Characterization of Potential Adverse Health Effects Associated with Consuming Fish from

Lake Como

Tarrant County, Texas

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Department of State Health Services
Division for Regulatory Services
Policy, Standards, and Quality Assurance Unit
Seafood and Aquatic Life Group
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	Inch
IH	Interstate Highway
IRIS	Integrated Risk Information System
kg	Kilogram
lb	Pound
LOAEL	Lowest Observed Adverse Effects Level
mcg	Microgram
mg	Milligram
mm	Millimeter
MRL	Minimal Risk Level
MS	Mass spectrometer
n	Sample Size
ND	Not Detected
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effects Level
nonca	Noncancer
p	Statistical Significance in a Hypothesis Test
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated Dibenzo-p-Dioxin
PCDF	Polychlorinated Dibenzofuran

LIST OF ACRONYMS CONT.

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

SUMMARY

A survey of Lake Como, Fort Worth, Texas in 1995 indicated that chlordane, DDT and its metabolites, and polychlorinated biphenyl concentrations in fish exceeded Texas Department of Health guidelines for protection of human health. On April 4, 1995, the Texas Department of Health issued Aquatic Life Order 10 to prohibit possession or harvest of fish from Como Lake. Subsequent surveys of Lake Como in 2000–2001 revealed that toxicants identified in the 1995 study were still present in largemouth bass, but at concentrations that no longer exceeded Texas Department of Health guidelines for protection of human health. Because only largemouth bass were collected from Lake Como, the Texas Department of Health recommended continuation of Aquatic Life Order 10 in anticipation of collection and analysis of other species of fish.

A 2005 survey of Lake Como revealed contaminant concentrations had decreased to acceptable levels and no longer exceeded the Texas Department of State Health Services guidelines for protection of human health. The Texas Department of State Health Services issued Aquatic Life Order 15 on September 25, 2007 to rescind Aquatic Life Order 10 making it legal to possess or harvest fish from Lake Como.

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

Results of the 2014 survey indicate that dieldrin, dioxin, and polychlorinated biphenyl concentrations in common carp exceeded Texas Department of State Health Services guidelines for protection of human health.

Conclusions

- Regular or long-term consumption of common carp may result in adverse systemic (noncarcinogenic) health effects and/or increase the likelihood of carcinogenic health risks. Therefore, consumption of common carp from Lake Como **poses an apparent risk to human health**.

Recommendations

- People **should not consume** common carp from Lake Como (Table 11).

INTRODUCTION

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

History of the Lake Como Fish Consumption Advisory

After finding elevated levels of chlordane and other organic contaminants in fish from Lake Como, the City of Fort Worth requested that the Texas Department of Health (TDH)[b] collect and analyze fish from Lake Como to confirm the city's findings and to determine if a fish consumption advisory should be issued. In August 1994, the TDH Seafood Safety Division (SSD)[c] collected 15 fish samples including channel catfish, largemouth bass, and white crappie from Lake Como. In 1995, the TDH SSD released a report entitled *Results and Risk Assessment for Fish Tissue Collected from Lake Como*. The data from TDH's 1994 survey indicated that concentrations of chlordane, DDT and its metabolites, and Aroclor 1260 exceeded TDH guidelines for protection of human health. The TDH issued Aquatic Life Order 10 (AL-10) on April 4, 1995 to prohibit possession or harvest of fish from Lake Como. [1]

In 2000 and 2001, TDH reassessed the possession ban issued in 1995. This survey examined only largemouth bass samples that revealed toxicants identified in the 1995 study were still present, but only at concentrations that no longer exceed TDH guidelines for protection of human health. Because the only species of fish sampled during this survey was largemouth bass, in contrast to the 1995 survey, risk assessors at TDH recommended continuation of AL-10 in anticipation of collection and analysis of other species of fish from Lake Como.

In 2005, the Texas Commission on Environmental Quality (TCEQ) requested a survey of the Lake Como as a five-year follow-up study under the Total Maximum Daily Load (TMDL) Program for previously adopted TMDLs. The 2005 survey revealed contaminant concentrations had decreased to acceptable levels and no longer exceed the Texas Department of State Health Services (DSHS) guidelines for protection of human health. The DSHS issued AL-15 on September 25, 2007 to rescind AL-10.[2]

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[a] The terms DSHS and SALG are used interchangeably throughout this document and refer to the same agency.
[b] Now the Department of State Health Services (DSHS)
[c] Now the Seafood and Aquatic Life Group (SALG)

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),[3] 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.[4] TMDLs incorporate margins of safety to ensure the usability of the water body for all designated purposes. States, territories, and tribes define the uses for a specific water body (e.g., drinking water, contact recreation, aquatic life support) along with the scientific criteria designated to support each specified use.

Fish consumption is a recognized use for many waters. A water body is impaired if fish from that water body contain contaminants that make those fish unfit for human consumption or if consumption of those contaminants potentially could harm human health. Although a water body and its aquatic life may clear toxicants over time with removal of the source(s), it is often necessary to institute some type of remediation such as those implemented by the TCEQ. Thus, whenever the DSHS issues a fish consumption advisory or prohibits possession of environmentally contaminated fish, the TCEQ places the water body in its current *Texas Integrated Report of Surface Water Quality* formerly called the Texas Water Quality Inventory and 303(d) List.[5] The TCEQ is responsible for confirming the impairment and, if necessary, the TMDL program, then prepares a TMDL for each contaminant present at concentrations that, if consumed, would be capable of negatively affecting human health. After approval of the TMDL, the stakeholders in the watershed prepare an Implementation Plan for each contaminant. These plans are designed to facilitate the rehabilitation of the water body over time. Successful remediation should result in return of the water body to conditions compatible with all stated uses, including consumption of fish from the water body. When the DSHS lifts a consumption advisory or possession ban, people may once again keep and consume fish from the water body. If fish in a water body are contaminated, one of the several items on an Implementation Plan for a water body on a state's 303(d) list consists of the periodic reassessment of contaminant levels in resident fish.

Description of Lake Como

Lake Como was built in 1889 as a recreation resort.[6] Lake Como is a 10.1-acre impoundment of an unnamed tributary to the Clear Fork Trinity River.[7] It drains a 743-acre predominantly residential watershed within the City of Fort Worth, Texas. Lake Como is located in Lake Como Park a few blocks south of Interstate Highway (IH) 30 and west of Hulen Street.

Population of Tarrant County Surrounding Lake Como

Lake Como is located in Fort Worth, Texas within 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.[8] In 2013, according to the United States Census Bureau's (USCB) estimate, the 12 county Dallas-Fort Worth-Arlington metropolitan area had a population near 6,810,913. The USCB also reported that the Dallas-Fort Worth-Arlington metropolitan area is the third fastest growing most populous metropolitan area in the United States, which gained 1,231,393 residents from 2000 to 2010.[9] The Metroplex covers approximately 9,286 square miles; an area larger than the combined U.S. states of Connecticut and Rhode Island.

Subsistence Fishing at Lake Como

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

METHODS

Fish Sampling, Preparation, and Analysis

The DSHS SALG collects and analyzes edible fish from the state's public waters to evaluate potential risks to the health of people consuming contaminated fish or shellfish. Fish tissue sampling follows standard operating procedures from the DSHS *Seafood and Aquatic Life Group Survey Team Standard Operating Procedures and Quality Control/Assurance Manual.*[11] 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.*[12] Advice and direction are also received from the *Fish Sampling Advisory Subcommittee* of the legislatively mandated *State of Texas Toxic Substances Coordinating Committee.*[13] 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 Como 2014 Sample Set

In April 2014, the SALG staff collected 20 fish samples from Lake Como. Risk assessors used data from these fish to assess the potential for adverse human health outcomes from consuming fish from this body of water.

Because Lake Como (10.1-acres) is small, the SALG did not select sample sites to provide spatial coverage of the study area; rather, the group utilized the entire lake as a single “site” (Figure 1). 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 commonly consumed by anglers and their families. The 20 fish collected from Lake Como 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: largemouth bass (17) and common carp (3).

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 5.0 GPP GPP electrofishing system settings: 4.0-6.0 amps, 60 pulses per second [pps], low range, 500 volts, 80% duty cycle and 1.0-2.0 amps, 15 pps, low range, 500 volts, 100% duty cycle) to stun fish that crossed the electric field in the water in front of the boat. Staff used dip nets over the bow of the boat to retrieve stunned fish, netting only fish pre-selected as target samples. Staff immediately stored retrieved samples on wet ice in large coolers to enhance tissue preservation.

