QUANTITATIVE RISK CHARACTERIZATION

Echo Lake

Fort Worth, Tarrant County, Texas

August 7, 2002

Prepared by

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Seafood Safety Division
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BACKGROUND AND STATEMENT OF ISSUES

The Texas Department of Health Seafood Safety Division prepared this evaluation of environmental contaminants in fish tissue from Echo Lake in response to requests from the City of Fort Worth, Texas and the Texas Natural Resource Conservation Commission (TNRCC). Echo Lake is a 15 surface-acre urban reservoir located in Echo Lake Park within the city limits of Fort Worth. Echo Lake, along with Cement Creek Reservoir and French Lake, serves as a storm- water retention pond for the nearby neighborhoods. Consequently, Echo Lake receives non-point source runoff from surrounding areas that may contain inorganic or organic pollutants. Despite regulations that prohibit possession of fish from Echo Lake, recreational catch-and-release fishing is, reportedly, common and subsistence fishing may be occurring at the reservoir.

In 1995, TDH identified small quantities of p,p'-DDE, dieldrin, heptachlor epoxide, mercury, and zinc in edible tissues of fish from Echo Lake. Polychlorinated biphenyls (PCBs) consistent with Aroclor 1254 and Aroclor 1260 were observed at levels exceeding TDH health-based guidelines in effect at that time. On December 5, 1995, the Commissioner of Health for the State of Texas issued Aquatic Life Order Number 11 (AL-11) closing Echo Lake to possession of any species of fish [1]. This advisory remains in effect. The purpose of the present screening study is to determine whether there is any indication that contaminant concentrations in fish from Echo Lake have changed between 1995 and the present. The study results will allow TDH to decide whether it is necessary, at this time, to reevaluate Aquatic Life Order Number 11 (AL-11).

DISCUSSION

Sample Collection and Chemical Analysis

To evaluate potential health risks to recreational and subsistence fishers who consume environmentally contaminated seafood, the Texas Department of Health (TDH) collects and analyzes samples of edible seafood tissues from the state's public waters that represent the species, trophic levels and legal-sized specimens available for consumption. When practical, TDH collects samples from several sites within a water body to characterize the geographical distribution of contaminants. The TDH laboratory utilizes established methodology to analyze edible fillets (skin off) of fish and edible meats of shellfish for seven metals – arsenic, cadmium, copper, lead, mercury, selenium, and zinc – and for many volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), twenty-seven pesticides, and seven polychlorinated biphenyl (PCB) mixtures (Aroclors 1016, 1221, 1224, 1232, 1248, 1254, and 1260).

Description of the Echo Lake Sample Set

The City of Fort Worth collected five *largemouth bass* from Echo Lake in October 2000. TDH Seafood Safety Division personnel collected an additional five samples (four *largemouth bass* and one *common carp*) in March 2001. The TDH laboratory analyzed all ten samples for all previously described compounds.

Derivation of Health-Based Assessment Comparison Values (HACs)

Generally, people who regularly eat contaminated seafood are exposed to low concentrations of contaminants over an extended time. This pattern of exposure seldom results in acute toxicity but may increase the risk of subtle, delayed or chronic adverse health effects. Presuming that people eat a variety of fish, TDH evaluates average contaminant concentrations across species and locations within a specific water body because this approach likely reflects the prototypical exposures of consumers of contaminated seafood. The agency also may examine the risks associated with ingestion of individual species from specific collection sites within a body of water.

TDH evaluates chemical contaminants in fish by comparing average contaminant concentrations with health-based assessment comparison (HAC) values (in mg contaminant per kg edible tissue or mg/kg) for non-cancer and cancer endpoints. Following approaches suggested by the United States Environmental Protection Agency (USEPA) in its *Guidance for assessing chemical contaminant data for use in fish advisories* [2], TDH has developed noncancer (HAC_{nonca}) and cancer (HAC_{ca}) comparison values. To derive HAC_{nonca} values, TDH uses oral reference doses (RfDs) from the USEPA or chronic oral minimal risk levels (MRLs) from the Agency for Toxic Substances and Disease Registry (ATSDR). RfDs are estimates of long-term (greater than three months) daily exposure doses that are considered unlikely to cause adverse noncancerous (systemic) health effects even if exposure occurs over a lifetime [4]. MRLs are similar to RfDs but may not be identical due to use of different assumptions or constants by the two agencies. TDH derives HAC_{ca} values from the USEPA's chemical-specific cancer slope factors (SFs) using an acceptable lifetime risk level (ARL) of 1 excess cancer in 10,000 (1×10^{-4}) people exposed and an exposure period of 30 years. For these derivations, TDH utilizes a standard adult body weight of 70 kilograms and assumes that adults consume 30 grams of fish per day (about one eight-ounce meal per week). TDH also utilizes the tissue concentration of a contaminant to calculate a hazard quotient (HQ) for the contaminant [3]. A hazard quotient is the ratio of the estimated exposure dose of a contaminant to its RfD or MRL. An HQ of less than 1.0 usually indicates that consumption of seafood containing an isolated contaminant will not present a significant hazard to human health.

