Characterization of Potential Adverse Health Effects Associated with Consuming Fish from the

Trinity River

Anderson, Freestone, Henderson, Houston, Leon, Liberty, Madison, Navarro, Polk, San Jacinto, Trinity, and Walker Counties, Texas

2015

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INTRODUCTION

This document summarizes the results of a survey of the Lower Trinity River Basin –including the Trinity River above Lake Livingston and the Trinity River below Lake Livingston– conducted in 2012–2013 by the Texas Department of State Health Services (DSHS) Seafood and Aquatic Life Group (SALG).[a] The SALG did this study to investigate potential polychlorinated biphenyls (PCBs) and polychlorinated dibenzo-*p*-dioxins and/or dibenzofurans (PCDDs/PCDFs) fish tissue contamination in the Lower Trinity River Basin and Lake Livingston. Previous studies of the Upper Trinity River Basin within the Dallas Fort Worth metropolitan area indicated the need to complete a comprehensive survey of the entire Trinity River Basin. The present study, ensuing from surveys of the Upper Trinity River Basin, examined fish from the Trinity River at U.S. Highway 287 downstream to U.S. Highway 90 including Lake Livingston 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 the Trinity River and suggests actions to reduce potential adverse health outcomes.

History of the Upper Trinity River Basin Fish Consumption Advisory

From 1990–2010, portions of the Clear Fork Trinity River, West Fork Trinity River, and the Upper Trinity River in the Dallas-Fort Worth metropolitan area (from the Seventh Street Bridge in Fort Worth downstream to the Interstate Highway (IH) 20 Bridge southeast of Dallas have been closed to the harvesting of fish. The Texas Department of Health (TDH)[b] issued Aquatic Life Order Number 2 (AL-2) on January 4, 1990, prohibiting possession of fish from this stretch of the river because fish samples contained chlordane, an organochlorine insecticide that posed a significant public health issue.[1] In 1996, the Texas Natural Resource Conservation Commission (TNRCC)[c] listed these segments of the Trinity River on the State of Texas Clean Water Act Section 303(d) List of impaired waters for not supporting the designated fish consumption use due to chlordane contamination.[2]

In 1998, the TNRCC requested that the TDH reassess the possession ban issued in 1990. This survey examined fish samples from several sites along the Trinity River between Fort Worth and Dallas; an assessment that supported the continuation of AL-2 due to the presence of PCBs at concentrations exceeding TDH health-based guidelines. The results of this survey also showed that chlordane concentrations in fish from this portion of the Trinity River were of less concern, in part due to decreases in concentration and to changes in the knowledge of the toxicity of chlordane.

In 2000 and 2001, the TDH re-examined fish from stretches of the Trinity River previously investigated as well as areas up- and downstream of the area delineated by AL-2. The 2000 and

[a] The terms DSHS and SALG may be used interchangeably throughout this document and mean the same agency. -
[b] Now the Department of State Health Services (DSHS) -
[c] Now the Texas Commission on Environmental Quality (TCEQ) -

2001 surveys revealed the presence of PCBs at concentration exceeding health-based guidelines in fish further downstream from the original area closed to the harvesting of fish. Because of these findings, TDH issued Fish Consumption Advisory 25 (ADV-25) on September 13, 2002 recommending no consumption of all species of gar from Texas State Highway (SH) 34 downstream to its confluence with the discharge canal of Cedar Creek Reservoir.[3] Subsequently, on September 27, 2002, TDH issued Aquatic Life Order Number 14 (AL-14), extending the Trinity River prohibited area to include waters of the Trinity River from the Seventh Street Bridge in Fort Worth downstream to SH 34.[4]

In 2008, the Texas Commission on Environmental Quality (TCEQ) requested that the DSHS perform a survey of the Trinity River as a five-year follow-up study under the Total Maximum Daily Load (TMDL) program for previously adopted TMDLs. The follow-up survey included sample sites up- and downstream of the prohibited and advisory areas. The 2008 survey revealed the presence of PCBs and PCDDs/PCDFs at concentrations exceeding health-based guidelines in fish up- and downstream of the prohibited and advisory areas. The DSHS issued AL-17 on July 7, 2010 to rescind AL-2 and AL-14.[5] Subsequently, DSHS issued ADV-43 advising people not to consume fish from the Clear Fork of the Trinity River below Benbrook Reservoir and the West Fork of the Trinity River below Lake Worth, including the main stem of the Trinity River downstream to the U.S. Highway 287 Bridge.[6]

Description of the Trinity River Basin

Four principal forks form the Trinity River in north central Texas: the Clear Fork, the West Fork, the Elm Fork, and the East Fork.[7] The Clear Fork originates east of Weatherford, Texas in Parker County and flows southeasterly and then northeasterly merging with the West Fork in Fort Worth, Texas. The West Fork, the longest fork of the four forks, rises in southeastern Archer County flowing southeasterly through Jack, Wise, and Tarrant Counties joining the main stem of the Trinity River in Dallas County. The Elm Fork originates in eastern Montague County and flows southeasterly through Cooke and Denton Counties to its confluence with the West Fork in Dallas County forming the main stem of the Trinity River west of downtown Dallas in central Dallas County. The East Fork originates in Cooke County and flows to the south through Collin and Kaufman Counties, merging with the main stem at the Kaufman-Ellis County line. The Trinity River flows 423 miles from the confluence of the Elm and West Forks to Trinity Bay along the Texas coast, making it the longest river having its entire course in Texas. The Trinity River Basin total drainage area is 17,969 square miles including 21 reservoirs and all or part of 37 counties. Major reservoirs in the basin include: Lake Bridgeport; Eagle Mountain Lake; and Lake Worth on the West Fork; Lake Weatherford and Benbrook Lake on the Clear Fork; Ray Roberts Lake and Lewisville Lake on the Elm Fork; Lavon Lake and Lake Ray Hubbard on the East Fork; and, Lake Livingston on the main stem of the Trinity River. In addition, 11 major reservoirs exist on smaller tributaries, mostly in the Dallas-Fort Worth metropolitan area.

The Trinity River in the Dallas-Fort Worth metropolitan area is highly urbanized. Urban development has led to the alteration of the riverbed for flood control, primarily with levees and channelization. The Trinity River is also impounded throughout the Dallas-Fort Worth metropolitan area to hold flood waters and provide a source for municipal and industrial water. This stretch of the Trinity River provides many public access points for river recreation.[8] The Trinity River between Dallas and Lake Livingston has rolling topography and is a narrow, slow-moving, meandering river with steep muddy banks.[7,9] Soils in the region are deep to shallow clay, clay loam, and sandy loam that support elms, sycamores, willows, oaks, junipers, mesquites, and grasses. This long stretch of the Trinity River provides limited recreational access. The Trinity River downstream of Lake Livingston is gently rolling to flat terrain with wide, shallow stream channels. Clay and sandy loams predominate and support water-tolerant hardwoods, conifers, and grasses. Recreational access is also limited in the lower Trinity River basin.

Demographics of the Trinity River Basin

The Trinity River flows through the Dallas-Fort Worth-Arlington metropolitan area, locally referred to as the "The Metroplex" and located within the Upper Trinity River Basin. The Metroplex is the largest metropolitan area in the state of Texas and the fourth largest in the United States.[10] In 2013, according to the United States Census Bureau's (USCB) estimate, the 13 county Dallas-Fort Worth-Arlington metropolitan area had a population near 6,810,913.[10] The USCB also reported that the Dallas-Fort Worth-Arlington metropolitan area was the second fastest growing metropolitan area in the United States, which gained 1,210,229 residents from 2000 to 2010.[10] The Metroplex covers approximately 9,286 square miles; an area larger than the combined U.S. states of Connecticut and Rhode Island.

The Lower Trinity River Basin (i.e., within the study area) located in rural East Texas spans 12 counties. The USCB estimated 2013 population of the 12 county area surrounding the Lower Trinity River Basin at 490,355 people.[11] Corsicana and Huntsville, Texas are the only metropolitan areas (population ≥ 20,000 people) within 25 miles of the Trinity River in the Lower Trinity River Basin (i.e., within the study area).

Subsistence Fishing within the Trinity River Basin

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.[12] 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.*[13] 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.*[14] Advice and direction are also received from the legislatively mandated *State of Texas Toxic Substances Coordinating Committee Fish Sampling Advisory Subcommittee.*[15] 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 Trinity River 2012–2013 Sample Set

In July–September 2012 and April 2013, the SALG staff collected 187 fish samples from the Trinity River. Risk assessors used data from these fish to assess the potential for adverse human health outcomes from consuming fish from this river.

The SALG selected nine sample sites to provide spatial coverage of the study area (Figure 1): Site 1 Trinity River at U.S. Highway (US) 287; Site 2 Trinity River at US 79/84; Site 3 Trinity River at State Highway (SH) 7; Site 4 Trinity River at SH 21; Site 5 Trinity River at Farm-to-Market (FM) 3478; Site 6 Trinity River at SH 19; Site 7 Trinity River at FM 3278, Site 8 Trinity River at US 59; and, Site 9 Trinity River at US 90. 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 187 fish collected from the Trinity River 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: blue catfish (40); flathead catfish (40); white bass (27); alligator gar (18); striped bass (16); longnose gar (15); smallmouth buffalo (11); freshwater drum (9); spotted bass (7); largemouth bass (2); hybrid alligator/longnose gar (1); and hybrid striped bass (1).

The SALG utilized a boat-mounted electrofisher to collect fish. The SALG staff conducted electrofishing activities during daylight hours using pulsed direct current (Smith Root 7.5 GPP/ 5.0 GPP electrofishing system settings: 4.0-8.0 amps, 60 pulses per second [pps], low range, 500 volts, 40-100% duty cycle and 1.0-2.0 amps, 15 pps, low range, 500 volts, 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 one treble hook tied to a free-floating device) and hook-and-line sampling techniques to catch alligator gar. The SALG staff baited lines with cut common carp, gizzard shad, or smallmouth buffalo. The survey team targeted habitat within each sample site likely to hold alligator gar.

The SALG staff processed fish onsite at the Trinity River. 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. For alligator gar samples too large to weigh on an electronic or spring scale, staff measured girth to the nearest mm at the widest part of the fish. 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 SALG staff used game shears and a fillet knife to prepare fillets from each alligator gar sample. The foil was changed and the game shears 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 blue catfish, channel catfish, flathead catfish, largemouth bass, spotted bass, striped bass, 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).[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.[16, 17]

The SALG staff removed the head from each alligator gar and wrapped each head in plastic. The SALG staff wrapped duct tape around each head to secure the plastic and labeled each head with its DSHS identification number. The SALG staff stored and transported the alligator gar heads on wet ice to their Austin, Texas headquarters, where the samples were stored temporarily in a locked freezer. The SALG staff removed sagittal otoliths from each alligator gar head at the DSHS SALG boat storage facility following GSMFC and TPWD procedures. The SALG staff shipped the alligator gar otoliths to the TPWD Heart of the Hills Fisheries Science Center Ingram, Texas for age estimation.

Analytical Laboratory Information

The GERG personnel documented receipt of the 187 Trinity River fish 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 the Trinity River 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,[d, 18] and 17 polychlorinated dibenzofurans and/or dibenzo-*p*-dioxins (PCDDs/PCDFs) congeners. The laboratory analyzed all 187 samples for mercury, PCBs, and PCDDs/PCDFs. A subset of 11 of the original 187 samples was analyzed for the following contaminant groups: metals, pesticides, SVOCs, and VOCs.[19] 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 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 11 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.[20] 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.[21] 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

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[d] 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.

analyses, the USEPA recommends that states determine total mercury concentration in a fish and that – to protect human health – states conservatively assume that 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.[22] (In these risk characterizations, the DSHS may interchangeably utilize 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.[23] A tissue sample is extracted with methylene chloride in the presence of sodium sulfate. An aliquot of the extract is 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[e] or Aroclors®[f] because the USEPA considers congener analysis the most sensitive technique for detecting PCBs in environmental media.[18, 24] Although only about 130 PCB congeners were routinely present in PCB mixtures manufactured and commonly used in the United States (US), 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),[25] from McFarland and Clarke,[26] and from the USEPA's guidance documents for assessing contaminants in fish and shellfish.[14, 19] 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

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[e] 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).

[f] 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).

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.[27] IRIS currently contains systemic 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.[28] 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.

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.[274]

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.[29, 30]

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.[31]

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

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.[32] 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.[32]

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 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[33] or the ATSDR's chronic oral MRLs.[34] 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.[g] 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.*[35]

The USEPA also states that the RfD

> … *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.*[35]

The ATSDR uses a similar technique to derive its MRLs.[34] 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).*[36] -

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."

[g] 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.

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.[34]

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.[33,35] 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.[35]

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)[35] 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.[37, 38] 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.[39] 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.[40]

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.[33] Additionally, in accordance with the ATSDR's *Child Health Initiative*[41] and the USEPA's *National Agenda to Protect Children's Health from Environmental Threats,*[42] 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 two 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), using Systat® to generate descriptive statistics (mean, 95% confidence limits of the arithmetic mean, standard deviation, median, minimum, and maximum concentrations) for reported chemical contaminants.[43] In computing descriptive statistics, SALG risk assessors utilized ½ the reporting limit (RL) for analytes designated as not detected (ND) or estimated (J-values).[h] The SALG risk assessors calculated PCDDs/PCDFs descriptive statistics using estimated concentrations (J-values) and assuming zero for PCDDs/PCDFs designated as ND.[i] 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 the Trinity River.[44] 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

[h] *"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.*

[i] *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.*

(PbB) level to exceed the Centers for Disease Control and Prevention's (CDC) lead concentration of concern in children's blood (5 mcg/dL).[45, 46]

The SALG risk assessors also performed other types of statistical analyses to evaluate the 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. PCDD/PCDF data were excluded from these analyses because the data were not normally distributed and the data could not be appropriately $\log_e$-transformed because of the 16 non-detects or zero concentrations. 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. The SALG risk assessors performed analysis of variance (ANOVA) and used Tukey's honestly significant difference (HSD) or Games-Howell post-hoc comparisons to compare sample site contaminant concentrations for blue catfish, flathead catfish, and all fish combined. The SALG risk assessors used Tukey's HSD for data that meet the assumption of homogeneity of variances and used the Games-Howell test for data that did not meet the homogeneity of variances assumption. Blue and flathead catfish were the only species collected at all sample sites where sample sizes were adequate to perform reliable comparisons.

RESULTS

The GERG laboratory completed analyses and electronically transmitted the results of the Trinity River samples collected from July–September 2012 and April 2013 to the SALG in February 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 2.1–2.7 present the results of metals analyses. Tables 3 and 4.1–4.5 contain summary results for pesticides and PCBs, respectively. Tables 5.1–5.5 summarize the PCDD/PCDF analyses. This report does not display SVOC and VOC data because these contaminants were not present at concentrations of concern in fish collected from the Trinity River 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 11 fish tissue samples (alligator gar [n = 2] and flathead catfish [n = 9]) for six inorganic contaminants and 187 samples for mercury. All fish tissue samples from the Trinity River contained concentrations of arsenic, cadmium, copper, mercury, selenium, and zinc (Tables 2.1–2.7).

The SALG evaluated three toxic metalloids having no known human physiological function (arsenic, cadmium, and lead) in the samples collected from the Trinity River. Eleven of 11 fish analyzed contained arsenic ranging from BDL–0.471 mg/kg (Table 2.1). The mean cadmium concentration in fish sampled from the Trinity River was 0.114±0.071 mg/kg. Lead concentrations ranged from ND to 0.078 mg/kg with a mean of 0.027±0.019 mg/kg(Table 2.2).

Three of the metalloids analyzed are essential trace elements: copper, selenium, and zinc. All 11 fish tissue samples contained copper (Table 2.2). The mean copper concentration in fish sampled from the Trinity River was 0.134±0.052 mg/kg. All fish tissue samples contained selenium. Selenium concentrations ranged from 0.214 to 1.614 mg/kg with a mean of 0.870±0.430 mg/kg (Table 2.2). All samples also contained zinc (Table 2.2). The mean zinc concentration in fish tissue samples from the Trinity River was 4.204±0.826 mg/kg.

<u>Mercury</u>

All fish tissue samples evaluated from the Trinity River contained mercury (Tables 2.3–2.7). Across all sample sites and species, mercury concentrations ranged from 0.052 (smallmouth buffalo) to 0.869 mg/kg (flathead catfish). The mean mercury concentration for the 187 fish tissue samples analyzed was 0.269±0.139 mg/kg (Table 2.7).

<u>Alligator gar</u>

Eighteen alligator gar ranging from 38.0 to 73.6 inches TL ($\overline{X}$ – 56.5 inches TL) and from five to 25 years of age were analyzed for mercury (Table 1; Figure 2). There is a limit of one alligator gar harvested per day per person.[47] Currently, there is no minimum length limit for alligator in Texas waters. Mercury concentrations ranged from 0.124 to 0.589 mg/kg with a mean of 0.319±0.129 mg/kg (Tables 2.3–2.7). Mercury concentrations in alligator gar were positively related to TL and age suggesting that mercury concentrations increase over time as alligator gar grow ($r^2 = 0.632$, $n = 18$, $p < 0.0005$; $r^2 = 0.435$, $n = 18$, $p = 0.003$; Figure 3; mercury–age figure not shown).

<u>Blue catfish</u>

Forty blue catfish ranging from 19.9 to 41.5 inches TL ($\overline{X}$ – 29.7 inches TL) and from six to 19 years of age were analyzed for mercury (Table 1; Figure 4). One-hundred percent of the blue catfish samples examined were of legal size (≥ 12 inches TL).[475] Mercury concentrations ranged from 0.091 to 0.691 mg/kg with a mean of 0.295±0.164 mg/kg and a median of 0.239 mg/kg (Tables 2.3–2.7). Mercury concentrations in blue catfish were positively related to TL and age (r^2 = 0.460, n = 40, $p < 0.0005$; r^2 = 0.632, n = 40, $p < 0.0005$; Figures 5–6).

Flathead catfish

Forty flathead catfish ranging from 27.70 to 47.1 inches TL ($\overline{X}$ – 33.0 inches TL) and from three to 22 years of age were analyzed for mercury (Table 1; Figure 7). One-hundred percent of the flathead catfish samples examined were of legal size (≥ 18 inches TL).[475] Mercury concentrations ranged from 0.101 to 0.869 mg/kg with a mean of 0.226±0.148 mg/kg and a median of 0.169 mg/kg (Tables 2.3–2.6). Mercury concentrations in flathead catfish were positively related to TL and age (r^2= 0.388, n = 40, $p < 0.0005$; r^2= 0.633, n = 40, $p < 0.0005$; Figures 8–9).

Freshwater drum

Nine freshwater drum ranging from 18.0 to 23.7 inches TL ($\overline{X}$ – 20.9 inches TL) were analyzed for mercury (Table 1). Currently, there is no minimum length limit for freshwater drum in Texas waters.[475] Mercury concentrations ranged from 0.124 to 0.481 mg/kg with a mean of 0.260±0.104 mg/kg and a median of 0.261 mg/kg (Tables 2.3–2.7).

Largemouth bass

Two largemouth bass ranging from 17.8 to 20.8 inches TL ($\overline{X}$ – 19.3 inches TL) and from three to six years of age were analyzed for mercury (Table 1). One-hundred percent of the largemouth bass samples examined were of legal size (≥ 14 inches TL).[475] Mercury concentrations ranged from 0.348 to 0.654 mg/kg with a mean of 0.501±0.216 mg/kg (Tables 2.3–2.7).

Longnose gar

Fifteen longnose gar ranging from 31.5 to 50.0 inches TL ($\overline{X}$ – 39.3 inches TL) were analyzed for mercury (Table 1). Currently, there is no minimum length limit for gar in Texas waters.[475] Mercury concentrations ranged from 0.127 to 0.430 mg/kg with a mean of 0.327±0.097 mg/kg and a median of 0.239 mg/kg (Tables 2.3–2.7). The SALG risk assessors computed a Pearson product-moment correlation coefficient to assess the relationship between mercury concentration and TL for longnose gar. There was no correlation between the two variables (r = 0.011, n = 15, p = 0.968).

Smallmouth buffalo

Eleven smallmouth buffalo ranging from 18.3 to 28.5 inches TL ($\overline{X}$ – 22.8 inches TL) were analyzed for mercury (Table 1). Currently, there is no minimum length limit for smallmouth buffalo in Texas waters.[475] Mercury concentrations ranged from 0.052 to 0.591 mg/kg with a mean of 0.310±0.157 mg/kg and a median of 0.331 mg/kg (Tables 2.3–2.7). The SALG risk assessors computed a Pearson product-moment correlation coefficient to assess the relationship between mercury concentration and TL for smallmouth buffalo. There was no apparent correlation between the two variables (r = 0.160, n = 15, p = 0.639).

Spotted bass

Seven spotted bass ranging from 12.8 to 16.0 inches TL ($\overline{X}$ – 14.6 inches TL) and from three to six years of age were analyzed for mercury (Table 1). Currently, there is no minimum length limit for spotted bass in Texas waters.[475] Mercury concentrations ranged from 0.210 to 0.588 mg/kg with a mean of 0.348±0.134 mg/kg and a median of 0.316 mg/kg (Tables 2.3–2.7).

Striped bass

Sixteen striped bass ranging from 18.5 to 25.6 inches TL ($\overline{X}$ – 21.5 inches TL) and from two to seven years of age were analyzed for mercury (Table 1; Figure 10). One-hundred percent of the striped bass samples examined were of legal size (≥ 18 inches TL).[475] Mercury concentrations in striped bass ranged from 0.126 to 0.466 mg/kg with a mean of 0.215±0.089 mg/kg and a median of 0.188 mg/kg (Tables 2.3–2.7). The SALG risk assessors computed a Pearson product-moment correlation coefficient to assess the relationships between mercury concentration and TL for striped bass. There was no statistically significant apparent correlation between the mercury and TL (r = 0.246, n = 16, p = 0.359). Mercury concentrations in striped bass were positively related to age (r^2= 0.701, n = 16, p < 0.0005; Figure 11).

White bass

Twenty-seven white bass ranging from 11.9 to 15.8 inches TL ($\overline{X}$ – 14.0 inches TL) and from one to five years of age were analyzed for mercury (Table 1; Figure 12). One-hundred percent of the white bass samples examined were of legal size (≥ 10 inches TL).[475] Mercury concentrations ranged from 0.108 to 0.400 mg/kg with a mean of 0.214±0.072 mg/kg and a median of 0.198 mg/kg (Tables 2.3–2.7). The SALG risk assessors computed a Pearson product-moment correlation coefficient to assess the relationships between mercury concentration and TL and mercury concentration and age for white bass. There was no correlation between mercury and TL and mercury and age (r = 0.065, n = 27, p = 0.748; r = 0.348, n = 27, p = 0.075).

Organic Contaminants

<u>Pesticides</u>

All samples examined contained concentrations of chlordane, 4,4′-dichlorodiphenyldichloroethylene (DDE), and 4,4′- dichlorodiphenyldichloroethane (DDD) (Table 3.). Chlordane concentrations ranged from 0.001 to 0.071 mg/kg with a mean of 0.023±0.026 mg/kg and a median of 0.010 mg/kg. Total dichlorodiphenyltrichloroethane (DDT) [4,4′-DDE + 4,4′-DDD] ranged from 0.008 to 0.310 mg/kg with a mean 0.074±0.098 mg/kg and a median of 0.024 mg/kg. Trace to low concentrations of heptachlor epoxide, dieldrin, and endrin were present in six of 11 fish samples (Table 3.) Trace to low concentrations of 2,4′-DDE, 2,4′-DDD, 4,4′-DDT, aldrin, alpha HCH, heptachlor, hexachlorobenzene, mirex, pentachloroanisole, pentachlorobenzene, and tetrachlorobenzene were present in one or more fish samples (data not presented).

<u>PCBs</u>

All fish tissue samples evaluated from the Trinity River contained PCBs (Tables 4.1–4.5). Across all sample sites and species, PCB concentrations ranged from 0.005 (spotted bass) to 1.031 mg/kg (longnose gar). The mean PCB concentration for the 187 fish tissue samples analyzed was 0.083±0.128 mg/kg (Table 4.5). PCB concentrations in fish appeared to be positively related to TL and percent lipids ($r^2 = 0.323$, $n = 187$, $p < 0.0005$; $r^2 = 0.303$, $n = 187$, $p < 0.0005$; Figures 13–15).

The SALG risk assessors visually examined the fish PCB concentrations noting that PCB concentrations appeared higher in the Trinity River above Lake Livingston (sample sites 1–6) than below Lake Livingston (sample sites 7–9; Figure 16). However, PCB concentrations collected from sample site seven appeared consistent with samples collected from the Trinity River sample sites above Lake Livingston. The SALG risk assessors performed ANOVA to test for differences in PCB concentration in fish collected from the Trinity River. Fish PCB concentrations differed significantly across the nine samples sites ($F [8, 178] = 3.894$, $p < 0.0005$; Figure 16). Tukey’s HSD post-hoc comparisons of fish PCB concentrations indicate that sample site nine had significantly lower PCB concentrations than the rest of the sampling sites (Table 9.1).

<u>Alligator gar</u>

PCB concentrations ranged from 0.016 to 0.445 mg/kg with a mean of 0.181±0.108 mg/kg and median 0.172 mg/kg ($n = 18$; Tables 4.1–4.5). PCB concentrations in alligator gar appeared to be positively related to TL, age, and percent lipids ($r^2 = 0.413$, $n = 18$, $p = 0.004$; $r^2 = 0.494$, $n = 18$, $p = 0.001$; $r^2 = 0.588$, $n = 18$, $p < 0.0005$; Figures 17–18; Figure for PCBs and age not shown).

Blue catfish

PCB concentrations ranged from 0.009 to 0.291 mg/kg with a mean of 0.081±0.075 mg/kg and a median of 0.057 mg/kg (n = 40; Tables 4.1–4.5). The SALG risk assessors computed a Pearson product-moment correlation coefficient to assess the relationship between PCB concentration and percent lipids. There appeared to be no correlation between the two variables ($r = 0.107$, $n = 40$, $p = 0.511$). PCB concentrations in blue catfish were positively related to TL and age ($r^2 = 0.262$, $n = 40$, $p = 0.001$; $r^2 = 0.349$, $n = 40$, $p < 0.0005$; Figures 19–20).

