Characterization of Potential Adverse Health Effects Associated with Consuming Fish from

Ellison Creek Reservoir
“Lone Star Lake”

Morris County, Texas

2016

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Division for Regulatory Services
Policy, Standards, and Quality Assurance Unit
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LIST OF ACRONYMS

ARL	Acceptable Lifetime Risk Level
ATSDR	Agency for Toxic Substances and Disease Registry
BDL	Below Detection Limit
BMD	Benchmark Dose
BMDL	Benchmark Dose (Lower Confidence Limit)
ca	Cancer
CDC	Centers for Disease Control
CPF	Cancer Potency Factor
CSF	Cancer Slope Factor
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
dL	Deciliter
DSHS	Department of State Health Services
g	Gram
GC	Gas Chromatograph
GERG	Geochemical and Environmental Research Group
GSMFC	Gulf States Marine Fisheries Commission
HAC	Health Assessment Comparison
HCH	Hexachlorocyclohexane
HI	Hazard Index
HQ	Hazard Quotient
in	Inches
IH	Interstate Highway
IRIS	Integrated Risk Information System
kg	Kilogram
lb	Pound
LOAEL	Lowest Observed Adverse Effects Level
mcg	Microgram
mg	Milligram
mm	Millimeter
MRL	Minimal Risk Level
MS	Mass spectrometer
n	Sample Size
ND	Not Detected
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effects Level
nonca	Noncancer
p	Statistical Significance in a Hypothesis Test
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated Dibenzo-p-Dioxin
PCDF	Polychlorinated Dibenzofuran

LIST OF ACRONYMS CONT.

pg	picogram
r	Correlation Coefficient
r^2	Coefficient of Determination
RfD	Reference Dose
RL	Reporting Limit
SALG	Seafood and Aquatic Life Group
SOP	Standard Operating Procedure
SSD	Seafood Safety Division
SVOC	Semivolatile Organic Compound
TCEQ	Texas Commission on Environmental Quality
TDH	Texas Department of Health
TEF	Toxicity Equivalence Factor
TEQ	Toxicity Equivalence
TL	Total Length
TMDL	Total Maximum Daily Load
TNRCC	Texas Natural Resources Conservation Commission
TPWD	Texas Parks and Wildlife Department
UL	Intake Level
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
$\overline{X}$	Mean

SUMMARY

A survey of Ellison Creek Reservoir Lone Star, Texas in 2005 indicated that polychlorinated biphenyl concentrations in fish exceeded Texas Department of Health guidelines for protection of human health. Since 2005, the Texas Department of State Health Services has recommended that people do not eat fish from Ellison Creek Reservoir.

In 2014, the Texas Department of State Health Services performed this study to investigate any potential change in fish tissue contamination in Ellison Creek Reservoir. The present study examined fish from Ellison Creek Reservoir for the presence and concentrations of environmental toxicants that, if eaten, potentially could affect human health negatively. The study also addresses the public health implications of consuming fish from Ellison Creek Reservoir and suggests actions to reduce potential adverse health outcomes.

Results of the 2014 survey indicate that polychlorinated biphenyl and dioxin concentrations in channel catfish, common carp, flathead catfish, hybrid striped bass, largemouth bass, spotted gar, sunfish *Spp*., and white bass continue to exceed Texas Department of State Health Services guidelines for protection of human health.

Conclusions

- Confidence in the conclusions for many species of fish is limited by the small sample size. Sampling a small number of fish (i.e., individual species of fish or all fish species combined) decreases the confidence of mean contaminant concentrations for the fish population thus adding uncertainty to the conclusions.

- Regular or long-term consumption of channel catfish, common carp, flathead catfish, hybrid striped bass, largemouth bass, spotted gar, sunfish *Spp*., and white bass may result in adverse systemic (noncarcinogenic) health effects. Therefore, consumption of these species of fish from Ellison Creek Reservoir **poses an apparent risk to human health**.

- Regular or long-term consumption of channel catfish, common carp, and hybrid striped bass may increase the likelihood of carcinogenic health risks. Therefore, consumption of these species of fish from Ellison Creek Reservoir **poses an apparent risk to human health**.

Recommendations

- People should not consume common carp and hybrid striped bass from Ellison Creek Reservoir (Table 10).

- Women of childbearing age (Women and girls under 50) including pregnant women,

women who may become pregnant, and women who are nursing infants and children less than 12 years of age, or who weigh less than 75 pounds should not consume channel catfish, common carp, flathead catfish, hybrid striped bass, spotted gar, sunfish *Spp*., and white bass from Ellison Creek Reservoir.

- Women of childbearing age (Women and girls under 50) including pregnant women, women who may become pregnant, and women who are nursing infants and children less than 12 years of age, or who weigh less than 75 pounds may consume up to one four-ounce meal per month of largemouth bass from Ellison Creek Reservoir.

- Women past childbearing age (Women 50 and older) and males 12 and older may consume up to one eight-ounce meal per month of channel catfish, flathead catfish, spotted gar, or sunfish *Spp*. from Ellison Creek Reservoir.

- Women past childbearing age (Women 50 and older) and males 12 and older may consume up to two eight-ounce meals per month of largemouth bass or white bass from Ellison Creek Reservoir.

- The DSHS advise TPWD to continue not stocking hybrid striped bass (i.e., Palmetto bass) in Ellison Creek Reservoir because hybrid striped bass bioaccumulate significant concentrations of PCBs and PCDDs/PCDFs that pose apparent hazards to public health. The TPWD discontinued stocking of hybrid striped bass following the issuance of the Ellison Creek Reservoir fish consumption advisory in 2005.

INTRODUCTION

This document summarizes the results of a survey of Ellison Creek Reservoir (ECR) also known as Lone Star Lake conducted in 2014 by the Texas Department of State Health Services (DSHS) Seafood and Aquatic Life Group (SALG).[a] The SALG did this study to investigate any potential change in fish tissue contamination in ECR. The present study examined fish from ECR for the presence and concentrations of environmental toxicants that, if eaten, potentially could affect human health negatively. The report addresses the public health implications of consuming fish from ECR and suggests actions to reduce potential adverse health outcomes.

History of the Ellison Creek Reservoir Fish Consumption Advisory

The Texas Commission on Environmental Quality (TCEQ) surveyed water and sediments from Ellison Creek Reservoir for chemical contaminants between March 1, 1998 and February 28, 2003. Following evaluation of this data, the TCEQ listed Ellison Creek Reservoir in the 2004 Texas Water Quality Inventory and on 303(d) List. In the 2004 Texas Water Quality Inventory, the TCEQ expressed “concern for toxicity in sediment to aquatic organisms in the southeast

[a] The terms DSHS and SALG may be used interchangeably throughout this document and mean the same agency.

part of the reservoir near the Lone Star facility due to … elevated levels of metal contaminants in sediment”.[1]

In December 2003, the SALG examined analytical data for nine fish fillets and five whole fish samples collected between June 2002 and July 2003 by TCEQ regional personnel. Laboratory analysis of these samples revealed several to contain lead and/or PCBs. Four of nine fish *fillet* samples contained PCBs at concentrations ranging from 0.150 to 0.320 mg/kg with a mean of 0.090 mg/kg. Three of five *whole fish* samples contained PCBs ranging from not detected (ND) to 0.210 mg/kg with a mean of 0.120 mg/kg. The mean concentration of PCBs in combined fish tissues collected from Ellison Creek Reservoir in 2002 and 2003 were approximately twice the DSHS guideline for protection of human health from exposure to PCBs (PCB Health Assessment Comparison value 0.047mg/kg).

In the 2002-2003 TCEQ data set, two fish *fillet* samples contained lead at levels below the laboratory's practical quantitation limit (PQL) for lead (4 mg/kg). *Whole fish* samples did not contain demonstrable lead. The SALG risk assessors were unable to assess the significance of lead in 2002-2003 fish collected from Ellison Creek Reservoir: because they could not determine whether lead concentrations were listed as dry-weight or wet-weight concentrations; because lead concentrations were below the PQL; and, because only two fish fillet samples contained lead, while no whole fish were found to contain measurable lead.

From the TCEQ 2002-2003 data for Ellison Creek Reservoir, the SALG risk assessors suggested to TCEQ that further investigation of fish from the reservoir to characterize adequately human health risks associated with consuming contaminants in fish from Ellison Creek Reservoir was necessary. Subsequent to that review, the TCEQ and the SALG determined that Ellison Creek Reservoir was a candidate for examination under the Statewide Fish Tissue Monitoring Program. In 2005, SALG staff performed a survey of Ellison Creek Reservoir with funding provided by the TCEQ through the Statewide Fish Tissue Monitoring Program.

The 2005 survey revealed the presence of PCBs at concentrations exceeding DSHS health-based guidelines in fish from Ellison Creek Reservoir.[2] The DSHS issued Fish and Shellfish Consumption Advisory 29 (ADV-29) on November 28, 2005 advising people not to consume fish from Ellison Creek Reservoir.[3]

The TMDL Program at the TCEQ and the Relationship between the TMDL Program and Consumption Advisories or Possession Bans Issued by the DSHS

The TCEQ enforces federal and state laws that promote judicious use of water bodies under state jurisdiction and protects state-controlled water bodies from pollution. Pursuant to the federal Clean Water Act, Section 303(d),[4] all states must establish a “total maximum daily load” (TMDL) for each pollutant contributing to the impairment of a water body for one or more designated uses. A TMDL is the maximum amount of a pollutant that a body of water can assimilate and still meet water quality standards.[5] TMDLs incorporate margins of safety to ensure the usability of the water body for all designated purposes. States, territories, and tribes define the uses for a specific water body (e.g., drinking water, contact recreation, aquatic life support) along with the scientific criteria designated to support each specified use.

Fish consumption is a recognized use for many waters. A water body is impaired if fish from that water body contain contaminants that make those fish unfit for human consumption or if consumption of those contaminants potentially could harm human health. Although a water body and its aquatic life may clear toxicants over time with removal of the source(s), it is often necessary to institute some type of remediation such as those implemented by the TCEQ. Thus, whenever the DSHS issues a fish consumption advisory or prohibits possession of environmentally contaminated fish, the TCEQ places the water body in its current *Texas Integrated Report of Surface Water Quality* formerly called the Texas Water Quality Inventory and 303(d) List.[6] The TCEQ is responsible for confirming the impairment and, if necessary, the TMDL program, then prepares a TMDL for each contaminant present at concentrations that, if consumed, would be capable of negatively affecting human health. After approval of the TMDL, the stakeholders in the watershed prepare an Implementation Plan for each contaminant. These plans are designed to facilitate the rehabilitation of the water body over time. Successful remediation should result in return of the water body to conditions compatible with all stated uses, including consumption of fish from the water body. When the DSHS lifts a consumption advisory or possession ban, people may once again keep and consume fish from the water body. If fish in a water body are contaminated, one of the several items on an Implementation Plan for a water body on a state's 303(d) list consists of the periodic reassessment of contaminant levels in resident fish.

Description of Ellison Creek Reservoir

Ellison Creek Reservoir (also known as Lone Star Lake) is a 1,516-acre impoundment of Ellison Creek.[7] The reservoir is located in Morris County within the City of Lone Star, Texas. The reservoir is owned and operated by U.S. Steel Tubular Products, Inc. (formerly owned by Lone Star Steel). Ellison Creek (also known as Bruton's Creek) is a tributary of Big Cypress Creek and part of the Cypress River Basin. It has a watershed that spans 37 square miles, a shoreline of 14 miles, and a maximum depth of 40 feet with moderate water clarity. Reservoir structural habitat is sparse and is comprised of inundated timber, brush, riprap, creek channels, and boat docks. Aquatic vegetation is also present in the reservoir. Predominant fish species include largemouth bass, hybrid striped bass, spotted bass, channel catfish, white bass, crappie, redbreast sunfish, bluegill, and redear sunfish. Texas Parks and Wildlife Department (TPWD) statewide harvest regulations govern management of fish species taken from Ellison Creek Reservoir. The reservoir has two public boat ramps and one privately operated ramp.[8]

Population of Morris County Surrounding Ellison Creek Reservoir

Ellison Creek Reservoir is located in Morris County in rural Northeast Texas. The United States Census Bureau estimated the 2014 Morris County population at 12,743 people.[9] Longview, Texas positioned approximately 30 miles south of Ellison Creek Reservoir is the closest metropolitan area (population ≥ 20,000 people) in Northeast Texas.[10]

Subsistence Fishing at Ellison Creek Reservoir

The USEPA suggests that, along with ethnic characteristics and cultural practices of an area's population, the poverty rate could contribute to any determination of the rate of subsistence fishing in an area.[11] The USEPA and the DSHS find it is important to consider subsistence fishing to occur at any water body because subsistence fishers (as well as recreational anglers and certain tribal and ethnic groups) usually consume more locally caught fish than the general population. These groups sometimes harvest fish or shellfish from the same water body over many years to supplement caloric and protein intake. People, who routinely eat fish from chemically contaminated bodies of water or those who eat large quantities of fish from the same waters, could increase their risk of adverse health effects. The USEPA suggests that states assume that at least 10% of licensed fishers in any area are subsistence fishers. Subsistence fishing, while not explicitly documented by the DSHS, likely occurs in Texas. The DSHS assumes the rate of subsistence fishing to be similar to that estimated by the USEPA.

METHODS

Fish Sampling, Preparation, and Analysis

The DSHS SALG collects and analyzes edible fish from the state's public waters to evaluate potential risks to the health of people consuming contaminated fish or shellfish. Fish tissue sampling follows standard operating procedures from the DSHS *Seafood and Aquatic Life Group Survey Team Standard Operating Procedures and Quality Control/Assurance Manual.*[12] The SALG bases its sampling and analysis protocols, in part, on procedures recommended by the USEPA's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1.*[13] Advice and direction are also received from the *Fish Sampling Advisory Subcommittee* of the legislatively mandated *State of Texas Toxic Substances Coordinating Committee.*[14] Samples usually represent species, trophic levels, and legal-sized specimens available for consumption from a water body. When practical, the DSHS collects samples from two or more sites within a water body to better characterize geographical distributions of contaminants.

Fish Sampling Methods and Description of the Ellison Creek Reservoir 2014 Sample Set

In April–May 2014, the SALG staff collected 108 fish samples from Ellison Creek Reservoir. Risk assessors used data from these fish to assess the potential for adverse human health outcomes from consuming fish from this reservoir.

The SALG selected four sample sites to provide spatial coverage of the study area (Figure 1): Site 1 ECR at the dam; Site 2 ECR near American Electric Power intake; Site 3 ECR at Barnes Creek; and, Site 4 ECR near Upper Reservoir. Species collected represent distinct ecological groups (i.e., predators and bottom-dwellers) that have some potential to bio-accumulate chemical contaminants, have a wide geographic distribution, are of local recreational fishing value, and/or that anglers and their families commonly consume. The 108 fish collected from

Ellison Creek Reservoir represent all species targeted for collection from this water body (Table 1). The list below contains the number of each target species, listed in descending order collected for this study: channel catfish (35); largemouth bass (30); common carp (13); flathead catfish (8); crappie (7); sunfish species (4); spotted gar (4); bowfin (3); hybrid striped bass (2); and white bass (2).

The survey team set gill nets at sample sites 1–4 in late afternoon (Figure 1); fished the sites overnight, and collected samples from the nets early the following morning. The gill nets were set at locations to maximize available cover and habitat at each sample site. During collection, to keep specimens from different sample sites separated, the team placed samples from each site into mesh bags labeled with the site number. The survey team immediately stored retrieved samples on wet ice in large coolers to ensure interim preservation. Survey team members returned to the reservoir any live fish culled from the catch and properly disposed of samples found dead in the gill nets.

The survey team set trap nets at sample sites 1–4 to target crappie samples (Figure 1); fished the sites overnight, and collected samples from the nets early the following morning. The trap nets were set at locations to maximize available cover and habitat at each sample site. During collection, to keep crappie samples from different sample sites separated, the team placed samples from each site into mesh bags labeled with the site number. The survey team immediately stored retrieved samples on wet ice in large coolers to ensure interim preservation. Survey team members returned to the reservoir any live fish culled from the catch.

The SALG utilized a boat-mounted electrofisher to collect fish from samples sites 1–4. The SALG staff conducted electrofishing activities during daylight hours using pulsed direct current (Smith Root 7.5 GPP/ 5.0 GPP electrofishing system settings: 6.0-8.0 amps, 60 pulses per second [pps], high range, 500 volts, 60-100% duty cycle and 1.0-2.0 amps, 15 pps, high range, 500 volts, 80-100% duty cycle) to stun fish that crossed the electric field in the water in front of the boat. Staff used dip nets over the bow of the boat to retrieve stunned fish, netting only fish pre-selected as target samples. Staff immediately stored retrieved samples on wet ice in large coolers to enhance tissue preservation.

The survey team utilized juglines (a fishing line with a three-way swivel, single circle hook, and bottom weight tied to a free-floating device) to catch flathead catfish. The SALG staff baited lines with live sunfish. The survey team targeted habitat likely to hold flathead catfish.

The SALG staff processed fish onsite at ECR. Staff weighed each sample to the nearest gram (g) on an electronic scale and measured total length (TL; tip of nose to tip of tail fin) to the nearest millimeter (mm; Table 1). All TL measurements were converted to inches for use in this report. After weighing and measuring a fish, staff used a cutting board covered with aluminum foil and a fillet knife to prepare two skin-off fillets from each fish. The foil was changed and knife cleaned with distilled water after each sample was processed. The SALG staff wrapped fillet(s) in two layers of fresh aluminum foil, placed in an unused, clean, pre-labeled plastic freezer bag, and stored on wet ice in an insulated chest until further processing. The SALG staff transported tissue samples on wet ice to their Austin, Texas headquarters, where the samples were stored temporarily at -5° Fahrenheit (-20° Celsius) in a locked freezer. The freezer key is accessible only to authorized SALG staff members to ensure chain of custody while samples are in the possession of agency staff. The SALG delivered the frozen fish tissue samples to the Geochemical and Environmental Research Group (GERG) Laboratory, Texas A&M University, College Station, Texas, for contaminant analysis.

Fish Age Estimation

The SALG staff removed sagittal otoliths from black and white crappie, channel catfish, flathead catfish, hybrid striped bass, largemouth bass, sunfish species, and white bass samples for age estimation. The SALG staff followed otolith extraction procedures recommended by the Gulf States Marine Fisheries Commission (GSMFC) and unpublished procedures recommended by the Texas Parks and Wildlife Department (TPWD).[15, 16] Staff performed all otolith extractions on each fish sample after the preparation of the two skin-off fillets for chemical contaminant analysis. Following extraction, staff placed otoliths in an individually labeled coin envelope and then in a plastic freezer bag to transport to their Austin, Texas headquarters. Staff processed otoliths and estimated ages according to procedures recommended by the GSMFC and TPWD.[15, 16]

Analytical Laboratory Information

The GERG personnel documented receipt of the 108 ECR samples and recorded the condition of each sample along with its DSHS identification number. Using established USEPA methods, the GERG laboratory analyzed fish fillets from ECR for inorganic and organic contaminants commonly identified in polluted environmental media. Analyses included seven metals (arsenic, cadmium, copper, lead, total mercury, selenium, and zinc), 123 semivolatile organic compounds (SVOCs), 70 volatile organic compounds (VOCs), 34 pesticides, 209 PCB congeners,[b, 17] and 17 polychlorinated dibenzo-*p*-dioxins and/or dibenzofurans (PCDDs/PCDFs) congeners. The laboratory analyzed all 108 samples for mercury and PCBs. A subset of 100 of the original 108 samples was analyzed for the following contaminant groups: metals and PCDDs/PCDFs,[18] and a subset of 16 of the original 108 samples was analyzed for the following contaminant groups: pesticides, SVOCs, and VOCs. The SALG risk assessors selected the subset of samples based on target species and size class selection procedures outlined in SALG standard operating procedures (SOPs). In addition to SALG SOPs, if available, the SALG risk assessors use TPWD creel surveys to determine the species of fish most frequently harvested from the body of water being evaluated and choose large specimens of the selected species of fish. The SALG risk

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[b] A PCB congener is any single, unique well-defined chemical compound in the PCB category. The name of a congener specifies the total number of chlorine substituents and the position of each chlorine (e.g., 4,4' dichlorobiphenyl is a congener comprising the biphenyl structure with two chlorine substituents, one on each of the number 4 carbons of the two rings). In 1980, a numbering system was developed, which assigned a sequential number to each of the 209 PCB congeners.

assessors choose large fish to assess conservatively contaminant exposure when evaluating small sample sizes.

Details of Some Analyses with Explanatory Notes

Arsenic

The GERG laboratory analyzed 100 fish samples for total (inorganic arsenic + organic arsenic = total arsenic) arsenic. Although the proportions of each form of arsenic may differ among fish species, under different water conditions, and, perhaps, with other variables, the scientific literature suggests that well over 90% of arsenic in fish is likely organic arsenic – a form of arsenic that is virtually non-toxic to humans.[19] The DSHS, taking a conservative approach, estimates 10% of the total arsenic in any fish is inorganic arsenic and derives estimates of inorganic arsenic concentration in each fish by multiplying the reported total arsenic concentration in the sample by a factor of 0.1.

Mercury

Nearly all mercury in upper trophic level fish three years of age or older is methylmercury.[20] Thus, the total mercury concentration in a fish of legal size for possession in Texas serves well as a surrogate for methylmercury concentration. Because methylmercury analyses are difficult to perform accurately and are more expensive than total mercury analyses, the USEPA recommends that states determine total mercury concentration in a fish and that – to protect human health – states conservatively assume all reported mercury in fish or shellfish is methylmercury. The GERG laboratory thus analyzed fish tissues for total mercury. In its risk characterizations, the DSHS compares mercury concentrations in tissues to a comparison value derived from the Agency for Toxic Substances and Disease Registry's (ATSDR) minimal risk level (MRL) for methylmercury.[21] (In these risk characterizations, the DSHS interchangeably utilizes the terms "mercury," "methylmercury," or "organic mercury" to refer to methylmercury in fish).

Percent Lipids

The percent lipids content (wet weight basis) of a tissue sample is defined as the percent of material extracted from biological tissue with methylene chloride.[22] Tissue samples were extracted with methylene chloride in the presence of sodium sulfate and an aliquot of the extract was removed for lipid determination, filtered and concentrated to a known volume. A subsample is removed, the solvent is evaporated, the lipid residue weighed, and the percent lipid content is determined.