Most constants employed to calculate HAC_{nonca} values contain built-in margins of safety (uncertainty factors). Uncertainty factors are based on scientific judgment and are chosen to minimize the potential for adverse health effects in those people – including sensitive subgroups: e.g., pregnant women, infants, children, the elderly, people with chronic illnesses, or those who consume large amounts of fish or shellfish – who eat environmentally contaminated seafood. The cancer slope factors (SFs) from which HAC_{ca} values are derived are also designed to ensure a wide margin of safety. Furthermore, health-based assessment comparison values (HAC values) are not meant to represent a sharp dividing line between safe and unsafe exposures. The strict demarcation between acceptable and unacceptable exposures or risks is a tool used by risk managers to assure protection of public health. TDH finds it unacceptable when consumption of four or fewer meals per month would result in exposures that exceed a HAC value or other measure of risk. People who wish to minimize exposure to environmental contaminants in seafood are further advised to eat a variety of fish and shellfish and to limit consumption of those species that are likely to contain environmental toxicants.

Addressing the Potential for Cumulative Effects

When multiple chemicals similarly affecting a target organ or having the same mechanism of action are found simultaneously in seafood samples, TDH assumes that potential adverse systemic or carcinogenic effects are cumulative (i.e., additive) [4].

Cumulative Systemic (Noncancerous) Effects

The Texas Department of Health Seafood Safety Division (SSD) evaluates potential cumulative noncancerous (systemic) health effects from simultaneous consumption of multiple chemicals in environmentally contaminated seafood by calculating a hazard index (HI) for those contaminants with similar effects. To calculate a HI for multiple contaminants, the TDH first calculates hazard quotients for all compounds identified in samples from the water body. To derive the HI, TDH sums the hazard quotients (HQs) for all contaminants. A HI of less than 1.0 usually indicates that no significant hazard is present for the observed combination of contaminants at the observed concentrations. On the other hand, while a HI greater than 1.0 may indicate some level of hazard, it does not mean that exposure to the contaminants at these doses will result in adverse health effects. Nonetheless, finding an HI that exceeds 1.0 may prompt TDH to consider some public health intervention strategy.

Cumulative Carcinogenic Effects

To estimate the potential additive effects of simultaneous consumption of multiple carcinogens in seafood on excess lifetime cancer risk, TDH sums the risks calculated for all carcinogenic contaminants observed in a sample set. TDH recommends limiting consumption of seafood containing multiple carcinogenic chemicals to quantities that would result in an estimated combined theoretical lifetime cancer risk of not more than 1 excess cancer in 10,000 exposed persons.

Addressing Children's Unique Vulnerabilities

TDH recognizes that fetuses, infants, and children may be uniquely susceptible to toxic chemicals and that any such vulnerabilities demand special attention. Windows of vulnerability (i.e., critical periods) exist during development. These critical periods are particularly evident during early gestation, but may also appear throughout pregnancy, infancy, childhood, and adolescence – indeed, at any time during development, when toxicants can permanently impair or alter the structure or function of vulnerable systems [5]. Unique childhood vulnerabilities may result because, at birth, most organs and body systems have not achieved structural or functional maturity, but continue to develop throughout childhood and adolescence. Because of these structural and functional differences, children can differ from adults in absorption, metabolism, storage, and excretion of toxicants, any of which could result in higher biologically effective doses at the target organ(s). Children's exposures to toxicants may be more extensive than those of adults because children consume more food and liquids in proportion to their body weight than do adults [5]. Children can also ingest toxicants through breast milk – often unrecognized as an exposure pathway. They may also experience toxic effects at a lower exposure dose than