The SALG risk assessors visually examined the blue catfish PCB concentrations noting that PCB concentrations appeared higher in the Trinity River above Lake Livingston (sample sites 1–6) than below Lake Livingston (sample sites 7–9; Figure 21). Blue catfish PCB concentrations differed significantly across the nine samples sites ($F_{[8, 31]} = 4.946$, $p = 0.001$; Figure 21). Tukey's HSD post-hoc comparisons of blue catfish PCB concentrations indicate that several sample sites (1, 3, 4, and 6) above Lake Livingston had significantly higher PCB concentrations than blue catfish from sample sites (8 and 9) below Lake Livingston (Table 9.2).

Flathead catfish

PCB concentrations ranged from 0.007 to 0.172 mg/kg with a mean of 0.047±0.039 mg/kg and a median of 0.031 mg/kg (n = 40; Tables 4.1–4.5). There was no apparent correlation between PCB concentration and TL and age, respectively ($r = 0.173$, $n = 40$, $p = 0.286$; $r = 0.246$, $n = 40$, $p = 0.127$). PCB concentrations in flathead catfish were positively related to percent lipids ($r^2 = 0.385$, $n = 40$, $p < 0.0005$; Figure 22).

The SALG risk assessors visually examined the flathead catfish PCB concentrations noting that PCB concentrations appeared higher in the Trinity River above Lake Livingston (sample sites 1–6) than below Lake Livingston (sample sites 7–9; Figure 23). Flathead catfish PCB concentrations differed significantly across the nine samples sites ($F_{[8, 31]} = 2.308$, $p = 0.045$; Figure 23). Games-Howell post-hoc comparisons of flathead catfish PCB concentrations indicate that only sample site five above Lake Livingston had significantly higher PCB concentrations than flathead catfish from sample site nine below Lake Livingston (Table 9.3).

Freshwater drum

PCB concentrations ranged from 0.010 to 0.132 mg/kg with a mean of 0.053±0.038 mg/kg and a median of 0.034 mg/kg (n = 9; Tables 4.1–4.5).

Largemouth bass

PCB concentrations ranged from 0.014 to 0.014 mg/kg with a mean of 0.014±0.000 mg/kg (Tables 4.1–4.5).

Longnose gar

PCB concentrations ranged from 0.034 to 1.031 mg/kg with a mean of 0.302±0.318 mg/kg and a median of 0.152 mg/kg (n = 15; Tables 4.1–4.5). The SALG risk assessors computed a Pearson product-moment correlation coefficient to assess the relationship between PCB concentration and TL and percent lipids for longnose gar. There was no apparent correlation between PCB concentration and TL and percent lipids, respectively (r = 0.268, n = 15, p = 0.334; r = 0.480, n = 15, p = 0.070).

Smallmouth buffalo

PCB concentrations ranged from 0.006 to 0.133 mg/kg with a mean of 0.044±0.044 mg/kg and a median of 0.025 mg/kg (n = 11; Tables 4.1–4.5). The SALG risk assessors computed a Pearson product-moment correlation coefficient to assess the relationship between PCB concentration and TL and percent lipids for smallmouth buffalo. There was no apparent correlation between PCB concentration and TL and percent lipids, respectively (r = 0.245, n = 15, p = 0.467; r = 0.416, n = 15, p = 0.203).

Spotted bass

PCB concentrations ranged from 0.005 to 0.019 mg/kg with a mean of 0.012±0.006 mg/kg and a median of 0.012 mg/kg (n = 7; Tables 4.1–4.5).

Striped bass

PCB concentrations in striped bass ranged from 0.018 to 0.088 mg/kg with a mean of 0.038±0.019 mg/kg and a median of 0.035 mg/kg (n = 16; Tables 4.1–4.5). The SALG risk assessors computed a Pearson product-moment correlation coefficient to assess the relationships between PCB concentration and TL and age for striped bass. There was no apparent correlation between PCB concentration and TL and age, respectively (r = 0.288, n = 16, p = 0.223; r = 0.132, n = 16, p = 0.627). PCB concentrations in striped bass were positively related to percent lipids (r^2= 0.299, n = 16, p = 0.028; Figure 24).

White bass

PCB concentrations ranged from 0.015 to 0.066 mg/kg with a mean of 0.034±0.012 mg/kg and a median of 0.031 mg/kg (n = 27; Tables 4.1–4.5). PCB concentrations in white bass were positively related to TL, age, and percent lipids (r^2 = 0.158, n = 27, p = 0.040; r^2 = 0.194, n = 27, p = 0.021; r^2 = 0.250, n = 27, p = 0.008; Figure 25; Figure for PCBs and TL and age not shown).

PCDDs/PCDFs

One-hundred seventy-one of 187 fish tissue samples contained at least one of the 17 PCDD/PCDF congeners ranging from ND–50.407 TEQ pg/g with a mean of 2.230±4.986 TEQ pg/g and a median of 0.795 TEQ pg/g (Tables 5.1–5.5). No samples contained all 17 congeners (data not shown). Longnose gar contained the highest mean PCDD/PCDF TEQ concentration (8.683±14.086 pg/g; Table 5.5). The SALG risk assessors plotted mean PCDD/PCDF TEQ concentrations for all fish to show how concentrations vary between sample sites (Figure 26).

<u>Alligator gar</u>

PCDD/PCDF TEQ concentrations ranged from 0.101 to 16.841 pg/g with a mean of 4.644±4.536 pg/g and median 2.816 pg/g (*n* = 18; Tables 5.1–5.5).

<u>Blue catfish</u>

PCDD/PCDF TEQ concentrations ranged from ND to 7.178 pg/g with a mean of 1.594±1.841 pg/g and median 0.829 pg/g (*n* = 40; Tables 5.1–5.5) The SALG risk assessors plotted mean PCDD/PCDF TEQ concentrations for blue catfish to show how concentrations vary between sample sites (Figure 27).

<u>Flathead catfish</u>

PCDD/PCDF TEQ concentrations ranged from ND to 13.702 pg/g with a mean of 1.634±2.404 pg/g and a median of 0.774 pg/g (*n* = 40; Tables 5.1–5.5). The SALG risk assessors plotted mean PCDD/PCDF TEQ concentrations for flathead catfish to show how concentrations vary between sample sites (Figure 28).

<u>Freshwater drum</u>

PCDD/PCDF TEQ concentrations ranged from 0.275 to 1.905 pg/g with a mean of 0.681±0.504 pg/g and a median of 0.537 pg/g (*n* = 9; Tables 5.1–5.5).

<u>Largemouth bass</u>

PCDD/PCDF TEQ concentrations ranged from 0.234 to 0.788 pg/g with a mean of 0.511±0.392 pg/g (*n* = 2; Tables 5.1–5.5).

<u>Longnose gar</u>

PCDD/PCDF TEQ concentrations ranged from 0.306 to 50.407 pg/g with a mean of 8.683±14.086 pg/g and a median of 1.876 pg/g (*n* = 15; Tables 5.1–5.5).

<u>Smallmouth buffalo</u>

PCDD/PCDF TEQ concentrations ranged from ND to 14.547 pg/g with a mean of 1.924±4.328 pg/g and a median of 0.135 pg/g (*n* = 11; Tables 5.1–5.5).

Spotted bass

PCDD/PCDF TEQ concentrations ranged from ND to 0.6.522 pg/g with a mean of 1.644±2.621 pg/g and a median of 0.265 pg/g (*n* = 7; Tables 5.1–5.5).

Striped bass

PCDD/PCDF TEQ concentrations in striped bass ranged from ND to 3.505 pg/g with a mean of 0.805±0.924 pg/g and a median of 0.582 pg/g (*n* = 16; Tables 5.1–5.5).

White bass

PCDD/PCDF TEQ concentrations ranged from ND to 2.149 pg/g with a mean of 0.709±0.452 pg/g and a median of 0.657 pg/g (*n* = 27; Tables 5.1–5.5).

SVOCs

The GERG laboratory analyzed a subset of 11 Trinity River fish tissue samples for SVOCs. Quantifiable concentrations > RL were reported for benzoic acid and phenol in one or more fish samples (data not presented). Estimated concentrations of nitrobenzene and 4-chloro-3-methylphenol were present in one or more fish samples analyzed (data not presented). The laboratory detected no other SVOCs in fish from the Trinity River.

VOCs

The GERG laboratory reported the 11 fish tissue samples selected for analysis from the Trinity River to contain quantifiable concentrations > RL of one or more VOCs: acetone; carbon disulfide; methylene chloride; 2-butanone (MEK); benzene; and trichlorofluoromethane (data not presented). Estimated quantities of many VOCs were also present in one or more fish tissue samples analyzed from the Trinity River (data not presented).

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. Numerous VOCs were also identified in one or more of the procedural blanks, indicating the possibility that these compounds were introduced during sample preparation. VOC concentrations < RL are difficult to interpret due to their uncertainty and may represent a false positive. The presence of many VOCs at concentrations < RL 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. Since 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.[33] 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 systemic and carcinogenic endpoints in those who would consume fish from the Trinity River. 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 (Noncancinogenic) Health Effects from Consumption of Fish from the Trinity River

Inorganic Contaminants

None of species of fish evaluated contained arsenic, cadmium, copper, lead, selenium, or zinc at concentrations that equaled or exceeded DSHS guidelines for protection of human health or would likely cause systemic risk to human health from consumption of fish from the Trinity River.

Mercury was observed in three of 187 fish from the Trinity River that equaled or exceeded its HAC_{nonca} (0.700 mg/kg; Tables 2.3–2.7 and 6). The mean mercury concentrations of the 10 species evaluated and the all fish combined mean concentration did not exceed the mercury HAC_{nonca} nor did the HQs exceed 1.0. Even though mercury concentrations did not exceed DSHS guidelines for protection of human health, it is important to understand that mercury concentrations in most predatory species of fish from the Trinity River were positively related to TL and age indicating that mercury concentrations increase over time as fish grow (Figures 2–13). These relationships are also affected by the slow rate at which fish eliminate mercury compared to the rate at which it is accumulated. People should consider these relationships when choosing the size and species of fish they consume. No species of fish evaluated contained any other inorganic contaminants at concentrations that equaled or exceeded DSHS guidelines for protection of human health or would likely cause systemic risk to human health from consumption of fish from the Trinity River.

Organic Contaminants

One (flathead catfish) of 11 fish tissue samples evaluated contained heptachlor epoxide (HE) exceeding the HAC_{nonca} for HE (0.030 mg/kg; Table 3). The mean HE concentrations for flathead catfish and all fish combined did not exceed the HE HAC_{nonca} nor did the HQs exceed 1.0. PCBs and PCDDs/PCDFs were observed in fish from the Trinity River that equaled or exceeded their respective HAC_{nonca} (0.047 mg/kg; 2.330 pg/g; Tables 4.1–4.5; 5.1–5.5; and7.1–7.3). 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 (noncarcinogenic) risk to human health from consumption of fish from the Trinity River.

<u>PCBs</u>

All fish tissue samples (*n* = 187) assayed contained PCBs. Forty-three percent of all samples analyzed contained PCB concentrations exceeding the HAC_{nonca} for PCBs (0.047 mg/kg; Tables 4.1–4.5 and 7.1–7.3). Five (alligator gar, blue catfish, flathead catfish, freshwater drum, and longnose gar) of 10 species evaluated had mean PCB concentrations exceeding the HAC_{nonca} for PCBs or an HQ of 1.0 (Tables 4.1–4.5 and 7.1–7.3). The all fish combined mean PCB concentration (0.084 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 13–25). People should consider these relationships when choosing the size and species of fish they consume. The consumption of alligator gar, blue catfish, flathead catfish, freshwater drum, and longnose gar from the Trinity River may pose potential systemic (noncarcinogenic) 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 the Trinity River that healthy adults could consume without significant risk of PCB-related adverse systemic effects (Tables 7.1–7.3). 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: 0.2 meals per week of alligator gar; 0.5 meals per week of blue catfish; 0.9 meals per week of flathead catfish; 0.8 meals per week of freshwater drum; or, 0.1 meals per week of longnose gar. The SALG risk assessors suggest that fish from the Trinity River contain PCBs at concentrations that may pose potential systemic health risks and that people should limit their consumption of fish from the Trinity River. Because the developing nervous system of the human fetus and young children may be especially susceptible to adverse systemic health effects associated with consuming PCB-contaminated fish, the SALG risk assessors recommend more conservative consumption guidance for this sensitive subpopulation.

PCDDs/PCDFs

One-hundred seventy-one of 187 fish tissue samples assayed contained PCDDs/PCDFs. Twenty-two percent of all samples analyzed contained PCDD/PCDF concentrations exceeding the HAC_{nonca} for PCDDs/PCDFs (2.330 pg/g; Tables 5.1–5.5 and 7.1–7.3). Two (alligator gar and longnose gar) of 10 species evaluated had mean PCDD/PCDF concentrations exceeding the HAC_{nonca} for PCDDs/PCDFs or an HQ of 1.0 (Tables 5.1–5.5 and 7.1–7.3). PCDD/PCDF concentrations that equaled or exceeded the HAC_{nonca} for PCDDs/PCDFs were observed in one or more samples of the following species: alligator gar; blue catfish; flathead catfish; longnose gar; smallmouth buffalo; spotted bass; striped bass; and, white bass. 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 alligator gar and longnose gar from the Trinity River may pose potential systemic (noncarcinogenic) 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 the Trinity River that healthy adults could consume without significant risk of PCDD/PCDF -related adverse systemic effects (Tables 7.1–7.3). 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 for these species of fish: 0.5 meals per week of alligator gar or 0.2 meals per week of longnose gar. The SALG risk assessors suggest that fish from the Trinity River contain PCDDs/PCDFs at concentrations that may pose potential systemic health risks and that people should limit their consumption of fish from the Trinity River. 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 the Trinity River

The USEPA classifies arsenic, most chlorinated pesticides, PCBs, and PCDDs/PCDFs as human carcinogens. Arsenic and chlorinated pesticides were present in fish samples analyzed from the Trinity River, 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.

PCBs

The mean PCB concentrations observed in longnose gar 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 4.1–4.5 and 8.1–8.4). PCB concentrations that equaled or exceeded the HAC_{ca} for PCBs were observed in one or more samples of the following species: alligator gar; blue catfish; and, longnose gar. 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 longnose gar from the Trinity River that healthy adults could consume without significantly increasing their lifetime excess cancer risk (Tables 8.1–8.4). The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week of longnose gar (0.8 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 longnose gar from the Trinity River likely increases the risk of cancer to exceed the DSHS guideline for protection of human health from PCB exposure.

PCDDs/PCDFs

The mean PCDD/PCDF concentrations observed in alligator gar and longnose gar 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 5.1–5.5 and 8.1–8.4). PCDD/PCDF concentrations that equaled or exceeded the HAC_{ca} for PCDDs/PCDFs were observed in one or more samples of the following species: alligator gar; blue catfish; flathead catfish; freshwater drum; longnose gar; smallmouth buffalo; spotted bass; and, striped bass. The all fish combined mean PCDD/PCDF concentration did not exceed the HAC_{ca} for PCDDs/PCDFs. The consumption of alligator gar and longnose gar from the Trinity River likely increases 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 alligator gar or longnose gar from the Trinity River that healthy adults could consume without significantly increasing their lifetime excess cancer risk (Tables 8.1–8.4). The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week of alligator gar (0.7 meals per week) or longnose gar (0.4 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 alligator gar and longnose gar from the Trinity River 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 the Trinity River

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 the Trinity River could have these properties, especially with respect to effects on the immune system. Multiple organic contaminants in Trinity River fish increased the likelihood of systemic adverse health outcomes for all species of fish assayed (Tables 7.1–7.3). The combined toxicity of PCBs and PCDDs/PCDFs in alligator gar, blue catfish, flathead catfish, freshwater drum, longnose gar, smallmouth buffalo, striped bass 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 the Trinity River that healthy adults could consume without significant risk of PCB and/or PCDD/PCDF -related adverse systemic effects (Tables 7.1–7.3). 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 for these species of fish: alligator gar; blue catfish; flathead catfish; freshwater drum; longnose gar; smallmouth buffalo striped bass; or, white bass (Tables 7.1–7.3). The SALG risk assessors suggest that fish from the Trinity River 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 the Trinity River. Because the developing nervous system 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 8.1–8.4). 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 alligator gar, flathead catfish, and longnose gar.

The consumption of alligator gar, flathead catfish, and longnose gar from the Trinity River 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 of alligator gar (0.2 meals per week), flathead catfish (0.6 meals per week), or longnose gar (0.3 meals per week; Tables 8.1–8.4). 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 alligator gar, flathead catfish, and longnose gar from the Trinity River would be likely to increase the risk of cancer to exceed the DSHS guideline for protection of human health from multiple contaminant exposures.

Characterization of Potential Exposure to Contaminants from Consumption of Fish from the Trinity River

The SALG risk assessors are also of the opinion that it is important to consider potential exposure when developing fish consumption advisories. Studies have shown that recoveries and yields from whole fish to skin-off fillets range from 17–58%.[48] The SALG risk assessors used an average of 38% recovery and yield from whole fish to skin-off fillets to estimate the number of eight-ounce meals for an average weight fish of each species from the Trinity River in 2012–2013 (Table 10). The recoveries and yields for an average fish of each species from the Trinity River in 2012–2013 ranged from 0.5–87.7 eight-ounce meals. Based on recoveries and yields ($\overline{X}$ – 38%) from whole fish to skin-off fillets for this project, the average Trinity River fish yields four pounds of skin-off fillets or approximately 8 eight-ounce meals (Table 10). To illustrate the importance of potential exposure from large catfish, buffalo, or gar, DSHS considered the alligator gar mean mercury concentration (0.319 mg/kg) for this project. Based on a mean mercury concentration of 0.319 mg/kg, a person consuming 8 eight-ounce meals per month, or two eight-ounce meals per week, would consume equivalent to the MRL. The maximum size alligator gar (116.0 pounds) for this project yields 44.1 pounds of skin-off fillets, approximately 88 eight-ounce meals. Due to the potential exposure from large-sized fish, it is important for high volume fish consumers (i.e., persons who eat more than 2 eight-ounce meals per week) to understand that even though an average fish mercury concentration does not exceed the HAC_{nonca} for mercury a person may easily consume enough fish meals to exceed the MRL. For the reasons stated in the above discussion, the SALG risk assessors considered both standard meal consumption calculations and potential exposure scenarios to develop fish consumption advice for fish from the Trinity River.

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 the Trinity River, located in Anderson, Freestone, Houston, Leon, Liberty, Madison Navarro, Polk, San Jacinto, Trinity, and Walker Counties, Texas. Risk assessors from the SALG conclude from the present characterization of potential adverse health effects from consuming fish from the Trinity River that:

1. - Alligator gar and flathead catfish mean concentrations of arsenic, cadmium, copper, lead, mercury, selenium, zinc, pesticides, SVOCs, or VOCs, either singly or in combination, do not exceed the DSHS guidelines for protection of human health. Therefore, consumption of these fish species containing the above-listed contaminants **poses no apparent risk to human health**.

2. - Largemouth bass and spotted bass mean PCB concentrations do not exceed the DSHS guidelines for protection of human health. Based on the mean concentrations for these species of fish in this study, consumption of largemouth bass and spotted bass containing PCBs poses no apparent risk to human health. Though, due to the small sample sizes for largemouth bass and spotted bass and the variability of PCB concentrations in fish from the Trinity River, the SALG risk assessors characterize the likelihood of adverse health effects from regular consumption of largemouth bass and spotted bass from the Trinity River as of **unknown significance to human health.**

3. - Smallmouth buffalo, striped bass, and white bass mean PCB concentrations do not exceed the DSHS guidelines for protection of human health. Therefore, consumption of these species containing only PCBs **poses no apparent risk to human health**.

4. - Largemouth bass and spotted bass mean PCDD/PCDF TEQ concentrations do not exceed the DSHS guidelines for protection of human health. Based on the mean concentrations for these species of fish in this study, consumption of largemouth bass and spotted bass containing PCDDs/PCDFs pose no apparent risk to human health. Though, due to the small sample sizes for largemouth bass and spotted bass and the variability of PCDD/PCDF TEQ concentrations in fish from the Trinity River, the SALG risk assessors characterize the likelihood of adverse health effects from regular consumption of largemouth bass and spotted bass from the Trinity River as of **unknown significance to human health.**

5. - Blue catfish, flathead catfish, freshwater drum, smallmouth buffalo, striped bass, and white bass mean PCDD/PCDF TEQ concentrations do not exceed the DSHS guidelines for protection of human health. Therefore, consumption of these species containing only PCDDs/PCDFs **poses no apparent risk to human health**.

6. - Alligator gar, blue catfish, flathead catfish, freshwater drum, and longnose gar mean PCB concentrations exceed the DSHS guidelines for protection of human health. Regular or long-term consumption of these species of fish may result in adverse systemic health

effects. Therefore, consumption of these species from the Trinity River **poses an apparent risk to human health**.

7. - Alligator gar and longnose gar mean PCDD/PCDF TEQ concentrations exceed the DSHS guidelines for protection of human health. Regular or long-term consumption of gar may result in adverse systemic health effects and/or increase the likelihood of carcinogenic health risks. Therefore, consumption of gar from the Trinity River **poses an apparent risk to human health**.

8. - Consumption of multiple organic contaminants (i.e., PCDDs/PCDFs and PCBs) in alligator gar, blue catfish, flathead catfish, freshwater drum, longnose gar, smallmouth buffalo, striped bass, and white bass increases the likelihood of systemic 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 the Trinity River **poses an apparent risk to human health**.

9. - Consumption of multiple inorganic and/or organic contaminants observed in alligator gar, flathead catfish, and longnose gar increases the likelihood of carcinogenic health risks. Therefore, consumption of fish 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.[14, 19, 49] 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).[50] Declarations of prohibited harvesting areas are enforceable under the Texas Health and Safety Code, Subchapter D, parts 436.091 and 436.101.[50] 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 alligator gar, blue catfish, flathead catfish, freshwater drum, longnose gar, smallmouth buffalo, striped bass, and white bass from the Trinity River (US 287– US 90) **poses an apparent hazard to public health.** Therefore, SALG risk assessors recommend that:[j]

[j] SALG risk assessor's consumption recommendations are based on evaluation of the Trinity River Basin data (i.e., Lake Livingston and the Trinity River).

1. People should not consume alligator gar and longnose gar from the Trinity River (Table 11).

2. - Pregnant women, women who may become pregnant, women who are nursing infants, and children less than 12 years of age, or who weigh less than 75 pounds, should not consume blue catfish, flathead catfish, freshwater drum, gar (all species), and smallmouth buffalo from the Trinity River.

3. - Pregnant women, women who may become pregnant, 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 eight-ounce meal per month of striped bass or white bass from the Trinity River.

4. - Women past childbearing age and adult men may consume up to one eight-ounce meal per month of blue catfish, flathead catfish, or smallmouth buffalo from the Trinity River.

5. - Women past childbearing age and adult men may consume up to two eight-ounce meals per month of freshwater drum from the Trinity River.

6. - Women past childbearing age and adult men may consume up to three eight-ounce meals per month of striped bass or white bass from the Trinity River.

7. - As resources become available, the DSHS should continue to monitor fish from the Trinity River for changes or 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.

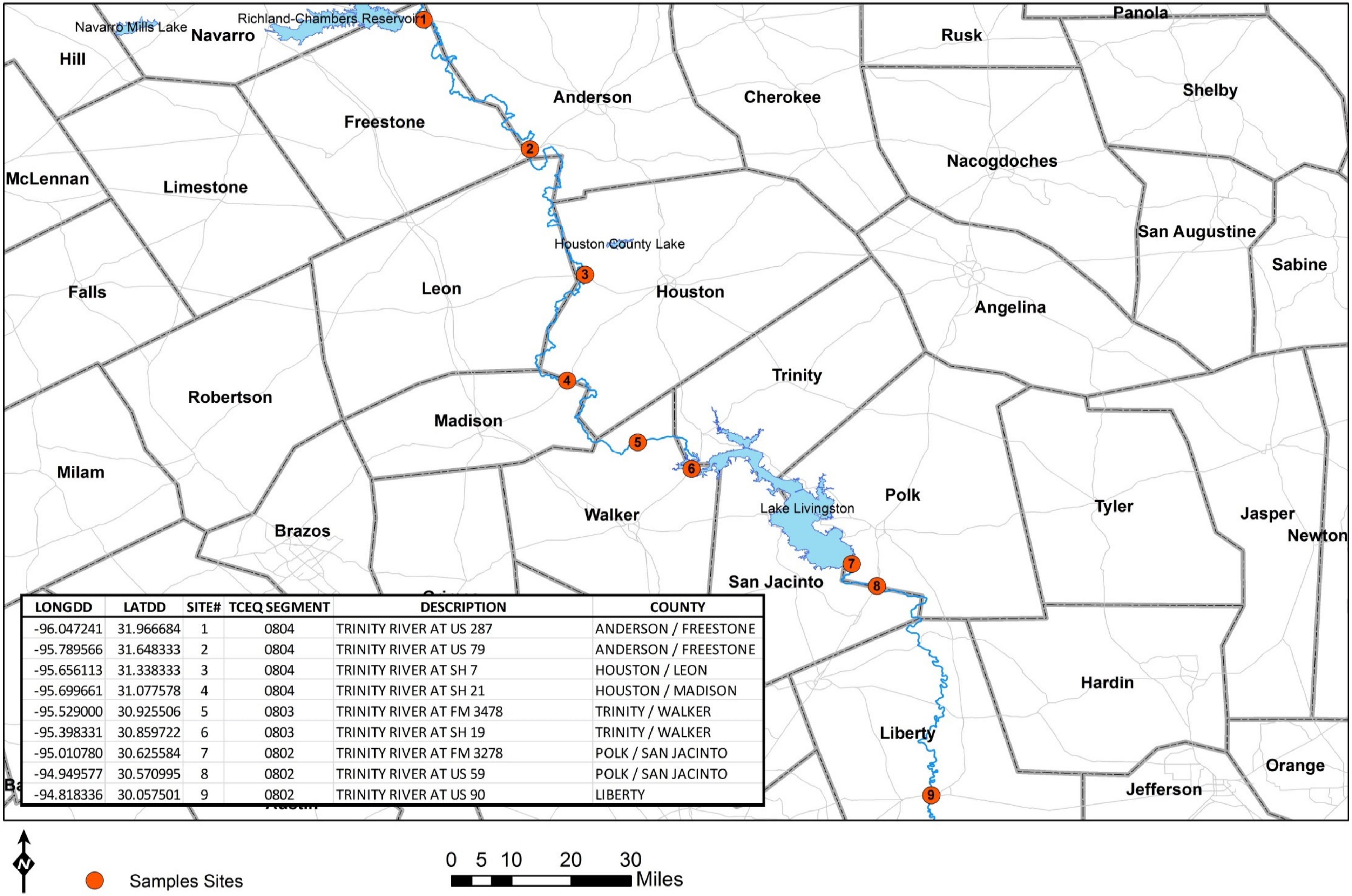
- The agency publishes fish consumption advisories and bans in a booklet available to the public through the SALG. To receive the booklet and/or the data, please contact the SALG at 512-834-6757.[51]
- The SALG also posts the most current information about advisories, bans, and the removal of either on the internet at http://www.dshs.state.tx.us/seafood.[52] 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 http://www.tpwd.state.tx.us/publications/pwdpubs/media/outdoorannual_2014_15.pdf. A booklet containing this information is available at all establishments selling Texas fishing licenses.[47]

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™ call 1-800-CDC-INFO (800-232-4636) or email a request to cdcinfo@cdc.gov.