Polychlorinated Biphenyls (PCBs)

For PCBs, the USEPA suggests that each state measures congeners of PCBs in fish and shellfish rather than homologs[c] or Aroclors®[d] because the USEPA considers congener analysis the most sensitive technique for detecting PCBs in environmental media.[23, 20] Although only about 130 PCB congeners were routinely present in PCB mixtures manufactured and commonly used in the U.S. The GERG laboratory analyzes and reports the presence and concentrations of all 209 possible PCB congeners. From the congener analyses, the laboratory also computes and reports concentrations of PCB homologs and of Aroclor® mixtures. Despite the USEPA's suggestion that the states utilize PCB congeners rather than Aroclors® or homologs for toxicity estimates, the toxicity literature does not reflect state-of-the-art laboratory science. To accommodate this inconsistency, the DSHS utilizes recommendations from the National Oceanic and Atmospheric Administration (NOAA),[24] from McFarland and Clarke,[25] and from the USEPA's guidance documents for assessing contaminants in fish and shellfish.[13, 18] Based on evaluation of these recommendations, the DSHS selected 43 of 209 congeners to characterize "total" PCBs. The referenced authors chose to use congeners that were relatively abundant in the environment, were likely to occur in aquatic life, and likely to show toxic effects. SALG risk assessors summed the 43 congeners to derive "total" PCB concentration in each sample. SALG risk assessors then averaged the summed congeners within each group (e.g., fish species, sample site, or combination of species and site) to derive a mean PCB concentration for each group.

Using only a few PCB congeners to determine total PCB concentrations could underestimate PCB levels in fish tissue. Nonetheless, the method complies with expert recommendations on evaluation of PCBs in fish or shellfish. Therefore, SALG risk assessors compare average PCB concentrations of the 43 congeners with health assessment comparison (HAC) values derived from information on PCB mixtures held in the USEPA's Integrated Risk Information System (IRIS) database.[26] IRIS currently contains noncarcinogenic toxicity information for three Aroclor® mixtures: Aroclors® 1016, 1248, and 1254. IRIS does not contain complete information for all mixtures. For instance, IRIS has derived reference doses (RfDs) for Aroclors 1016 and 1254. Aroclor 1016 was a commercial mixture produced in the latter years of commercial production of PCBs in the United States. Aroclor 1016 was a fraction of Aroclor 1254 that was supposedly devoid of dibenzofurans, in contrast to Aroclor 1254.[27] Systemic toxicity estimates in the present document reflect comparisons derived from the USEPA's RfD for Aroclor 1254 because Aroclor 1254 contains many of the 43 congeners selected by McFarland and Clark and NOAA. As of yet, IRIS does not contain information on the systemic toxicity of individual PCB congeners.

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[c] PCB homologs are subcategories of PCB congeners having equal numbers of chlorine substituents (e.g., the tetrachlorobiphenyls are all PCB congeners with exactly four chlorine substituents that may be in any arrangement).

[d] Aroclor is a PCB mixture produced from 1930 to 1979. It is one of the most commonly known trade names for PCB mixtures. There are many types of Aroclors and each has a distinguishing suffix number that indicates the degree of chlorination. The numbering standard is as follows: The first two digits refer to the number of carbon atoms in the phenyl rings and the third and fourth digits indicate the percentage of chlorine by mass in the mixture (e.g., Aroclor 1254 means that the mixture has 12 carbon atoms and contains 54% chlorine by weight).

For assessment of cancer risk from exposure to PCBs, the SALG uses the USEPA's highest slope factor of 2.0 milligram per kilogram per day (mg/kg/day) to calculate the probability of lifetime excess cancer risk from PCB ingestion. The SALG based its decision to use the most conservative slope factor available for PCBs on factors, such as food chain exposure; the presence of dioxin-like tumor-promoting or persistent congeners; and, the likelihood of early-life exposure.[26]

Calculation of Dioxin Toxicity Equivalence (TEQ)

PCDDs/PCDFs are families of aromatic chemicals containing one to eight chlorine atoms. The molecular structures differ not only with respect to the number of chlorines on the molecule, but also with the positions of those chlorines on the carbon atoms of the molecule. The number and positions of the chlorines on the dibenzofuran or dibenzo-*p*-dioxin nucleus directly affects the toxicity of the various congeners. Toxicity increases as the number of chlorines increases to four chlorines, then decreases with increasing numbers of chlorine atoms - up to a maximum of eight. With respect to the position of chlorines on the dibenzo-*p*-dioxin/dibenzofuran nucleus, it appears that those congeners with chlorine substitutions in the 2, 3, 7, and 8 positions are more toxic than congeners with chlorine substitutions in other positions. To illustrate, the most toxic form of PCDDs is 2,3,7,8–tetrachlorodibenzo-*p*-dioxin (2,3,7,8–TCDD), a 4-chlorine molecule having one chlorine substituted for hydrogen at each of the 2, 3, 7, and 8 carbon positions on the dibenzo-*p*-dioxin. To gain some measure of toxic equivalence, 2,3,7,8–TCDD – assigned a toxicity equivalency factor (TEF) of 1.0 – is the standard against which other congeners are measured. Other congeners are given weighting factors, or TEFs, of 1.0 or less based on experiments comparing the toxicity of the congener relative to that of 2,3,7,8-TCDD.[28, 29]

Using this technique, the DSHS converted PCDD or PCDF congeners in each tissue sample from the present survey to toxic equivalent concentrations (TEQs) by multiplying each congener’s concentration by its TEF, producing a dose roughly equivalent in toxicity to that of the same dose of 2,3,7,8-TCDD. The total TEQ for any sample is the sum of the TEQs for each of the congeners in the sample, calculated according to the following formula.[30]

$$\text{Total TEQs} = \sum_{i=1}^{n}(\text{CI} \times \text{TEF})$$

CI = concentration of a given congener
TEF = toxicity equivalence factor for the given congener
n = # of congeners
i = initial congener
∑ = sum

Derivation and Application of Health-Based Assessment Comparison Values for Systemic (Noncarcinogenic) Effects (HAC_{nonca}) of Consumed Chemical Contaminants

The effects of exposure to any hazardous substance depend, among other factors, on the dose, the route of exposure, the duration of exposure, the manner in which the exposure occurs, the genetic makeup, personal traits and habits of the exposed, or the presence of other chemicals.[31] People who regularly consume contaminated fish or shellfish conceivably suffer repeated low-dose exposures to contaminants in fish or shellfish over extended periods (episodic exposures to low doses). Such exposures are unlikely to result in acute toxicity but may increase risk of subtle, chronic, and/or delayed adverse health effects that may include: cancer, benign tumors; birth defects; infertility; blood disorders; brain damage; peripheral nerve damage; lung disease; and kidney disease.[31]

If diverse species of fish or shellfish are available, the SALG presumes that people eat a variety of species from a water body. Further, SALG risk assessors assume that most fish species are mobile. SALG risk assessors may combine data from different fish species and/or sample sites within a water body to evaluate mean contaminant concentrations of toxicants in all samples as a whole. This approach intuitively reflects consumers' likely exposure over time to contaminants in fish or shellfish from any water body but may not reflect the reality of exposure at a specific location within a water body or a single point in time. The DSHS reserves the right to project risks associated with ingestion of individual species of fish or shellfish from separate collection sites within a water body or at higher than average concentrations (e.g., the upper 95 percent confidence limit on the mean). The SALG evaluates contaminants in fish or shellfish by comparing the mean or the 95% upper confidence limit on the mean concentration of a contaminant to its HAC value (e.g., in mg/kg) for non-cancer or cancer endpoints. The mean is the preferred comparison statistic. However, the 95% upper confidence limit may be used when evaluating small sample sizes.

In deriving HAC values for systemic (noncarcinogenic; HAC_{nonca}) effects, the SALG assumes a standard adult weighs 70 kilograms (kg) and consumes 30 g of fish or shellfish per day (about one eight-ounce meal per week) and uses the USEPA's RfD[32] or the ATSDR's chronic oral MRLs.[33] When RfDs or MRLs are not available the SALG may use a Food and Nutrition Board, Institute of Medicine, National Academies tolerable upper intake level (UL) for nutrients.[e] The USEPA defines an RfD as

> *An estimate of a daily oral exposure for a given duration to the human population (including susceptible subgroups) that is likely to be without an appreciable risk of adverse health effects over a lifetime.*[34]

The USEPA also states that the RfD

[e] A tolerable upper intake level (UL) is the highest average daily nutrient intake level that is likely to pose no risk of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects may increase. The UL represents total intake from food, water, and supplements.

> … *is derived from a BMDL* (benchmark dose lower confidence limit)*, a NOAEL* (no observed adverse effect level*), a LOAEL* (lowest observed adverse effect level)*, or another suitable point of departure, with uncertainty/variability factors applied to reflect limitations of the data used. [Durations include acute, short-term, subchronic, and chronic and are defined individually in this glossary]* and *RfDs are generally reserved for health effects thought to have a threshold or a low dose limit for producing effects.*[34]

The ATSDR uses a similar technique to derive its MRLs.[33] The DSHS divides the estimated daily dose derived from the measured concentration in fish tissue by the contaminant's RfD or MRL to derive a hazard quotient (HQ). The USEPA defines an HQ as

> *…the ratio of the estimated exposure dose of a contaminant (mg/kg/day) to the contaminant's RfD or MRL (mg/kg/day).*[35]

Note that, according to the USEPA, a linear increase in the HQ for a toxicant does not imply a linear increase in the likelihood or severity of systemic adverse effects. Thus, an HQ of 4.0 does not mean the concentration in the dose will be four times as toxic as that same substance would be if the HQ were equal to 1.0. An HQ of 4.0 also does not imply that adverse events will occur four times as often as if the HQ for the substance in question were 1.0. Rather, the USEPA suggests that an HQ or a hazard index (HI) – defined as the sum of HQs for contaminants to which an individual is exposed simultaneously – that computes to less than 1.0 should be interpreted as "no cause for concern" whereas, an HQ or HI greater than or equal to 1.0 "should indicate some cause for concern."

The SALG does not utilize HQs to determine the likelihood of occurrence of adverse systemic (noncarcinogenic) health effects. Instead, in a manner similar to the USEPA's decision process, the SALG may utilize computed HQs as a qualitative measurement. Qualitatively, HQs less than 1.0 are unlikely to be cause for concern while HQs greater than or equal to 1.0 might suggest the recommendation of a regulatory action to ensure protection of public health. Similarly, risk assessors at the DSHS may utilize an HQ to determine the need for further study of a water body's fauna. Notwithstanding the above discussion, the oral RfD derived by the USEPA represents chronic consumption. Thus, regularly eating fish containing a toxic chemical, the HQ of which is less than 1.0 is unlikely to cause adverse systemic health effects, whereas routine consumption of fish or shellfish in which the HQ equals or exceeds 1.0 represents a qualitatively unacceptable increase in the likelihood of systemic adverse health outcomes.

Although the DSHS utilizes chemical specific RfDs when possible, if an RfD is not available for a contaminant, the USEPA advises risk assessors to consider evaluating the contaminant by comparing it to the published RfD (or the MRL) of a contaminant of similar molecular structure or one with a similar mode or mechanism of action. For instance, Aroclor® 1260 has no RfD, so the DSHS uses the reference dose for Aroclor 1254 to assess the likelihood of systemic (noncarcinogenic) effects of Aroclor 1260.[33]

In developing oral RfDs and MRLs, federal scientists review the extant literature to devise NOAELs, LOAELs, or benchmark doses (BMDs) from experimental studies. Uncertainty factors are then utilized to minimize potential systemic adverse health effects in people who are exposed through consumption of contaminated materials by accounting for certain conditions that may be undetermined by the experimental data. These include extrapolation from animals to humans (interspecies variability), intra-human variability, and use of a subchronic study rather than a chronic study to determine the NOAEL, LOAEL, or BMD, and database insufficiencies.[32,34] Vulnerable groups such as women who are pregnant or lactating, women who may become pregnant, infants, children, people with chronic illnesses, those with compromised immune systems, the elderly, or those who consume exceptionally large servings are considered sensitive populations by risk assessors and USEPA. These sensitive groups also receive special consideration in calculation of an RfD.[34]

The primary method for assessing the toxicity of component-based mixtures of chemicals in environmental media is the HI. The USEPA recommends HI methodology for groups of toxicologically similar chemicals or chemicals that affect the same target organ. The HI for the toxic effects of a chemical mixture on a single target organ is actually a simulated HQ calculated as if the mixture were a single chemical. The default procedure for calculating the HI for the exposure mixture is to add the hazard quotients (the ratio of the external exposure dose to the RfD) for all the mixture's component chemicals that affect the same target organ (e.g., the liver). The toxicity of a particular mixture on the liver represented by the HI should approximate the toxicity that would have occurred were the observed effects caused by a higher dose of a single toxicant (additive effects). The components to be included in the HI calculation are any chemical components of the mixture that show the effect described by the HI, regardless of the critical effect from which the RfD came. Assessors should calculate a separate HI for each toxic effect.

Because the RfD is derived for the critical effect (the "toxic effect occurring at the lowest dose of a chemical"), an HI computed from HQs based on the RfDs for the separate chemicals may be overly conservative. That is, using RfDs to calculate HIs may overestimate health risks from consumption of specific mixtures for which no experimentally derived information is available. The USEPA states that

> *the HI is a quantitative decision aid that requires toxicity values as well as exposure estimates. When each organ-specific HI for a mixture is less than one and all relevant effects have been considered in the assessment, the exposure being assessed for potential systemic toxicity should be interpreted as unlikely to result in significant toxicity.*

And

When any effect-specific HI exceeds one, concern exists over potential toxicity. As more HIs for different effects exceed one, the potential for human toxicity also increases.

Thus,

Concern should increase as the number of effect-specific HI's exceeding one increases. As a larger number of effect-specific HIs exceed one, concern over potential toxicity should also increase. As with HQs, this potential for risk is not the same as probabilistic risk; a doubling of the HI does not necessarily indicate a doubling of toxic risk.

Derivation and Application of Health-Based Assessment Comparison Values for Application to the Carcinogenic Effects (HAC_{ca}) of Consumed Chemical Contaminants

The DSHS calculates cancer-risk comparison values (HAC_{ca}) from the USEPA's chemical-specific cancer potency factors (CPFs), also known as cancer slope factors (CSFs), derived through mathematical modeling from carcinogenicity studies. For carcinogenic outcomes, the DSHS calculates a theoretical lifetime excess risk of cancer for specific exposure scenarios for carcinogens, using a standard 70-kg body weight and assuming an adult consumes 30 grams of edible tissue per day. The SALG risk assessors incorporate two additional factors into determinations of theoretical lifetime excess cancer risk: (1) an acceptable lifetime risk level (ARL)[34] of one excess cancer case in 10,000 persons whose average daily exposure is equivalent; and, (2) daily exposure for 30 years, a modification of the 70-year lifetime exposure assumed by the USEPA. Comparison values used to assess the probability of cancer do not contain "uncertainty" factors. However, conclusions drawn from probability determinations infer substantial safety margins for all people by virtue of the models utilized to derive the slope factors (cancer potency factors) used in calculating the HAC_{ca}.

Because the calculated comparison values (HAC values) are conservative, exceeding a HAC value does not necessarily mean adverse health effects will occur. The perceived strict demarcation between acceptable and unacceptable exposures or risks is primarily a tool used by risk managers along with other information to make decisions about the degree of risk incurred by those who consume contaminated fish or shellfish. Moreover, comparison values for adverse health effects do not represent sharp dividing lines (obvious demarcations) between safe and unsafe exposures. For example, the DSHS considers it unacceptable when consumption of four or fewer meals per month of contaminated fish or shellfish would result in exposure to contaminant(s) in excess of a HAC value or other measure of risk. The DSHS also advises people who wish to minimize exposure to contaminants in fish or shellfish to eat a variety of fish and/or shellfish and to limit consumption of those species most likely to contain toxic contaminants. The DSHS aims to protect vulnerable subpopulations with its consumption advice, assuming that advice protective of vulnerable subgroups will also protect the general population from potential adverse health effects associated with consumption of contaminated fish or shellfish.

Children's Health Considerations

The DSHS recognizes that fetuses, infants, and children may be uniquely susceptible to the effects of toxic chemicals and suggests that exceptional susceptibilities demand special attention. [36, 37] Windows of special vulnerability (known as "critical developmental periods") exist during development. Critical periods occur particularly during early gestation (weeks 0 through 8) but can occur at any time during development (pregnancy, infancy, childhood, or adolescence) at times when toxicants can impair or alter the structure or function of susceptible systems.[38] Unique early sensitivities may exist after birth because organs and body systems are structurally or functionally immature at birth, continuing to develop throughout infancy, childhood, and adolescence. Developmental variables may influence the mechanisms or rates of absorption, metabolism, storage, or excretion of toxicants. Any of these factors could alter the concentration of biologically effective toxicant at the target organ(s) or could modulate target organ response to the toxicant. Children's exposures to toxicants may be more extensive than adults' exposures because children consume more food and liquids in proportion to their body weights than adults consume. Infants can ingest toxicants through breast milk, an exposure pathway that often goes unrecognized. Nonetheless, the advantages of breastfeeding outweigh the probability of significant exposure to infants through breast milk and women are encouraged to continue breastfeeding and to limit exposure of their infants by limiting intake of the contaminated foodstuff. Children may experience effects at a lower exposure dose than might adults because children's organs may be more sensitive to the effects of toxicants. Stated differently, children's systems could respond more extensively or with greater severity to a given dose than would an adult organ exposed to an equivalent dose of a toxicant. Children could be more prone to developing certain cancers from chemical exposures than are adults.[39] In any case, if a chemical or a class of chemicals is observed to be, or is thought to be, more toxic to fetuses, infants, or children, the constants (e.g., RfD, MRL, or CPF) are usually modified further to assure the immature systems' potentially greater susceptibilities are not perturbed.[32] Additionally, in accordance with the ATSDR's *Child Health Initiative*[40] and the USEPA's *National Agenda to Protect Children's Health from Environmental Threats,*[41] the DSHS further seeks to protect children from the possible negative effects of toxicants in fish by suggesting that this potentially sensitive subgroup consume smaller quantities of contaminated fish or shellfish than adults consume. Thus, the DSHS recommends that children weighing 35 kg or less and/or who are 11 years of age or younger limit exposure to contaminants in fish or shellfish by eating no more than four-ounces per meal of the contaminated species. The DSHS also recommends that consumers spread these meals over time. For instance, if the DSHS issues consumption advice that recommends consumption of no more than two meals per month of a contaminated species, those children should eat no more than 24 four ounce meals of the contaminated fish or shellfish per year and should not eat such fish or shellfish more than twice per month.

Data Analysis and Statistical Methods

The SALG risk assessors imported Excel© files into Systat® statistical software, version 13.1 installed on IBM-compatible microcomputers (Dell, Inc), to generate descriptive statistics (mean, 95% confidence limits of the arithmetic mean, standard deviation, median, minimum, and maximum concentrations) for reported chemical contaminants.[42] In computing descriptive statistics, SALG risk assessors utilized ½ the reporting limit (RL) for analytes designated as not detected (ND) or estimated (J-values).[f] The SALG risk assessors calculated PCDDs/PCDFs descriptive statistics using estimated concentrations (J-values) and assuming zero for PCDDs/PCDFs designated as ND.[g] The change in methodology for computing PCDDs/PCDFs descriptive statistics is due to the proximity of the reporting limits to the HAC value. Assuming ½ the RL for PCDDs/PCDFs designated as ND or J-values would unnecessarily overestimate the concentration of PCDDs/PCDFs in each fish tissue sample. The SALG used the descriptive statistics from the above calculations to produce the present report. The SALG employed Microsoft Excel® spreadsheets to create figures, to compute HAC_{nonca} and HAC_{ca} values for contaminants, and to calculate HQs, HIs, cancer risk probabilities, and meal consumption limits for fish from Ellison Creek Reservoir.[43] When lead concentrations in fish or shellfish are high, SALG risk assessors may utilize the USEPA's Interactive Environmental Uptake Bio-Kinetic (IEUBK) model to determine whether consumption of lead-contaminated fish could cause a child's blood lead (PbB) level to exceed the Centers for Disease Control and Prevention's (CDC) lead concentration of concern in children's blood (5 mcg/dL).[44, 45]

The SALG risk assessors also performed other types of statistical analyses to evaluate dioxin and PCB data. Statistical significance was determined at $p \leq 0.05$ for all statistical analyses. When appropriate and as needed to meet assumptions of the statistical tests, the SALG risk assessors $\log_e$-transformed the data to improve normality and best fit. The SALG risk assessors performed linear correlation (r) to describe associations between contaminant concentrations and total length (TL), fish age, and percent lipid composition. For those associations that were positive and significant, the SALG risk assessors performed linear regression analyses (r^2) to measure the strength and further describe the relationships.

RESULTS

The GERG laboratory completed analyses and electronically transmitted the results of the Ellison Creek Reservoir samples collected April–May 2014 to the SALG in August 2014. The laboratory reported the analytical results for metals, pesticides, PCBs, PCDDs/PCDFs, SVOCs, and VOCs.

For reference, Table 1 contains a list of fish samples collected by sample site. Tables 2.1–2.9 present the results of metals analyses. Tables 3 and 4.1–4.3 contain summary results for

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[f] *"J-value" is standard laboratory nomenclature for analyte concentrations that are detected and reported below the reporting limit (<RL). The reported concentration is considered an estimate, quantitation of which may be suspect and may not be reproducible. The DSHS treats J-Values as "not detected" in its statistical analyses of a sample set.*

[g] *The SALG risk assessors' rationale for computing PCDDs/PCDFs descriptive statistics using the aforementioned method is based on the proximity of the laboratory reporting limits and the health assessment comparison value for PCDDs/PCDFs. Thus, applying the standard SALG method utilizing ½ the reporting limit for analytes designated as not detected (ND) or estimated (J) will likely overestimate the PCDDs/PCDFs fish tissue concentration.*

pesticides and PCBs, respectively. Table 5.1–5.3 summarizes the PCDD/PCDF analyses. Table 6 depicts summary results for VOCs (i.e., trichlorofluoromethane). This report does not display SVOC data because these contaminants were not present at concentrations of concern in fish collected from Ellison Creek Reservoir during the described survey. Unless otherwise stated, table summaries present the number of samples with detected concentrations of contaminants, the number of samples tested, the mean concentration and standard deviation, and the minimum and the maximum concentrations. In the tables, results may be reported as ND, below detection limit (BDL) for estimated concentrations or “J-values”, or as concentrations at or above the reporting limit (RL).

