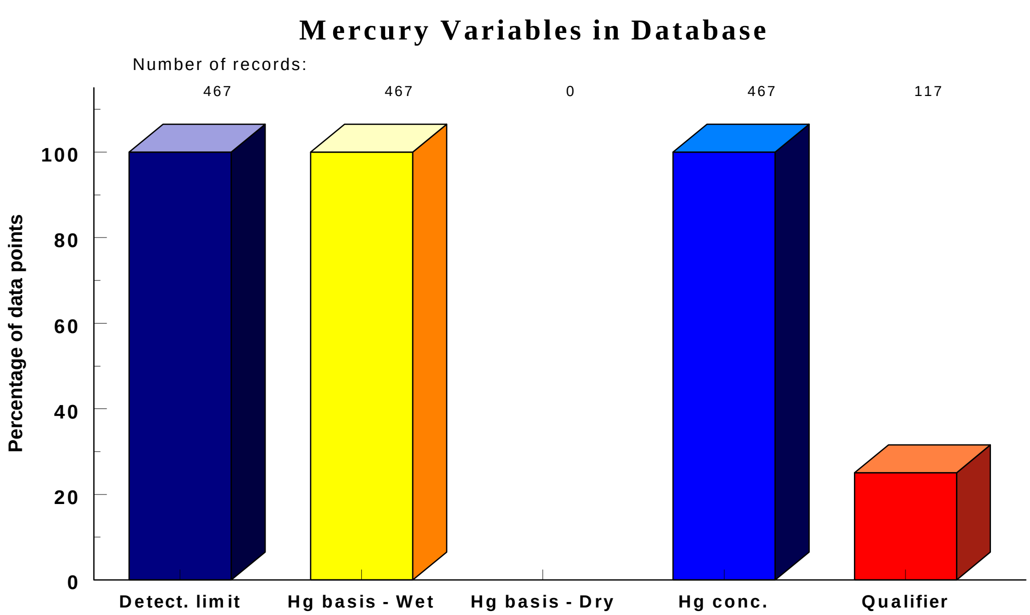
Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis



Latitude and Longitude Data Not Available



Mercury Concentration for the Three Most Abundant Species: Summary Statistics									
			Mercury Statistics Weighted by No. of Fish in Sample[a]						
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Channel catfish	78	78	0.100	1.800	0.297	0.200	0.276	93.02
Walleye	67	67	0.070	3.000	0.875	0.710	0.663	75.76
Rainbow trout	45	45	0.100	0.200	0.107	0.100	0.021	19.28

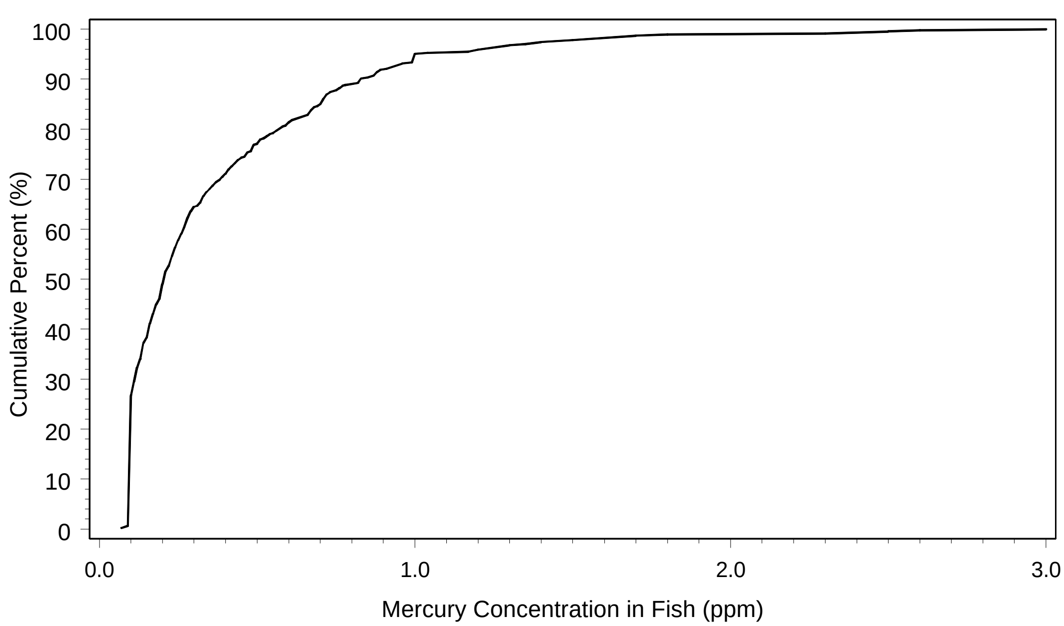
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

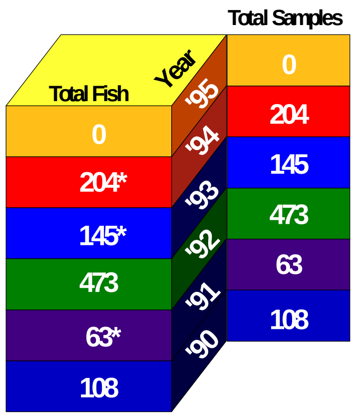
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \; / \; (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

Cumulative Distribution of Mercury Concentrations for All Fish Species in New Mexico



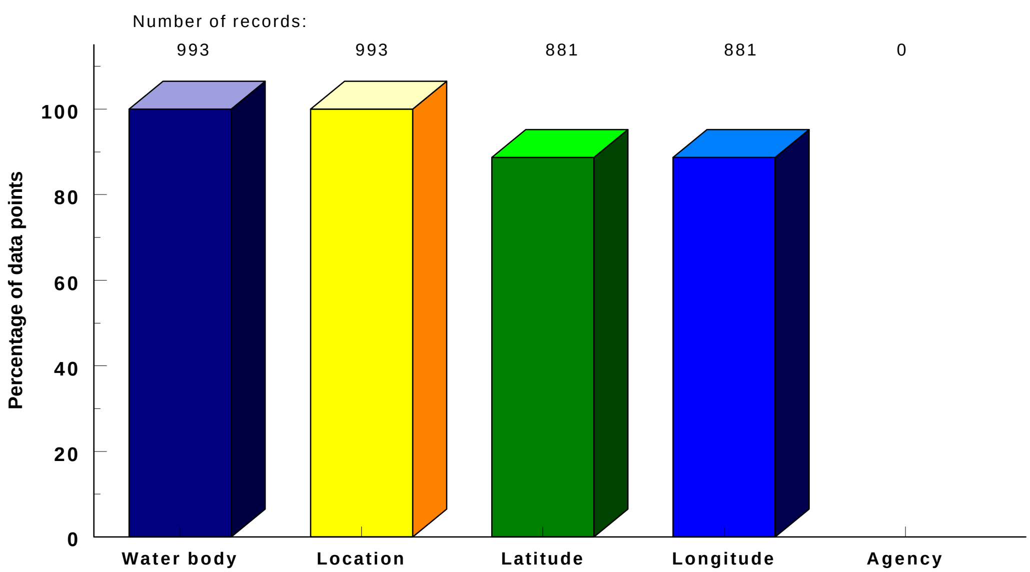
Records Analyzed by Year



* indicates number of records

Sampling Locations

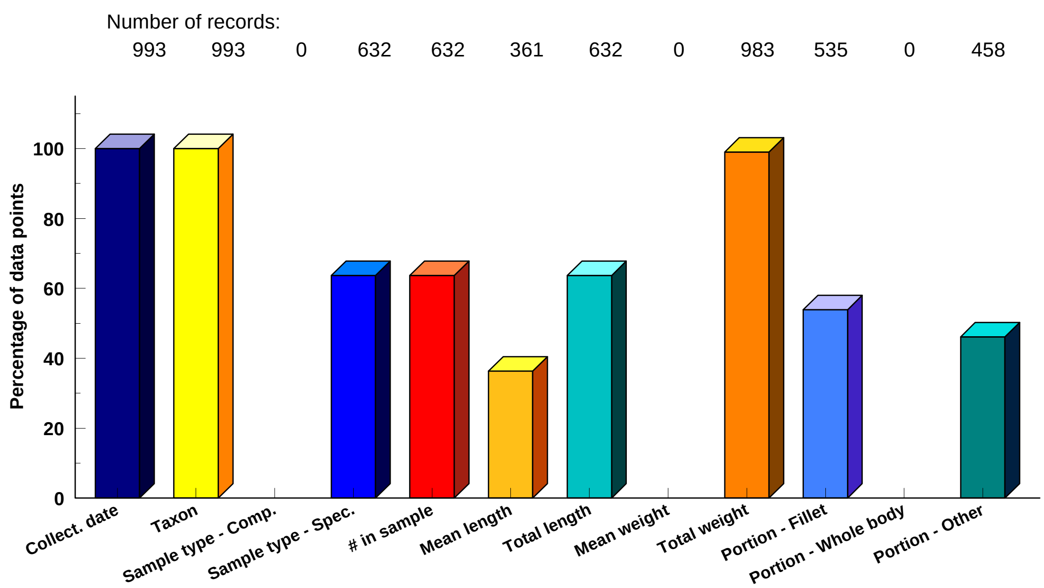
Location Variables in Database



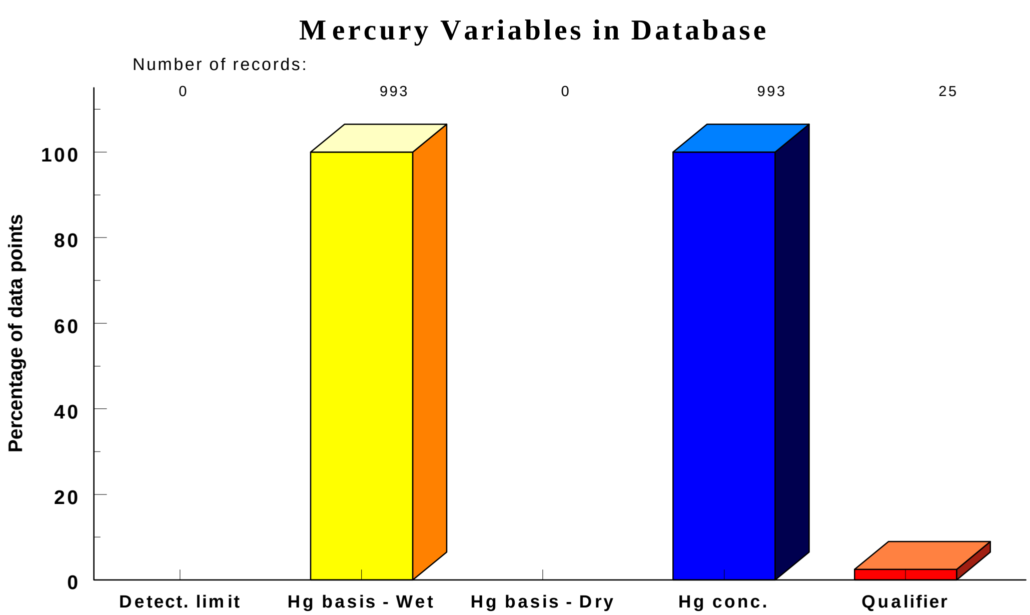
Top Ten Fish Species

Common Name	Percent	Common Name	Percent
Yellow perch	50	Brown trout	4
Lake trout	11	American eel	3
Largemouth bass	5	Northern pike	3
Smallmouth bass	4	Brown bullhead	3
Rock bass	4	Common carp	2

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis



Mercury Concentration for the Three Most Abundant Species: Summary Statistics									
			Mercury Statistics Weighted by No. of Fish in Sample[a]						
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Yellow perch	490	490	0.010	2.140	0.477	0.380	0.346	72.49
Lake trout	108	108	0.010	0.860	0.162	0.120	0.138	85.36
Largemouth bass	53	53	0.050	0.950	0.462	0.430	0.253	54.67

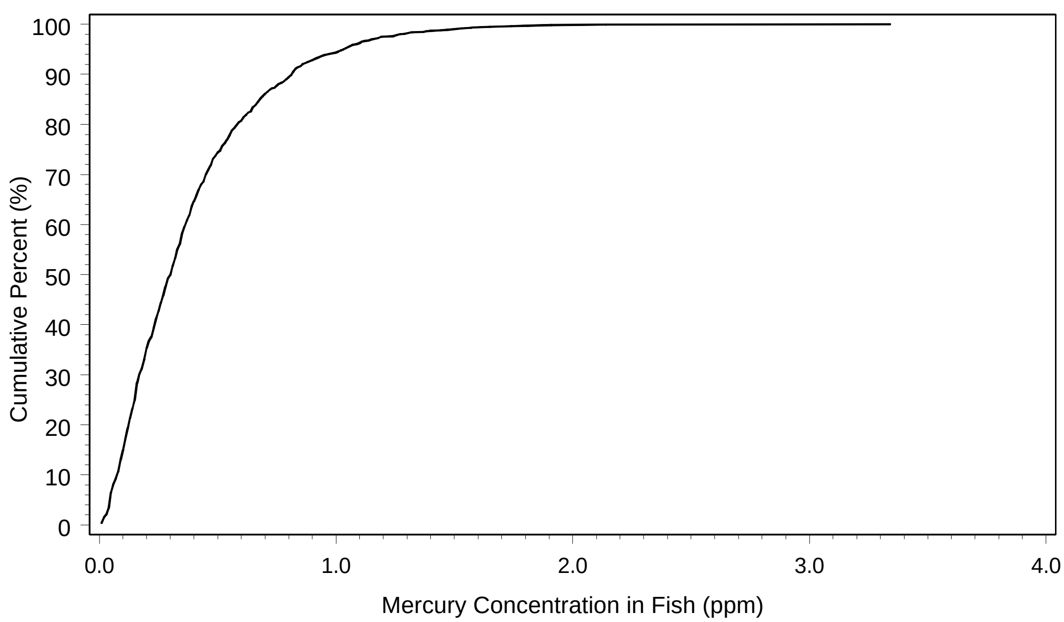
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

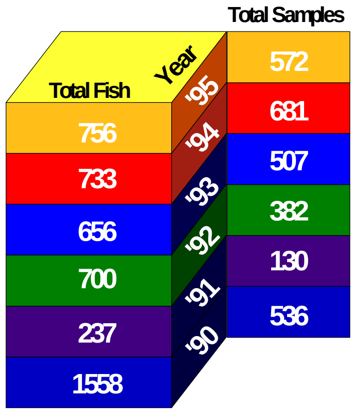
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \;/\; (\Sigma_i w_i - 1)}$

[d] CV = $(SD_w / \bar{x}_w) * 100$

Cumulative Distribution of Mercury Concentrations for All Fish Species in New York

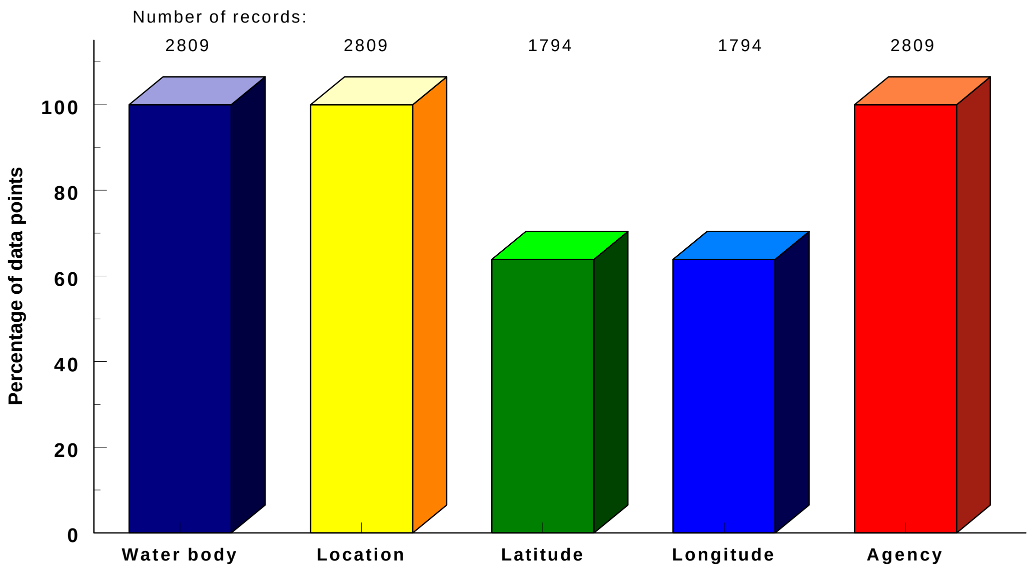


Records Analyzed by Year



Sampling Locations

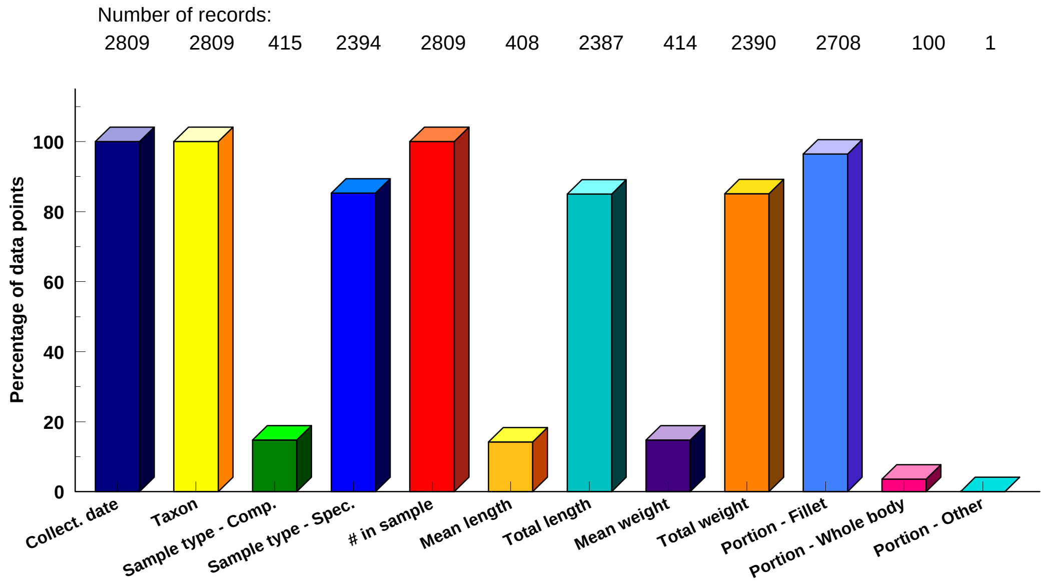
Location Variables in Database



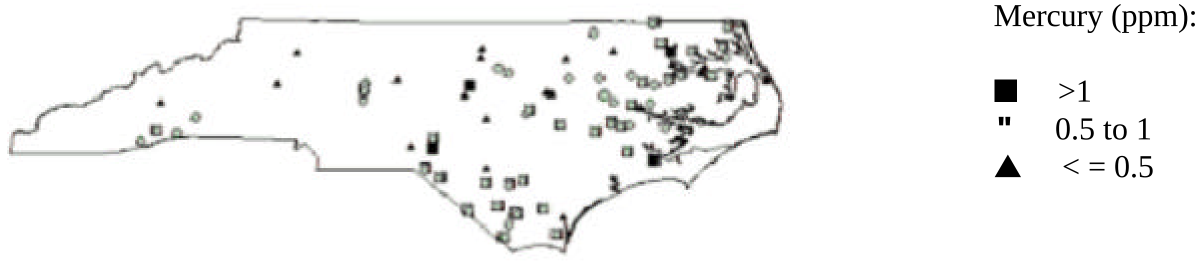
Top Ten Fish Species

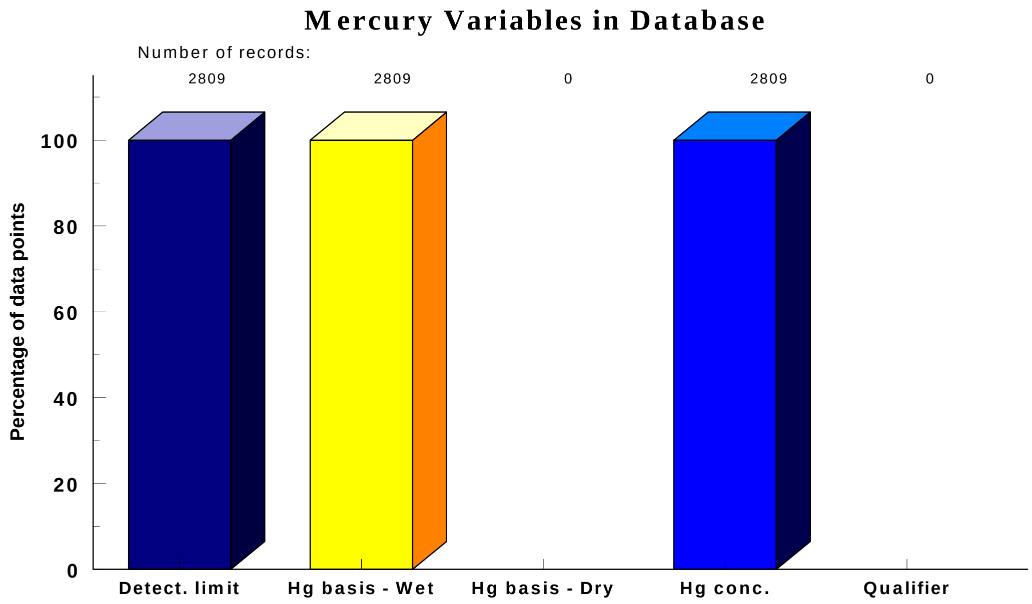
Common Name	Percent		Common Name	Percent
Largemouth bass	34		Channel catfish	3
Bluegill sunfish	15		White catfish	3
Bowfin	8		Redhorse sucker	2
Redbreast sunfish	7		White perch	2
Black crappie	4		Common carp	2

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Largemouth bass	1327	1569	0.020	3.600	0.532	0.390	0.504	94.76
Bluegill sunfish	304	699	0.020	0.780	0.186	0.160	0.130	69.79
Bowfin	349	357	0.110	5.700	0.944	0.760	0.692	73.27

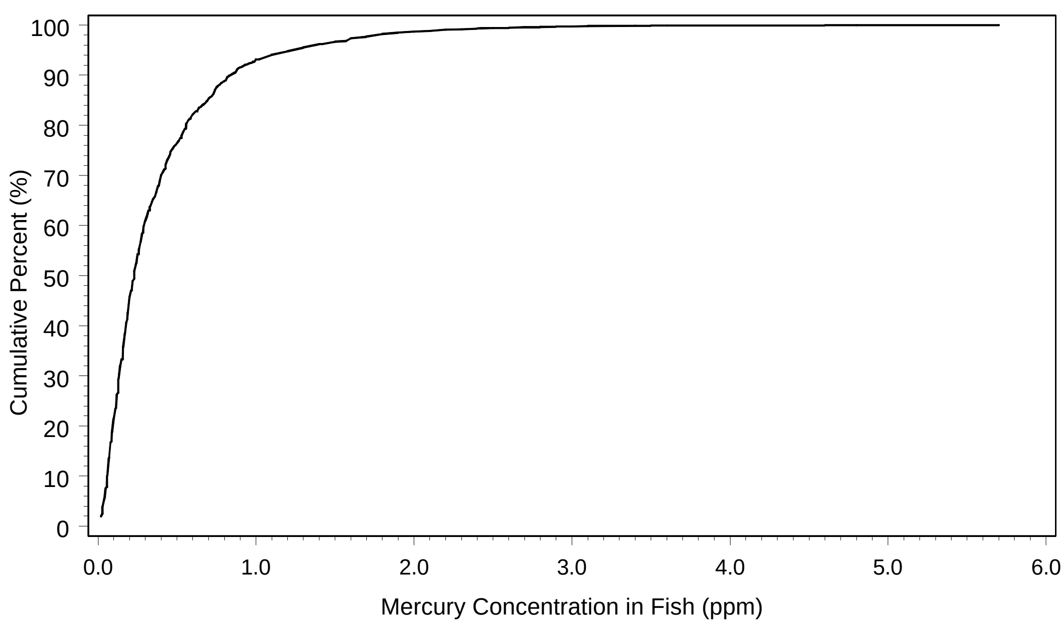
a Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

b Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

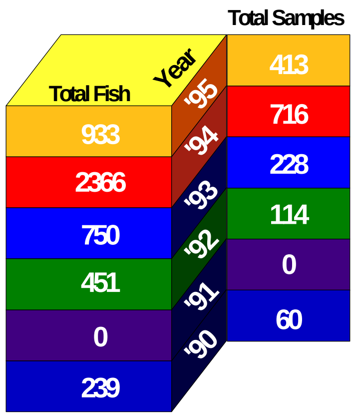
c Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

d $CV = (SD_w / \bar{x}_w) * 100$

Cumulative Distribution of Mercury Concentrations for All Fish Species in North Carolina