Figure 1. 2012–2013 Trinity River Sample Sites



LONGDD	LATDD	SITE#	TCEQ SEGMENT	DESCRIPTION	COUNTY
-96.047241	31.966684	1	0804	TRINITY RIVER AT US 287	ANDERSON / FREESTONE
-95.789566	31.648333	2	0804	TRINITY RIVER AT US 79	ANDERSON / FREESTONE
-95.656113	31.338333	3	0804	TRINITY RIVER AT SH 7	HOUSTON / LEON
-95.699661	31.077578	4	0804	TRINITY RIVER AT SH 21	HOUSTON / MADISON
-95.529000	30.925506	5	0803	TRINITY RIVER AT FM 3478	TRINITY / WALKER
-95.398331	30.859722	6	0803	TRINITY RIVER AT SH 19	TRINITY / WALKER
-95.010780	30.625584	7	0802	TRINITY RIVER AT FM 3278	POLK / SAN JACINTO
-94.949577	30.570995	8	0802	TRINITY RIVER AT US 59	POLK / SAN JACINTO
-94.818336	30.057501	9	0802	TRINITY RIVER AT US 90	LIBERTY

Figure 2. Length at age for alligator gar collected from the Trinity River, Texas, 2012.

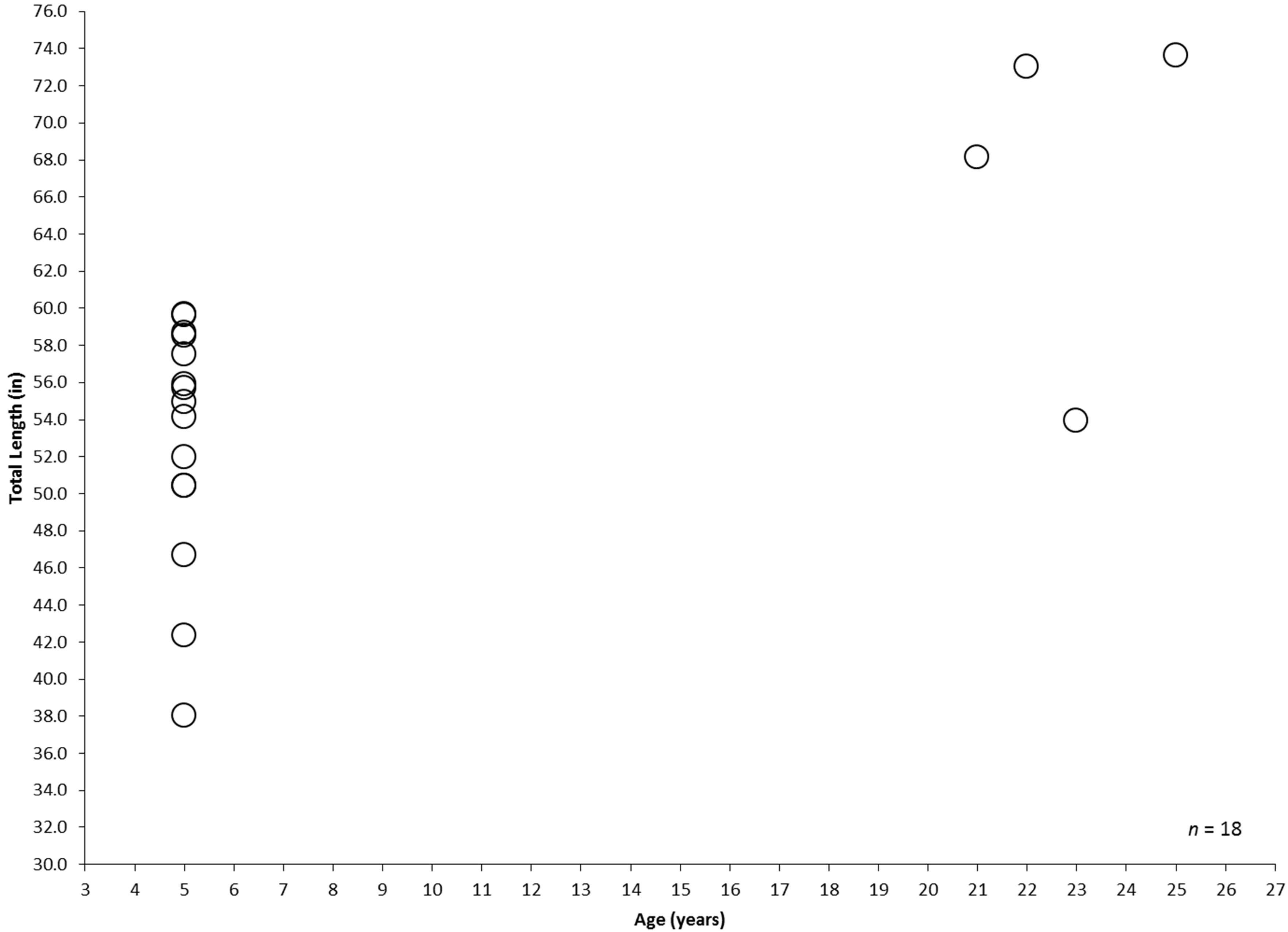


Figure 3. The relationship between mercury concentration and total length for alligator gar collected from the Trinity River, Texas, 2012.

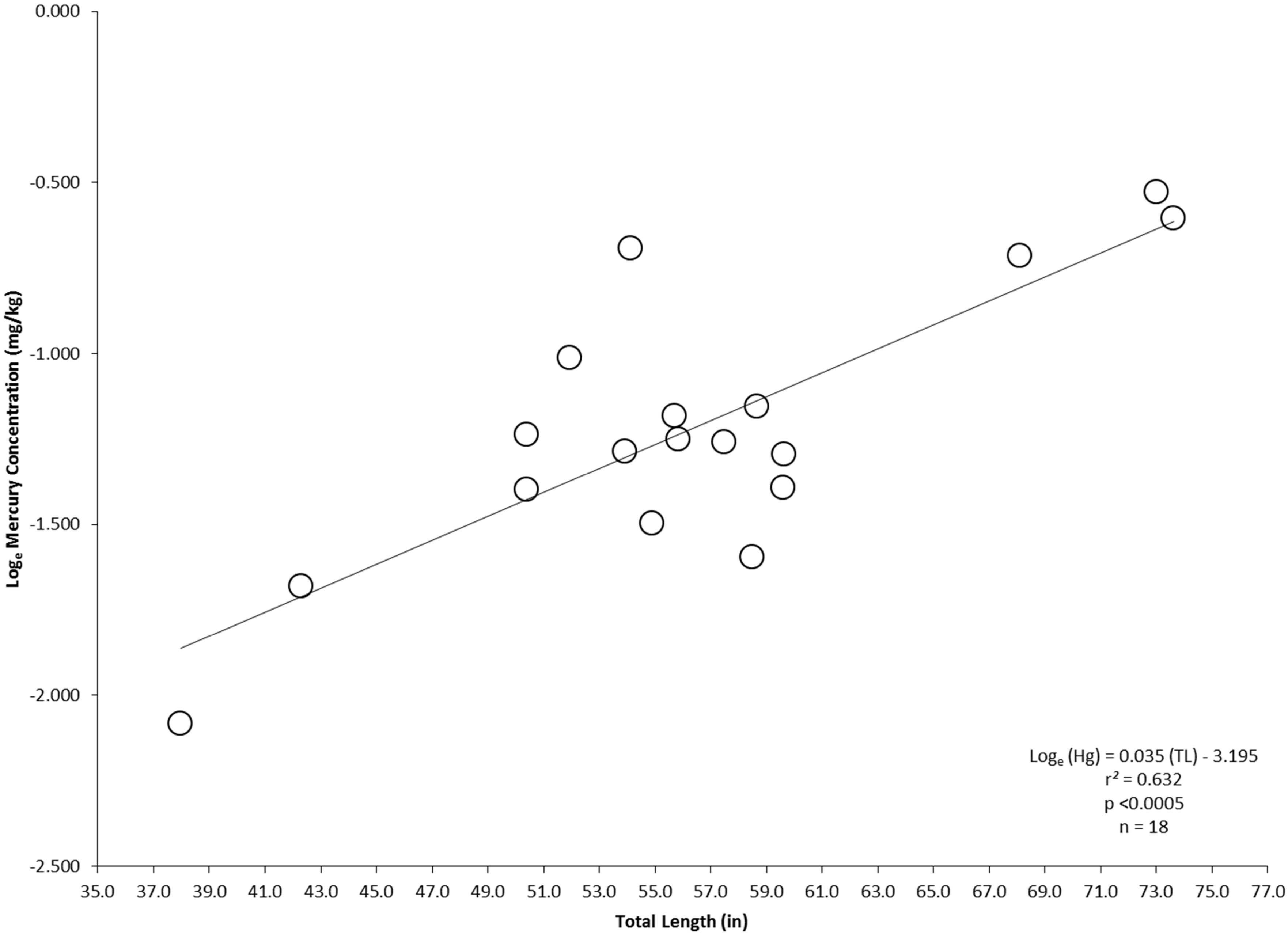


Figure 4. Length at age for blue catfish collected from the Trinity River, Texas, 2012.

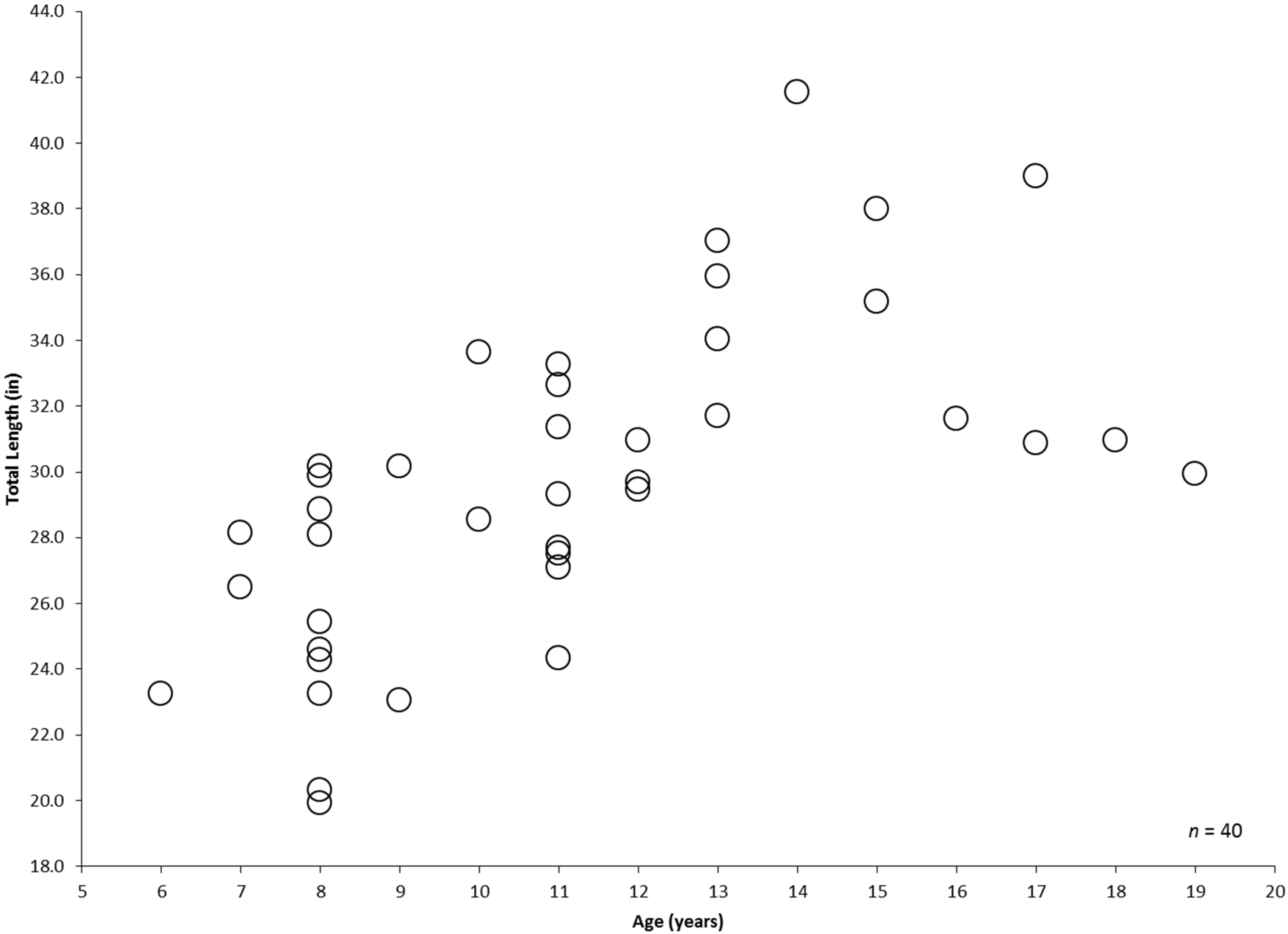


Figure 5. The relationship between mercury concentration and total length for blue catfish collected from the Trinity River, Texas, 2012.

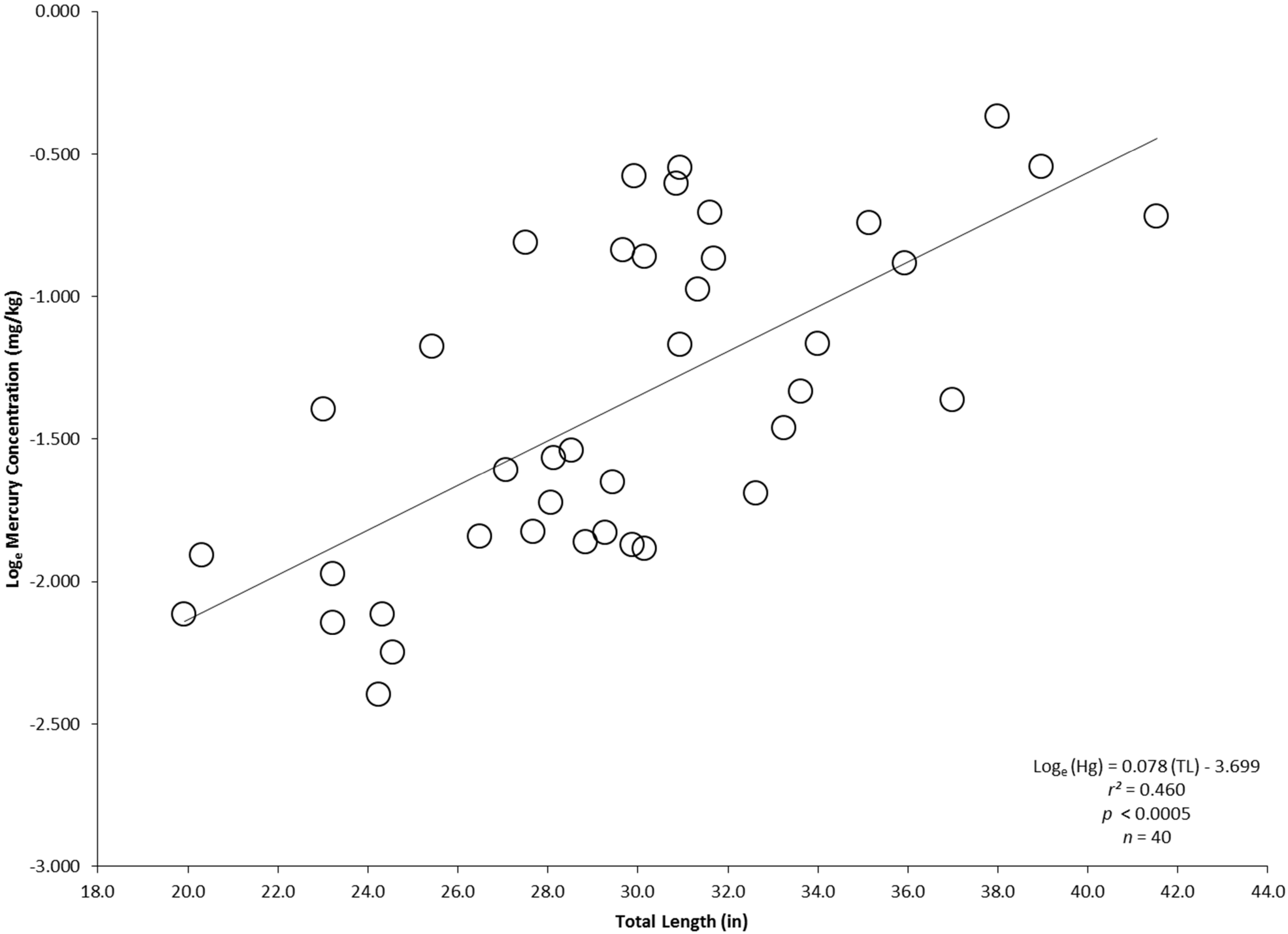


Figure 6. The relationship between mercury concentration and age for blue catfish collected from the Trinity River, Texas, 2012.

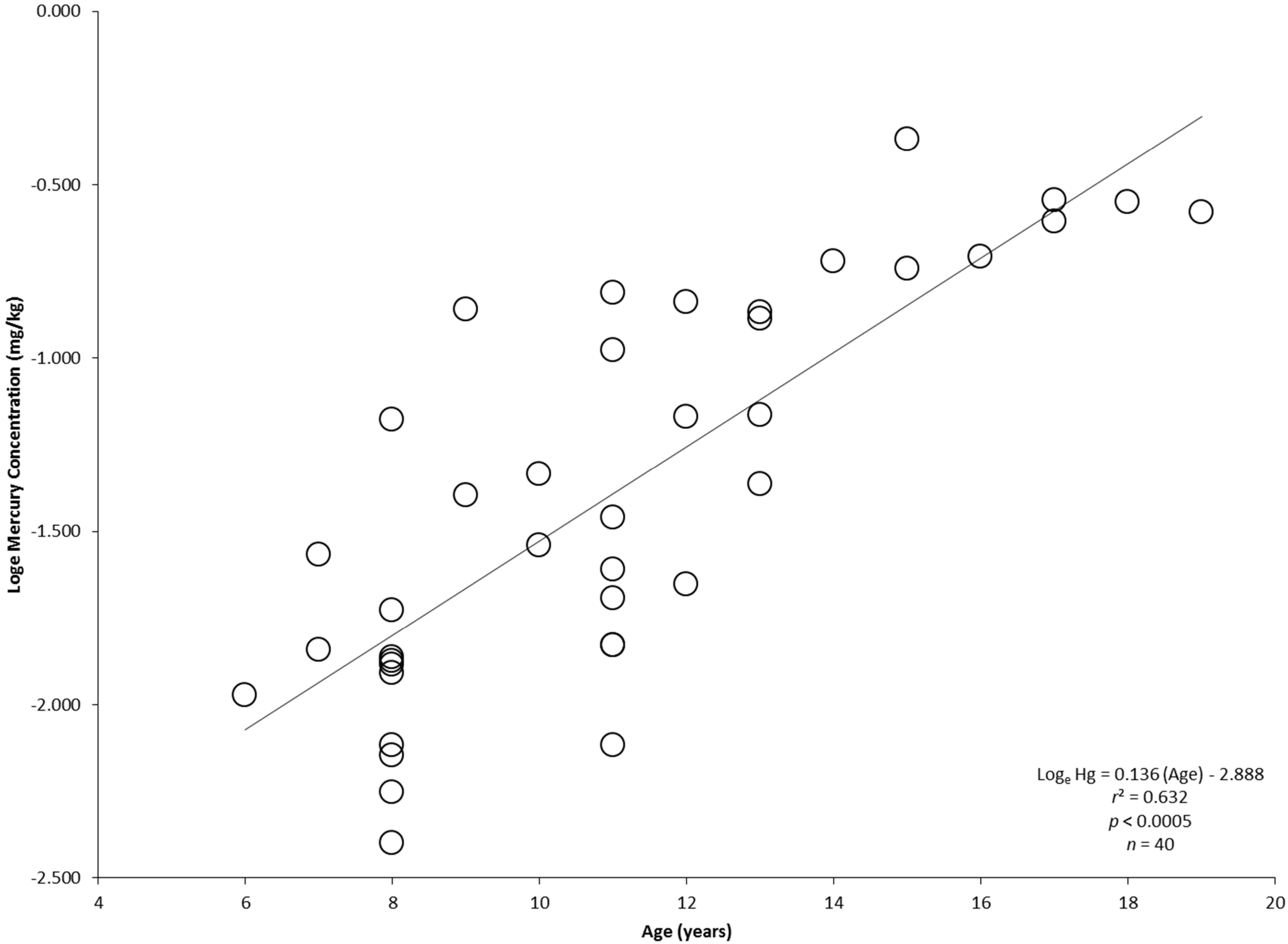


Figure 7. Length at age for flathead catfish collected from the Trinity River, Texas, 2012.

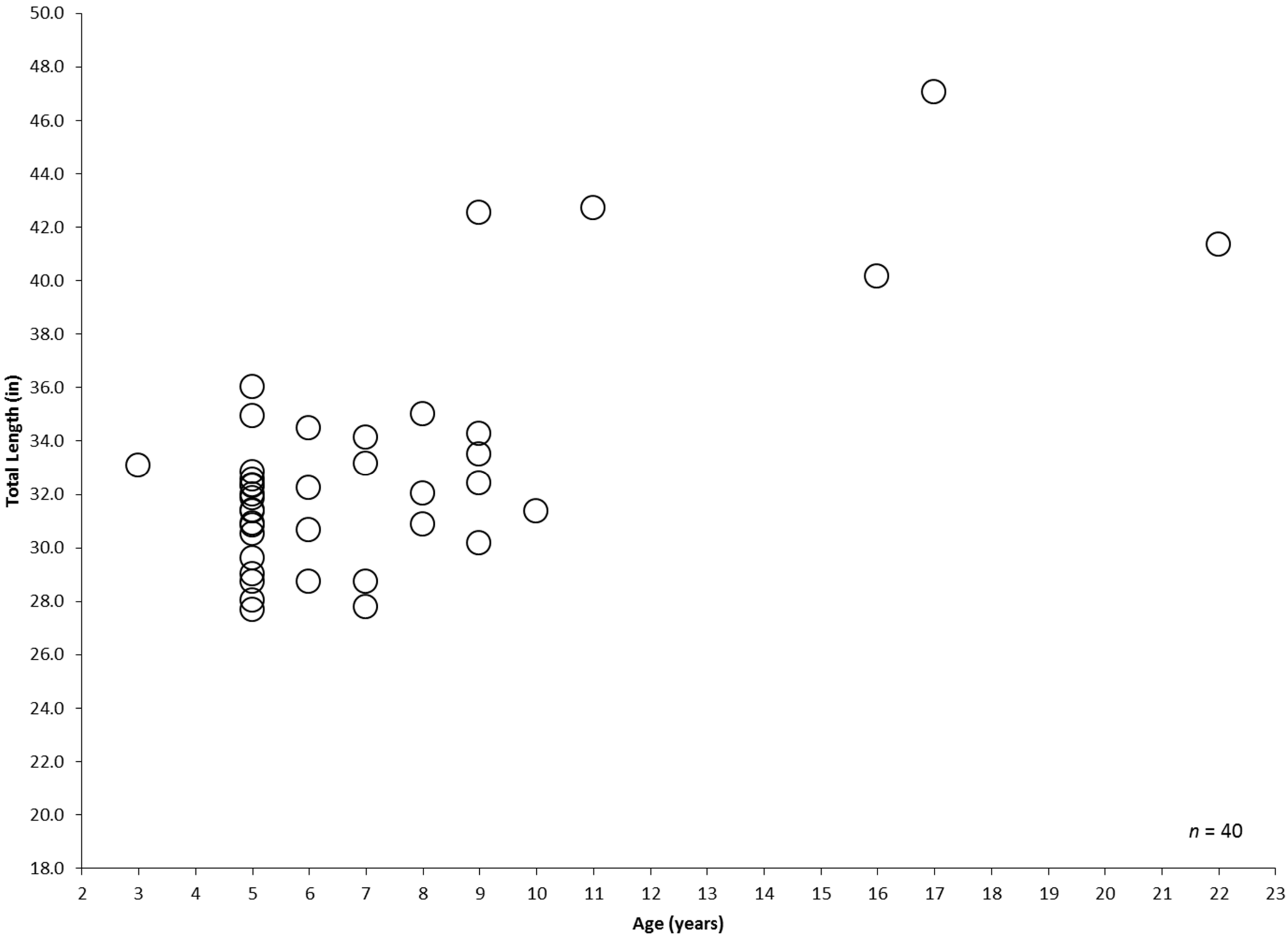


Figure 8. The relationship between mercury concentration and total length for flathead catfish collected from the Trinity River, Texas, 2012.