Inorganic Contaminants

<u>Arsenic, Cadmium, Copper, Lead, Selenium, and Zinc</u>

The GERG laboratory analyzed a subset of 100 fish tissue samples for six inorganic contaminants and 108 samples for mercury. All fish tissue samples from Ellison Creek Reservoir contained concentrations of arsenic, copper, mercury, selenium, and zinc (Tables 2.1–2.9).

The SALG evaluated three toxic metalloids having no known human physiological function (arsenic, cadmium, and lead) in the samples collected from Ellison Creek Reservoir. Arsenic concentrations ranged from BDL to 0.445 mg/kg with a mean of 0.074±0.067 mg/kg (Table 2.1). Ninety-three of 100 fish analyzed contained estimated concentrations below the RL for cadmium (Table 2.2). Lead concentrations ranged from ND to 1.011 mg/kg with a mean of 0.258±0.154 mg/kg (Table 2.4).

Three of the metalloids analyzed are essential trace elements: copper, selenium, and zinc. Copper concentrations ranged from BDL to 2.714 mg/kg (Table 2.3). All fish tissue samples contained selenium. Selenium concentrations ranged from BDL to 4.477 mg/kg with a mean of 0.429±0.797 mg/kg (Table 2.5). All samples also contained zinc. The mean zinc concentration in fish tissue samples from Ellison Creek Reservoir was 4.122±1.531 mg/kg (Table 2.6).

<u>Mercury</u>

All fish tissue samples evaluated from Ellison Creek Reservoir contained mercury (Tables 2.7–2.9). Mercury concentrations ranged from 0.009 to 0.527 mg/kg. The mean mercury concentration for the 108 fish tissue samples analyzed was 0.078±0.084 mg/kg.

Organic Contaminants

<u>Pesticides</u>

All samples examined contained concentrations of chlordane and 4,4’-dichlorodiphenyldichloroethylene (DDE). Chlordane concentrations ranged from 0.0010 to 0.0216 mg/kg with a mean of 0.0068±0.0055 mg/kg (Table 3). DDE ranged from 0.0007 to

0.0117 mg/kg with a mean 0.0041±0.0029 mg/kg (Table 3). The mean pentachloroanisole concentration in fish tissue samples from Ellison Creek Reservoir was 0.0007±0.0009 (Table 3). Estimated to low concentrations greater than the reporting limit of hexachlorobenzene, heptachlor epoxide, and methoxychlor were present in one or more fish samples (data not presented). Estimated concentrations were reported for 4,4'- dichlorodiphenyldichloroethane (DDD), dacthal, mirex, pentachlorobenzene, and tetrachlorobenzene (data not presented).

PCBs

All fish tissue samples evaluated from Ellison Creek Reservoir contained PCBs (Tables 4.1–4.3). One redbreast sunfish sample was removed from data analysis for failure to meet the contract required reporting limit for PCBs. Across all sample sites and species, PCB concentrations ranged from 0.009 (black crappie) to 0.423 mg/kg (common carp). The mean PCB concentration for the 107 fish tissue samples evaluated was 0.102±0.085 mg/kg. PCB concentrations in fish appeared to be positively related to TL and percent lipids ($r^2 = 0.263$, $n = 107$, $p < 0.0005$; $r^2 = 0.470$, $n = 107$, $p < 0.0005$; Figures 2–3).

Bowfin

Three bowfin ranging from 20.7 to 27.6 inches TL ($\overline{X}$ – 24.0 inches TL) were analyzed for PCBs (Table 1). Currently, there is no minimum length limit for bowfin in Texas waters.[46] PCBs concentrations ranged from 0.010 to 0.048 mg/kg with a mean of 0.027±0.019 mg/kg (Tables 4.1–4.3).

Channel catfish

Thirty-five channel catfish ranging from 14.8 to 24.8 inches TL ($\overline{X}$ – 19.2 inches TL) and from three to 13 years of age were analyzed for PCBs (Table 1; Figure 4). One-hundred percent of the channel catfish samples examined were of legal size (≥ 12 inches TL).[46] PCB concentrations ranged from 0.027 to 0.408 mg/kg with a mean of 0.111±0.084 mg/kg (Tables 4.1–4.3). PCB concentrations in channel catfish appeared to be positively related to TL and age ($r^2 = 0.483$, $n = 35$, $p < 0.0005$; $r^2 = 0.289$, $n = 35$, $p = 0.0009$; Figures 5–6). There was no apparent correlation between PCB concentration and percent lipids ($r = 0.241$, $n = 35$, $p = 0.163$).

Common carp

Thirteen common carp ranging from 23.1 to 29.1 inches TL ($\overline{X}$ – 26.0 inches TL) were analyzed for PCBs (Table 1). Currently, there is no minimum length limit for common carp in Texas waters.[46] PCB concentrations ranged from 0.098 to 0.423 mg/kg with a mean of 0.209±0.086 mg/kg (Tables 4.1–4.3).

Crappie Spp. (black and white)

Seven crappie ranging from 10.2 to 13.7 inches TL ($\overline{X}$ – 11.8 inches TL) and from three to six years of age were analyzed for PCBs (Table 1; Figure 7). One-hundred percent of the crappie samples examined were of legal size (≥ 10 inches TL).[46] PCB concentrations ranged from 0.009 to 0.048 mg/kg with a mean of 0.022±0.013 mg/kg (Tables 4.1–4.3).

Flathead catfish

Eight flathead catfish ranging from 18.3 to 35.4 inches TL ($\overline{X}$ – 27.6 inches TL) and from four to 13 years of age were analyzed for PCBs (Table 1; Figure 8). One-hundred percent of the flathead catfish samples examined were of legal size (≥ 18 inches TL).[46] PCB concentrations ranged from 0.045 to 0.229 mg/kg with a mean of 0.095±0.065 mg/kg (Tables 4.1–4.3).

Hybrid striped bass

Two hybrid striped bass ranging from 24.4 to 24.5 inches TL ($\overline{X}$ – 24.5 inches TL) and nine years of age were analyzed for PCBs (Table 1). One-hundred percent of the hybrid striped bass samples examined were of legal size (≥ 18 inches TL).[46] PCB concentrations ranged from 0.190 to 0.357 mg/kg with a mean of 0.273±0.118 mg/kg (Tables 4.1–4.3).

Largemouth bass

Thirty largemouth bass ranging from 14.7 to 22.8 inches TL ($\overline{X}$ – 18.3 inches TL) and from three to nine years of age were analyzed for PCBs (Table 1; Figure 9). One-hundred percent of the largemouth samples examined were of legal size (≥ 14 inches TL).[46] PCB concentrations ranged from 0.018 to 0.227 mg/kg with a mean of 0.064±0.038 mg/kg (Tables 4.1–4.3). PCB concentrations in largemouth bass appeared to be positively related to percent lipids (r^2 = 0.473, n = 30, p < 0.0005; Figure 10). There was no apparent correlation between PCB concentration and TL and age (r = 0.187, n = 30, p = 0.322; r = 0.150, n = 30, p = 0.431).

Spotted gar

Four spotted gar ranging from 25.5 to 28.1 inches TL ($\overline{X}$ – 27.0 inches TL) were analyzed for PCBs (Table 1). Currently, there is no minimum length limit for spotted gar in Texas waters.[46] PCB concentrations ranged from 0.036 to 0.179 mg/kg with a mean of 0.111±0.061 mg/kg (Tables 4.1–4.3).

Sunfish Spp. (bluegill, green, and redbreast)

Three sunfish ranging from 7.2 to 8.9 inches TL ($\overline{X}$ – 8.3 inches TL) and from three to seven years of age were analyzed for PCBs (Table 1). Currently, there is no minimum length limit for any sunfish species in Texas waters.[46] PCB concentrations ranged from 0.012 to 0.162 mg/kg with a mean of 0.103±0.080 mg/kg (Tables 4.1–4.3).

White bass

Two white bass ranging from 24.4 to 24.5 inches TL ($\overline{X}$ – 24.5 inches TL) and from four to five years of age were analyzed for PCBs (Table 1). One-hundred percent of the white bass samples examined were of legal size (≥ 10 inches TL).[46] PCB concentrations ranged from 0.058 to 0.088 mg/kg with a mean of 0.073±0.021 mg/kg (Tables 4.1–4.3).

PCDDs/PCDFs

Ninety-eight of 100 fish tissue samples contained at least one of the 17 PCDD/PCDF congeners ranging from ND–10.400 TEQ pg/g with a mean of 1.013±1.340 TEQ pg/g and a median of 0.634 TEQ pg/g (Table 5.1–5.3). No samples contained all 17 congeners (data not shown). Hybrid striped bass contained the highest mean PCDD/PCDF TEQ concentration (3.803±3.005 pg/g; Table 5.3). PCDD/PCDF TEQ concentrations in fish appeared to be positively related to TL and percent lipids (r^2 = 0.103, n = 100, p = 0.001; r^2 = 0.196, n = 100, p < 0.0005; Figures 11–12).

Bowfin

PCDD/PCDF TEQ concentrations ranged from 0.031 to 0.541 pg/g with a mean of 0.216±0.282 pg/g and median 0.076 pg/g (n = 3; Tables 5.1–5.3).

Channel catfish

PCDD/PCDF TEQ concentrations ranged from 0.142 to 10.400 pg/g with a mean of 1.323±1.895 pg/g and median 0.676 pg/g (n = 33; Tables 5.1–5.3). PCDD/PCDF TEQ concentration in channel catfish appeared to be positively related to TL and percent lipid (r^2 = 0.410, n = 33, p = 0.0001; r^2 = 0.135, n = 33, p = 0.04; Figures 13–14). There was no apparent correlation between PCB concentration and age (r = 0.265, n = 33, p = 0.137).

Common carp

PCDD/PCDF TEQ concentrations ranged from 0.575 to 3.241 pg/g with a mean of 1.575±0.917 pg/g and median 1.401 pg/g (n = 13; Tables 5.1–5.3).

Crappie Spp. (black and white)

PCDD/PCDF TEQ concentrations ranged from ND to 0.294 pg/g with a mean of 0.139±0.121 pg/g and median 0.123 pg/g (*n* = 7; Tables 5.1–5.3).

Flathead catfish

PCDD/PCDF TEQ concentrations ranged from 0.260 to 1.689 pg/g with a mean of 0.842±0.456 pg/g and median 0.716 pg/g (*n* = 8; Tables 5.1–5.3).

Hybrid striped bass

PCDD/PCDF TEQ concentrations ranged from 1.678 to 5.928 pg/g with a mean of 3.803±3.005 pg/g and median 3.803 pg/g (*n* = 2; Tables 5.1–5.3).

Largemouth bass

PCDD/PCDF TEQ concentrations ranged from ND to 1.927 pg/g with a mean of 0.556±0.432 pg/g and median 0.427 pg/g (*n* = 28; Tables 5.1–5.3). There was no apparent correlation between PCDD/PCDF TEQ concentration and TL, age, and percent lipids, respectively (r = 0.361, n = 28, p = 0.06; r = -0.010, n = 28, p = 0.960; r = 0.337, n = 28, p = 0.079).

Spotted gar

PCDD/PCDF TEQ concentrations ranged from 0.253 to 1.416 pg/g with a mean of 0.969±0.507 pg/g and median 1.104 pg/g (*n* = 4; Tables 5.1–5.3).

White bass

PCDD/PCDF TEQ concentrations ranged from 0.769 to 1.045 pg/g with a mean of 0.907±0.195 pg/g and median 0.907 pg/g (*n* = 2; Tables 5.1–5.3).

SVOCs

The GERG laboratory analyzed a subset of 16 Ellison Creek Reservoir fish tissue samples for SVOCs. Quantifiable concentrations greater than the reporting limit were reported for 7-12-Dimethylbenz(a)anthracene in one fish sample (data not presented). Estimated concentrations of benzo(g,h,i)perylene, dibenz(a,j)acridine, dibenz(a,h)anthracene, diethyl phthalate, di-n-butyl phthalate, bis (2-ethylhexyl) phthalate, di-n-octyl phthalate, acetophenone, ethyl methaneasulfonate, and 2,6-dinitrotoluene were present in one or more fish samples analyzed (data not presented). The laboratory detected no other SVOCs in fish from Ellison Creek Reservoir.

<u>VOCs</u>

The Seafood and Aquatic Life Group Survey Team Standard Operating Procedures and Quality Control/Assurance Manual contain a complete list of the 70 VOCs selected for analysis. A subset of 16 fish tissue samples were selected for analysis from Ellison Creek Reservoir. Trichlorofluoromethane concentrations ranged from ND–0.332 mg/kg with a mean of 0.061±0.080 mg/kg (Table 6). Quantifiable concentrations greater than the reporting limit were reported for acetone, methylene chloride, and naphthalene in one or more fish samples (data not presented in tables). Estimated quantities of 2-butanone, m+p-xylene, o-xylene, and toluene were also present in one or more fish tissue samples analyzed from Ellison Creek Reservoir (data not presented).

Acetone, methylene chloride, and naphthalene were also identified in one or more of the procedural blanks, suggesting that that these compounds were introduced during sample preparation. VOC concentrations less than the reporting limit are difficult to interpret due to their uncertainty and may represent a false positive. The presence of many VOCs at concentrations less than the reporting limit may be the result of incomplete removal of the calibration standard from the adsorbent trap, so they are observed in the blank. VOC analytical methodology requires that the VOCs be thermally released from the adsorbent trap, transferred to the gas chromatograph (GC), and into the mass spectrometer (MS) for quantification.

DISCUSSION

Risk Characterization

Because variability and uncertainty are inherent to quantitative assessment of risk, the calculated risks of adverse health outcomes from exposure to toxicants can be orders of magnitude above or below actual risks. Variability in calculated and in actual risk may depend upon factors such as the use of animal instead of human studies, use of subchronic rather than chronic studies, interspecies variability, intra-species variability, and database insufficiency. Because most factors used to calculate comparison values result from experimental studies conducted in the laboratory on nonhuman subjects, variability and uncertainty might arise from the study chosen as the "critical" one, the species/strain of animal used in the critical study, the target organ selected as the "critical organ," exposure periods, exposure route, doses, or uncontrolled variations in other conditions.[32] Despite such limitations, risk assessors must calculate parameters to represent potential toxicity to humans who consume contaminants in fish and other environmental media. The DSHS calculated risk parameters for noncarcinogenic and carcinogenic endpoints in those who would consume fish from the Ellison Creek Reservoir. Conclusions and recommendations predicated upon the stated goal of the DSHS to protect human health follow the discussion of the relevance of findings to risk.

Characterization of Systemic (Noncarcinogenic) Health Effects from Consumption of Fish from Ellison Creek Reservoir

Inorganic Contaminants

None of the species of fish evaluated contained arsenic, cadmium, copper, lead, mercury, selenium, or zinc at concentrations that equaled or exceeded DSHS guidelines for protection of human health or would likely cause systemic (noncancerous) risk to human health from consumption of fish from Ellison Creek Reservoir.

Organic Contaminants

PCBs and PCDDs/PCDFs were observed in fish from Ellison Creek Reservoir at concentrations at or above their respective HAC_{nonca} (0.047 mg/kg; 2.330 pg/g; Tables 4.1–4.3, 5.1–5.3, and 8.1–8.3). None of the species of fish evaluated contained any other organic contaminants at concentrations that equaled or exceeded DSHS guidelines for protection of human health or would likely cause systemic (noncancerous) risk to human health from consumption of fish from Ellison Creek Reservoir.

<u>PCBs</u>

All fish tissue samples (*n* = 107) evaluated contained PCBs. Seventy-seven percent of all samples analyzed contained PCB concentrations equaling or exceeding the HAC_{nonca} for PCBs (0.047 mg/kg; Tables 4.1–4.3). Nine (bluegill, channel catfish, common carp, flathead catfish, hybrid striped bass, largemouth bass, redbreast sunfish, spotted gar, and white bass) of the 13 species of fish evaluated had mean PCB concentrations exceeding the HAC_{nonca} for PCBs or an HQ of 1.0 (Tables 4.1–4.3 and 8.1–8.3). The all fish combined mean PCB concentration (0.102 mg/kg) exceeded the HAC_{nonca} for PCBs or an HQ of 1.0. PCB concentrations were positively related to TL and percent lipids indicating that PCB concentrations increase as fish grow and as their body fat increases (Figures 2–3). People should consider these relationships when choosing the size and species of fish they consume. The consumption of bluegill, channel catfish, common carp, flathead catfish, hybrid striped bass, largemouth bass, redbreast sunfish, spotted gar, and white bass from Ellison Creek Reservoir may pose potential systemic (noncancerous) health risks.

Meal consumption calculations are useful for risk managers to make fish consumption recommendations and/or take regulatory action. The SALG risk assessors calculated the number of eight-ounce meals of fish from Ellison Creek Reservoir that healthy adults could consume without significant risk of PCB-related adverse systemic effects (Tables 8.1–8.3). Meal consumption rates were based on the overall mean PCB concentration by species. The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week for these species of fish: 0.4 meals per week of channel catfish; or, 0.2 meals per week of common carp; 0.5 meals per week of flathead catfish; 0.2 meals per week of hybrid striped bass; 0.7 meals per week of largemouth bass; 0.4 meals per week of spotted gar; 0.4 meals per week of sunfish S*pp*.; or, 0.6 meals per week of white bass. The SALG risk assessors suggest that fish from Ellison Creek Reservoir contain PCBs at concentrations that may pose potential systemic (noncancerous) health risks and that people should not consume common carp and hybrid striped bass and limit their consumption of channel catfish, flathead catfish, largemouth bass, spotted gar, sunfish S*pp*., and white bass from Ellison Creek Reservoir. Because the developing nervous system of the human fetus and young children may be especially susceptible to adverse systemic (noncancerous) health effects associated with consuming PCB-contaminated fish, the SALG risk assessors recommend more conservative consumption guidance for this sensitive subpopulation.

<u>PCDDs/PCDFs</u>

Ninety-eight of 100 fish tissue samples assayed contained PCDDs/PCDFs. Nine percent of all samples analyzed contained PCDD/PCDF concentrations exceeding the HAC_{nonca} for PCDDs/PCDFs (2.330 pg/g; Tables 5.1–5.3 and 8.1–8.3). One (hybrid striped bass) of 10 species of fish evaluated had mean PCDD/PCDF concentrations exceeding the HAC_{nonca} for PCDDs/PCDFs or an HQ of 1.0 (Tables 5.1–5.3 and 8.1–8.3). The all fish combined mean PCDD/PCDF concentration did not exceed the HAC_{nonca} for PCDDs/PCDFs or an HQ of 1.0. The consumption of hybrid striped bass from Ellison Creek Reservoir may pose potential systemic (noncancerous) health risks.

Meal consumption calculations are useful for risk managers to make fish consumption recommendations and/or take regulatory action. The SALG risk assessors calculated the number of eight-ounce meals of fish from Ellison Creek Reservoir that healthy adults could consume without significant risk of PCDD/PCDF -related adverse systemic effects (Tables 8.1–8.3). Meal consumption rates were based on the overall mean PCDD/PCDF concentration by species. The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week of hybrid striped bass. The SALG risk assessors estimated that people should not consume more than 0.6 meals per week. The SALG risk assessors suggest that hybrid striped bass from Ellison Creek Reservoir contain PCDDs/PCDFs at concentrations that may pose potential systemic (noncancerous) health risks and that people should limit their consumption of hybrid striped bass from Ellison Creek Reservoir. Because the developing nervous system of the human fetus and young children may be especially susceptible to adverse systemic health effects associated with consuming PCDD/PCDF-contaminated fish, the SALG risk assessors recommend more conservative consumption guidance for this sensitive subpopulation.

Characterization of Theoretical Lifetime Excess Cancer Risk from Consumption of Fish from Ellison Creek Reservoir

The USEPA classifies arsenic, most chlorinated pesticides, PCBs, and PCDDs/PCDFs as human carcinogens. Arsenic, chlordane, and DDE were present in fish samples analyzed from Ellison Creek Reservoir, but none of these contaminants evaluated singly by species or all species combined had mean contaminant concentrations that would be likely to increase the risk of cancer to exceed the DSHS guideline for protection of human health of one excess cancer in 10,000 equally exposed individuals.

<u>PCBs</u>

The mean PCB concentrations observed in hybrid striped bass exceed the DSHS guideline for protection of human health of one excess cancer in 10,000 equally exposed individuals and the HAC_{ca} for PCBs (0.272 mg/kg; Tables 4.1–4.3 and 9.1–9.4). PCB concentrations that equaled or exceeded the HAC_{ca} for PCBs were observed in one or more samples of channel catfish and common carp. The all fish combined mean PCB concentration did not exceed the HAC_{ca} for PCBs.

The SALG risk assessors calculated the number of eight-ounce meals of hybrid striped bass from Ellison Creek Reservoir that healthy adults could consume without significantly increasing their lifetime excess cancer risk (Table 9.1–9.4). The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week of hybrid striped bass (0.9 meals per week). Because children may experience effects at a lower exposure dose than adults, the SALG risk assessors recommend more conservative consumption guidance for this sensitive subpopulation. The SALG risk assessors suggest that consumption of hybrid striped bass from Ellison Creek Reservoir would be likely to increase the risk of cancer to exceed the DSHS guideline for protection of human health from PCB exposure.

<u>PCDDs/PCDFs</u>

The mean PCDD/PCDF concentrations observed in hybrid striped bass exceed the DSHS guideline for protection of human health of one excess cancer in 10,000 equally exposed individuals or the HAC_{ca} for PCDDs/PCDFs (3.490 pg/g; Tables 5.1–5.3 and 9.1–9.4). The all fish combined mean PCDD/PCDF concentration did not exceed the HAC_{ca} for PCDDs/PCDFs. The consumption of hybrid striped bass from Ellison Creek Reservoir would be likely to increase the risk of cancer to exceed the DSHS guideline for protection of human health.