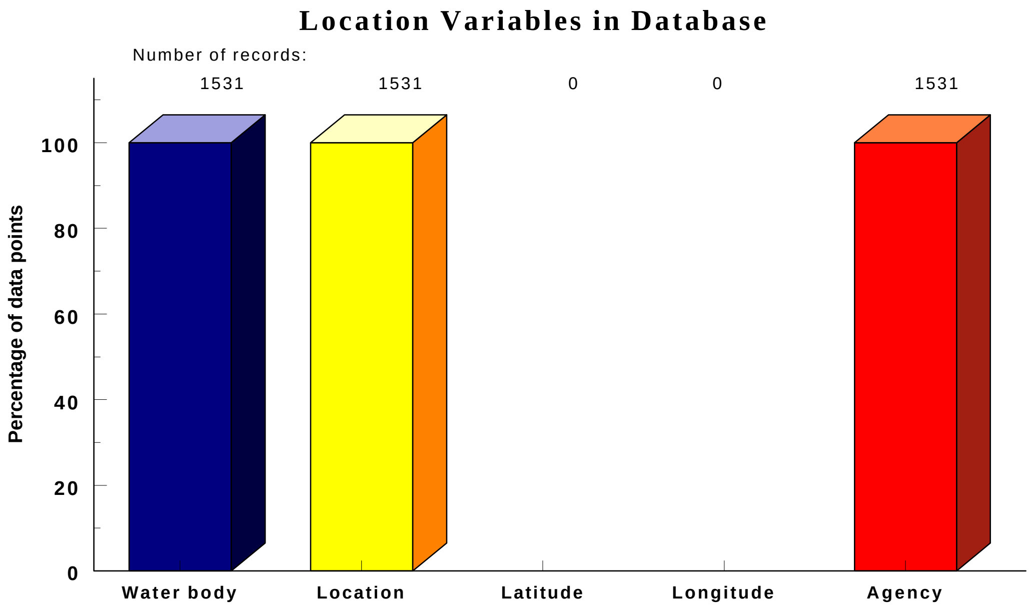


Records Analyzed by Year



Sampling Locations

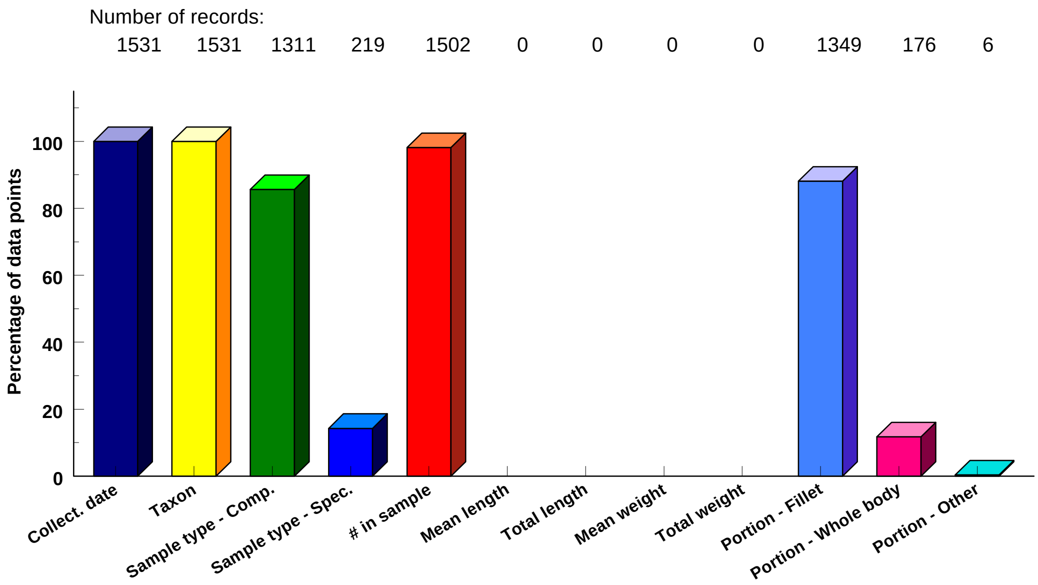
Latitude and Longitude Data Not Available



Top Ten Fish Species

Common Name	Percent		Common Name	Percent
Common carp	17		White bass	5
Smallmouth bass	15		Sauger	4
Channel catfish	12		Freshwater drum	4
Rock bass	10		White crappie	3
Largemouth bass	7		Hybrid bass	3

Fish Variables in Database



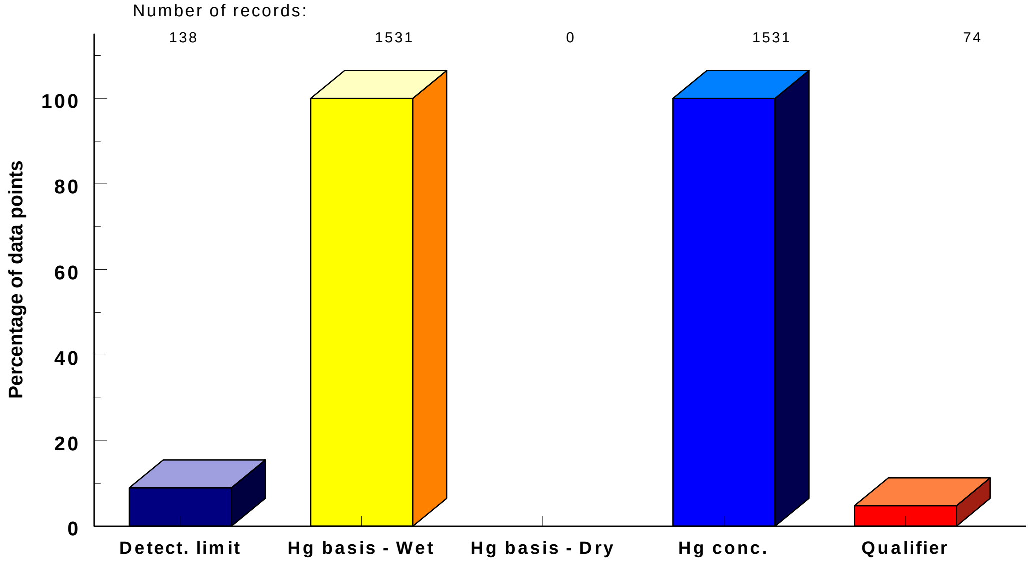
Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis

Mercury (ppm):

- ■ >1
- " 0.5 to 1
- ▲ < = 0.5

Latitude and Longitude Data Not Available

Mercury Variables in Database



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Common carp	234	816	0.013	1.097	0.124	0.106	0.107	86.12
Smallmouth bass	236	716	0.022	0.743	0.173	0.158	0.096	55.19
Channel catfish	205	574	0.018	1.040	0.118	0.098	0.103	87.25

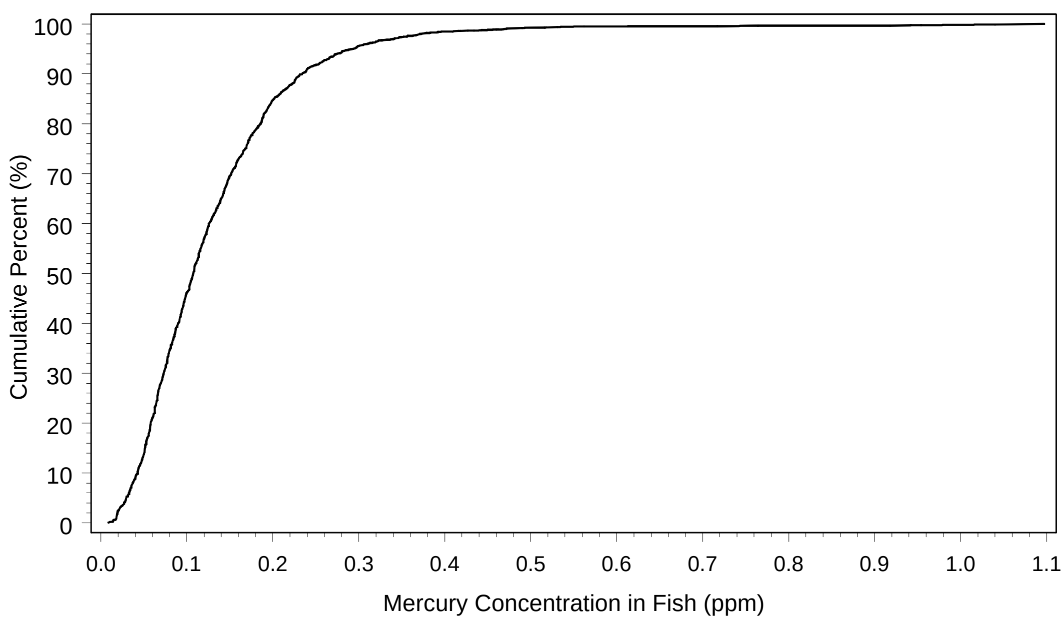
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

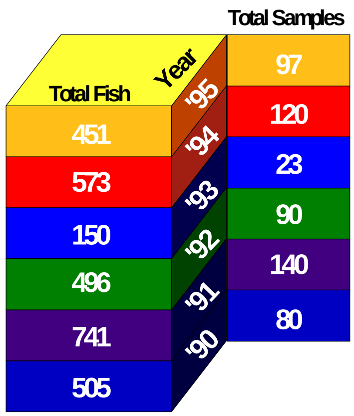
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

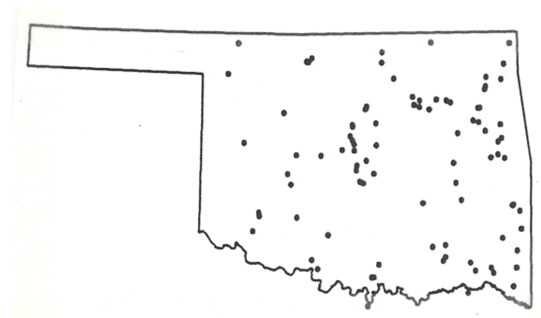
Cumulative Distribution of Mercury Concentrations for All Fish Species in Ohio

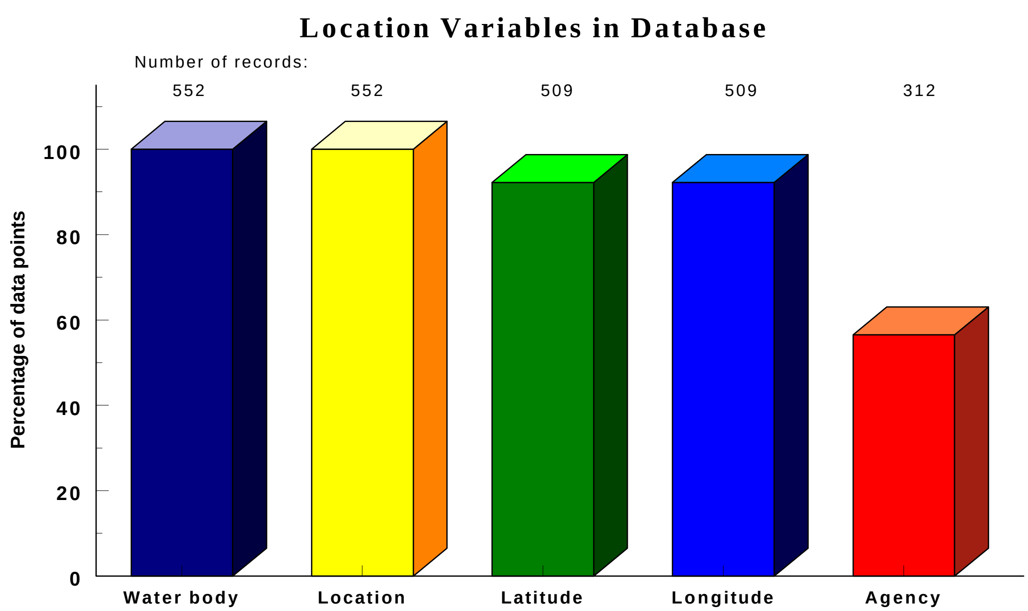


Records Analyzed by Year



Sampling Locations

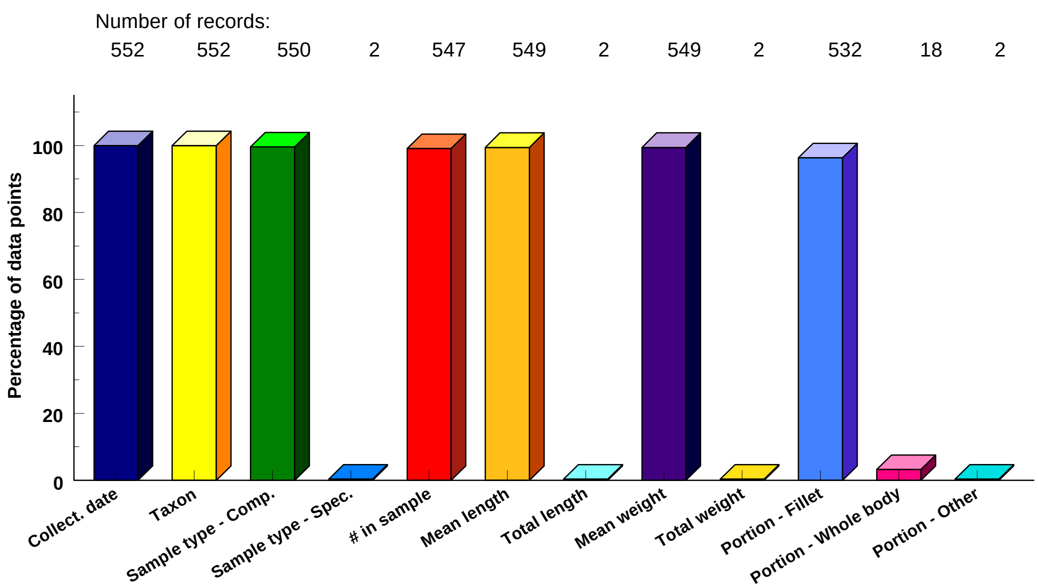




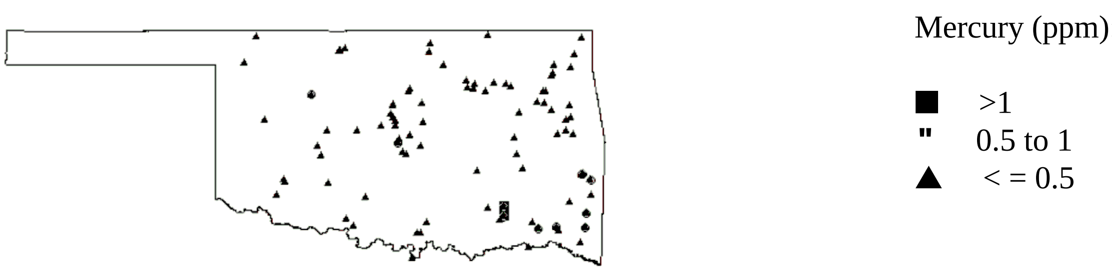
Top Ten Fish Species

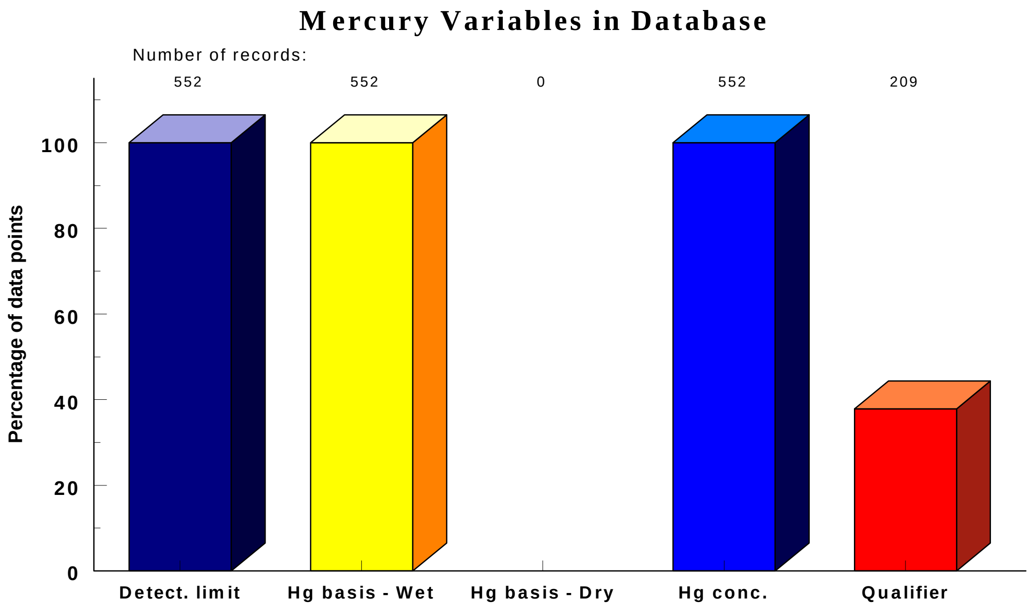
Common Name	Percent		Common Name	Percent
Gizzard shad	15		White bass	7
Channel catfish	11		White crappie	5
Common carp	10		Smallmouth buffalo	5
River carpsucker	8		Freshwater drum	4
Largemouth bass	8		Plains killifish	3

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Gizzard shad	76	431	0.100	0.660	0.117	0.100	0.064	54.58
Channel catfish	67	324	0.100	0.640	0.193	0.140	0.126	65.26
Common carp	56	277	0.100	0.280	0.133	0.100	0.046	34.35

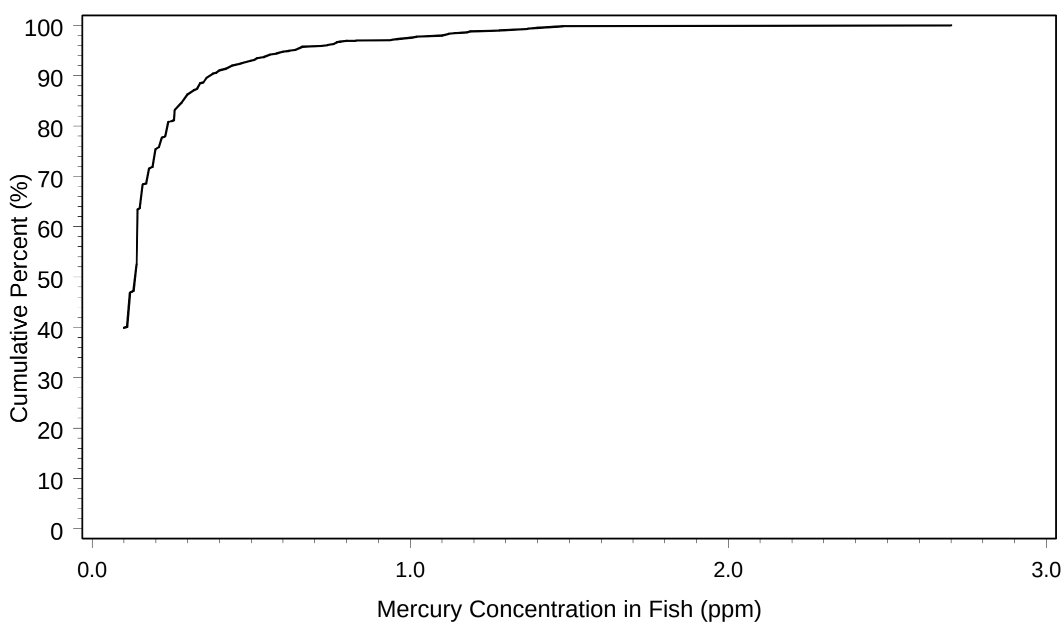
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

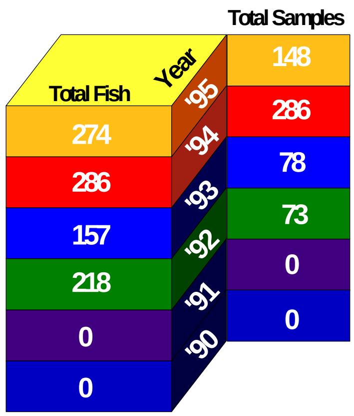
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

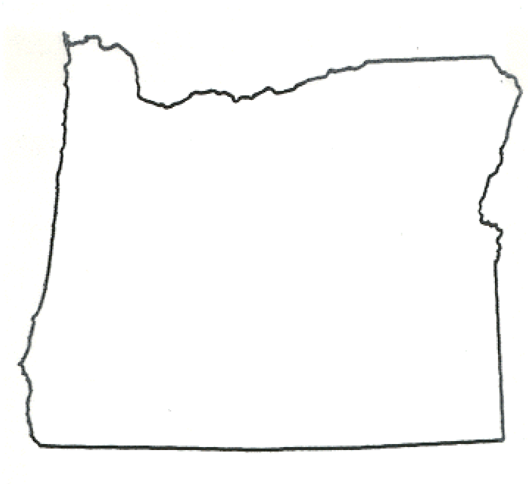
Cumulative Distribution of Mercury Concentrations for All Fish Species in Oklahoma



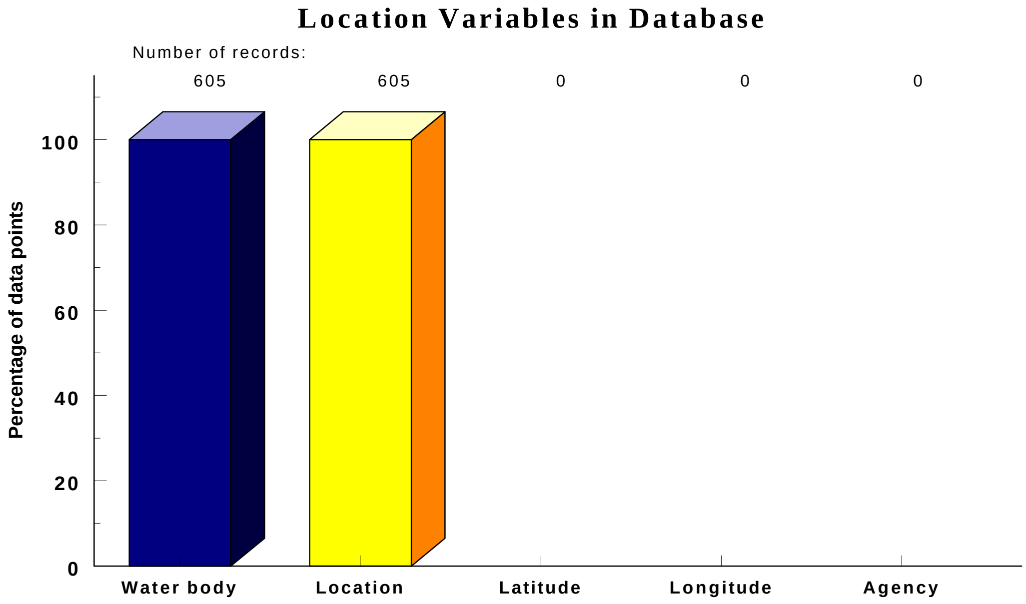
Records Analyzed by Year



Sampling Locations



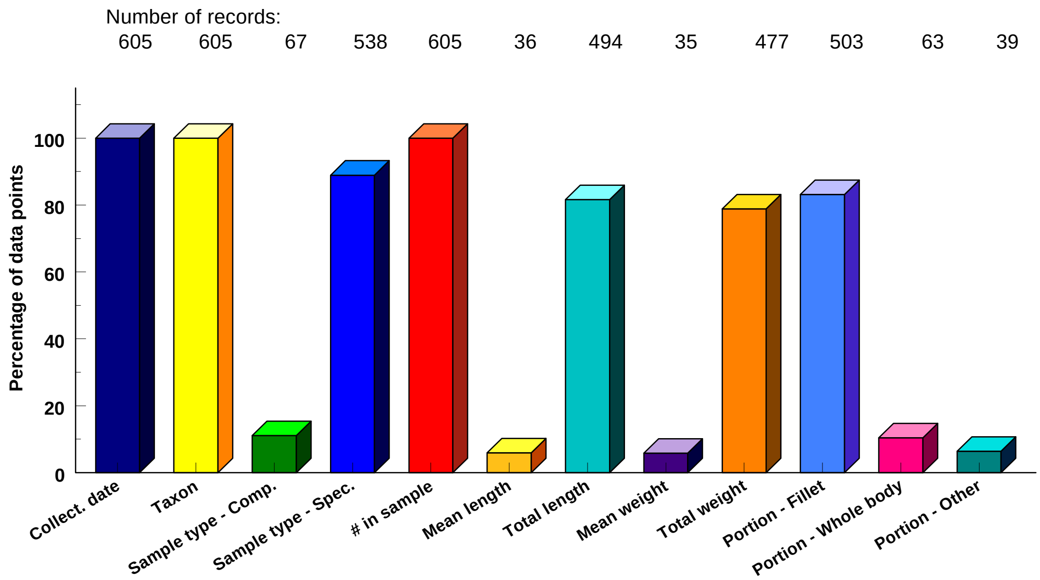
Latitude and Longitude Data Not Available