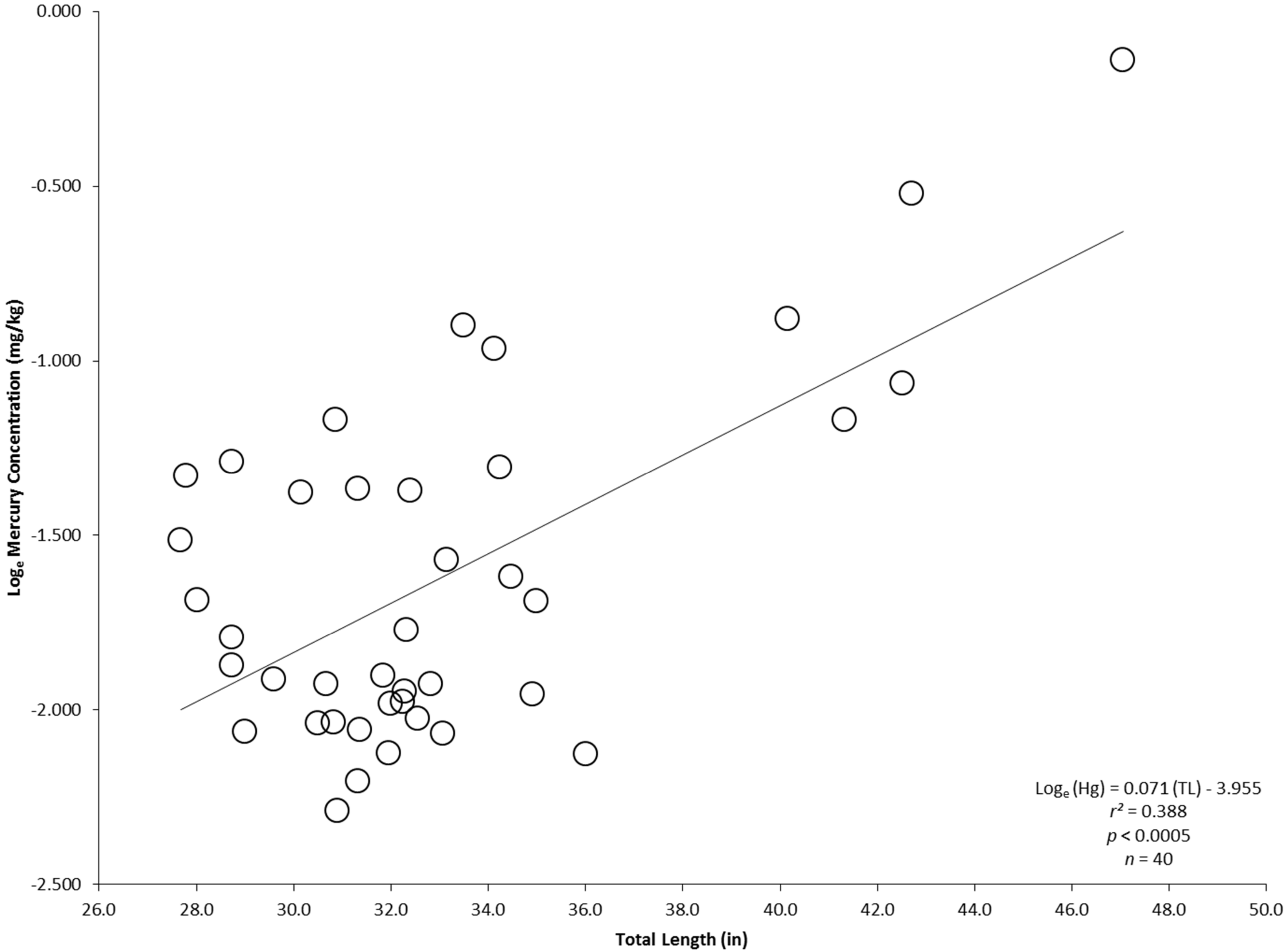


Figure 9. The relationship between mercury concentration and age for flathead catfish collected from the Trinity River, Texas, 2012.

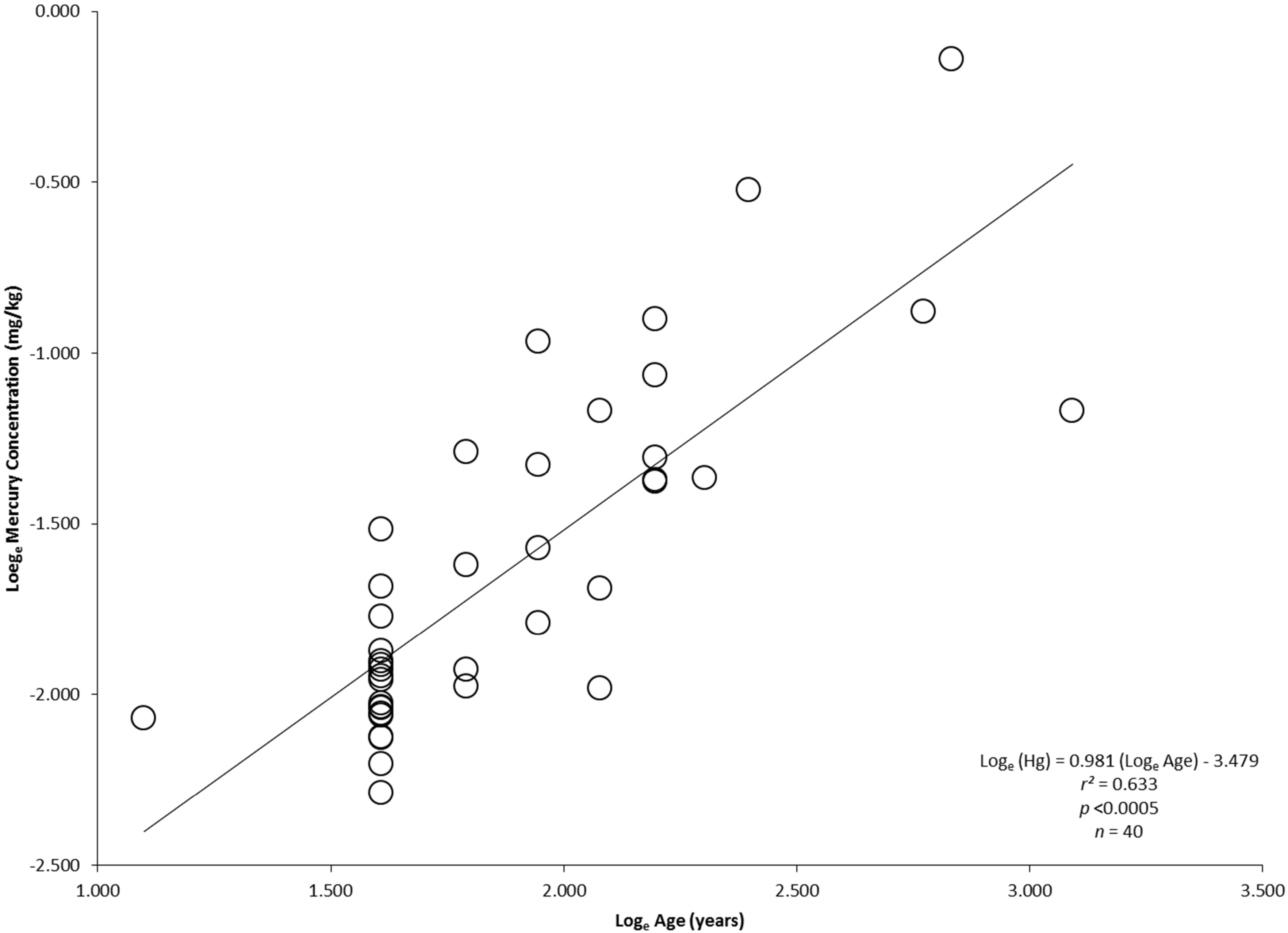


Figure 10. Length at age for striped bass collected from the Trinity River, Texas, 2012.

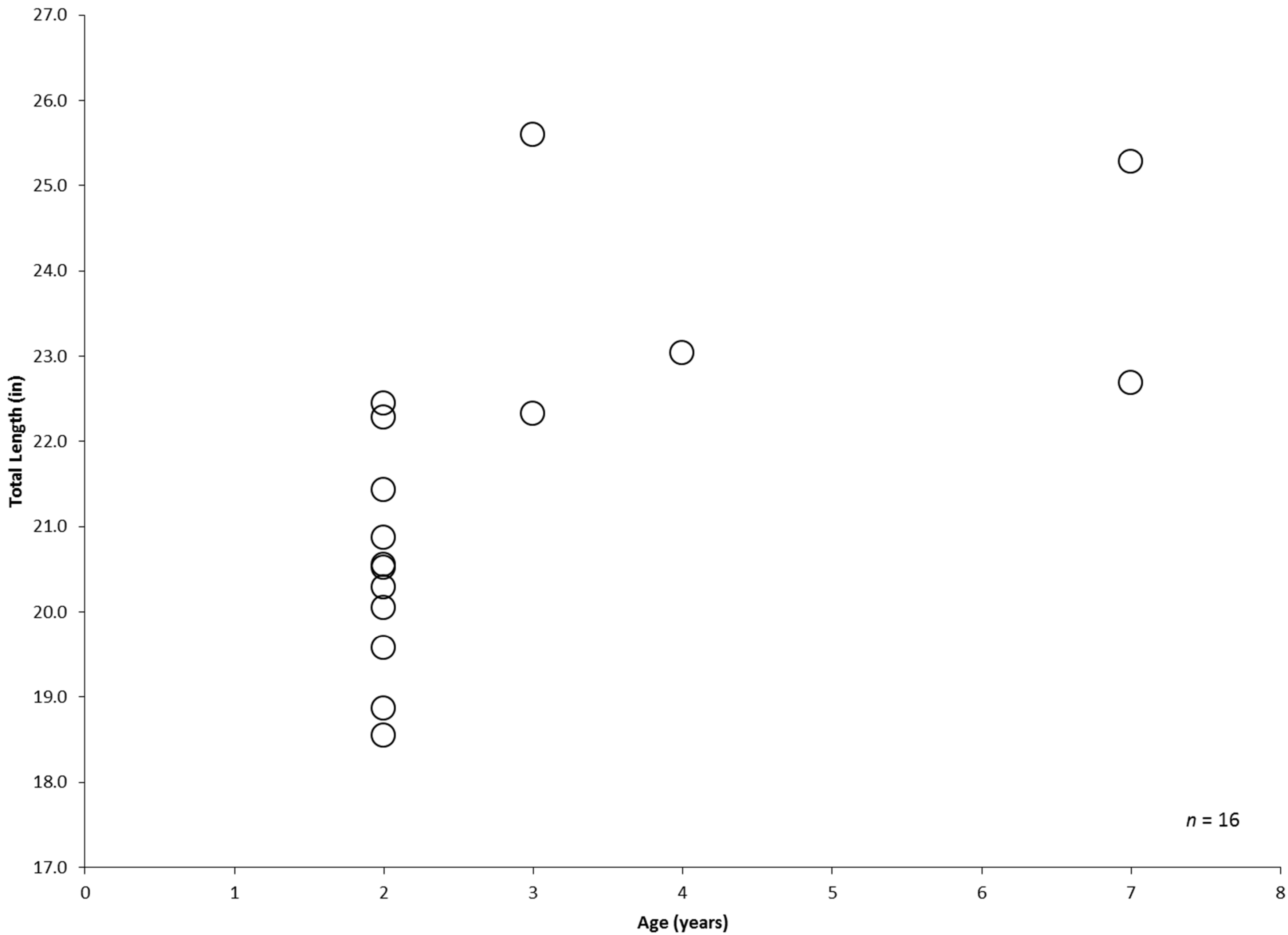


Figure 11. The relationship between mercury concentration and age for striped bass collected from the Trinity River, Texas, 2012.

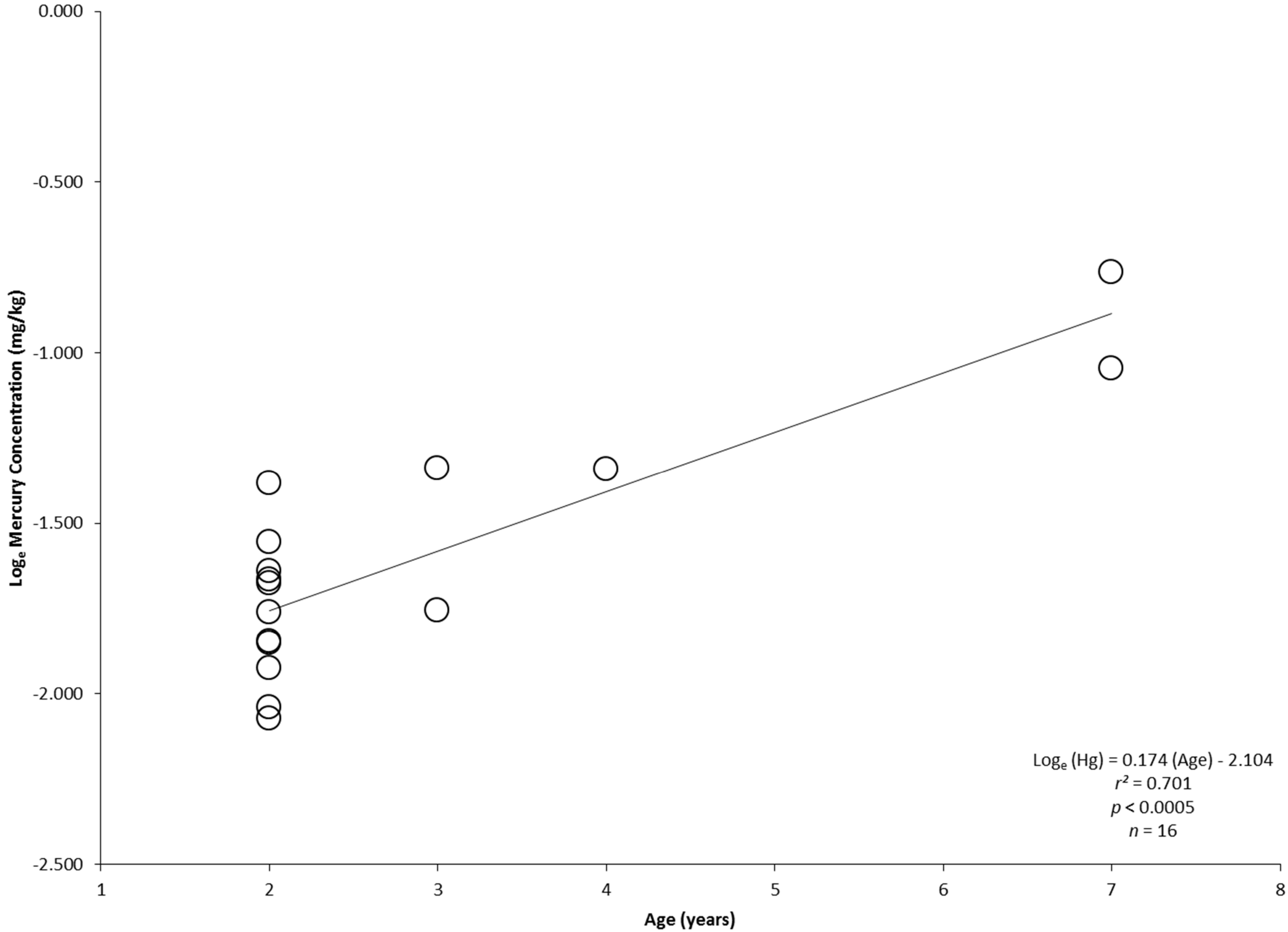


Figure 12. Length at age for white bass collected from the Trinity River, Texas, 2012–2013.

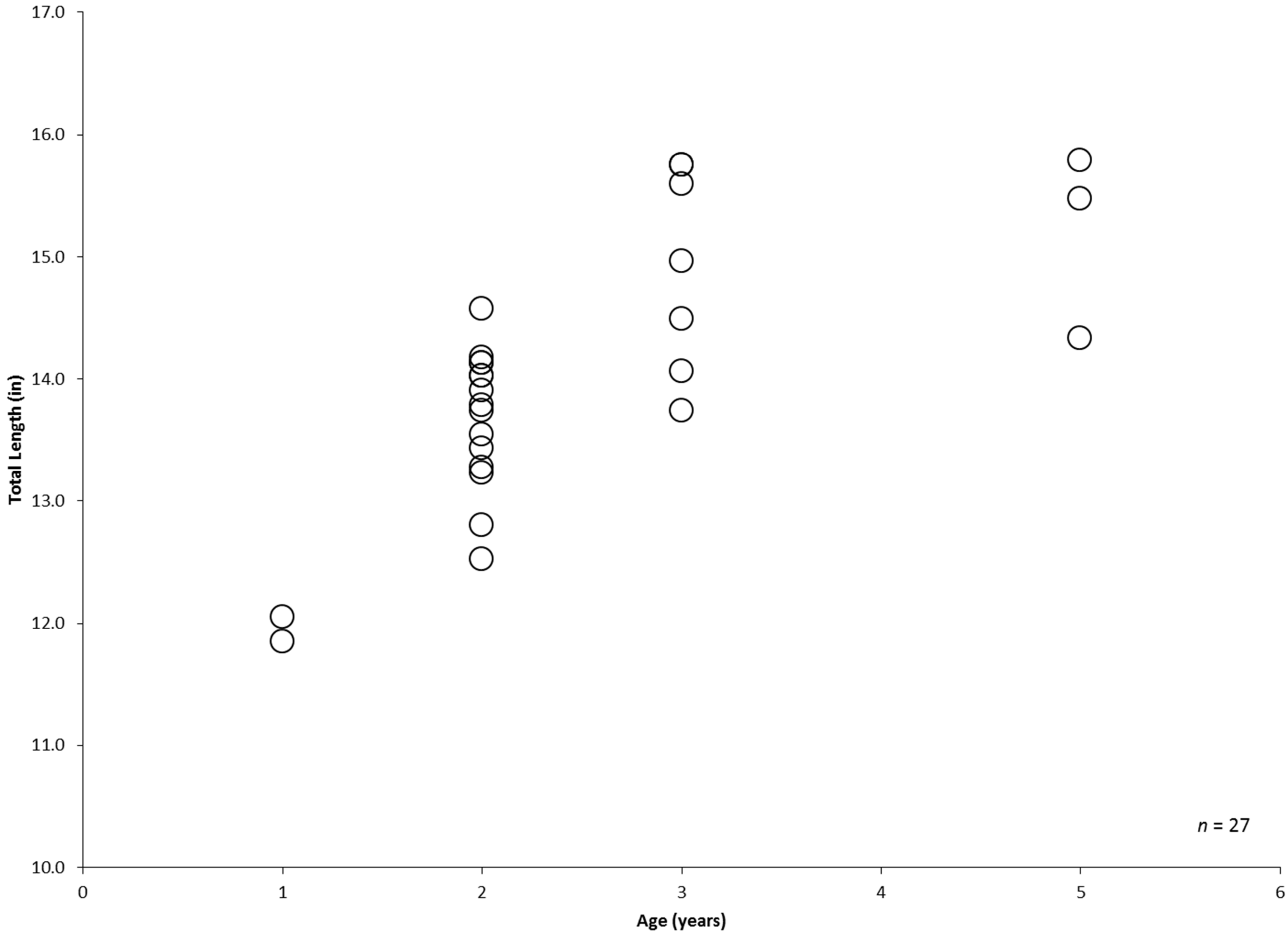


Figure 13. The relationship between PCB concentration and total length for fish collected from the Trinity River, Texas, 2012–2013.

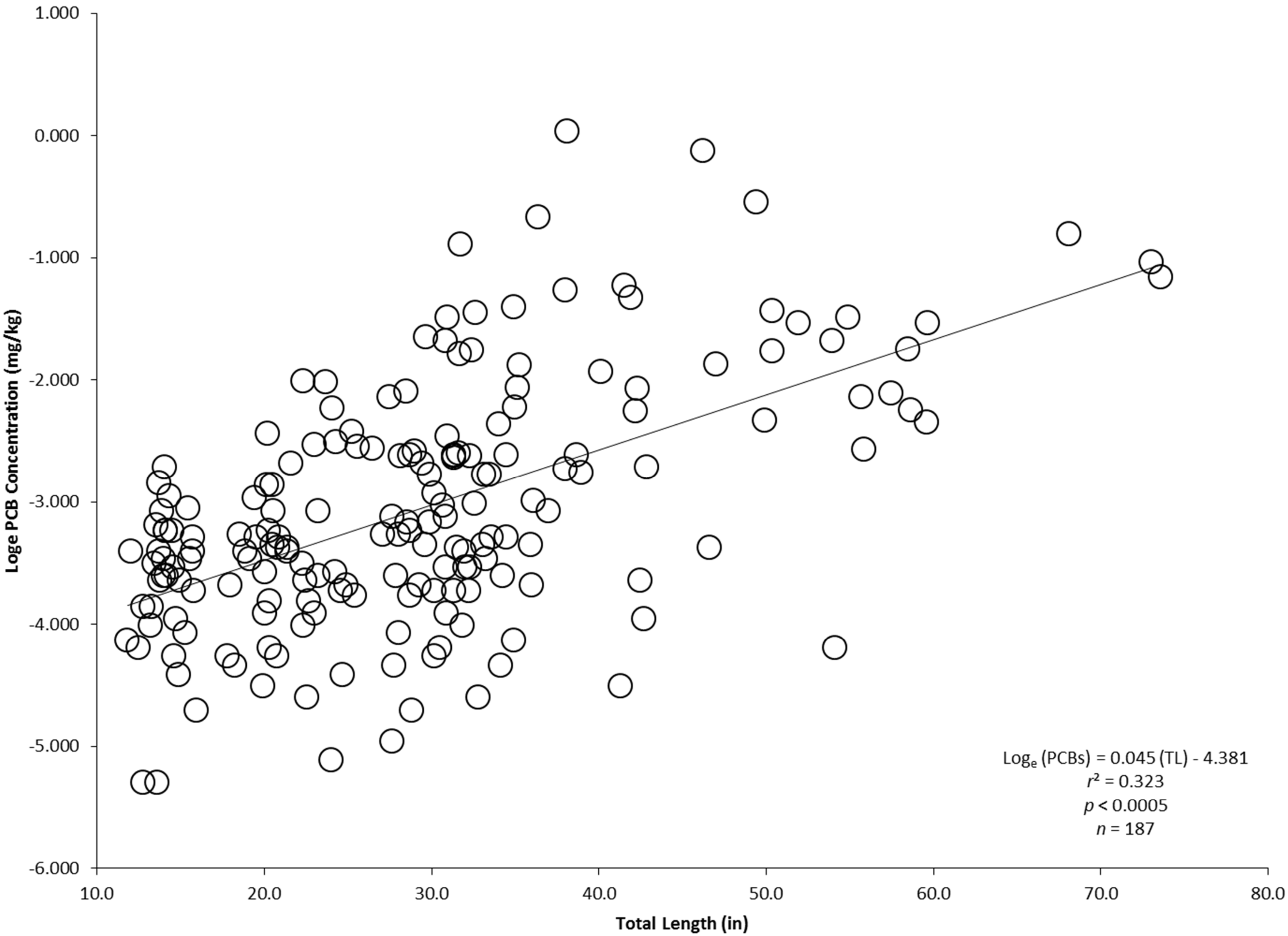


Figure 14. The relationship between PCB concentration and percent lipids for fish collected from the Trinity River, Texas, 2012–2013.

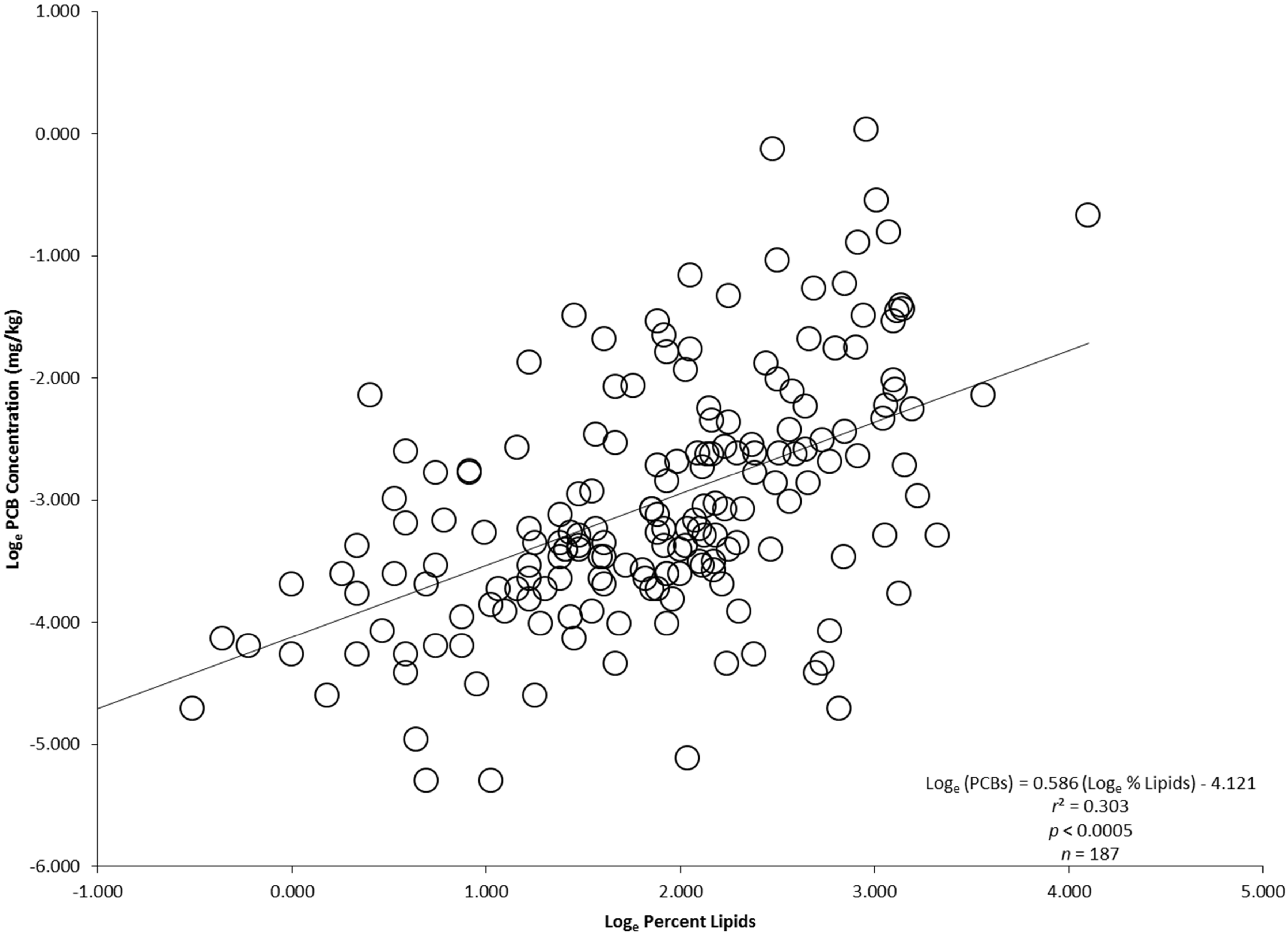


Figure 15. Mean Percent lipids and PCB concentration by species Trinity River, Texas, 2012–2013.