The SALG risk assessors calculated the number of eight-ounce meals of hybrid striped bass from Ellison Creek Reservoir that healthy adults could consume without significantly increasing their lifetime excess cancer risk (Tables 9.1–9.4). The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week of hybrid striped bass (0.8 meals per week). Because children may experience effects at a lower exposure dose than might adults because children’s systems may be more sensitive to the effects of toxicants, the SALG risk assessors recommend more conservative consumption guidance for this sensitive subpopulation. The SALG risk assessors suggest that consumption of hybrid striped bass from Ellison Creek Reservoir would be likely to increase the risk of cancer to exceed the DSHS guideline for protection of human health from PCDD/PCDF exposure.

Characterization of Calculated Cumulative Systemic (Noncarcinogenic) Health Effects and of Cumulative Excess Lifetime Cancer Risk from Consumption of Fish from Ellison Creek Reservoir

Cumulative Systemic (Noncarcinogenic) Health Effects

Cumulative systemic (noncarcinogenic) effects of toxicants may occur if more than one contaminant acts upon the same target organ or acts by the same mode or mechanism of action. PCBs and PCDDs/PCDFs in fish from Ellison Creek Reservoir could have these properties, especially with respect to effects on the immune system. Multiple organic contaminants in Ellison Creek Reservoir fish increased the likelihood of systemic adverse health outcomes for all species of fish evaluated (Tables 8.1–8.3). The combined toxicity of PCBs and PCDDs/PCDFs in channel catfish, common carp, flathead catfish, hybrid striped bass, largemouth bass, spotted gar, Sunfish *Spp*., and white bass exceeded an HI of 1.0.

Meal consumption calculations are useful for risk managers to make fish consumption recommendations and/or take regulatory action. The SALG risk assessors calculated the number of eight-ounce meals of fish from Ellison Creek Reservoir that healthy adults could consume without significant risk of PCB and/or PCDD/PCDF -related adverse systemic effects (Tables 8.1–8.3). Meal consumption rates were based on cumulative toxicity from exposure to PCBs and PCDDs/PCDFs by species. The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week of channel catfish, common carp, flathead catfish, hybrid striped bass, largemouth bass, spotted gar, Sunfish *Spp*., or white bass (Tables 8.1–8.3). The SALG risk assessors suggest that channel catfish, common carp, flathead catfish, hybrid striped bass, largemouth bass, spotted gar, Sunfish *Spp*., and white bass from Ellison Creek Reservoir contain PCBs and PCDDs/PCDFs at concentrations that may pose potential systemic (noncarcinogenic) health risks and that people should limit their consumption of fish from Ellison Creek Reservoir. Because the developing body systems of the human fetus and young children may be especially susceptible, the SALG risk assessors recommend more conservative consumption guidance for these sensitive subpopulations.

Cumulative Carcinogenic Health Effects

The SALG also queried the probability of increasing lifetime excess cancer risk from consuming fish containing multiple inorganic and organic contaminants. In most assessments of cancer risk from environmental exposures to chemical mixtures, researchers have considered any increase in cancerous or benign growths in one or more organs as cumulative, no matter the mode or mechanism of action of the contaminant. In this assessment, risk assessors added the calculated carcinogenic effect of arsenic, chlorinated pesticides, PCBs, and PCDFs/PCDDs (Tables 9.1–9.4). In each instance, addition of the cancer risk for these chemicals increased the theoretical lifetime excess cancer risk. The cancer risk increase did elevate lifetime excess cancer risk to a level greater than the DSHS guideline for protection of human health of one excess cancer in 10,000 persons equivalently exposed for channel catfish, common carp, and hybrid striped bass.

The consumption of channel catfish, common carp, and hybrid striped bass from Ellison Creek Reservoir likely increases the risk of cancer to exceed the DSHS guideline for protection of human health. The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week for these species of fish: 0.9 meals per week of channel catfish; 0.7 meals per week of or common carp; or, 0.4 meals per week of hybrid striped bass (Tables 9.1–9.4). Because children may experience effects at a lower exposure dose than adults, the SALG risk assessors recommend more conservative consumption guidance for this sensitive subpopulation. The SALG risk assessors suggest that consumption of channel catfish, common carp, and hybrid striped bass from Ellison Creek Reservoir would be likely to increase the risk of cancer to exceed the DSHS guideline for protection of human health from multiple contaminant exposures.

CONCLUSIONS

The SALG risk assessors prepare risk characterizations to determine public health hazards from consumption of fish and shellfish harvested from Texas water bodies by recreational or subsistence fishers. If necessary, the SALG risk assessors may suggest strategies for reducing risk to the health of those who may eat contaminated fish or seafood to risk managers at the DSHS, including the Texas Commissioner of Health.

This study addressed the public health implications of consuming fish from Ellison Creek Reservoir, located in Morris County, Texas. Risk assessors from the SALG conclude from the present characterization of potential adverse health effects from consuming fish from Ellison Creek Reservoir that:

1. Confidence in the conclusions for many species of fish is limited by the small sample size. Sampling a small number of fish (i.e., individual species of fish or all fish species combined) decreases the confidence of mean contaminant concentrations for the fish population thus adding uncertainty to the conclusions.

2. Black crappie, bowfin, channel catfish, common carp, flathead catfish, hybrid striped bass, largemouth bass, spotted gar, white bass, and white crappie mean concentrations of arsenic, cadmium, copper, lead, mercury, selenium, zinc, most pesticides, SVOCs, or VOCs; either singly, or in combination do not exceed the DSHS guidelines for protection of human health. Therefore, consumption of these species of fish from Ellison Creek Reservoir containing the above-listed contaminants **poses no apparent risk to human health**.

3. Black crappie, bowfin, green sunfish, and white crappie mean PCB concentrations do not exceed the DSHS guidelines for protection of human health for women past childbearing age and males 12 and older. Therefore, consumption of these species of fish from Ellison Creek Reservoir containing only PCBs **poses no apparent risk to human health**.

4. Black crappie, bowfin, channel catfish, common carp, flathead catfish, largemouth bass, spotted gar, white bass, and white crappie mean PCDD/PCDF TEQ concentrations do not exceed the DSHS guidelines for protection of human health for women past childbearing age and males 12 and older. Therefore, consumption of these species of fish from Ellison Creek Reservoir containing only PCDDs/PCDFs **poses no apparent risk to human health**.

5. Bluegill, channel catfish, common carp, flathead catfish, hybrid striped bass, largemouth bass, redbreast sunfish, spotted gar, and white bass mean PCB concentrations exceed the DSHS guidelines for protection of human health for women past childbearing age and males 12 and older. Regular or long-term consumption of these species of fish may result in adverse systemic (noncarcinogenic) health effects and/or increase the likelihood of carcinogenic health risks. Therefore, consumption of these species of fish from Ellison Creek Reservoir **poses an apparent risk to human health**.

6. Hybrid striped bass mean PCDD/PCDF TEQ concentrations exceed the DSHS guidelines for protection of human health for women past childbearing age and males 12 and older. Regular or long-term consumption of hybrid striped bass may result in adverse systemic (noncarcinogenic) health effects and/or increase the likelihood of carcinogenic health risks. Therefore, consumption of hybrid striped bass from Ellison Creek Reservoir **poses an apparent risk to human health**.

7. Consumption of multiple organic contaminants (i.e., PCDDs/PCDFs and PCBs) in channel catfish, common carp, flathead catfish, hybrid striped bass, largemouth bass, spotted gar, and white bass increases the likelihood of systemic (noncarcinogenic) health risks. Regular or long-term consumption of these species of fish may result in adverse systemic (noncarcinogenic) health effects. Therefore, consumption of these species of fish from Ellison Creek Reservoir **poses an apparent risk to human health**.

8. Consumption of multiple inorganic and/or organic contaminants observed in channel catfish, and hybrid striped bass increases the likelihood of carcinogenic health risks. Therefore, consumption of these species of fish from Ellison Creek Reservoir containing multiple contaminants **poses an apparent risk to human health**.

RECOMMENDATIONS

Risk managers at the DSHS have established criteria for issuing fish consumption advisories based on approaches suggested by the USEPA.[13, 18, 47] Risk managers at the DSHS may decide to take action to protect public health if a risk characterization confirms that people can eat four or fewer meals per month (adults: eight-ounces per meal; children: four-ounces per meal) of fish or shellfish from a water body under investigation. Risk management recommendations may be in the form of consumption advice or a ban on possession of fish from the affected water body. Fish or shellfish possession bans are enforceable under subchapter D of the Texas Health and Safety Code, part 436.061(a).[48] Declarations of prohibited harvesting areas are enforceable under the Texas Health and Safety Code, Subchapter D, parts 436.091 and 436.101.[48] The DSHS consumption advice carries no penalty for noncompliance. Consumption advisories, instead, inform the public of potential health hazards associated with consuming contaminated fish or shellfish from Texas waters. With this information, people can make informed decisions about whether and/or how much, contaminated fish or shellfish, they wish to consume. The SALG concludes from this risk characterization that consuming channel catfish, common carp, flathead catfish, hybrid striped bass, largemouth bass, spotted gar, sunfish Spp., and white bass from Ellison Creek Reservoir **poses an apparent hazard to public health.** Therefore, SALG risk assessors recommend that:

1. People should not consume hybrid striped bass and common carp from Ellison Creek Reservoir (Table 10).

2. Women of childbearing age (Women and girls under 50) including pregnant women, women who may become pregnant, and women who are nursing infants and children less than 12 years of age, or who weigh less than 75 pounds should not consume channel catfish, common carp, flathead catfish, hybrid striped bass, spotted gar, sunfish *Spp*., and white bass from Ellison Creek Reservoir.

3. Women of childbearing age (Women and girls under 50) including pregnant women, women who may become pregnant, and women who are nursing infants and children less than 12 years of age, or who weigh less than 75 pounds may consume up to one four-ounce meal per month of largemouth bass from Ellison Creek Reservoir.

4. Women past childbearing age (Women 50 and older) and males 12 and older may consume up to one eight-ounce meal per month of channel catfish, flathead catfish, spotted gar, or sunfish *Spp*. from Ellison Creek Reservoir.

5. Women past childbearing age (Women 50 and older) and males 12 and older may consume up to two eight-ounce meal per month of largemouth bass or white bass from Ellison Creek Reservoir.

6. The DSHS advise TPWD to continue not stocking hybrid striped bass (i.e., Palmetto bass) in Ellison Creek Reservoir because hybrid striped bass bioaccumulate significant concentrations of PCBs and PCDDs/PCDFs that pose apparent hazards to public health. The TPWD discontinued stocking of hybrid striped bass following the issuance of the Ellison Creek Reservoir fish consumption advisory in 2005.

7. As resources become available, the DSHS should continue to monitor fish from Ellison Creek Reservoir for changes and establish trends in contaminants of concern or contaminant concentrations that would require a change in consumption advice.

PUBLIC HEALTH ACTION PLAN

Communication to the public of new and continuing possession bans or consumption advisories, or the removal of either, is essential to effective management of risk from consuming contaminated fish. In fulfillment of the responsibility for communication, the DSHS takes several steps.

- The agency publishes fish consumption advisories and bans in a booklet available to the public through the SALG. To receive the booklet and/or the data, please contact the SALG at 512-834-6757.[49]
- The SALG also posts the most current information about advisories, bans, and the removal of either on the internet at http://www.dshs.state.tx.us/seafood.[50] The SALG regularly updates this Web site.
- The DSHS also provides the USEPA (http://epa.gov/waterscience/fish/advisories/), the TCEQ (http://www.tceq.state.tx.us), and the TPWD (http://www.tpwd.state.tx.us) with information on all consumption advisories and possession bans. Each year, the TPWD informs the public of consumption advisories and fishing bans on its Web site and in an official downloadable PDF file containing general hunting and fishing regulations available at https://tpwd.texas.gov/publications/pwdpubs/media/cs_bk_k0700_0284.pdf. A booklet containing this information is available at all establishments selling Texas fishing licenses.[46]

Communication to the public of scientific information related to this risk characterization and information for environmental contaminants found in seafood is essential to effective risk management. To achieve this responsibility for communication, the DSHS provides contact information to ask specific questions and/or resources to obtain more information about environmental contaminants in fish.

- Readers may direct questions about the scientific information or recommendations in this risk characterization to the SALG at 512-834-6757 or may find the information at the SALG's Web site (http://www.dshs.state.tx.us/seafood). Secondarily, one may address inquiries to the Environmental and Injury Epidemiology and Toxicology Unit of DSHS (800-588-1248).
- The USEPA's IRIS Web site (http://www.epa.gov/iris/) contains information on environmental contaminants found in food and environmental media.
- The ATSDR, Division of Toxicology (888-42-ATSDR or 888-422-8737 or the ATSDR's Web site (http://www.atsdr.cdc.gov) supplies brief information via ToxFAQs.™ ToxFAQs™ are available on the ATSDR Web site in either English or Spanish (http://www.atsdr.cdc.gov/toxfaqs/index.asp). The ATSDR also publishes more in-depth reviews of many toxic substances in its *Toxicological Profiles* (ToxProfiles™) http://www.atsdr.cdc.gov/toxprofiles/index.asp. To request a copy of the ToxProfiles™

CD-ROM, PHS, or ToxFAQs^{TM} call 1-800-CDC-INFO (800-232-4636) or email a request to cdcinfo@cdc.gov.

Figure 1. Ellison Creek Reservoir Map

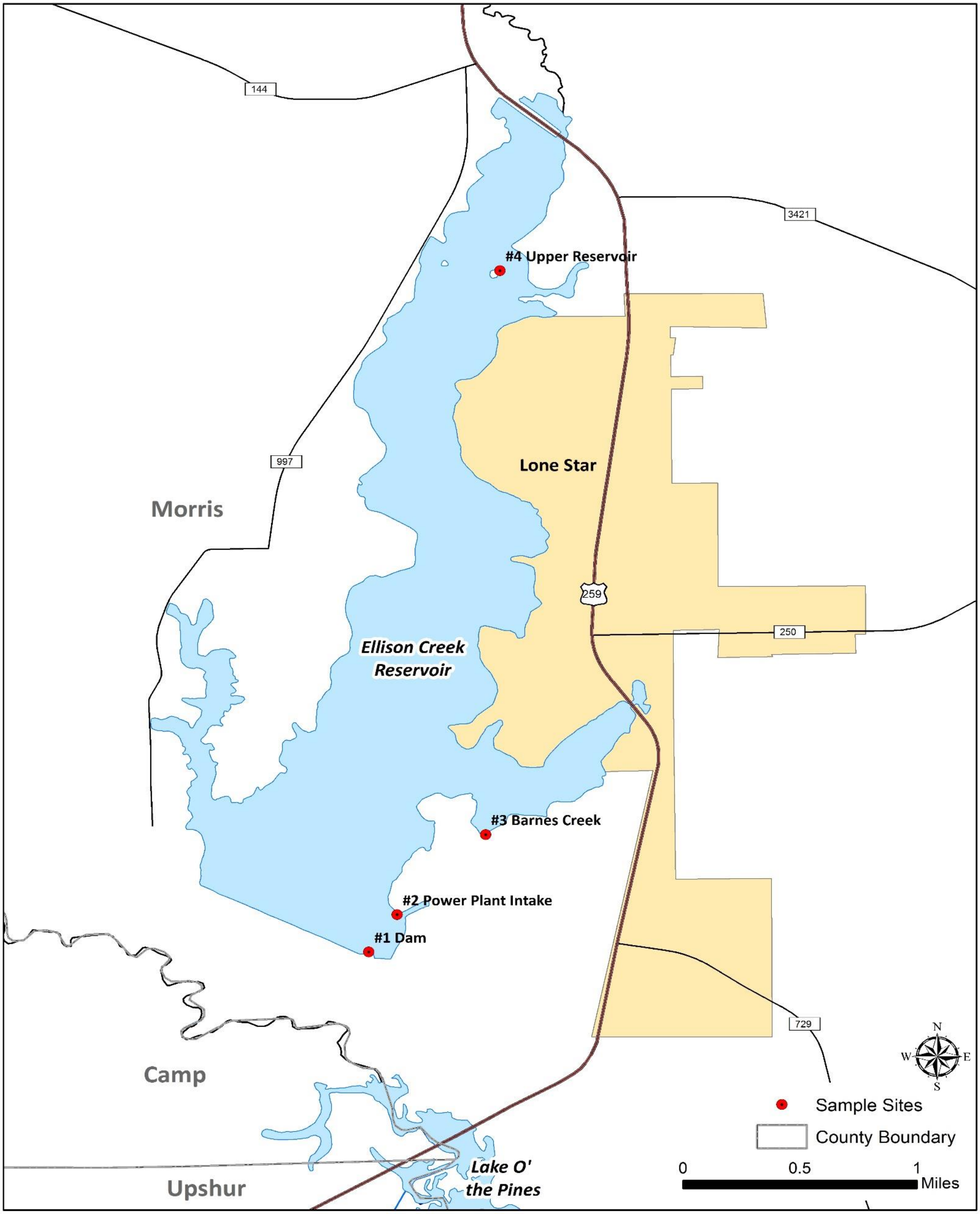


Figure 2. The relationship between PCB concentration and total length for fish collected from Ellison Creek Reservoir, Texas, 2014.

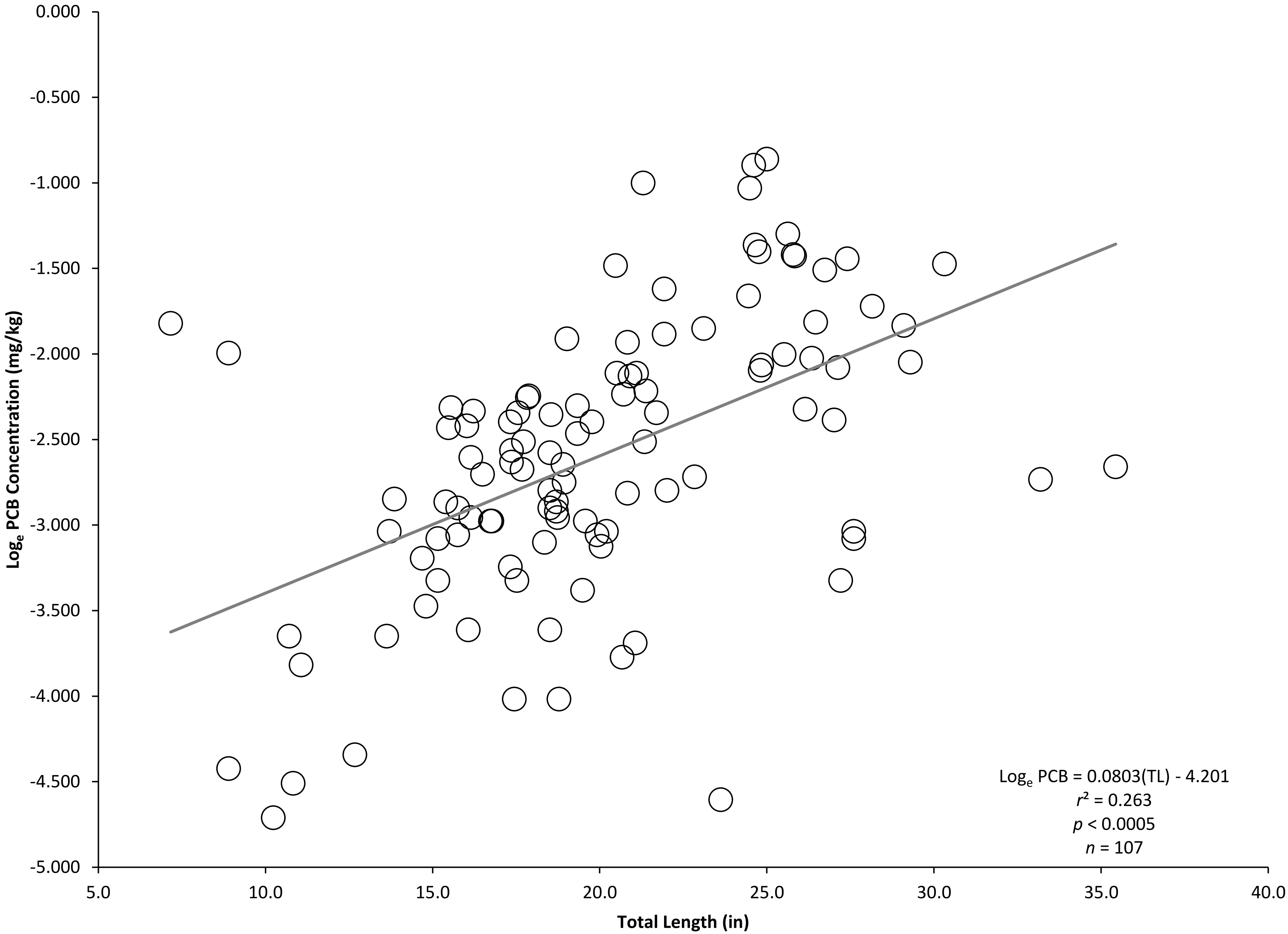


Figure 3. The relationship between PCB concentration and percent lipids for fish collected from Ellison Creek Reservoir, Texas, 2014.

