Characterization of Potential Adverse Health Effects Associated with Consuming Fish from

Lake Worth

Tarrant County, Texas

2016

Department of State Health Services
Consumer Protection Division
Policy, Standards, and Quality Assurance Section
Seafood and Aquatic Life Unit
Austin, Texas

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LIST OF ACRONYMS

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

LIST OF ACRONYMS CONT.

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

SUMMARY

Surveys of Lake Worth, Fort Worth, Texas in 1999 and 2008 indicated that polychlorinated biphenyl (PCB) concentrations in fish exceeded Texas Department of State Health Service (DSHS) guidelines for protection of human health. In 2008, the surveys also showed that the combination of carcinogenic contaminants, primarily aldrin and dieldrin in channel catfish exceeded DSHS guidelines for protection of human health. From 2000–2010, the DSHS recommended that people do not eat fish from Lake Worth (Fish and Shellfish Consumption Advisory 18 [ADV-18]). In 2010, DSHS rescinded ADV-18 and issued a revised fish consumption advisory because contaminant concentrations did not exceed DSHS guidelines for protection of human health in all species of fish. Fish and Shellfish Consumption Advisory 45 issued by the DSHS on November 15, 2010 recommended that people do not eat blue catfish, channel catfish, and smallmouth buffalo from Lake Worth.

In 2016, the DSHS performed this study to investigate any potential change in fish tissue contamination in Lake Worth. The present study examined fish from Lake Worth for the presence and concentrations of environmental toxicants that, if eaten, potentially could negatively affect human health. The study also addresses the public health implications of consuming fish from Lake Worth and suggests actions to reduce potential adverse health outcomes.

Results of the 2016 survey indicate that the combination of PCBs and dioxins in blue catfish, common carp, flathead catfish, freshwater drum, smallmouth buffalo, striped bass, and white bass exceed DSHS guidelines for protection of human health. Confidence in the conclusions for many species of fish is limited by the small sample size. Sampling a small number of fish (i.e., individual species of fish or all fish species combined) decreases the confidence of mean contaminant concentrations for the fish population thus adding uncertainty to the conclusions.

Conclusions

- Regular or long-term consumption of blue catfish, common carp, flathead catfish, freshwater drum, smallmouth buffalo, striped bass, and white bass may result in adverse noncarcinogenic health effects. Therefore, consumption of these species of fish from Lake Worth **poses an apparent risk to human health**.

- Regular or long-term consumption of flathead catfish and smallmouth buffalo may increase the likelihood of carcinogenic health risks.

Therefore, consumption of these species of fish from Lake Worth **poses an apparent risk to human health**.

Recommendations

- People should not consume smallmouth buffalo from Lake Worth (Table 10).

- Women of childbearing age (Women and girls under 50) including pregnant women, women who may become pregnant, and women who are nursing infants and children less than 12 years of age, or who weigh less than 75 pounds should not consume flathead catfish from Lake Worth.

- Women of childbearing age (Women and girls under 50) including pregnant women, women who may become pregnant, and women who are nursing infants, and children less than 12 years of age, or who weigh less than 75 pounds may consume up to one four-ounce meal per month of blue catfish, common carp, freshwater drum, striped bass, **or** white bass from Lake Worth.

- Women past childbearing age (Women 50 and older) and males 12 and older may consume up to one eight-ounce meal per month of flathead catfish from Lake Worth.

- Women past childbearing age (Women 50 and older) and males 12 and older may consume up to two eight-ounce meals per month of blue catfish, common carp, striped bass, **or** white bass from Lake Worth.

- Women past childbearing age (Women 50 and older) and males 12 and older may consume up to three eight-ounce meals per month of freshwater drum from Lake Worth.

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

INTRODUCTION

This document summarizes the results of a survey of Lake Worth conducted in 2016 by the DSHS Seafood and Aquatic Life Group (SALG).[a] The SALG performed this study to investigate any potential change in fish tissue contamination in Lake Worth fish. The present study examined fish from Lake Worth for environmental toxicants to determine if adverse health effects are likely following fish consumption. The report also addresses the public health implications of consuming fish from Lake Worth and suggests actions to reduce potential adverse health outcomes.

History of the Lake Worth Fish Consumption Advisory

In August 1990, the United States Environmental Protection Agency (USEPA) placed Air Force Plant No. 4 (AFP4) on the USEPA National Priorities List (NPL) as a Superfund site. The site was listed primarily because past activities had resulted in the contamination of groundwater in the superficial and deeper aquifers.[1] In 1998, the Texas Department of Health (TDH)[b] and the Agency for Toxic Substances and Disease Registry (ATSDR) released a public health assessment (PHA) for the AFP4 site. During the preparation of the PHA, TDH reviewed sampling data from small nonedible fish, known as mosquito fish, collected from five locations along Lake Worth and Meandering Road Creek. TDH noted that the mosquito fish collected adjacent to AFP4 had higher concentrations of polychlorinated biphenyls (PCBs), dieldrin, naphthalene, and polyaromatic hydrocarbons (PAHs; phenanthrene and benzo(b)fluoranthene) than those collected from the background locations. Because commonly consumed species of fish routinely eaten from Lake Worth were not available for the PHA, TDH and ATSDR recommended that the United States Air Force (USAF) collect commonly consumed fish from Lake Worth to determine whether eating fish from the reservoir poses a threat to public health.

In response to this recommendation, the United States Geological Survey (USGS) in cooperation with the USAF collected and analyzed commonly consumed fish from Lake Worth and provided the data to the TDH Seafood Safety Division[c] for evaluation. In March and April 1999, the USGS collected 55 fish samples from several sites in Lake Worth.[2] Left side, skin-off fillet samples were collected from 10 individuals each of channel catfish, common carp, freshwater drum, largemouth bass, and white crappie and five

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[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 Seafood and Aquatic Life Group (SALG)

smallmouth buffalo. The USGS National Water Quality Laboratory analyzed the samples for selected trace metals, organochlorine pesticides, PCBs, and semivolatile organic compounds (SVOCs). The results of this investigation showed widespread contamination of fish from Lake Worth due to PCBs at concentrations exceeding TDH guidelines for protection of human health.[3] On April 19, 2000, TDH issued Fish and Shellfish Consumption Advisory 18 (ADV-18) recommending that people should not consume fish from Lake Worth.[4]

In 2008, at the request of the TCEQ, as a part of its Total Maximum Daily Load (TMDL) 5-year follow-up program, the DSHS SALG collected fish from the Lake Worth to reevaluate the extant Lake Worth prohibited area. The 2008 study was expanded to include additional study sites and to include an additional target analyte, polychlorinated dibenzo-p-dioxins and/or dibenzofurans (PCDDs/PCDFs), that the DSHS assessed in Lake Worth fish. The DSHS have not examined PCDDs/PCDFs in previous fish contaminant studies of Lake Worth. Currently, DSHS fish sampling procedures include PCDDs/PCDFs in its target analyte list or suite of contaminants that DSHS routinely analyzes in fish.

The 2008 survey of Lake Worth revealed the presence of chemical contaminants at concentrations exceeding DSHS guidelines for protection of human health. Blue catfish and smallmouth buffalo PCB concentrations exceeded DSHS guidelines for protection of human health (0.047 mg/kg). Potential exposure to multiple organic contaminants (aldrin, dieldrin, PCBs, and PCDDs/PCDFs) in channel catfish exceeded DSHS guidelines for protection of human health.[5] Concentrations of PCBs have decreased in other species of fish from 2000 that led to the issuance of ADV-18. Therefore, the DSHS risk assessors recommended the rescission of ADV-18 for Lake Worth and the issuance of a revised fish consumption advisory. The DSHS issued Fish and Shellfish Consumption Advisory 45 (ADV-45) [6] (to rescind ADV-18) on November 15, 2010 advising people not to consume blue catfish, channel catfish, and smallmouth buffalo from Lake Worth.

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

The TCEQ enforces federal and state laws that promote judicious use of water bodies under state jurisdiction and protects state-controlled water bodies from pollution. Pursuant to the federal Clean Water Act, Section 303(d),[7] all states must establish a "total maximum daily load" (TMDL) for each pollutant contributing to the impairment of a water body for one or more designated uses. A TMDL is the maximum amount of a pollutant that a body of water can assimilate and still meet water quality standards.[8] TMDLs incorporate margins of safety to ensure the usability of the water body for all designated purposes. States, territories, and tribes define the uses for a specific water body (e.g., drinking water, contact recreation, aquatic life support) along with the scientific criteria designated to support each specified use.

Fish consumption is a recognized use for many waters. A water body is impaired if fish from the water body contain contaminants that make those fish unfit for human consumption or if consumption of those contaminants potentially could harm human health. Although a water body and its aquatic life may clear toxicants over time with removal of the source(s), it is often necessary to institute some type of remediation such as those implemented by the TCEQ. Thus, whenever the DSHS issues a fish consumption advisory or prohibits possession of environmentally contaminated fish, the TCEQ places the water body in its current *Texas Integrated Report of Surface Water Quality* formerly called the Texas Water Quality Inventory and 303(d) List.[9] The TCEQ is responsible for confirming the impairment and, if necessary, the TMDL program, then prepares a TMDL for each contaminant present that, if consumed, would be capable of negatively affecting human health. After approval of the TMDL, the stakeholders in the watershed prepare an Implementation Plan for each contaminant. These plans are designed to facilitate the rehabilitation of the water body over time. Successful remediation should result in return of the water body to conditions compatible with all stated uses, including consumption of fish from the water body. When the DSHS lifts a consumption advisory or possession ban, people may once again keep and consume fish from the water body. If fish in a water body are contaminated, one of the several items on an Implementation Plan for a water body on a state's 303(d) List consists of the periodic reassessment of contaminant levels in resident fish.

Description of Lake Worth

Lake Worth is a 3,489-acre impoundment of the West Fork Trinity River located within the city limits of Fort Worth, Texas in northwest Tarrant County.[10] The reservoir was constructed in 1914 by the City of Fort Worth to provide a municipal water supply. The reservoir extends approximately 6 miles upstream from the dam and drains a 2,064-square mile watershed. Three tributary creeks (Silver Creek, Live Oak Creek, and Meandering Road Creek) representing approximately 94 square miles of the Lake Worth watershed have contributed most of the flow to the reservoir due to the construction of Eagle Mountain Lake, an upstream reservoir, in 1932.[11] The reservoir is bordered by the Fort Worth Nature Center and Refuge at the upstream end of the lake as well as residential and commercial properties surround most of the lake. Two large industrial facilities are located adjacent to the south side of the reservoir: United States Air Station Joint Reserve Base–Fort Worth (NASFW) and AFP4. Lake Worth is a shallow, eutrophic reservoir. Fishery habitat is primarily composed of rocky and gravel shorelines, shallow flats with emergent aquatic vegetation, and standing timber. The reservoir's numerous boat docks also provide valuable structure and cover for fish. There are three parks and one marina that provide public access to the lake.[12] The lake is also known by recreational fishers for its abundance of crappie and catfish.

Population of Dallas County Surrounding Lake Worth

Dallas County is part of the Dallas-Fort Worth-Arlington metropolitan area, locally referred to as the "The Metroplex". The Metroplex is the largest metropolitan area in the state of Texas and the fourth largest in the United States. In 2016, according to the United States Census Bureau's (USCB) estimate, the 12 county Dallas-Fort Worth-Arlington metropolitan area population was near 7,233,323.[13] The USCB also reported that the Dallas-Fort Worth-Arlington metropolitan area as the largest numeric growing metropolitan area in the United States, which gained over 100,000 residents between 2015 and 2016.[14] The Metroplex covers approximately 9,286 square miles; an area larger than the combined states of Connecticut and Rhode Island.

Subsistence Fishing at Lake Worth

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. 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. [15]

METHODS

Fish Sampling, Preparation, and Analysis

The DSHS SALG collects edible fish from the state's public waters and evaluates the potential risks to the health of people consuming contaminated fish or shellfish. Fish tissue sampling follows standard operating procedures described in *Texas Fish Consumption Advisory Program Standard Operating Procedures Field Operations and Data Quality.*[16] 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.*[17] Advice and direction are also received from the Fish Sampling Advisory Subcommittee of the legislatively mandated Texas Toxic Substances Coordinating Committee.[18] 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 Lake Worth 2016 Sample Set

In November 2016, the SALG collected 80 fish samples from 10 sample sites to provide spatial coverage of the study area (Figure 1): Site 1 Lake Worth (LWO) at the Dam; Site 2 LWO near the Naval Air Station; Site 3 LWO near the Carswell Field Runway; Site 4 LWO near Meandering Creek Road; Site 5 LWO at Woods Inlet; Site 6 LWO at Live Oak Creek; and, Site 7 LWO near Woods Island; Site 8 LWO near Mosque Point; Site 9 LWO at State Highway (SH) 199 Bridge; and, Site 10 at West Fork Trinity River. 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 80 fish collected from Lake Worth 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 (14); black and white crappie (10); smallmouth buffalo (10); white bass (10); channel catfish (9); freshwater drum (7); flathead catfish (7) largemouth bass (7); common carp (5); and, striped bass (1).

The survey team set gill nets at sample sites 1–10 in late afternoon (Figure 1); fished the sites overnight, and collected samples from the nets early the following morning. The gill nets were set at locations to maximize available cover and habitat at each sample site. During collection, to keep specimens from different sample sites separated, the team placed samples from each site into mesh bags labeled with the site number. The survey team immediately stored retrieved samples on wet ice in large coolers to ensure interim preservation. Survey team members returned to the reservoir any live fish culled from the catch and properly disposed of samples found dead in the gill nets.

The 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 electrofishing system settings: (6.0-8.0 amps, 60 pulses per second [pps], low range, 500 volts, 30-50% duty cycle and 1.0-2.0 amps, 15 pps, low range, 500 volts, 80-100% duty cycle) to stun fish that crossed the electric field in the water in front of the boat. Staff used dip nets over the bow of the boat to retrieve stunned fish, netting only fish pre-selected as target samples. Staff immediately stored retrieved samples on wet ice in large coolers to enhance tissue preservation.

The survey team utilized juglines (a fishing line with a three-way swivel, single circle hook, and bottom weight tied to a free-floating device) to target catfish species. The SALG staff baited lines with cut gizzard shad or smallmouth buffalo or live sunfish. The survey team targeted habitat likely to hold catfish species.