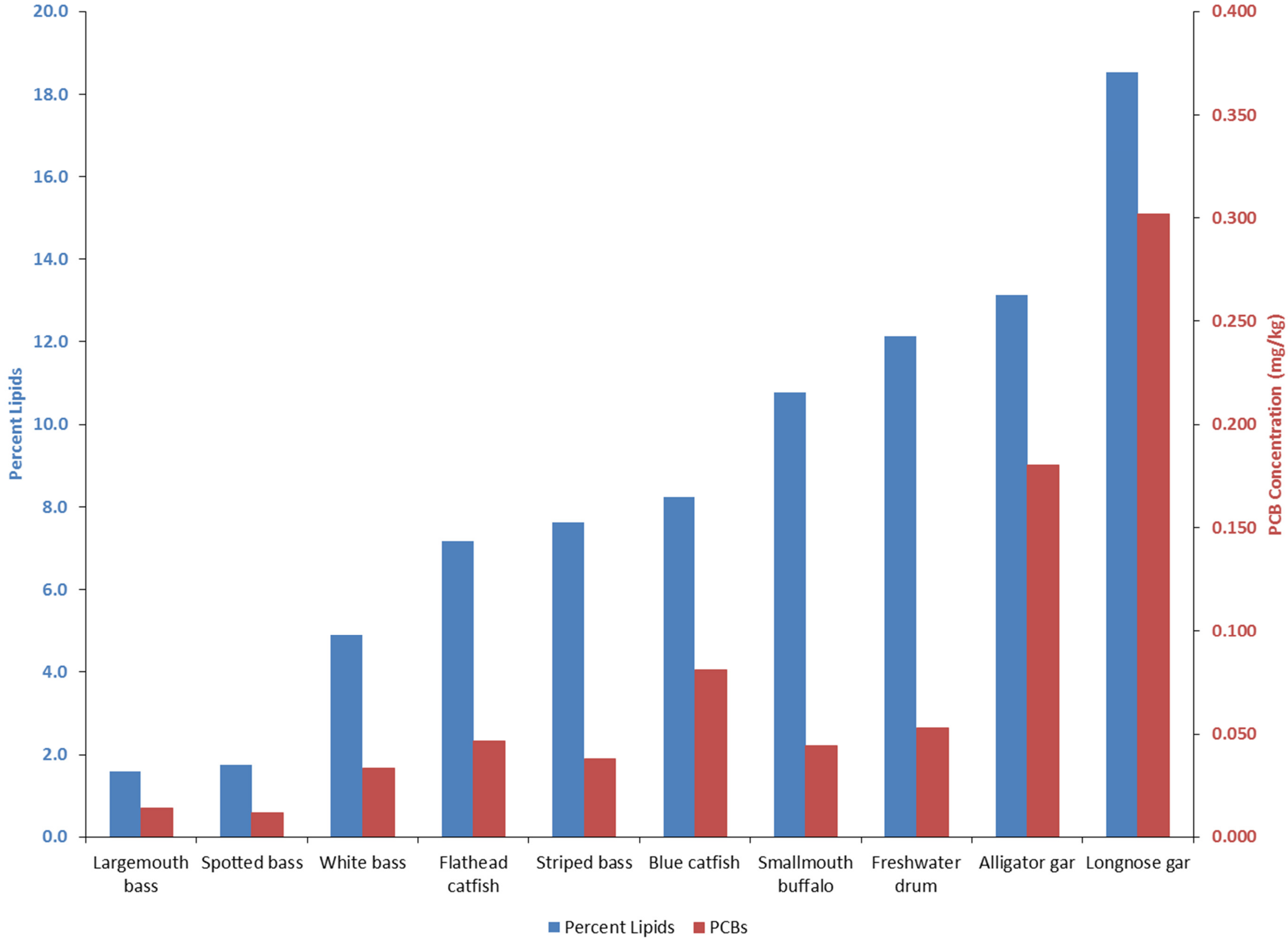


Figure 16. Mean Log_e PCBs (mg/kg, wet wt.) in fish by sample site collected from the Trinity River, Texas 2012–2013. The error bars denote the standard error of the mean.

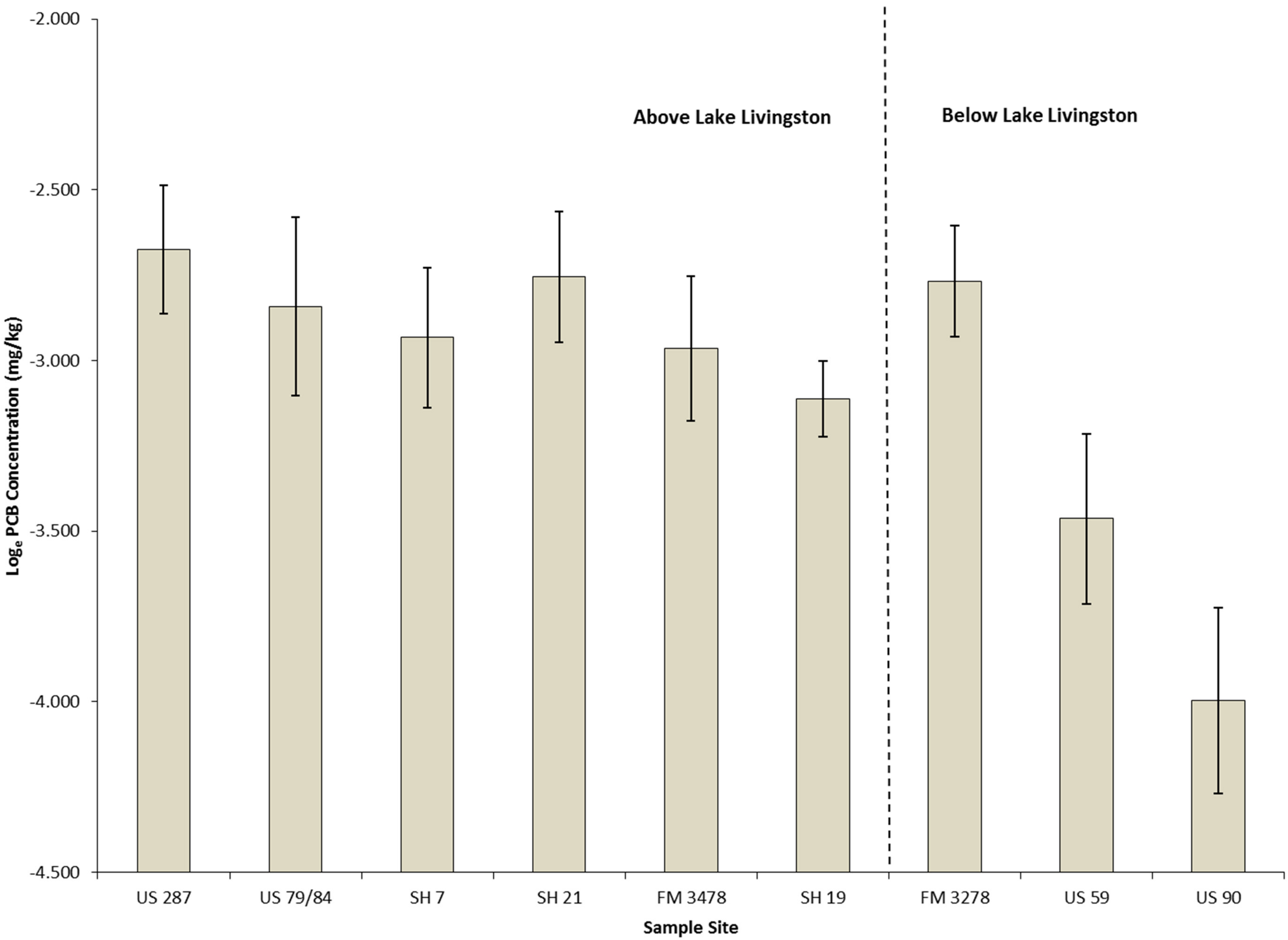


Figure 17. The relationship between PCB concentration and total length for alligator gar collected from the Trinity River, Texas, 2012.

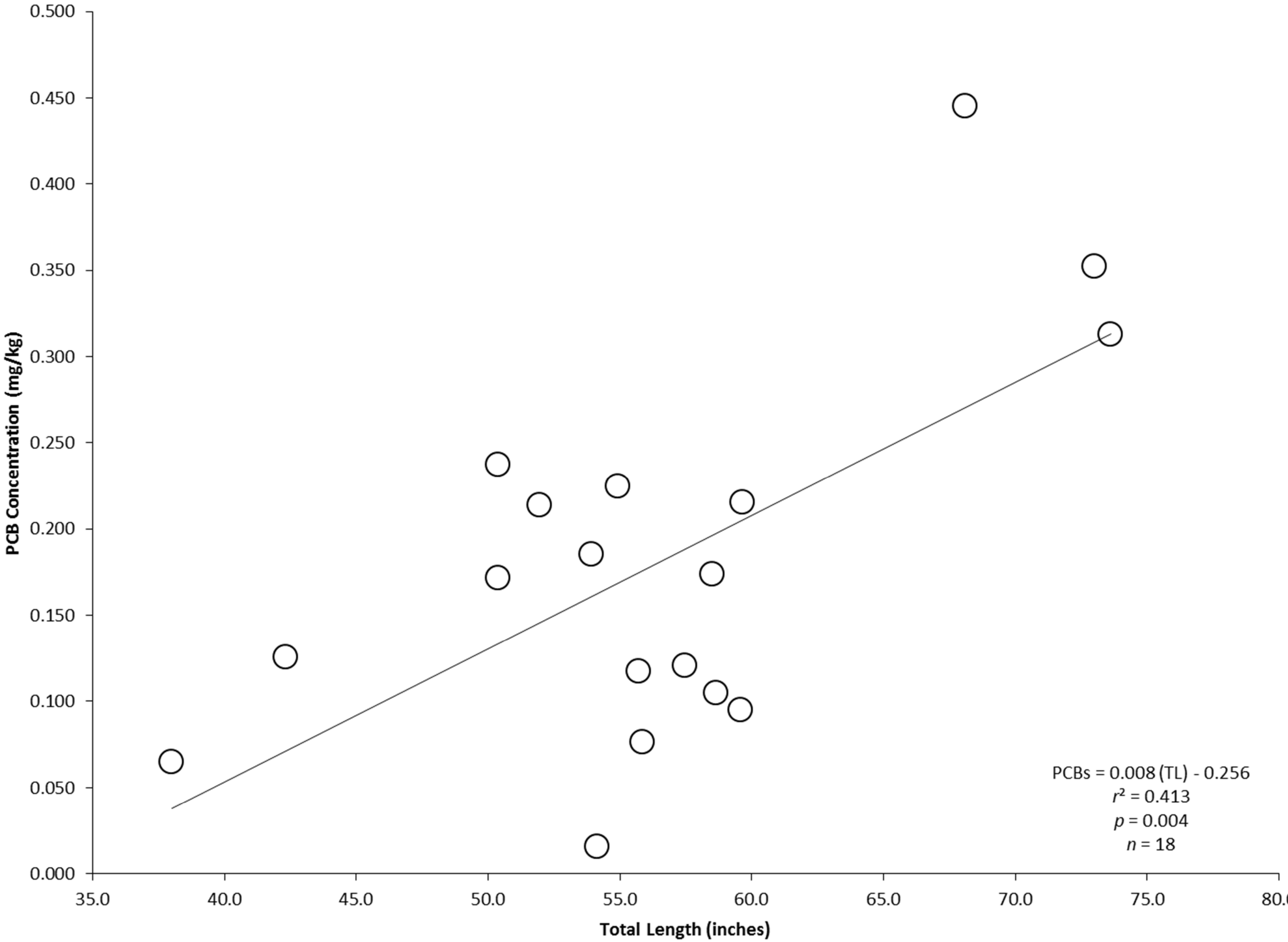


Figure 18. The relationship between PCB concentration and percent lipids for alligator gar collected from the Trinity River, Texas, 2012.

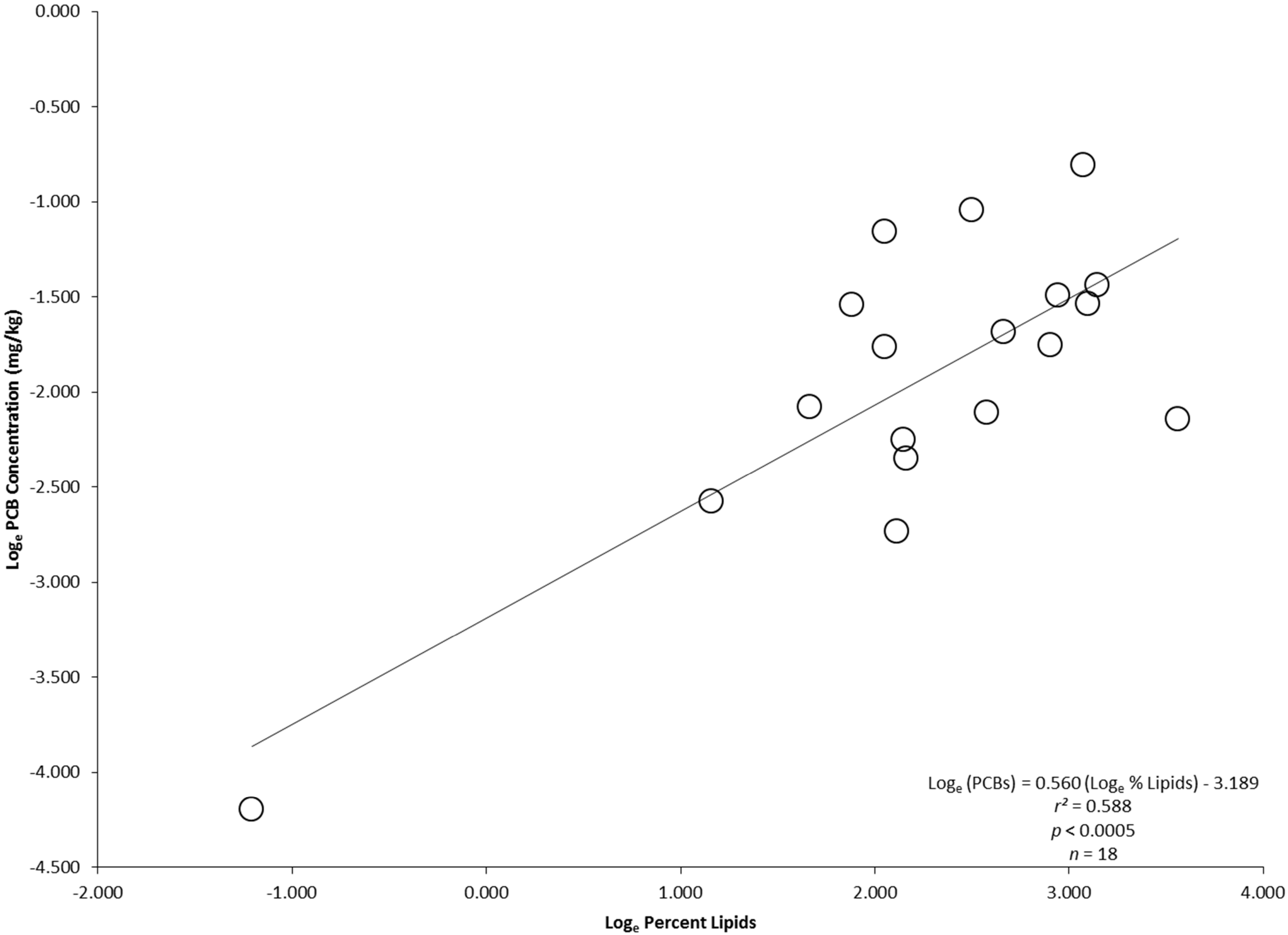


Figure 19. The relationship between PCB concentration and total length for blue catfish collected from the Trinity River, Texas, 2012.

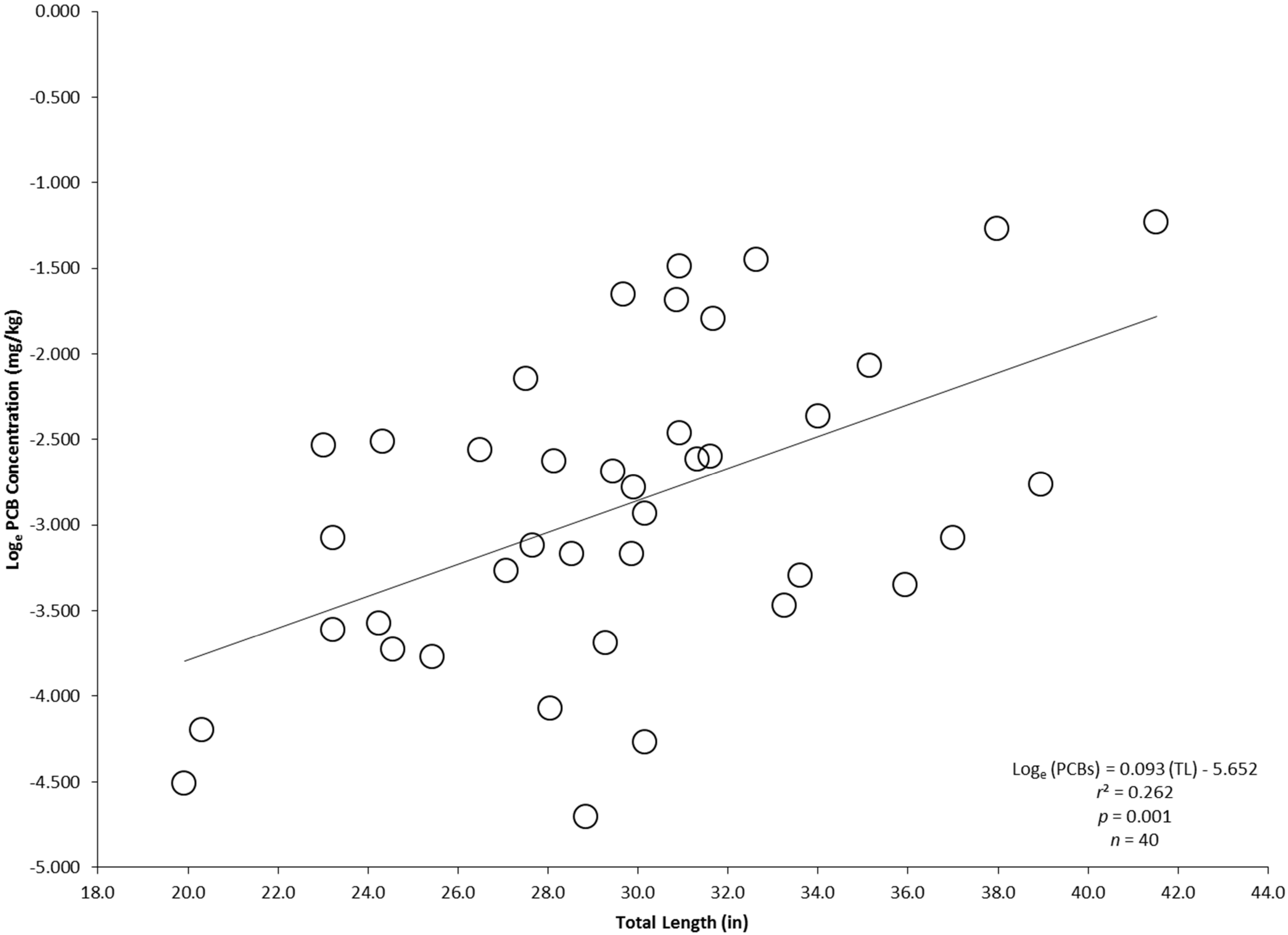


Figure 20. The relationship between PCB concentration and age for blue catfish collected from the Trinity River, Texas, 2012.

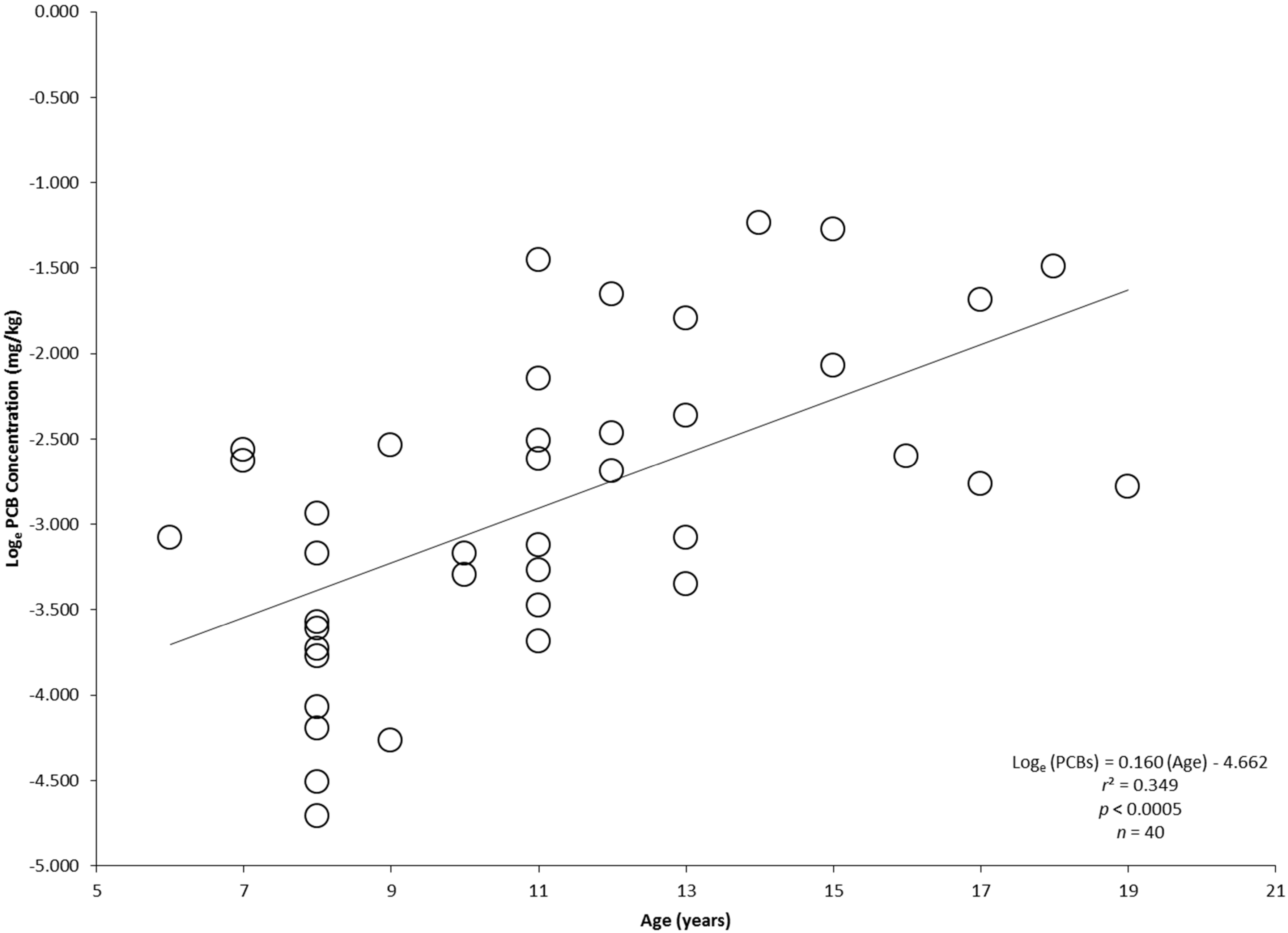


Figure 21. Means plot of Log_e PCBs (mg/kg, wet wt.) in blue catfish by sample site collected from the Trinity River, Texas 2012. The error bars denote the standard error of the mean.

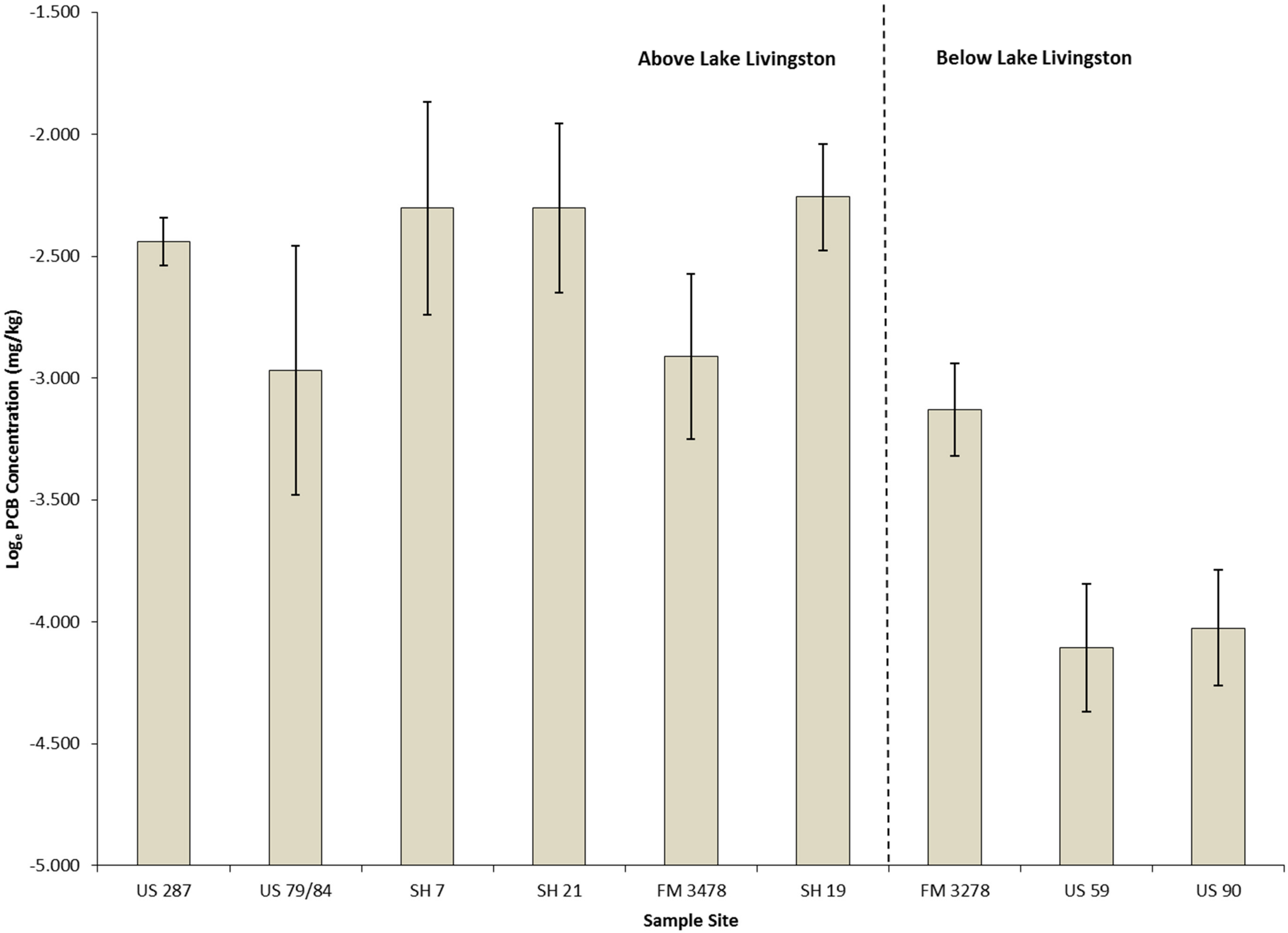


Figure 22. The relationship between PCB concentration and percent lipids for flathead catfish collected from the Trinity River, Texas, 2012.