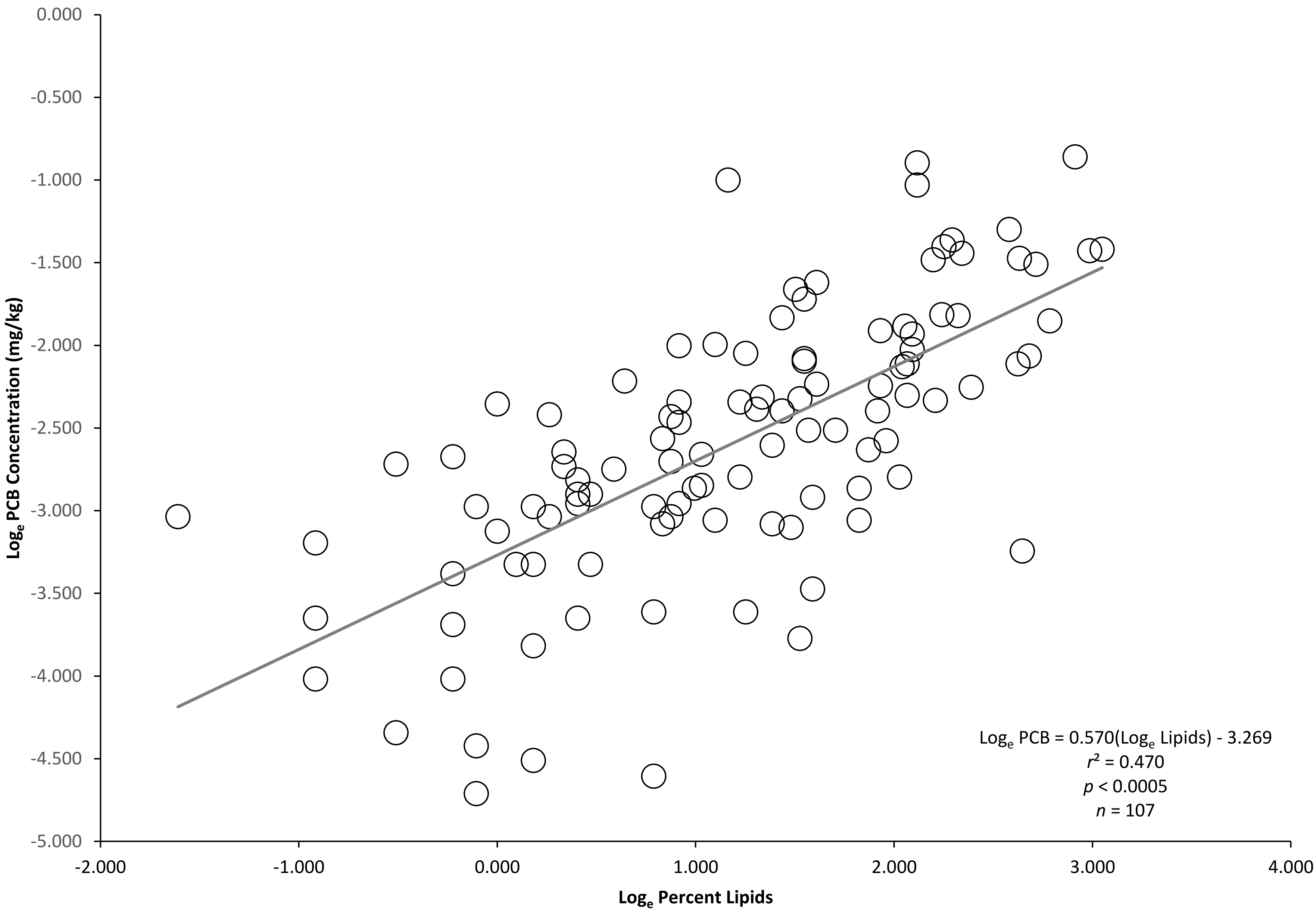


Figure 4. Length at age for channel catfish collected from Ellison Creek Reservoir, Texas, 2014.

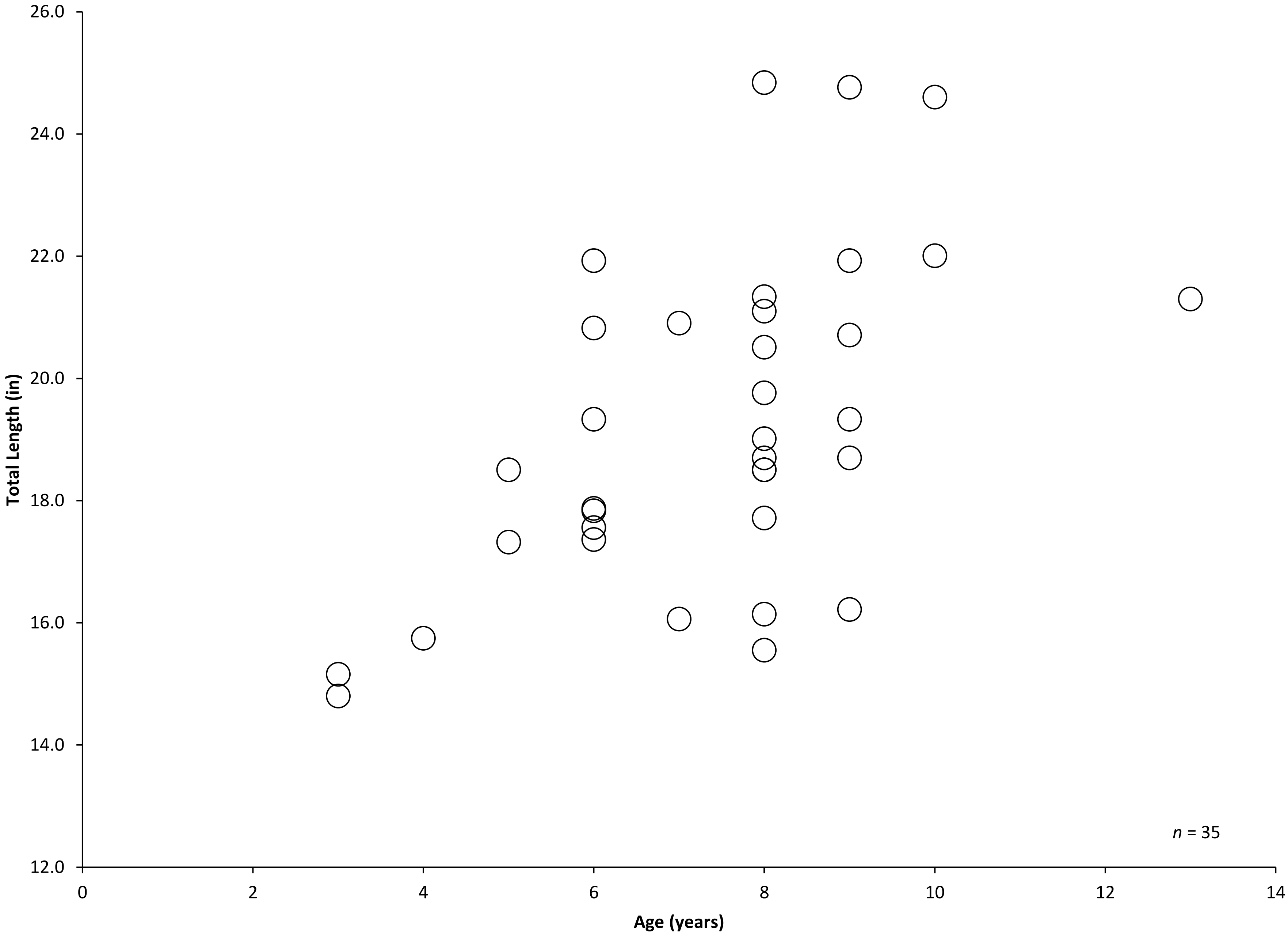


Figure 5. The relationship between PCB concentration and total length for channel catfish collected from Ellison Creek Reservoir, Texas, 2014.

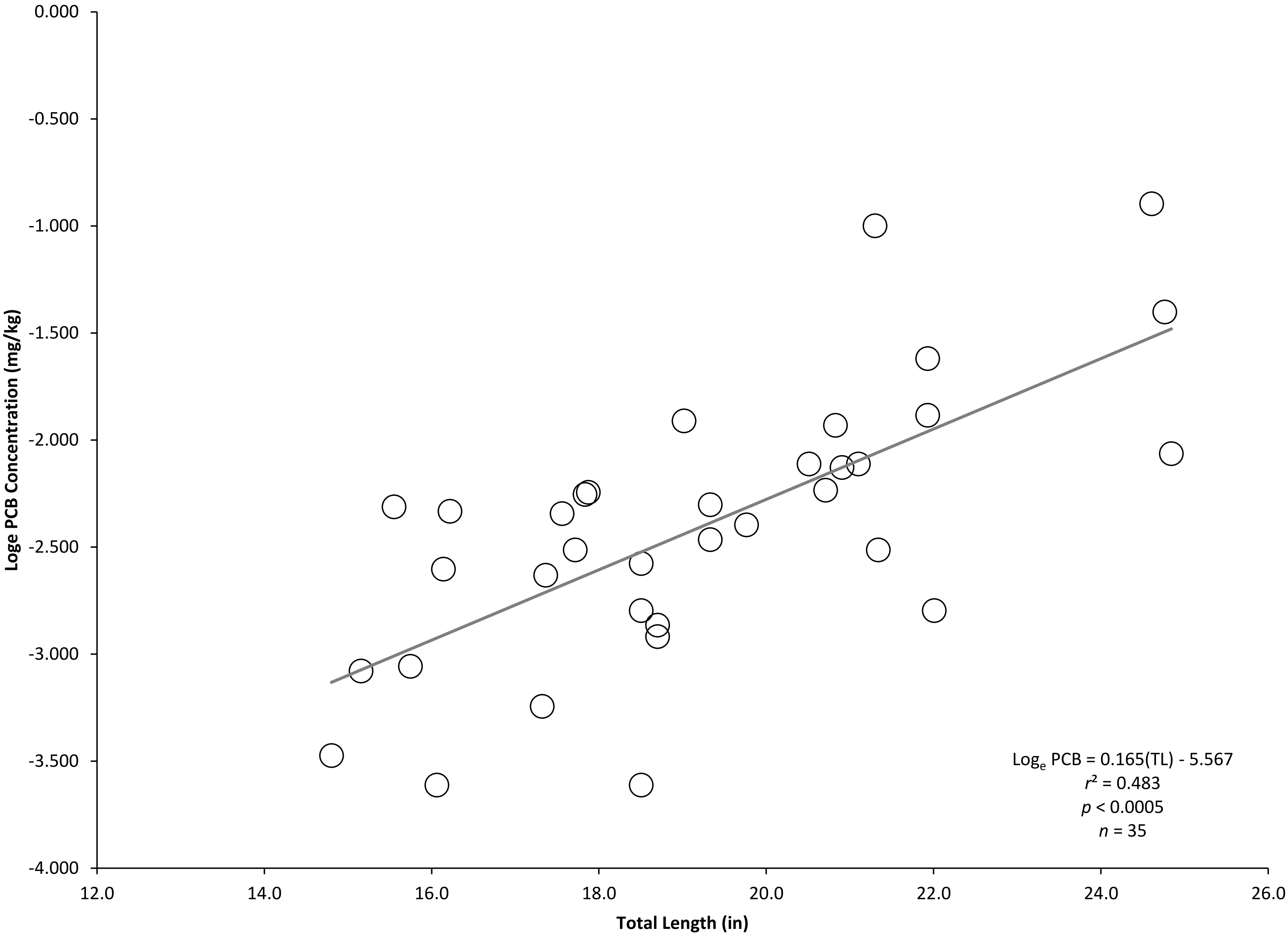


Figure 6. The relationship between PCB concentration and age for channel catfish collected from Ellison Creek Reservoir, Texas, 2014.

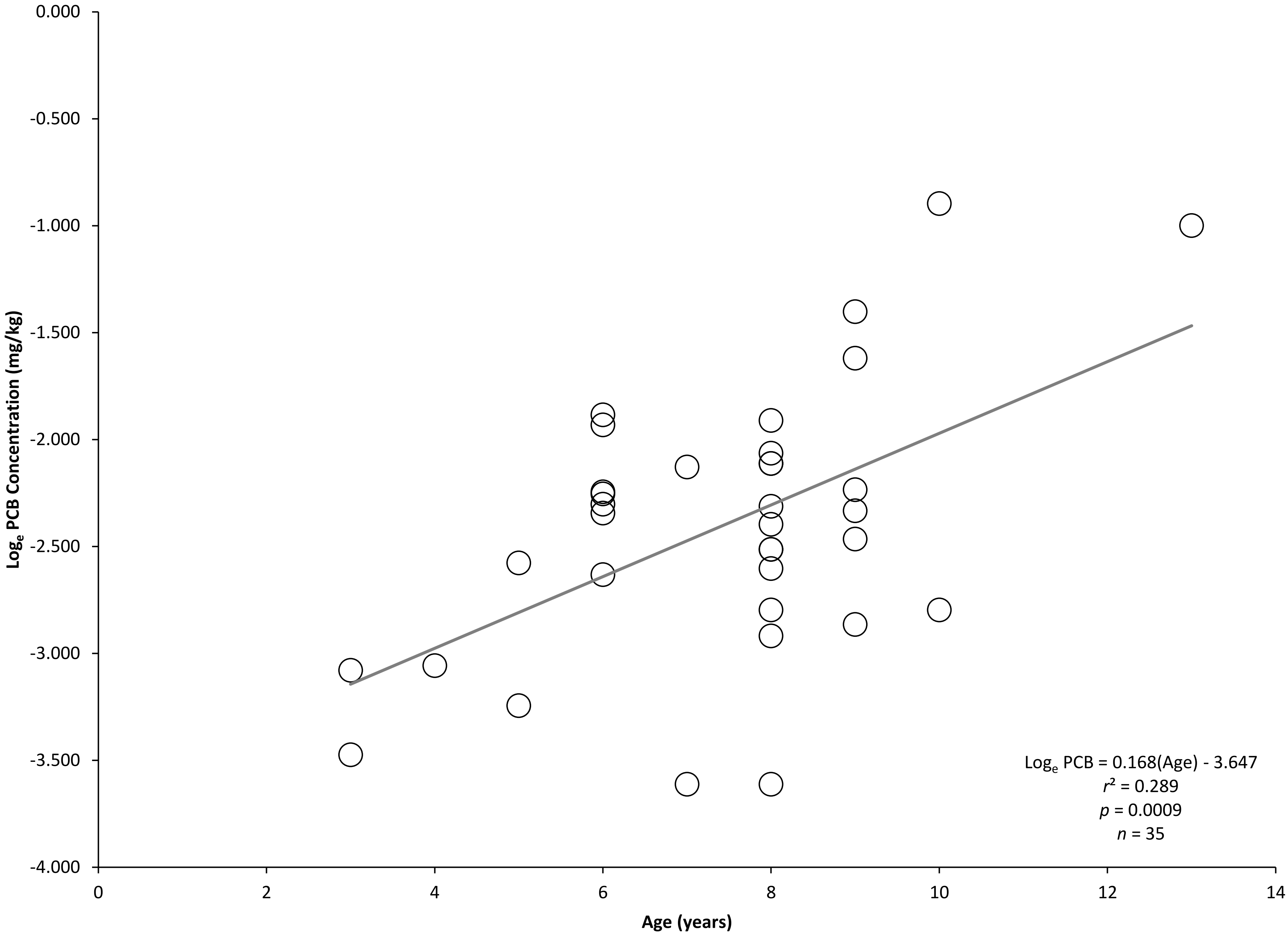


Figure 7. Length at age for crappie collected from Ellison Creek Reservoir, Texas, 2014.

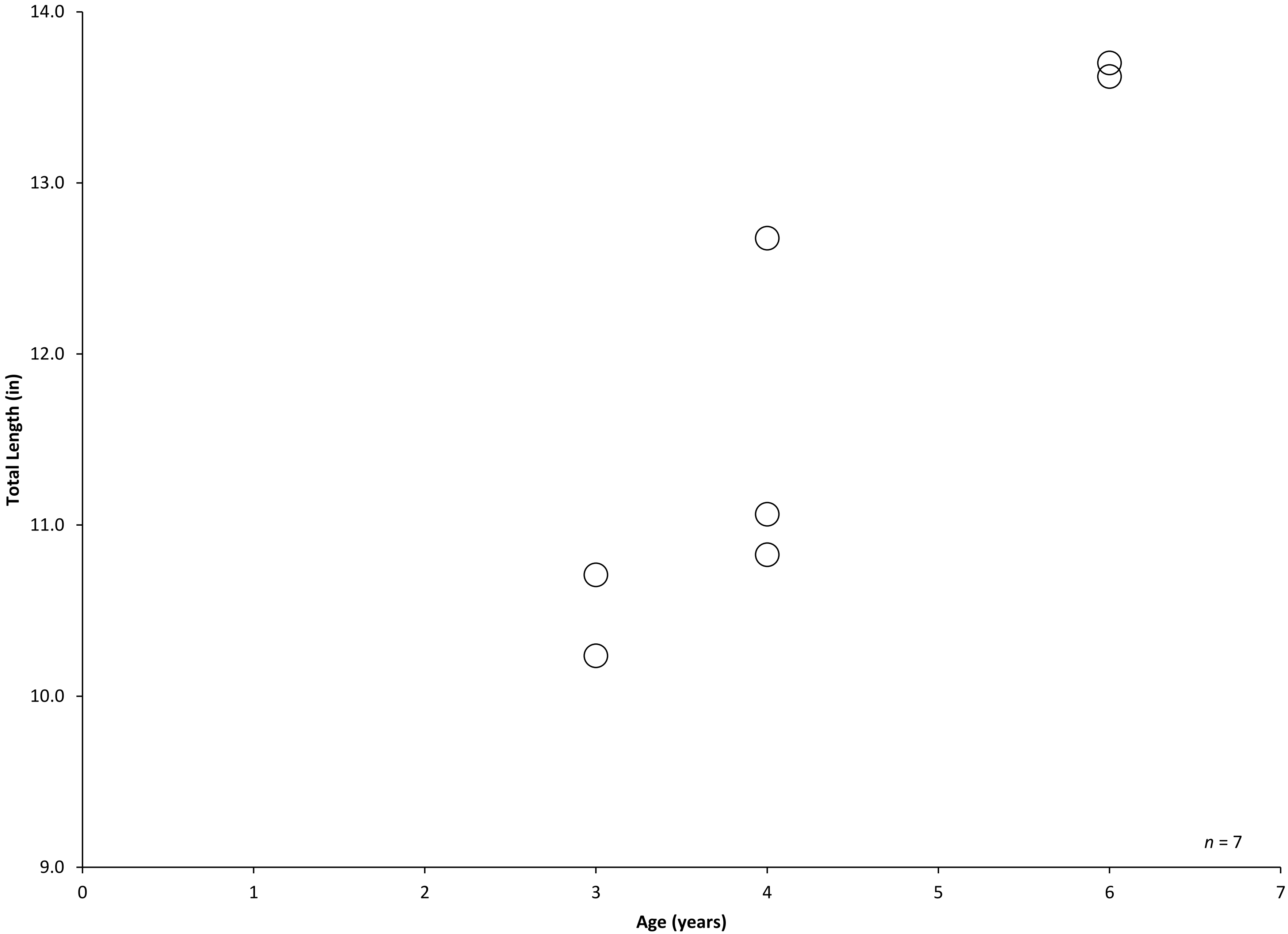


Figure 8. Length at age for flathead catfish collected from Ellison Creek Reservoir, Texas, 2014.

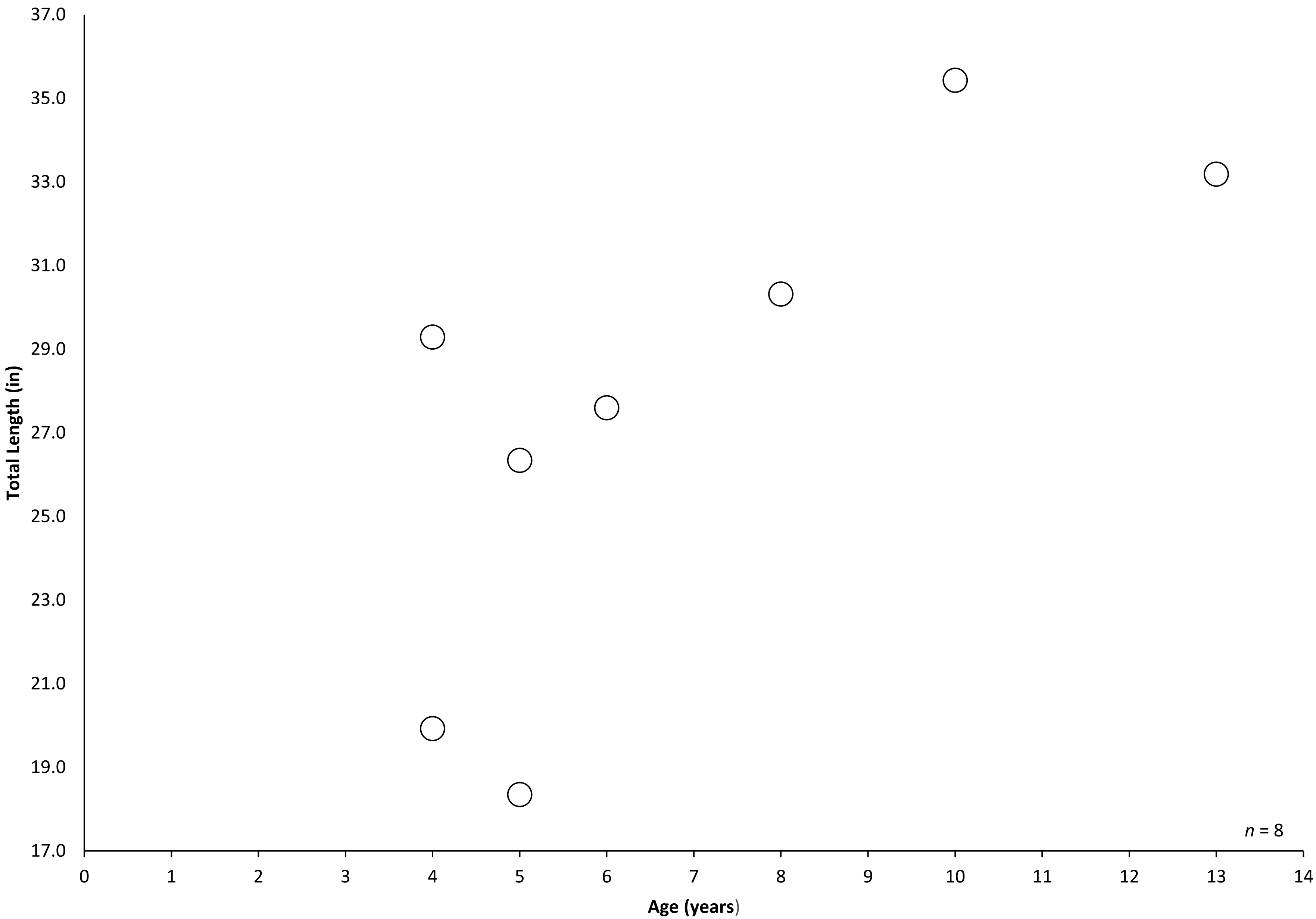


Figure 9. Length at age for largemouth bass collected from Ellison Creek Reservoir, Texas, 2014.