adults due to differences in target organ sensitivity. Stated differently, children could respond more severely than would adults to an equivalent exposure dose [5]. Children may also be more prone to developing certain cancers from chemical exposures than are adults. When scientific studies suggest that a chemical, or a class of chemicals, is more toxic to children than adults, the RfD or MRL is designed to reflect children's potentially greater susceptibility. Additionally, in accordance with ATSDR's *Child Health Initiative* [6] and USEPA's *National Agenda to Protect Children's Health from Environmental Threats* [5], TDH further seeks to protect children from the potential effects of toxicants in fish or shellfish by suggesting that this sensitive group consume smaller quantities of environmentally contaminated fish or shellfish than adults. Therefore, TDH routinely recommends that children who weigh 35 kg or less and/or who are eleven years of age or under, eat no more than four ounces of contaminated seafood per meal. TDH also suggests spreading out over time the recommended number of meals. For instance, if the consumption advice recommends eating no more than two meals per month, children consuming seafood from the affected water body should eat no more than one meal every two weeks.

Analytical Results

Table 1 shows the principal organic contaminants in fish from Echo Lake. Most samples also contained cadmium, copper, lead, mercury, selenium, and zinc, none of which exceeded TDH guidelines for protection of public health. Eight *largemouth bass* contained small quantities of chlordane; four *largemouth bass* contained p,p'-DDE at concentrations near the laboratory's practical quantitation limit. The lone *common carp* collected contained Aroclor 1260, along with chlordane, p,p'-DDD, p,p'-DDE, dieldrin, and heptachlor epoxide.

Risk Characterization

Characterizing Potential Risk of Systemic (Noncancerous) Health Effects Associated with Consumption of Fish from Echo Lake that Contain One or More Contaminants

Largemouth bass from Echo Lake contained detectable amounts of the organochlorine pesticides chlordane and p,p'-DDE. However, neither compound exceeded its HAC_{nonca} value. The hazard quotient for *largemouth bass* containing chlordane was 0.04, while that for *largemouth bass* containing p,p'-DDE was 0.004, meaning that eating *largemouth bass* from Echo Lake that contain either of these compounds at average concentrations should not pose an unacceptable risk of noncancerous adverse health effects for consumers. The *common carp* contained several chlorinated pesticides at concentrations that did not exceed their HAC_{nonca} values. The *common carp* sample contained Aroclor 1260 at a concentration that exceeds the HAC_{nonca} for Aroclor 1254, a similar mixture of PCBs (Aroclor 1260 has no HAC_{nonca}). If one assumes that the average concentration of Aroclor 1260 in all *common carp* in Echo Lake is similar to the concentration of Aroclor 1260 measured in the present sample, then people consuming one *common carp* meal every three months from Echo Lake would likely exceed health-based guidelines for Aroclor exposure.

Characterizing Potential Cumulative Systemic Effects Associated with Consumption of

Fish from Echo Lake that Contain Multiple Contaminants

Aroclor 1260, DDD, DDE, dieldrin, and heptachlor epoxide each reportedly have adverse noncancerous effects on hepatic structure or function in experimental animals [7]. Both *largemouth bass* and *common* carp contained multiple contaminants. The hazard index for *largemouth bass* was less than 1.0. On the other hand, the hazard index for contaminants in *common carp* was 10.1, most of which is attributable to Aroclor 1260 (HQ: 9.24). Although the high HI associated with the *common carp* sample could indicate that consumption of this species from Echo Lake might increase the risk of noncancerous adverse health effects, data from one sample are insufficient to completely characterize the risks. It is worth noting, however, that otoliths taken from the *common carp* sample indicate that this fish was approximately 2.5 years of age. Since older or larger specimens of *common carp* may contain far higher concentrations of fat-soluble contaminants such as PCBs, DDE, chlordane, and dieldrin, it is important to augment this sample with larger samples of this species.

Characterizing the Independent Risks of Cancer from Consumption of Fish from Echo Lake that Contain Only a Single Contaminant

The USEPA classifies chlordane, DDD, DDE, dieldrin, heptachlor epoxide, and Aroclor 1260 as probable human carcinogens (Group B2) based on reported increases in the incidence of tumors in laboratory animals [7]. *Largemouth bass* samples from Echo Lake contained both chlordane and DDE. However, estimated exposure doses did not exceed HAC_{ca} values (Table 1). Therefore, consumption *of largemouth bass* from Echo Lake that contain average levels of either DDE or chlordane would not increase the theoretical excess lifetime risk of cancer. However, Aroclor 1260 concentrations in the *common carp* from this sample set did exceed the HAC_{ca} for long-term consumption of PCBs. The theoretical excess risk of cancer from consuming one meal a week of *common carp* from Echo Lake that contain Aroclor 1260 at observed levels was approximately 1 in 6,300, a mathematic projection that is, nevertheless, above TDH's acceptable risk level of 1 in 10,000.