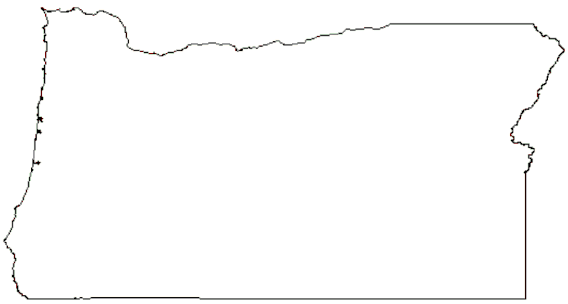
Top Ten Fish Species

Common Name	Percent	Common Name	Percent
Sockeye salmon	13	Rainbow trout	6
Largemouth bass	13	Black crappie	5
Smallmouth bass	10	Brown trout	5
Sucker	7	Chiselmouth	5
Common carp	6	Bullhead catfish	4

Fish Variables in Database



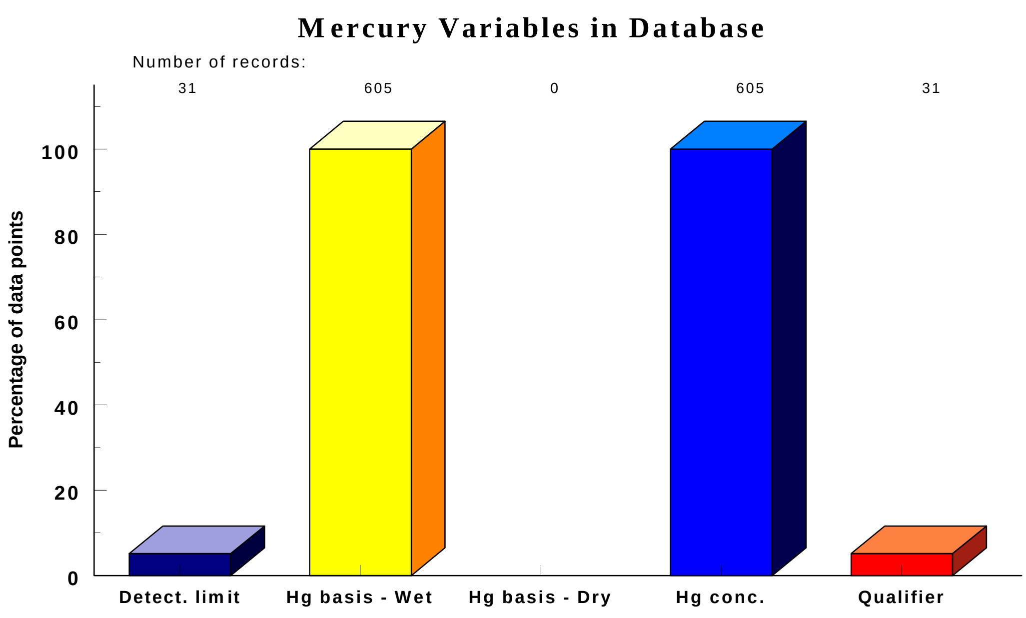
Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis



Mercury (ppm):

- ■ >1
- " 0.5 to 1
- ▲ < = 0.5

Latitude and Longitude Data Not Available



Mercury Concentration for the Three Most Abundant Species: Summary Statistics									
			Mercury Statistics Weighted by No. of Fish in Sample[a]						
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Sockeye salmon	42	124	0.040	1.390	0.186	0.043	0.352	189.41
Largemouth bass	116	120	0.030	0.980	0.369	0.340	0.210	56.72
Smallmouth bass	71	95	0.060	2.540	0.366	0.310	0.325	88.96

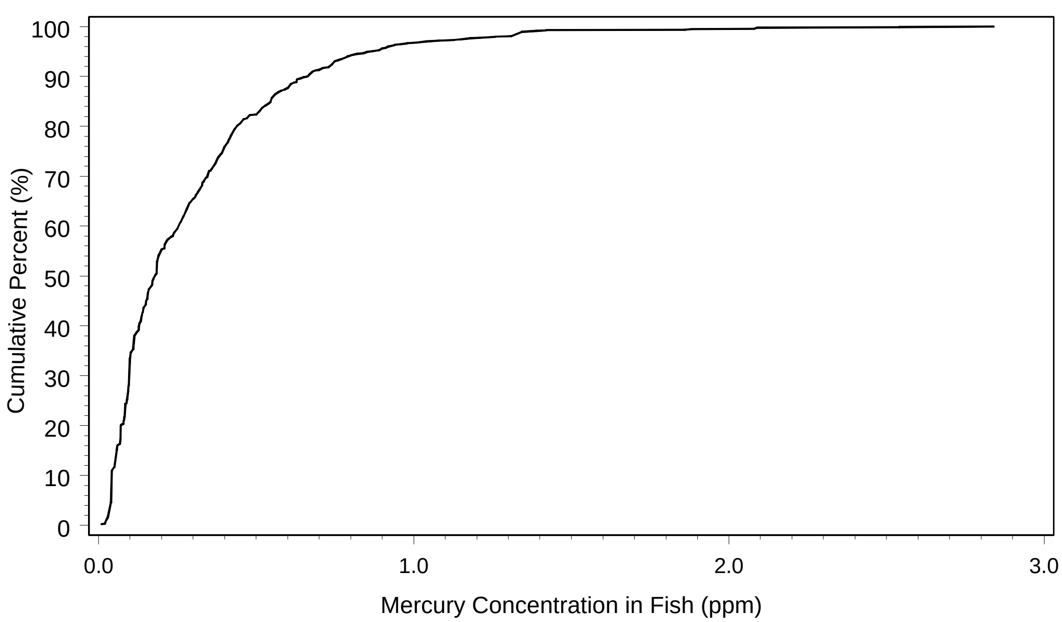
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

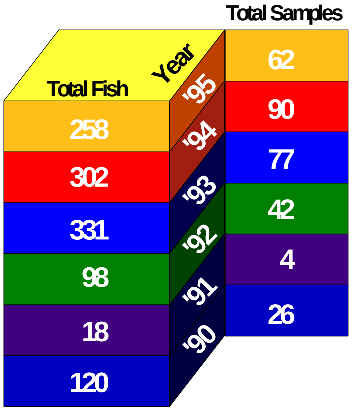
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] CV = $(SD_w / \bar{x}_w) * 100$

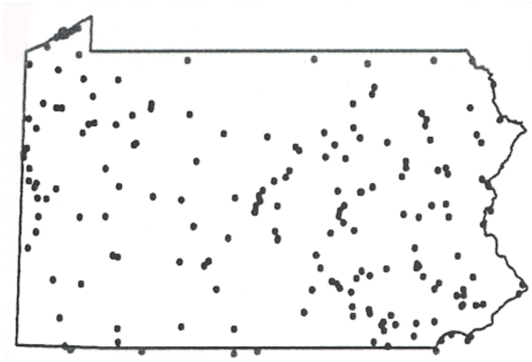
Cumulative Distribution of Mercury Concentrations for All Fish Species in Oregon

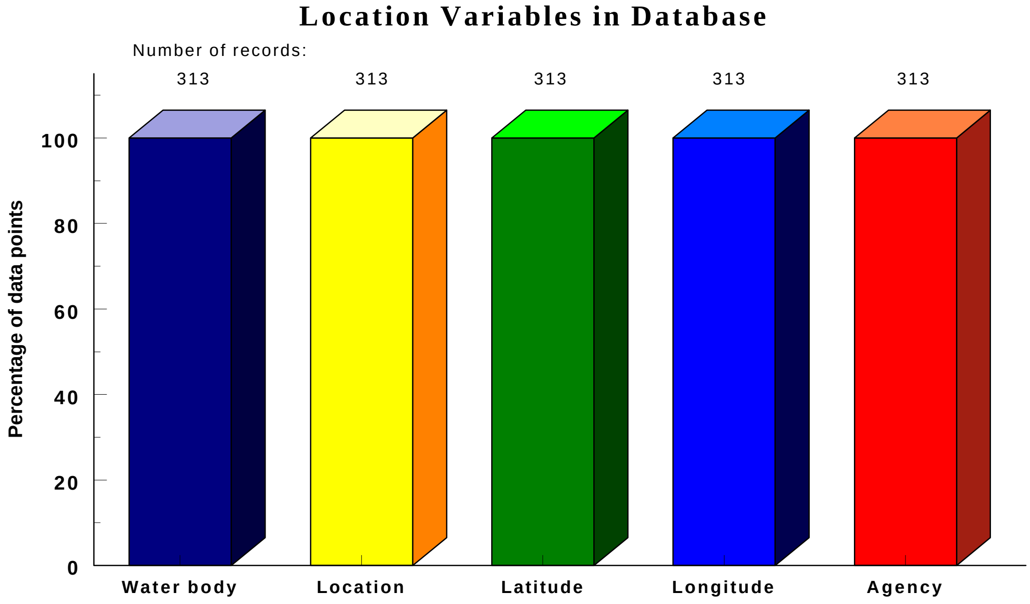


Records Analyzed by Year



Sampling Locations



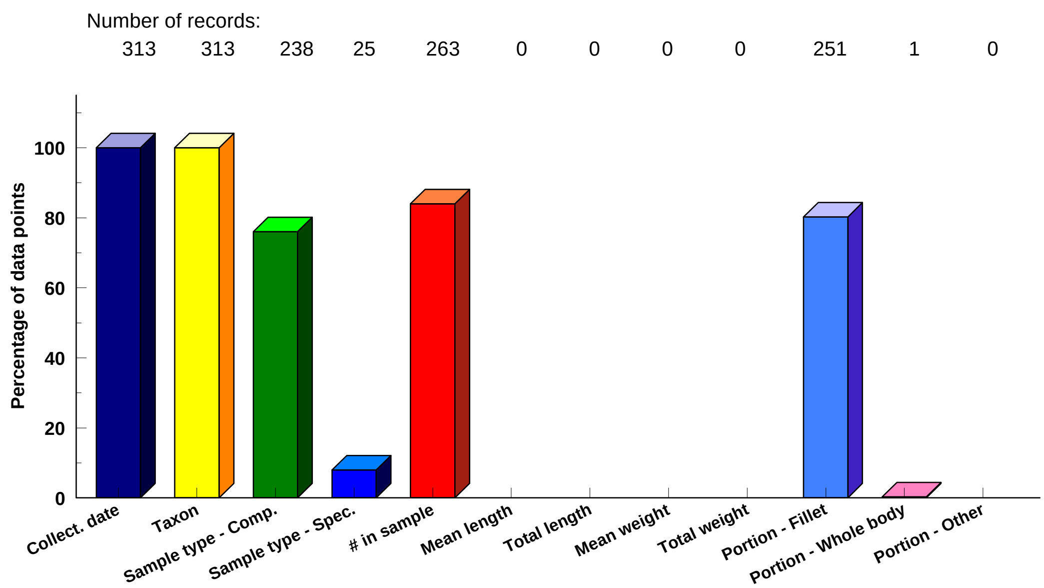


Top Ten Fish Species[a]

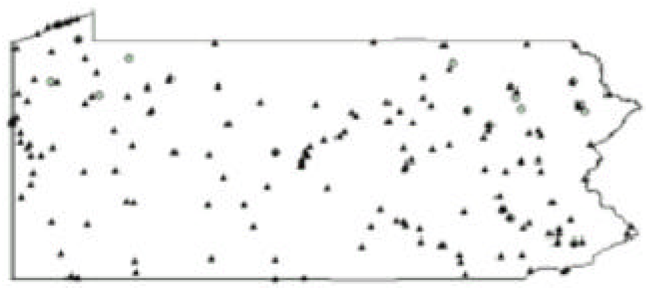
Common Name	Percent		Common Name	Percent
Smallmouth bass	18		Channel catfish	8
Largemouth bass	13		Rock bass	6
Brown trout	12		Yellow perch	6
Common carp	9		White sucker	4
Walleye	8		Rainbow trout	2

[a] Species identified as "Unknown" were excluded from this analysis.

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis

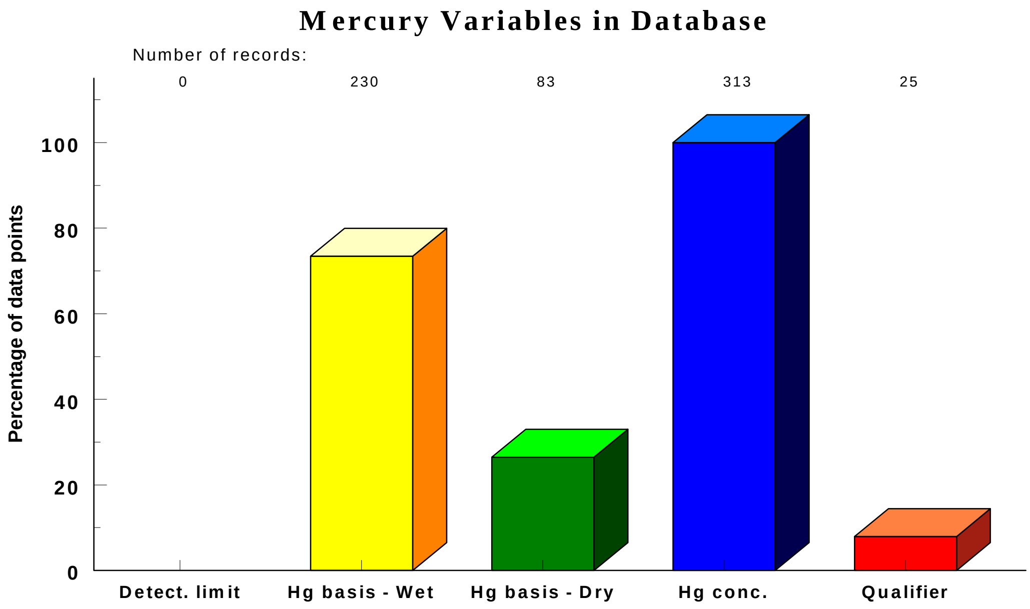


Mercury (ppm):

■ >1

" 0.5 to 1

▲ < = 0.5



Mercury Concentration for the Three Most Abundant Species: Summary Statistics									
			Mercury Statistics Weighted by No. of Fish in Sample[a]						
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Smallmouth bass	50	191	0.070	0.580	0.259	0.230	0.129	49.76
Largemouth bass	32	139	0090	0.750	0.293	0.250	0.178	60.70
Brown trout	27	133	0.020	0.560	0.120	0.100	0.102	85.02

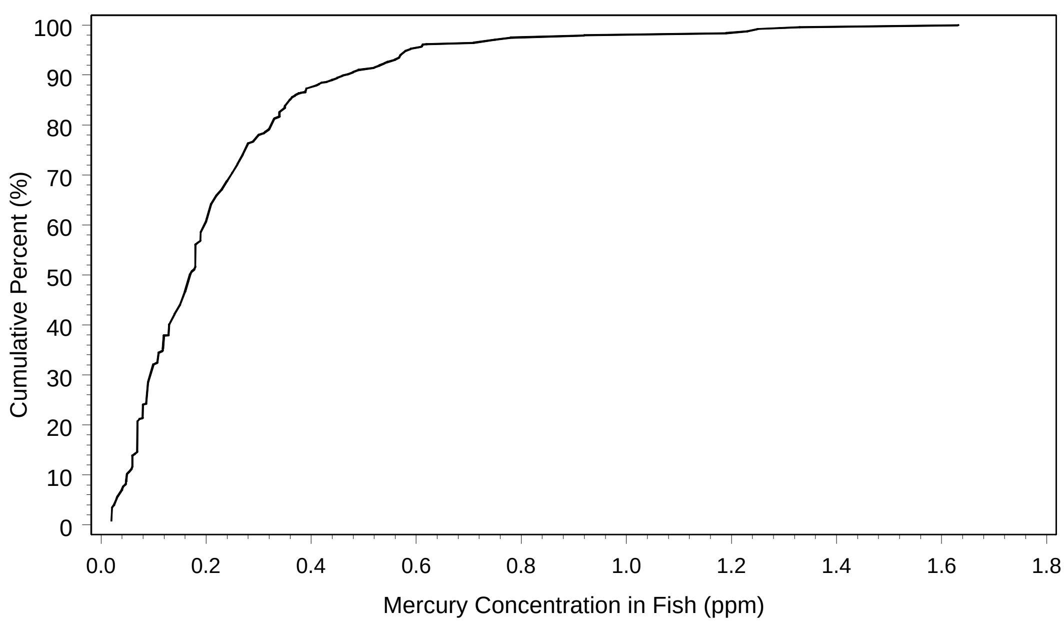
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

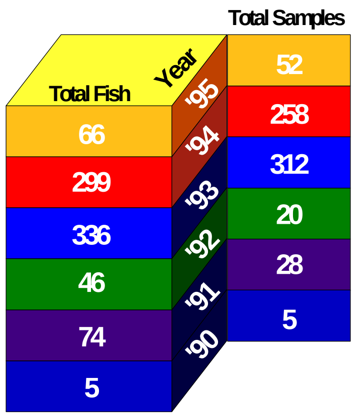
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

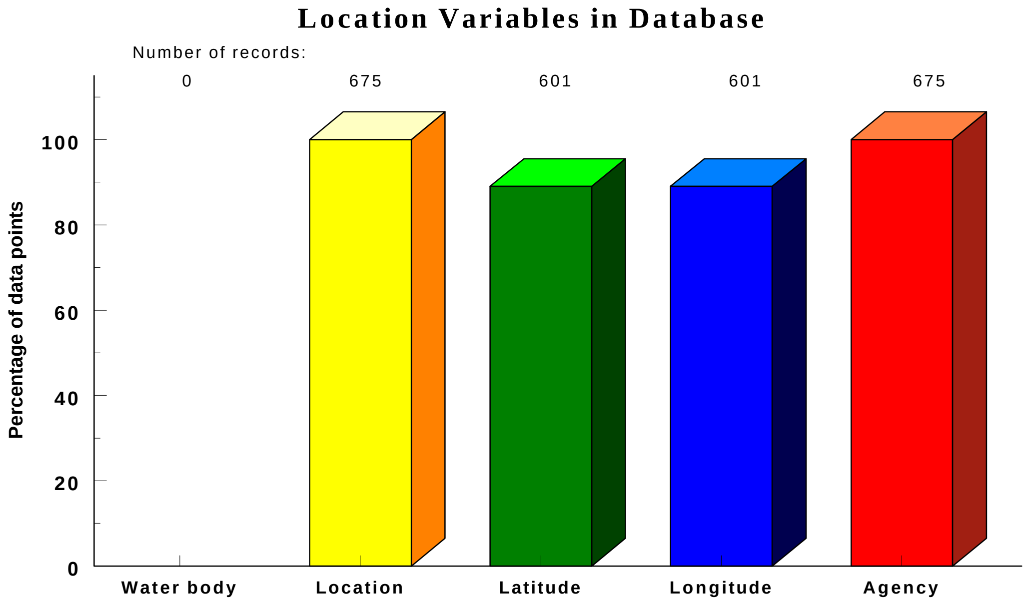
Cumulative Distribution of Mercury Concentrations for All Fish Species in Pennsylvania



Records Analyzed by Year



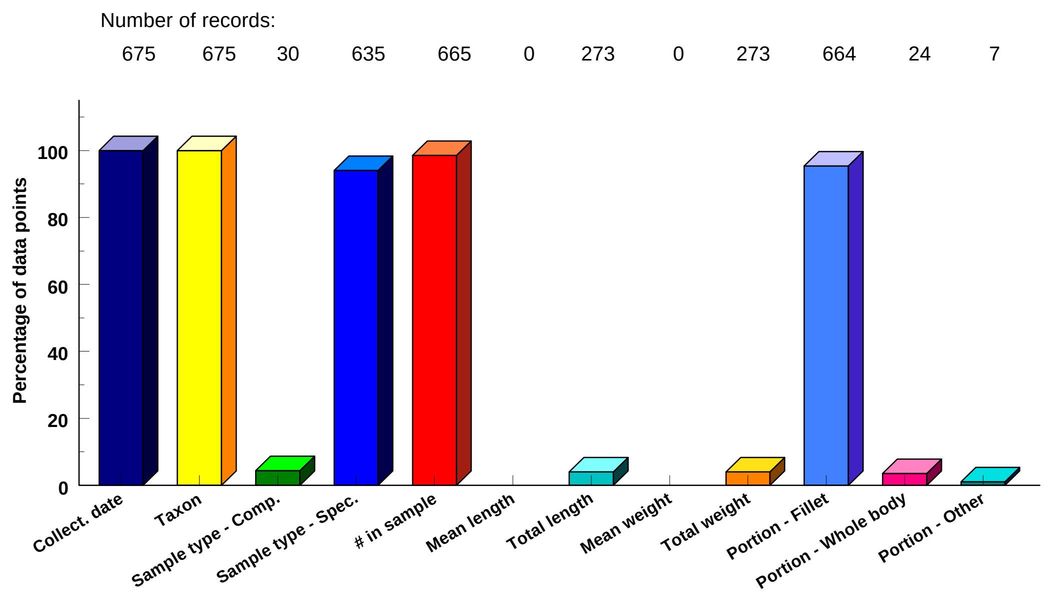
Sampling Locations



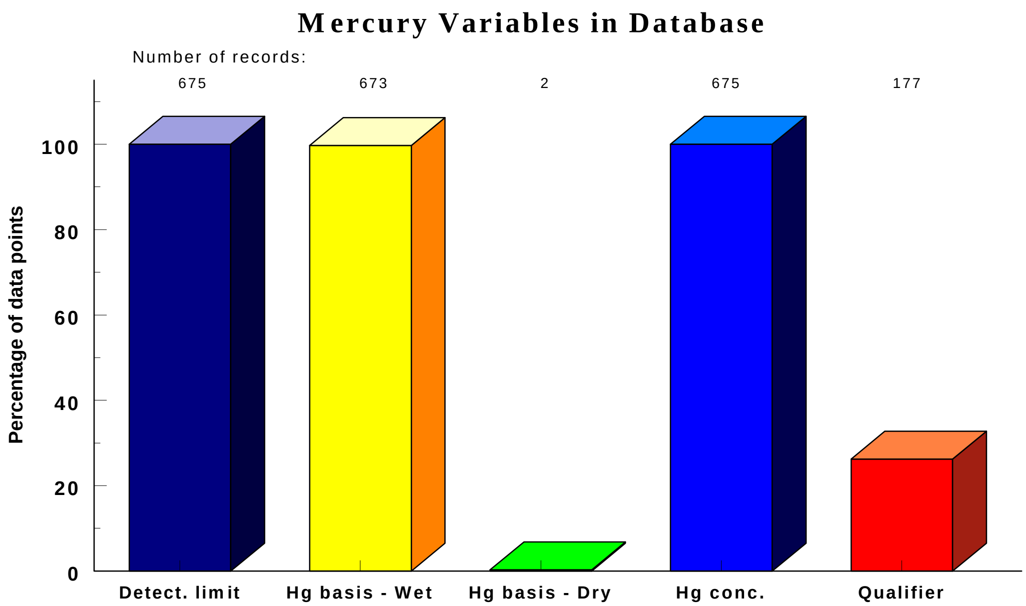
Top Ten Fish Species

Common Name	Percent		Common Name	Percent
Largemouth bass	62		Red drum	2
Bowfin	11		Redear sunfish	2
Channel catfish	5		Bluntnose minnow	2
Striped bass	3		Blue catfish	2
Bluegill sunfish	2		Black crappie	1