The SALG staff processed fish onsite at the Lake Como. 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 largemouth bass samples for age estimation. The SALG staff followed otolith extraction procedures recommended by the Gulf States Marine Fisheries Commission (GSMFC) and unpublished procedures recommended by the Texas Parks and Wildlife Department (TPWD).[14, 13] 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.[14, 15]

Analytical Laboratory Information

The GERG personnel documented receipt of the 20 Lake Como samples and recorded the condition of each sample along with its DSHS identification number. Using established USEPA methods, the GERG laboratory analyzed fish fillets from the Lake Como 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, 16] and 17 polychlorinated dibenzofurans and/or dibenzo-*p*-dioxins (PCDDs/PCDFs) congeners. The laboratory analyzed all 20 samples for mercury and PCBs. A subset of five of the original 20 samples was analyzed for the following contaminant groups: metals, pesticides, PCDDs/PCDFs, SVOCs, and VOCs.[17] The SALG risk assessors selected the subset of samples based on target species and size class selection procedures outlined in SALG standard operating procedures (SOPs). In addition to SALG SOPs, if available, the SALG risk assessors use TPWD creel surveys to determine the species of fish most frequently harvested from the body of water being evaluated and choose large specimens of the selected species of fish. The SALG risk assessors choose large fish to assess conservatively contaminant exposure when evaluating small sample sizes.

Details of Some Analyses with Explanatory Notes

Arsenic

The GERG laboratory analyzed 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.[18] The DSHS, taking a conservative approach, estimates 10% of the total arsenic in any fish is inorganic arsenic and derives estimates of inorganic arsenic concentration in each fish by multiplying the reported total arsenic concentration in the sample by a factor of 0.1.

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

Mercury

Nearly all mercury in upper trophic level fish three years of age or older is methylmercury.[19] 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 that all reported mercury in fish or shellfish is methylmercury. The GERG laboratory thus analyzed fish tissues for total mercury. In its risk characterizations, the DSHS compares mercury concentrations in tissues to a comparison value derived from the Agency for Toxic Substances and Disease Registry's (ATSDR) minimal risk level (MRL) for methylmercury.[20] (In these risk characterizations, the DSHS may interchangeably utilize the terms "mercury," "methylmercury," or "organic mercury" to refer to methylmercury in fish).

Percent Lipids

The percent lipids content (wet weight basis) of a tissue sample is defined as the percent of material extracted from biological tissue with methylene chloride.[21] 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.

PCBs

For PCBs, the USEPA suggests that each state measures congeners of PCBs in fish and shellfish rather than homologs[e] or Aroclors®[f] because the USEPA considers congener analysis the most sensitive technique for detecting PCBs in environmental media.[22, 21] 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

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

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

inconsistency, the DSHS utilizes recommendations from the National Oceanic and Atmospheric Administration (NOAA),[23] from McFarland and Clarke,[24] and from the USEPA's guidance documents for assessing contaminants in fish and shellfish.[12, 17] Based on evaluation of these recommendations, the DSHS selected 43 of 209 congeners to characterize "total" PCBs. The referenced authors chose to use congeners that were relatively abundant in the environment, were likely to occur in aquatic life, and likely to show toxic effects. SALG risk assessors summed the 43 congeners to derive "total" PCB concentration in each sample. SALG risk assessors then averaged the summed congeners within each group (e.g., fish species, sample site, or combination of species and site) to derive a mean PCB concentration for each group.

Using only a few PCB congeners to determine total PCB concentrations could underestimate PCB levels in fish tissue. Nonetheless, the method complies with expert recommendations on evaluation of PCBs in fish or shellfish. Therefore, SALG risk assessors compare average PCB concentrations of the 43 congeners with health assessment comparison (HAC) values derived from information on PCB mixtures held in the USEPA's Integrated Risk Information System (IRIS) database.[25] IRIS currently contains noncarcinogenic toxicity information for three Aroclor® mixtures: Aroclors® 1016, 1248, and 1254. IRIS does not contain complete information for all mixtures. For instance, IRIS has derived reference doses (RfDs) for Aroclors 1016 and 1254. Aroclor 1016 was a commercial mixture produced in the latter years of commercial production of PCBs in the United States. Aroclor 1016 was a fraction of Aroclor 1254 that was supposedly devoid of dibenzofurans, in contrast to Aroclor 1254.[26] Systemic toxicity estimates in the present document reflect comparisons derived from the USEPA's RfD for Aroclor 1254 because Aroclor 1254 contains many of the 43 congeners selected by McFarland and Clark and NOAA. As of yet, IRIS does not contain information on the systemic toxicity of individual PCB congeners.

For assessment of cancer risk from exposure to PCBs, the SALG uses the USEPA's highest slope factor of 2.0 milligram per kilogram per day (mg/kg/day) to calculate the probability of lifetime excess cancer risk from PCB ingestion. The SALG based its decision to use the most conservative slope factor available for PCBs on factors, such as food chain exposure; the presence of dioxin-like, tumor-promoting, or persistent congeners; and, the likelihood of early-life exposure.[25]

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.[27, 28] 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.[29]

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

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

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

The effects of exposure to any hazardous substance depend, among other factors, on the dose, the route of exposure, the duration of exposure, the manner in which the exposure occurs, the genetic makeup, personal traits and habits of the exposed, or the presence of other chemicals.[30] 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.[30]

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

In deriving HAC values for systemic (noncarcinogenic; HAC_{nonca}) effects, the SALG assumes a standard adult weighs 70 kilograms (kg) and consumes 30 g of fish or shellfish per day (about one eight-ounce meal per week) and uses the USEPA's RfD[31] or the ATSDR's chronic oral MRLs.[32] When RfDs or MRLs are not available the SALG may use a Food and Nutrition Board, Institute of Medicine, National Academies tolerable upper intake level (UL) for nutrients.[g] The USEPA defines an RfD as

> *An estimate of a daily oral exposure for a given duration to the human population (including susceptible subgroups) that is likely to be without an appreciable risk of adverse health effects over a lifetime.*[33]

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.*[33]

The ATSDR uses a similar technique to derive its MRLs.[32] 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).*[34]

Note that, according to the USEPA, a linear increase in the HQ for a toxicant does not imply a linear increase in the likelihood or severity of systemic adverse effects. Thus, an HQ of 4.0 does not mean the concentration in the dose will be four times as toxic as that same substance would be if the HQ were equal to 1.0. An HQ of 4.0 also does not imply that adverse events will occur four times as often as if the HQ for the substance in question were 1.0. Rather, the USEPA suggests that an HQ or a hazard index (HI) – defined as the sum of HQs for contaminants to which an individual is exposed simultaneously – that computes to less than 1.0 should be

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

interpreted as "no cause for concern" whereas, an HQ or HI greater than or equal to 1.0 "should indicate some cause for concern."

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

Although the DSHS utilizes chemical specific RfDs when possible, if an RfD is not available for a contaminant, the USEPA advises risk assessors to consider evaluating the contaminant by comparing it to the published RfD (or the MRL) of a contaminant of similar molecular structure or one with a similar mode or mechanism of action. For instance, Aroclor® 1260 has no RfD, so the DSHS uses the reference dose for Aroclor 1254 to assess the likelihood of systemic (noncarcinogenic) effects of Aroclor 1260.[32]

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.[31,33] 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.[33]

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

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

The USEPA states that

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

And

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

Thus,

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

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

The DSHS calculates cancer-risk comparison values (HAC_{ca}) from the USEPA's chemical-specific cancer potency factors (CPFs), also known as cancer slope factors (CSFs), derived through mathematical modeling from carcinogenicity studies. For carcinogenic outcomes, the DSHS calculates a theoretical lifetime excess risk of cancer for specific exposure scenarios for carcinogens, using a standard 70-kg body weight and assuming an adult consumes 30 grams of edible tissue per day. The SALG risk assessors incorporate two additional factors into determinations of theoretical lifetime excess cancer risk: (1) an acceptable lifetime risk level (ARL)[33] 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. [35, 36] 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.[37] 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.[38] 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.[31] Additionally, in accordance with the ATSDR's *Child Health Initiative*[39] and the USEPA's *National Agenda to Protect Children's Health from Environmental Threats,*[40] the DSHS further seeks to protect children from the possible negative effects of toxicants in fish by suggesting that this potentially sensitive subgroup consume smaller quantities of contaminated fish or shellfish than adults consume. Thus, the DSHS recommends that children weighing 35 kg or less and/or who are 11 years of age or younger limit exposure to contaminants in fish or shellfish by eating no more than four-ounces per meal of the contaminated species. The DSHS also recommends that consumers spread these meals over time. For instance, if the DSHS issues consumption advice that recommends consumption of no more than two meals per month of a contaminated species, those children should eat no more than 24 four ounce meals of the contaminated fish or shellfish per year and should not eat such fish or shellfish more than twice per month.