Characterizing the Potential for Cumulative Carcinogenic Effects from Consumption of Fish from Echo Lake that Contain Multiple Contaminants

The several contaminants in the *common carp* and the two observed in *largemouth bass* that are classified as carcinogens could have cumulative carcinogenic effects if exposure to all occurs simultaneously. For instance, people eating *largemouth bass* from Echo Lake could theoretically be exposed simultaneously to chlordane and p,p'-DDE. Using EPA's chemical-specific cancer slope factors and average concentrations of chlordane and DDE, TDH calculated a cumulative theoretical excess cancer risk of 1 in 313,000 exposed persons who regularly eat one meal per week of *largemouth bass* from Echo Lake, a risk level well below TDH's acceptable risk level of 1 in 10,000. On the other hand, the theoretical excess cancer risk from eating only *common carp* from Echo Lake containing average levels of chlordane, DDD, DDE, dieldrin, heptachlor epoxide, and Aroclor 1260 [8], is considerably higher – perhaps as high as one excess cancer in 4,100 exposed persons. Since these risks are mathematical projections, the actual risks may be much lower than those cited. However, a single sample is inadequate to define the excess cancer risk from consumption of contaminated *common carp* from Echo Lake. It is, therefore, important

to conduct additional sampling of *common carp* and other available species from Echo Lake to better characterize the risks associated with consuming fish from this reservoir that contain organochlorine contaminants – particularly PCBs.

CONCLUSIONS AND PUBLIC HEALTH IMPLICATIONS

Nine *largemouth bass* and one *common carp* were examined for a variety of contaminants for this risk characterization. The hazard index for the *common carp* was extremely high, mainly due to the high concentration of Aroclor 1260 in that sample, while the HI for *largemouth bass* was less than 1. The skewed species distribution of this sample set limits conclusions drawn from the data. Most significantly, it is difficult to interpret the results of the PCB analysis because only one sample contained this contaminant. If the Aroclor 1260 concentration in the *common carp* sample is representative of all *common carp* in the reservoir, continuation of the existing ban on possession of *common carp* from Echo Lake may be justified. The nine *largemouth bass*, conversely, appeared to represent no hazard to public health. Should the results of this survey be confirmed, banning possession of *largemouth bass* from Echo Lake might be more restrictive than is necessary for protection of human health. The very limited data from this sample set suggest that:

1. Because the limited sample from this survey contains insufficient data for definitive designation of "apparent public health hazard, TDH concludes that regular or long-term consumption of *common carp* from Echo Lake presently **poses an indeterminate public health hazard** because data are insufficient to support other conclusions. However, these species from Echo Lake have historically contained unacceptable levels of organic toxicants, leading to the existing ban on possession of fish from Echo Lake.

2. Consumption of *largemouth bass* from Echo Lake **poses no apparent public health hazard.**

RECOMMENDATIONS

TDH risk managers have established certain criteria for issuing fish consumption advisories. When characterization of risk confirms that consumption of four or fewer meals per month would result in exposures that exceed TDH health-based guidelines for protection of human health, risk managers may wish to recommend that the Commissioner of Health issue consumption advice or ban possession of fish from the affected water body. Based on quantitative assessments of the risk of systemic adverse health effects or cancer that could result from consumption of *common carp* from Echo Lake that contain average concentrations of Aroclor 1260 and/or other chlorinated contaminants, the Seafood Safety Division (SSD) and the Environmental Epidemiology and Toxicology Division (EE&TD), Texas Department of Health (TDH), recommend that:

1. TDH continues the existing ban on possession of fish from Echo Lake pending further investigation of contaminants in *common carp* because high contaminant concentrations in the single *common carp* led to borderline overall risk estimates for this water body.

2. If resources allow, TDH conducts additional sampling to better characterize the levels of contamination in *common carp* and other fish species taken from Echo Lake.

PUBLIC HEALTH ACTION PLAN

TDH fish consumption advisories and bans are published in a booklet that is available to the public through the TDH Seafood Safety Division: (512-719-0215). This information is also posted on the Internet at URL http://www.tdh.state.tx.us/bfds/ssd, which is updated regularly. Some risk characterizations (previously called health consultations) for water bodies surveyed by the Texas Department of Health may also be available from the Agency for Toxic Substances and Disease Registry (http://www.atsdr.cdc.gov/HAC/PHA/region6.html). The Texas Department of Health provides all consumption advisory and ban information to the U.S. Environmental Protection Agency (URL: http://fish.rti.org), the Texas Natural Resource Conservation Commission (TNRCC; URL: http://www.tnrcc.state.tx.us) and the Texas Parks and Wildlife Department (TPWD; URL: http://www.tpwd.state.tx.us). Each year, the TPWD informs the fishing and hunting public of fishing bans in an official hunting and fishing regulations booklet [9] that is available at some state parks and at establishments that sell fishing licenses.