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis



Mercury Concentration for the Three Most Abundant Species: Summary Statistics									
			Mercury Statistics Weighted by No. of Fish in Sample[a]						
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Largemouth bass	403	505	0.230	3.330	0.994	0.920	0.711	71.45
Bowfin	87	87	0.250	7.000	1.348	1.060	1.122	83.21
Channel catfish	32	42	0.250	1.610	0.345	0.250	0.304	88.18

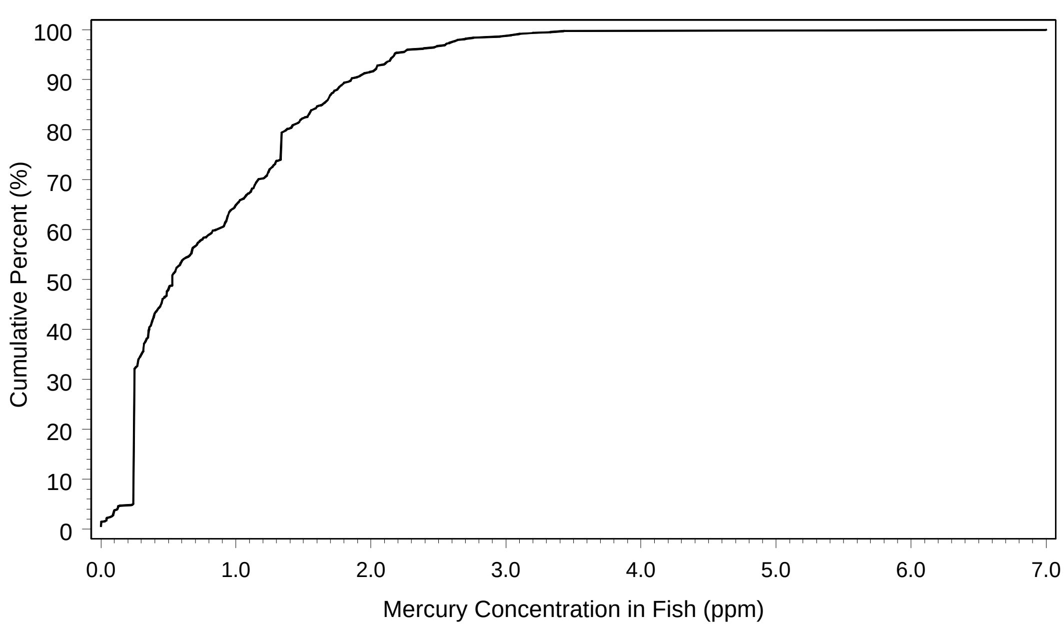
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

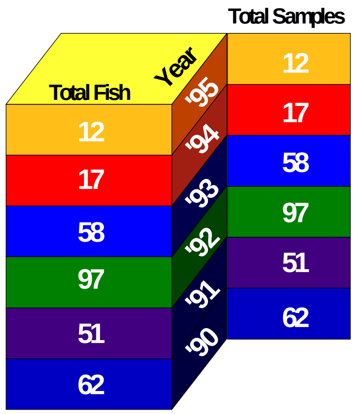
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

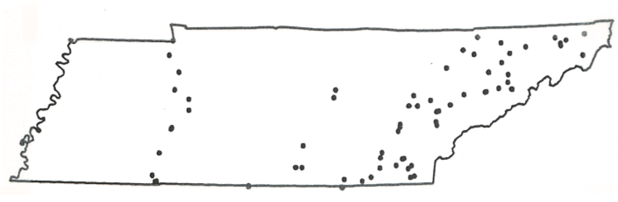
Cumulative Distribution of Mercury Concentrations for All Fish Species in South Carolina

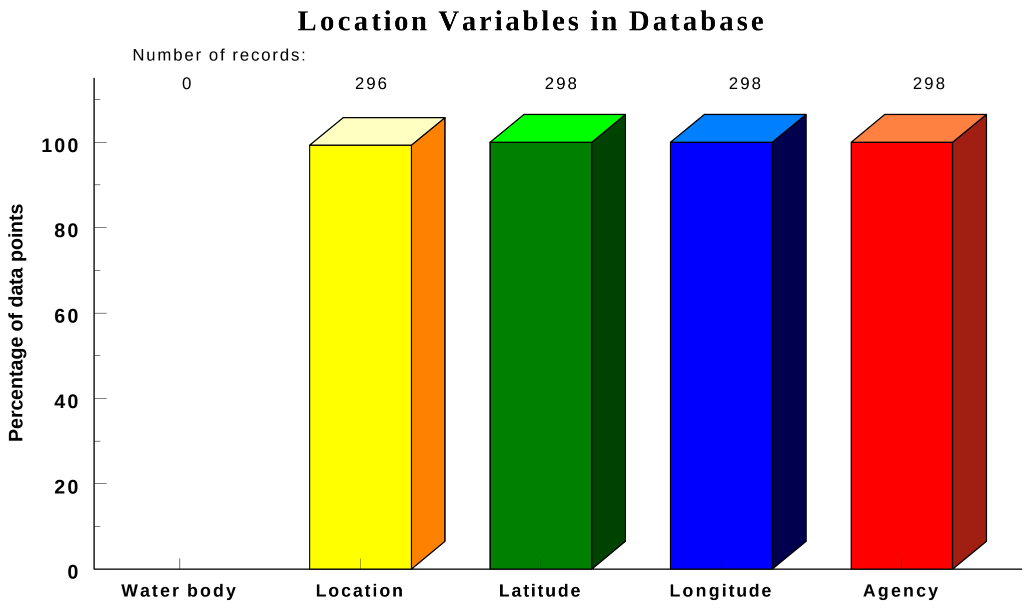


Records Analyzed by Year



Sampling Locations



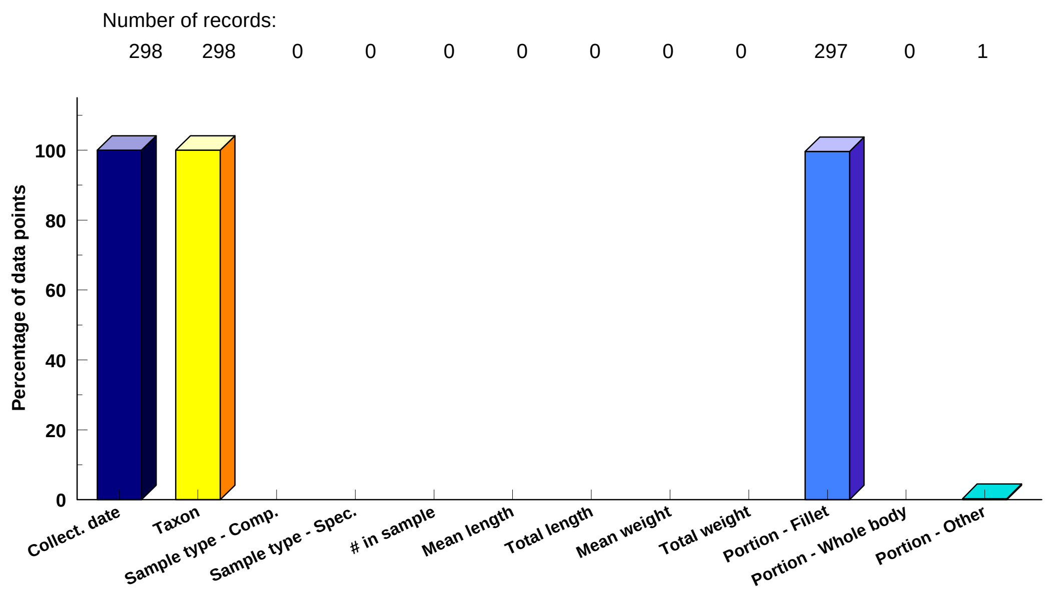


Top Ten Fish Species[a]

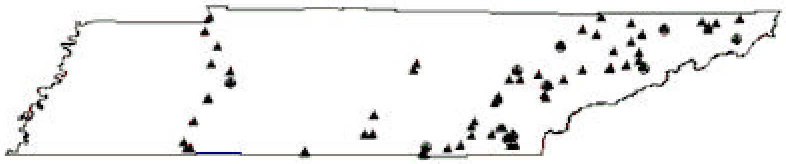
Common Name	Percent		Common Name	Percent
Channel catfish	54		Bullhead catfish	2
Largemouth bass	25		Bluegill sunfish	1
Common carp	6		Golden redhorse	1
Drum family	2		Rock bass	1
Spotted bass	2		Freshwater drum	1

[a] Species identified as "Unknown" were excluded from this analysis.

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis

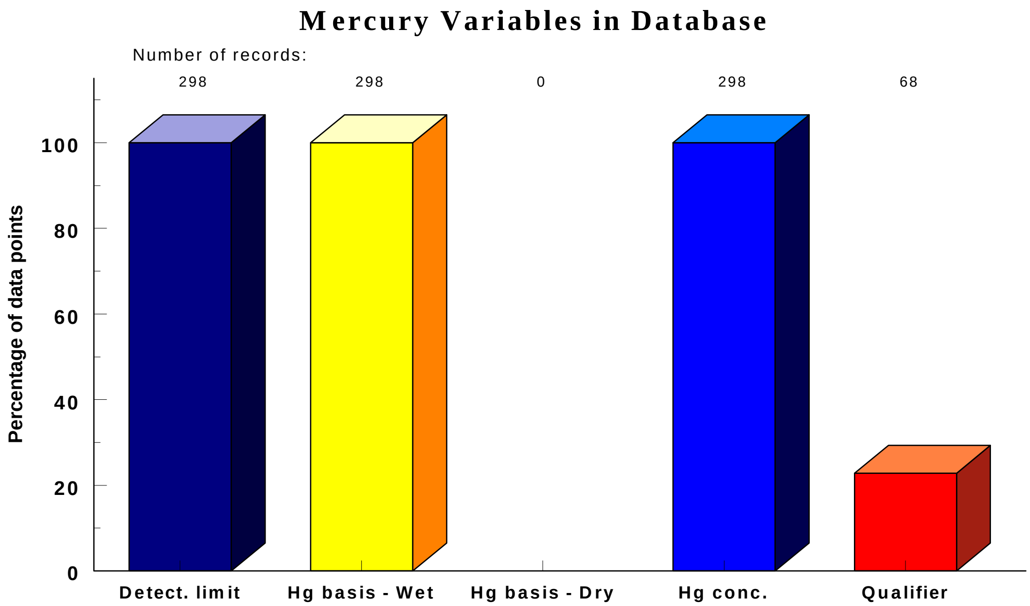


Mercury (ppm):

■ >1

" 0.5 to 1

▲ < = 0.5



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Channel catfish	137	137	0.100	0.650	0.173	0.120	0.111	64.32
Largemouth bass	64	64	0.100	0.830	0.255	0.190	0.153	59.97
Common carp	16	16	0.100	0.340	0.208	0.200	0.076	36.72

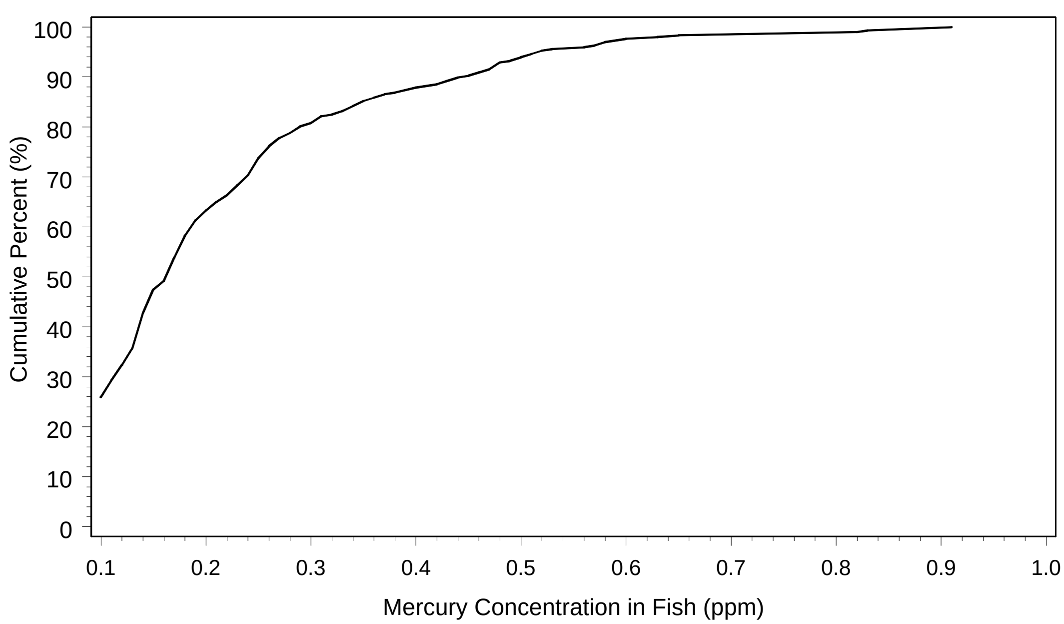
a Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

b Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

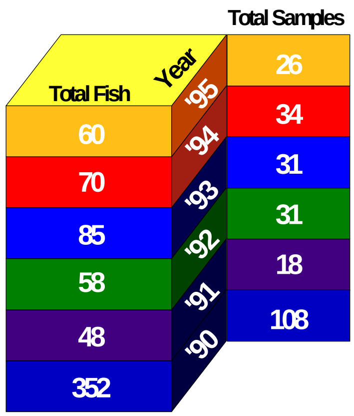
c Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

d $CV = (SD_w / \bar{x}_w) * 100$

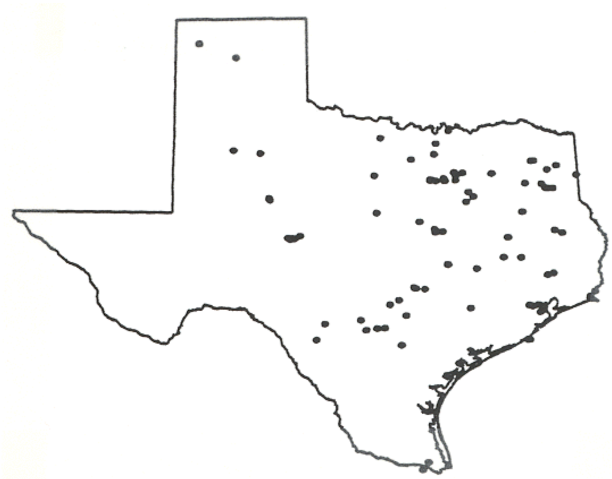
Cumulative Distribution of Mercury Concentrations for All Fish Species in Tennessee

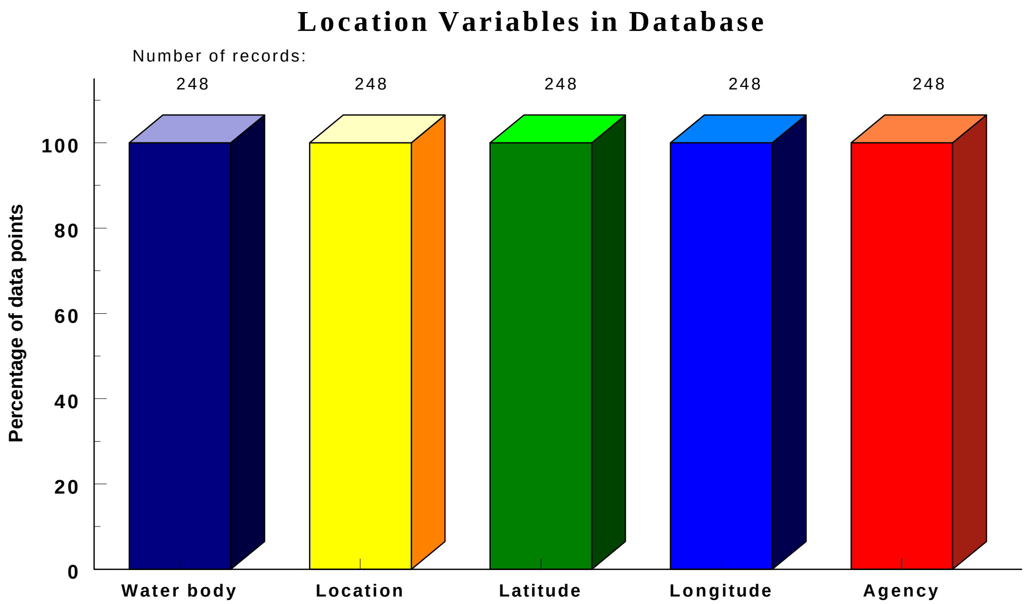


Records Analyzed by Year



Sampling Locations



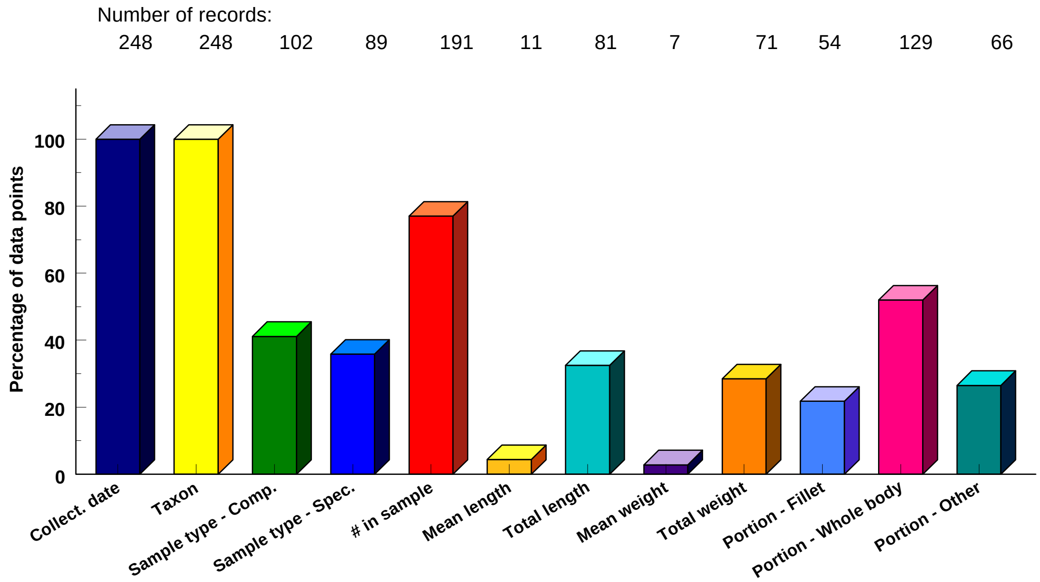


Top Ten Fish Species[a]

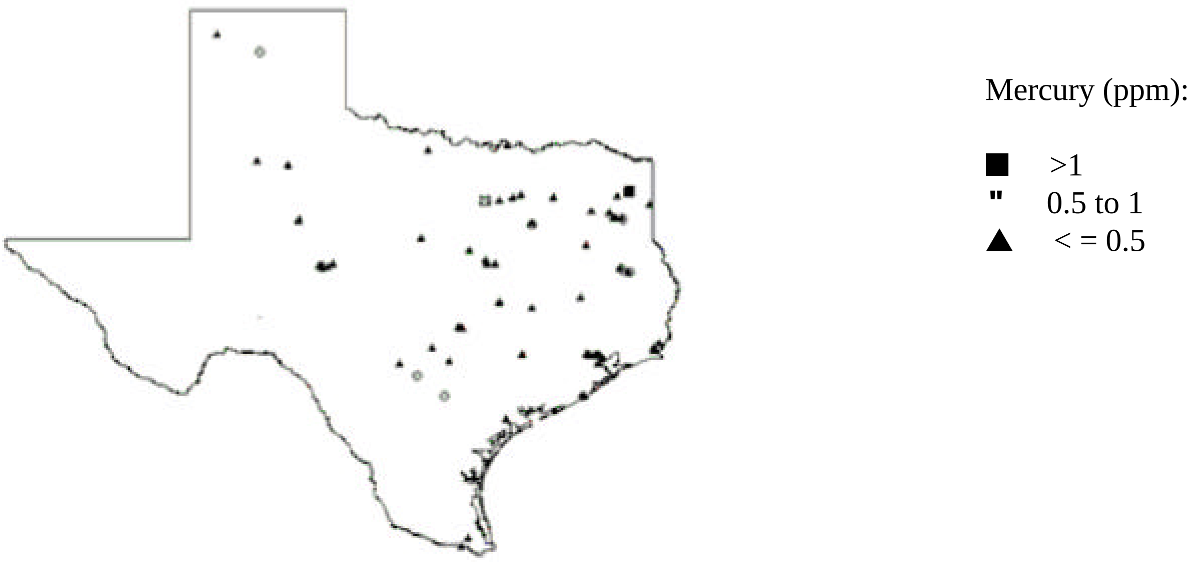
Common Name	Percent		Common Name	Percent
Sea catfish	16		Common carp	6
Largemouth bass	13		Bluegill sunfish	5
Channel catfish	10		Long ear sunfish	4
Blue catfish	7		Gafftopsail catfish	3
Croaker	6		Southern flounder	3

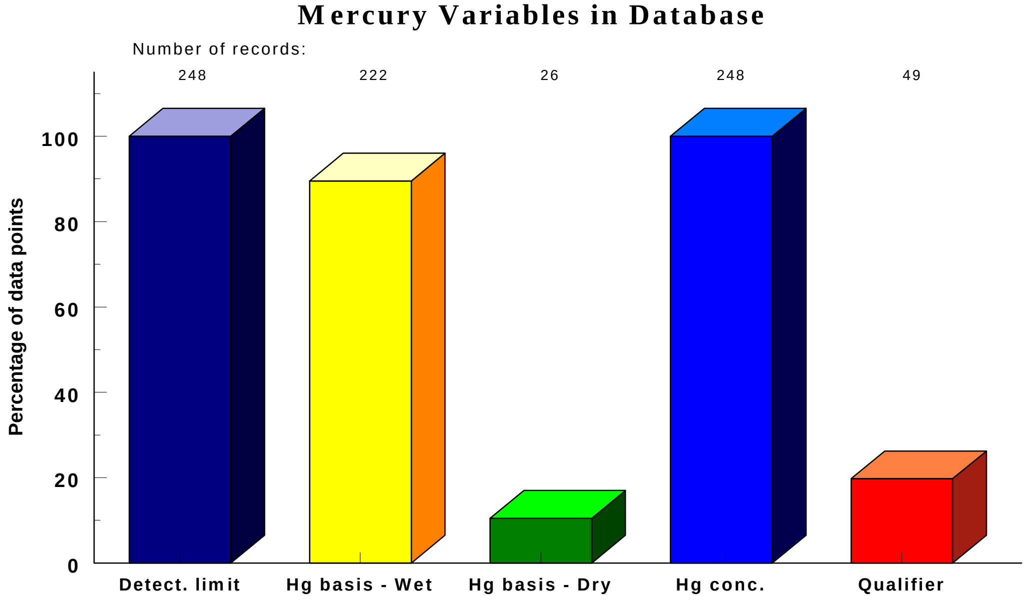
[a] Species identified as "Unknown" were excluded from this analysis.