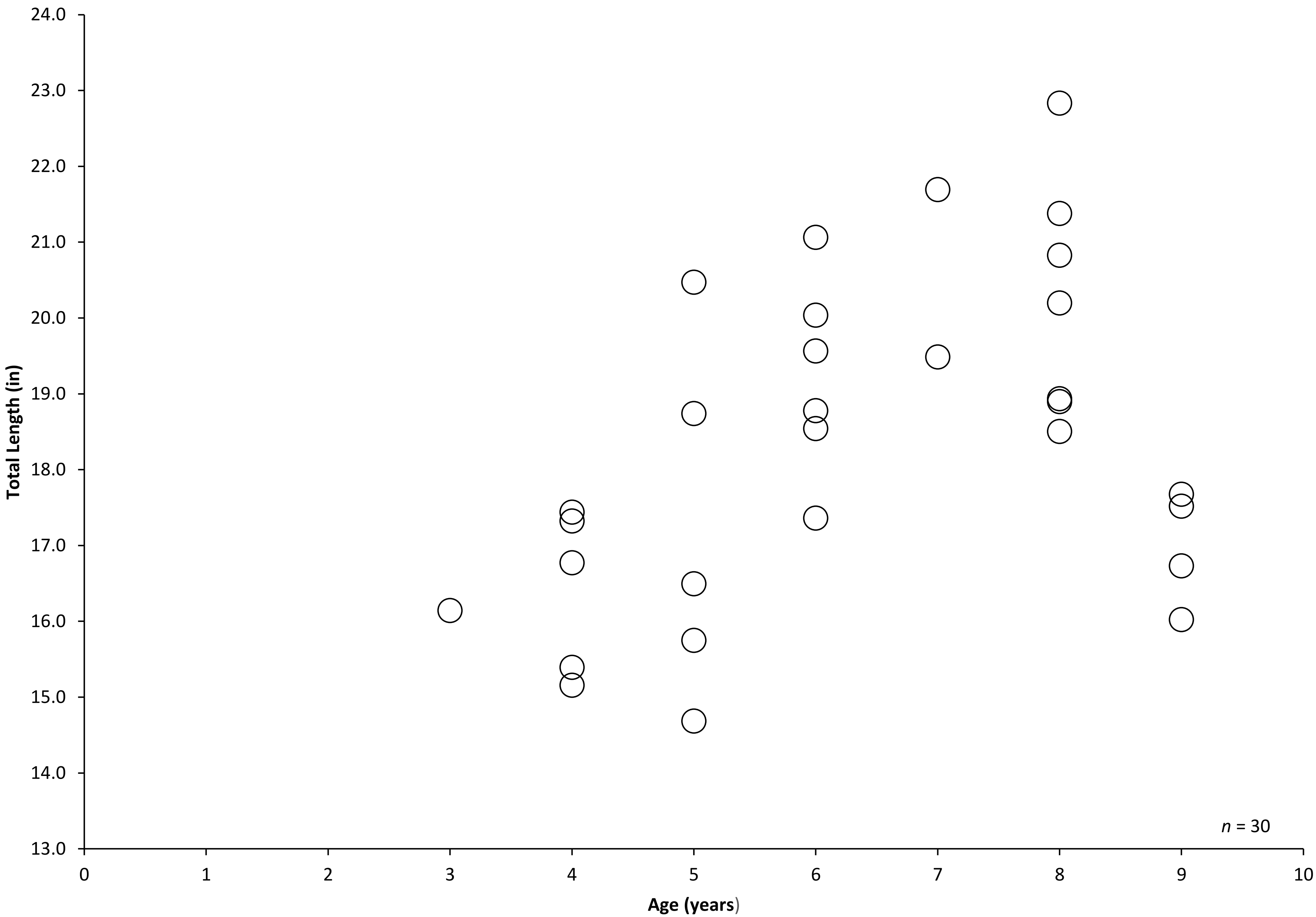


Figure 10. The relationship between PCB concentration and percent lipid for largemouth bass collected from Ellison Creek Reservoir, Texas, 2014.

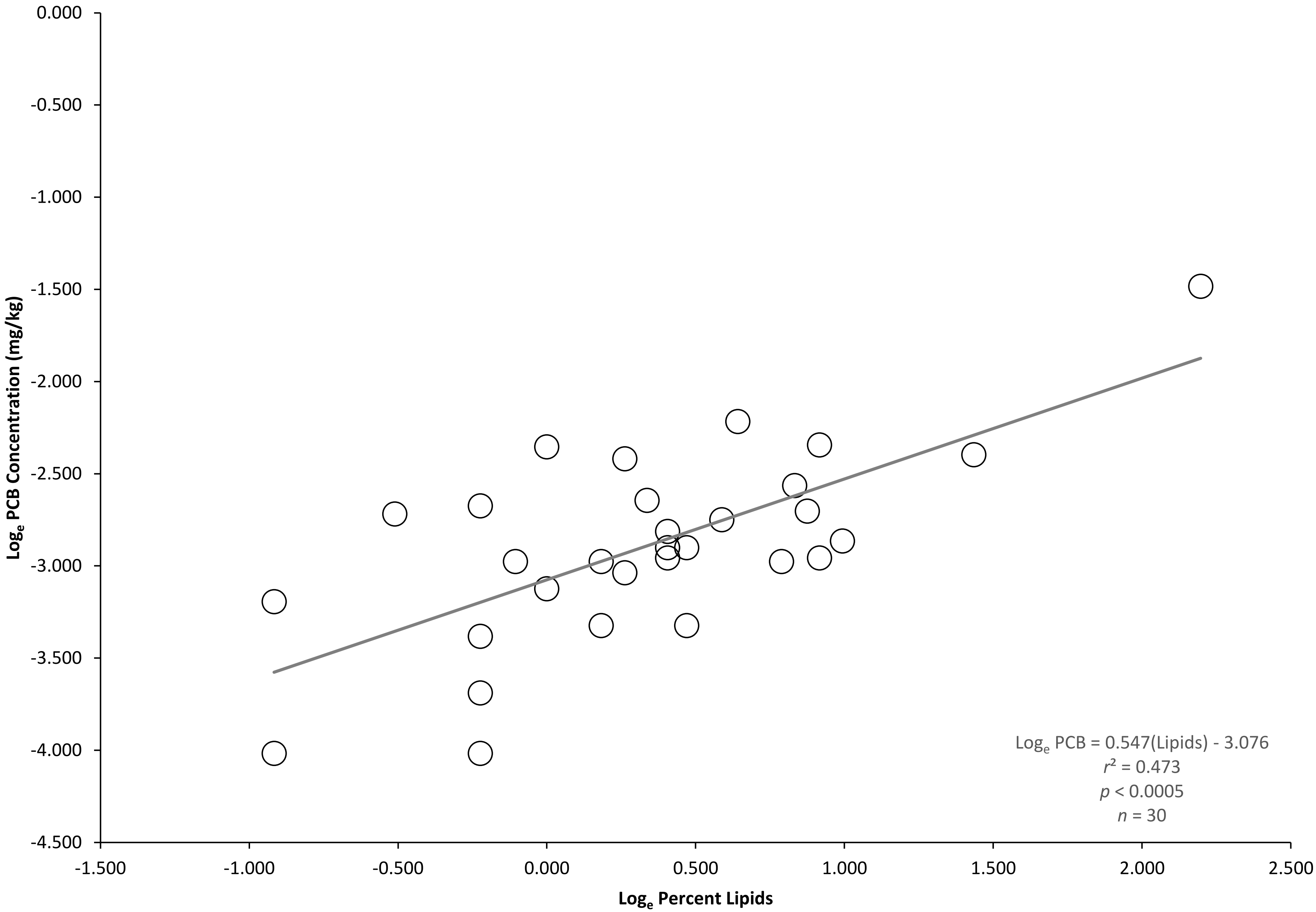


Figure 11. The relationship between PCDD/PCDF concentration and total length for fish collected from Ellison Creek Reservoir, Texas, 2014.

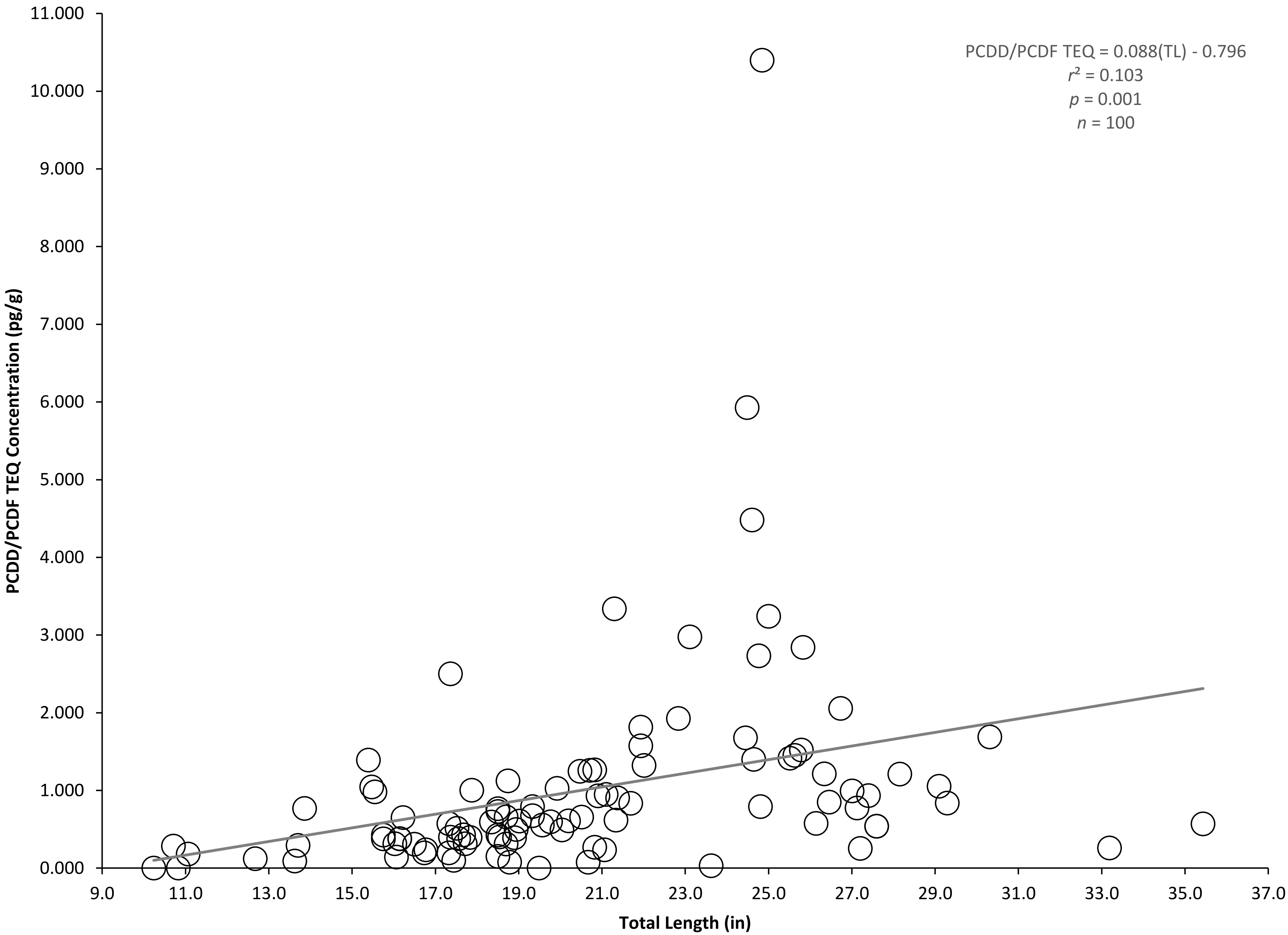


Figure 12. The relationship between PCDD/PCDF concentration and percent lipid for fish collected from Ellison Creek Reservoir, Texas, 2014.

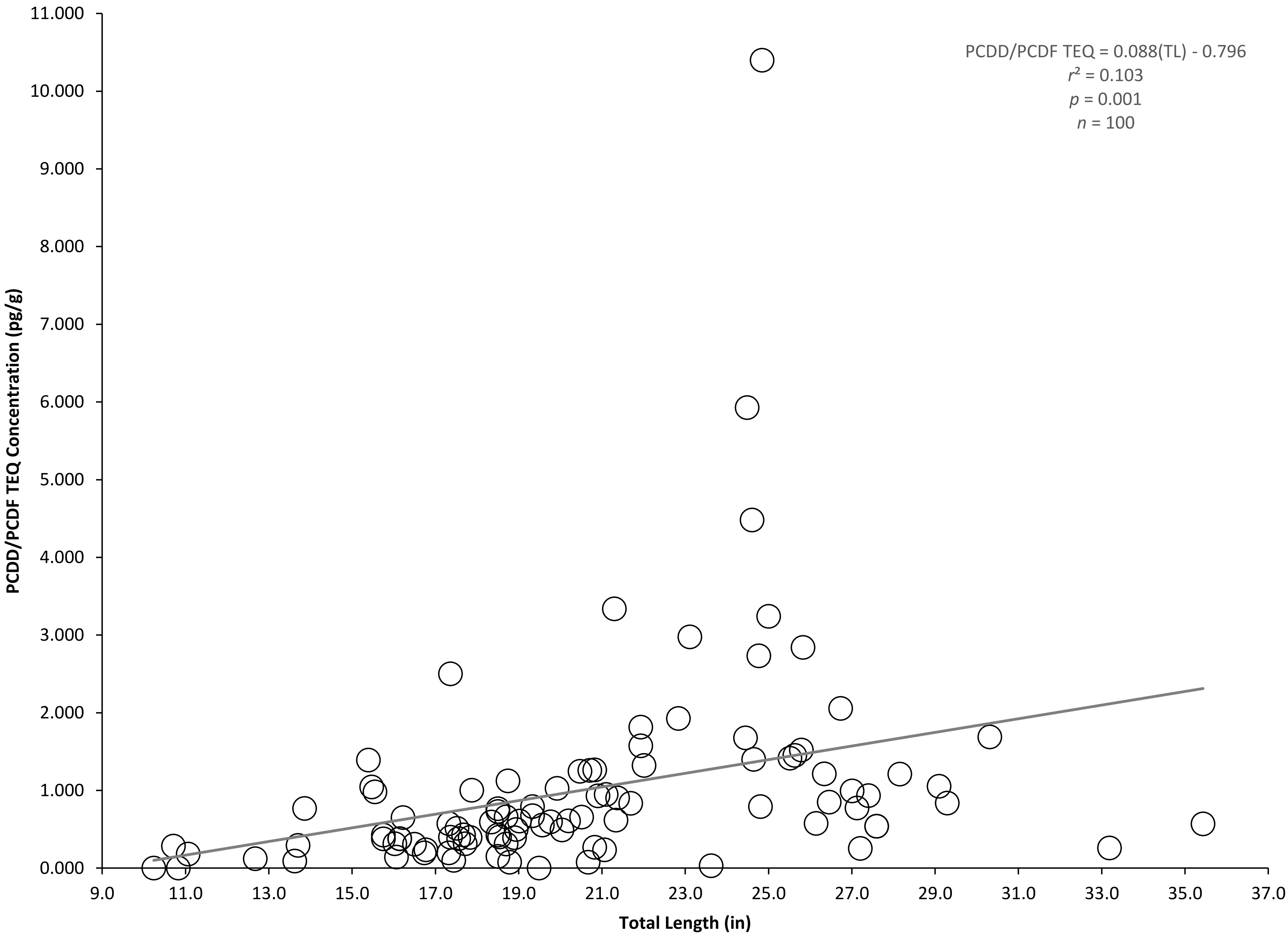


Figure 13. The relationship between PCDD/PCDF concentration and total length for channel catfish collected from Ellison Creek Reservoir, Texas, 2014.

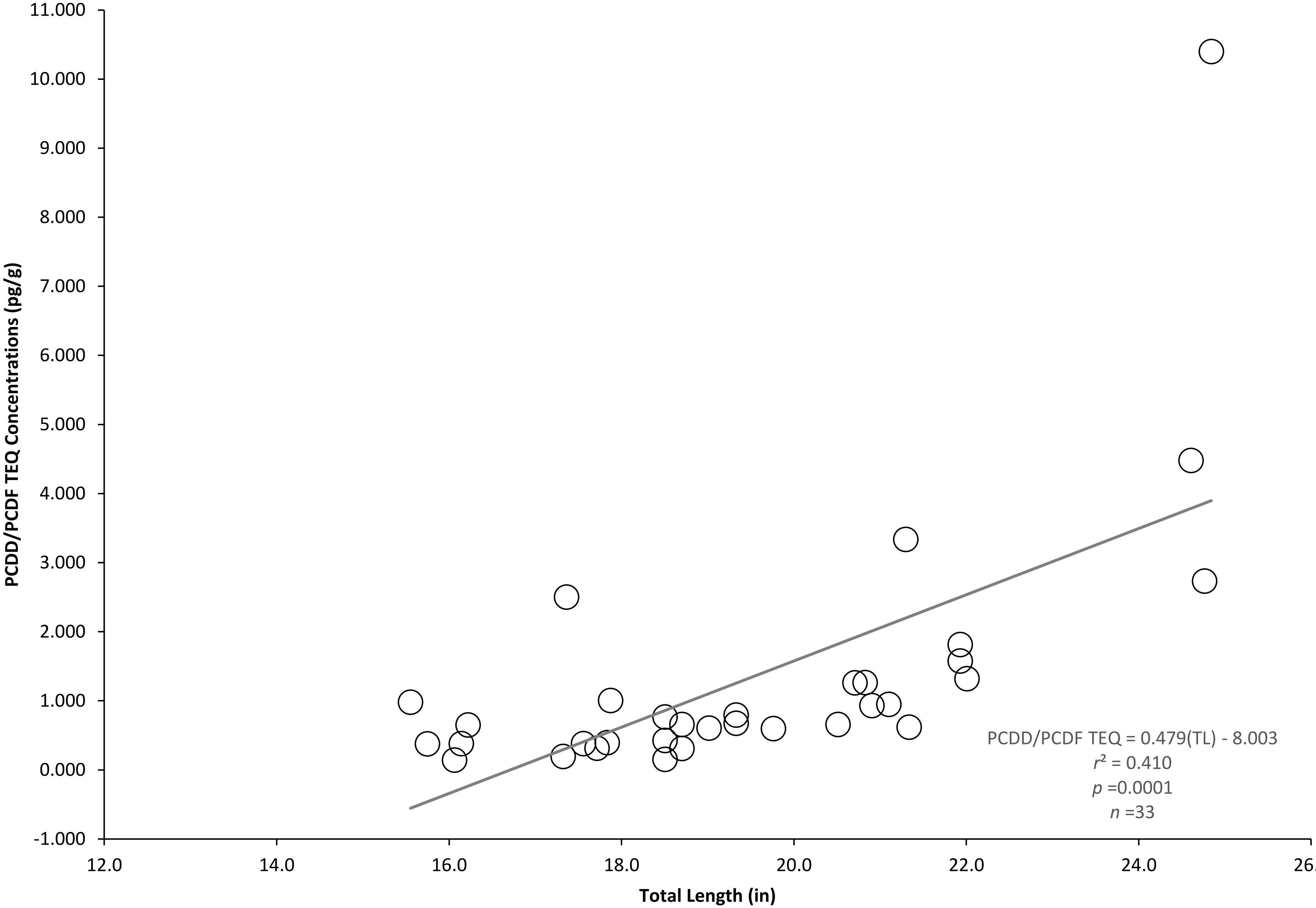
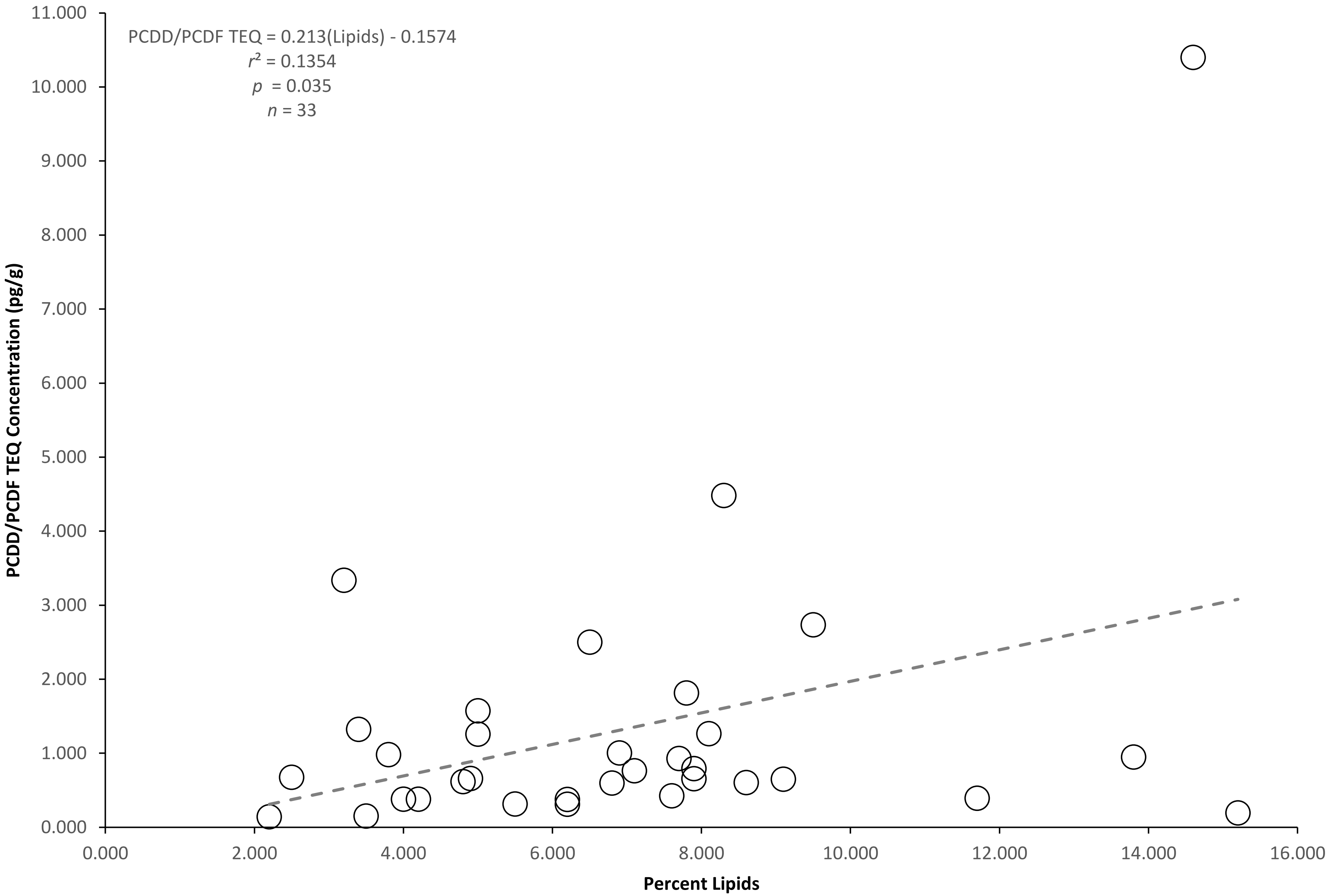


Figure 14. The relationship between PCDD/PCDF concentration and percent lipid for channel catfish collected from Ellison Creek Reservoir, Texas, 2014.