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

Fish Age Estimation

The SALG staff removed sagittal otoliths from blue catfish, black crappie, channel catfish, flathead catfish, largemouth bass, striped bass, white bass, and white crappie samples for age estimation following otolith extraction procedures recommended by the Gulf States Marine Fisheries Commission (GSMFC) and Texas Parks and Wildlife Department (TPWD) unpublished procedures.[19, 20] 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.[19, 20]

Analytical Laboratory Information

The GERG personnel documented receipt of the 80 Lake Worth samples and recorded the condition of each sample along with its DSHS identification number. Using established USEPA methods,[21] the GERG laboratory analyzed fish fillets from Lake Worth 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, 22] and 17 polychlorinated dibenzo-*p*-dioxins and/or dibenzofurans (PCDDs/PCDFs) congeners.[23] The laboratory analyzed all 80 samples for mercury, pesticides, PCBs and PCDDs/PCDFs. A subset of 16 of the original 80 samples was analyzed for the following contaminant groups: metals, SVOCs, and VOCs. The SALG risk assessors selected the subset of samples based on target species and size class selection procedures outlined in SALG standard operating procedures (SOPs). In addition to SALG SOPs, if available, the SALG risk assessors use TPWD creel surveys to determine the species of fish most frequently harvested from the body of water 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.

[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.

Details of Some Analyses with Explanatory Notes

Arsenic

The GERG laboratory analyzed five 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.[24] The DSHS, taking a conservative approach, estimated 10% of the total arsenic in any fish is inorganic arsenic and derived 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[e] in upper trophic level fish three years or older is methylmercury.[25] Thus, the total mercury concentration in a fish of legal size for possession in Texas serves well as a surrogate for methylmercury concentration. Because methylmercury analyses are difficult to perform accurately and are more expensive than total mercury analyses, the USEPA recommends that states determine total mercury concentration in a fish and that – to protect human health – states conservatively assume all reported mercury in fish or shellfish is methylmercury. The GERG laboratory thus analyzed fish tissues for total mercury. In its risk characterizations, the DSHS compared 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.[26]

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.[27] Tissue samples were extracted with methylene chloride in the presence of sodium sulfate and an aliquot of the extract was removed for lipid determination, filtered and concentrated to a known volume. A subsample is removed, the solvent is evaporated, the lipid residue weighed, and the percent lipid content is determined.

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[e] DSHS interchangeably utilizes the terms "mercury," "methylmercury," or "organic mercury" to refer to methylmercury in fish.

Polychlorinated Biphenyls (PCBs)

For PCBs, the USEPA suggests that each state measures congeners of PCBs in fish and shellfish rather than homologs[f] or Aroclors®[g] because the USEPA considers congener analysis the most sensitive technique for detecting PCBs in environmental media.[28,] Although only about 130 PCB congeners were routinely present in PCB mixtures manufactured and commonly used in the U.S. The GERG laboratory analyzes and reports the presence and concentrations of all 209 possible PCB congeners. From the congener analyses, the laboratory also computes and reports concentrations of PCB homologs and of Aroclor® mixtures. Despite the USEPA's suggestion that the states utilize PCB congeners rather than Aroclors® or homologs for toxicity estimates, the toxicity literature does not reflect state-of-the-art laboratory science. To accommodate this inconsistency, the DSHS utilizes recommendations from the National Oceanic and Atmospheric Administration (NOAA),[29] from McFarland and Clarke,[30] and from the USEPA's guidance documents for assessing contaminants in fish and shellfish.[17, 23] Based on evaluation of these recommendations, the DSHS selected 43 of 209 congeners to characterize "total" PCBs. The referenced authors chose to use congeners that were relatively abundant in the environment, were likely to occur in aquatic life, and likely to show toxic effects. SALG risk assessors summed the 43 congeners to derive "total" PCB concentration in each sample. SALG risk assessors then averaged the summed congeners within each group (e.g., fish species, sample site, or combination of species and site) to derive a mean PCB concentration for each group.

Using only a few PCB congeners to determine total PCB concentrations could underestimate PCB levels in fish tissue. Nonetheless, the method complies with expert recommendations on evaluation of PCBs in fish or shellfish. 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.[31] IRIS currently contains noncarcinogenic toxicity information for three Aroclor® mixtures: Aroclors® 1016, 1248, and 1254. IRIS does not contain complete information for all mixtures. For instance, IRIS has derived reference doses (RfDs) for Aroclors 1016 and 1254. Aroclor

[f] 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).
[g] 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).

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.[32] Noncarcinogenic 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 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.[31]

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.[33, 34]
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.[35]

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

CI = concentration of a given congener
TEF = toxicity equivalence factor for the given congener
n = # of congeners
i = initial congener
Σ = 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.[36] 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.[36]

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

In deriving HAC values for 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[37] or the ATSDR's chronic oral MRLs.[38] 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.[h] 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.*[39]

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.*[39]

The ATSDR uses a similar technique to derive its MRLs.[38] 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).*[40]

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

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[h] 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.

as the sum of HQs for contaminants to which an individual is exposed simultaneously – that computes to less than 1.0 should be interpreted as "no cause for concern" whereas, an HQ or HI greater than or equal to 1.0 "should indicate some cause for concern."

The SALG does not utilize HQs to determine the likelihood of occurrence of noncarcinogenic health effects. Instead, in a manner similar to the USEPA's decision process, the SALG 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 utilized 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.[38]

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.[37,39] 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.[39]

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 calculated 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 calculated 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 fish 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)[39] 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. [41, 42] 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.[43] 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.[44] 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.[37] Additionally, in accordance with the ATSDR's *Child Health Initiative*[45] and the USEPA's *National Agenda to Protect Children's Health from Environmental Threats,*[46] the DSHS further seeks to protect children from the possible negative effects of toxicants in fish by suggesting that this potentially sensitive subgroup consume smaller quantities of contaminated fish or shellfish than adults consume. Thus, the DSHS recommends that children weighing 35 kg or less and/or who are 11 years of age or younger limit exposure to contaminants in fish or shellfish by eating no more than four-ounces per meal of the contaminated species. The DSHS also recommends that consumers spread these meals over time. For instance, if the DSHS issues consumption advice that recommends consumption of no more than two meals per month of a contaminated species, those children should eat no more than 24 four ounce meals of the contaminated fish or shellfish per year and should not eat such fish or shellfish more than twice per month.

Data Analysis and Statistical Methods

The SALG risk assessors imported Excel© files into Systat® statistical software, version 13.1 installed on IBM-compatible microcomputers (Dell, Inc.), to generate descriptive statistics (mean, 95% confidence limits of the arithmetic mean, standard deviation, minimum, and maximum concentrations) for reported chemical contaminants.[47] In computing descriptive statistics, SALG risk assessors utilized ½ the reporting limit (RL) for analytes designated as not detected (ND) or estimated (J-values).[i] The SALG risk assessors calculated PCDDs/PCDFs descriptive statistics using estimated concentrations (J-values) and assuming zero for PCDDs/PCDFs designated as ND.[j] 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 mentioned 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 Lake Worth.[48] When lead concentrations in fish or shellfish are high, SALG risk assessors may utilize the USEPA's Interactive Environmental Uptake Bio-Kinetic (IEUBK) model to determine whether consumption of lead-contaminated fish could cause a child's blood lead (PbB) level to exceed the Centers for Disease Control and Prevention's (CDC) lead concentration of concern in children's blood (5 mcg/dL).[49, 50]

RESULTS

The GERG laboratory completed analyses and electronically transmitted the results of the Lake Worth samples collected November 2016 to the SALG in

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[i] "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.

[j] 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.

August 2017. 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 2.1–2.11 present the results of metals analyses. Tables 3.1–3.2 and 4.1–4.5 contain summary results for pesticides and PCBs, respectively. Tables 5.1–5.5 summarizes the PCDD/PCDF analyses. Table 6 depicts summary results for VOCs (i.e., trichlorofluoromethane). This report does not display SVOC data because these contaminants were not present at concentrations of concern in fish collected from Lake Worth 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

Arsenic, Cadmium, Copper, Lead, Selenium, and Zinc

The GERG laboratory analyzed a subset of 16 fish tissue samples for six inorganic contaminants. All fish tissue samples from Lake Worth contained concentrations of selenium and zinc (Tables 2.5 and 2.6).

The SALG evaluated three toxic metalloids having no known human physiological function (arsenic, cadmium, and lead) in the samples collected from Lake Worth. Total arsenic concentrations ranged from BDL to 0.182 mg/kg with a mean of 0.062±0.036 mg/kg (Table 2.1). Sixteen of 16 fish analyzed contained estimated concentrations below the RL for cadmium and lead (Tables 2.2 and 2.4).

Three of the metalloids analyzed are essential trace elements: copper, selenium, and zinc. Copper concentrations in fish tissue samples ranged from BDL to 1.605 mg/kg (Table 2.3). Selenium concentrations ranged from 0.155 to 0.487 mg/kg with a mean of 0.220±0.081 mg/kg (Table 2.5). All samples also contained zinc. The mean zinc concentration in fish tissue samples from Lake Worth was 4.156±1.197 mg/kg (Table 2.6).

Mercury

Eighty of 80 fish tissue samples evaluated from Lake Worth contained mercury (Table 2.7–2.11). Mercury concentrations ranged from 0.028 to

0.633 mg/kg. The mean mercury concentration for the 80 fish tissue samples analyzed was 0.167±0.111 mg/kg.

Organic Contaminants

Pesticides

All samples examined contained concentrations of chlordane and 4,4′-dichlorodiphenyldichloroethylene (DDE). Chlordane (total) concentrations ranged from BDL to 0.0683 mg/kg with a mean of 0.0047±0.0093 mg/kg (Table 3.2). DDT (total) [2,4′-DDE + 4,4′-DDE + 2,4′-DDD + 4,4′-DDD + 2,4′-DDT + 4,4′-DDT] ranged from BDL to 0.0461 mg/kg with a mean 0.0063±0.0080 mg/kg (Table 3.2). Dieldrin ranged from ND to 0.0042 mg/kg with a mean 0.0003±0.0006 mg/kg (Table 3.1). Aldrin concentrations were reported in two of 80 fish tissues samples analyzed (Table 3.1). Estimated to low concentrations greater than the reporting limit of chlorpyrifos, endosulfan II, endrin, hexachlorobenzene, heptachlor epoxide, and pentachloroanisole were present in one or more fish samples (data not presented). Estimated concentrations were reported for alpha HCH, mirex, pentachlorobenzene, and tetrachlorobenzene (data not presented).

PCBs

All fish tissue samples evaluated from Lake Worth contained PCBs (Tables 4.1–4.5). Across all sample sites and species, PCB concentrations ranged from 0.005 to 0.304 mg/kg (smallmouth buffalo). The mean PCB concentration for the 80 fish tissue samples evaluated was 0.032±0.050 mg/kg.

Black crappie

Five black crappie ranging from 10.3 to 12.1 inches TL ($\overline{X}$ – 11.2 inches TL) and from two to six years of age were analyzed for PCBs (Table 1; Figure 2). One-hundred percent of the white crappie samples examined were of legal size (≥ 10 inches TL).[51] PCB concentrations ranged from 0.005 to 0.007 mg/kg with a mean of 0.005±0.001 mg/kg (Tables 4.1–4.5).

Blue catfish

Fourteen blue catfish ranging from 12.4 to 45.1 inches TL ($\overline{X}$ – 21.7 inches TL) and from one to 12 years of age were analyzed for PCBs (Table 1; Figure 3). One-hundred percent of the channel catfish samples examined were of legal size (≥ 12 inches TL).[51] PCB concentrations ranged from 0.007 to 0.057 mg/kg with a mean of 0.019±0.015 mg/kg (Tables 4.1–4.5).

Channel catfish

Nine channel catfish ranging from 14.6 to 22.7 inches TL ($\bar{X}$ – 18.2 inches TL) and from two to eight years of age were analyzed for PCBs (Table 1; Figure 4). One-hundred percent of the channel catfish samples examined were of legal size (≥ 12 inches TL).[52] PCB concentrations ranged from 0.005 to 0.092 mg/kg with a mean of 0.020±0.028 mg/kg (Tables 4.1–4.5).

Common carp

Five common carp ranging from 21.4 to 27.4 inches TL ($\bar{X}$ – 23.7 inches TL) were analyzed for PCBs (Table 1). Currently, there is no minimum length limit for common carp in Texas waters.[51] PCB concentrations ranged from 0.010 to 0.112 mg/kg with a mean of 0.034±0.044 mg/kg (Tables 4.1–4.5).

Flathead catfish

Seven flathead catfish ranging from 20.9 to 46.7 inches TL ($\bar{X}$ – 33.5 inches TL) and from two to 21 years of age were analyzed for PCBs (Table 1; Figure 5). One-hundred percent of the flathead catfish samples examined were of legal size (≥ 18 inches TL).[51] PCB concentrations ranged from 0.014 to 0.126 mg/kg with a mean of 0.043±0.040 mg/kg (Tables 4.1–4.5).

Freshwater drum

Seven freshwater drum ranging from 13.9 to 22.1 inches TL ($\bar{X}$ – 18.0 inches TL) were analyzed for PCBs (Table 1). Currently, there is no minimum length limit for freshwater drum in Texas waters.[51] PCB concentrations ranged from 0.006 to 0.023 mg/kg with a mean of 0.012±0.007 mg/kg (Tables 4.1–4.5).

Largemouth bass

Seven largemouth bass ranging from 17.6 to 21.7 inches TL ($\bar{X}$ – 19.5 inches TL) and from three to seven years of age were analyzed for PCBs (Table 1; Figure 6). One-hundred percent of the largemouth bass samples examined were of legal size (≥ 14 inches TL).[51] PCB concentrations ranged from 0.006 to 0.014 mg/kg with a mean of 0.009±0.003 mg/kg (Tables 4.1–4.5).

Smallmouth buffalo

Ten smallmouth buffalo ranging from 22.6 to 30.4 inches TL ($\bar{X}$ – 25.5 inches TL) were analyzed for PCBs (Table 1). Currently, there is no minimum length limit for smallmouth buffalo in Texas waters.[51] PCB concentrations ranged from 0.022 to 0.304 mg/kg with a mean of 0.106±0.088 mg/kg (Tables 4.1–4.5).

Striped bass

One striped bass was 23.2 inches TL and three years of age. The striped bass sample examined was of legal size (≥ 18 inches TL).[51] The PCB concentration of the single striped bass was 0.035 mg/kg (Tables 4.1–4.5).