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Sea catfish	16	71	0.029	0.543	0.152	0.129	0.104	68.75
Largemouth bass	23	58	0.043	0.657	0.237	0.243	0.145	61.28
Channel catfish	28	44	0.043	1.186	0.193	0.171	0.180	93.20

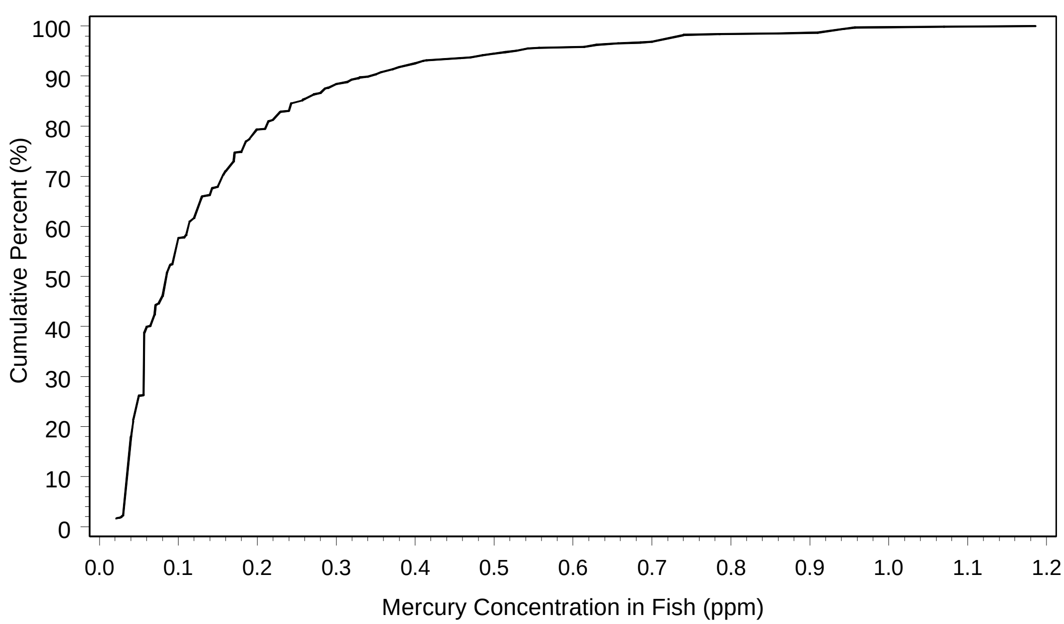
a Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

b Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

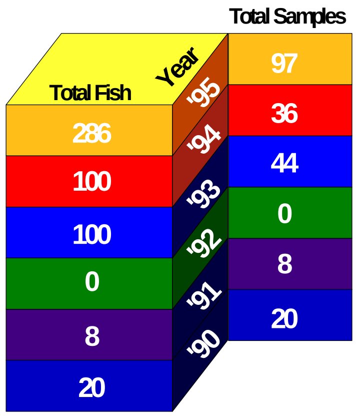
c Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

d $CV = (SD_w / \bar{x}_w) * 100$

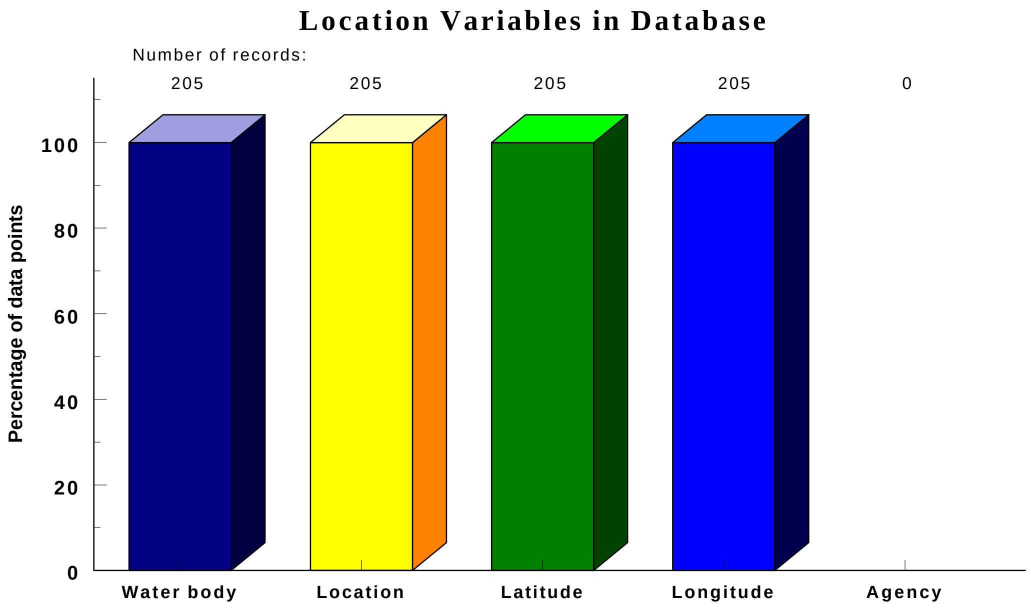
Cumulative Distribution of Mercury Concentrations for All Fish Species in Texas



Records Analyzed by Year



Sampling Locations

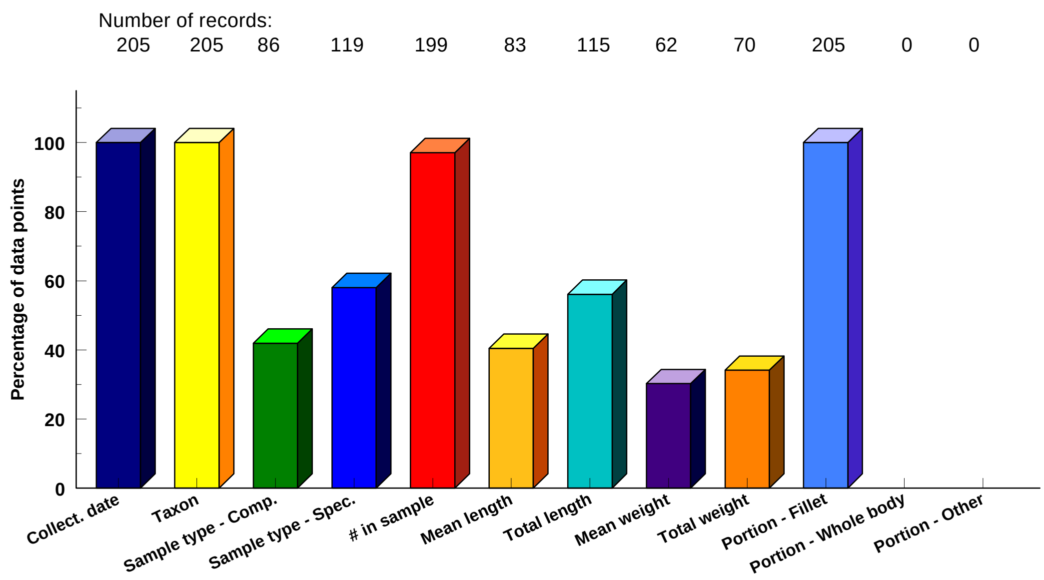


Top Ten Fish Species[a]

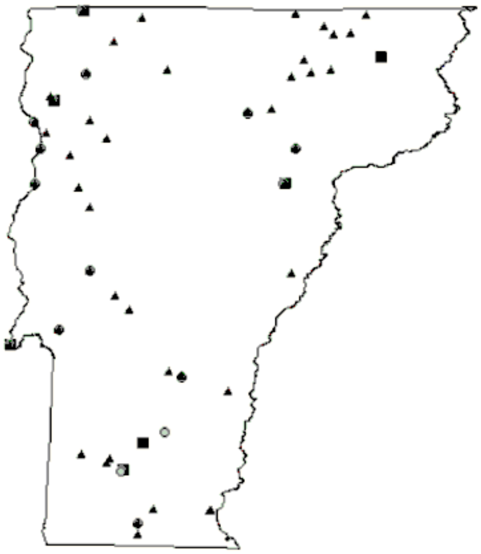
Common Name	Percent		Common Name	Percent
Yellow perch	27		Lake trout	7
Largemouth bass	20		Northern pike	6
Brown bullhead	10		Brook trout	5
Smallmouth bass	8		Rainbow trout	3
Chain pickerel	7		Pumpkinseed sunfish	2

[a] Species identified as "Unknown" were excluded from analysis.

Fish Variables in Database

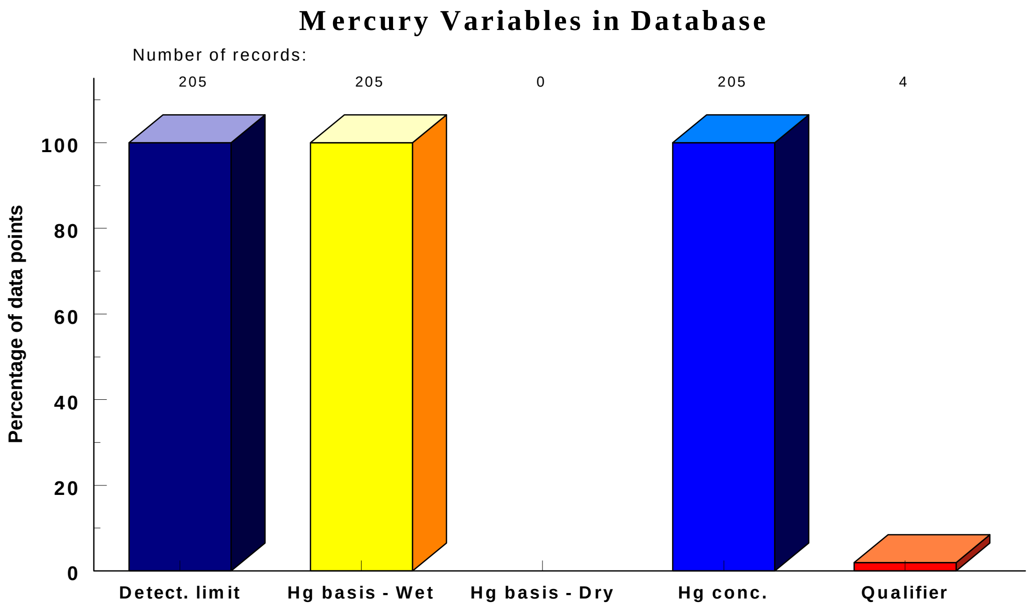


Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis



Mercury (ppm):

■ >1
" 0.5 to 1
▲ < = 0.5



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Yellow perch	46	127	0.090	0.890	0.333	0.300	0.193	58.03
Largemouth bass	11	93	0.150	1.200	0.802	1.200	0.473	58.90
Brown bullhead	11	47	0.050	0.200	0.120	0.100	0.053	43.86

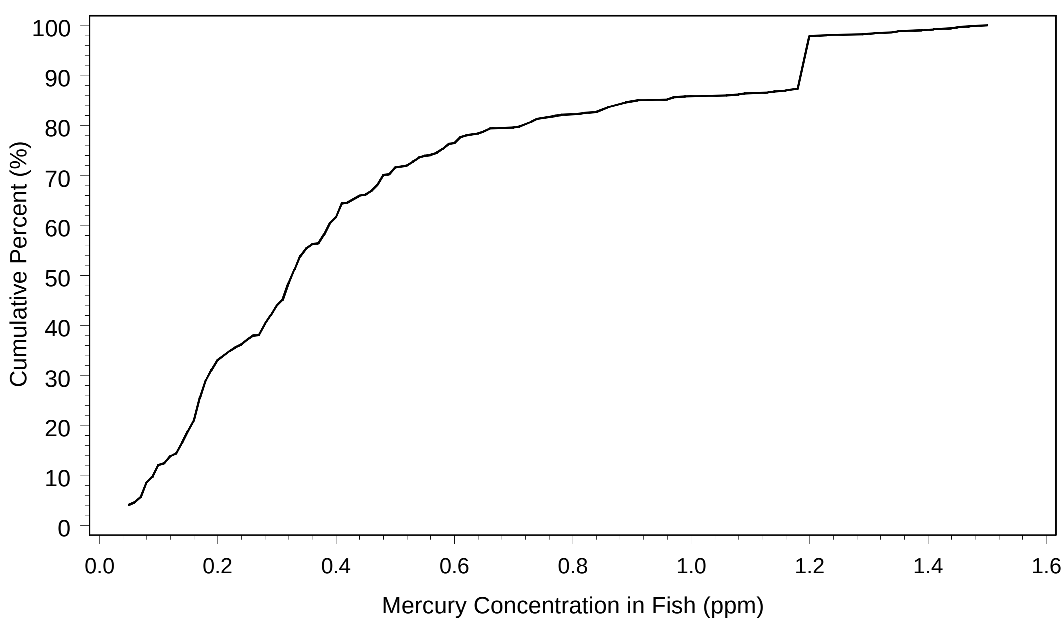
a Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

b Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

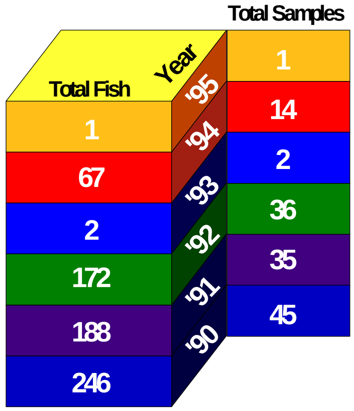
c Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 / (\Sigma_i w_i - 1)}$

d $CV = (SD_w / \bar{x}_w) * 100$

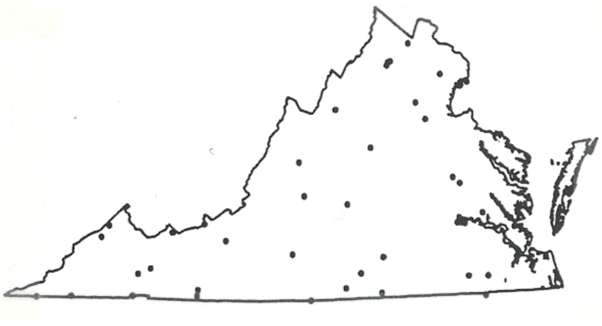
Cumulative Distribution of Mercury Concentrations for All Fish Species in Vermont

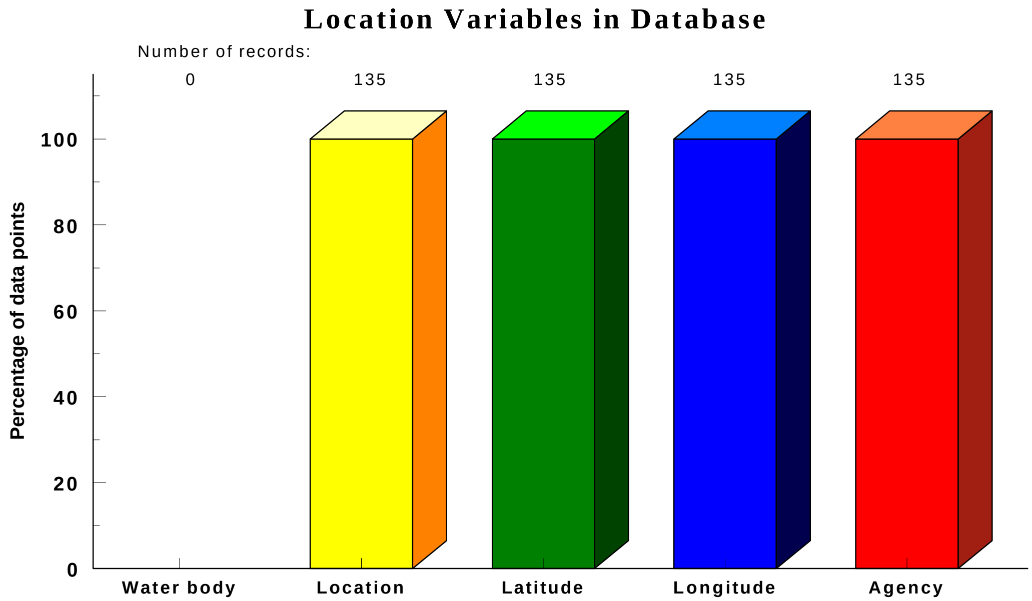


Records Analyzed by Year



Sampling Locations



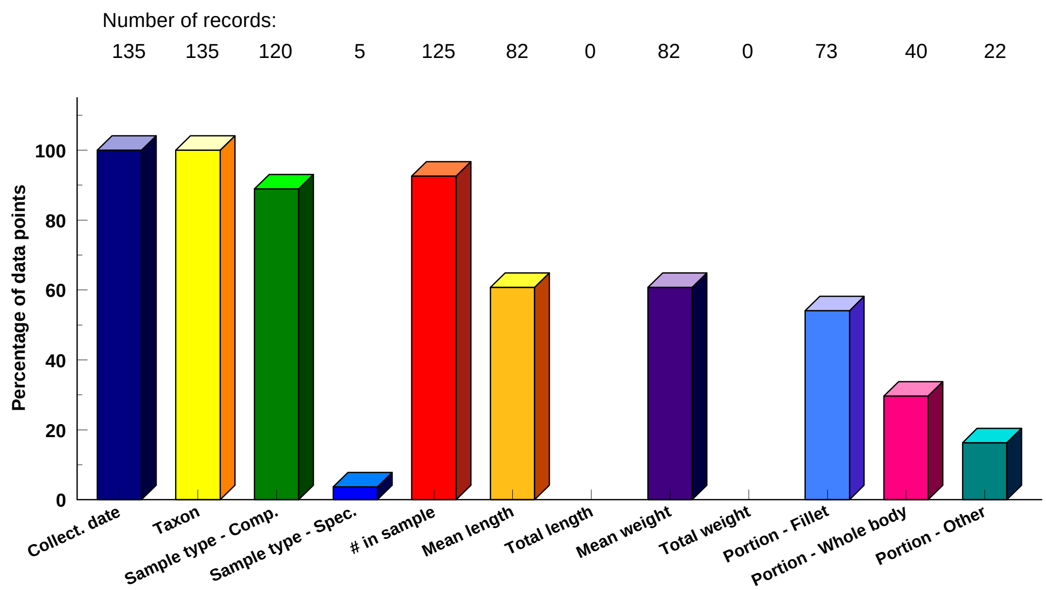


Top Ten Fish Species[a]

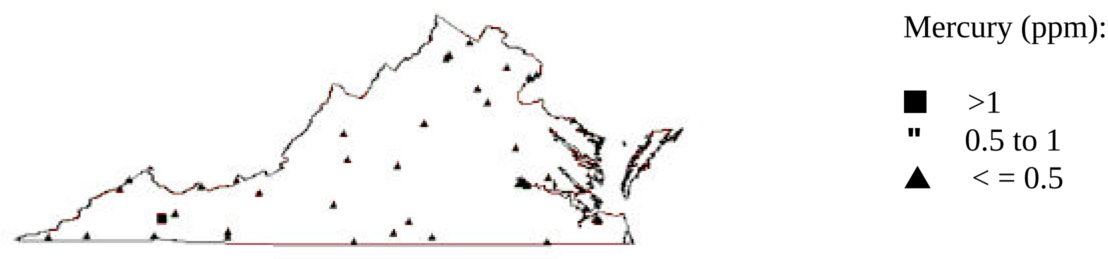
Common Name	Percent		Common Name	Percent
Redfin darter	18		Logfin smelt	8
Papio	18		American dab	7
Ocean pout	12		Calico surfperch	3
Coho salmon	11		Atlantic sturgeon	2
Jack	8		Yellowfin goby	2

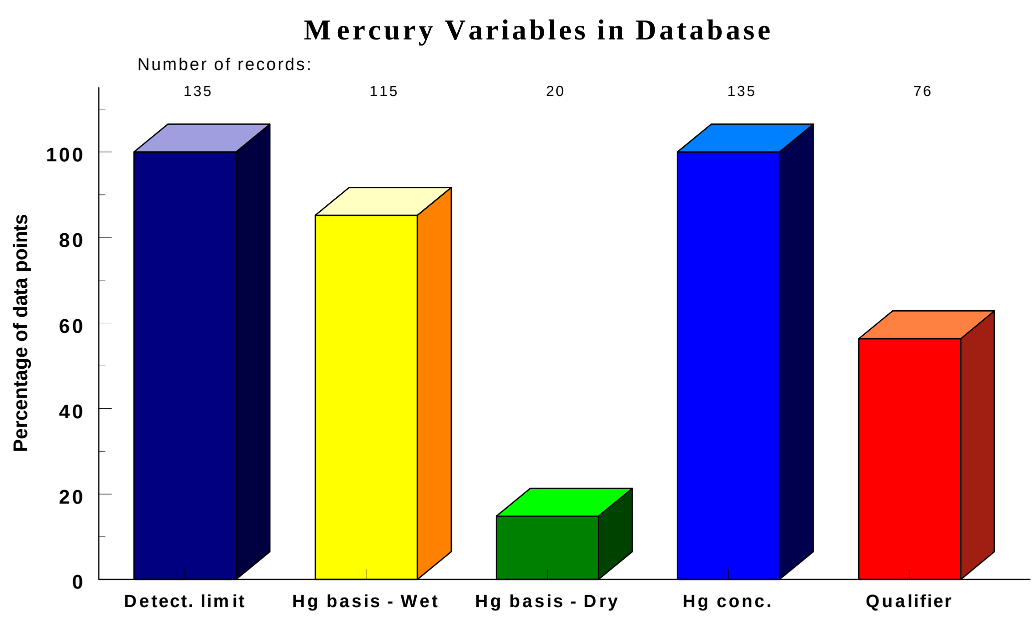
[a] Species identified as "Unknown" were excluded from this analysis.