TABLES

Table 1. Fish samples collected from Ellison Creek Reservoir 2014. Sample number, species, total length, and weight recorded for each sample.

Sample Number	Species	Total Length		Weight	
		Millimeters (mm)	Inches (in)	Grams (g)	Pounds (lb)
Site 1 Ellison Creek Reservoir at the Dam					
ECR1	Hybrid striped	622	24.5	4052	8.9
ECR2	Largemouth bass	535	21.1	1971	4.3
ECR4	Flathead catfish	669	26.3	4373	9.6
ECR5	Flathead catfish	506	19.9	1493	3.3
ECR6	Flathead catfish	466	18.3	1215	2.7
ECR7	Channel catfish	531	20.9	1665	3.7
ECR8	Channel catfish	536	21.1	1523	3.4
ECR9	Channel catfish	491	19.3	1064	2.3
ECR10	Channel catfish	475	18.7	1109	2.4
ECR11	Channel catfish	470	18.5	919	2.0
ECR12	Channel catfish	408	16.1	651	1.4
ECR13	Common carp	656	25.8	3853	8.5
ECR14	Common carp	587	23.1	2702	6.0
ECR15	Largemouth bass	509	20.0	1921	4.2
ECR16	Largemouth bass	481	18.9	1733	3.8
ECR17	Largemouth bass	443	17.4	1366	3.0
ECR18	Largemouth bass	445	17.5	1251	2.8
ECR19	Largemouth bass	449	17.7	1124	2.5
ECR20	Largemouth bass	410	16.1	1014	2.2
ECR22	Largemouth bass	407	16.0	1055	2.3
ECR23	Channel catfish	400	15.7	676	1.5
ECR24	Channel catfish	376	14.8	508	1.1
ECR86	Black crappie	281	11.1	335	0.7
ECR87	Channel catfish	470	18.5	952	2.1
ECR88	Channel catfish	470	18.5	1042	2.3
ECR89	Flathead catfish	701	27.6	4892	10.8
ECR90	Flathead catfish	900	35.4	8800	19.4
ECR93	Flathead catfish	770	30.3	5727	12.6
ECR112	Channel catfish	483	19.0	1424	3.1
Site 2 Ellison Creek Reservoir AEP Intake					
ECR25	Largemouth bass	419	16.5	1052	2.3
ECR26	Largemouth bass	385	15.2	843	1.9
ECR27	Largemouth bass	440	17.3	1266	2.8
ECR28	Largemouth bass	400	15.7	929	2.0
ECR29	Common carp	696	27.4	4160	9.2
ECR30	Common carp	655	25.8	4443	9.8

Table 1. cont. Fish samples collected from Ellison Creek Reservoir 2014. Sample number, species, total length, and weight recorded for each sample.					
Sample Number	Species	Total Length		Weight	
		Millimeters (mm)	Inches (in)	Grams (g)	Pounds (lb)
Site 2 Cont. Ellison Creek Reservoir AEP Intake					
ECR31	Common carp	651	25.6	3966	8.7
ECR32	Flathead catfish	744	29.3	5492	12.1
ECR33	Channel catfish	557	21.9	2463	5.4
ECR34	Channel catfish	502	19.8	1614	3.6
ECR35	Channel catfish	557	21.9	2071	4.6
ECR36	Channel catfish	526	20.7	1771	3.9
ECR37	Channel catfish	521	20.5	1568	3.5
ECR38	Channel catfish	410	16.1	736	1.6
ECR39	Largemouth bass	497	19.6	2046	4.5
ECR40	Hybrid striped	621	24.4	3901	8.6
ECR49	Channel catfish	412	16.2	625	1.4
ECR50	Channel catfish	395	15.6	571	1.3
ECR51	Common carp	739	29.1	5760	12.7
ECR52	Largemouth bass	480	18.9	1847	4.1
ECR53	Channel catfish	542	21.3	1566	3.5
ECR85	White bass	352	13.9	706	1.6
Site 3 Ellison Creek Reservoir at Barnes Creek					
ECR41	Flathead catfish	843	33.2	8624	19.0
ECR42	Channel catfish	629	24.8	3512	7.7
ECR43	Channel catfish	450	17.7	866	1.9
ECR44	Channel catfish	385	15.2	458	1.0
ECR45	Largemouth bass	529	20.8	2004	4.4
ECR46	Common carp	626	24.6	3136	6.9
ECR47	Common carp	664	26.1	4083	9.0
ECR48	Common carp	672	26.5	4569	10.1
ECR91	Spotted gar	648	25.5	1178	2.6
ECR92	Spotted gar	691	27.2	1150	2.5
ECR94	Green sunfish	226	8.9	265	0.6
ECR95	Black crappie	260	10.2	265	0.6
ECR96	Black crappie	275	10.8	322	0.7
ECR97	Bowfin	525	20.7	1624	3.6
ECR98	Bowfin	600	23.6	2338	5.2
ECR99	Channel catfish	541	21.3	1621	3.6
ECR100	Channel catfish	440	17.3	1004	2.2
ECR101	Channel catfish	446	17.6	1118	2.5
ECR102	Channel catfish	453	17.8	918	2.0
ECR103	Largemouth bass	520	20.5	2319	5.1

Table 1. cont. Fish samples collected from Ellison Creek Reservoir 2014. Sample number, species, total length, and weight recorded for each sample.					
Sample Number	**Species**	**Total Length**		**Weight**	
		Millimeters (mm)	**Inches (in)**	**Grams (g)**	**Pounds (lb)**
Site 3 cont. Ellison Creek Reservoir at Barnes Creek					
ECR104	Largemouth bass	543	21.4	2568	5.7
ECR105	Largemouth bass	495	19.5	1735	3.8
ECR106	Largemouth bass	470	18.5	1513	3.3
ECR107	Largemouth bass	471	18.5	1334	2.9
ECR108	Largemouth bass	425	16.7	1312	2.9
ECR109	Largemouth bass	441	17.4	1294	2.9
ECR111	Spotted gar	715	28.1	1751	3.9
Site 4 Ellison Creek Reservoir Upper Reservoir					
ECR54	Channel catfish	631	24.8	3215	7.1
ECR55	Channel catfish	475	18.7	1093	2.4
ECR56	Channel catfish	559	22.0	1598	3.5
ECR57	Channel catfish	625	24.6	3168	7.0
ECR59	Channel catfish	529	20.8	1595	3.5
ECR60	White bass	393	15.5	725	1.6
ECR61	Largemouth bass	477	18.8	1514	3.3
ECR62	Common carp	679	26.7	4713	10.4
ECR63	Common carp	630	24.8	3859	8.5
ECR64	Common carp	689	27.1	4264	9.4
ECR65	Common carp	635	25.0	3651	8.0
ECR66	Spotted gar	686	27.0	1198	2.6
ECR67	Bowfin	701	27.6	3077	6.8
ECR68	White crappie	346	13.6	545	1.2
ECR69	White crappie	322	12.7	478	1.1
ECR70	White crappie	348	13.7	495	1.1
ECR71	Black crappie	272	10.7	282	0.6
ECR72	Largemouth bass	580	22.8	3080	6.8
ECR73	Largemouth bass	476	18.7	1580	3.5
ECR74	Largemouth bass	551	21.7	2726	6.0
ECR75	Largemouth bass	513	20.2	1947	4.3
ECR76	Largemouth bass	426	16.8	1080	2.4
ECR77	Largemouth bass	391	15.4	897	2.0
ECR78	Largemouth bass	373	14.7	641	1.4
ECR79	Channel catfish	454	17.9	982	2.2
ECR80	Channel catfish	491	19.3	1150	2.5
ECR81	Channel catfish	441	17.4	761	1.7
ECR84	Redbreast sunfish	201	7.9	141	0.3
ECR113	Redbreast sunfish	226	8.9	249	0.5
ECR114	Bluegill	182	7.2	135	0.3

Table 2.1. Arsenic (mg/kg) in fish collected from Ellison Creek Reservoir by species, 2014.					
Species	**Number Detected/ Number Tested**	**Total Arsenic Mean ± S.D. (Min-Max)**	**Inorganic Arsenic Mean[h]**	**HAC Value (nonca) and HAC Value (ca; mg/kg)[i]**	**Basis for Comparison Value**
Black crappie	4/4	0.101±0.036 (BDL-0.136)	0.010	0.700 0.363	EPA Chronic Oral RfD for Inorganic Arsenic — 0.0003 mg/kg–day EPA Oral Slope Factor for Inorganic Arsenic — 1.5 per mg/kg–day
Bowfin	3/3	0.157±0.110 (BDL-0.269)	0.016		
Channel catfish	33/33	0.070±0.069 (BDL-0.333)	0.007		
Common carp	13/13	0.054±0.016 (BDL-0.107)	0.005		
Flathead catfish	8/8	0.065±0.041 (BDL-0.167)	0.007		
Hybrid striped bass	2/2	BDL	BDL		
Largemouth bass	28/28	0.071±0.079 (BDL-0.445)	0.007		
Spotted gar	4/4	BDL	BDL		
White bass	2/2	0.216±0.018 (0.203-0.228)	0.022		
White crappie	3/3	0.088±0.033 (BDL-0.108)	0.009		
Crappie Spp. (black and white)	7/7	0.096±0.033 (BDL-0.136)	0.010		
Temperate basses	4/4	0.133±0.096 (BDL-0.228)	0.013		
All fish combined	100/100	0.074±0.067 (BDL-0.445)	0.007		

[h] *Most arsenic in fish and shellfish occurs as organic arsenic, considered virtually nontoxic. For risk assessment calculations, DSHS assumes that total arsenic is composed of 10% inorganic arsenic in fish and shellfish tissues.*
[i] *Derived from the MRL or RfD for noncarcinogens or the EPA slope factor for carcinogens; assumes a body weight of 70 kg, and a consumption rate of 30 grams per day, and assumes a 30-year exposure period for carcinogens and an excess lifetime cancer risk of 1x10^{-4}.*

Table 2.2. Cadmium (mg/kg) in fish collected from Ellison Creek Reservoir by species, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Black crappie	4/4	BDL	0.233	ATSDR Chronic Oral MRL— 0.0001 mg/kg–day
Bowfin	2/3	ND-BDL		
Channel catfish	31/33	ND-BDL		
Common carp	12/13	ND-BDL		
Flathead catfish	8/8	BDL		
Hybrid striped bass	2/2	BDL		
Largemouth bass	28/30	ND-BDL		
Spotted gar	4/4	BDL		
White bass	1/2	ND-BDL		
White crappie	3/3	BDL		
Crappie Spp. (black and white)	7/7	BDL		
All fish combined	93/100	ND-BDL		

Table 2.3. Copper (mg/kg) in fish collected from Ellison Creek Reservoir by species, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Black crappie	4/4	BDL	334	Based on the Tolerable Upper Intake Level (UL) — 0.143 mg/kg–day[j]
Bowfin	3/3	1.038±1.451 (BDL-2.714)		
Channel catfish	33/33	0.228±0.160 (BDL-1.117)		
Common carp	13/13	0.535±0.313 (BDL-1.033)		
Flathead catfish	8/8	BDL		
Hybrid striped bass	2/2	BDL		
Largemouth bass	30/30	BDL		
Spotted gar	4/4	BDL		
White bass	2/2	BDL		
White crappie	3/3	BDL		
Crappie Spp. (black and white)	7/7	BDL		
All fish combined	100/100	0.278±0.305 (BDL-2.714)		

[j] The Food and Nutrition Board, Institute of Medicine, National Academies UL for copper is 10 mg/day.

Table 2.4. Lead (mg/kg) in fish collected from Ellison Creek Reservoir by species, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Black crappie	4/4	0.522±0.216 (BDL-0.658)	N/A	N/A
Bowfin	3/3	BDL		
Channel catfish	32/33	0.206±0.035 (ND-0.401)		
Common carp	11/13	ND-BDL		
Flathead catfish	8/8	BDL		
Hybrid striped bass	2/2	0.472±0.385 (BDL-0.744)		
Largemouth bass	30/30	0.296±0.171 (BDL-0.753)		
Spotted gar	4/4	0.270±0.141 (BDL-0.482)		
White bass	2/2	0.605±0.573 (BDL-1.011)		
White crappie	3/3	BDL		
Crappie Spp. (black and white)	7/7	0.384±0.230 (BDL-0.658)		
Temperate bass	4/4	0.539±0.406 (BDL-1.011)		
All fish combined	97/100	0.258±0.154 (ND-1.011)		

Table 2.5. Selenium (mg/kg) in fish collected from Ellison Creek Reservoir by species, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Black crappie	4/4	0.178±0.256 (BDL-0.563)	6	EPA Chronic Oral RfD — 0.005 mg/kg–day ATSDR Chronic Oral MRL — 0.005 mg/kg–day UL: 0.400 mg/day (0.005 mg/kg–day) RfD or MRL/2 — (0.005 mg/kg –day/2= 0.0025 mg/kg–day)[k, 51]
Bowfin	3/3	0.207±0.157 (BDL-0.363)		
Channel catfish	33/33	0.425±1.021 (BDL-4.477)		
Common carp	13/13	0.506±0.157 (BDL-0.661)		
Flathead catfish	8/8	0.148±0.145 (BDL-0.470)		
Hybrid striped bass	2/2	0.332±0.284 (0.131-0.533)		
Largemouth bass	30/30	0.567±0.988 (BDL-3.528)		
Spotted gar	4/4	0.165±0.184 (BDL-0.436)		
White bass	2/2	0.433±0.542 (BDL-0.816)		
White crappie	3/3	0.569±0.089 (0.487-0.663)		
Crappie Spp. (black and white)	7/7	0.346±0.281 (BDL-0.663)		
Temperate bass	4/4	0.382±0.358 (BDL-0.816)		
All fish combined	100/100	0.429±0.797 (BDL-4.477)		

[k] The DSHS applied relative source contribution methodology (RSC) developed by EPA to derive a HAC value for selenium. DSHS risk assessor's assumed that 50% of the daily selenium intake is from other foods or supplements (≈ 200 µg/day for a 70 kg adult or one-half the RfD) and subtracted an amount equal to 50% of the RfD from the RfD to account for other sources of exposure to selenium. The remainder of the RfD, 0.0025 mg/kg/day, was utilized to calculate the HAC value for selenium.

Table 2.6. Zinc (mg/kg) in fish collected from Ellison Creek Reservoir by species, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Black crappie	4/4	3.952±0.467 (3.371-4.505)	700	EPA Chronic Oral RfD — 0.3 mg/kg–day
Bowfin	3/3	2.848±0.622 (2.357-3.548)		
Channel catfish	33/33	4.694±1.332 (2.764-9.781)		
Common carp	13/13	5.842±2.351 (1.260-11.452)		
Flathead catfish	8/8	3.477±0.433 (2.718-3.971)		
Hybrid striped bass	2/2	2.856±0.120 (2.771-2.941)		
Largemouth bass	30/30	3.356±0.804 (1.307-5.337)		
Spotted gar	4/4	2.622±0.330 (2.334-2.938)		
White bass	2/2	3.346±0.337 (3.108-3.585)		
White crappie	3/3	4.113±0.645 (3.647-4.849)		
Crappie Spp. (black and white)	7/7	4.021±0.505 (3.371-4.849)		
Temperate bass	4/4	3.101±0.351 (2.771-3.585)		
All fish combined	100/100	4.122±1.531 (1.260-11.452)		

Table 2.7. Mercury (mg/kg) in fish collected from Ellison Creek Reservoir by sample site, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Site 1 Ellison Creek Reservoir at the Dam				
Black crappie	1/1	0.031	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Channel catfish	11/11	0.042±0.063 (0.009-0.216)		
Common carp	2/2	0.031±0.006 (0.027-0.035)		
Flathead catfish	6/6	0.058±0.031 (0.029-0.106)		
Hybrid striped bass	1/1	0.124		
Largemouth bass	8/8	0.143±0.114 (0.068-0.416)		
All fish combined	29/29	0.075±0.083 (0.009-0.416)		
Site 2 Ellison Creek Reservoir near AEP Intake				
Channel catfish	9/9	0.022±0.011 (0.010-0.042)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Common carp	4/4	0.026±0.011 (0.012-0.035)		
Flathead catfish	1/1	0.044		
Hybrid striped bass	1/1	0.213		
Largemouth bass	6/6	0.076±0.018 (0.058-0.108)		
White bass	1/1	0.122		
All fish combined	22/22	0.052±0.048 (0.010-0.213)		
Site 3 Ellison Creek Reservoir at Barnes Creek				
Black crappie	2/2	0.032±0.009 (0.025-0.038)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Bowfin	2/2	0.364±0.231 (0.201-0.527)		
Channel catfish	7/7	0.032±0.031 (0.009-0.095)		
Common carp	3/3	0.038±0.007 (0.031-0.045)		
Flathead catfish	1/1	0.101		
Green sunfish	1/1	0.052		
Largemouth bass	8/8	0.155±0.047 (0.094-0.229)		
Spotted gar	3/3	0.101±0.066 (0.051-0.176)		
All fish combined	27/27	0.104±0.108 (0.009-0.527)		

Table 2.8. Mercury (mg/kg) in fish collected from Ellison Creek Reservoir by sample site, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Site 4 Ellison Creek Reservoir Upper Reservoir				
Black crappie	1/1	0.027	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Bluegill	1/1	0.012		
Bowfin	1/1	0.417		
Channel catfish	8/8	0.036±0.020 (0.009-0.071)		
Common carp	4/4	0.059±0.015 (0.043-0.079)		
Largemouth bass	8/8	0.113±0.053 (0.066-0.231)		
Redbreast sunfish	2/2	0.014±0.001 (0.013-0.014)		
Spotted gar	1/1	0.080		
White bass	1/1	0.081		
White crappie	3/3	0.056±0.017 (0.039-0.072)		
All fish combined	30/30	0.075±0.079 (0.009-0.417)		

Table 2.9. Mercury (mg/kg) in fish collected from Ellison Creek Reservoir by species, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Black crappie	4/4	0.030±0.006 (0.025-0.038)	0.7	ATSDR chronic oral MRL for methylmercury — 0.0003 mg/kg–day
Bluegill	1/1	0.012		
Bowfin	3/3	0.382±0.166 (0.201-0.527)		
Channel catfish	35/35	0.033±0.039 (0.009-0.216)		
Common carp	13/13	0.040±0.017 (0.012-0.079)		
Flathead catfish	8/8	0.062±0.031 (0.029-0.106)		
Green sunfish	1/1	0.052		
Hybrid striped bass	2/2	0.168±0.063 (0.124-0.213)		
Largemouth bass	30/30	0.125±0.073 (0.058-0.416)		
Redbreast sunfish	2/2	0.014±0.001 (0.013-0.014)		
Spotted gar	4/4	0.096±0.055 (0.051-0.176)		
White bass	2/2	0.102±0.029 (0.081-0.122)		
White crappie	3/3	0.056±0.017 (0.039-0.072)		
Crappie Spp. (black and white)	7/7	0.041±0.017 (0.025-0.072)		
Sunfish Spp. (Bluegill, Green, Redbreast)	4/4	0.023±0.020 (0.012-0.052)		
Temperate basses	4/4	0.135±0.056 (0.081-0.213)		
All fish combined	108/108	0.078±0.084 (0.009-0.527)		

Table 3. Pesticides (mg/kg) in fish collected from Ellison Creek Reservoir by species, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; mg/kg)**	**Basis for Comparison Value**
Chlordane (sum)				
Channel catfish	8/8	0.0110±0.0045 (0.0076-0.0216)	1.167	EPA Chronic Oral RfD — 0.0005 mg/kg–day
Largemouth bass	8/8	0.0026±0.0019 (0.0010-0.0067)		
All fish combined	16/16	0.0068±0.0055 (0.0010-0.0216)	1.556	EPA Oral Slope Factor — 0.35 per mg/kg–day
4,4'-DDE				
Channel catfish	8/8	0.0061±0.0027 (0.0040-0.0117)	1.167	EPA Chronic Oral RfD for DDT — 5.0E-4 mg/kg–day
Largemouth bass	8/8	0.0020±0.0014 (0.0007-0.0047)		
All fish combined	16/16	0.0041±0.0029 (0.0007-0.0117)	1.601	EPA Oral Slope Factor for DDT— 3.4E-1 per mg/kg–day
Pentachloroanisole				
Channel catfish	8/8	0.0013±0.0009 (0.0004-0.0034)	N/A	N/A
Largemouth bass	0/8	ND		
All fish combined	8/16	0.0007±0.0009 (ND-0.0034)		

Table 4.1. PCBs (mg/kg) in fish collected from Ellison Creek Reservoir by sample site, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Site 1 Ellison Creek Reservoir at the Dam				
Black crappie	1/1	0.022	0.047 0.272	EPA Chronic Oral RfD for Aroclor 1254 — 0.00002 mg/kg–day EPA Slope Factor — 2.0 per mg/kg–day
Channel catfish	11/11	**0.074**[1]±0.042 (0.027-**0.148**)		
Common carp	2/2	**0.199**±0.059 (**0.157**-**0.240**)		
Flathead catfish	6/6	**0.095**±0.074 (0.045-**0.229**)		
Hybrid striped bass	1/1	**0.357**		
Largemouth bass	8/8	**0.050**±0.024 (0.018-**0.089**)		
All fish combined	29/29	**0.088**±0.077 (0.018-**0.357**)		
Site 2 Ellison Creek Reservoir near AEP Intake				
Channel catfish	9/9	**0.113**±0.039 (**0.074**-**0.198**)	0.047 0.272	EPA Chronic Oral RfD for Aroclor 1254 — 0.00002 mg/kg–day EPA Slope Factor — 2.0 per mg/kg–day
Common carp	4/4	**0.228**±0.048 (**0.160**-**0.273**)		
Flathead catfish	1/1	**0.129**		
Hybrid striped bass	1/1	**0.190**		
Largemouth bass	6/6	**0.062**±0.019 (0.036-**0.091**)		
White bass	1/1	**0.058**		
All fish combined	22/22	**0.122**±0.068 (0.036-**0.273**)		