Data Analysis and Statistical Methods

The SALG risk assessors imported Excel© files into Systat® statistical software, version 13.1 installed on IBM-compatible microcomputers (Dell, Inc), to generate descriptive statistics (mean, 95% confidence limits of the arithmetic mean, standard deviation, median, minimum, and maximum concentrations) for reported chemical contaminants.[41] In computing descriptive statistics, SALG risk assessors utilized ½ the reporting limit (RL) for analytes designated as not detected (ND) or estimated (J-values).[h] The SALG risk assessors calculated PCDDs/PCDFs descriptive statistics using estimated concentrations (J-values) and assuming zero for PCDDs/PCDFs designated as ND.[i] The change in methodology for computing PCDDs/PCDFs descriptive statistics is due to the proximity of the reporting limits to the HAC value. Assuming ½ the RL for PCDDs/PCDFs designated as ND or J-values would unnecessarily overestimate the concentration of PCDDs/PCDFs in each fish tissue sample. The SALG used the descriptive statistics from the above calculations to produce the present report. The SALG employed Microsoft Excel® spreadsheets to create figures, to compute HAC_{nonca} and HAC_{ca} values for contaminants, and to calculate HQs, HIs, cancer risk probabilities, and meal consumption limits for fish from Lake Como.[42] When lead concentrations in fish or shellfish are high, SALG risk assessors may utilize the USEPA's Interactive Environmental Uptake Bio-Kinetic (IEUBK) model

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

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

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).[43, 44]

The SALG risk assessors also performed other types of statistical analyses to evaluate mercury and PCB data for largemouth bass. Statistical significance was determined at $p \leq 0.05$ for all statistical analyses. The SALG risk assessors performed linear correlation (r) to describe associations between contaminant concentrations and total length (TL), fish age, and percent lipid composition. For those associations that were positive and significant, the SALG risk assessors performed linear regression analyses (r^2) to measure the strength and further describe the relationships.

RESULTS

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

For reference, Table 1 contains a list of fish samples collected from Lake Como. Tables 2.1–2.2 present the results of metals analyses. Tables 3 and 4 contain summary results for pesticides and PCBs, respectively. Table 5 summarizes the PCDD/PCDF analyses. Table 6 contains summary results for VOCs (i.e., trichlorofluoromethane and naphthalene). This report does not display SVOC data because these contaminants were not present at concentrations of concern in fish collected from Lake Como 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 five fish tissue samples (common carp [n = 2] and largemouth bass [n = 3]) for six inorganic contaminants and 20 samples for mercury. All fish tissue samples from Lake Como contained concentrations > RL of arsenic, mercury, selenium, and zinc (Tables 2.1–2.2).

The SALG evaluated three toxic metalloids having no known human physiological function (arsenic, cadmium, and lead) in the samples collected from Lake Como. Five of five fish analyzed contained arsenic ranging from 0.105–0.647 mg/kg (Table 2.1). The mean cadmium concentration in fish sampled from the Lake Como was 0.068±0.028 mg/kg. All five samples evaluated for lead contained estimated concentrations below the RL (Table 2.2).

Three of the metalloids analyzed are essential trace elements: copper, selenium, and zinc. The mean copper concentration in fish from Lake Como was 0.312±0.182 mg/kg (Table 2.2). All fish tissue samples contained selenium. Selenium concentrations ranged from 0.020 to 0.668 mg/kg with a mean of 0.322±0.230 mg/kg (Table 2.2). All samples also contained zinc (Table 2.2). The mean zinc concentration in fish tissue samples from Lake Como was 6.997±11.741 mg/kg.

<u>Mercury</u>

All fish tissue samples evaluated from Lake Como contained mercury (Tables 2.2). Mercury concentrations ranged from 0.030–0.275 mg/kg. The mean mercury concentration for the 20 fish tissue samples analyzed was 0.117±0.053 mg/kg (Table 2.2).

<u>Largemouth bass</u>

Two largemouth bass ranging from 15.0 to 20.0 inches TL ($\overline{X}$ – 16.3 inches TL) and from two to five years of age were analyzed for mercury (Table 1; Figure 2). One-hundred percent of the largemouth bass samples examined were of legal size (≥ 14 inches TL).[45] Mercury concentrations ranged from 0.098 to 0.275 mg/kg with a mean of 0.131±0.044 mg/kg (Table 2.2). Mercury concentrations in largemouth bass appeared to be positively related to TL and age (r^2 = 0.710, n = 17, p < 0.0005; r^2 = 0.602, n = 17, p = 0.0003; Figures 3–4).

<u>Common carp</u>

Three common carp ranging from 27.1 to 28.0 inches TL ($\overline{X}$ – 27.6 inches TL) were analyzed for mercury (Table 1). Currently, there is no minimum length limit for common carp in Texas waters.[45] Mercury concentrations ranged from 0.030 to 0.051 mg/kg with a mean of 0.038±0.011 mg/kg (Table 2.2).

Organic Contaminants

<u>Pesticides</u>

All samples examined contained concentrations of chlordane, 4,4′-dichlorodiphenyldichloroethylene (DDE), dieldrin, and endosulfan I. Chlordane concentrations ranged from 0.004 to 0.228 mg/kg with a mean of 0.093±0.115 mg/kg (Table 3). Total dichlorodiphenyltrichloroethane (DDT) [2,4′-DDE+4,4′-DDE + 2,4′-DDD +4,4′-DDD+2,4′-DDT+4,4′-DDT] ranged from 0.002 to 0.100 mg/kg with a mean 0.039±0.0048 mg/kg (Table 3). Dieldrin concentrations ranged from 0.001 to 0.042 mg/kg (Table 3.). The mean endosulfan I concentrations in fish tissue samples from Lake Como were 0.016±0.021 (Table 3.) Low concentrations > RL of endrin and heptachlor epoxide were present in three or more fish samples (Table 3.) Trace to low concentrations of 2,4′-DDE, 2,4′-DDD, 2,4′-DDT, 4,4′-DDT, aldrin, alpha hexachlorocyclohexane (HCH), beta-HCH, chlorpyrifos, dacthal, delta-HCH, gamma-HCH, hexachlorobenzene, mirex, pentachloroanisole, pentachlorobenzene, and tetrachlorobenzene were present in one or more fish samples (data not presented).

PCBs

All fish tissue samples evaluated from Lake Como contained PCBs (Tables 4). Across all species, PCB concentrations ranged from 0.010 to 0.227 mg/kg. The mean PCB concentration for the 20 fish tissue samples analyzed was 0.041±0.070 mg/kg (Table 4).

Common carp

PCB concentrations ranged from 0.151–0.227 mg/kg with a mean of 0.200±0.043 mg/kg and a median of 0.224 mg/kg (n = 3; Table 4).

Largemouth bass

PCB concentrations ranged from 0.010–0.021 mg/kg with a mean of 0.013±0.003 mg/kg and a median of 0.012 mg/kg (n = 17; Table 4). There was no apparent correlation between PCB concentration and TL, age, and percent lipids, respectively (r = 0.233, n = 17, p = 0.369; r = 0.188, n = 17, p = 0.471; r = -0.073, n = 17, p = 0.782).

PCDDs/PCDFs

Four of five fish tissue samples contained at least one of the 17 PCDD/PCDF congeners ranging from ND–7.184 TEQ pg/g with a mean of 2.471±3.229 TEQ pg/g and a median of 0.504 TEQ pg/g (Table 5). No samples contained all 17 congeners (data not shown). Common carp contained the highest mean PCDD/PCDF TEQ concentration (5.848±1.889 pg/g; Table 5).

SVOCs

The GERG laboratory analyzed a subset of five Lake Como fish tissue samples for SVOCs. Quantifiable concentrations greater than the reporting limit were reported for benzoic acid and diethyl phthalate in one fish sample (data not presented). Estimated concentrations of acetophenone, 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 Como.

VOCs

The Seafood and Aquatic Life Group Survey Team Standard Operating Procedures and Quality Control/Assurance Manual contain a complete list of the 70 VOCs selected for analysis. The GERG laboratory reported the five fish tissue samples selected for analysis from Lake Como to contain quantifiable concentrations greater than the reporting limit of one or more VOCs: 2-butanone; 1,2,3-trichlorobenzene; 1,2,4-trichlorobenzene; methylene chloride; naphthalene; trichlorofluoromethane; and toluene (all data not presented in tables). Trichlorofluoromethane concentrations ranged from BDL–0.177 mg/kg with a mean of 0.063±0.073 mg/kg. Naphthalene concentrations ranged from BDL–0.084 mg/kg (Table 6.) Estimated quantities of many VOCs were also present in one or more fish tissue samples analyzed from Lake Como (data not presented).