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics									
			Mercury Statistics Weighted by No. of Fish in Sample[a]						
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Redfin darter	18	89	0.010	8.000	0.677	0.050	2.152	317.76
Papio	15	87	0.010	5.000	0.336	0.040	1.160	344.92
Ocean pout	12	60	0.006	0.100	0.035	0.030	0.033	93.03

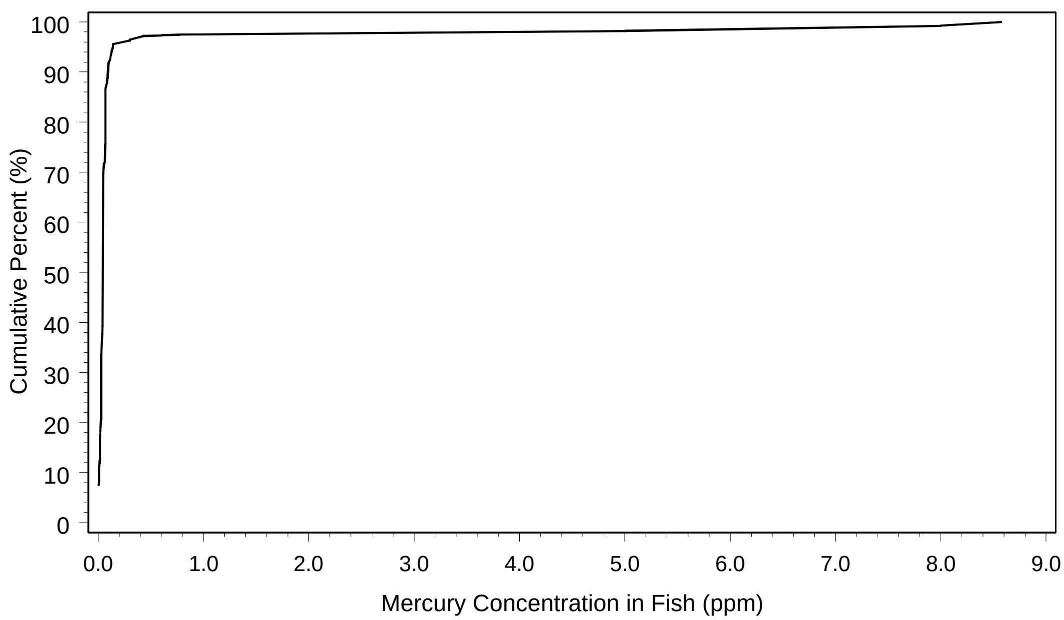
a Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

b Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

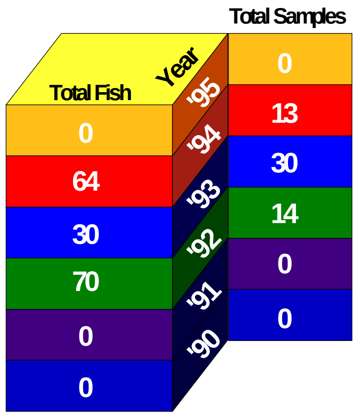
c Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \; / \; (\Sigma_i w_i - 1)}$

d CV = $(SD_w / \bar{x}_w) * 100$

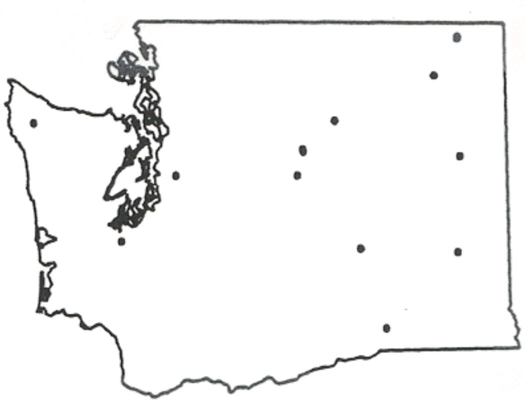
Cumulative Distribution of Mercury Concentrations
for All Fish Species in Virginia

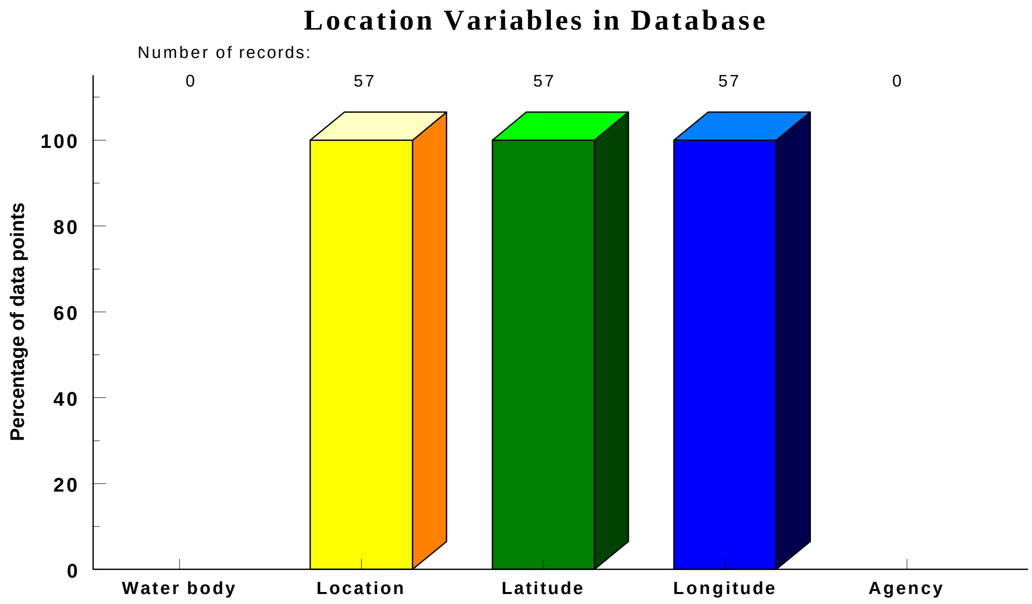


Records Analyzed by Year



Sampling Locations

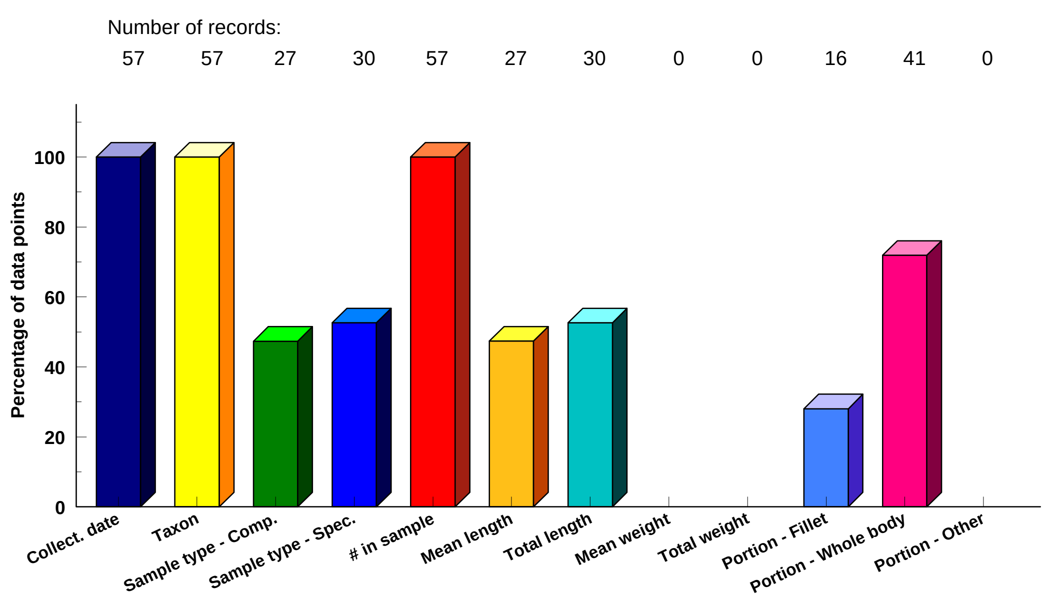




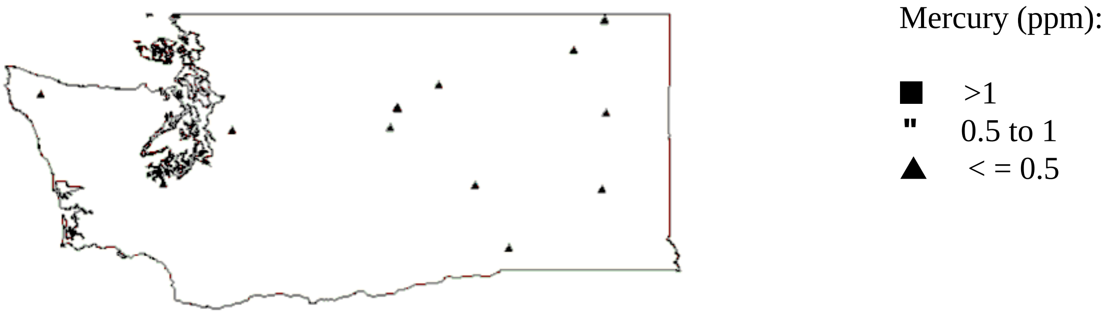
Top Ten Fish Species

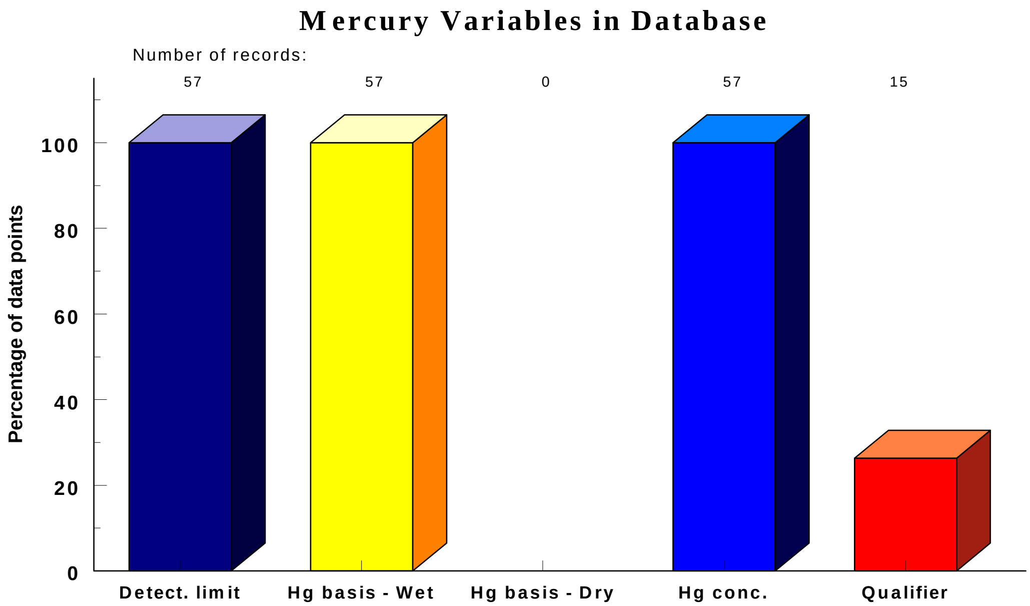
Common Name	Percent	Common Name	Percent
Largescale sucker	48	Common carp	3
Largemouth bass	12	Lake sturgeon	3
Rainbow trout	10	Mountain whitefish	3
Brown bullhead	9	Northern squawfish	3
Channel catfish	3	Yellow perch	3

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics									
			Mercury Statistics Weighted by No. of Fish in Sample[a]						
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Largescale sucker	40	79	0.036	0.496	0.166	0.157	0.087	52.72
Largemouth bass	4	20	0.024	0.350	0.137	0.087	0.129	94.13
Rainbow trout	3	16	0.020	0.053	0.032	0.026	0.015	45.72

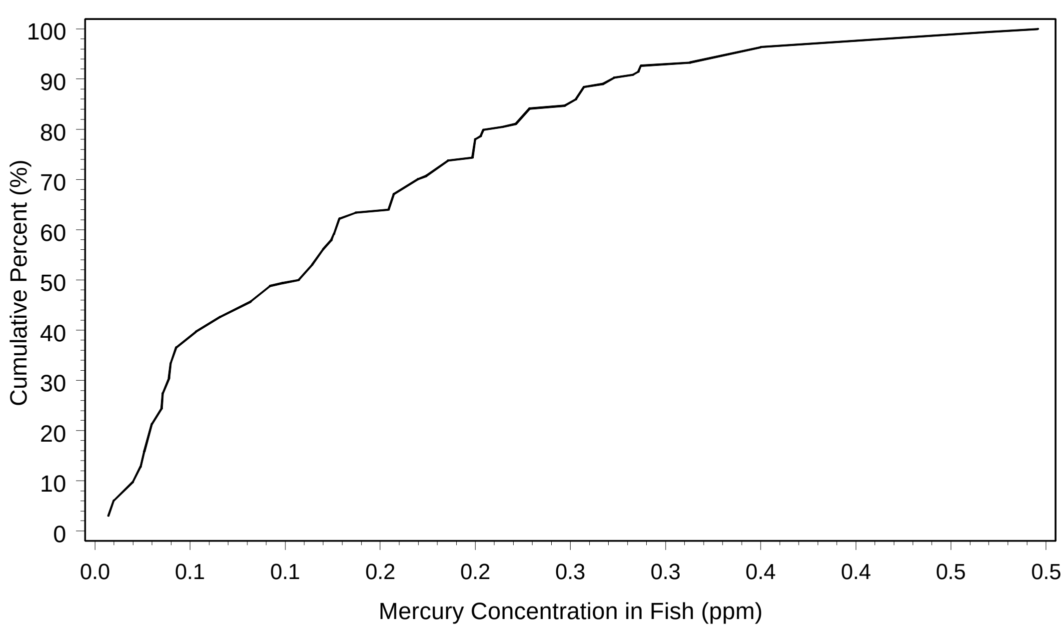
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

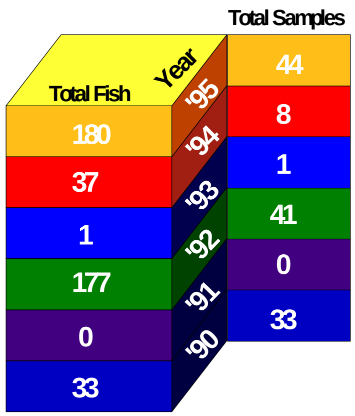
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \; / \; (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

Cumulative Distribution of Mercury Concentrations for All Fish Species in Washington

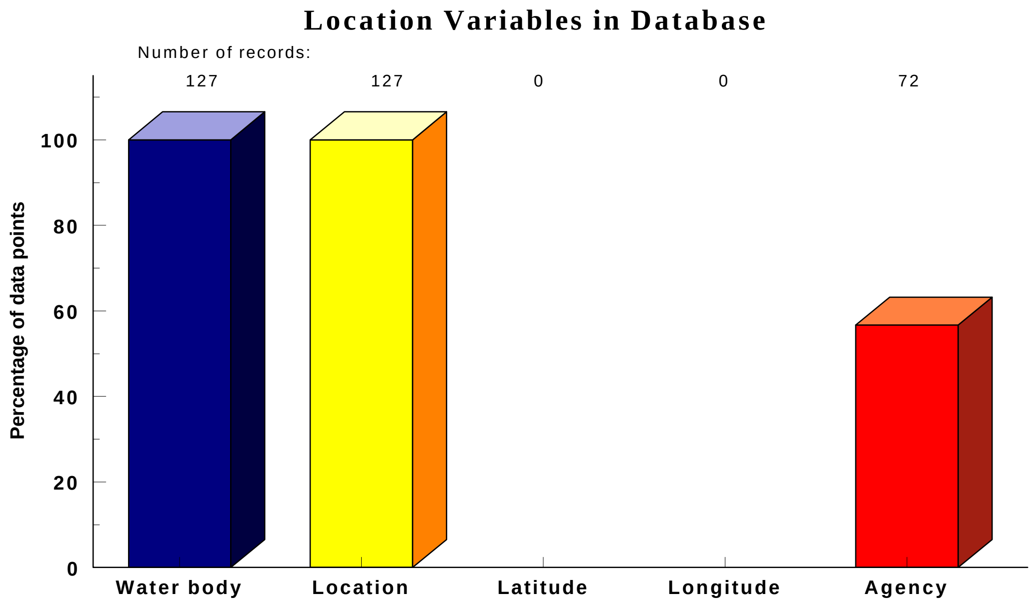


Records Analyzed by Year



Sampling Locations

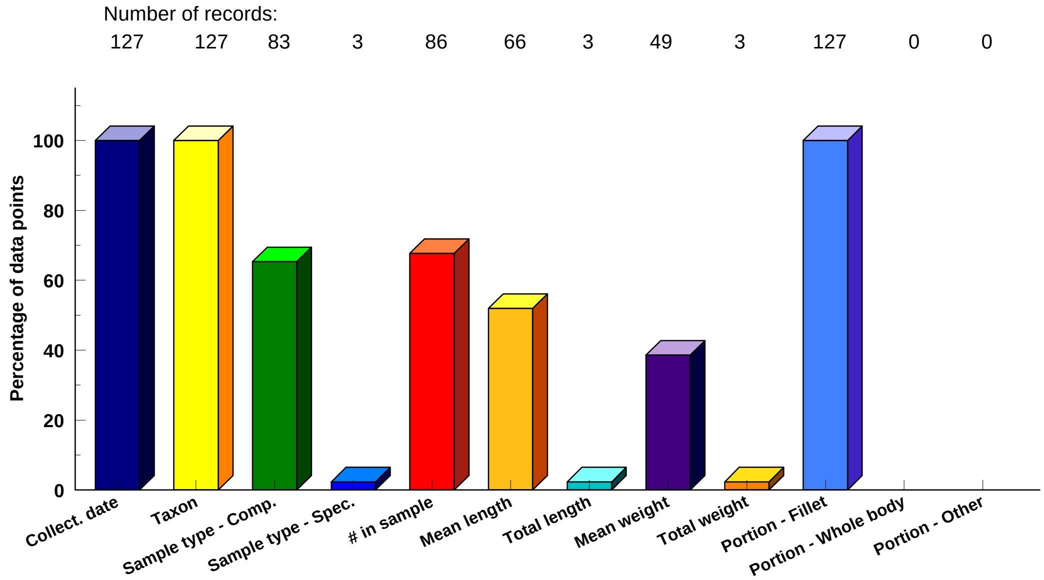
Latitude and Longitude Data Not Available



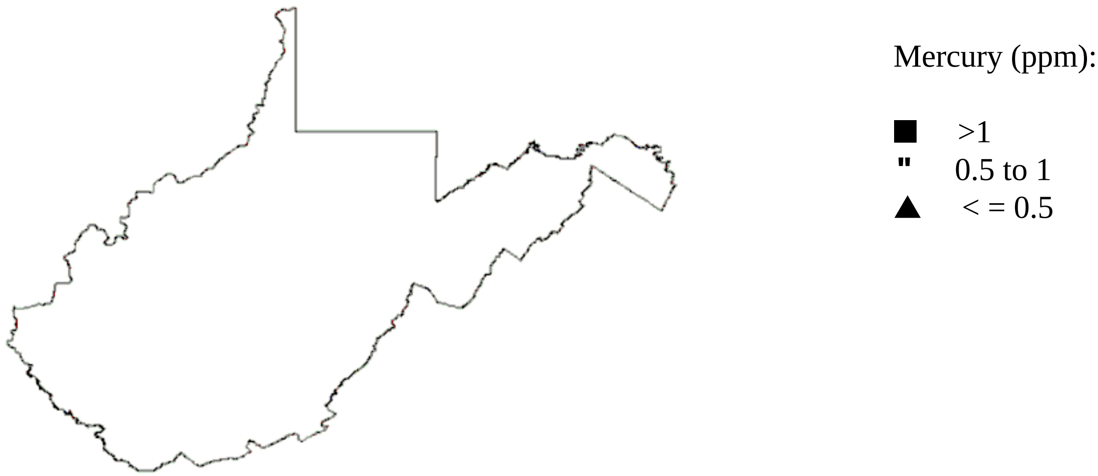
Top Ten Fish Species

Common Name	Percent		Common Name	Percent
Channel catfish	43		Bass	3
Common carp	12		Greater redhorse	3
Flathead sunfish	9		White bass	3
Smallmouth bass	8		White crappie	3
Hybrid bass	5		Sauger	3

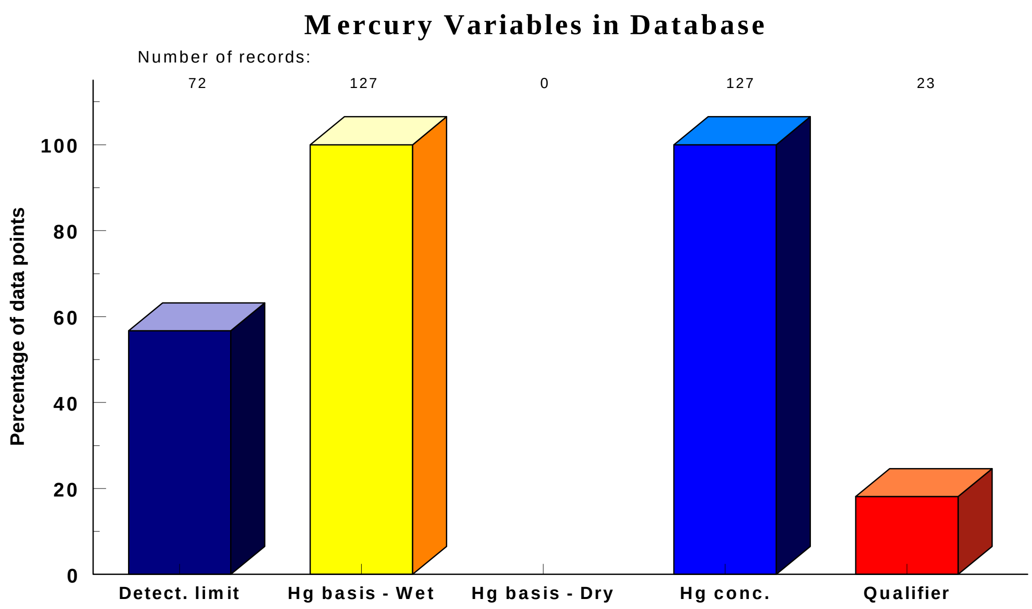
Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis



Latitude and Longitude Data Not Available



Mercury Concentration for the Three Most Abundant Species: Summary Statistics								
			Mercury Statistics Weighted by No. of Fish in Sample[a]					
Species	No. of Samples	No. of Fish	Min (ppm)	Max (ppm)	Wt. Mean (ppm)[b]	Wt. Median (ppm)	Wt. SD_w[c]	CV (%)[d]
Channel catfish	57	184	0.030	1.583	0.130	0.100	0.132	101.92
Common carp	14	52	0.056	0.287	0.179	0.155	0.073	40.88
Flathead catfish	10	38	0.100	0.340	0.223	0.225	0.042	18.88

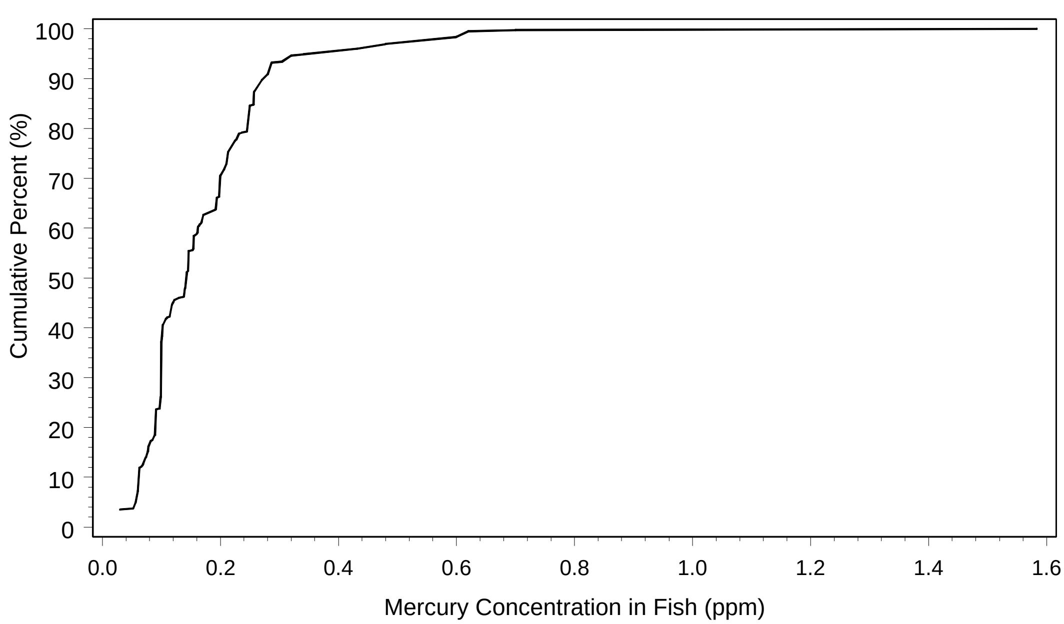
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

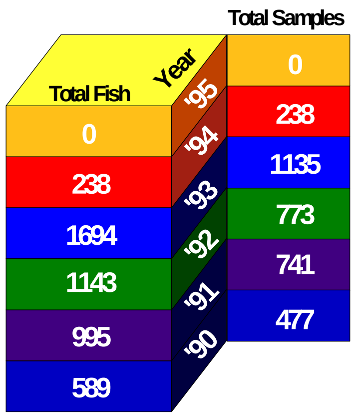
[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