White bass

Ten white bass ranging from 11.0 to 15.6 inches TL ($\bar{X}$ – 13.1 inches TL) and from one to four years of age were analyzed for PCBs (Table 1; Figure 7). One-hundred percent of the white bass samples examined were of legal size (≥ 10 inches TL).[51] PCB concentrations ranged from 0.009 to 0.186 mg/kg with a mean of 0.035±0.054 mg/kg (Tables 4.1–4.5).

White crappie

Five white crappie ranging from 10.7 to 12.0 inches TL ($\bar{X}$ – 11.4 inches TL) and from two to six years of age were analyzed for PCBs (Table 1; Figure 8). One-hundred percent of the white crappie samples examined were of legal size (≥ 10 inches TL).[51] PCB concentrations ranged from 0.005 to 0.007 mg/kg with a mean of 0.006±0.001 mg/kg (Tables 4.1–4.5).

PCDDs/PCDFs

Eighty of 80 fish tissue samples contained at least one of the 17 PCDD/PCDF congeners ranging from 0.026–15.333 TEQ pg/g with a mean of 2.067±2.656 TEQ pg/g (Table 5.1–5.5). No samples contained all 17 congeners (data not shown). Smallmouth buffalo contained the highest mean PCDD/PCDF TEQ concentration (5.533±3.898 pg/g; Table 5.5).

SVOCs

The GERG laboratory analyzed a subset of 16 Lake Worth fish tissue samples for SVOCs. Quantifiable concentrations greater than the reporting limit were reported for phenol in one fish sample (data not presented). Estimated concentrations of phenol, diethyl phthalate, and bis (2-ethylhexyl) phthalate were present in one or more fish samples analyzed (data not presented). The laboratory detected no other SVOCs in fish from Lake Worth.

VOCs

The Texas Fish Consumption Advisory Program Standard Operating Procedures Field Operations and Data Quality contain a complete list of the 70 VOCs selected for analysis. A subset of 16 fish tissue samples were selected for analysis from Lake Worth. Trichlorofluoromethane concentrations ranged from 0.065–0.810 mg/kg with a mean of 0.225±0.183 mg/kg (Table 6). Quantifiable concentrations greater than the reporting limit were reported for acetone, ethylbenzene, methylene chloride, m+p-xylene, o-xylene, and toluene, in one or more fish samples (data not presented in tables). Estimated quantities of toluene and 1,2,3-trichlorobenzene were also present in one or more fish tissue samples analyzed from Lake Worth (data not presented).

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

DISCUSSION

Risk Characterization

Because variability and uncertainty are inherent to quantitative assessment of risk, the calculated risks of adverse health outcomes from exposure to toxicants can be orders of magnitude above or below actual risks. Variability in calculated and in actual risk may depend upon factors such as the use of animal instead of human studies, use of subchronic rather than chronic studies, interspecies variability, intra-species variability, and database insufficiency. Because most factors used to calculate comparison values result from experimental studies conducted in the laboratory on nonhuman subjects, variability and uncertainty might arise from the study chosen as the "critical" one, the species/strain of animal used in the critical study, the target organ selected as the "critical organ," exposure periods, exposure route, doses, or uncontrolled variations in other conditions.[37] Despite such limitations, risk assessors must calculate parameters to represent potential toxicity to humans who consume contaminants in fish and other environmental media. The DSHS calculated risk parameters for noncarcinogenic and carcinogenic endpoints in those who would consume fish from the Lake Worth. 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 Noncarcinogenic Health Effects from Consumption of Fish from Lake Worth

Inorganic Contaminants

None of the species of fish evaluated contained arsenic, cadmium, copper, lead, mercury, selenium, or zinc at concentrations at or above DSHS guidelines for protection of human health.

Organic Contaminants

PCBs and PCDDs/PCDFs were observed in fish from Lake Worth at concentrations at or above respective HAC_{nonca} (0.047 mg/kg; 1.630 pg/g; Tables 4.1–4.5, 5.1–5.5, and 8.1–8.3). None of the species of fish evaluated contained any other organic contaminants at concentrations at or above DSHS guidelines for protection of human.

PCBs

All fish tissue samples (n = 80) evaluated contained PCBs. Sixteen percent of all samples analyzed contained PCB concentrations exceeding the HAC_{nonca} for PCBs (0.047 mg/kg; Tables 4.1–4.5). One (smallmouth buffalo) of the 11 species of fish evaluated had mean PCB concentrations exceeding the HAC_{nonca} for PCBs or an HQ of 1.0 (Tables 4.1–4.5 and 8.1–8.3). The all fish combined mean PCB concentration (0.032 mg/kg) did not exceed the HAC_{nonca} for PCBs or an HQ 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 Lake Worth that healthy adults could consume without significant risk of PCB-related adverse noncarcinogenic effects (Tables 8.1–8.3). Meal consumption rates were based on the overall mean PCB concentration by species. The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week of smallmouth buffalo. The SALG risk assessors estimated that people should not consume more than 0.4 meals per week. The SALG risk assessors suggest that smallmouth buffalo from Lake Worth contain PCBs at concentrations that may pose potential noncarcinogenic health risks and that people should limit their consumption of smallmouth buffalo from Lake Worth. Because the developing nervous system of the human fetus and young children may be especially susceptible to adverse noncarcinogenic health effects associated with consuming PCB-contaminated fish, the SALG risk assessors recommend more conservative consumption guidance for this sensitive subpopulation.

PCDDs/PCDFs

Eighty of 80 fish tissue samples assayed contained PCDDs/PCDFs. Thirty-nine percent of all samples analyzed contained PCDD/PCDF concentrations exceeding the HAC_{nonca} for PCDDs/PCDFs (1.630 pg/g; Tables 5.1–5.5 and 8.1–8.3). Five (blue catfish, flathead catfish, freshwater drum, smallmouth buffalo, and white bass) of 11 species of fish evaluated had mean PCDD/PCDF concentrations exceeding the HAC_{nonca} for PCDDs/PCDFs or an HQ of 1.0 (Tables 5.1–5.5 and 8.1–8.3). The all fish combined mean PCDD/PCDF concentration exceeded the HAC_{nonca} for PCDDs/PCDFs or an HQ of 1.0. The consumption of fish from Lake Worth may pose potential noncarcinogenic health risks from exposures to PCDDs/PCDFs.

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 Lake Worth that healthy adults could consume without significant risk of PCDD/PCDF -related adverse systemic effects (Tables 8.1–8.3). Meal consumption rates were based on the overall mean PCDD/PCDF concentration by species. The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week of for the following species of fish: blue catfish (0.8 meals per week), flathead catfish (0.3 meals per week), freshwater drum (0.9 meals per week), smallmouth buffalo (0.3 meals per week), or white bass (0.9 meals per week). The SALG risk assessors suggest that fish from Lake Worth contain PCDDs/PCDFs at concentrations that may pose potential noncarcinogenic health risks and that people should limit their consumption of blue catfish, flathead catfish, freshwater drum, smallmouth buffalo, or white bass from Lake Worth. 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 Lake Worth

The USEPA classifies arsenic, most chlorinated pesticides, PCBs, and PCDDs/PCDFs as human carcinogens. Arsenic, chlordane, dieldrin, and DDT (total) were present in fish samples analyzed from Lake Worth, 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 (Tables 9.1–9.6).

PCBs

The mean PCB concentrations observed in observed in fish from Lake Worth did not 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 9.1–9.6). However, PCB concentrations at or above the HAC_{ca} for PCBs were observed in one or more samples of smallmouth buffalo. The all fish combined mean PCB concentration did not exceed the HAC_{ca} for PCBs.

PCDDs/PCDFs

The mean PCDD/PCDF concentrations observed in flathead catfish and smallmouth buffalo 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 9.1–9.6). The all fish combined mean PCDD/PCDF concentration did not exceed the HAC_{ca} for PCDDs/PCDFs. The consumption of flathead catfish and smallmouth buffalo from Lake Worth would be likely to increase the risk of cancer to exceed the DSHS guideline for protection of human health.

The SALG risk assessors calculated the number of eight-ounce meals of flathead catfish and smallmouth buffalo from Lake Worth that healthy adults could consume without significantly increasing their lifetime excess cancer risk (Tables 9.1–9.6). The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week of flathead catfish (0.7 meals per week) or smallmouth buffalo (0.6 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 flathead catfish and smallmouth buffalo from Lake Worth 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 Noncarcinogenic Health Effects and of Cumulative Excess Lifetime Cancer Risk from Consumption of Fish from Lake Worth

Cumulative Noncarcinogenic Health Effects

Cumulative 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 Lake Worth could have these properties, especially with respect to effects on the immune system. Multiple organic contaminants in Lake Worth fish increased the likelihood of noncarcinogenic adverse health outcomes for all species of fish evaluated (Tables 8.1–8.3). The combined toxicity of PCBs and PCDDs/PCDFs in blue catfish, common carp, flathead catfish, freshwater drum, 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 Lake Worth that healthy adults could consume without significant risk of PCB and/or PCDD/PCDF -related adverse systemic effects (Tables 8.1–8.3). Meal consumption rates were based on cumulative toxicity from exposure to PCBs and PCDDs/PCDFs by species. The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week of blue catfish, channel catfish, common carp, flathead catfish, freshwater drum, smallmouth buffalo, striped bass, or white bass (Tables 8.1–8.3). The SALG risk assessors suggest that blue catfish, channel catfish, common carp, flathead catfish, freshwater drum, smallmouth buffalo, striped bass, and white bass from Lake Worth contain PCBs and PCDDs/PCDFs at concentrations in combination that may pose potential noncarcinogenic health risks and that people should limit their consumption of fish from Lake Worth. 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 PCDDs/PCDFs (Tables 9.1–9.6). In each instance, addition of the cancer risk for these chemicals increased the theoretical lifetime excess cancer risk. The cancer risk increase did not 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 most species of fish from Lake Worth. However, the consumption of flathead catfish and smallmouth buffalo from Lake Worth would be likely to increase the risk of cancer to exceed the DSHS guideline for protection of human health from exposures to PCDDs/PCDFs.

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 Lake Worth, located in Tarrant County, Texas. Confidence in the conclusions for many species of fish is limited by the small sample size. Sampling a small number of fish (i.e., individual species of fish or all fish species combined) decreases the confidence of mean contaminant concentrations for the fish population thus adding uncertainty to the conclusions. Risk assessors from the SALG conclude from the present characterization of potential adverse health effects from consuming fish from Lake Worth that:

1. Black crappie, blue catfish, channel catfish, common carp, flathead catfish, freshwater drum, largemouth bass, smallmouth buffalo, striped bass, white bass, and white crappie 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 species of fish containing the above-listed contaminants **poses no apparent risk to human health**.

2. Black crappie, blue catfish, channel catfish, common carp, flathead catfish, freshwater drum, largemouth bass, striped bass, white bass, and white crappie mean PCB concentrations do not exceed the DSHS guidelines for protection of human health. Therefore, consumption of these species of fish containing only PCBs **poses no apparent risk to human health**.

3. Black crappie, channel catfish, common carp, largemouth bass, striped bass, and white crappie mean PCDD/PCDF TEQ concentrations do not exceed the DSHS guidelines for protection of human health. Therefore, consumption of these species of fish containing only PCDDs/PCDFs **poses no apparent risk to human health**.

4. Smallmouth buffalo mean PCB concentrations exceed the DSHS guidelines for protection of human health. Regular or long-term consumption of smallmouth buffalo may result in adverse noncarcinogenic health effects and/or increase the likelihood of carcinogenic health risks. Therefore, consumption of smallmouth buffalo from Lake Worth containing only PCBs **poses an apparent risk to human health**.

5. Blue catfish, flathead catfish, freshwater drum, smallmouth buffalo, and white bass mean PCDD/PCDF TEQ concentrations exceed the DSHS guidelines for protection of human health. Regular or long-term consumption of these species of fish may result in adverse noncarcinogenic health effects and/or increase the likelihood of carcinogenic health risks. Therefore, consumption of these species of fish from Lake Worth **poses an apparent risk to human health**.

6. Consumption of multiple organic contaminants (i.e., PCDDs/PCDFs and PCBs) in blue catfish, common carp, flathead catfish, freshwater drum, smallmouth buffalo, striped bass, and white bass increases the likelihood of noncarcinogenic health risks. Regular or long-term consumption of these species of fish may result in adverse noncarcinogenic health effects. Therefore, consumption of these species of fish from Lake Worth **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.[17, 23, 53] 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 (women past childbearing age [women 50 and older] and males 12 and older: eight-ounces per meal; women of childbearing age [women and girls under 50] and children less than 12: 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).[54] Declarations of prohibited harvesting areas are enforceable under the Texas Health and Safety Code, Subchapter D, parts 436.091 and 436.101.[54] 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 blue catfish, common carp, flathead catfish, freshwater drum, smallmouth buffalo, striped bass, and white bass from Lake Worth **poses an apparent hazard to public health.** Therefore, SALG risk assessors recommend that:

- People should not consume smallmouth buffalo from Lake Worth (Table 10).

- Women of childbearing age (Women and girls under 50) including pregnant women, women who may become pregnant, and women who are nursing infants and children less than 12 years of age, or who weigh less than 75 pounds should not consume flathead catfish from Lake Worth.

- Women of childbearing age (Women and girls under 50) including pregnant women, women who may become pregnant, and women who are nursing infants and children less than 12 years of age, or who weigh less than 75 pounds may consume up to one four-ounce meal per month of blue catfish, common carp, freshwater drum, striped bass, or white bass from Lake Worth.

- Women past childbearing age (Women 50 and older) and males 12 and older may consume up to one eight-ounce meal per month of flathead catfish from Lake Worth.

- Women past childbearing age (Women 50 and older) and males 12 and older may consume up to two eight-ounce meals per month of blue catfish, common carp, striped bass, or white bass from Lake Worth.

- Women past childbearing age (Women 50 and older) and males 12 and older may consume up to three eight-ounce meals per month of freshwater drum from Lake Worth.