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

DISCUSSION

Risk Characterization

Because variability and uncertainty are inherent to quantitative assessment of risk, the calculated risks of adverse health outcomes from exposure to toxicants can be orders of magnitude above or below actual risks. Variability in calculated and in actual risk may depend upon factors such as the use of animal instead of human studies, use of subchronic rather than chronic studies, interspecies variability, intra-species variability, and database insufficiency. Because most factors used to calculate comparison values result from experimental studies conducted in the laboratory on nonhuman subjects, variability and uncertainty might arise from the study chosen as the "critical" one, the species/strain of animal used in the critical study, the target organ selected as the "critical organ," exposure periods, exposure route, doses, or uncontrolled variations in other conditions.[31] Despite such limitations, risk assessors must calculate parameters to represent potential toxicity to humans who consume contaminants in fish and other environmental media. The DSHS calculated risk parameters for systemic and carcinogenic endpoints in those who would consume fish from the Lake Como. Conclusions and recommendations are predicated upon the stated goal of the DSHS to protect human health follow the discussion of the relevance of findings to risk.

Characterization of Systemic (Noncarcinogenic) Health Effects from Consumption of Fish from Lake Como

Inorganic Contaminants

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

Even though mercury concentrations did not exceed DSHS guidelines for protection of human health, it is important to understand that mercury concentrations in largemouth bass from Lake Como were positively related to TL and age indicating that mercury concentrations increase over time as fish grow (Figures 3–4). These relationships are also affected by the slow rate at which fish eliminate mercury compared to the rate at which it is accumulated. People should consider these relationships when choosing the size and species of fish they consume.

Organic Contaminants

PCBs and PCDDs/PCDFs were observed in common carp from Lake Como that equaled or exceeded their respective HAC_{nonca} (0.047 mg/kg; 2.330 pg/g; Tables 4, 5, and 8). None of the species of fish evaluated contained any other organic contaminants at concentrations that equaled or exceeded DSHS guidelines for protection of human health or would likely cause systemic (noncancerous) risk to human health from consumption of fish from Lake Como.

PCBs

All fish tissue samples (n = 20) evaluated contained PCBs. Fifteen percent of all samples analyzed contained PCB concentrations exceeding the HAC_{nonca} for PCBs (0.047 mg/kg; Table 4). Common carp samples evaluated had mean PCB concentrations exceeding the HAC_{nonca} for PCBs or an HQ of 1.0 (Tables 4 and 8). The all fish combined mean PCB concentration did not exceed the HAC_{nonca} for PCBs or an HQ of 1.0. The consumption of common carp from Lake Como may pose potential systemic (noncancerous) health risks.

Meal consumption calculations are useful for risk managers to make fish consumption recommendations and/or take regulatory action. The SALG risk assessors calculated the number of eight-ounce meals of fish from Lake Como that healthy adults could consume without significant risk of PCB-related adverse systemic effects (Table 8). Meal consumption rates were based on the overall mean PCB concentration by species. The SALG risk assessors estimated that healthy adults could consume 0.2 eight-ounce meals per week of common carp. The SALG risk assessors suggest that common carp from Lake Como contain PCBs at concentrations that may pose potential systemic (noncancerous) health risks and that people should not consume common carp from Lake Como. Because the developing nervous system of the human fetus and young children may be especially susceptible to adverse systemic (noncancerous) health effects associated with consuming PCB-contaminated fish, the SALG risk assessors recommend more conservative consumption guidance for this sensitive subpopulation.

PCDDs/PCDFs

Four of five fish tissue samples assayed contained PCDDs/PCDFs. Forty percent of all samples analyzed contained PCDD/PCDF concentrations exceeding the HAC_{nonca} for PCDDs/PCDFs (2.330 pg/g; Tables 5 and 8). One (common carp) of two species evaluated had mean PCDD/PCDF concentrations exceeding the HAC_{nonca} for PCDDs/PCDFs or an HQ of 1.0 (Tables 5 and 8). The consumption of common carp from Lake Como may pose potential systemic (noncancerous) health risks.

Meal consumption calculations are useful for risk managers to make fish consumption recommendations and/or take regulatory action. The SALG risk assessors calculated the number of eight-ounce meals of fish from Lake Como that healthy adults could consume without significant risk of PCDD/PCDF -related adverse systemic effects (Table 8). Meal consumption rates were based on the overall mean PCDD/PCDF concentration by species. The SALG risk assessors estimated that healthy adults could consume 0.4 eight-ounce meals per week of common carp. The SALG risk assessors suggest that common carp from Lake Como contain PCDDs/PCDFs at concentrations that may pose potential systemic (noncancerous) health risks and that people should limit their consumption of common carp from Lake Como. Because the developing nervous system of the human fetus and young children may be especially susceptible to adverse systemic health effects associated with consuming PCDD/PCDF-contaminated fish, the SALG risk assessors recommend more conservative consumption guidance for this sensitive subpopulation.

Characterization of Theoretical Lifetime Excess Cancer Risk from Consumption of Fish from the Lake Como

The USEPA classifies arsenic, most chlorinated pesticides, PCBs, and PCDDs/PCDFs as human carcinogens. Arsenic, chlordane, DDT (total), dieldrin, heptachlor epoxide, PCBs, and PCDDs/PCDFs were present in fish samples analyzed from Lake Como. Mean dieldrin and PCDDs/PCDFs concentrations in common carp would increase the risk of cancer to exceed the DSHS guideline for protection of human health of one excess cancer in 10,000 equally exposed individuals.

<u>Dieldrin</u>

All common carp tissue samples evaluated contained dieldrin exceeding the HAC_{ca} for dieldrin (0.034 mg/kg; *n* = 2; Table 3). The mean dieldrin concentration observed in common carp exceeds the DSHS guideline for protection of human health of one excess cancer in 10,000 equally exposed individuals and the HAC_{ca} for dieldrin (0.034 mg/kg; Tables 3 and 9). The all fish combined mean dieldrin concentration did not exceed the HAC_{ca} for dieldrin.

The SALG risk assessors calculated the number of eight-ounce meals of common carp from Lake Como that healthy adults could consume without significantly increasing their lifetime excess cancer risk (Tables 9). The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week of common carp (0.8 meals per week). Because children may experience effects at a lower exposure dose than might adults because children's systems may be more sensitive to the effects of toxicants, the SALG risk assessors recommend more conservative consumption guidance for this sensitive subpopulation. The SALG risk assessors suggest that consumption of common carp from Lake Como likely increases the risk of cancer to exceed the DSHS guideline for protection of human health from dieldrin exposure.

PCDDs/PCDFs

The mean PCDD/PCDF concentrations observed in common carp 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 and 9). The all fish combined mean PCDD/PCDF concentration did not exceed the HAC_{ca} for PCDDs/PCDFs. The consumption of common carp from Lake Como 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 common carp from Lake Como that healthy adults could consume without significantly increasing their lifetime excess cancer risk (Tables 9). The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week of common carp (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 common carp from Lake Como would be likely to increase the risk of cancer to exceed the DSHS guideline for protection of human health from PCDD/PCDF exposure.

Characterization of Calculated Cumulative Systemic (Noncarcinogenic) Health Effects and of Cumulative Excess Lifetime Cancer Risk from Consumption of Fish from Lake Como

Cumulative Systemic (Noncarcinogenic) Health Effects

Cumulative systemic (noncarcinogenic) effects of toxicants may occur if more than one contaminant acts upon the same target organ or acts by the same mode or mechanism of action. PCBs and PCDDs/PCDFs in fish from Lake Como could have these properties, especially with respect to effects on the immune system. Multiple organic contaminants in Lake Como fish increased the likelihood of systemic adverse health outcomes for all species of fish assayed (Table 8). The combined toxicity of PCBs and PCDDs/PCDFs in common carp 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 Como that healthy adults could consume without significant risk of PCB and/or PCDD/PCDF -related adverse systemic effects (Tables 8). 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 (0.1) eight-ounce meal per week of common carp (Table 8). The SALG risk assessors suggest that common carp from Lake Como contain PCBs and PCDDs/PCDFs at concentrations that may pose potential systemic (noncarcinogenic) health risks and that people should limit their consumption of fish from Lake Como. Because the developing nervous system of the human fetus and young children may be especially susceptible, the SALG risk assessors recommend more conservative consumption guidance for these sensitive subpopulations.