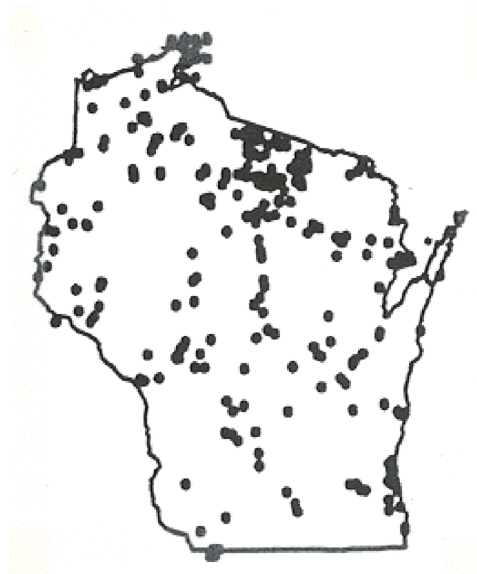
Cumulative Distribution of Mercury Concentrations
for All Fish Species in West Virginia



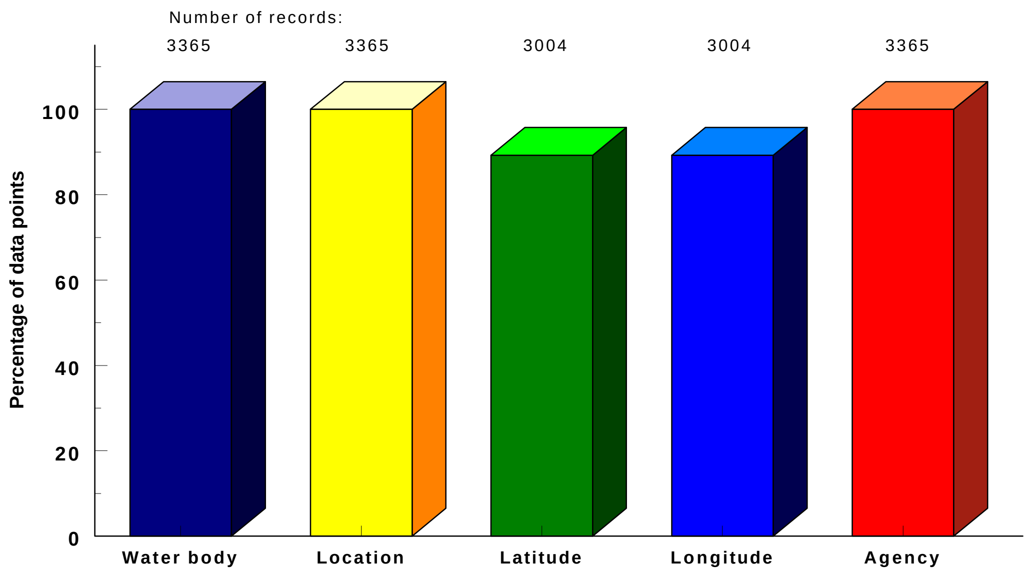
Records Analyzed by Year



Sampling Locations



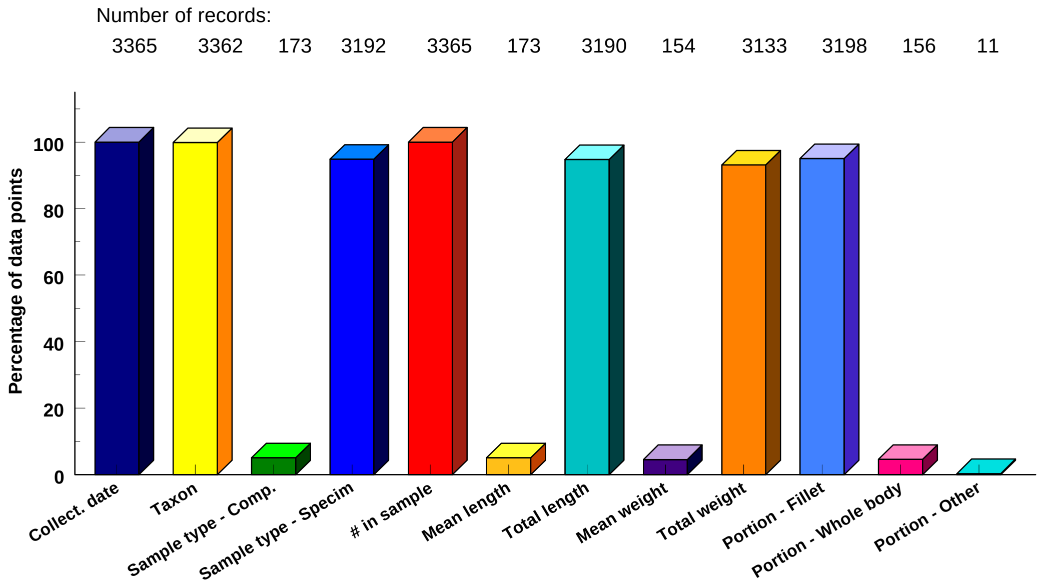
Location Variables in Database



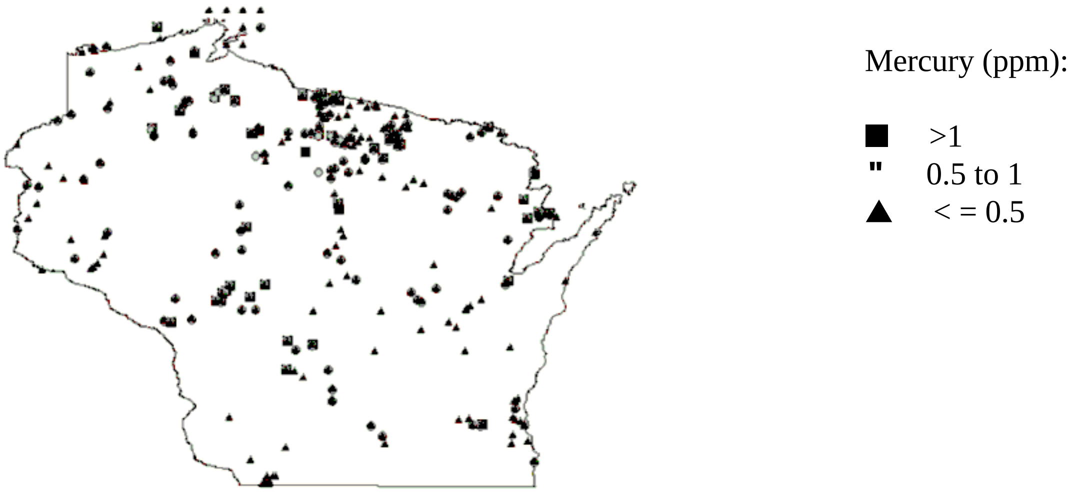
Top Ten Fish Species

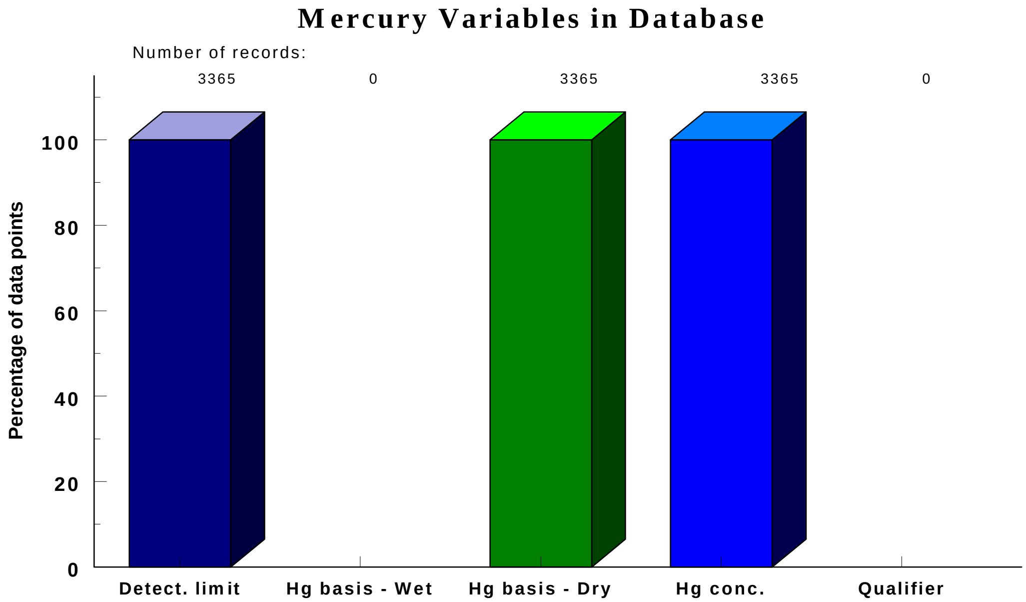
Common Name	Percent		Common Name	Percent
Walleye	26		Black crappie	6
Northern pike	11		Bluegill sunfish	5
Rainbow smelt	10		Smallmouth bass	4
Largemouth bass	7		Slimy sculpin	3
Yellow perch	6		Cyprinidae minnow	3

Fish Variables in Database



Geographic Distribution of Mercury Concentrations in Fish Tissue on a Wet Weight and Fillet Basis





Mercury Concentration for the Three Most Abundant Species: Summary Statistics									
			Mercury Statistics Weighted by No. of Fish in Sample[a]						
Species	**No. of Samples**	**No. of Fish**	**Min (ppm)**	**Max (ppm)**	**Wt. Mean (ppm)[b]**	**Wt. Median (ppm)**	**Wt. SD_w[c]**	**CV (%)[d]**
Walleye	1183	1218	0.022	1.800	0.440	0.380	0.286	64.95
Northern pike	478	491	0.030	1.600	0.317	0.280	0.192	60.54
Rainbow smelt	6	467	0.026	0.071	0.034	0.029	0.013	38.35

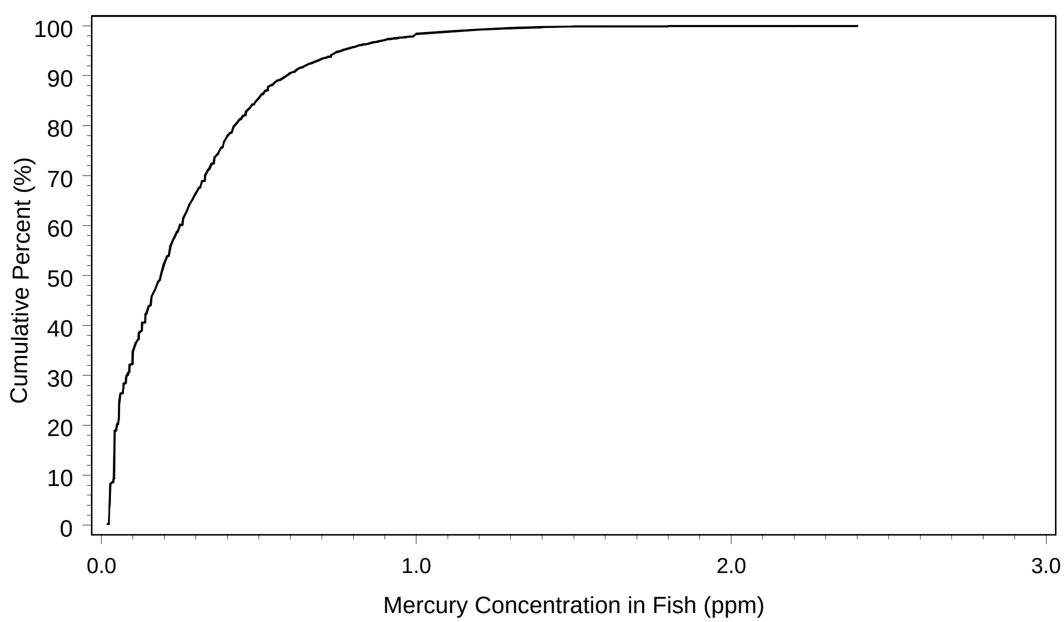
[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed.

[b] Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where *w* is the weight (# of fish in composite sample) and *x* is the average mercury concentration (ppm) in the composite sample.

[c] Weighted Standard Deviation: $SD_w = \sqrt{\Sigma_i w_i (x_i - \bar{x}_w)^2 \ / \ (\Sigma_i w_i - 1)}$

[d] $CV = (SD_w / \bar{x}_w) * 100$

Cumulative Distribution of Mercury Concentrations
for All Fish Species in Wisconsin



SECTION 4
ANALYSIS AND ANALYSIS ISSUES

4.1 VARIABILITY IN THE DATA BASE

Although the data from each state are standardized and were subjected to a thorough quality assurance process before being included in the data base, variability among the state data sets must be accounted for when performing interpretive analyses. Several factors contribute to variability in the data base, including those presented below:

- States collect data for purposes other than mercury analyses, and not all sampling strategies are based on a random sample. For example, data collected for the purpose of annual water quality monitoring may not produce the same results as a site-specific study of fish tissue mercury concentrations.

- States use different techniques, including electrofishing, trap nets and gill nets, angling, and trawling, to sample fish. The sampling techniques used by each state influence sample size, fish size, and fish type.

- States do not adhere to the same standards for assimilating a composite sample. Although grouping fish of the same species, size, and age is preferable, not all states have done so. The absence of a standardized method for grouping fish may result in grouping different species of fish into composites, which can affect both the representativeness of the sample and the results of analyses. For example, different results may be obtained from a composite with two species (i.e., brown and rainbow trout) than from a composite of known genus (i.e., trout), but unknown species.

- States use various analytical procedures to measure the concentration of total mercury in fish. Variation among analytical equipment, use of various protocols and procedures, and different levels of laboratory staff experience can all bias the assessment of mercury concentrations in fish. Mercury analyses reported on a wet weight basis cannot be directly compared to concentrations reported on a dry weight basis.

To assist States and Tribes in conducting consistent fish tissue sampling and analysis, EPA has published a guidance document covering topics such as target species selection, field procedures, lab procedures, and data analysis and reporting (EPA 1995b).

4.2 TREATMENT OF NON DETECTS

Several states reported mercury concentrations as “non-detected,” that is, the concentration of mercury was not detectable given the limitations of the analytical equipment or measurement method. For example, if the detection limit is 0.2 ppm, the sensitivity of the equipment and analytical procedures is insufficient to measure mercury concentrations less than 0.2 ppm.

When performing data analysis on mercury concentrations, non-detected concentrations, or “nondetects,” can be treated in several ways. For example, nondetects can be excluded from the analysis, decreasing the number of available records. If non-detected records are excluded from the analysis for the state of Alabama, for example, the number of fish analyzed decreases from 2,236 to 916. Alternatively, the detection limit for the particular mercury method can be used to provide an estimate of the mercury concentration. This approach does not decrease the number of records in the data base, but it does provide a conservative estimate of the mercury concentration. Less conservative treatment of nondetects assigns the mercury concentration equal to half the detection limit. The most non-conservative treatment is to assign a value of zero to all nondetects. This approach, however, may impact the analyses when a significant number of nondetects are present in the data base.

A sensitivity analysis was performed using two extreme treatments of nondetects to determine (1) the impact of removing all non-detected values from the data base, (2) the influence of setting nondetects equal to the detection limit, and (3) the effect of setting nondetects equal to zero. Table 4-1 presents the results analyzing the changes in the weighted mean and median mercury concentrations in fish for each state. The percent differences of mean mercury concentrations with varying treatment of non detects presented in Table 4-1 indicate that non detects may cause mean mercury concentration to vary by as much as 50 percent. For most states, however, the difference is within 10 percent. The percent difference is greater than 20 percent for Alabama, Delaware, Kentucky, and Oklahoma. A closer examination of the numbers reveals that most of the mean mercury concentrations are relatively low (below 0.5 ppm), even with the most conservative approach (i.e., setting non detects equal to the detection limit.) Therefore, the difference is not significant in practice, and the most conservative approach for all data analyses (i.e., set all non detects to the detection limit) was used.

The number of records analyzed for each treatment of the nondetects is also presented in Table 4-1. In the sensitivity analyses, the differences in the mean and median mercury concentrations among each of the three possible treatments of the nondetects may be influenced by the number of non-detect records in the data base. The magnitude of the detection limit also impacts the mean and median concentrations that result from incorporation of non detects into analyses. Although the detection limit generally is a fixed number for most states, the magnitude of the detection limit must be considered for those states that report multiple detection limits.

Table 4-1. Effects of Non-detected Observations on Mercury Concentrations in Fish[a]

St.	Total Observations Including Detected Records Only				Total Observations Including Both Detected and Nondetected (ND) Records								
					ND = 0				ND=Detection Limit				
	No. of Records	No. of Fish	Mean (ppm)	Med. (ppm)	No. of Records	No. of Fish	Mean (ppm)	Med. (ppm)	No. of Records	No. of Fish	Mean (ppm)	Med. (ppm)	% Diff.[b]
AL	208	916	0.364	0.240	472	2236	0.149	0.000	472	2236	0.296	0.170	49.63
AZ	51	51	1.147	1.060	51	51	1.147	1.060	51	51	1.147	1.060	0.00
AR	809	2307	0.673	0.590	829	2389	0.650	0.560	829	2389	0.654	0.560	0.56
CA	386	4289	0.151	0.086	409	4914	0.132	0.071	409	4914	0.135	0.071	2.35
CT	618	618	0.464	0.391	618	618	0.464	0.391	618	618	0.464	0.391	0.00
DE	48	129	0.078	0.062	69	190	0.053	0.042	69	190	0.070	0.050	24.54
DC	75	75	0.090	0.076	75	75	0.090	0.076	75	75	0.090	0.076	0.00
FL	2819	2819	0.604	0.510	2819	2819	0.604	0.510	2819	2819	0.604	0.510	0.00
GA	667	3068	0.172	0.100	745	3412	0.155	0.100	745	3412	0.162	0.100	4.25
IL	99	428	0.159	0.120	105	458	0.149	0.100	105	458	0.154	0.100	3.61
IN	502	1978	0.172	0.143	505	1987	0.171	0.143	505	1987	0.171	0.143	0.05
IA	130	545	0.146	0.110	132	549	0.145	0.110	132	549	0.145	0.110	0.00
KS	193	755	0.164	0.150	193	755	0.164	0.150	193	755	0.164	0.150	0.00
KY	200	828	0.276	0.156	248	1323	0.173	0.020	248	1323	0.249	0.167	30.70
LA	1021	1021	0.318	0.236	1093	1093	0.297	0.212	1093	1093	0.298	0.212	0.10
ME	352	1547	0.499	0.410	354	1557	0.496	0.400	354	1557	0.496	0.400	0.00
MD	317	799	0.041	0.026	317	799	0.041	0.026	317	799	0.041	0.026	0.00
MA	550	550	0.285	0.233	550	550	0.285	0.233	550	550	0.285	0.233	0.00
MI	4199	5063	0.233	0.170	4199	5063	0.233	0.170	4199	5063	0.233	0.170	0.00
MN	5361	21145	0.225	0.160	5450	21537	0.221	0.160	5450	21537	0.221	0.160	0.00
MS	378	1127	0.575	0.510	378	1127	0.575	0.510	378	1127	0.575	0.510	0.00
MO	390	2061	0.126	0.119	402	2077	0.125	0.119	402	2077	0.125	0.119	0.00
NE	271	1022	0.184	0.141	271	1022	0.184	0.141	271	1022	0.184	0.141	0.00
NH	169	185	0.359	0.250	177	199	0.334	0.230	177	199	0.341	0.230	2.06
NJ	373	373	0.530	0.280	373	373	0.530	0.280	373	373	0.530	0.280	0.00
NM	350	350	0.454	0.290	467	467	0.340	0.210	467	467	0.365	0.210	6.86
NY	968	968	0.394	0.310	993	993	0.384	0.310	993	993	0.385	0.310	0.31
NC	2808	4640	0.383	0.230	2808	4640	0.383	0.230	2808	4640	0.383	0.230	0.00
OH	1457	4547	0.133	0.109	1531	4739	0.127	0.106	1531	4739	0.130	0.108	1.91
OK	342	1644	0.289	0.190	550	2916	0.163	0.100	550	2916	0.211	0.140	22.75
OR	554	887	0.304	0.186	585	935	0.289	0.180	585	935	0.292	0.180	1.15
PA	276	1102	0.232	0.178	301	1127	0.227	0.170	301	1127	0.228	0.170	0.42
SC	498	592	1.085	0.985	675	826	0.777	0.530	675	826	0.850	0.530	8.53
TN	230	230	0.253	0.195	297	297	0.196	0.170	297	297	0.219	0.170	10.32
TX	199	410	0.210	0.150	248	673	0.128	0.060	248	673	0.154	0.086	16.86
VT	201	498	0.464	0.340	205	514	0.449	0.330	205	514	0.451	0.330	0.34
VA	58	268	0.534	0.057	133	676	0.212	0.000	133	676	0.237	0.050	10.60
WA	56	159	0.133	0.114	57	164	0.129	0.111	57	164	0.129	0.111	0.00
WV	104	345	0.173	0.143	127	428	0.139	0.108	127	428	0.172	0.143	18.92
WI	3364	4659	0.264	0.190	3364	4659	0.264	0.190	3364	4659	0.264	0.190	0.00

[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed. Weighted Mean $\bar{x}_w = \sum_i w_i x_i / \sum_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

[b] Percent Difference = ($|x - y|$ / x) * 100, where x = mean concentration when ND=Detection Limit, and y = mean concentration when ND=0.

4.3 MERCURY CONTENT FOR DIFFERENT CATEGORIES OF FISH

Recognizing the limitations in the quantitative aspects of the data (see Section 4.1), this data base can be used to explore potential nationwide differences in mercury concentrations of various categories of fish. While such an analysis may be possible to conduct on a state-by-state basis, we examined the data on a national basis only, due to limitations in sample sizes within some states.

For this examination, an EPA data base (EPA 1997) that sorts fish species into categories on the basis of scientific name is used. Each species name in the program is coded according to whether it is resident (remaining for most of its life cycle within a given body of water) or migratory (periodically moving from one body of water to another during its life cycle, such as migrating to the ocean from a high-mountain river); demersal (bottom-water habitat) or pelagic (open-water habitat); and edible (typically consumed by humans) or inedible (typically not eaten by humans).

The data base contains common and scientific names that are coded according to these categories:

1. Resident (r) versus migratory (m);
2. Edible (e) versus inedible (i); and
3. Demersal (d) versus pelagic (p).

The fish information was sorted into two classes in each of the three categories by fish name. This analysis is incomplete, because matches could not be made for all fish species in the data base, and not all data currently included in the data base were used (additional data from CT, MA, MI, MN, NJ, and WV were added subsequent to this analysis). Distribution functions of the cumulative percent of fish species versus mercury concentration in tissues (in ppm) were generated with the results for resident versus migratory in Figure 4-1; for edible versus inedible in Figure 4-2; and for demersal versus pelagic in Figure 4-3. Summary statistics including the minimum, maximum, weighted mean, and the mercury concentration for the 50^{th}, 75^{th}, 80^{th}, 90^{th}, 95^{th}, and 99^{th} percentiles for the distributions, are shown in Table 4-2. These figures and tables indicate that higher mercury concentrations occurred in resident fish than in migratory fish. Higher mercury concentrations were also observed in pelagic than in demersal fish species, and edible fish have higher mercury concentrations than inedible ones.