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

PUBLIC HEALTH ACTION PLAN

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

- The SALG posts the most current information about advisories, bans, and the removal of either on the internet at http://www.dshs.texas.gov/seafood.[55] The SALG regularly updates this Web site.
- The SALG also provides fish consumption advisory information through the Texas Fish Consumption Advisory Viewer (TFCAV; http://www.dshs.texas.gov/seafood/TFCAV.aspx). The TFCAV is an interactive map that allows users to identify current water body-specific health advisory information for fish from Texas waters.[56]
- The agency publishes fish consumption advisories and bans in a booklet available to the public through the SALG Web site (http://www.dshs.texas.gov/seafood/PDF2/HlthAdvisories/HealthAdvisoryGuide2016/). To receive the booklet and/or the data, please contact the SALG at 512-834-6757.[57]
- The DSHS also provides the USEPA (https://www.epa.gov/fish-tech), the TCEQ (http://www.tceq.texas.gov), and the TPWD (http://www.tpwd.texas.gov) 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://tpwd.texas.gov/regulations/outdoor-annual/. A booklet containing this information is available at all establishments selling Texas fishing licenses.[51]

Communication to the public of scientific information related to this risk characterization and information for environmental contaminants found in fish 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.texas.gov/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. Lake Worth Map

Figure 2. Length at age for black crappie collected from Lake Worth, Texas, 2016.

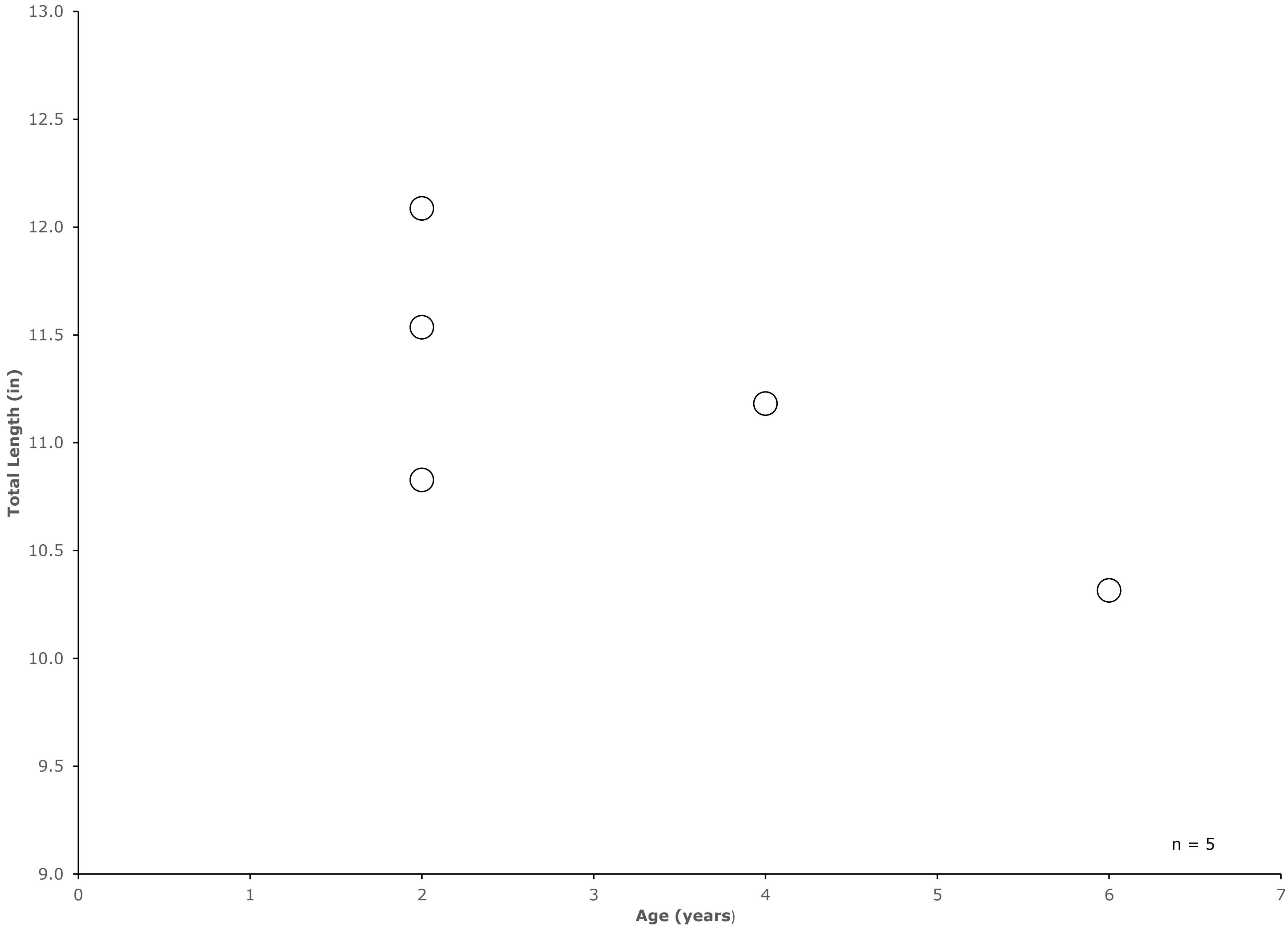


Figure 3. Length at age for blue catfish collected from Lake Worth, Texas, 2016.

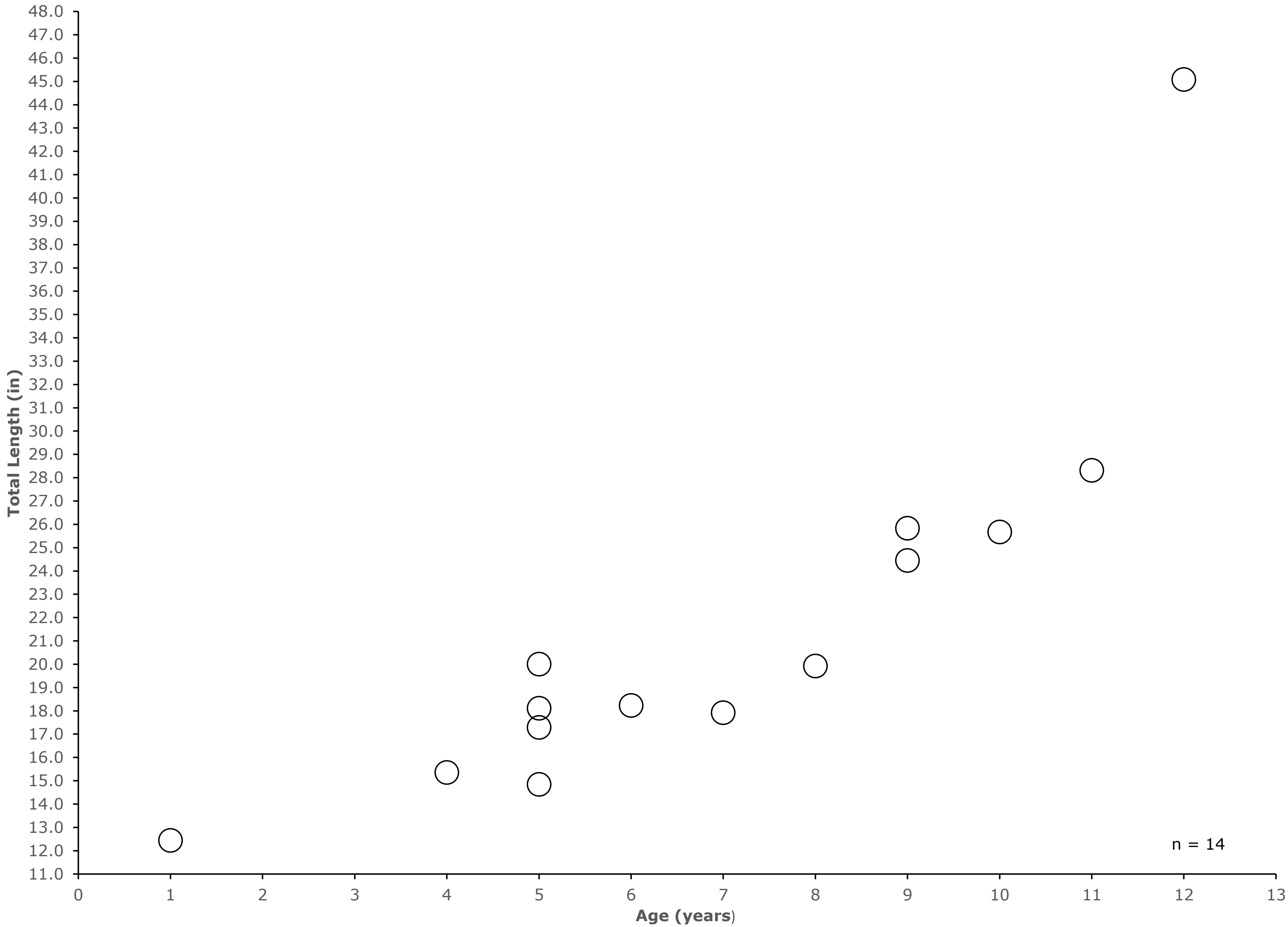


Figure 4. Length at age for channel catfish collected from Lake Worth, Texas, 2016.

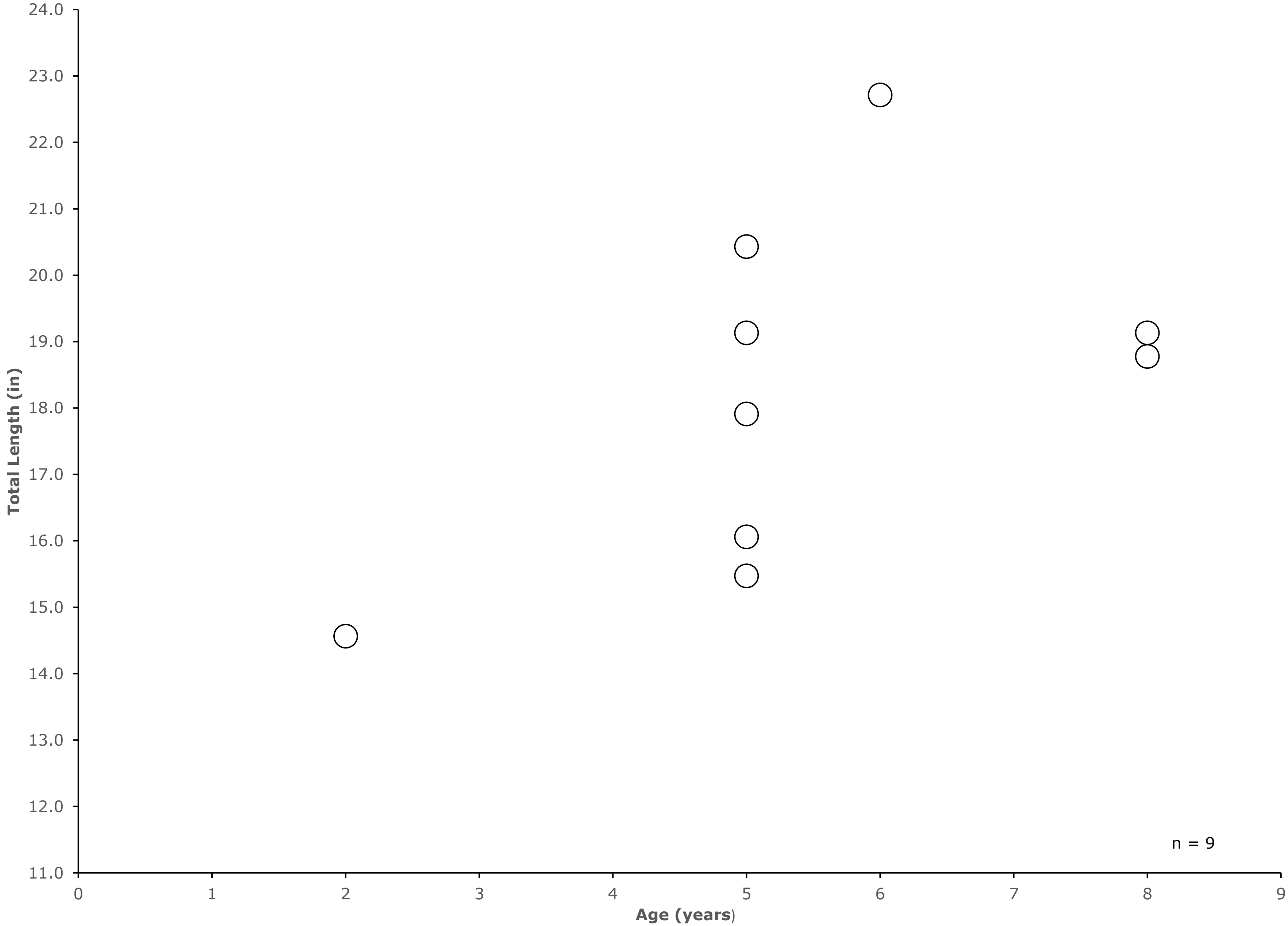


Figure 5. Length at age for flathead catfish collected from Lake Worth, Texas, 2016.