Cumulative Carcinogenic Health Effects

The SALG also queried the probability of increasing lifetime excess cancer risk from consuming fish containing multiple inorganic and organic contaminants. In most assessments of cancer risk from environmental exposures to chemical mixtures, researchers have considered any increase in cancerous or benign growths in one or more organs as cumulative, no matter the mode or mechanism of action of the contaminant. In this assessment, risk assessors added the calculated carcinogenic effect of arsenic, chlorinated pesticides, PCBs, and PCDFs/PCDDs (Table 9). In each instance, addition of the cancer risk for these chemicals increased the theoretical lifetime excess cancer risk. The cancer risk increase did elevate lifetime excess cancer risk to a level greater than the DSHS guideline for protection of human health of one excess cancer in 10,000 persons equivalently exposed for common carp.

The consumption of common carp from Lake Como would be likely to increase the risk of cancer to exceed the DSHS guideline for protection of human health. The SALG risk assessors estimated that healthy adults could consume less than one eight-ounce meal per week of common carp (0.2 meals per week; Table 9). Because children may experience effects at a lower exposure dose than adults, the SALG risk assessors recommend more conservative consumption guidance for this sensitive subpopulation. The SALG risk assessors suggest that consumption of common carp from Lake Como would be likely to increase the risk of cancer to exceed the DSHS guideline for protection of human health from multiple contaminant exposures.

CONCLUSIONS

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

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

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

2. The SALG was unable to collect any bottom feeding species of fish (e.g., channel catfish) from Lake Como besides common carp. Bottom feeding fish generally have higher lipid composition than predatory species and organic contaminants (e.g., PCBs) mostly concentrate in lipid tissue. Because of the history of organic contaminants in Lake Como fish, there is potential concern that stocking of any bottom feeding species of fish along with subsequent harvest could continue to pose risk to human health.

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

4. Largemouth bass mean PCB and PCDD/PCDF TEQ concentrations do not exceed the DSHS guidelines for protection of human health. Therefore, consumption of largemouth bass containing only PCBs and PCDDs/PCDFs **poses no apparent risk to human health**.

5. Common carp mean PCB and PCDD/PCDF TEQ concentrations exceed the DSHS guidelines for protection of human health. Regular or long-term consumption of common carp may result in adverse systemic (noncarcinogenic) health effects. Therefore, consumption of common carp from Lake Como **poses an apparent risk to human health**.

6. Common carp mean dieldrin concentrations exceed the DSHS guidelines for protection of human health. Regular or long-term consumption of common carp may increase the likelihood of carcinogenic health risks. Therefore, consumption of common carp from Lake Como **poses an apparent risk to human health**.

7. Common carp mean PCDD/PCDF TEQ concentrations exceed the DSHS guidelines for protection of human health. Regular or long-term consumption of common carp may increase the likelihood of carcinogenic health risks. Therefore, consumption of common carp from Lake Como **poses an apparent risk to human health**.

8. Consumption of multiple organic contaminants (i.e., PCDDs/PCDFs and PCBs) in common carp may increase the likelihood of systemic (noncarcinogenic) health risks. Regular or long-term consumption of common carp may result in adverse systemic (noncarcinogenic) health effects. Therefore, consumption of common carp from Lake Como **poses an apparent risk to human health**.

9. Consumption of multiple inorganic and/or organic contaminants observed in common carp may increase the likelihood of carcinogenic health risks. Therefore, consumption of common carp containing multiple contaminants **poses an apparent risk to human health**.

RECOMMENDATIONS

Risk managers at the DSHS have established criteria for issuing fish consumption advisories based on approaches suggested by the USEPA.[12, 17, 46] Risk managers at the DSHS may decide to take action to protect public health if a risk characterization confirms that people can eat four or fewer meals per month (adults: eight-ounces per meal; children: four-ounces per meal) of fish or shellfish from a water body under investigation. Risk management recommendations may be in the form of consumption advice or a ban on possession of fish from the affected water body. Fish or shellfish possession bans are enforceable under subchapter D of the Texas Health and Safety Code, part 436.061(a).[47] Declarations of prohibited harvesting areas are enforceable under the Texas Health and Safety Code, Subchapter D, parts 436.091 and 436.101. 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 common carp from Lake Como **poses an apparent hazard to public health.** Therefore, SALG risk assessors recommend that:

1. People should not consume common carp from Lake Como (Table 11).

2. The DSHS advise that if any stocking of fish should occur in Lake Como that harvest of stocked fish should not be allowed until SALG risk assessors evaluate sufficiently to determine if the fish are safe to consume.

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

PUBLIC HEALTH ACTION PLAN

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

- The agency publishes fish consumption advisories and bans in a booklet available to the public through the SALG. To receive the booklet and/or the data, please contact the SALG at 512-834-6757.[48]
- The SALG also posts the most current information about advisories, bans, and the removal of either on the internet at http://www.dshs.state.tx.us/seafood.[49] The SALG regularly updates this Web site.
- The DSHS also provides the USEPA (http://epa.gov/waterscience/fish/advisories/), the TCEQ (http://www.tceq.state.tx.us), and the TPWD (http://www.tpwd.state.tx.us) with

information on all consumption advisories and possession bans. Each year, the TPWD informs the public of consumption advisories and fishing bans on its Web site and in an official downloadable PDF file containing general hunting and fishing regulations available at http://www.tpwd.state.tx.us/publications/pwdpubs/media/outdoorannual_2014_15.pdf. A booklet containing this information is available at all establishments selling Texas fishing licenses.[45]

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

- Readers may direct questions about the scientific information or recommendations in this risk characterization to the SALG at 512-834-6757 or may find the information at the SALG's Web site (http://www.dshs.state.tx.us/seafood). Secondarily, one may address inquiries to the Environmental and Injury Epidemiology and Toxicology Unit of DSHS (800-588-1248).
- The USEPA's IRIS Web site (http://www.epa.gov/iris/) contains information on environmental contaminants found in food and environmental media.
- The ATSDR, Division of Toxicology (888-42-ATSDR or 888-422-8737 or the ATSDR's Web site (http://www.atsdr.cdc.gov) supplies brief information via ToxFAQs.™ ToxFAQs™ are available on the ATSDR Web site in either English or Spanish (http://www.atsdr.cdc.gov/toxfaqs/index.asp). The ATSDR also publishes more in-depth reviews of many toxic substances in its *Toxicological Profiles* (ToxProfiles™) http://www.atsdr.cdc.gov/toxprofiles/index.asp. To request a copy of the ToxProfiles™ CD-ROM, PHS, or ToxFAQs™ call 1-800-CDC-INFO (800-232-4636) or email a request to cdcinfo@cdc.gov.