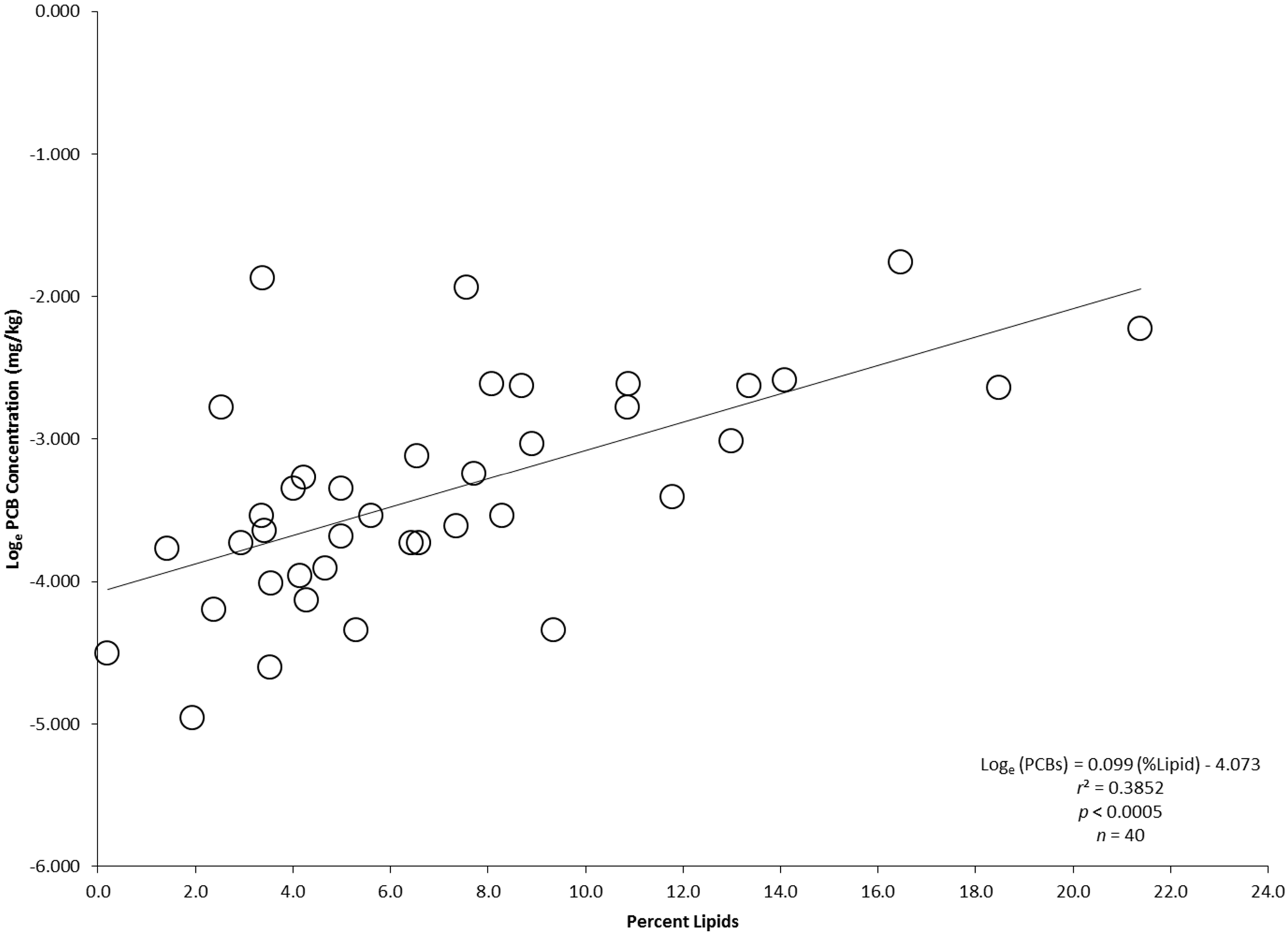


Figure 23. Mean Log$_e$ PCBs (mg/kg, wet wt.) in flathead catfish by sample site collected from the Trinity River, Texas 2012. The error bars denote the standard error of the mean.

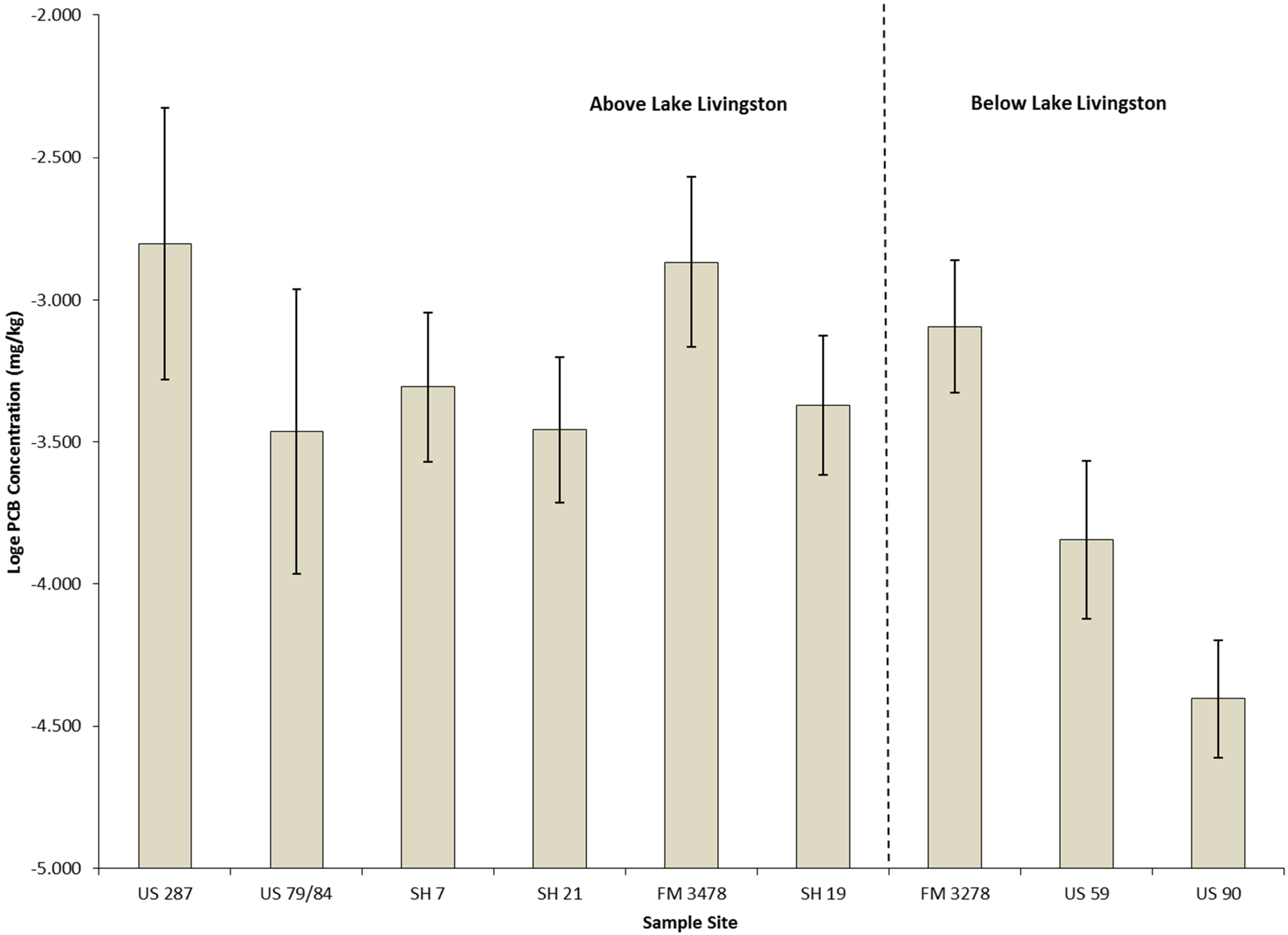


Figure 24. The relationship between PCB concentration and percent lipids for striped bass collected from the Trinity River, Texas, 2012.

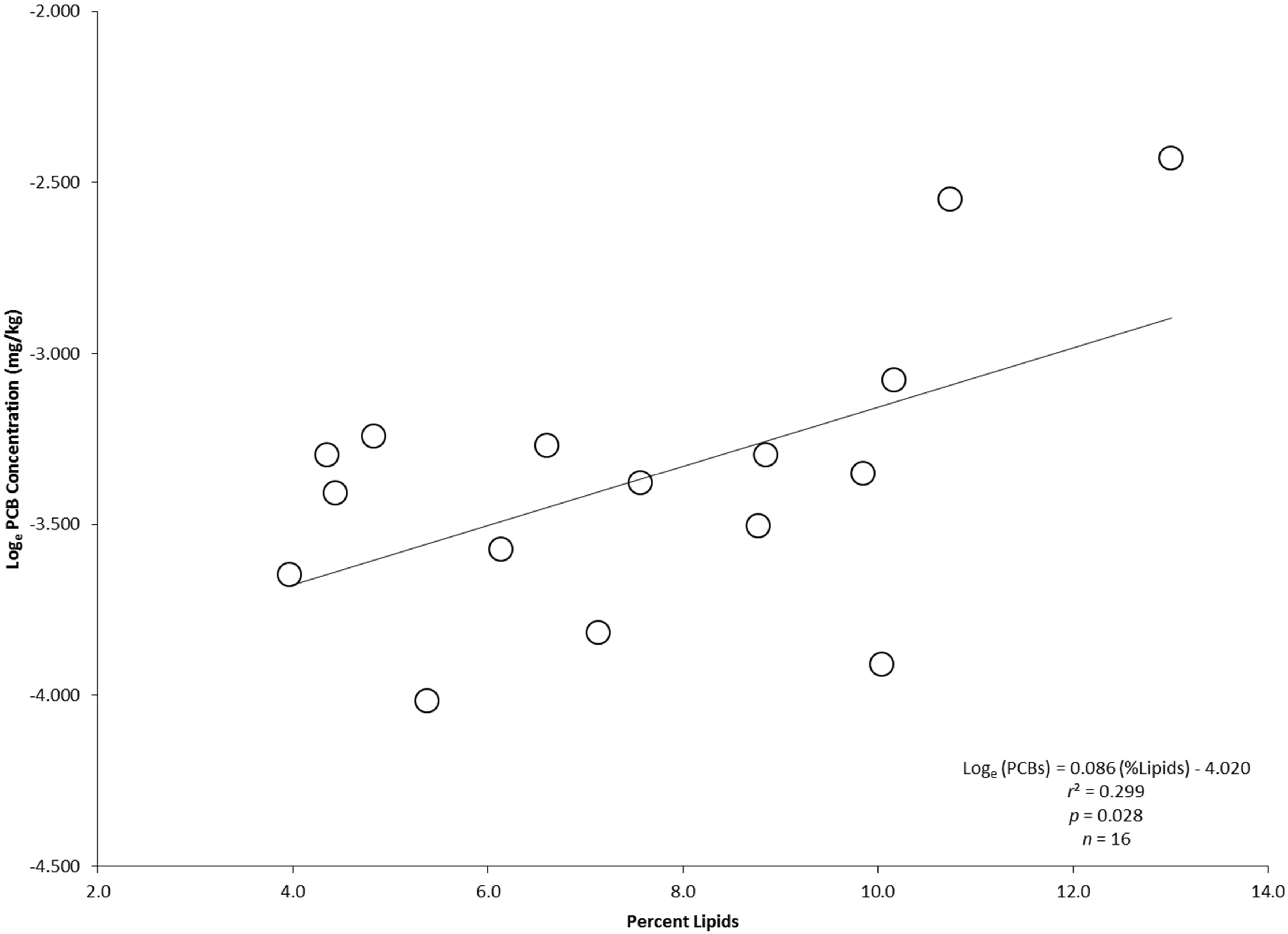


Figure 25. The relationship between PCB concentration and percent lipids for white bass collected from the Trinity River, Texas, 2012–2013.

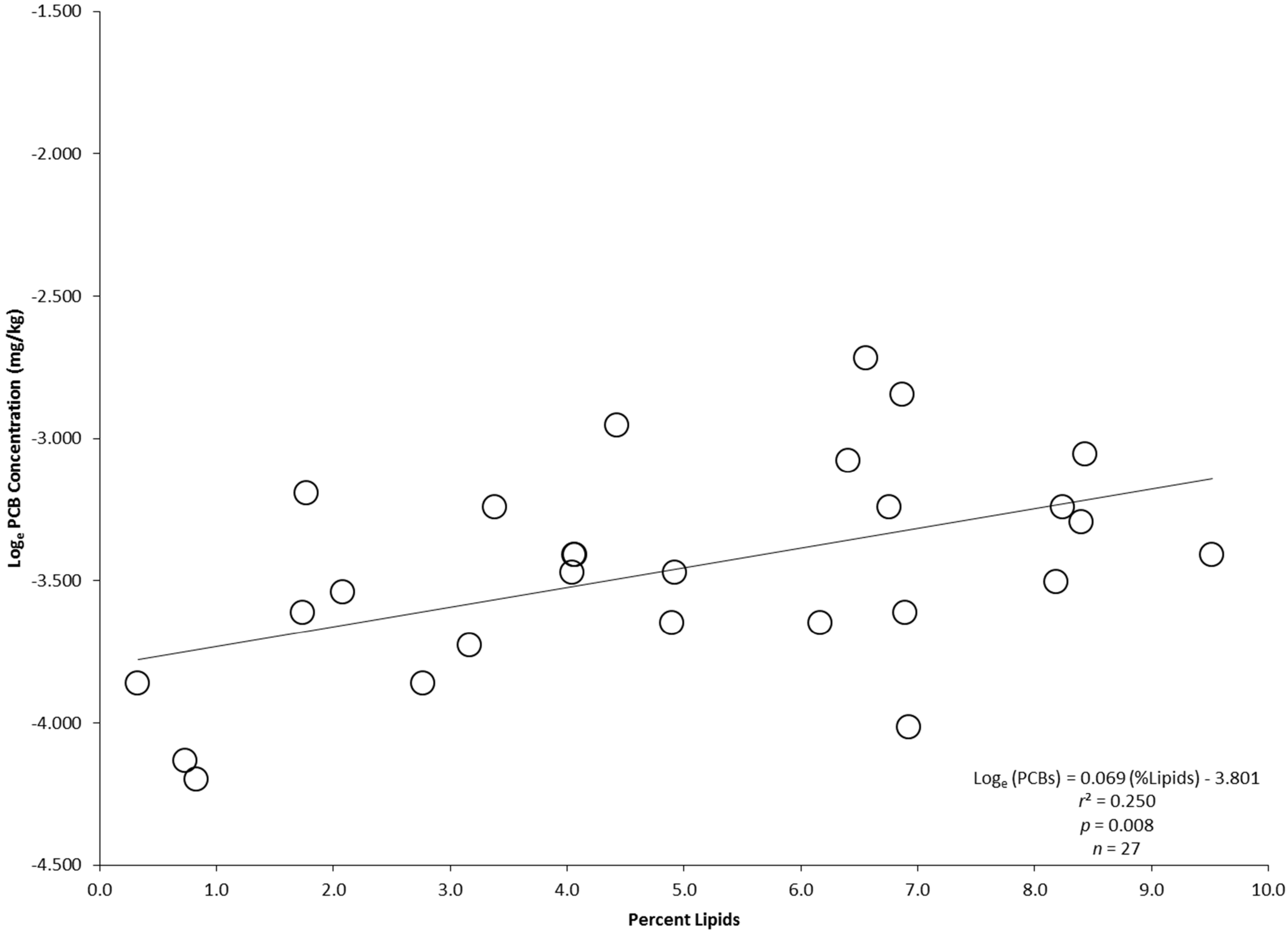


Figure 26. Mean PCDD/PCDF TEQs (pg/g, wet wt.) in fish by sample site collected from the Trinity River, Texas 2012–2013. The error bars denote the standard error of the mean.

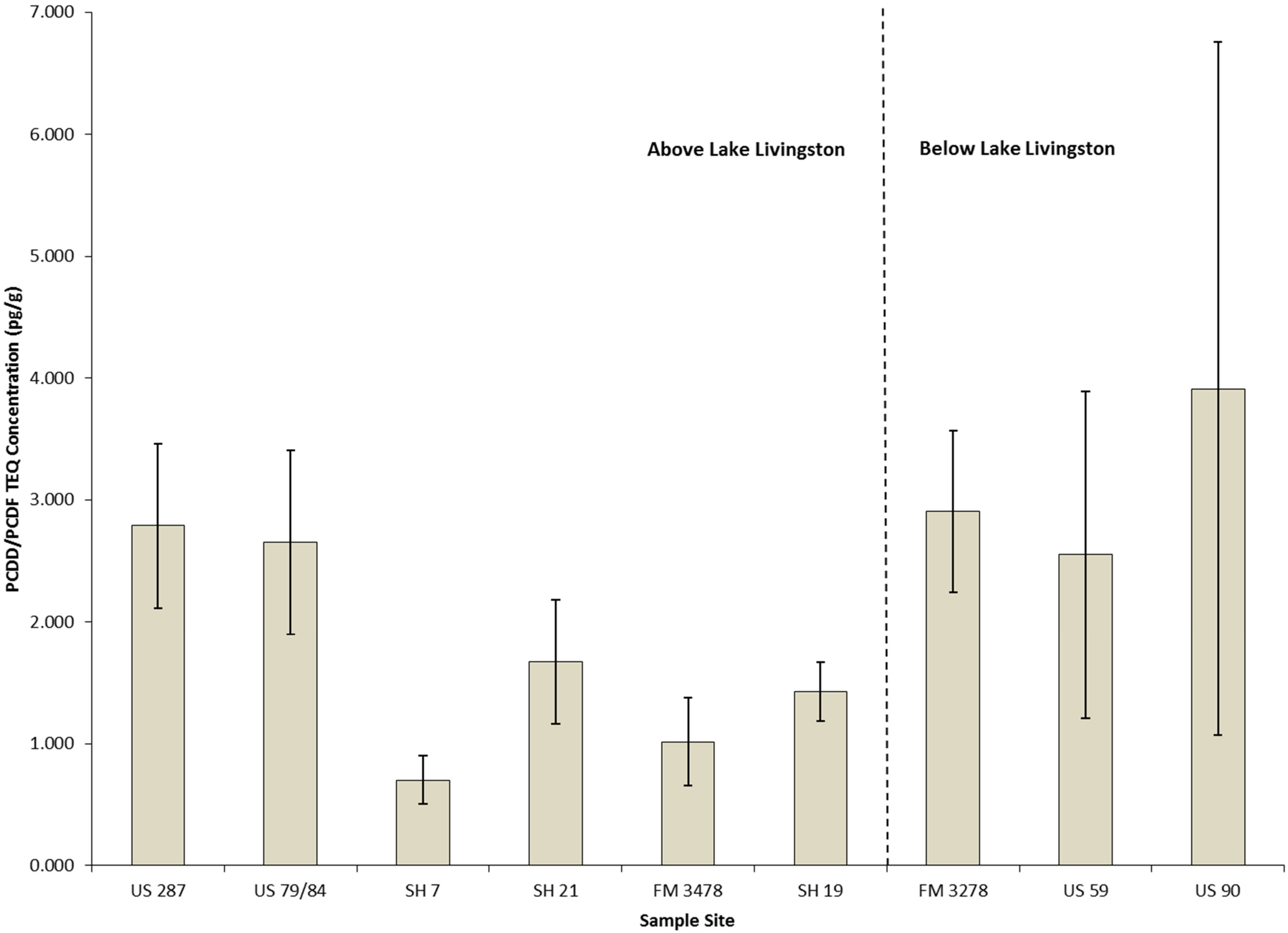


Figure 27. Mean PCDD/PCDF TEQs (pg/g, wet wt.) in blue catfish by sample site collected from the Trinity River, Texas 2012. The error bars denote the standard error of the mean.

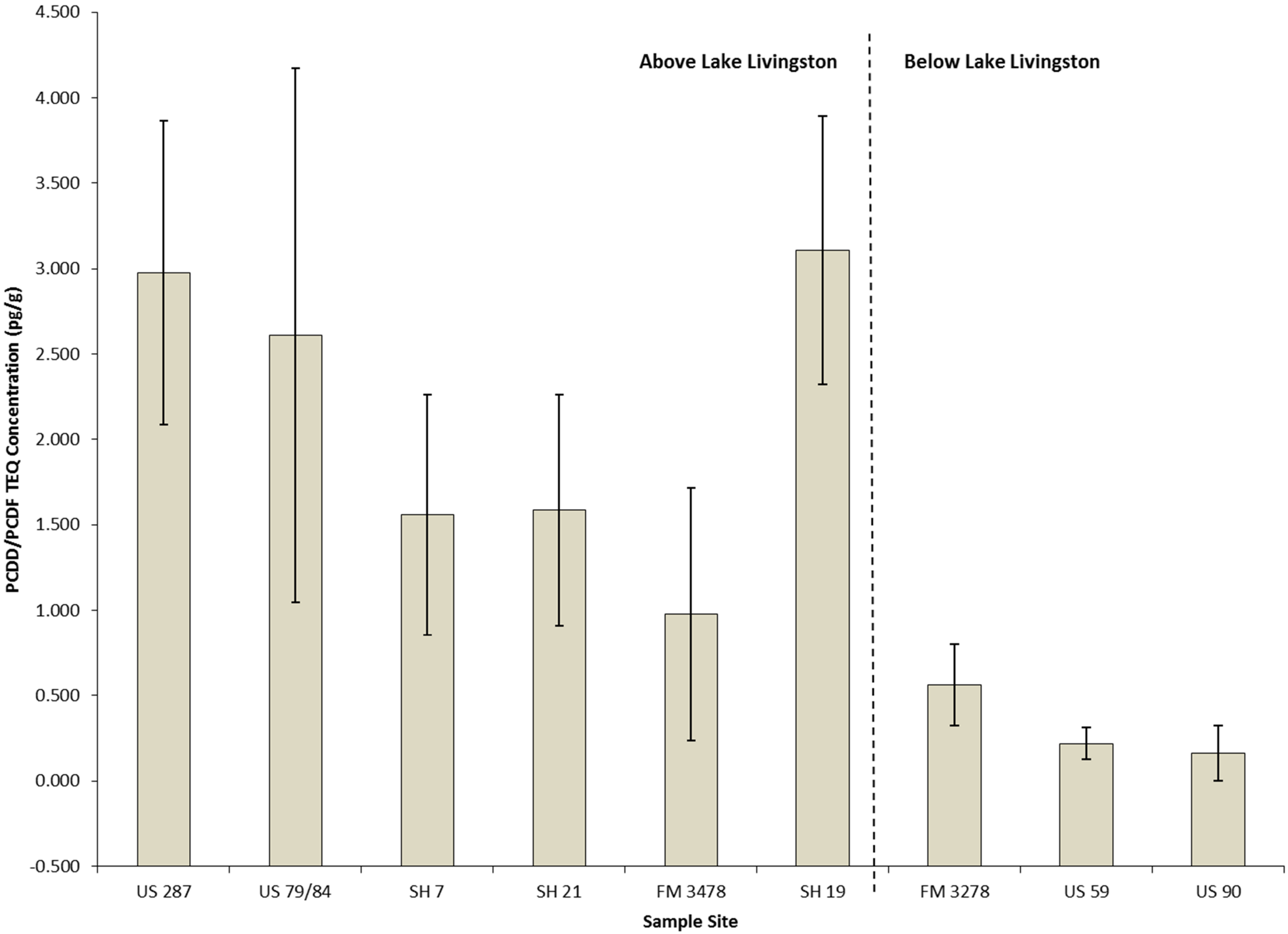
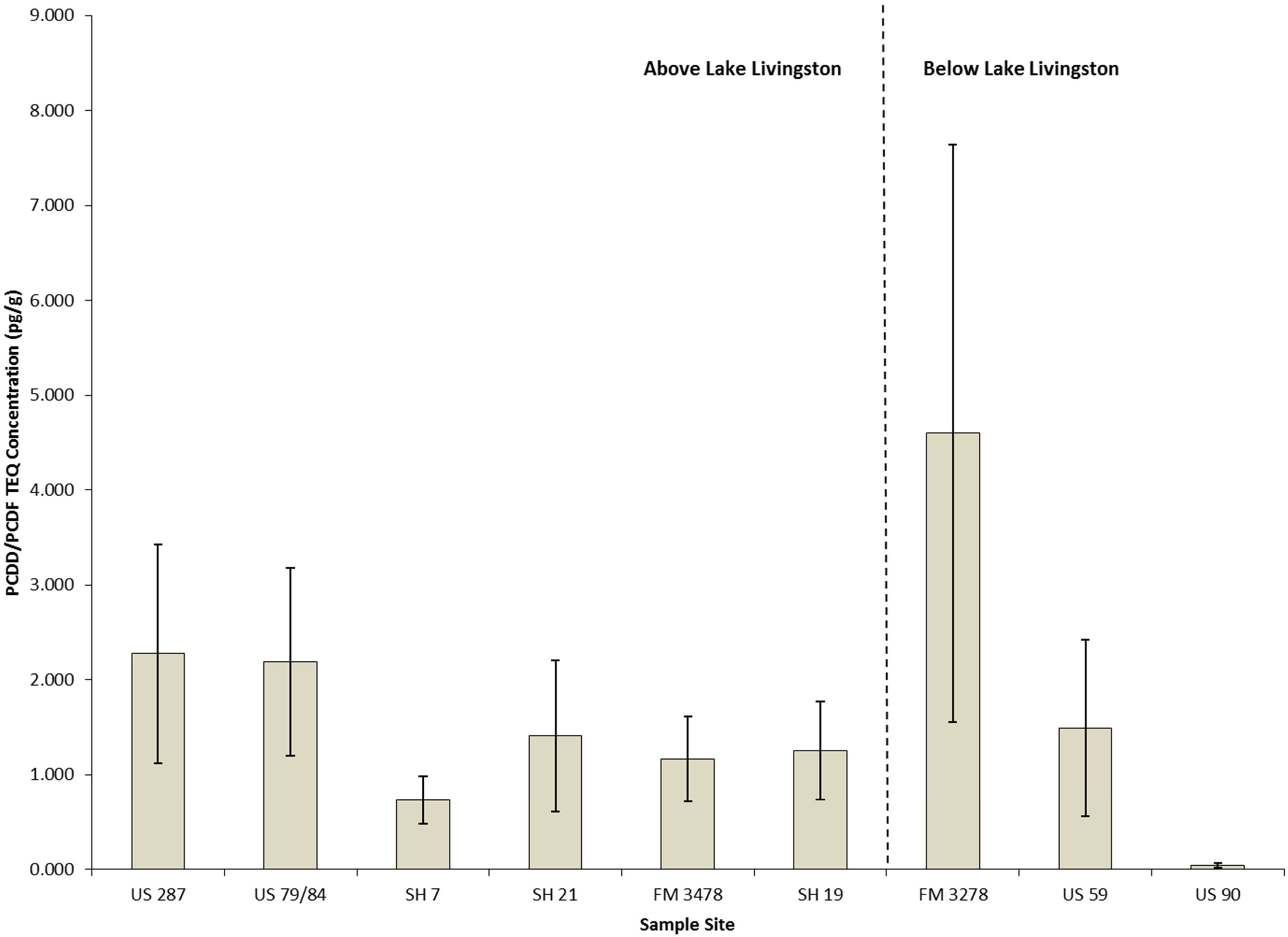


Figure 28. Mean PCDD/PCDF TEQs (pg/g, wet wt.) in flathead catfish by sample site collected from the Trinity River, Texas 2012. The error bars denote the standard error of the mean.