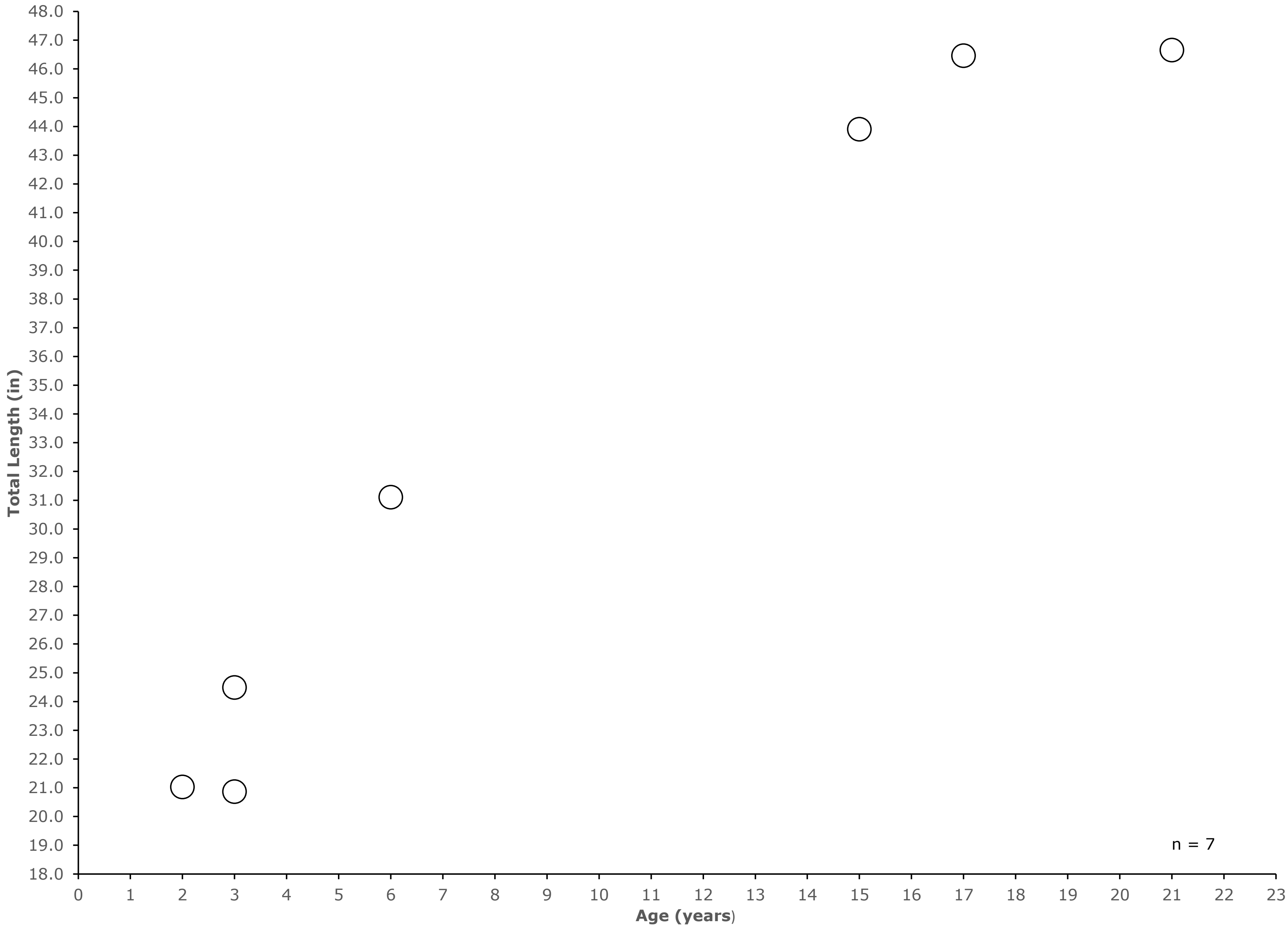


Figure 6. Length at age for largemouth bass collected from Lake Worth, Texas, 2016.

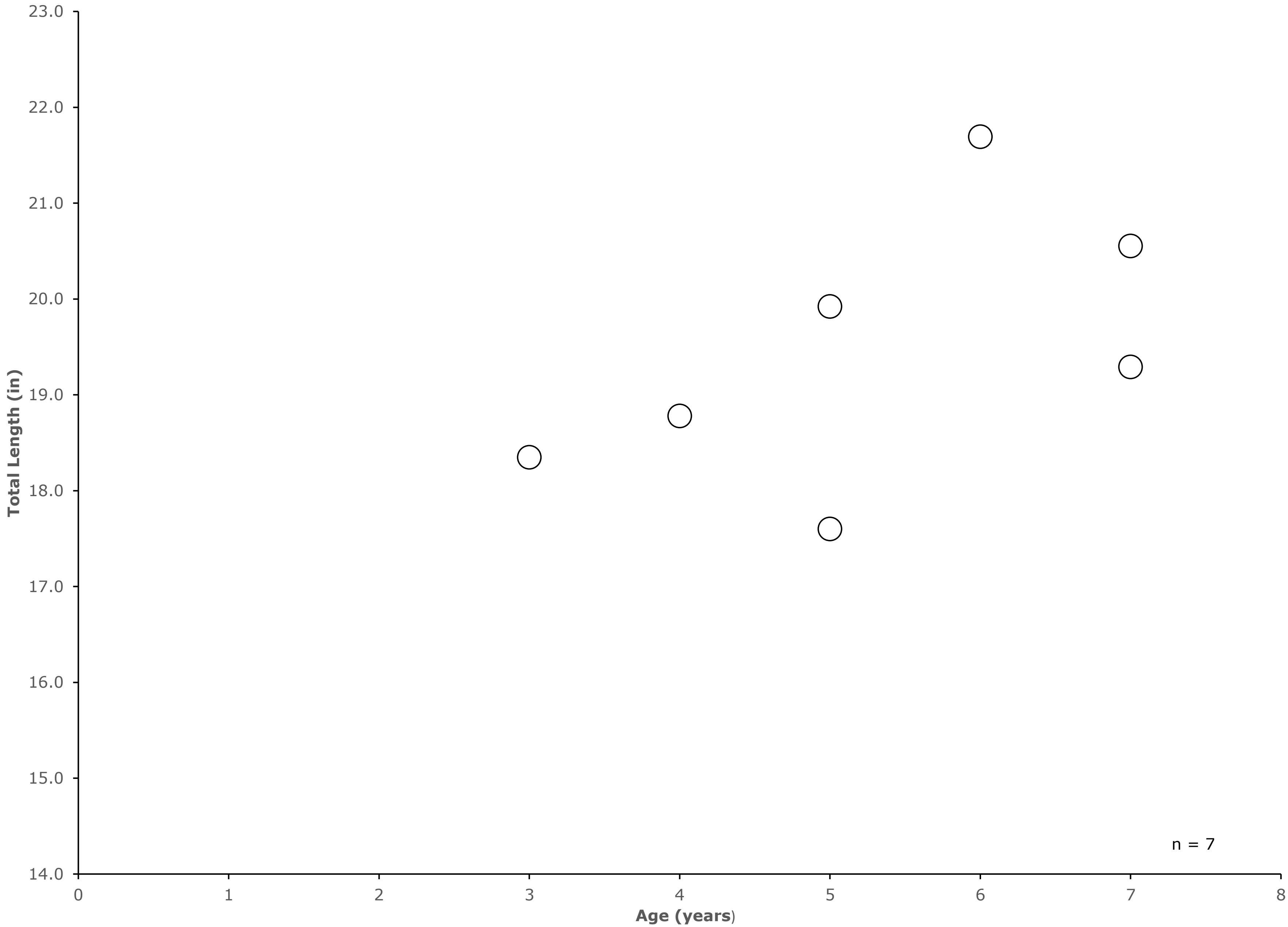


Figure 7. Length at age for white bass collected from Lake Worth, Texas, 2016.

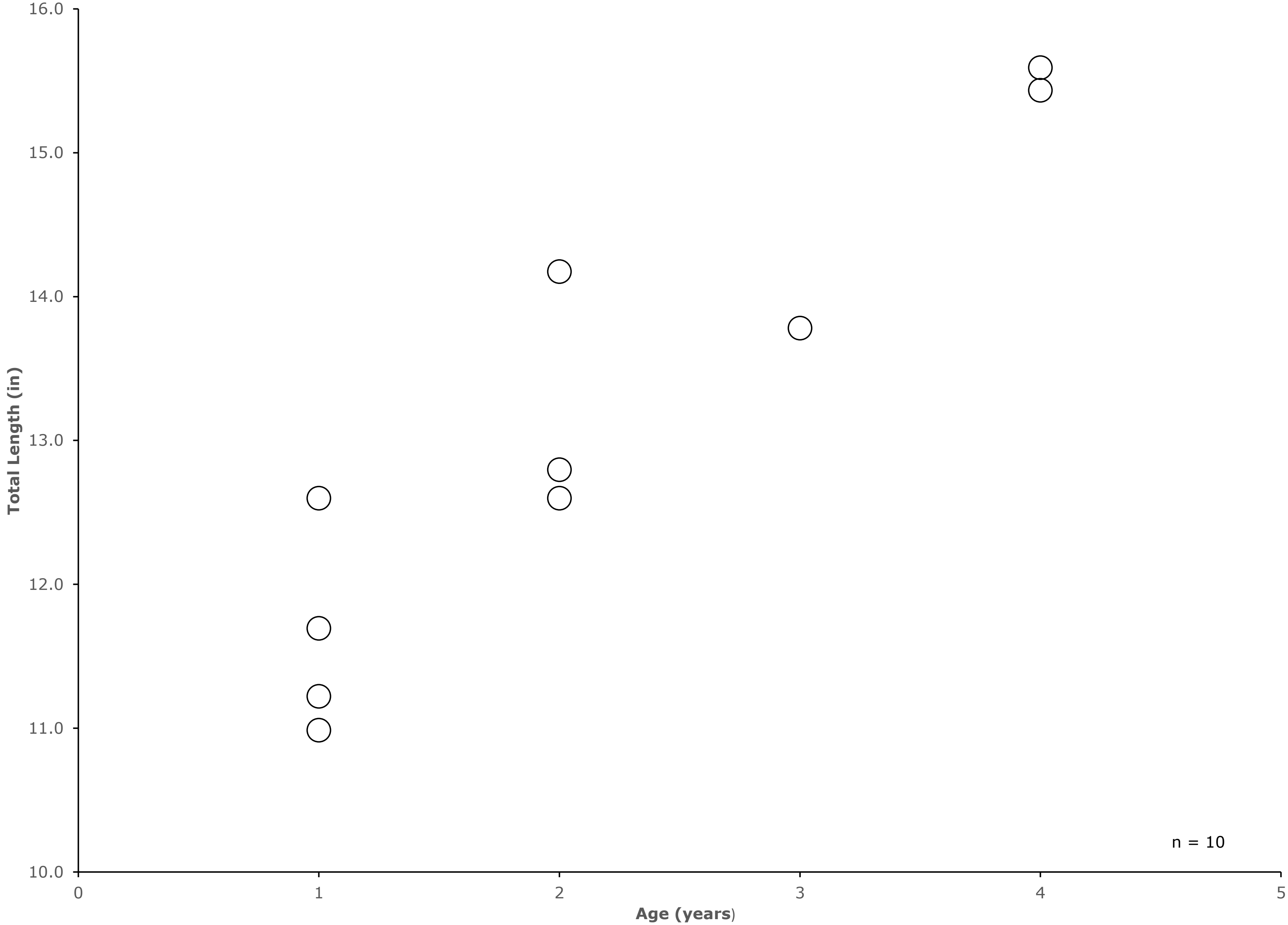
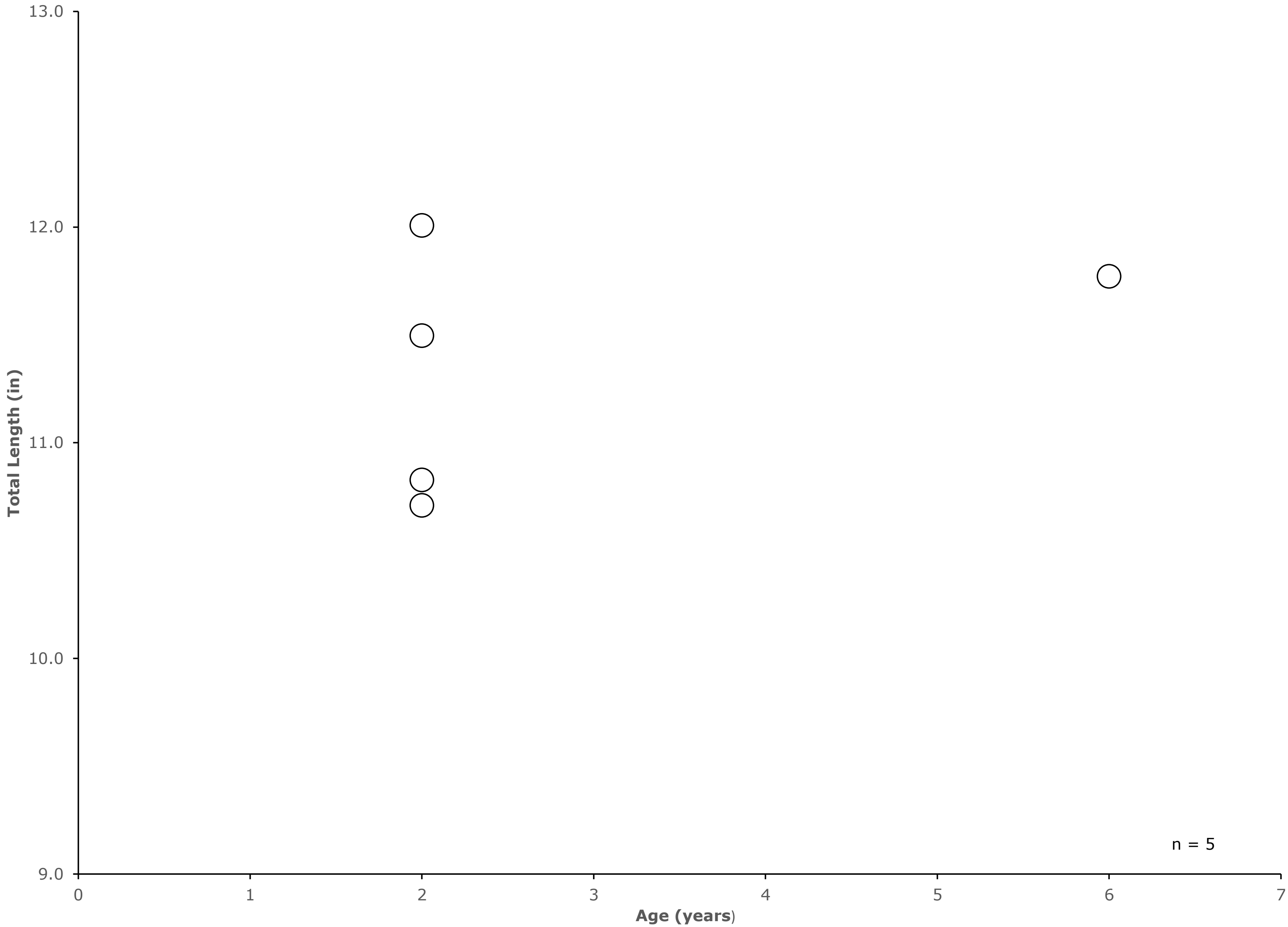


Figure 8. Length at age for white crappie collected from Lake Worth, Texas, 2016.



TABLES

Table 1. Fish samples collected from Lake Worth 2016. Sample number, species, total length, and weight recorded for each sample.