Figure 1. Lake Como Map

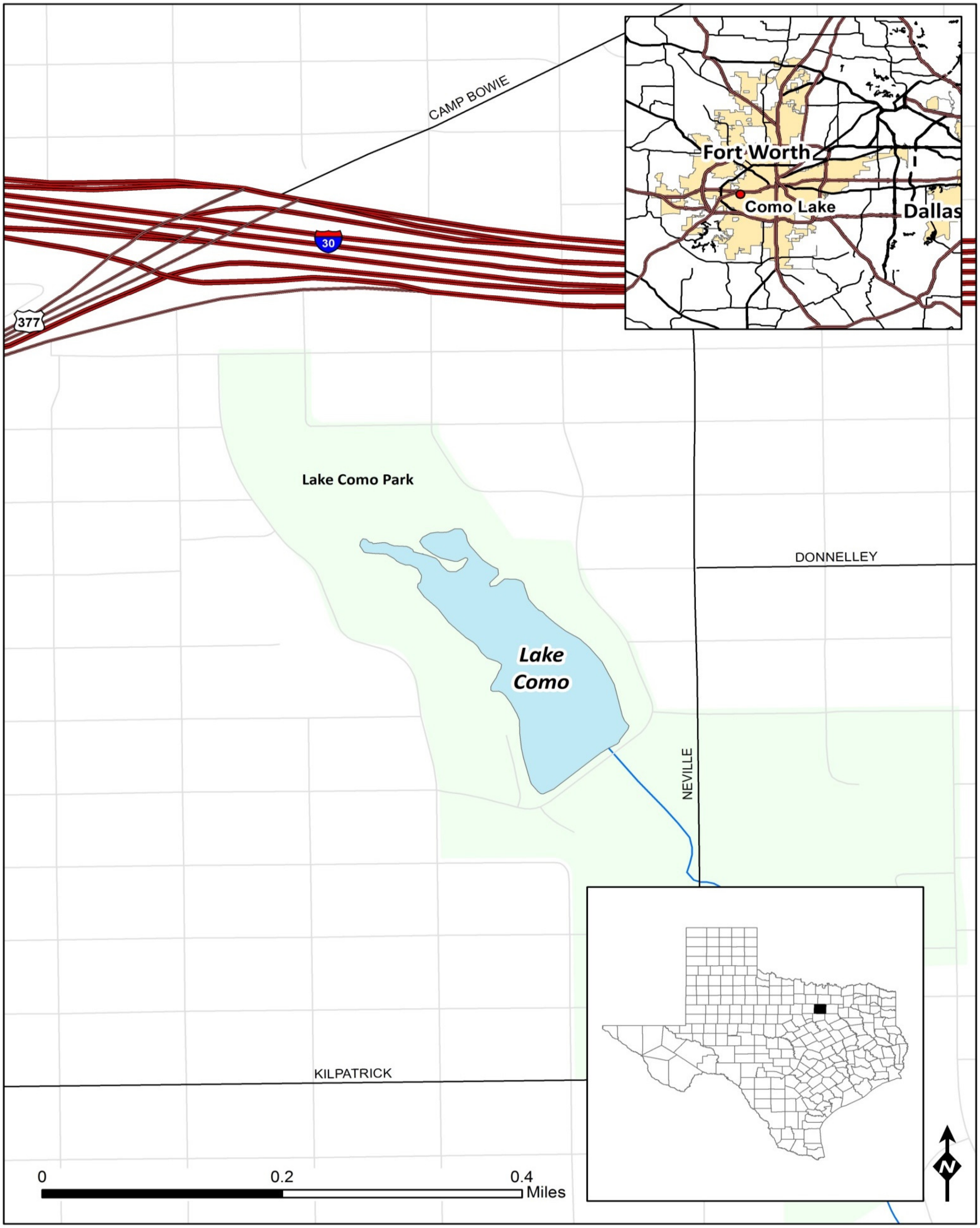


Figure 2. Length at age for largemouth bass collected from Lake Como, Texas, 2014.

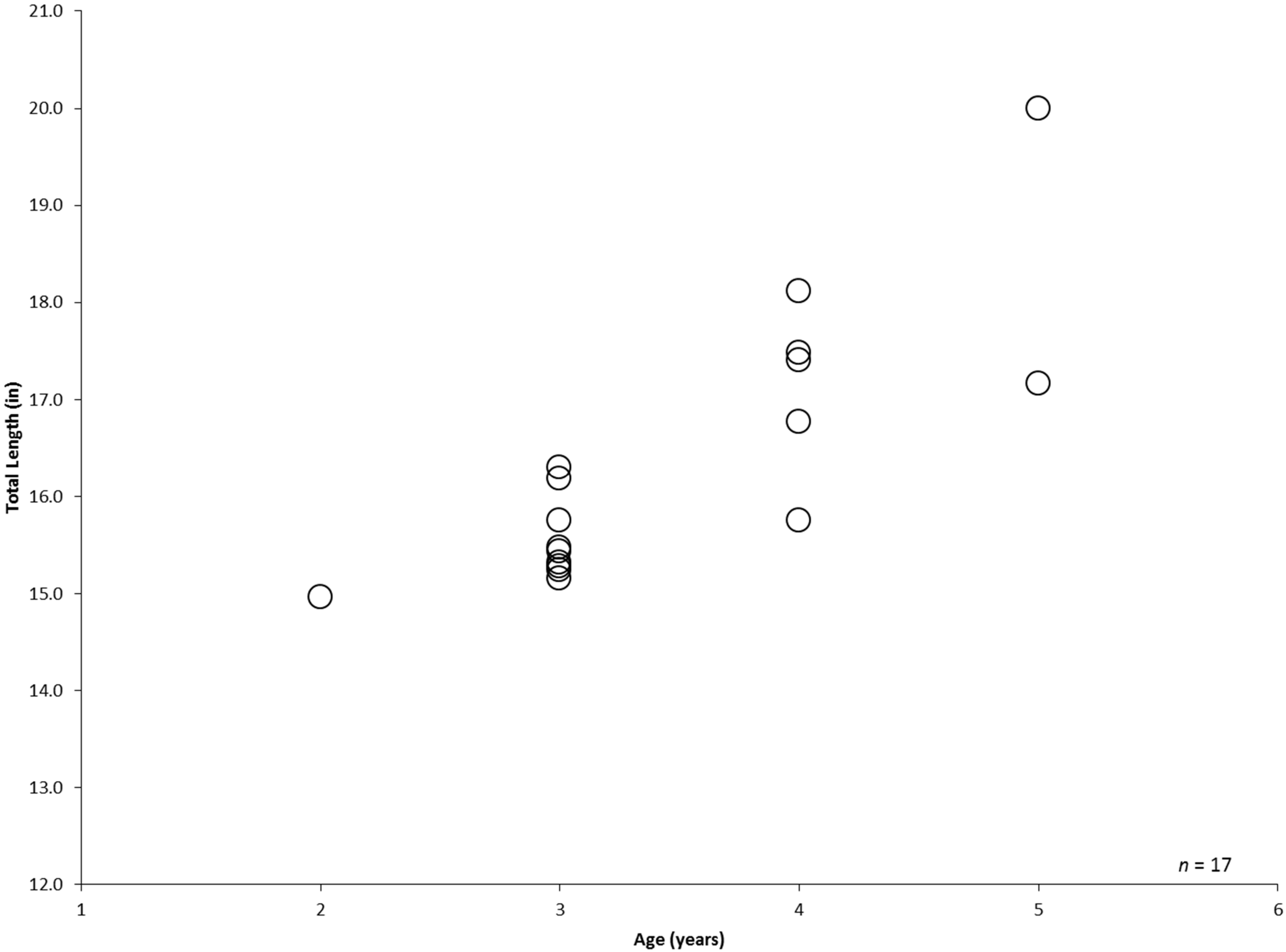


Figure 3. The relationship between mercury concentration and total length for largemouth bass collected from Lake Como, Texas, 2014.