TABLES

Table 1. Fish samples collected from the Trinity River 2012–2013. Sample number, species, length, and weight recorded for each sample.

Sample Number	Species	Length (mm)	Weight (g)
Site 1 Trinity River at US 287			
TRR1	Flathead catfish	820	7799
TRR4	Flathead catfish	915	10750
TRR5	Flathead catfish	889	10000
TRR7	Flathead catfish	823	6280
TRR8	Blue catfish	618	2341
TRR9	Blue catfish	673	3595
TRR10	Blue catfish	699	3286
TRR13	Blue catfish	585	2091
TRR18	Longnose gar	917	1898
TRR19	Longnose gar	800	1297
TRR20	Smallmouth buffalo	493	2265
TRR230	Alligator gar	1280	N/A
Site 2 Trinity River at US 79			
TRR21	Flathead catfish	1050	13250
TRR22	Flathead catfish	887	10500
TRR26	Flathead catfish	737	4372
TRR27	Flathead catfish	730	5336
TRR28	Blue catfish	786	4824
TRR29	Blue catfish	616	2354
TRR32	Blue catfish	624	2248
TRR34	Blue catfish	590	1985
TRR37	Smallmouth buffalo	516	2828
TRR38	Longnose gar	887	2416
TRR39	Longnose gar	896	1960
TRR40	Longnose gar	983	2763
TRR231	Alligator gar	1514	22000
TRR232	Alligator gar	1486	20500
TRR236	Alligator gar	1375	13000
TRR237	Alligator gar	1370	17000
Site 3 Trinity River at SH 7			
TRR62	Smallmouth buffalo	567	3115
TRR63	Longnose gar	1072	4750
TRR65	Longnose gar	807	1967
TRR66	Longnose gar	876	2740
TRR69	Striped bass	479	480
TRR70	Striped bass	567	2087

Table 1. cont. Fish samples collected from the Trinity River 2012–2013. Sample number, species, length, and weight recorded for each sample.			
Sample Number	**Species**	**Length (mm)**	**Weight (g)**
Site 3 Trinity River at SH 7 (cont.)			
TRR71	Striped bass	497	1378
TRR72	Striped bass	471	1135
TRR73	Striped bass	576	2140
TRR74	Striped bass	585	2390
TRR76	Flathead catfish	784	7030
TRR79	Flathead catfish	797	7263
TRR81	Flathead catfish	796	7221
TRR82	Flathead catfish	766	5745
TRR84	Blue catfish	766	4267
TRR86	Blue catfish	829	8084
TRR87	Blue catfish	754	5206
TRR89	Blue catfish	759	5086
TRR91	White bass	353	526
Site 4 Trinity River at SH 21			
TRR41	Flathead catfish	730	5211
TRR42	Flathead catfish	775	5552
TRR45	Flathead catfish	779	5769
TRR47	Flathead catfish	840	9000
TRR48	Blue catfish	725	4338
TRR50	Blue catfish	748	5547
TRR51	Blue catfish	805	6102
TRR52	Blue catfish	715	7758
TRR54	Blue catfish	1055	14500
TRR55	White bass	306	365
TRR56	Smallmouth buffalo	709	4994
TRR57	Alligator gar	965	5255
TRR229	Hybrid LNG-ALG	1185	7250
TRR233	Alligator gar	1075	8250
TRR234	Alligator gar	1320	14750
TRR235	Alligator gar	1419	19000
TRR229	Hybrid LNG-ALG	1185	7250
Site 5 Trinity River at 3478			
TRR92	Flathead catfish	1195	24000
TRR93	Flathead catfish	842	8365
TRR95	Flathead catfish	876	10400
TRR96	Flathead catfish	783	6278
TRR98	Flathead catfish	812	6856
TRR100	Blue catfish	703	3848

Table 1 cont. Fish samples collected from the Trinity River 2012–2013. Sample number, species, length, and weight recorded for each sample.			
Sample Number	**Species**	**Length (mm)**	**Weight (g)**
Site 5 Trinity River at 3478 (cont.)			
TRR101	Blue catfish	760	4956
TRR102	Blue catfish	784	6002
TRR107	Blue catfish	744	4912
TRR109	Blue catfish	688	3722
TRR111	Smallmouth buffalo	509	2136
TRR114	Flathead catfish	785	6157
TRR115	Flathead catfish	1020	15250
Site 6 Trinity River at SH 19			
TRR117	Smallmouth buffalo	512	2367
TRR121	Blue catfish	990	12750
TRR122	Blue catfish	965	12500
TRR123	Blue catfish	893	11000
TRR124	Blue catfish	803	5749
TRR127	Flathead catfish	1080	20500
TRR128	Flathead catfish	827	7818
TRR130	Flathead catfish	809	6432
TRR131	Flathead catfish	813	7852
TRR134	Flathead catfish	796	6979
TRR135	Blue catfish	786	5477
TRR138	Blue catfish	864	9750
LLV139	White bass	360	634
LLV140	White bass	400	847
LLV143	White bass	380	809
LLV144	White bass	400	860
LLV146	White bass	359	625
LLV147	White bass	396	885
LLV148	White bass	368	588
LLV149	White bass	356	654
LLV150	White bass	325	453
Site 7 Trinity River at FM 3278			
TRR139	Freshwater drum	602	3720
TRR140	Smallmouth buffalo	724	6128
TRR141	Striped bass	570	1738
TRR142	Striped bass	522	1380
TRR143	Striped bass	566	1663
TRR144	Striped bass	515	1386
TRR145	Striped bass	521	1433

Table 1 cont. Fish samples collected from the Trinity River 2012–2013. Sample number, species, length, and weight recorded for each sample.

Sample Number	Species	Length (mm)	Weight (g)
Site 7 Trinity River at FM 3278 (cont.)			
TRR146	Striped bass	642	3077
TRR147	Spotted bass	374	768
TRR150	Longnose gar	1065	7250
TRR151	Longnose gar	1255	10000
TRR152	Alligator gar	1280	13500
TRR153	Alligator gar	1460	22500
TRR154	Alligator gar	1515	20250
TRR155	Alligator gar	1870	N/A
TRR156	Alligator gar	1730	N/A
TRR157	Alligator gar	1395	16000
TRR158	Alligator gar	1490	20750
TRR159	Alligator gar	1855	N/A
TRR160	Blue catfish	845	5708
TRR161	Blue catfish	796	5744
TRR162	Blue catfish	940	15250
TRR163	Flathead catfish	870	7582
TRR164	Flathead catfish	851	7250
TRR165	Flathead catfish	752	4810
TRR167	Largemouth bass	528	2538
TRR168	Largemouth bass	453	1334
TRR169	Freshwater drum	487	1735
TRR170	Freshwater drum	457	1315
TRR171	Freshwater drum	529	2207
TRR172	Hybrid striped bass	612	2671
TRR173	Striped bass	650	2522
TRR174	Striped bass	544	1510
TRR175	Striped bass	530	1337
TRR176	Striped bass	509	1219
TRR177	White bass	318	318
TRR178	White bass	356	400
TRR182	Blue catfish	913	10750
TRR185	Flathead catfish	821	6750
Site 8 Trinity River at US 59			
TRR186	Smallmouth buffalo	633	4444
TRR187	Flathead catfish	819	6836

Table 1 cont. Fish samples collected from the Trinity River 2012–2013. Sample number, species, length, and weight recorded for each sample.			
Sample Number	**Species**	**Length (mm)**	**Weight (g)**
Site 8 Trinity River at US 59 (cont.)			
TRR188	Flathead catfish	712	3753
TRR189	Flathead catfish	730	4756
TRR190	Flathead catfish	834	6611
TRR191	Blue catfish	506	1238
TRR192	Blue catfish	516	1406
TRR193	Blue catfish	590	2465
TRR194	Freshwater drum	573	2718
TRR195	Freshwater drum	544	3087
TRR196	Freshwater drum	549	3335
TRR197	Freshwater drum	514	2316
TRR198	Freshwater drum	521	2762
TRR199	White bass	349	468
TRR200	White bass	370	544
TRR201	White bass	301	314
TRR202	White bass	337	340
TRR203	White bass	344	375
TRR204	Spotted bass	378	938
TRR205	Spotted bass	371	765
TRR206	Spotted bass	406	1098
TRR207	Spotted bass	388	892
TRR208	Longnose gar	969	3379
TRR209	Longnose gar	1174	6431
Site 9 Trinity River at US 90			
TRR210	Longnose gar	1269	8750
TRR211	Flathead catfish	1085	21000
TRR212	Flathead catfish	703	4233
TRR213	Blue catfish	766	5892
TRR214	Blue catfish	854	7510
TRR215	Blue catfish	733	4062
TRR216	Blue catfish	646	2983
TRR217	White bass	336	474
TRR218	Spotted bass	324	525
TRR219	Spotted bass	346	599
TRR220	Smallmouth buffalo	628	4346
TRR221	Smallmouth buffalo	464	1795
TRR222	Smallmouth buffalo	610	3900

Table 1 cont. Fish samples collected from the Trinity River 2012–2013. Sample number, species, length, and weight recorded for each sample.			
Sample Number	**Species**	**Length (mm)**	**Weight (g)**
Site 9 Trinity River at US 90 (cont.)			
TRR223	Flathead catfish	867	8346
TRR224	Flathead catfish	706	4608
TRR225	Blue catfish	713	4118
TRR226	Longnose gar	925	2942
TRR227	Longnose gar	1090	4659
TRR223	Flathead catfish	867	8346
TRR224	Flathead catfish	706	4608
TRR225	Blue catfish	713	4118
TRR226	Longnose gar	925	2942
TRR227	Longnose gar	1090	4659

Table 2.1. Arsenic (mg/kg) in fish collected from the Trinity River, 2012–2013.

Species	Number Detected/ Number Tested	Total Arsenic Mean ± S.D. (Min-Max)	Inorganic Arsenic Mean[k]	HAC Value (nonca) and HAC Value (ca; mg/kg)[l]	Basis for Comparison Value
Alligator gar	2/2	0.416±0.078 (0.361-0.471)	0.041	0.700	EPA Chronic Oral RfD for Inorganic Arsenic — 0.0003 mg/kg–day
Flathead catfish	9/9	0.217±0.146 (BDL-0.471)	0.022	0.363	EPA Oral Slope Factor for Inorganic Arsenic — 1.5 per mg/kg–day
All fish combined	11/11	0.253±0.156 (BDL-0.471)	0.025		

[k] *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.*
[l] *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. Inorganic contaminants (mg/kg) in fish collected from the Trinity River, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Cadmium				
Alligator gar	2/2	0.187±0.028 (0.167-0.207)	0.233	ATSDR Chronic Oral MRL— 0.0001 mg/kg–day
Flathead catfish	9/9	0.098±0.068 (BDL-0.169)		
All fish combined	11/11	0.114±0.071 (BDL-0.207)		
Copper				
Alligator gar	2/2	0.080±0.024 (0.063-0.097)	334	Based on the Tolerable Upper Intake Level (UL) — 0.143 mg/kg–day[m]
Flathead catfish	9/9	0.145±0.050 (0.086-0.214)		
All fish combined	11/11	0.134±0.052 (0.063-0.214)		
Lead				
Alligator gar	2/2	0.053±0.035 (0.028-0.078)	N/A	N/A
Flathead catfish	6/9	0.022±0.010 (ND-0.035)		
All fish combined	8/11	0.027±0.019 (ND-0.078)		
Selenium				
Alligator gar	2/2	1.199±0.140 (1.100-1.298)	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)[n, 53]
Flathead catfish	9/9	0.797±0.443 (0.214-1.614)		
All fish combined	11/11	0.870±0.430 (0.214-1.614)		
Zinc				
Alligator gar	2/2	3.095±0.207 (2.948-3.241)	700	EPA Chronic Oral RfD — 0.3 mg/kg–day
Flathead catfish	9/9	4.450±0.686 (3.523-5.672)		
All fish combined	11/11	4.204±0.826 (2.948-5.672)		

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

[n] 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 2.3. Mercury (mg/kg) in fish collected from the Trinity River by sample site, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Site 1 Trinity River at US 287				
Alligator gar	1/1	0.290	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Blue catfish	4/4	0.242± 0.145 (0.120-0.444)		
Flathead catfish	4/4	0.175±0.059 (0.119-0.254)		
Longnose gar	2/2	0.277±0.016 (0.266-0.288)		
Smallmouth buffalo	1/1	0.052		
All fish combined	12/12	0.214±0.106 (0.052-0.444)		
Site 2 Trinity River at US 79				
Alligator gar	4/4	0.307±0.132 (0.203-0.500)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Blue catfish	4/4	0.228±0.233 (0.091-0.576)		
Flathead catfish	4/4	0.186±0.084 (0.127-0.310)		
Longnose gar	3/3	0.396±0.052 (0.337-0.430)		
Smallmouth buffalo	1/1	0.331		
All fish combined	16/16	0.275±0.149 (0.091-0.576)		
Site 3 Trinity River at SH 7				
Blue catfish	4/4	0.230±0.136 (0.152-0.433)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Flathead catfish	4/4	0.200±0.097 (0.110-0.311)		
Longnose gar	3/3	0.203±0.099 (0.127-0.315)		
Smallmouth buffalo	1/1	0.293		
Striped bass	6/6	0.274±0.098 (0.194-0.466)		
White bass	1/1	0.310		
All fish combined	19/19	0.241±0.099 (0.110-0.466)		

Table 2.4. Mercury (mg/kg) in fish collected from the Trinity River by sample site, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Site 4 Trinity River at SH 21				
Alligator gar	5/5	0.253± 0.096 (0.124-0.363)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Blue catfish	5/5	0.304±0.138 (0.192-0.486)		
Flathead catfish	4/4	0.139±0.013 (0.126-0.154)		
Hybrid gar Longnose-Alligator	1/1	0.139		
Smallmouth buffalo	1/1	0.485		
White bass	1/1	0.198		
All fish combined	17/17	0.245±0.124 (0.124-0.486)		
Site 5 Trinity River at 3478				
Blue catfish	5/5	0.325±0.208 (0.160-0.560)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Flathead catfish	7/7	0.291±0.276 (0.101-**0.869**[o])		
Smallmouth buffalo	1/1	0.362		
All fish combined	13/13	0.310±0.230 (0.101-**0.869**)		
Site 6 Trinity River at SH 19				
Blue catfish	6/6	0.477±0.149 (0.311-0.691)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Flathead catfish	5/5	0.204±0.094 (0.132-0.345)		
Smallmouth buffalo	1/1	0.170		
White bass	17/17	0.194±0.067 (0.108-0.329)		
All fish combined	29/29	0.253±0.146 (0.108-0.691)		
Site 7 Trinity River at FM 3278				
Alligator gar	8/8	0.371±0.146 (0.223-0.589)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Blue catfish	4/4	0.319±0.089 (0.232-0.412)		
Flathead catfish	4/4	0.249±0.118 (0.148-0.406)		
Freshwater drum	4/4	0.198±0.061 (0.124-0.261)		

[o] *Emboldened numbers denote that mercury concentrations equal and/or exceed the DSHS HAC value for mercury.*

Table 2.5. Mercury (mg/kg) in fish collected from the Trinity River by sample site, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Site 7 Trinity River at FM 3278 (cont.)				
Hybrid striped bass	1/1	0.273	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Largemouth bass	2/2	0.501±0.216 (0.348-**0.654**[p])		
Longnose gar	2/2	0.304±0.057 (0.264-0.344)		
Smallmouth buffalo	1/1	0.245		
Spotted bass	1/1	0.239		
Striped bass	10/10	0.179±0.064 (0.126-0.351)		
White bass	2/2	0.197±0.012 (0.188-0.205)		
All fish combined	39/39	0.271±0.129 (0.124-0.654)		
Site 8 Trinity River at US 59				
Blue catfish	3/3	0.128±0.017 (0.117-0.148)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Flathead catfish	4/4	0.186±0.063 (0.138-0.275)		
Freshwater drum	5/5	0.310±0.110 (0.174-0.481)		
Longnose gar	2/2	0.418±0.008 (0.413-0.424)		
Smallmouth buffalo	1/1	0.128		
Spotted bass	4/4	0.417±0.137 (0.255-0.588)		
White bass	5/5	0.235±0.043 (0.181-0.288)		
All fish combined	24/24	0.271±0.128 (0.117-0.588)		
Site 9 Trinity River at US 90				
Blue catfish	5/5	0.265±0.108 (0.155-0.423)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Flathead catfish	4/4	0.364±0.166 (0.220-0.592)		
Longnose gar	3/3	0.370±0.088 (0.269-0.430)		
Smallmouth buffalo	3/3	0.449±0.125 (0.356-0.591)		

[p] *Emboldened numbers denote that mercury concentrations equal and/or exceed the DSHS HAC value for mercury.*

Table 2.6. Mercury (mg/kg) in fish collected from the Trinity River by sample site, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Site 9 Trinity River at US 90 (cont.)				
Spotted bass	2/2	0.263±0.075 (0.210-0.316)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
White bass	1/1	0.400		
All fish combined	18/18	0.343±0.125 (0.155-0.592)		

Table 2.7. Mercury (mg/kg) in fish collected from the Trinity River by species, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Alligator gar	18/18	0.319±0.129 (0.124-0.589)	0.7	ATSDR chronic oral MRL for methylmercury — 0.0003 mg/kg–day
Blue catfish	40/40	0.295±0.164 (0.091-**0.691**[q])		
Flathead catfish	40/40	0.226±0.148 (0.101-**0.869**)		
Freshwater drum	9/9	0.260±0.104 (0.124-0.481)		
Hybrid gar Longnose-Alligator	1/1	0.139		
Hybrid striped bass	1/1	0.273		
Largemouth bass	2/2	0.501±0.216 (0.348-**0.654**)		
Longnose gar	15/15	0.327±0.097 (0.127-0.430)		
Smallmouth buffalo	11/11	0.310±0.157 (0.052-0.591)		
Spotted bass	7/7	0.348±0.134 (0.210-0.588)		
Striped bass	16/16	0.215±0.089 (0.126-0.466)		
White bass	27/27	0.214±0.072 (0.108-0.400)		
All fish combined	187/187	0.269±0.139 (0.052-0.869)		

[q] *Emboldened numbers denote that mercury concentrations equal and/or exceed the DSHS HAC value for mercury.*

Table 3. Pesticides (mg/kg) in fish collected from the Trinity River by sample site, 2012–2013.

Species	Number Detected/ Number Tested	Mean ± S.D. (Min-Max)	HAC Value (nonca) and HAC Value (ca; mg/kg)	Basis for Comparison Value
Heptachlor Epoxide				
Alligator gar	1/2	0.001±0.001 (ND-0.002)	0.030	EPA Chronic Oral RfD — 1.3E-5 mg/kg–day
Flathead catfish	5/9	0.006±0.016 (ND-**0.048**[r])		
All fish combined	6/11	0.005±0.014 (BDL-**0.048**)	0.060	EPA Oral Slope Factor — 9.1E+0 per mg/kg–day
Chlordane				
Alligator gar	2/2	0.055±0.022 (0.040-0.071)	1.167	EPA Chronic Oral RfD — 0.0005 mg/kg–day
Flathead catfish	9/9	0.016±0.022 (0.001-0.070)		
All fish combined	11/11	0.023±0.026 (0.001-0.071)	1.556	EPA Oral Slope Factor — 0.35 per mg/kg–day
Dieldrin				
Alligator gar	1/2	0.002±0.003 (ND-0.004)	0.117	EPA Chronic Oral RfD — 0.00005 mg/kg–day
Flathead catfish	5/9	0.003±0.003 (ND-0.009)		
All fish combined	6/11	0.002±0.003 (ND-0.009)	0.034	EPA Oral Slope Factor — 16 per mg/kg–day
Endrin				
Alligator gar	1/2	0.003±0.004 (ND-0.006)		
Flathead catfish	5/9	0.003±0.003 (ND-0.007)	0.700	EPA Chronic Oral RfD — 3.0E-4 mg/kg–day
All fish combined	6/11	0.003±0.003 (ND-0.007)		
4,4'-DDE				
Alligator gar	2/2	0.239±0.063 (0.195-0.284)	1.167	EPA Chronic Oral RfD for DDT — 5.0E-4 mg/kg–day
Flathead catfish	9/9	0.030±0.026 (0.008-0.082)		
All fish combined	11/11	0.068±0.090 (0.008-0.284)	1.601	EPA Oral Slope Factor for DDT— 3.4E-1 per mg/kg–day
4,4'-DDD				
Alligator gar	2/2	0.021±0.006 (0.017-0.026)	1.167	EPA Chronic Oral RfD for DDT — 5.0E-4 mg/kg–day
Flathead catfish	9/9	0.003±0.003 (0.0003-0.008)		
All fish combined	11/11	0.006±0.008 (0.0003-0.026)	2.269	EPA Oral Slope Factor for DDD — 2.4E-1 per mg/kg–day

[r] *Emboldened numbers denote that pesticide concentrations equal and/or exceed its DSHS HAC value .*

Table 4.1. PCBs (mg/kg) in fish collected from the Trinity River by sample site, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; mg/kg)**	**Basis for Comparison Value**
Site 1 Trinity River at US 287				
Alligator gar	1/1	**0.171**[s]	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
Blue catfish	4/4	**0.089**±0.020 (**0.077**-**0.118**)		
Flathead catfish	4/4	**0.084**±0.070 (0.026-**0.172**)		
Longnose gar	2/2	0.042±0.011 (0.034-**0.050**)		
Smallmouth buffalo	1/1	**0.051**		
All fish combined	12/12	**0.083**±0.051 (0.026-**0.172**)		
Site 2 Trinity River at US 79				
Alligator gar	4/4	**0.117**±0.079 (0.016-**0.185**)	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
Blue catfish	4/4	**0.081**±0.097 (0.024-**0.226**)		
Flathead catfish	4/4	0.044±0.035 (0.011-**0.075**)		
Longnose gar	3/3	**0.156**±0.086 (**0.073**-**0.244**)		
Smallmouth buffalo	1/1	0.022		
All fish combined	16/16	**0.091**±0.080 (0.011-**0.244**)		
Site 3 Trinity River at SH 7				
Blue catfish	4/4	**0.130**±0.097 (0.042-**0.234**)	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
Flathead catfish	4/4	0.041±0.022 (0.024-**0.071**)		
Longnose gar	3/3	**0.183**±0.198 (0.037-**0.408**)		
Smallmouth buffalo	1/1	**0.133**		
Striped bass	6/6	0.028±0.009 (0.018-0.038)		
White bass	1/1	0.046		
All fish combined	19/19	**0.083**±0.099 (0.018-**0.408**)		

[s] *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 the Trinity River by sample site, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; mg/kg)**	**Basis for Comparison Value**
Site 4 Trinity River at SH 21				
Alligator gar	5/5	**0.119**[t]±0.059 (**0.065**-**0.214**)	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
Blue catfish	5/5	**0.128**±0.103 (0.042-**0.291**)		
Flathead catfish	4/4	0.034±0.014 (0.015-**0.048**)		
Hybrid gar Longnose-Alligator	1/1	0.034		
Smallmouth buffalo	1/1	0.027		
White bass	1/1	0.033		
All fish combined	17/17	**0.086**±0.075 (0.015-**0.291**)		
Site 5 Trinity River at 3478				
Blue catfish	5/5	**0.071**±0.065 (0.025-**0.185**)	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
Flathead catfish	7/7	**0.073**±0.055 (0.020-**0.153**)		
Smallmouth buffalo	1/1	0.020		
All fish combined	16/16	**0.068**±0.056 (0.020-**0.185**)		
Site 6 Trinity River at SH 19				
Blue catfish	6/6	**0.120**±0.081 (**0.063**-**0.280**)	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
Flathead catfish	5/5	0.039±0.022 (0.018-**0.072**)		
Smallmouth buffalo	1/1	**0.057**		
White bass	17/17	0.037±0.013 (0.021-**0.066**)		
All fish combined	39/39	**0.055**±0.050 (0.018-**0.280**)		

[t] *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 the Trinity River by sample site, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; mg/kg)**	**Basis for Comparison Value**
Site 7 Trinity River at FM 3278				
Alligator gar	8/8	**0.252**[u]±0.115 (**0.105**-**0.445**)	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
Blue catfish	4/4	0.046±0.019 (0.031-**0.073**)		
Flathead catfish	4/4	**0.049**±0.021 (0.027-**0.072**)		
Freshwater drum	4/4	**0.056**±0.051 (0.025-**0.132**)		
Hybrid striped bass	1/1	**0.107**		
Largemouth bass	2/2	0.014±0.000 (0.014-0.014)		
Longnose gar	2/2	**0.420**±0.221 (**0.264**-**0.576**)		
Smallmouth buffalo	1/1	**0.123**		
Spotted bass	1/1	0.019		
Striped bass	10/10	0.044±0.021 (0.026-**0.088**)		
White bass	2/2	0.021±0.008 (0.015-0.027)		
All fish combined	39/39	**0.108**±0.129 (0.014-**0.576**)		
Site 8 Trinity River at US 59				
Blue catfish	3/3	0.018±0.008 (0.011-0.027)	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
Flathead catfish	4/4	0.024±0.011 (0.011-0.038)		
Freshwater drum	5/5	**0.051**±0.030 (0.010-**0.087**)		
Longnose gar	2/2	**0.954**±0.108 (**0.878**-**1.031**)		
Smallmouth buffalo	1/1	0.025		
Spotted bass	4/4	0.014±0.003 (0.010-0.017)		
White bass	5/5	0.028±0.010 (0.016-0.041)		
All fish combined	24/24	**0.106**±0.263 (0.010-**1.031**)		