Sample Number	Species	Total Length		Weight	
		Millimeters (mm)	Inches (in)	Grams (g)	Pounds (lb)
Site 1 Lake Worth at Dam					
LWO1	Channel catfish	408	16.1	534	1.2
LWO2	Channel catfish	486	19.1	1018	2.2
LWO4	Largemouth bass	551	21.7	2928	6.5
LWO5	Largemouth bass	466	18.3	1620	3.6
LWO8	Black crappie	284	11.2	373	0.8
LWO9	Common carp	696	27.4	5066	11.2
LWO10	Blue catfish	621	24.4	2626	5.8
LWO11	Channel catfish	577	22.7	2075	4.6
LWO12	Striped bass	590	23.2	2716	6.0
LWO13	Smallmouth	687	27.0	5920	13.1
Site 2 Lake Worth near Naval Air Station					
LWO14	Freshwater drum	436	17.2	1246	2.7
LWO19	Largemouth bass	506	19.9	1805	4.0
LWO20	Largemouth bass	447	17.6	1153	2.5
LWO22	White bass	279	11.0	207	0.5
LWO23	White crappie	275	10.8	337	0.7
LWO24	Blue catfish	656	25.8	2885	6.4
LWO77	Smallmouth	634	25.0	5296	11.7
Site 3 Lake Worth near Carswell Field Runway					
LWO25	Smallmouth	771	30.4	8857	19.5
LWO91	Channel catfish	393	15.5	508	1.1
LWO92	Flathead catfish	530	20.9	1535	3.4
Site 4 Lake Worth near Meandering Creek Road					
LWO87	White crappie	272	10.7	302	0.7
LWO88	White bass	285	11.2	278	0.6
LWO89	Freshwater drum	354	13.9	476	1.0
LWO90	Smallmouth	575	22.6	3919	8.6
Site 5 Lake Worth at Woods Inlet					
LWO26	Common carp	648	25.5	3514	7.7
LWO27	Largemouth bass	477	18.8	1508	3.3
LWO28	White crappie	299	11.8	414	0.9
LWO29	Blue catfish	652	25.7	3543	7.8
LWO67	White crappie	305	12.0	479	1.1
LWO70	Black crappie	262	10.3	272	0.6
LWO72	Freshwater drum	474	18.7	1434	3.2
LWO73	Freshwater drum	510	20.1	2028	4.5
LWO76	Smallmouth	590	23.2	4696	10.4

Table 1. cont. Fish samples collected from Lake Worth 2016. Sample number, species, total length, and weight recorded for each sample.					
Sample Number	**Species**	**Total Length**		**Weight**	
		Millimeters (mm)	**Inches (in)**	**Grams (g)**	**Pounds (lb)**
Site 6 Lake Worth at Live Oak Creek					
LWO31	White crappie	292	11.5	464	1.0
LWO66	Blue catfish	506	19.9	1195	2.6
LWO78	Smallmouth	594	23.4	4156	9.2
LWO79	Channel catfish	455	17.9	796	1.8
LWO80	Channel catfish	477	18.8	832	1.8
LWO81	Blue catfish	463	18.2	846	1.9
LWO82	White bass	320	12.6	384	0.8
LWO84	Black crappie	275	10.8	284	0.6
LWO85	Black crappie	307	12.1	470	1.0
LWO86	Largemouth bass	490	19.3	2132	4.7
Site 7 Lake Worth near Woods Island					
LWO32	Smallmouth	700	27.6	6485	14.3
LWO33	Largemouth bass	522	20.6	2370	5.2
LWO34	Common carp	544	21.4	2415	5.3
LWO35	Freshwater drum	466	18.3	1303	2.9
LWO36	Freshwater drum	404	15.9	787	1.7
LWO46	Flathead catfish	1180	46.5	22450	49.5
LWO47	Flathead catfish	1115	43.9	18240	40.2
LWO48	Flathead catfish	1185	46.7	18360	40.5
LWO49	Blue catfish	460	18.1	835	1.8
LWO50	Blue catfish	377	14.8	358	0.8
LWO51	Blue catfish	390	15.4	483	1.1
LWO52	Blue catfish	455	17.9	827	1.8
LWO53	Channel catfish	486	19.1	794	1.8
LWO54	White bass	320	12.6	277	0.6
LWO55	White bass	360	14.2	583	1.3
Site 8 Lake Worth near Mosque Point					
LWO57	Channel catfish	370	14.6	366	0.8
LWO58	Blue catfish	316	12.4	239	0.5
LWO59	Blue catfish	439	17.3	657	1.4
LWO60	Flathead catfish	534	21.0	1500	3.3
LWO61	Flathead catfish	622	24.5	2479	5.5
LWO62	Freshwater drum	562	22.1	2598	5.7
LWO63	White bass	350	13.8	466	1.0
LWO64	White bass	396	15.6	645	1.4

Table 1. cont. Fish samples collected from Lake Worth 2016. Sample number, species, total length, and weight recorded for each sample.					
Sample Number	Species	Total Length		Weight	
		Millimeters (mm)	Inches (in)	Grams (g)	Pounds (lb)
Site 9 Lake Worth at SH 199 Bridge					
LWO38	Smallmouth	607	23.9	4946	10.9
LWO39	Common carp	563	22.2	2523	5.6
LWO40	Blue catfish	508	20.0	1185	2.6
LWO93	Flathead catfish	790	31.1	6646	14.7
LWO94	Smallmouth	675	26.6	6232	13.7
LWO95	White bass	392	15.4	743	1.6
LWO96	White bass	325	12.8	355	0.8
LWO97	Black crappie	293	11.5	423	0.9
Site 9 Lake Worth at SH 199 Bridge					
LWO41	Smallmouth	650	25.6	5998	13.2
LWO42	Common carp	558	22.0	2383	5.3
LWO43	Blue catfish	719	28.3	3881	8.6
LWO44	Blue catfish	1145	45.1	5822	12.8
LWO45	Channel catfish	519	20.4	1520	3.4
LWO56	White bass	297	11.7	312	0.7

Table 2.1. Arsenic (mg/kg) in fish collected from Lake Worth by species, 2016.					
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**
Blue catfish	9/9	0.072±0.047 (BDL-0.182)	0.007	0.700	EPA Chronic Oral RfD for Inorganic Arsenic — 0.0003 mg/kg–day
Flathead catfish	7/7	BDL	BDL		
All fish combined	16/16	0.062±0.036 (BDL-0.182)	0.006	0.363	EPA Oral Slope Factor for Inorganic Arsenic — 1.5 per mg/kg–day

Table 2.2. Cadmium (mg/kg) in fish collected from Lake Worth by species, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Blue catfish	9/9	BDL	0.233	ATSDR Chronic Oral MRL— 0.0001 mg/kg–day
Flathead catfish	7/7	BDL		
All fish combined	16/16	BDL		

[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 2.3. Copper (mg/kg) in fish collected from Lake Worth by species, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Blue catfish	9/9	BDL	334	Based on the Tolerable Upper Intake Level (UL) — 0.143 mg/kg–day[m]
Flathead catfish	7/7	0.401±0.531 (BDL-1.605)		
All fish combined	16/16	0.288±0.351 (BDL-1.605)		

Table 2.4. Lead (mg/kg) in fish collected from Lake Worth by species, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Blue catfish	9/9	BDL	N/A	N/A
Flathead catfish	7/7	BDL		
All fish combined	16/16	BDL		

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

Table 2.5. Selenium (mg/kg) in fish collected from Lake Worth by species, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Blue catfish	9/9	0.243±0.103 (0.155-0.487)	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, 58]
Flathead catfish	7/7	0.190±0.020 (0.160-0.216)		
All fish combined	16/16	0.220±0.081 (0.155-0.487)		

Table 2.6. Zinc (mg/kg) in fish collected from Lake Worth by species, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Blue catfish	9/9	4.304±1.531 (3.319-8.087)	700	EPA Chronic Oral RfD — 0.3 mg/kg–day
Flathead catfish	7/7	3.965±0.618 (3.113-4.770)		
All fish combined	16/16	4.156±1.197 (3.113-8.087)		

[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 2.7. Mercury (mg/kg) in fish collected from Lake Worth by sample site, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Site 1 Lake Worth at Dam				
Black crappie	1/1	0.192	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Blue catfish	1/1	0.202		
Channel catfish	3/3	0.142±0.101 (0.060-0.255)		
Common carp	1/1	0.042		
Largemouth bass	2/2	0.219±0.006 (0.214-0.223)		
Smallmouth buffalo	1/1	0.104		
Striped bass	1/1	0.443		
All fish combined	10/10	0.185±0.116 (0.042-0.443)		
Site 2 Lake Worth near Naval Station				
Blue catfish	1/1	0.165	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Freshwater drum	1/1	0.107		
Largemouth bass	2/2	0.214±0.018 (0.201-0.226)		
Smallmouth buffalo	1/1	0.131		
White bass	1/1	0.365		
White crappie	1/1	0.065		
All fish combined	7/7	0.180±0.098 (0.065-0.365)		
Site 3 Lake Worth near Carswell Field Runway				
Channel catfish	1/1	0.063	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Flathead catfish	1/1	0.131		
Smallmouth buffalo	1/1	0.240		
All fish combined	3/3	0.145±0.089 (0.063-0.240)		

Table 2.8. Mercury (mg/kg) in fish collected from Lake Worth by sample site, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Site 4 Lake Worth near Meandering Creek Road				
Freshwater drum	1/1	0.101	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Smallmouth buffalo	1/1	0.084		
White bass	1/1	0.109		
White crappie	1/1	0.028		
All fish combined	4/4	0.081±0.037 (0.028-0.109)		
Site 5 Lake Worth at Woods Inlet				
Black crappie	1/1	0.075	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Blue catfish	1/1	0.129		
Common carp	1/1	0.071		
Freshwater drum	2/2	0.232±0.073 (0.181-0.284)		
Largemouth bass	1/1	0.166		
Smallmouth buffalo	1/1	0.066		
White crappie	2/2	0.100±0.055 (0.061-0.139)		
All fish combined	9/9	0.130±0.073 (0.061-0.284)		

Table 2.9. Mercury (mg/kg) in fish collected from Lake Worth by sample site, 2016.

Species	Number Detected/ Number Tested	Mean ± S.D. (Min-Max)	HAC Value (nonca; mg/kg)	Basis for Comparison Value
Site 6 Lake Worth at Live Oak Creek				
Black crappie	2/2	0.049±0.015 (0.038-0.059)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Blue catfish	2/2	0.131±0.016 (0.119-0.142)		
Channel catfish	2/2	0.134±0.083 (0.075-0.193)		
Largemouth bass	1/1	0.215		
Smallmouth buffalo	1/1	0.109		
White bass	1/1	0.081		
White crappie	1/1	0.057		
All fish combined	10/10	0.109±0.059 (0.038-0.215)		
Site 7 Lake Worth near Woods Island				
Blue catfish	4/4	0.115±0.031 (0.072-0.146)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Channel catfish	1/1	0.104		
Common carp	1/1	0.149		
Flathead catfish	3/3	0.298±0.047 (0.265-0.352)		
Freshwater drum	2/2	0.129±0.004 (0.126-0.132)		
Largemouth bass	1/1	0.181		
Smallmouth buffalo	1/1	0.113		
White bass	2/2	0.232±0.070 (0.183-0.282)		
All fish combined	15/15	0.175±0.081 (0.072-0.352)		

Table 2.10. Mercury (mg/kg) in fish collected from Lake Worth by sample site, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Site 8 Lake Worth near Mosque Point				
Blue catfish	2/2	0.065±0.048 (0.031-0.099)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Channel catfish	1/1	0.028		
Flathead catfish	2/2	0.150±0.033 (0.127-0.173)		
Freshwater drum	1/1	0.414		
White bass	2/2	0.509±0.175 (0.385-0.633)		
All fish combined	8/8	0.236±0.218 (0.028-0.633)		
Site 9 Lake Worth at SH 199 Bridge				
Black crappie	1/1	0.073	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Blue catfish	1/1	0.152		
Common carp	1/1	0.178		
Flathead catfish	1/1	0.197		
Smallmouth buffalo	2/2	0.105±0.011 (0.097-0.113)		
White bass	2/2	0.231±0.078 (0.176-0.286)		
All fish combined	8/8	0.159±0.067 (0.073-0.286)		
Site 10 Lake Worth West Fork Trinity River				
Blue catfish	2/2	0.358±0.145 (0.255-0.460)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Channel catfish	1/1	0.103		
Common carp	1/1	0.325		
Smallmouth buffalo	1/1	0.171		
White bass	1/1	0.120		
All fish combined	6/6	0.236±0.140 (0.102-0.460)		

Table 2.11. Mercury (mg/kg) in fish collected from Lake Worth by species, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Black crappie	5/5	0.087±0.060 (0.038-0.192)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Blue catfish	14/14	0.158±0.102 (0.031-0.460)		
Channel catfish	9/9	0.110±0.071 (0.028-0.255)		
Common carp	5/5	0.153±0.111 (0.042-0.325)		
Flathead catfish	7/7	0.218±0.084 (0.127-0.352)		
Freshwater drum	7/7	0.192±0.116 (0.101-0.414)		
Largemouth bass	7/7	0.204±0.023 (0.166-0.266)		
Smallmouth buffalo	10/10	0.123±0.050 (0.066-0.240)		
Striped bass	1/1	0.443		
White bass	10/10	0.260±0.170 (0.081-0.633)		
White crappie	5/5	0.070±0.041 (0.028-0.139)		
All fish combined	80/80	0.167±0.111 (0.028-0.633)		

Table 3.1. Pesticides (mg/kg) in fish collected from Lake Worth by species, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; mg/kg)**	**Basis for Comparison Value**
Aldrin				
Black crappie	0/5	ND	0.070 0.032	EPA Chronic Oral RfD — 0.00003 mg/kg–day EPA Oral Slope Factor — 17 per (mg/kg)/day
Blue catfish	0/14	ND		
Channel catfish	1/9	BDL		
Common carp	1/5	0.0001±0.0000 (ND -0.0005)		
Flathead catfish	0/7	ND		
Freshwater drum	0/7	ND		
Largemouth bass	0/7	ND		
Smallmouth buffalo	0/10	ND		
Striped bass	0/1	ND		
White bass	0/10	ND		
White crappie	0/5	ND		
All fish combined	2/80	0.0002±0.0001 (ND -0.0005)		
Dieldrin				
Black crappie	1/5	0.0002±0.0002 (ND -0.0005)	0.117 0.034	EPA Chronic Oral RfD — 0.00005 mg/kg–day EPA Oral Slope Factor — 16 per (mg/kg)/day
Blue catfish	1/14	0.0002±0.0001 (ND -0.0005)		
Channel catfish	1/9	0.0002±0.0001 (ND -0.0004)		
Common carp	0/5	ND		
Flathead catfish	0/7	ND		
Freshwater drum	0/7	ND		
Largemouth bass	0/7	ND		
Smallmouth buffalo	3/10	0.0010±0.0015 (ND -0.0042)		
Striped bass	0/1	ND		
White bass	0/10	ND		
White crappie	0/5	ND		
All fish combined	6/80	0.0003±0.0006 (ND -0.0042)		