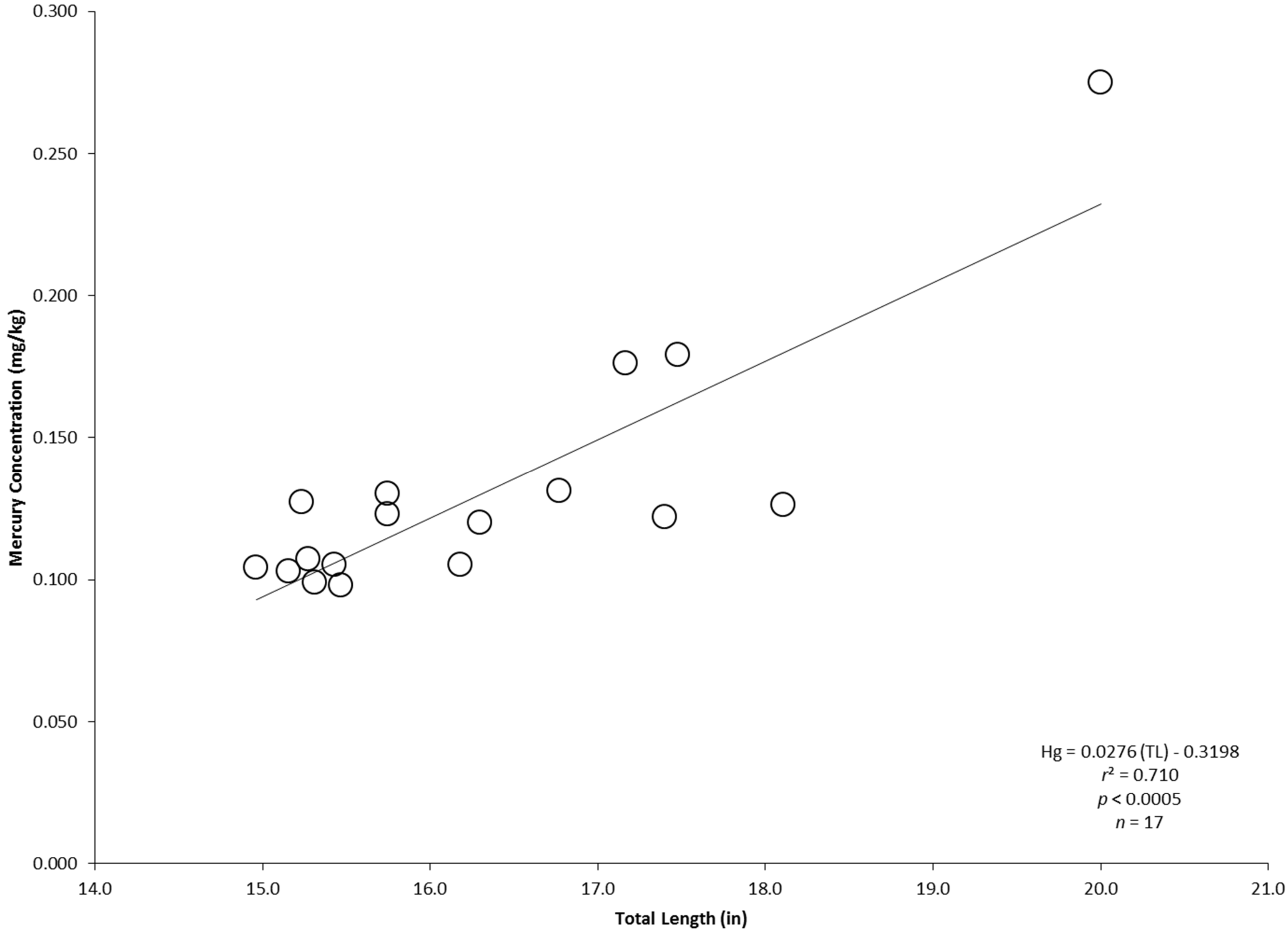
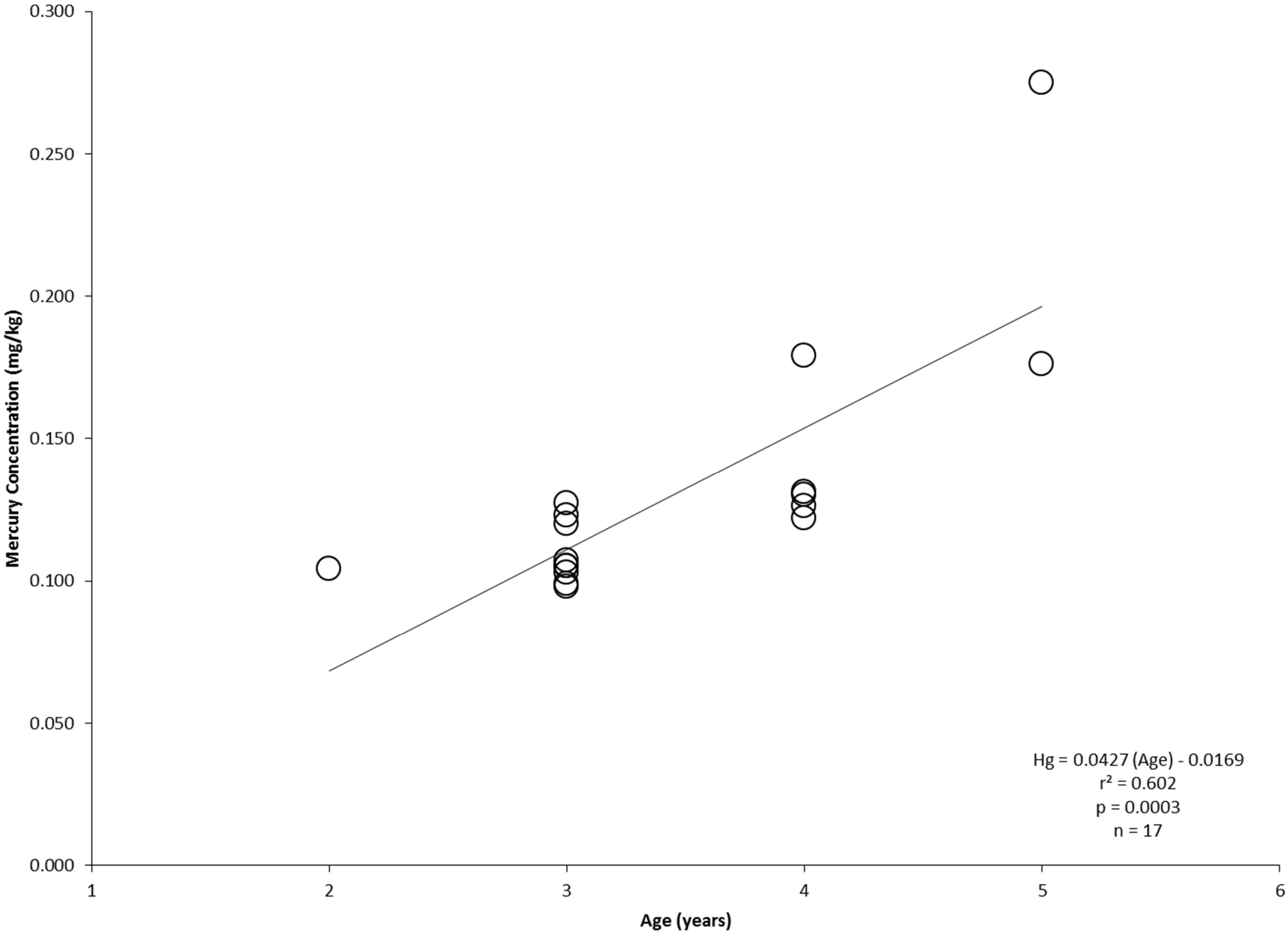


Figure 4. The relationship between mercury concentration and age for largemouth bass collected from Lake Como, Texas, 2014.



TABLES

Table 1. Fish samples collected from Como Lake 2014. Sample number, species, total length, and weight recorded for each sample.					
Sample Number	Species	Total Length		Weight	
		Millimeters (mm)	Inches (in)	Grams (g)	Pounds (lb)
COM1	Common carp	706	27.8	6977	15.4
COM2	Common carp	689	27.1	5907	13.0
COM3	Common carp	711	28	7171	15.8
COM4	Largemouth bass	400	15.7	855	1.9
COM5	Largemouth bass	508	20	2464	5.4
COM6	Largemouth bass	460	18.1	1631	3.6
COM7	Largemouth bass	426	16.8	1174	2.6
COM8	Largemouth bass	436	17.2	1164	2.6
COM9	Largemouth bass	411	16.2	1039	2.3
COM10	Largemouth bass	442	17.4	1363	3.0
COM11	Largemouth bass	444	17.5	1160	2.6
COM12	Largemouth bass	389	15.3	869	1.9
COM13	Largemouth bass	380	15	744	1.6
COM14	Largemouth bass	388	15.3	846	1.9
COM15	Largemouth bass	387	15.2	742	1.6
COM16	Largemouth bass	414	16.3	920	2.0
COM17	Largemouth bass	393	15.5	834	1.8
COM18	Largemouth bass	400	15.7	1036	2.3
COM19	Largemouth bass	392	15.4	1068	2.4
COM20	Largemouth bass	385	15.2	843	1.9

Table 2.1. Arsenic (mg/kg) in fish collected from Lake Como, 2014.					
Species	**Number Detected/ Number Tested**	**Total Arsenic Mean ± S.D. (Min-Max)**	**Inorganic Arsenic Mean[j]**	**HAC Value (nonca) and HAC Value (ca; mg/kg) [k]**	**Basis for Comparison Value**
Common carp	2/2	0.379±0.379 (0.111-0.647)	0.038	0.700	EPA Chronic Oral RfD for Inorganic Arsenic — 0.0003 mg/kg–day
Largemouth bass	3/3	0.118±0.013 (0.105-0.130)	0.012		
All fish combined	5/5	0.223±0.237 (0.105-0.647)	0.022	0.363	EPA Oral Slope Factor for Inorganic Arsenic — 1.5 per mg/kg–day

[j] *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.*

[k] *Derived from the MRL or RfD for noncarcinogens or the EPA slope factor for carcinogens; assumes a body weight of 70 kg, and a consumption rate of 30 grams per day, and assumes a 30-year exposure period for carcinogens and an excess lifetime cancer risk of $1x10^{-4}$.*

Table 2.2. Inorganic contaminants (mg/kg) in fish collected from Lake Como, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca; mg/kg)**	**Basis for Comparison Value**
Cadmium				
Common carp	2/2	0.085±0.044 (BDL-0.116)	0.233	ATSDR Chronic Oral MRL— 0.0001 mg/kg–day
Largemouth bass	3/3	BDL		
All fish combined	5/5	0.068±0.028 (BDL-0.116)		
Copper				
Common carp	2/2	0.510±0.032 (0.487-0.532)	334	Based on the Tolerable Upper Intake Level (UL) — 0.143 mg/kg–day[l]
Largemouth bass	3/3	BDL		
All fish combined	5/5	0.312±0.182 (BDL-0.532)		
Lead				
Common carp	2/2	BDL	N/A	N/A
Largemouth bass	3/3	BDL		
All fish combined	5/5	BDL		
Mercury				
Common carp	3/3	0.038±0.011 (0.030-0.051)	0.7	ATSDR Chronic Oral MRL for Methylmercury — 0.0003 mg/kg–day
Largemouth bass	17/17	0.131±0.044 (0.098-0.275)		
All fish combined	20/20	0.117±0.053 (0.030-0.275)		
Selenium				
Common carp	2/2	0.344±0.458 (0.020-0.668)	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)[m, 50]
Largemouth bass	3/3	0.308±0.009 (0.297-0.313)		
All fish combined	5/5	0.322±0.230 (0.020-0.668)		
Zinc				
Common carp	2/2	11.235±0.716 (10.729-11.741)	700	EPA Chronic Oral RfD — 0.3 mg/kg–day
Largemouth bass	3/3	4.172±0.805 (3.666-5.100)		
All fish combined	5/5	6.997±3.926 (3.666-11.741)		