[1] *Emboldened numbers denote that PCB concentrations equal and/or exceed the DSHS HAC value for PCBs.*

Table 4.2. PCBs (mg/kg) in fish collected from Ellison Creek Reservoir by sample site, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Site 3 Ellison Creek Reservoir at Barnes Creek				
Black crappie	2/2	0.010±0.001 (0.009-0.011)	0.047 0.272	EPA Chronic Oral RfD for Aroclor 1254 — 0.00002 mg/kg–day EPA Slope Factor — 2.0 per mg/kg–day
Bowfin	2/2	0.017±0.009 (0.010-0.023)		
Channel catfish	7/7	**0.140**[m]±0.122 (0.039-**0.368**)		
Common carp	3/3	**0.172**±0.079 (**0.098**-**0.256**)		
Flathead catfish	1/1	**0.065**		
Green sunfish	1/1	0.012		
Largemouth bass	8/8	**0.088**±0.061 (0.034-**0.227**)		
Spotted gar	3/3	**0.117**±0.073 (0.036-**0.179**)		
All fish combined	27/27	**0.099**±0.089 (0.009-**0.368**)		
Site 4 Ellison Creek Reservoir Upper Reservoir				
Black crappie	1/1	0.026	0.047 0.272	EPA Chronic Oral RfD for Aroclor 1254 — 0.00002 mg/kg–day EPA Slope Factor — 2.0 per mg/kg–day
Bluegill	1/1	**0.162**		
Bowfin	1/1	**0.048**		
Channel catfish	8/8	**0.132**±0.116 (**0.054**-**0.408**)		
Common carp	4/4	**0.223**±0.141 (**0.123**-**0.423**)		
Largemouth bass	8/8	**0.054**±0.022 (0.018-**0.096**)		
Redbreast sunfish	1/1	**0.136**		
Spotted gar	1/1	**0.092**		
White bass	1/1	**0.088**		
White crappie	3/3	0.029±0.018 (0.013-**0.048**)		
All fish combined	29/29	**0.104**±0.099 (0.013-**0.423**)		

[m] *Emboldened numbers denote that PCB concentrations equal and/or exceed the DSHS HAC value for PCBs.*

Table 4.3. PCBs (mg/kg) in fish collected from Ellison Creek Reservoir by species, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Black crappie	4/4	0.017±0.008 (0.009-0.026)	0.047 0.272	EPA Chronic Oral RfD for Aroclor 1254 — 0.00002 mg/kg–day EPA Slope Factor — 2.0 per mg/kg–day
Bluegill	1/1	**0.162**[n]		
Bowfin	3/3	0.027±0.019 (0.010-**0.048**)		
Channel catfish	35/35	**0.111**±0.084 (0.027-**0.408**)		
Common carp	13/13	**0.209**±0.086 (**0.098**-**0.423**)		
Flathead catfish	8/8	**0.095**±0.065 (0.045-**0.229**)		
Green sunfish	1/1	0.012		
Hybrid striped bass	2/2	**0.273**±0.118 (**0.190**-**0.357**)		
Largemouth bass	30/30	**0.064**±0.038 (0.018-**0.227**)		
Redbreast sunfish	1/1	**0.136**		
Spotted gar	4/4	**0.111**±0.061 (0.036-**0.179**)		
White bass	2/2	**0.073**±0.021 (**0.058**-**0.088**)		
White crappie	3/3	0.029±0.018 (0.013-**0.048**)		
Crappie Spp. (black and white)	7/7	0.022±0.013 (0.009-**0.048**)		
Sunfish Spp. (Bluegill, Green, Redbreast)	3/3	**0.103**±0.080 (0.012-**0.162**)		
Temperate basses	4/4	**0.173**±0.135 (**0.058**-**0.357**)		
All fish combined	107/107	**0.102**±0.085 (0.009-**0.423**)		

[n] *Emboldened numbers denote that PCB concentrations equal and/or exceed the DSHS HAC value for PCBs.*

Table 5.1. PCDDs/PCDFs toxicity equivalent (TEQ) concentrations (pg/g) in fish collected from the Ellison Creek Reservoir by sample site, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; pg/g)**	**Basis for Comparison Value**
Site 1 Ellison Creek Reservoir at the Dam				
Black crappie	1/1	0.182	2.33 3.49	ATSDR Chronic Oral MRL for 2,3,7,8 – TCDD —1.0 x 10-9 mg/kg–day EPA Slope Factor — 1.56 x 105 per mg/kg–day
Channel catfish	10/10	0.545±0.306 (0.142-0.950)		
Common carp	2/2	**2.908**[o]±0.095 (**2.841**-**2.975**)		
Flathead catfish	6/6	0.939±0.461 (0.540-1.689)		
Hybrid striped bass	1/1	**5.928**		
Largemouth bass	8/8	0.370±0.146 (0.100-0.513)		
All fish combined	28/28	0.928±1.208 (0.100-**5.928**)		
Site 2 Ellison Creek Reservoir near AEP Intake				
Channel catfish	9/9	0.948±0.497 (0.379-1.816)	2.33 3.49	ATSDR Chronic Oral MRL for 2,3,7,8 – TCDD —1.0 x 10-9 mg/kg–day EPA Slope Factor — 1.56 x 105 per mg/kg–day
Common carp	4/4	1.241±0.290 (0.934-1.521)		
Flathead catfish	1/1	0.838		
Hybrid striped bass	1/1	1.678		
Largemouth bass	5/5	0.451±0.112 (0.308-0.573)		
White bass	1/1	0.769		
All fish combined	21/21	0.906±0.469 (0.308-1.816)		

[o] *Emboldened numbers denote that PCDD/PCDF TEQ concentrations equal and/or exceed the DSHS HAC value for PCDDs/PCDFs.*

Table 5.2. PCDDs/PCDFs toxicity equivalent (TEQ) concentrations (pg/g) in fish collected from the Ellison Creek Reservoir by sample site, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; pg/g)**	**Basis for Comparison Value**
Site 3 Ellison Creek Reservoir at Barnes Creek				
Black crappie	1/2	0.001±0.001 (ND-0.002)	2.33 3.49	ATSDR Chronic Oral MRL for 2,3,7,8 – TCDD —1.0 x 10-9 mg/kg–day EPA Slope Factor — 1.56 x 105 per mg/kg–day
Bowfin	2/2	0.053±0.032 (0.031-0.076)		
Channel catfish	6/6	1.226±1.416 (0.196-**3.338**[p])		
Common carp	3/3	0.942±0.420 (0.575-1.401)		
Flathead catfish	1/1	0.260		
Largemouth bass	7/8	0.518±0.412 (ND-1.247)		
Spotted gar	3/3	0.960±0.621 (0.253-1.416)		
All fish combined	23/25	0.703±0.833 (ND-**3.338**)		
Site 4 Ellison Creek Reservoir Upper Reservoir				
Black crappie	1/1	0.283	2.33 3.49	ATSDR Chronic Oral MRL for 2,3,7,8 – TCDD —1.0 x 10-9 mg/kg–day EPA Slope Factor — 1.56 x 105 per mg/kg–day
Bowfin	1/1	0.541		
Channel catfish	8/8	2.789±3.328 (0.659-**10.400**)		
Common carp	4/4	1.717±1.181 (0.774-**3.241**)		
Largemouth bass	7/7	0.886±0.652 (0.077-1.927)		
Spotted gar	1/1	0.995		
White bass	1/1	1.045		
White crappie	3/3	0.169±0.109 (0.091-0.294)		
All fish combined	26/26	1.490±2.084 (0.077-**10.400**)		

[p] *Emboldened numbers denote that PCDD/PCDF TEQ concentrations equal and/or exceed the DSHS HAC value for PCDDs/PCDFs.*

Table 5.3. PCDDs/PCDFs toxicity equivalent (TEQ) concentrations (pg/g) in fish collected from the Ellison Creek Reservoir by species, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; pg/g)**	**Basis for Comparison Value**
Black crappie	3/4	0.117±0.140 (ND-0.283)	2.33 3.49	ATSDR Chronic Oral MRL for 2,3,7,8 – TCDD —1.0 x 10-9 mg/kg–day EPA Slope Factor — 1.56 x 105 per mg/kg–day
Bowfin	3/3	0.216±0.282 (0.031-0.541)		
Channel catfish	33/33	1.323±1.895 (0.142-**10.400**[q])		
Common carp	13/13	1.575±0.917 (0.575-**3.241**)		
Flathead catfish	8/8	0.842±0.456 (0.260-1.689)		
Hybrid striped bass	2/2	**3.803**±3.005 (1.678-**5.928**)		
Largemouth bass	27/28	0.556±0.432 (ND-1.927)		
Spotted gar	4/4	0.969±0.507 (0.253-1.416)		
White bass	2/2	0.907±0.195 (0.769-1.045)		
White crappie	3/3	0.169±0.109 (0.091-0.294)		
Crappie Spp. (black and white)	6/7	0.139±0.121 (ND-0.294)		
Temperate basses	4/4	**2.355**±2.412 (0.769-**5.928**)		
All fish combined	98/100	1.013±1.340 (ND-**10.400**)		

[q] *Emboldened numbers denote that PCDD/PCDF TEQ concentrations equal and/or exceed the DSHS HAC value for PCDDs/PCDFs.*

Table 6.0. Volatile organic compounds (mg/kg) in fish collected from the Ellison Creek Reservoir by species, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Trichlorofluoromethane				
Channel catfish	8/8	0.090±0.105 (0.013-0.332)	700	EPA Chronic Oral RfD — 3.0E-1 (mg/kg)/day
Largemouth bass	7/8	0.032±0.026 (ND-0.079)		
All fish combined	15/16	0.061±0.080 (ND -0.332)		

Table 7. Hazard quotients (HQs) for mercury in fish collected from Ellison Creek Reservoir in 2014. Table 7 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[r]			
Species	**Number of Samples**	**Hazard Quotient**	**Meals per Week**
Bowfin	3	0.55	1.7
Channel catfish	35	0.05	unrestricted[s]
Common carp	13	0.06	unrestricted
Flathead catfish	8	0.09	10.4
Hybrid striped bass	2	0.24	3.9
Largemouth bass	30	0.18	5.2
Spotted gar	4	0.14	6.7
White bass	2	0.15	6.3
Crappie Spp. (black and white)	7	0.06	15.8
Sunfish Spp. (Bluegill, Green, Redbreast)	4	0.03	unrestricted
Temperate basses	4	0.19	4.8
All fish combined	108	0.11	8.3

[r] *DSHS assumes that children under 12 years of age and/or those that weigh less than 35 kg eat four-ounce meals.*

[s] *Denotes that the allowable eight-ounce meals per week are > 16.0.*

Table 8.1. Hazard quotients (HQs) and hazard indices (HIs) for PCBs and/or PCDDs/PCDFs in fish collected from Ellison Creek Reservoir in 2014. Table 8.1 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[t]			
Contaminant/Species	**Number of Samples**	**Hazard Quotient**	**Meals per Week**
Bowfin			
PCBs	3	0.58	1.6
PCDDs/PCDFs		0.09	10.0
Hazard Index (meals per week)		0.67	1.4
Channel catfish			
PCBs	35	**2.38**[u]	**0.4**[v]
PCDDs/PCDFs	33	0.57	1.6
Hazard Index (meals per week)		**2.95**	**0.3**
Common carp			
PCBs	13	**4.48**	**0.2**
PCDDs/PCDFs		0.68	1.4
Hazard Index (meals per week)		**5.15**	**0.2**
Flathead catfish			
PCBs	**8**	**2.04**	**0.5**
PCDDs/PCDFs		0.36	2.6
Hazard Index (meals per week)		**2.40**	**0.4**
Hybrid striped bass			
PCBs	**2**	**5.85**	**0.2**
PCDDs/PCDFs		**1.63**	**0.6**
Hazard Index (meals per week)		**7.48**	**0.1**

[t] *DSHS assumes that children under 12 years of age and/or those that weigh less than 35 kg eat four-ounce meals.*

[u] *Emboldened numbers denote that the HQ or HI is ≥ 1.0.*

[v] *Emboldened numbers denote that the calculated allowable meals for an adult are ≤ one meal per week.*

Table 8.2. Hazard quotients (HQs) and hazard indices (HIs) for PCBs and/or PCDDs/PCDFs in fish collected from Ellison Creek Reservoir in 2014. Table 8.2 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[w]			
Contaminant/Species	**Number of Samples**	**Hazard Quotient**	**Meals per Week**
Largemouth bass			
PCBs	30	**1.37**[x]	**0.7**[y]
PCDDs/PCDFs	28	0.24	3.9
Hazard Index (meals per week)		**1.61**	**0.6**
Spotted gar			
PCBs	4	**2.38**	**0.4**
PCDDs/PCDFs		0.42	2.2
Hazard Index (meals per week)		**2.79**	**0.3**
White bass			
PCBs	2	**1.56**	**0.6**
PCDDs/PCDFs		0.39	2.4
Hazard Index (meals per week)		**1.95**	**0.5**
Crappie Spp. (black and white)			
PCBs	**7**	0.47	2.0
PCDDs/PCDFs		0.06	15.5
Hazard Index (meals per week)		0.53	1.7
Sunfish Spp. (Bluegill, Green, Redbreast)			
PCBs	**3**	**2.21**	**0.4**
Hazard Index (meals per week)		**2.21**	**0.4**

[w] *DSHS assumes that children under 12 years of age and/or those that weigh less than 35 kg eat four-ounce meals.*

[x] *Emboldened numbers denote that the HQ or HI is ≥ 1.0.*

[y] *Emboldened numbers denote that the calculated allowable meals for an adult are ≤ one meal per week.*

Table 8.3. Hazard quotients (HQs) and hazard indices (HIs) for PCBs and/or PCDDs/PCDFs in fish collected from Ellison Creek Reservoir in 2014. Table 8.3 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[z]

Contaminant/Species	Number of Samples	Hazard Quotient	Meals per Week
Temperate basses			
PCBs	4	**3.71**[aa]	**0.2**[bb]
PCDDs/PCDFs		**1.01**	**0.9**
Hazard Index (meals per week)		**4.72**	**0.2**
All fish combined			
PCBs	107	**2.19**	**0.4**
PCDDs/PCDFs	100	0.43	2.1
Hazard Index (meals per week)		**2.62**	**0.4**

[z] *DSHS assumes that children under 12 years of age and/or those that weigh less than 35 kg eat four-ounce meals.*
[aa] *Emboldened numbers denote that the HQ or HI is ≥ 1.0.*
[bb] *Emboldened numbers denote that the calculated allowable meals for an adult are ≤ one meal per week.*

Table 9.1. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2014 from Ellison Creek Reservoir containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish from Ellison Creek Reservoir over a 30-year period.[cc]

Species/Contaminant	Number of Samples	Theoretical Lifetime Excess Cancer Risk		Meals per Week
		Risk	Population Size that Would Result in One Excess Cancer	
Bowfin				
PCBs	3	9.9E-06	100,823	9.3
PCDDs/PCDFs		6.2E-06	161,575	14.9
Arsenic		4.4E-06	226,852	unrestricted[dd]
Cumulative Cancer Risk		2.1E-05	48,743	4.5
Channel catfish				
Arsenic	33	1.9E-06	518,519	unrestricted
Chlordane	8	7.07E-07	1,414,141	unrestricted
DDE		1.79E-05	55,783	5.2
PCBs	35	4.1E-05	24,525	2.3
PCDDs/PCDFs	33	3.8E-05	26,380	2.4
Cumulative Cancer Risk		**9.9E-05**[ee]	**10,076**	**0.9**[ff]
Common carp				
Arsenic	13	1.4E-06	725,926	unrestricted
PCBs		7.7E-05	13,025	1.2
PCDDs/PCDFs		4.5E-05	22,159	2.0
Cumulative Cancer Risk		**1.2E-04**	**8,112**	**0.7**

[cc] *DSHS assumes that children under 12 years of age and/or those who weigh less than 35 kg eat 4-ounce meals.*
[dd] *Denotes that the allowable eight-ounce meals per week are > 16.0.*
[ee] *Emboldened numbers denote calculated excess lifetime cancer risk after 30 years exposure is greater than 1.0E-04.*
[ff] *Emboldened numbers denote that the calculated allowable meals for an adult are ≤ one meal per week.*

Table 9.2. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2014 from Ellison Creek Reservoir containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish from Ellison Creek Reservoir over a 30-year period.[gg]

Species/Contaminant	Number of Samples	Theoretical Lifetime Excess Cancer Risk		Meals per Week
		Risk	Population Size that Would Result in One Excess Cancer	
Flathead catfish				
Arsenic	8	1.9E-06	518,519	unrestricted[hh]
PCBs		3.5E-05	28,655	2.6
PCDDs/PCDFs		2.4E-05	41,449	3.8
Cumulative Cancer Risk		6.1E-05	16,406	1.5
Hybrid striped bass				
PCBs	2	**1.0E-04**[ii]	**9,972**	**0.9**[jj]
PCDDs/PCDFs		**1.1E-04**	**9,177**	**0.8**
Cumulative Cancer Risk		**2.1E-04**	**4,779**	**0.4**
Largemouth bass				
Chlordane	8	1.67E-07	5,982,906	unrestricted
DDE		5.88E-06	170,139	15.7
PCBs	30	2.4E-05	42,535	3.9
PCDDs/PCDFs	28	1.6E-05	62,770	5.8
Cumulative Cancer Risk		4.7E-05	21,091	1.9
Spotted gar				
PCBs	4	4.1E-05	24,525	2.3
PCDDs/PCDFs		2.8E-05	36,017	3.3
Cumulative Cancer Risk		6.9E-05	14,590	1.3

[gg] *DSHS assumes that children under 12 years of age and/or those who weigh less than 35 kg eat 4-ounce meals.*
[hh] *Denotes that the allowable eight-ounce meals per week are > 16.0.*
[ii] *Emboldened numbers denote calculated excess lifetime cancer risk after 30 years exposure is greater than 1.0E-04.*
[jj] *Emboldened numbers denote that the calculated allowable meals for an adult are ≤ one meal per week.*

Table 9.3. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2014 from Ellison Creek Reservoir containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish from Ellison Creek Reservoir over a 30-year period.[kk]				
Species/Contaminant	**Number of Samples**	**Theoretical Lifetime Excess Cancer Risk**		**Meals per Week**
		Risk	**Population Size that Would Result in One Excess Cancer**	
White bass				
Arsenic	2	6.1E-06	164,983	15.2
PCBs		2.7E-05	37,291	3.4
PCDDs/PCDFs		2.6E-05	38,479	3.6
Cumulative Cancer Risk		5.9E-05	16,988	1.6
Crappie Spp. (black and white)				
Arsenic	7	2.8E-06	362,963	unrestricted[ll]
PCBs		8.1E-06	123,737	11.4
PCDDs/PCDFs		4.0E-06	251,081	unrestricted
Cumulative Cancer Risk		1.5E-05	67,479	6.2
Sunfish Spp. (Bluegill, Green, Redbreast)				
PCBs	3	3.8E-05	26,429	2.4
Cumulative Cancer Risk		3.8E-05	26,429	2.4

[kk] *DSHS assumes that children under 12 years of age and/or those who weigh less than 35 kg eat 4-ounce meals.*
[ll] *Denotes that the allowable eight-ounce meals per week are > 16.0.*

Table 9.4. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2014 from Ellison Creek Reservoir containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish from Ellison Creek Reservoir over a 30-year period.[mm]				
Species/Contaminant	**Number of Samples**	**Theoretical Lifetime Excess Cancer Risk**		**Meals per Week**
		Risk	**Population Size that Would Result in One Excess Cancer**	
Temperate basses				
Arsenic	4	3.6E-06	279,202	unrestricted[nn]
PCBs		6.4E-05	15,735	1.5
PCDDs/PCDFs		6.7E-05	14,820	1.4
Cumulative Cancer Risk		**1.3E-04**[oo]	**7,429**	**0.7**[pp]
All fish combined				
Arsenic	100	1.9E-06	518,519	unrestricted
Chlordane	16	4.37E-07	2,287,582	unrestricted
DDE		1.18E-05	85,069	7.9
PCBs	107	3.7E-05	26,668	2.5
PCDDs/PCDFs	100	2.9E-05	34,452	3.2
Cumulative Cancer Risk		8.1E-05	12,405	1.1

[mm] *DSHS assumes that children under 12 years of age and/or those who weigh less than 35 kg eat 4-ounce meals.*

[nn] *Denotes that the allowable eight-ounce meals per week are > 16.0.*

[oo] *Emboldened numbers denote calculated excess lifetime cancer risk after 30 years exposure is greater than 1.0E-04.*

[pp] *Emboldened numbers denote that the calculated allowable meals for an adult are ≤ one meal per week.*

Table 10. SALG recommended fish consumption advice for Ellison Creek Reservoir, 2014.			
Contaminants of Concern	**Species**	**Women of childbearing age and children < 12**[qq]	**Women past childbearing age and males 12 and older**[rr]
Dioxins and PCBs	Channel catfish	**DO NOT EAT**	1 meal/month
	Common carp	**DO NOT EAT**	**DO NOT EAT**
	Flathead catfish	**DO NOT EAT**	1 meal/month
	Hybrid striped bass	**DO NOT EAT**	**DO NOT EAT**
	Largemouth bass	1 meal/month	2 meals/month
	Spotted gar	**DO NOT EAT**	1 meal/month
	Sunfish Spp. (Bluegill, Green, Redbreast)	**DO NOT EAT**	1 meal/month
	White bass	**DO NOT EAT**	2 meals/month

[qq] A meal is four ounces of fish.
[rr] A meal is eight ounces of fish.

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