Table 3.2. Pesticides (mg/kg) in fish collected from Lake Worth by species, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; mg/kg)**	**Basis for Comparison Value**
Chlordane (Total)				
Black crappie	5/5	0.0010±0.0007 (BDL-0.0022)	1.167 1.556	EPA Chronic Oral RfD — 0.0005 mg/kg–day EPA Oral Slope Factor — 0.35 per mg/kg–day
Blue catfish	14/14	0.0039±0.0046 (BDL-0.0189)		
Channel catfish	9/9	0.0023±0.0033 (BDL-0.0111)		
Common carp	5/5	0.0059±0.0100 (BDL-0.0237)		
Flathead catfish	7/7	0.0048±0.0036 (0.0018-0.0126)		
Freshwater drum	7/7	0.0015±0.0013 (BDL-0.0041)		
Largemouth bass	7/7	0.0010±0.0006 (BDL-0.0021)		
Smallmouth buffalo	10/10	0.0115±0.0104 (0.0026-0.0338)		
Striped bass	1/1	0.0683		
White bass	10/10	0.0027±0.0015 (BDL-0.0049)		
White crappie	5/5	BDL		
All fish combined	80/80	0.0047±0.0093 (BDL-0.0683)		
Total DDT				
Black crappie	5/5	0.0018±0.0017 (BDL-0.0048)	1.167 1.601	EPA Chronic Oral RfD — 5.0E-4 mg/kg–day EPA Oral Slope Factor — 3.4E-1 per (mg/kg)/day
Blue catfish	14/14	0.0043±0.0030 (BDL-0.0123)		
Channel catfish	9/9	0.0031±0.0026 (0.0007-0.0092)		
Common carp	5/5	0.0035±0.0022 (0.0022-0.0074)		
Flathead catfish	7/7	0.0091±0.0078 (0.0031-0.0263)		
Freshwater drum	7/7	0.0032±0.0015 (0.0013-0.0057)		
Largemouth bass	7/7	0.0032±0.0036 (0.0011-0.0113)		
Smallmouth buffalo	10/10	0.0173±0.0104 (0.0053-0.0337)		
Striped bass	1/1	0.0461		
White bass	10/10	0.0044±0.0022 (BDL-0.0075)		
White crappie	5/5	0.0038±0.0040 (0.0007-0.0094)		
All fish combined	80/80	0.0063±0.0080 (BDL-0.0461)		

Table 4.1. PCBs (mg/kg) in fish collected from Lake Worth by sample site, 2016.				
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 Lake Worth at Dam				
Black crappie	1/1	0.005	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	1/1	0.013		
Channel catfish	3/3	0.007±0.002 (0.005-0.009)		
Common carp	1/1	0.010		
Largemouth bass	2/2	0.007 ±0.002 (0.006-0.009)		
Smallmouth buffalo	1/1	0.034		
Striped bass	1/1	0.035		
All fish combined	10/10	0.013±0.011 (0.005-0.035)		
Site 2 Lake Worth near Naval Air Station				
Blue catfish	1/1	0.017	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
Freshwater drum	1/1	0.008		
Largemouth bass	2/2	0.007±0.000 (0.007-0.007)		
Smallmouth buffalo	1/1	**0.098**[o]		
White bass	1/1	0.020		
White crappie	1/1	0.005		
All fish combined	7/7	0.023±0.033 (0.005-0.0.98)		

[o] 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 Lake Worth by sample site, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; mg/kg)**	**Basis for Comparison Value**
Site 3 Lake Worth near Carswell Field Runway				
Channel catfish	1/1	**0.092**[p]	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	1/1	0.018		
Smallmouth buffalo	1/1	**0.186**		
All fish combined	3/3	**0.099**±0.084 (0.018-**0.186**)		
Site 4 Lake Worth near Meandering Creek Road				
Freshwater drum	1/1	0.008	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
Smallmouth buffalo	1/1	**0.304**		
White bass	1/1	0.014		
White crappie	1/1	0.006		
All fish combined	4/4	**0.083**±0.147 (0.006-**0.304**)		
Site 5 Lake Worth at Woods Inlet				
Black crappie	1/1	0.007	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	1/1	0.028		
Common carp	1/1	**0.112**		
Freshwater drum	2/2	0.014±0.011 (0.006-0.022)		
Largemouth bass	1/1	0.014		
Smallmouth buffalo	1/1	**0.125**		
White crappie	2/2	0.007±0.001 (0.006-0.007)		
All fish combined	9/9	0.036±0.047 (0.006-**0.125**)		

[p] 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 Lake Worth by sample site, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; mg/kg)**	**Basis for Comparison Value**
Site 6 Lake Worth at Live Oak Creek				
Black crappie	2/2	0.005±0.000 (0.005-0.005)	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	2/2	0.016±0.002 (0.014-0.017)		
Channel catfish	2/2	0.017±0.006 (0.013-0.022)		
Largemouth bass	1/1	0.010		
Smallmouth buffalo	1/1	0.022		
White bass	1/1	0.011		
White crappie	1/1	0.005		
All fish combined	10/10	0.012±0.007 (0.005-0.022)		
Site 7 Lake Worth near Woods Island				
Blue catfish	4/4	0.022±0.024 (0.008-**0.057**[q])	0.047 0.272	EPA Chronic Oral RfD for Aroclor 1254 — 0.00002 mg/kg–day EPA Slope Factor — 2.0 per mg/kg–day
Channel catfish	1/1	0.008		
Common carp	1/1	0.016		
Flathead catfish	3/3	**0.074**±0.047 (0.035-**0.126**)		
Freshwater drum	2/2	0.009±0.005 (0.006-0.013)		
Largemouth bass	1/1	0.007		
Smallmouth buffalo	1/1	**0.062**		
White bass	2/2	0.025±0.006 (0.020-0.029)		
All fish combined	15/15	0.031±0.033 (0.006-**0.126**)		

[q] 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 Lake Worth by sample site, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; mg/kg)**	**Basis for Comparison Value**
Site 8 Lake Worth near Mosque Point				
Blue catfish	2/2	0.007±0.000 (0.007-0.007)	0.047 0.272	EPA Chronic Oral RfD for Aroclor 1254 — 0.00002 mg/kg–day EPA Slope Factor — 2.0 per mg/kg–day
Channel catfish	1/1	0.008		
Flathead catfish	2/2	0.016±0.003 (0.014-0.018)		
Freshwater drum	1/1	0.023		
White bass	1/1	0.022±0.006 (0.018-0.027)		
All fish combined	8/8	0.015±0.008 (0.007-0.027)		
Site 9 Lake Worth at SH 199 Bridge				
Black crappie	1/1	0.005	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	1/1	0.009		
Common carp	1/1	0.019		
Flathead catfish	1/1	0.032		
Smallmouth buffalo	2/2	**0.087**[r]±0.079 (0.031-**0.143**)		
White bass	2/2	**0.098**±0.125 (0.009-**0.186**)		
All fish combined	8/8	**0.054**±0.070 (0.005-**0.186**)		
Site 10 Lake Worth at West Fork Trinity River				
Blue catfish	2/2	0.033±0.012 (0.024-0.041)	0.047 0.272	EPA Chronic Oral RfD for Aroclor 1254 — 0.00002 mg/kg–day EPA Slope Factor — 2.0 per mg/kg–day
Channel catfish	1/1	0.012		
Common carp	1/1	0.015		
Smallmouth buffalo	1/1	**0.056**		
White bass	1/1	0.013		
All fish combined	6/6	0.027±0.018 (0.012-**0.056**)		

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

Table 4.5. PCBs (mg/kg) in fish collected from Lake Worth by species, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; mg/kg)**	**Basis for Comparison Value**
Black crappie	5/5	0.005±0.001 (0.005-0.007)	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	14/14	0.019±0.015 (0.007-**0.057**[s])		
Channel catfish	9/9	0.020±0.028 (0.005-**0.092**)		
Common carp	5/5	0.034±0.044 (0.010-**0.112**)		
Flathead catfish	7/7	0.043±0.040 (0.014-**0.126**)		
Freshwater drum	7/7	0.012±0.007 (0.006-0.023)		
Largemouth bass	7/7	0.009±0.003 (0.006-0.014)		
Smallmouth buffalo	10/10	**0.106**±0.088 (0.022-**0.304**)		
Striped bass	1/1	0.035		
White bass	10/10	0.035±0.054 (0.009-**0.186**)		
White crappie	5/5	0.006±0.001 (0.005-0.007)		
All fish combined	80/80	0.032±0.050 (0.005-**0.304**)		

[s] 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 Lake Worth by sample site, 2016.

Species	Number Detected/ Number Tested	Mean ± S.D. (Min-Max)	HAC Value (nonca) and HAC Value (ca; ng/kg)	Basis for Comparison Value
Site 1 Lake Worth at Dam				
Black crappie	1/1	0.118	1.63 3.49	EPA RfD of 7.0×10^{-10} mg/kg/day EPA Slope Factor — 1.56×10^{5} per mg/kg–day
Blue catfish	1/1	0.283		
Channel catfish	3/3	0.146±0.095 (0.079-0.255)		
Common carp	1/1	0.137		
Largemouth bass	2/2	0.151 ±0.071 (0.101-0.201)		
Smallmouth buffalo	1/1	**4.876**[t]		
Striped bass	1/1	0.740		
All fish combined	10/10	0.689±1.484 (0.079-**4.876**)		
Site 2 Lake Worth near Naval Air Station				
Blue catfish	1/1	0.403	1.63 3.49	EPA RfD of 7.0×10^{-10} mg/kg/day EPA Slope Factor — 1.56×10^{5} per mg/kg–day
Freshwater drum	1/1	0.092		
Largemouth bass	2/2	0.231±0.187 (0.098-0.363)		
Smallmouth buffalo	1/1	**5.442**		
White bass	1/1	0.528		
White crappie	1/1	0.026		
All fish combined	7/7	0.993±1.971 (0.026-**5.442**)		

[t] Emboldened numbers denote that PCDDs/PCDFs 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 Lake Worth by sample site, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; ng/kg)**	**Basis for Comparison Value**
Site 3 Lake Worth near Carswell Field Runway				
Channel catfish	1/1	0.821	1.63 3.49	EPA RfD of 7.0 x 10^{-10} mg/kg/day EPA Slope Factor — 1.56 x 10^{5} per mg/kg–day
Flathead catfish	1/1	0.697		
Smallmouth buffalo	1/1	**2.133**[u]		
All fish combined	3/3	1.217±0.796 (0.697-**2.133**)		
Site 4 Lake Worth near Meandering Creek Road				
Freshwater drum	1/1	0.306	1.63 3.49	EPA RfD of 7.0 x 10^{-10} mg/kg/day EPA Slope Factor — 1.56 x 10^{5} per mg/kg–day
Smallmouth buffalo	1/1	**5.807**		
White bass	1/1	1.153		
White crappie	1/1	0.094		
All fish combined	4/4	**1.840**±2.684 (0.094-**5.807**)		
Site 5 Lake Worth at Woods Inlet				
Black crappie	1/1	0.337	1.63 3.49	EPA RfD of 7.0 x 10^{-10} mg/kg/day EPA Slope Factor — 1.56 x 10^{5} per mg/kg–day
Blue catfish	1/1	**6.906**		
Common carp	1/1	0.428		
Freshwater drum	2/2	**3.354**±2.857 (**1.334**-**5.374**)		
Largemouth bass	1/1	0.268		
Smallmouth buffalo	1/1	**5.455**		
White crappie	2/2	0.357±0.066 (0.310-0.404)		
All fish combined	9/9	**2.313**±2.752 (0.268-**6.906**)		

[u] Emboldened numbers denote that PCDDs/PCDFs 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 Lake Worth by species, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; ng/kg)**	**Basis for Comparison Value**
Site 6 Lake Worth at Live Oak Creek				
Black crappie	2/2	0.045±0.019 (0.032-0.059)		
Blue catfish	2/2	**2.031**[v]±0.824 (1.448-**2.613**)		
Channel catfish	2/2	**1.368**±0.979 (0.676-**2.060**)		
Largemouth bass	1/1	**2.756**	1.63	EPA RfD of 7.0 x 10^{-10} mg/kg/day
Smallmouth buffalo	1/1	0.783	3.49	EPA Slope Factor — 1.56 x 10^{5} per mg/kg–day
White bass	1/1	0.962		
White crappie	1/1	0.066		
All fish combined	10/10	1.146±1.035 (0.032-**2.756**)		
Site 7 Lake Worth near Woods Island				
Blue catfish	4/4	0.998±0.208 (0.693-1.152)		
Channel catfish	1/1	0.594		
Common carp	1/1	**1.876**		
Flathead catfish	3/3	**7.362**±4.039 (**4.124**-**11.888**)	1.63	EPA RfD of 7.0 x 10^{-10} mg/kg/day
Freshwater drum	2/2	0.564±0.553 (0.173-0.955)		
Largemouth bass	1/1	**4.045**	3.49	EPA Slope Factor — 1.56 x 10^{5} per mg/kg–day
Smallmouth buffalo	1/1	**7.110**		
White bass	2/2	**2.821**±0.800 (**2.255**-**3.387**)		
All fish combined	15/15	**3.098**±3.203 (0.173-**11.888**)		

[v] Emboldened numbers denote that PCDDs/PCDFs 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 Lake Worth by species, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; ng/kg)**	**Basis for Comparison Value**
Site 8 Lake Worth near Mosque Point				
Blue catfish	2/2	0.829±0.670 (0.356-1.303)	1.63 3.49	EPA RfD of 7.0 x 10^{-10} mg/kg/day EPA Slope Factor — 1.56 x 10^5 per mg/kg–day
Channel catfish	1/1	0.678		
Flathead catfish	2/2	**2.160**[w]±0.013 (**2.151**-**2.169**)		
Freshwater drum	1/1	**3.181**		
White bass	2/2	**2.681**±0.519 (**2.314**-**3.048**)		
All fish combined	8/8	**1.900**±1.035 (0.356-**3.181**)		
Site 9 Lake Worth at SH 199 Bridge				
Black crappie	1/1	0.063	1.63 3.49	EPA RfD of 7.0 x 10^{-10} mg/kg/day EPA Slope Factor — 1.56 x 10^5 per mg/kg–day
Blue catfish	1/1	0.778		
Common carp	1/1	**2.967**		
Flathead catfish	1/1	**5.596**		
Smallmouth buffalo	2/2	**9.821**±7.795 (**4.309**-**15.333**)		
White bass	2/2	**1.356**±1.312 (0.428-**2.284**)		
All fish combined	8/8	**3.970**±4.982 (0.063-**15.333**)		
Site 10 Lake Worth at West Fork Trinity River				
Blue catfish	2/2	**3.554**±1.286 (**2.645**-**4.463**)	1.63 3.49	EPA RfD of 7.0 x 10^{-10} mg/kg/day EPA Slope Factor — 1.56 x 10^5 per mg/kg–day
Channel catfish	1/1	1.190		
Common carp	1/1	1.009		
Smallmouth buffalo	1/1	**4.086**		
White bass	1/1	1.403		
All fish combined	6/6	**2.466**±1.518 (1.009-**4.463**)		

[w] Emboldened numbers denote that PCDDs/PCDFs concentrations equal and/or exceed the DSHS HAC value for PCDDs/PCDFs.