Figure 4-1. Cumulative Distribution of Mercury Concentrations in Resident & Migratory Fish

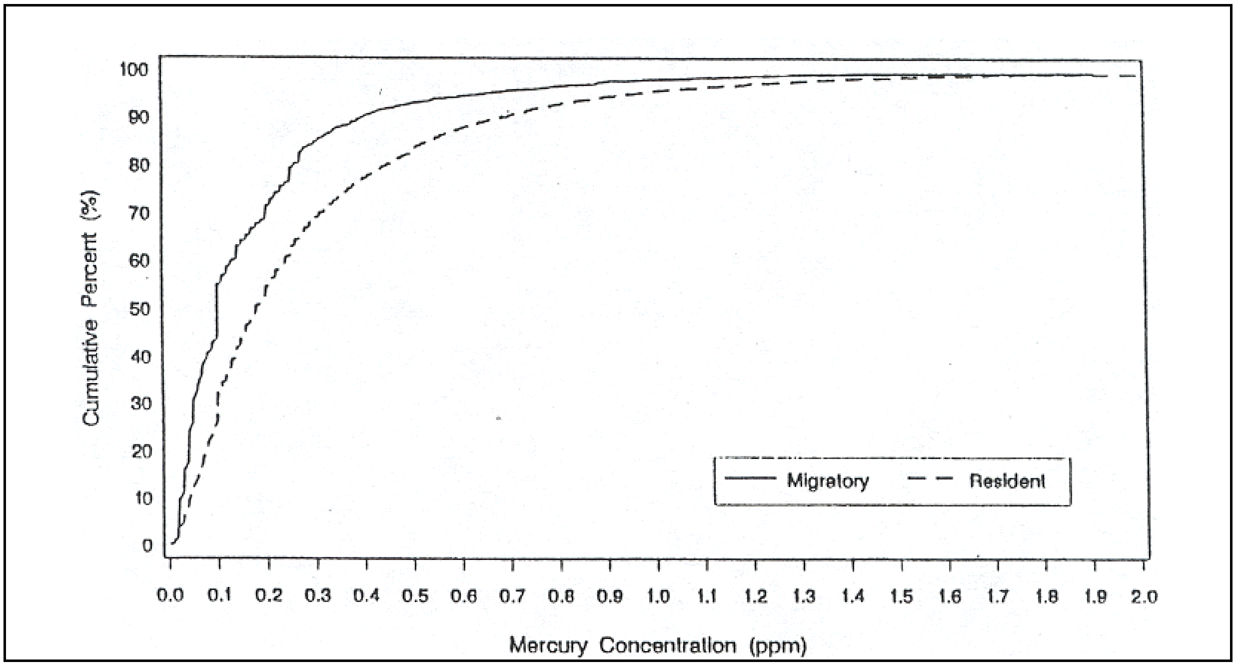


Figure 4-2. Cumulative Distribution of Mercury Concentrations in Edible and Inedible Fish

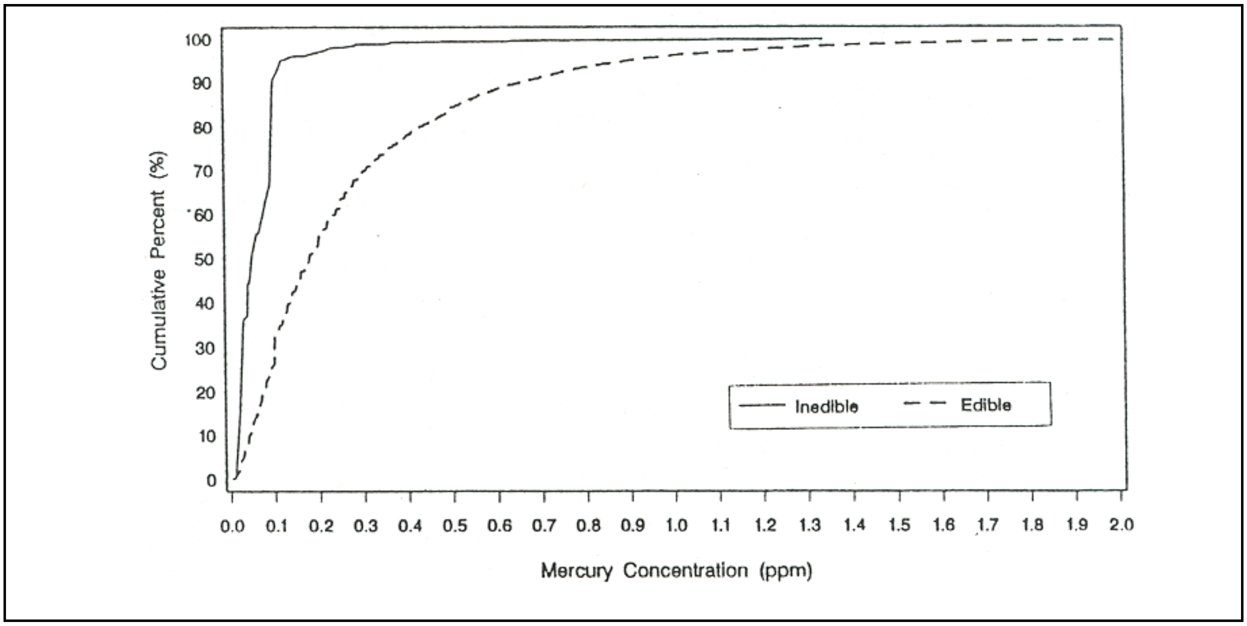


Figure 4-3. Cumulative Distribution of Mercury Concentrations in Demersal and Pelagic Fish

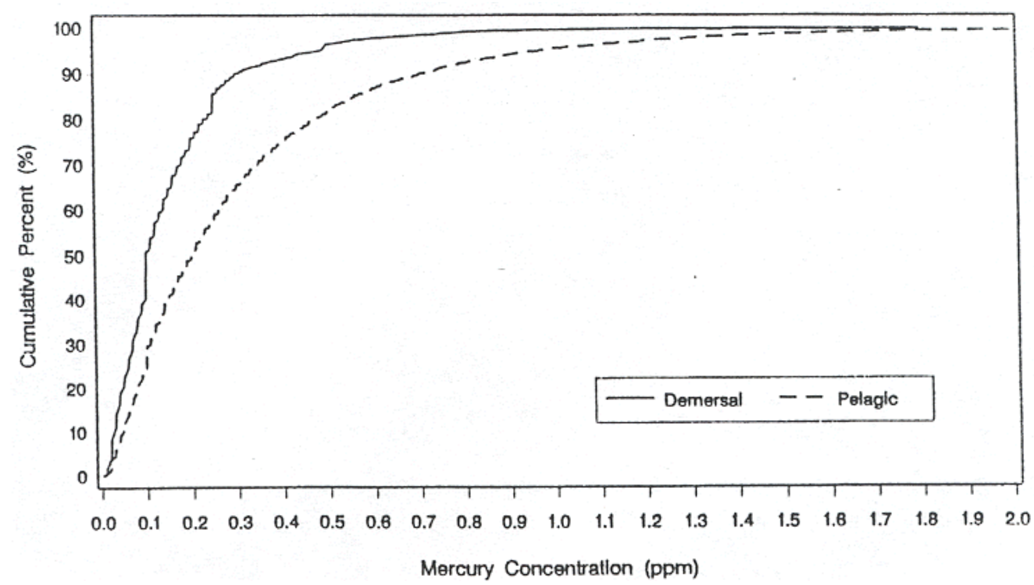


Table 4-2. Weighted Mean and Mercury Concentration (ppm) by Percentile for Different Categories of Fish[a,b]

Category	No. of Fish	Min. Hg (all fish)	Mean Hg (all fish)	Max. Hg (all fish)	Mercury Concentrations for the following Percentiles (all fish):					
					50th[c]	75th	80th	90th	95th	99th
Resident	54,800	0.001	0.30	8.00	0.18	0.37	0.45	0.68	0.94	1.66
Migratory	6,129	0.001	0.19	6.00	0.10	0.23	0.26	0.40	0.64	1.20
Demersal	14,797	0.001	0.16	8.00	0.10	0.20	0.23	0.30	0.49	0.80
Pelagic	46,781	0.001	0.31	7.59	0.20	0.40	0.48	0.71	0.97	1.63
Edible	61,509	0.010	0.29	7.59	0.18	0.36	0.43	0.66	0.92	1.61
Inedible	2,738	0.001	0.09	8.00	0.05	0.10	0.10	0.10	0.13	0.37

[a] Note: If the number of fish in the composite sample is missing, a value of 1 was assumed. Weighted Mean $\bar{x}_w = \Sigma_i w_i x_i / \Sigma_i w_i$, where w is the weight (# of fish in composite sample) and x is the average mercury concentration (ppm) in the composite sample.

[b] Not all data currently in the data base were used in this analysis (additional data from CT, MA, MI, MN, NJ, and WV were added subsequent to this analysis).

[c] This column is to read as follows: Fifty percent of the fish species in this category have median concentrations less than or equal to 0.18 ppm. Other columns can be similarly interpreted.

4.4 ADDITIONAL DATA

The national mercury data base represents a first step in assembling a nationwide source of information that can be used to form hypotheses regarding potential accumulation of mercury in geographical “hot spots” or in particular species of fish. The utility of the data base for quantifying mercury contamination on a national basis or with regard to a particular type or species of fish can be improved by incorporating additional environmental and biotic variables, as discussed in the following subsections.

4.4.1 Environmental Parameters

***pH*:** Fish in poorly buffered waters may accumulate elevated levels of mercury, as the tendency for mercury to bioaccumulate appears to be inversely correlated with pH and alkalinity (or acid-neutralizing capacity) in many aquatic systems (Wren and MacCrimmon, 1983). Deposition of air-borne pollutants from the Midwest and other places in combination with bedrock geology and watershed characteristics have reduced the natural buffering capacity of many water bodies in the United States. Acidification of water bodies via atmospheric deposition from anthropogenic sources not only subjects the fish to stress from the acid, but may also increase exposure to metals; acidification increases the mobilization of metals from soils and sediments by altering the partitioning of methylmercury between the water and sediments. In addition to increased availability, acidification of lakes impacts fish uptake of mercury by enhancing optimum conditions for methylation by microbial populations. For example, the rate of microbial production of methylmercury is reported to be highest in lakes with pH ranging from 6 to 6.5 (Fagerstrom and Jernelov, 1972). The relationship between pH in water bodies and the mercury concentrations in fish from those water bodies has been characterized using correlation and regression analyses (Hanten, et al., 1997; NJDEP, 1994; Rose, et al., 1999).

***Calcium*:** In addition to low pH, the bioavailability of methylmercury is enhanced by decreased levels of calcium in water bodies. Substantial literature detailing the interaction of calcium and metal regulation by aquatic organisms suggests this cation plays an important role in determining mercury levels in fish tissue (Wren and MacCrimmon, 1983). Increased gill permeability at low calcium levels (Spry et al., 1981) or competition between metals and calcium for cellular binding sites (Zitko and Carson, 1976) is thought to be the mechanism of this effect.

***Regional or Climatic Trends*:** In temperate waters, the accumulation of mercury by fish is most rapid in summer, when feeding and metabolic rates of fish and microbial production of methylmercury are highest (Weiner and Spry, 1994). Analyzing the relationship between water temperature and mercury concentrations in fish on a national basis may provide insight on which regions of the nation may be more prone to higher mercury concentrations in fish due to geographical location. Although water temperature is not a variable available in the data base, analyzing the mercury concentrations in fish species by season, using collection date as a surrogate for temperature, may be a promising preliminary step to examining regional trends.

***Volume and Depth*:** Wren and MacCrimmon (1983) reported that environmental parameters such as lake volume and depth are important variables in explaining mercury concentrations in the fish species commonly known as pumpkin seeds. This study postulated that shallow-water species are exposed to a larger proportion of sediments containing mercury in the epilimnion and in the littoral zone. Whole-lake experiments suggest that mercury tends to enter food chains more rapidly in small, shallow lakes with high littoral-to-pelagic area ratios than in large, deep lakes. Organisms that live, reproduce, and feed in the surface of water bodies experience much different exposures than those that live, reproduce, and feed on seston and detritus in the water column. Exposure of species that inhabit the benthic zone will also differ. Thus, additional information on volume and depth of the aquatic system (e.g., river, small stream, lake) from which fish samples were taken, as well as information on the sampling depth or feeding habitats, may be useful.

***Lake Classification*:** Improved descriptions of whether a water body is a seepage lake or a drainage lake may be useful in examining mercury concentrations in fish. Mercury concentrations in seepage lakes, which lack surface inflows, are generally not as high as mercury concentrations in drainage lakes. In addition to direct influxes of mercury through wet and dry deposition, drainage lakes also receive indirect contributions of mercury from runoff in the watershed. Runoff enhances the amount of mercury entering a lake either by directly supplying mercury from watershed soils or by supplying organic material to which mercury is bound. The transport of organically bound mercury from the watershed thus increases the supply of mercury available to fish (Zillioux et al., 1993). More definitive lake classification may therefore enhance the understanding of mercury concentrations in fish tissue.

***Wetlands*:** Concentrations of methylmercury tend to be higher in surface waters that drain wetlands than in other waters. Wetlands, which may direct and supply discharges of mercury wastes or runoff from mercuriferous sources, can confound interpretations of atmospheric mercury deposition. The Florida Everglades and Davis Creek Reservoir in California provide examples of the importance of wetlands and watershed runoff as sources of mercury. Although Lindqvist et al. (1991) state that mercury runoff from watersheds is reduced when wetlands are present, wetland transport of mercury from watersheds can occur because of the strong association of mercury species with organic matter. Wetland disturbance and the creation of new reservoirs increase the mobility of organic matter, suggesting that mercury may be mobilized and thus become available to fish from both natural and anthropogenic sources.

***Nutrient Conditions*:** Incorporating nutrient conditions or trophic status of the aquatic system into the data base would be informative. Akielaszek and Haines (1981) reported higher levels of mercury in trout from oligiotrophic (nutrient-poor) waters than in trout from eutrophic (nutrient-rich) waters in unpolluted areas in Maine. Position in the trophic food web and difference in available foods are important factors influencing the degree of bioaccumulation of mercury in fish, but complexation and precipitation reactions that normally decrease the availability of trace elements can also be important determinants. Such reactions are less predominant in oligotrophic waters. Therefore, the mercuric ion (Hg^{+2}) and methylmercury, which both have a strong affinity for organic substances, are methylated in sediments or in the water column and subsequently are accumulated in fish in oligiotrophic lakes in greater concentrations than in fish in eutrophic lakes.

4.4.2 Fish Parameters

***Diet*:** The trophic structure of a water body influences mercury concentrations in fish, particularly for piscivorous fish species. Thus, information in the data base regarding feeding habits and food-chain structure would be useful for analyzing the dietary influence of methylmercury uptake in fish. Studies show that lake trout, *Salvelinus namaycush,* have higher mercury concentrations when forage fish, such as rainbow smelt, *Osmorius mordax*, are present (Akileaszek and Haines, 1981). Similarly, mercury concentrations in northern pike in a Finnish lake lacking forage fish are approximately one-fourth those in northern pike in a nearby, similar lake with forage fish (Weiner and Spry, 1994).

***Age*:** Field studies indicate that most fish accumulate mercury throughout their lives. Thus, age—and consequently size—of the fish are variables that impact the bioaccumulation of mercury. In addition to increasing with age, mercury concentrations in fish tissue changes as the diet of the maturing fish changes. The rate of methylmercury accumulation in lake trout, for example, increases when the trout becomes large enough to switch from a diet of invertebrates to a diet of forage fish. Age would be an important variable to examine in fish that become completely piscivorous as adults. While very few states collect age data, many states record length and weight, which may be used as indicators of fish age. With this information, future analyses can more carefully examine the relationship between fish species, age, and mercury concentration.

***Mercury Intoxication*:** Recording symptoms of methylmercury intoxication in laboratory toxicity can be useful. Symptoms of acute mercury poisoning of fish include increased secretion of mucous, flaring of gill covers, increased rate of respiration, loss of equilibrium, and sluggishness. Signs of chronic poisoning include emaciation (due to reduced food intake), brain lesions, cataracts, inability to capture food, abnormal motor coordination, and various erratic behaviors. Although it may be difficult to discern in field settings, the presence of such symptoms, coincident with high concentrations of mercury in fish tissue, would serve to strengthen any diagnoses of methylmercury toxicity.

4.5 Predictive Statistical Analysis

Many researchers have examined fish parameters, source parameters, environmental parameters, and location parameters and performed studies to relate these parameters to the associated mercury concentration in fish. The goals of these studies are to understand the factors causing or contributing to mercury accumulation and to gain the ability to predict mercury accumulation both in the present and in the future. Two general types of approaches have been used in these studies. *Mechanistic* approaches aim to express chemical, physical, and biological processes mathematically, whereas *empirical* approaches aim to explain relationships quantitatively using statistics, regardless of the specifics of the underlying natural processes. These approaches are complementary and, when both approaches are fully developed and produce the same results, the greatest level of understanding and verification is achieved. Empirical approaches are quite useful for addressing problems such as mercury accumulation in fish where the underlying natural processes are highly complex, are poorly understood or described, and require basic research to fully express in mathematical terms. Both approaches require high-quality data, assembled and organized in an accurate and logical manner.

Making use of the data compiled, EPA has initiated an empirical study of the fish parameters and location parameters contained in this data base with additional source parameters and environmental parameters that have been linked to mercury accumulation in fish from past mechanistic and empirical studies. EPA's initial efforts have focused on a region in the southeastern United States (Alabama, Arkansas, Louisiana, and Mississippi), where sufficient data are available, to demonstrate a statistical approach for building a predictive model. This exercise involves conducting a three-part statistical analysis, performed sequentially in a hierarchical fashion. EPA anticipates that this approach, once fully developed and reviewed, can produce reasonable predictions of mercury concentrations in fish from a subset of fish parameters, environmental parameters, and location parameters.

The objective of this statistical analysis is to explain the variability of mercury concentrations associated with various contributing factors (such as water body pH, proximity to sources of mercury, fish species, and fish size), as well as the inherent spatial variability, using established advanced statistical methods. The first step in this analysis is to apply classification and regression tree (CART) modeling to identify important variables in explaining the variance of mercury concentrations. CART is a particularly useful technique to apply to non-continuous category variables. For example, CART modeling could reveal a split in the data based on *State* (presumably reflecting the variability inherent in different state sampling and analysis methods, as well as geographic variability) or a split by *Genus* of fish (presumably reflecting differences primarily in feeding behavior). The remaining variance in the data is analyzed using generalized additive modeling (GAM), a nonparametric regression technique for revealing nonlinear relationships. The GAM analysis can help reveal statistically significant predictor variables such as *pH* of the water body (higher mercury concentrations would be expected in waters with lower pH) or fish *Weight* (higher mercury concentrations would be expected in heavier fish, reflecting greater exposure duration). Once large-scale trends have been removed, the final step of the analysis is to apply universal kriging (a second-order polynomial function of spatial *Latitude* and *Longitude* coordinates) to account for spatial trends in the data.

The resulting predictive model has great promise for application to this and other data compilation efforts. Predictive models using the same general approach of CART, GAM, and kriging could be constructed for various regions of the country and could result in different sets of predictor variables. The predictive model can also be refined to better account for important variables that can be added to the analysis as they become available. The model approach may be useful for predicting mercury concentrations in fish for waters within a particular study region that have not yet been sampled, and thus has conceivable utility for a variety of potential management applications. EPA intends to continue these efforts and anticipates posting additional information and a description of an example predictive model for the southeastern U.S. study area on the Agency web site at www.epa.gov/ost in the future as it becomes available.

4.6 Potential Future Uses of the Data Base

The national mercury data base may be used in the future to examine trends in mercury concentrations across ecoregions. Using the data base across a multi-state region, perhaps by ecoregion or watersheds, would be informative for several reasons. Examining the data by ecoregions would provide a more holistic picture of the issues relevant to different geographical areas. Mercury concentrations tend to vary across states. For example, in the Southeast, mercury concentrations in fish tissue from the coastal plain are generally higher than those found in the Piedmont or the montane regions.

Future analysis by ecoregion may enhance the understanding of the relationships among mercury concentration, geographic location, and environmental characteristics particular to a type of aquatic system. For example, acidic, organic-rich black waters commonly found in the southeastern coastal plain will methylate mercury, making toxic forms of mercury more available to fish. Analyzing the data by ecoregions may provide additional insight on potential sources of mercury. For example, mercury may originate from non-localized sources such as incinerators or from localized land-use modifications, such as mining operations, that liberate mercury from the crust of the earth.

Addressing mercury concentrations by ecoregion would require state geologic survey groups to assist with assigning appropriate mapping coordinates. Mapping mercury concentrations in fish tissue by ecoregions, particularly showing the relationship between concentration and elevation, provides a useful means of presenting the data. Geographic Information System (GIS) mapping software packages, which allow the integration and layering of data, could be used to examine the impacts that pH, alkalinity, hardness, dissolved organic carbon, and other water quality characteristics have on mercury speciation, solubility, and complexation. Also, mapping that allows data integration would be useful for identifying the contribution of mercury from localized and non-localized sources.

SECTION 5
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THE NATIONAL SURVEY OF MERCURY CONCENTRATIONS IN FISH

DATA BASE SUMMARY 1990 - 1995

APPENDIX

REQUEST FOR MERCURY CONCENTRATIONS IN FISH TISSUE DATA

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
WATER

Mr. Brian Farkus
Public Information Officer
WV Division of Environmental Protection
10 McJunkin Road
Nitro, West Virginia 25143-2506

Dear Mr. Farkus:

We are writing to request your assistance on an issue of continuing concern to many States and the U. S. Environmental Protection Agency (EPA) -- the widespread occurrence of mercury in fish tissues. Because of this concern, EPA has begun a project to protect human health by developing a more detailed national picture of the nature and extent of mercury contamination. To do this, we need to examine the detailed data that underlie one portion of the 305(b) water quality reports that your State submits to EPA.

Section 305(b)(1) of the Clean Water Act requires each State to prepare and submit a water quality assessment to the EPA Administrator. As you are aware, the 305(b) report contains a detailed description of a State's water quality including an evaluation of each State's attainment of "fishable and swimmable" goals of the Act. The fishable goal is evaluated in that portion of the report devoted to fish consumption, shellfishing, and aquatic life support uses.

EPA uses the 305(b) reports, in part, to target persistent and emerging water quality problems. Our review of the 305(b) reports, EPA's database of State-issued fish consumption advisories, and other references confirms that human exposure to mercury contamination in fish is an important public health concern. For example, our updated fish advisory database reveals that many States have issued new or revised mercury advisories during the past several years. Unfortunately, the advisory information that States provide to EPA usually does not include the detailed fish tissue monitoring data.

We are, therefore, writing to the fish consumption advisory contact for each State. We are requesting your help in gathering copies of existing fish tissue monitoring data for mercury that may have been collected during the last five years (FY91-95). We would appreciate an electronic copy of your State's data in

Recycled/Recyclable Prepared with Vegetable Oil Based Inks on 100% Recycled Paper (40% Postconsumer) whatever format the data is stored in, especially if it can be converted and imported into a DBASE-compatible database. We are not asking you to duplicate any information that exists in national databases such as STORET; if your State's data is in a national database, simply identify where such information exists and we will access it. We are also requesting copies of existing written reports on mercury in fish tissue that your State may have completed within the last three to five years. Other available, closely-related technical analyses would also be helpful. We are prepared to offer any technical assistance needed to respond to this request.

This compiled information will have two primary uses. One is to strengthen EPA technical assistance to States with fish consumption advisories. Many States have banded together to establish Regional "mercury task forces" which meet to share information about mercury-related fish consumption advisories. One of our objectives is to compile and store state fish tissue data in an interim database, if feasible. When this electronic "library" becomes available, it should be a valuable service to the state mercury task forces since it will help them compare their data sets.

EPA will also develop a preliminary national characterization of the mercury issue. We will develop a qualitative overview that looks at issues such as: availability of data and ongoing sampling efforts, fish tissue concentrations, and factors that might influence tissue concentrations (sources, associations with particular methylating environments or ecoregions, etc.). Since several States have intensive research efforts underway, EPA will consult with States individually as with state coalitions. We believe this national review will provide a valuable perspective to state agencies. Eventually, the Office of Water will use the compiled information to improve its overall water quality assessment process, including a detailed "snapshot" of the mercury issue in the next 305(b) Report.

Please send the above-requested information to: Mr. Rick Hoffmann (4305); EPA; 401 M St., S.W.; Washington, D.C. 20460. We would appreciate receiving the information no later than February 23, 1996, so we can begin compiling the information as soon as possible. If you have any questions about this project

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or you require technical assistance in responding to this information request, please feel free to call Mr. Hoffmann at (202) 260-0642. Thank you for your assistance in this important effort.

Sincerely,

Elizabeth Southerland
Acting Director
Standards and Applied Science Division
Office of Science and Technology

cc: State 305(b) Coordinators
EPA Regional 305(b) Coordinators
EPA Regional Fish Contamination Contracts