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

[m] 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 3. Pesticides (mg/kg) in fish collected from Lake Como, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; mg/kg)**	**Basis for Comparison Value**
Chlordane				
Common carp	2/2	0.2193±0.0124 (0.2105-0.2281)	1.167	EPA Chronic Oral RfD — 0.0005 mg/kg–day
Largemouth bass	3/3	0.0091±0.0066 (0.0038-0.0165)		
All fish combined	5/5	0.0932±0.1154 (0.0038-0.2281)	1.556	EPA Oral Slope Factor — 0.35 per mg/kg–day
DDT (total)				
Common carp	2/2	0.0907±0.0134 (0.0812-0.1002)	1.167	EPA Chronic Oral RfD for DDT — 5.0E-4 mg/kg–day
Largemouth bass	3/3	0.0044±0.0025 (0.0022-0.0072)		
All fish combined	5/5	0.0389±0.0478 (0.0022-0.1002)	1.601	EPA Oral Slope Factor for DDT— 3.4E-1 per mg/kg–day
Dieldrin				
Common carp	2/2	**0.0405**[n]±0.0027 (**0.0386-0.0424**)	0.117	EPA Chronic Oral RfD — 0.00005 mg/kg–day
Largemouth bass	3/3	0.0032±0.0023 (0.0012-0.0057)		
All fish combined	5/5	0.0181±0.0206 (0.0012-**0.0424**)	0.034	EPA Oral Slope Factor — 16 per mg/kg–day
Endosulfan I				
Common carp	2/2	0.0396±0.0003 (0.0394-0.0398)	4.667	ATSDR Chronic Oral MRL— 2.0E-3 mg/kg–day
Largemouth bass	3/3	0.0008±0.0005 (0.0005-0.0014)		
All fish combined	5/5	0.0163±0.0212 (0.0005-0.0398)		
Endrin				
Common carp	1/2	0.0169±0.0237 (ND-0.0336)	0.700	EPA Chronic Oral RfD — 3.0E-4 mg/kg–day
Largemouth bass	3/3	0.0020±0.0013 (0.0007-0.0033)		
All fish combined	4/5	0.0079±0.0144 (ND-0.0336)		
Heptachlor epoxide				
Common carp	1/2	0.0019±0.0026 (ND-0.0038)	0.030	EPA Chronic Oral RfD — 1.3E-5 mg/kg–day
Largemouth bass	3/3	0.0004±0.0004 (BDL-0.0008)		
All fish combined	4/5	0.0010±0.0016 (ND-0.0038)	0.060	EPA Oral Slope Factor — 9.1 per mg/kg–day

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

Table 4. PCBs (mg/kg) in fish collected from Lake Como, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; mg/kg)**	**Basis for Comparison Value**
Common carp	3/3	**0.200**[o]±0.043 (**0.151-0.227**)	0.047	EPA Chronic Oral RfD for Aroclor 1254 — 0.00002 mg/kg–day
Largemouth bass	17/17	0.013±0.003 (0.010-0.021)		
All fish combined	20/20	0.041±0.070 (0.010-**0.227**)	0.272	EPA Slope Factor — 2.0 per mg/kg–day

Table 5. PCDDs/PCDFs toxicity equivalent (TEQ) concentrations (pg/g) in fish collected from Lake Como, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; pg/g)**	**Basis for Comparison Value**
Common carp	2/2	**5.848**±1.889 (**4.512-7.184**)	2.33	ATSDR Chronic Oral MRL for 2,3,7,8 – TCDD — 1.0×10^{-9} mg/kg–day
Largemouth bass	2/3	0.220±0.258 (ND-0.504)		
All fish combined	4/5	**2.471**±3.229 (ND-**7.184**)	3.49	EPA Slope Factor — 1.56×10^{5} per mg/kg–day

Table 6. Volatile organic compounds (mg/kg) in fish collected from Lake Como, 2014.				
Species	**Number Detected/ Number Tested**	**Mean ± S.D. (Min-Max)**	**HAC Value (nonca) and HAC Value (ca; pg/g)**	**Basis for Comparison Value**
Naphthalene				
Common carp	2/2	0.064±0.028 (0.044-0.084)	700	EPA Chronic Oral RfD — 3.0E-01 mg/kg–day
Largemouth bass	3/3	0.006±0.004 (BDL-0.009)		
All fish combined	5/5	0.029±0.035 (BDL-0.084)		
Trichlorofluoromethane				
Common carp	2/2	0.135±0.059 (0.094-0.177)	47	EPA Chronic Oral RfD — 2.0E-02 mg/kg–day
Largemouth bass	3/3	0.015±0.009 (BDL-0.022)		
All fish combined	5/5	0.063±0.073 (BDL-0.177)		

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

Table 7. Hazard quotients (HQs) for mercury in fish collected from Lake Como in 2014. Table 7 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[p]			
Species	**Number of Samples**	**Hazard Quotient**	**Meals per Week**
Common carp	3	0.05	unrestricted[q]
Largemouth bass	17	0.19	4.9
All fish combined	20	0.17	5.5

Table 8. Hazard quotients (HQs) and hazard indices (HIs) for PCBs and/or PCDDs/PCDFs in fish collected from Lake Como in 2014. Table 7.1 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[r]			
Contaminant/Species	**Number of Samples**	**Hazard Quotient**	**Meals per Week**
Common carp			
PCBs	3	**4.29**[s]	**0.2**[t]
PCDDs/PCDFs	2	**2.51**	**0.4**
Hazard Index (meals per week)		**6.79**	**0.1**
Largemouth bass			
PCBs	17	0.28	3.3
PCDDs/PCDFs	3	0.09	10.8
Hazard Index (meals per week)		0.36	2.5
All fish combined			
PCBs	20	0.88	1.1
PCDDs/PCDFs	5	**1.06**	**0.9**
Hazard Index (meals per week)		**1.94**	**0.5**

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

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

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

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

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

Table 9. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish collected in 2014 from Lake Como containing carcinogens and suggested consumption rate (eight-ounce meals/week) for 70 kg adults who regularly eat fish Lake Como over a 30-year period.u				
Species/Contaminant	**Number of Samples**	**Theoretical Lifetime Excess Cancer Risk**		**Meals per Week**
		Risk	**Population Size that Would Result in One Excess Cancer**	
Common Carp				
Arsenic	2	1.0E-05	95,517	8.8
Chlordane		1.4E-05	71,030	6.6
DDT (total)		5.7E-06	175,968	unrestricted[v]
Dieldrin		**1.2E-04**[w]	**8.299**	**0.8**[x]
PCBs	3	7.3E-05	13,611	1.3
PCDDs/PCDFs	2	**1.7E-04**	**5,968**	**0.6**
Cumulative Cancer Risk		**3.9E-04**	**2,553**	**0.2**
Largemouth bass				
Arsenic	3	3.3E-06	302,469	unrestricted
Chlordane		5.8E-07	1,728,395	unrestricted
DDT (total)		1.2E-07	8,006,536	unrestricted
Dieldrin		8.8E-06	113,426	unrestricted
PCBs	17	4.8E-06	209,402	unrestricted
PCDDs/PCDFs	3	5.7E-06	174,501	unrestricted
Cumulative Cancer Risk		2.3E-05	42,860	4.0
All fish combined				
Arsenic	5	6.1E-06	164,983	15.2
Chlordane		6.0E-06	167,264	15.5
DDT (total)		2.4E-06	410,592	unrestricted
Dieldrin		5.3E-05	18,904	1.7
PCBs	20	1.5E-05	66,396	6.1
PCDDs/PCDFs	5	7.1E-05	14,124	1.3
Cumulative Cancer Risk		**1.5E-04**	**6,526**	**0.6**

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

Table 10. SALG recommended fish consumption advice for Lake Como, 2014.			
Contaminants of Concern	**Species**	**Women of childbearing age and children < 12**	**Women past childbearing age and adult men**
Dieldrin, dioxins, and PCBs	Common carp	**DO NOT EAT**	**DO NOT EAT**

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