Table 5.5. PCDDs/PCDFs toxicity equivalent (TEQ) concentrations (pg/g) in fish collected from the Lake Worth by species, 2016.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; ng/kg)**	**Basis for Comparison Value**
Black crappie	5/5	0.122±0.124 (0.032-0.337)	1.63 3.49	EPA RfD of 7.0 x 10^{-10} mg/kg/day EPA Slope Factor — 1.56 x 10^{5} per mg/kg–day
Blue catfish	14/14	**1.799**[x]±1.860 (0.283-**6.906**)		
Channel catfish	9/9	0.717±0.618 (0.079-**2.060**)		
Common carp	5/5	1.283±1.152 (0.137-**2.967**)		
Flathead catfish	7/7	**4.671**±3.733 (0.697-**11.888**)		
Freshwater drum	7/7	**1.631**±1.967 (0.092-**5.374**)		
Largemouth bass	7/7	1.119±1.605 (0.098-**4.045**)		
Smallmouth buffalo	10/10	**5.533**±3.898 (0.783-**15.333**)		
Striped bass	1/1	0.740		
White bass	10/10	**1.776**±1.030 (0.428-**3.387**)		
White crappie	5/5	0.180±0.167 (0.026-0.404)		
All fish combined	80/80	**2.067**±2.656 (0.026-**15.333**)		

[x] Emboldened numbers denote that PCDDs/PCDFs concentrations equal and/or exceed the DSHS HAC value for PCDDs/PCDFs.

Table 6. Volatile organic compounds (mg/kg) in fish collected from the Lake Worth by species, 2016.

Species	Number Detected/ Number Tested	Mean ± S.D. (Min-Max)	HAC Value (nonca; mg/kg)	Basis for Comparison Value
Trichlorofluoromethane				
Blue catfish	9/9	0.304±0.213 (0.099-0.810)	700	EPA Chronic Oral RfD — 3.0E-1 (mg/kg)/day
Flathead catfish	7/7	0.122±0.035 (0.065-0.168)		
All fish combined	16/16	0.225±0.183 (0.065 -0.810)		

Table 7. Hazard quotients (HQs) for mercury in fish collected from Lake Worth in 2016. Table 7 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[y]			
Species	**Number of Samples**	**Hazard Quotient**	**Meals per Week**
Black crappie	5	0.12	7.4
Blue catfish	14	0.04	unrestricted[z]
Channel catfish	9	0.16	5.9
Common carp	5	0.22	4.2
Flathead catfish	7	0.31	3.0
Freshwater drum	7	0.27	3.4
Largemouth bass	7	0.29	3.2
Smallmouth buffalo	10	0.18	5.3
Striped bass	1	0.63	1.5
White bass	10	0.37	2.5
White crappie	5	0.10	9.3
All fish combined	80	0.24	3.9

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

Table 8.1. Hazard quotients (HQs) and hazard indices (HIs) for PCBs and/or PCDDs/PCDFs in fish collected from Lake Worth in 2016. Table 8.1 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[aa]			
Contaminant/Species	**Number of Samples**	**Hazard Quotient**	**Meals per Week**
Black crappie			
PCBs	5	0.11	8.6
PCDDs/PCDFs		0.07	12.4
Hazard Index (meals per week)		0.18	5.1
Blue catfish			
PCBs	14	0.41	2.3
PCDDs/PCDFs		**1.10**[bb]	**0.8**[cc]
Hazard Index (meals per week)		**1.51**	**0.6**
Channel catfish			
PCBs	9	0.43	2.2
PCDDs/PCDFs		0.44	2.1
Hazard Index (meals per week)		0.87	1.1
Common carp			
PCBs	5	0.73	1.3
PCDDs/PCDFs		0.79	1.2
Hazard Index (meals per week)		**1.51**	**0.6**

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

Table 8.2. Hazard quotients (HQs) and hazard indices (HIs) for PCBs and/or PCDDs/PCDFs in fish collected from Lake Worth in 2016. Table 8.1 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[dd]			
Contaminant/Species	**Number of Samples**	**Hazard Quotient**	**Meals per Week**
Flathead catfish			
PCBs	7	0.92	1.0
PCDDs/PCDFs		**2.86**[ee]	**0.3**[ff]
Hazard Index (meals per week)		**3.78**	**0.2**
Freshwater drum			
PCBs	7	0.26	3.6
PCDDs/PCDFs		**1.00**	**0.9**
Hazard Index (meals per week)		**1.26**	**0.7**
Largemouth bass			
PCBs	7	0.19	4.8
PCDDs/PCDFs		0.69	1.4
Hazard Index (meals per week)		0.88	1.1
Smallmouth buffalo			
PCBs	10	**2.27**	**0.4**
PCDDs/PCDFs		**3.39**	**0.3**
Hazard Index (meals per week)		**5.66**	**0.2**

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

Table 8.3. Hazard quotients (HQs) and hazard indices (HIs) for PCBs and/or PCDDs/PCDFs in fish collected from Lake Worth in 2016. Table 8.2 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[gg]			
Contaminant/Species	**Number of Samples**	**Hazard Quotient**	**Meals per Week**
Striped bass			
PCBs	1	0.75	1.2
PCDDs/PCDFs		0.45	2.0
Hazard Index (meals per week)		**1.20[hh]**	**0.8[ii]**
White bass			
PCBs	10	0.75	1.2
PCDDs/PCDFs		**1.09**	**0.9**
Hazard Index (meals per week)		**1.84**	**0.5**
White crappie			
PCBs	5	0.13	7.2
PCDDs/PCDFs		0.11	8.4
Hazard Index (meals per week)		0.24	3.9
All fish combined			
PCBs	80	0.69	1.3
PCDDs/PCDFs		**1.27**	**0.7**
Hazard Index (meals per week)		**1.95**	**0.5**

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

Table 9.1. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2016 from Lake Worth containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish from Lake Worth over a 30-year period.[jj]				
Species/Contaminant	**Number of Samples**	**Theoretical Lifetime Excess Cancer Risk**		**Meals per Week**
		Risk	**Population Size that Would Result in One Excess Cancer**	
Black crappie				
Aldrin	5	3.1E-07	3,202,614	unrestricted[kk]
Chlordane		6.43E-08	15,555,556	unrestricted
Dieldrin		5.9E-07	1,701,389	unrestricted
Total DDT		1.12E-07	8,896,151	unrestricted
PCBs		1.8E-06	544,444	unrestricted
PCDDs/PCDFs		3.5E-06	286,068	unrestricted
Cumulative Cancer Risk		6.4E-06	156,028	14.4
Blue catfish				
Arsenic	9	1.9E-06	518,519	unrestricted
Aldrin	14	3.1E-07	3,202,614	unrestricted
Chlordane		2.51E-07	3,988,604	unrestricted
Dieldrin		5.9E-07	1,701,389	unrestricted
Total DDT		2.69E-07	3,723,970	unrestricted
PCBs		7.0E-06	143,275	13.2
PCDDs/PCDFs		5.2E-05	19,400	1.8
Cumulative Cancer Risk		6.2E-05	16,162	1.5

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

Table 9.2. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2016 from Lake Worth containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish from Lake Worth over a 30-year period.[ll]				
Species/Contaminant	**Number of Samples**	**Theoretical Lifetime Excess Cancer Risk**		**Meals per Week**
		Risk	**Population Size that Would Result in One Excess Cancer**	
Channel catfish				
Aldrin	9	3.1E-07	3,202,614	unrestricted[mm]
Chlordane		1.48E-07	6,763,285	unrestricted
Dieldrin		5.9E-07	1,701,389	unrestricted
Total DDT		1.94E-07	5,165,507	unrestricted
PCBs		7.3E-06	136,111	12.6
PCDDs/PCDFs		2.1E-05	48,675	4.5
Cumulative Cancer Risk		2.9E-05	34,326	3.2
Common carp				
Aldrin	5	6.2E-07	1,601,307	unrestricted
Chlordane		3.79E-07	2,636,535	unrestricted
Dieldrin		2.9E-07	3,402,778	unrestricted
Total DDT		2.19E-07	4,575,163	unrestricted
PCBs		1.2E-05	80,065	7.4
PCDDs/PCDFs		3.7E-05	27,202	2.5
Cumulative Cancer Risk		5.1E-05	19,697	1.8

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

Table 9.3. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2016 from Lake Worth containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish from Lake Worth over a 30-year period.[nn]				
Species/Contaminant	**Number of Samples**	**Theoretical Lifetime Excess Cancer Risk**		**Meals per Week**
		Risk	**Population Size that Would Result in One Excess Cancer**	
Flathead catfish				
Arsenic	7	1.4E-06	725,926	unrestricted[oo]
Aldrin		3.1E-07	3,202,614	unrestricted
Chlordane		3.09E-07	3,240,741	unrestricted
Dieldrin		2.9E-07	3,402,778	unrestricted
Total DDT		5.68E-07	1,759,678	unrestricted
PCBs		1.6E-05	63,307	5.8
PCDDs/PCDFs		**1.3E-04**[pp]	**7,472**	**0.7**[qq]
Cumulative Cancer Risk		**1.5E-04**	**6,558**	**0.6**
Freshwater drum				
Aldrin	7	3.1E-07	3,202,614	unrestricted
Chlordane		9.64E-08	10,370,370	unrestricted
Dieldrin		2.9E-07	3,402,778	unrestricted
Total DDT		2.00E-07	5,004,085	unrestricted
PCBs		4.4E-06	226,852	unrestricted
PCDDs/PCDFs		4.7E-05	21,398	2.0
Cumulative Cancer Risk		5.2E-05	19,215	1.8

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

Table 9.4. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2016 from Lake Worth containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish from Lake Worth over a 30-year period.[rr]				
Species/Contaminant	**Number of Samples**	**Theoretical Lifetime Excess Cancer Risk**		**Meals per Week**
		Risk	**Population Size that Would Result in One Excess Cancer**	
Largemouth bass				
Aldrin	7	3.1E-07	3,202,614	unrestricted
Chlordane		6.43E-08	15,555,556	unrestricted
Dieldrin		2.9E-07	3,402,778	unrestricted
Total DDT		2.00E-07	5,004,085	unrestricted
PCBs		3.3E-06	302,469	unrestricted
PCDDs/PCDFs		3.2E-05	31,189	2.9
Cumulative Cancer Risk		3.6E-05	27,594	2.5
Smallmouth buffalo				
Aldrin	10	9.4E-07	1,067,538	unrestricted
Chlordane		7.39E-07	1,352,657	unrestricted
Dieldrin		2.9E-06	340,278	unrestricted
Total DDT		1.08E-06	925,611	unrestricted
PCBs		3.9E-05	25,681	2.4
PCDDs/PCDFs		**1.6E-04**[ss]	**6,308**	**0.6**[tt]
Cumulative Cancer Risk		**2.0E-04**	**4,922**	**0.5**

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

Table 9.5. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2016 from Lake Worth containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish from Lake Worth over a 30-year period.[uu]

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				
Aldrin	1	3.1E-07	3,202,614	unrestricted[vv]
Chlordane		4.39E-06	227,753	unrestricted
Dieldrin		2.9E-07	3,402,778	unrestricted
Total DDT		2.88E-06	347,355	unrestricted
PCBs		1.3E-05	77,778	7.2
PCDDs/PCDFs		2.1E-05	47,163	4.4
Cumulative Cancer Risk		4.2E-05	23,846	2.2
White bass				
Aldrin	10	6.2E-07	1,601,307	unrestricted
Chlordane		1.74E-07	5,761,317	unrestricted
Dieldrin		5.9E-07	1,701,389	unrestricted
Total DDT		2.75E-07	3,639,335	unrestricted
PCBs		1.3E-05	77,778	7.2
PCDDs/PCDFs		5.1E-05	19,651	1.8
Cumulative Cancer Risk		6.5E-05	15,289	1.4

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

Table 9.6. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2016 from Lake Worth containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish from Lake Worth 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**	
White crappie				
Aldrin	5	3.1E-07	3,202,614	unrestricted[xx]
Chlordane		4.50E-08	22,222,222	unrestricted
Dieldrin		2.9E-07	3,402,778	unrestricted
Total DDT		2.37E-07	4,213,966	unrestricted
PCBs		2.2E-06	453,704	unrestricted
PCDDs/PCDFs		5.2E-06	193,890	unrestricted
Cumulative Cancer Risk		8.3E-06	121,211	11.2
All fish				
Arsenic	16	1.7E-06	604,938	unrestricted
Aldrin	80	6.2E-07	1,601,307	unrestricted
Chlordane		3.02E-07	3,309,693	unrestricted
Dieldrin		8.8E-07	1,134,259	unrestricted
Total DDT		3.93E-07	2,541,757	unrestricted
PCBs		1.2E-05	85,069	7.9
PCDDs/PCDFs		5.9E-05	16,885	1.6
Cumulative Cancer Risk		7.5E-05	13,363	1.2

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

Table 10. SALG recommended fish consumption advice for Lake Worth, 2016.			
Contaminants of Concern	**Species**	**Women of childbearing age and children < 12**	**Women past childbearing age and males 12 and older**
Dioxins and PCBs	Blue catfish	1 meal/month	2 meals/month
	Common carp	1 meal/month	2 meals/month
	Flathead catfish	**DO NOT EAT**	1 meal/month
	Freshwater drum	1 meal/month	3 meals/month
	Smallmouth buffalo	**DO NOT EAT**	**DO NOT EAT**
	Striped bass	1 meal/month	2 meals/month
	White bass	1 meal/month	2 meals/month

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