Readers may direct questions about the scientific information or recommendations in this risk characterization to the Seafood Safety Division (512-719-0215) or the Environmental Epidemiology and Toxicology Division (512-458-7269) at the Texas Department of Health. Toxicological information on a variety of environmental contaminants can also be obtained from the Agency for Toxic Substances and Disease Registry (ATSDR), Division of Toxicology by telephoning that agency at the toll free number (800-447-1544) or by visiting their website (URL: http://www.atsdr.cdc.gov).

Table 1. Principal organic contaminants (mg/kg) detected in fish from Echo Lake, 2000				
Contaminant	**# Detected/ # Sampled**	**Average Concentration (Min-Max)***	**Health Assessment Comparison Value†**	**Basis for Comparison Value**
Common Carp				
Aroclor 1260	1/1	**0.431**	0.047	EPA chronic oral RfD for Aroclor 1254: 0.00002 mg/kg – day
			0.272	EPA slope factor for PCBs: 2.0 per (mg/kg) – day
Chlordane	1/1	0.499	1.2	EPA chronic oral RfD: 0.0005 mg/kg – day
			1.6	EPA slope factor: 0.35 per (mg/kg) –day
p,p'-DDD	1/1	0.024	2.3	EPA slope factor: 0.24 per (mg/kg) – day
p,p'-DDE	1/1	0.116	1.6	EPA slope factor: 0.34 per (mg/kg) – day
Dieldrin	1/1	0.011	0.12	EPA chronic oral RfD: 0.00005 mg/kg – day
			0.03	EPA slope factor: 16 per (mg/kg) – day
Heptachlor epoxide	1/1	0.007	0.03	EPA chronic oral RfD: 0.000013 mg/kg – day
			0.06	EPA slope factor: 9.1 per (mg/kg) – day
Largemouth Bass				
Chlordane	8/9	0.045 (nd‡-0.128)	1.2	EPA chronic oral RfD: 0.0005 mg/kg – day
			1.6	EPA slope factor: 0.35 per (mg/kg) – day
p,p'-DDE	4/9	0.0052 (nd-0.020)	1.6	EPA slope factor: 0.34 per (mg/kg) – day

** Data Spread: Minimum to Maximum: Smallest reported value to largest reported value; (range = maximum conc - minimum conc)*
† 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 $1x10^{-4}$
‡ nd-not detected at concentrations above the laboratory reporting limit

REFERENCES

1. [TDH] Texas Department of Health. Seafood Safety Division. Fish advisories and bans, 2001. Austin, Tex.: 2000. Information available at URL: http://www.tdh.state.tx.us/bfds/ssd/.

2. [USEPA] U.S. Environmental Protection Agency. Guidance for assessing chemical contaminant data for use in fish advisories, vol. 2. Risk assessment and fish consumption limits, 3rd ed. Office of Science and Technology, Office of Water. Washington, D.C.: 2000.

3. [USDOE]. U.S. Department of Energy. CERCLA Baseline risk assessment: human health evaluation. CERCLA Information Brief. Office of Environmental Guidance EH-231-012/0692. June 1992.

4. [USEPA] U.S. Environmental Protection Agency. Guidelines for the health risk assessment of chemical mixtures. Office of Research and Development. Washington, D.C.: 1986.

5. [USEPA] U.S. Environmental Protection Agency. Strategy for research on environmental risks to children, section 1.2. Office of Research and Development, Washington D.C.: 2000.

6. [ATSDR] Agency for Toxic Substances and Disease Registry, Office of Children=s Health. Child health initiative. Atlanta, Ga.: 1995.

7. [ATSDR] Agency for Toxic Substances and Disease Registry. Toxicological profile for polychlorinated biphenyls, Atlanta, Ga.: 1997.

8. [IRIS] Integrated risk information system. U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. Information available at URL: http://www.epa.gov/iris.

9. [TPWD] Texas Parks and Wildlife 2000-2001 Outdoor Annual: Official Hunting and Fishing Regulations. Emmis Communications Custom Publishing. Austin, TX: 2000.

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