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

Table 4.4. PCBs (mg/kg) in fish collected from the Trinity River by sample site, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; mg/kg)**	**Basis for Comparison Value**
Site 9 Trinity River at US 90				
Blue catfish	5/5	0.020±0.011 (0.009-0.037)	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
Flathead catfish	4/4	0.013±0.005 (0.007-0.019)		
Longnose gar	3/3	**0.225**[v]±0.248 (**0.066**-**0.511**)		
Smallmouth buffalo	3/3	0.010±0.004 (0.006-0.013)		
Spotted bass	2/2	0.005±0.000 (0.005-0.005)		
White bass	1/1	0.018		
All fish combined	16/18	**0.049**±0.118 (0.005-**0.511**)		

Table 4.5. PCBs (mg/kg) in fish collected from the Trinity River by species, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; pg/g)**	**Basis for Comparison Value**
Alligator gar	18/18	**0.181**±0.108 (0.016-**0.445**)	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
Blue catfish	40/40	**0.081**±0.075 (0.009-**0.291**)		
Flathead catfish	40/40	0.047±0.039 (0.007-**0.172**)		
Freshwater drum	9/9	**0.053**±0.038 (0.010-**0.132**)		
Hybrid gar Longnose-Alligator	1/1	0.034		
Hybrid striped bass	1/1	**0.107**		
Largemouth bass	2/2	0.014±0.000 (0.014-0.014)		
Longnose gar	15/15	**0.302**±0.318 (0.034-**1.031**)		
Smallmouth buffalo	11/11	0.044±0.044 (0.006-**0.133**)		
Spotted bass	7/7	0.012±0.006 (0.005-0.019)		
Striped bass	16/16	0.038±0.019 (0.018-**0.088**)		
White bass	27/27	0.034±0.012 (0.015-**0.066**)		
All fish combined	187/187	**0.083**±0.128 (0.005-**1.031**)		

[v] *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 Trinity River by sample site, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; pg/g)**	**Basis for Comparison Value**
Site 1 Trinity River at US 287				
Alligator gar	1/1	**7.582**[w]	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 10^{5} per mg/kg–day
Blue catfish	4/4	**2.975**±1.780 (1.829-**5.615**)		
Flathead catfish	4/4	2.276±2.306 (0.385-**5.618**)		
Longnose gar	2/2	0.595±0.007 (0.590-0.600)		
Smallmouth buffalo	1/1	**3.661**		
All fish combined	12/12	**2.787**±2.336 (0.385-**7.582**)		
Site 2 Trinity River at US 79				
Alligator gar	4/4	**4.832**±4.560 (0.101-**9.336**)	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 10^{5} per mg/kg–day
Blue catfish	4/4	**2.610**±3.122 (0.188-**7.178**)		
Flathead catfish	4/4	2.189±1.980 (0.373-**4.257**)		
Longnose gar	3/3	1.302±0.585 (0.795-1.942)		
Smallmouth buffalo	0/1	ND		
All fish combined	15/16	**2.652**±3.016 (ND-**9.336**)		
Site 3 Trinity River at SH 7				
Blue catfish	4/4	1.559±1.410 (0.301-**3.403**)	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 10^{5} per mg/kg–day
Flathead catfish	4/4	0.732±0.508 (0.126-1.356)		
Longnose gar	3/3	0.904±0.849 (0.306-1.876)		
Smallmouth buffalo	1/1	0.383		
Striped bass	4/6	0.131±0.109 (ND-0.266)		
White bass	1/1	0.240		
All fish combined	17/19	0.699±0.868 (ND-**3.403**)		

[w] *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 Trinity River by sample site, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; pg/g)**	**Basis for Comparison Value**
Site 4 Trinity River at SH 21				
Alligator gar	5/5	**2.912**[x]±3.075 (0.236-**8.014**)	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 10^{5} per mg/kg–day
Blue catfish	5/5	1.588±1.512 (0.268-**3.833**)		
Flathead catfish	4/4	1.406±1.592 (0.249-**3.759**)		
Hybrid gar Longnose-Alligator	1/1	0.196		
Smallmouth buffalo	1/1	0.072		
White bass	0/1	ND		
All fish combined	16/17	1.670±2.093 (ND-**8.014**)		
Site 5 Trinity River at 3478				
Blue catfish	4/5	0.977±1.656 (ND-**3.921**)	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 10^{5} per mg/kg–day
Flathead catfish	7/7	1.165±1.186 (0.176-**3.215**)		
Smallmouth buffalo	1/1	0.135		
All fish combined	12/13	1.014±1.302 (ND-**3.921**)		
Site 6 Trinity River at SH 19				
Blue catfish	6/6	**3.108**±1.922 (1.033-**6.348**)	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 10^{5} per mg/kg–day
Flathead catfish	5/5	1.255±1.150 (0.474-**3.201**)		
Smallmouth buffalo	1/1	0.978		
White bass	17/17	0.911±0.418 (0.464-2.149)		
All fish combined	29/29	1.427±1.315 (0.464-**6.348**)		

[x] *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 Trinity River by sample site, 2012–2013.

Species	Number Detected/ Number Tested	Mean ± S.D. (Min-Max)	HAC Value (nonca) and HAC Value (ca; pg/g)	Basis for Comparison Value
Site 7 Trinity River at FM 3278				
Alligator gar	8/8	**5.264**[y]±5.642 (1.093-**16.841**)	2.33 3.49	ATSDR Chronic Oral MRL for 2,3,7,8 – TCDD — 1.0×10^{-9} mg/kg–day EPA Slope Factor — 1.56×10^{5} per mg/kg–day
Blue catfish	4/4	0.562±0.477 (0.109-1.085)		
Flathead catfish	4/4	**4.598**±6.089 (1.166-**13.702**)		
Freshwater drum	4/4	0.941±0.670 (0.414-1.905)		
Hybrid striped bass	1/1	2.002		
Largemouth bass	2/2	0.511±0.392 (0.234-0.788)		
Longnose gar	2/2	**4.861**±0.087 (**4.799**-**4.922**)		
Smallmouth buffalo	1/1	**14.547**		
Spotted bass	1/1	**6.522**		
Striped bass	10/10	1.209±0.965 (0.346-**3.505**)		
White bass	2/2	0.431±0.269 (0.241-0.621)		
All fish combined	39/39	**2.905**±4.128 (0.109-**16.841**)		
Site 8 Trinity River at US 59				
Blue catfish	3/3	0.220±0.158 (0.096-0.398)	2.33 3.49	ATSDR Chronic Oral MRL for 2,3,7,8 – TCDD — 1.0×10^{-9} mg/kg–day EPA Slope Factor — 1.56×10^{5} per mg/kg–day
Flathead catfish	4/4	1.487±1.860 (0.255-**4.244**)		
Freshwater drum	5/5	0.473±0.222 (0.275-0.828)		
Longnose gar	2/2	**23.722**±0.307 (**23.505**-**23.939**)		
Smallmouth buffalo	1/1	1.393		
Spotted bass	4/4	0.204±0.106 (0.048-0.278)		
White bass	5/5	0.510±0.211 (0.179-0.690)		
All fish combined	24/24	**2.549**±6.574 (0.048-**23.939**)		

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

Table 5.4. PCDDs/PCDFs toxicity equivalent (TEQ) concentrations (pg/g) in fish collected from the Trinity River by sample site, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; pg/g)**	**Basis for Comparison Value**
Site 9 Trinity River at US 90				
Blue catfish	1/5	0.163±0.364 (ND-0.815)	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 10^{5} per mg/kg–day
Flathead catfish	2/4	0.039±0.052 (ND-0.109)		
Longnose gar	3/3	**21.759**[z]±25.547 (1.342-**50.407**)		
Smallmouth buffalo	0/3	ND		
Spotted bass	1/2	2.087±2.951 (ND-**4.173**)		
White bass	0/1	ND		
All fish combined	7/18	**3.912**±12.050 (ND-**50.407**)		

Table 5.5. PCDDs/PCDFs toxicity equivalent (TEQ) concentrations (pg/g) in fish collected from Trinity River by sample site, 2012–2013.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; pg/g)**	**Basis for Comparison Value**
Alligator gar	18/18	**4.644**±4.536 (0.101-**16.841**)	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 10^{5} per mg/kg–day
Blue catfish	35/40	1.594±1.841 (ND-**7.178**)		
Flathead catfish	38/40	1.634±2.404 (ND-**13.702**)		
Freshwater drum	9/9	0.681±0.504 (0.275-**1.905**)		
Hybrid gar Longnose-Alligator	1/1	0.196		
Hybrid striped bass	1/1	2.002		
Largemouth bass	2/2	0.511±0.392 (0.234-0.788)		
Longnose gar	15/15	**8.683**±14.086 (0.306-**50.407**)		
Smallmouth buffalo	7/11	1.924±4.328 (ND-**14.547**)		
Spotted bass	6/7	1.644±2.621 (ND-**6.522**)		
Striped bass	14/16	0.805±0.924 (ND-**3.505**)		
White bass	25/27	0.709±0.452 (ND-2.149)		
All fish combined	171/187	2.230±4.986 (ND-**50.407**)		

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

Table 6. Hazard quotients (HQs) for mercury in fish collected from the Trinity River in 2012–2013. Table 6.1 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[aa]			
Species	**Number of Samples**	**Hazard Quotient**	**Meals per Week**
Trinity River All Sites			
Alligator gar	18	0.46	2.0
Blue catfish	40	0.42	2.2
Flathead catfish	40	0.32	2.9
Freshwater drum	9	0.37	2.5
Largemouth bass	2	0.72	1.3
Longnose gar	15	0.47	2.0
Smallmouth buffalo	11	0.44	2.1
Spotted bass	7	0.50	1.9
Striped bass	16	0.31	3.0
White bass	27	0.31	3.0
Gar spp.	34	0.45	2.0
Largemouth and Spotted basss (*Micropterus* spp.)	9	0.55	1.7
Striped and White bass (*Morone* spp.)	44	0.31	3.0
All fish combined	187	0.38	2.4

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

Table 7.1. Hazard quotients (HQs) and hazard indices (HIs) for PCBs and/or PCDDs/PCDFs in fish collected from the Trinity River in 2012–2013. Table 7.1 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[bb]

Contaminant/Species	Number of Samples	Hazard Quotient	Meals per Week
Alligator gar			
PCBs	18	**3.86**[cc]	**0.2**[dd]
PCDDs/PCDFs		**1.99**	**0.5**
Hazard Index (meals per week)		**5.85**	**0.2**
Blue catfish			
PCBs	40	**1.74**	**0.5**
PCDDs/PCDFs		0.68	1.4
Hazard Index (meals per week)		**2.42**	**0.4**
Flathead catfish			
PCBs	40	**1.01**	**0.9**
PCDDs/PCDFs		0.70	1.3
Hazard Index (meals per week)		**1.71**	**0.5**
Freshwater drum			
PCBs	9	**1.14**	**0.8**
PCDDs/PCDFs		0.29	3.2
Hazard Index (meals per week)		**1.43**	**0.6**
Largemouth bass			
PCBs	2	0.30	3.1
PCDDs/PCDFs		0.22	4.2
Hazard Index (meals per week)		0.52	1.8

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

Table 7.2. Hazard quotients (HQs) and hazard indices (HIs) for PCBs and/or PCDDs/PCDFs in fish collected from the Trinity River 2012-2013. Table 7.2 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[ee]			
Contaminant/Species	**Number of Samples**	**Hazard Quotient**	**Meals per Week**
Longnose gar			
PCBs	15	**6.47**[ff]	**0.1**[gg]
PCDDs/PCDFs		**3.72**	**0.2**
Hazard Index (meals per week)		**10.19**	**0.1**
Smallmouth buffalo			
PCBs	11	0.94	1.0
PCDDs/PCDFs		0.82	1.1
Hazard Index (meals per week)		**1.77**	**0.5**
Spotted bass			
PCBs	7	0.26	3.6
PCDDs/PCDFs		0.70	1.3
Hazard Index (meals per week)		0.96	1.0
Striped bass			
PCBs	16	0.81	1.1
PCDDs/PCDFs		0.35	2.7
Hazard Index (meals per week)		**1.16**	**0.8**
White bass			
PCBs	27	0.73	1.3
PCDDs/PCDFs		0.30	3.0
Hazard Index (meals per week)		**1.03**	**0.9**

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

Table 7.3. Hazard quotients (HQs) and hazard indices (HIs) for PCBs and/or PCDDs/PCDFs in fish collected from the Trinity River 2012-2013. Table 7.3 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[hh]			
Contaminant/Species	**Number of Samples**	**Hazard Quotient**	**Meals per Week**
Gar spp.			
PCBs	34	**4.93**[ii]	**0.2**[jj]
PCDDs/PCDFs		**2.70**	**0.3**
Hazard Index (meals per week)		**7.63**	**0.1**
Largemouth and spotted bass (*Micropterus* spp.)			
PCBs	9	0.26	3.6
PCDDs/PCDFs		0.60	1.6
Hazard Index (meals per week)		0.85	1.1
Striped and white bass (*Morone* spp.)			
PCBs	44	0.79	1.2
PCDDs/PCDFs		0.33	2.8
Hazard Index (meals per week)		**1.12**	**0.8**
All fish combined			
PCBs	187	**1.78**	**0.5**
PCDDs/PCDFs		0.96	1.0
Hazard Index (meals per week)		**2.73**	**0.3**

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

Table 8.1. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2012–2013 from the Trinity River containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish the Trinity River 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	
Alligator gar				
Arsenic	2	1.1E-05	88,528	8.2
Chlordane		3.5E-06	282,828	unrestricted[ll]
DDT (total)		1.6E-05	61,353	5.7
Dieldrin		5.9E-06	170,139	15.7
Heptachlor epoxide		1.7E-06	598,291	unrestricted
PCBs	18	6.6E-05	15,123	1.4
PCDDs/PCDFs		**1.3E-04**[mm]	**7,515**	**0.7**[nn]
Cumulative Cancer Risk		**4.4E-04**	**2,288**	**0.2**
Blue catfish				
PCBs	40	3.0E-05	33,608	3.1
PCDDs/PCDFs		4.6E-05	21,895	2.0
Cumulative Cancer Risk		7.5E-05	13,258	1.2
Flathead catfish				
Arsenic	9	6.1E-06	164,983	15.2
Chlordane		1.0E-06	972,222	unrestricted
DDT (total)		2.0E-06	500,408	unrestricted
Dieldrin		8.8E-06	113,426	10.5
Heptachlor epoxide		1.0E-05	99,715	9.2
PCBs	40	1.7E-05	57,920	5.4
PCDDs/PCDFs		4.7E-05	21,359	2.0
Cumulative Cancer Risk		**1.6E-04**	**6,406**	**0.6**

[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.*
[mm] *Emboldened numbers denote calculated excess lifetime cancer risk after 30 years exposure is greater than 1.0E-04.*
[nn] *Emboldened numbers denote that the calculated allowable meals for an adult are ≤ one meal per week.*

Table 8.2. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2012–2013 from the Trinity River containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish the Trinity River over a 30-year period.[oo]

Species/Contaminant	Number of Samples	Theoretical Lifetime Excess Cancer Risk		Meals per Week
		Risk	Population Size that Would Result in One Excess Cancer	
Freshwater drum				
PCBs	9	1.9E-05	51,363	4.7
PCDDs/PCDFs		2.0E-05	51,249	4.7
Cumulative Cancer Risk		3.9E-05	25,653	2.4
Largemouth bass				
PCBs	2	5.1E-06	194,444	unrestricted[pp]
PCDDs/PCDFs		1.5E-05	68,298	6.3
Cumulative Cancer Risk		2.0E-05	50,544	4.7
Longnose gar				
PCBs	15	**1.1E-04**[qq]	**9,014**	**0.8**[rr]
PCDDs/PCDFs		**2.5E-04**	**4,019**	**0.4**
Cumulative Cancer Risk		**3.6E-04**	**2,780**	**0.3**
Smallmouth buffalo				
PCBs	11	1.6E-05	61,869	5.7
PCDDs/PCDFs		5.5E-05	18,139	1.7
Cumulative Cancer Risk		7.1E-05	14,027	1.3
Spotted bass				
PCBs	7	4.4E-06	226,852	unrestricted
PCDDs/PCDFs		4.7E-05	21,229	2.0
Cumulative Cancer Risk		5.2E-05	19,412	1.8

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

Table 8.3. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2012–2013 from the Trinity River containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish the Trinity River over a 30-year period.[ss]

Species/Contaminant	Number of Samples	Theoretical Lifetime Excess Cancer Risk		Meals per Week
		Risk	Population Size that Would Result in One Excess Cancer	
Striped bass				
PCBs	16	1.4E-05	71,637	6.6
PCDDs/PCDFs		2.3E-05	43,354	4.0
Cumulative Cancer Risk		3.7E-05	27,009	2.5
White bass				
PCBs	27	1.2E-05	80,065	7.4
PCDDs/PCDFs		2.0E-05	49,225	4.5
Cumulative Cancer Risk		3.3E-05	30,483	2.8
Gar spp.				
PCBs	34	8.4E-05	11,836	1.1
PCDDs/PCDFs		**1.8E-04**[tt]	**5,544**	**0.5**[uu]
Cumulative Cancer Risk		**2.6E-04**	**3,776**	**0.3**
Largemouth and spotted bass (*Micropterus* spp.)				
PCBs	9	4.4E-06	226,852	unrestricted[vv]
PCDDs/PCDFs		4.0E-05	25,072	2.3
Cumulative Cancer Risk		4.4E-05	22,577	2.1
Striped and white bass (*Morone* spp.)				
PCBs	44	1.4E-05	73,574	6.8
PCDDs/PCDFs		2.2E-05	45,149	4.2
Cumulative Cancer Risk		3.6E-05	27,979	2.6

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

Table 8.4. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2012–2013 from the Trinity River containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish the Trinity River over a 30-year period.[ww]

Species/Contaminant	Number of Samples	Theoretical Lifetime Excess Cancer Risk		Meals per Week
		Risk	Population Size that Would Result in One Excess Cancer	
All fish combined				
PCBs	187	3.0E-05	32,798	3.0
PCDDs/PCDFs		6.4E-05	15,650	1.4
Cumulative Cancer Risk		9.4E-05	10,595	1.0

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

Table 9.1. Tukey HSD post hoc comparisons of all fish combined PCB concentrations between samples sites from the Trinity River 2012–2013.

Site	Site	Difference	p-Value	95% Confidence Interval	
				Lower	Upper
1	2	0.166	1.000	-0.951	1.283
1	3	0.258	0.998	-0.820	1.337
1	4	0.080	1.000	-1.022	1.183
1	5	0.290	0.998	-0.881	1.461
1	6	0.437	0.916	-0.567	1.441
1	7	0.092	1.000	-0.873	1.058
1	8	0.789	0.303	-0.245	1.823
1	9	1.323	**0.005**[xx]	0.233	2.413
2	3	0.092	1.000	-0.901	1.084
2	4	-0.086	1.000	-1.105	0.933
2	5	0.124	1.000	-0.968	1.216
2	6	0.271	0.992	-0.640	1.182
2	7	-0.074	1.000	-0.942	0.795
2	8	0.623	0.511	-0.321	1.567
2	9	1.157	**0.011**	0.152	2.162
3	4	-0.178	1.000	-1.154	0.799
3	5	0.032	1.000	-1.021	1.085
3	6	0.179	0.999	-0.684	1.042
3	7	-0.166	0.999	-0.984	0.653
3	8	0.531	0.660	-0.368	1.429
3	9	1.065	**0.017**	0.103	2.027
4	5	0.210	1.000	-0.868	1.287
4	6	0.357	0.948	-0.537	1.250
4	7	0.012	1.000	-0.838	0.862
4	8	0.708	0.301	-0.219	1.636
4	9	1.242	0.003	0.253	2.232
5	6	0.147	1.000	-0.829	1.123
5	7	-0.198	0.999	-1.134	0.739
5	8	0.499	0.839	-0.509	1.506
5	9	1.033	0.066	-0.032	2.097
6	7	-0.345	0.860	-1.062	0.373
6	8	0.352	0.916	-0.456	1.159
6	9	0.886	**0.046**	0.008	1.763
7	8	0.696	0.102	-0.063	1.455
7	9	1.230	**0.000**	0.397	2.064
8	9	0.534	0.671	-0.378	1.446

[xx] *Emboldened numbers denote that the p-Value is < 0.05.*

Table 9.2. Tukey HSD post hoc comparisons of blue catfish PCB concentrations between sample sites from the Trinity River 2012–2013.					
Site	Site	Difference	p-Value	95% Confidence Interval	
				Lower	Upper
1	2	0.529	0.965	-1.035	2.092
1	3	-0.136	1.000	-1.700	1.427
1	4	-0.136	1.000	-1.619	1.347
1	5	0.470	0.977	-1.013	1.953
1	6	-0.183	1.000	-1.610	1.244
1	7	0.690	0.860	-0.873	2.254
1	8	1.667	0.055	-0.022	3.355
1	9	1.584	**0.029**[yy]	0.101	3.067
2	3	-0.665	0.883	-2.228	0.898
2	4	-0.665	0.850	-2.148	0.818
2	5	-0.059	1.000	-1.542	1.424
2	6	-0.712	0.764	-2.139	0.715
2	7	0.162	1.000	-1.402	1.725
2	8	1.138	0.404	-0.550	2.827
2	9	1.056	0.335	-0.427	2.539
3	4	0.000	1.000	-1.483	1.483
3	5	0.606	0.904	-0.877	2.089
3	6	-0.047	1.000	-1.474	1.380
3	7	0.827	0.706	-0.736	2.390
3	8	1.803	**0.029**	0.115	3.492
3	9	1.721	**0.014**	0.238	3.204
4	5	0.606	0.872	-0.792	2.004
4	6	-0.047	1.000	-1.386	1.292
4	7	0.827	0.647	-0.656	2.310
4	8	1.803	**0.020**	0.189	3.418
4	9	1.721	**0.007**	0.322	3.119
5	6	-0.653	0.785	-1.992	0.686
5	7	0.221	1.000	-1.263	1.704
5	8	1.197	0.285	-0.417	2.812
5	9	1.114	0.206	-0.284	2.513
6	7	0.874	0.530	-0.553	2.301
6	8	1.850	**0.011**	0.287	3.413
6	9	1.768	**0.003**	0.429	3.106
7	8	0.977	0.602	-0.712	2.665
7	9	0.894	0.550	-0.589	2.377
8	9	-0.083	1.000	-1.697	1.532

[yy] *Emboldened numbers denote that the p-Value is < 0.05.*

Table 9.3. Games-Howell post hoc comparisons of flathead catfish PCB concentrations between sample sites from the Trinity River 2012–2013.					
Site	**Site**	**Difference**	**p-Value**	**95% Confidence Interval**	
				Lower	**Upper**
1	2	0.659	0.979	-2.443	3.761
1	3	0.503	0.979	-2.210	3.216
1	4	0.654	0.922	-2.063	3.372
1	5	0.064	1.000	-2.565	2.694
1	6	0.567	0.958	-2.137	3.271
1	7	0.290	0.999	-2.448	3.028
1	8	1.041	0.651	-1.667	3.748
1	9	1.599	0.261	-1.172	4.370
2	3	-0.156	1.000	-3.010	2.698
2	4	-0.005	1.000	-2.865	2.855
2	5	-0.595	0.967	-3.363	2.172
2	6	-0.092	1.000	-2.943	2.759
2	7	-0.369	0.997	-3.254	2.516
2	8	0.381	0.997	-2.463	3.226
2	9	0.940	0.720	-1.959	3.838
3	4	0.151	1.000	-1.488	1.790
3	5	-0.439	0.959	-2.032	1.154
3	6	0.064	1.000	-1.482	1.609
3	7	-0.213	0.999	-1.789	1.363
3	8	0.537	0.863	-1.174	2.249
3	9	1.096	0.175	-0.429	2.621
4	5	-0.590	0.831	-2.160	0.980
4	6	-0.087	1.000	-1.605	1.430
4	7	-0.364	0.963	-1.913	1.185
4	8	0.386	0.968	-1.306	2.078
4	9	0.944	0.262	-0.549	2.438
5	6	0.503	0.910	-0.989	1.995
5	7	0.226	0.999	-1.275	1.727
5	8	0.976	0.389	-0.669	2.621
5	9	1.535	**0.035**[zz]	0.096	2.973
6	7	-0.277	0.992	-1.712	1.158
6	8	0.473	0.909	-1.134	2.081
6	9	1.032	0.161	-0.327	2.391
7	8	0.750	0.556	-0.887	2.388
7	9	1.309	0.066	-0.088	2.705
8	9	0.558	0.774	-1.037	2.154

[zz] *Emboldened numbers denote that the p-Value is < 0.05.*

Table 10. The number of eight-ounce meals (assuming 38% yield from whole fish to skin-off fillets) for an average, minimum, and maximum weight fish of each species collected from the Trinity River in 2012–2013.

Species	Average	Minimum	Maximum
	Number of Eight-Ounce Meals		
Alligator gar	36.7	8.8	87.7
Blue catfish	9.7	2.1	25.6
Flathead catfish	14.0	6.3	40.2
Freshwater drum	4.3	2.2	6.2
Largemouth bass	3.2	2.2	4.3
Longnose gar	7.1	2.2	16.8
Smallmouth buffalo	5.8	3.0	10.3
Spotted bass	1.3	0.9	1.8
Striped bass	2.8	0.8	5.2
White bass	1.0	0.5	1.5
All fish combined	8.6	0.5	87.7

Table 11. Recommended fish consumption advice by species for the Trinity River 2012–2013.			
Contaminants of Concern	**Species**	**Women of childbearing age and children < 12**	**Women past childbearing age and adult men**
Dioxins and PCBs	Blue catfish	**DO NOT EAT**	1 meal/month
	Flathead catfish	**DO NOT EAT**	1 meal/month
	Freshwater drum	**DO NOT EAT**	2 meals/month
	Gar (all species)	**DO NOT EAT**	**DO NOT EAT**
	Smallmouth buffalo	**DO NOT EAT**	1 meal/month
	Striped bass	1 meal/month	3 meals/month
	White bass	1 meal/month	3 meals/month

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