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

DONNA IRRIGATION SYSTEM

Hidalgo County, TX

August 2007

Department of State Health Services
Austin, Texas
Seafood and Aquatic Life Group
Policy, Standards, and Quality Assurance Unit
Division for Regulatory Services
and the
Environmental and Injury Epidemiology and Toxicology Branch

INTRODUCTION

Description of the Donna Irrigation System and History of the Extant Possession Ban

The Donna Irrigation District reservoirs are located in the Hidalgo County, one of the Texas Rio Grande Valley counties directly bordering Mexico. The Donna District Reservoirs (Donna Irrigation System (DIS) Donna Reservoirs; Donna West and a larger Donna East) lie slightly southwest of the town of Donna, TX. The main canal winds its way south between County Roads 907 and 493 traveling for a distance with the main floodway. East of Bentsen Rio Grande Valley State Park, the canal crosses U.S. Highway 281, from which point the channel runs almost due south to empty into the Rio Grande a few miles south of U.S. Highway 281.[1]

The United States Environmental Protection Agency (USEPA) first detected PCBs in fish from the Donna Canal in 1993. In an environmental study of the Lower Rio Grande Valley of Texas, the agency sampled *cooked* fish from representative households in the valley, taking blood and urine from families who participated. Laboratory analyses of fish from this study revealed high concentrations of PCBs, with one carp – reportedly from the Donna Canal – containing 399 milligrams PCBs per kilogram tissue – some 1500 times the concentration that, if consumed, was thought to pose a hazard to human health. Blood from people who ate that particular fish contained excessive concentrations of PCBs. Upon receiving this information, the Texas Commissioner of Health informed the Seafood Safety Division of the Texas Department of Health (TDH). The SSD quickly confirmed the information and sent a collection team to the Donna Reservoir to sample fish. Fish collected by the TDH at that time contained high concentrations of PCBs consistent with Aroclor® 1248, 1254, and 1260.[2,3] On February 9, 1994, consequent to this finding, the TDH issued Aquatic Life Order #9 (AL-9). AL-9 prohibited possession of any fish species from the DIS.[4] Despite this possession ban, evidence abounds that the DIS remains a popular fishing spot for residents of Hidalgo County. For instance, in 2002, the USGS published a document with photographs of locals fishing outside the Donna Canal pump house and at the Donna Reservoir.[3] Although the source of the PCBs in the DIS remains a mystery, in that document, the USGS outlined a 600-meter reach in the northernmost 90-degree curve of the canal, suspended sediment from which has the highest PCB concentrations identified in the system. From these data, the USGS proposed that 600-meter reach as likely to contain the source of PCBs in the DIS. Fish caught from this same area have historically contained high levels of PCBs.[3]

The Seafood and Aquatic Life Group (SALG) of the Department of State Health Services (DSHS, formerly the Texas Department of Health) – with funding from the Total Maximum Daily Load (TMDL) Program of the Texas Commission on Environmental Quality (TCEQ) collected fish in 2005 and 2006 from the DIS (DIS). The analytical results from those fish form the basis for this report. The report, written some 13 years after AL-9 prohibited possession of fish from the DIS, describes results, presents conclusions from the study, addresses implications to public health from consumption of contaminated fish from the DIS, recommends public health actions, and supplies the TMDL Program with needed data. In the present study (2005-2006), DSHS again characterized PCB contamination in fish from the DIS. The 2005-2006 tissue data show that fish from the DIS continue to contain PCBs in excess of the health-related concentrations used by the DSHS to protect public health. Interestingly, PCBs in fish collected for this report from sites in the DIS positively correlate with PCB concentrations in sediments from the same sites as measured by the USGS for PCBs.[3]

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

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),[5] 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 sum of the allowable loads of a single pollutant from all contributing point and non-point sources, and including a margin of safety to ensure the usability of the water body for all designated purposes, accounting for seasonal variation in water quality. States, territories, and tribes define the uses for a specific water body (e.g., drinking water, contact recreation, aquatic life support [fish consumption] along with the scientific criteria designated to support each specified use). The Clean Water Act, section 303, which promulgates rules that promote water quality, orders the states to establish TMDLs and implementation plans for impaired waters.[5] 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 spontaneously clear toxicants over time with removal of the source(s), it is often necessary to institute some type of remediation such as those devised by the TMDL Program. Thus, when the DSHS prohibits possession of environmentally contaminated fish, the TMDL Program automatically places the water body on its current draft 303(d) List.[5] TMDL staff members then prepare a TMDL for each contaminant present at concentrations that, if consumed, would be capable of negatively affecting human health. Once the TMDLs are approved, the group prepares an Implementation Plan – a "remediation" plan, if you will – for each contaminant. Upon "implementation," these plans facilitate rehabilitation of the water body. 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 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 might be the periodic reassessment of contaminant levels in fish. For the DIS, the TMDL Program does specify such periodic reassessments.

Demographics of Hidalgo County and the Likelihood of Subsistence Fishing in the Area of the Donna Irrigation System

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.[6] In Hidalgo County, TX, the 2005 population was 671,967 people.[7]. Of this population, 5,099 claimed Asian heritage or ethnicity. Of the 252,000+ people in the labor force, 12.6% were unemployed. The median household income in 2005 inflation-adjusted figures was $24,501. For the year 2005, 41% of people in Hidalgo County lived in poverty. Fifty-two percent of related children less than 18 years of age lived below the poverty level, while 29% of those 65 years or older lived below the poverty level. Thirty-six percent of all families and 55% of families with a female householder (no husband present) had incomes below the poverty level. Of those people over 25 years of age, 42% had less than a 9th grade education but 58% had at least a high school diploma (or an equivalency). Fifteen percent had a bachelor's degree or higher. Of people in Hidalgo County with a mortgage, 46% pay more than 30% of their income for housing, leaving less money for other essentials such as food. Finally, about one in six individuals over five years of age claimed a disability, with the percentage increasing with increasing age.[8] Disabilities affect income. All of these demographic variables may affect the likelihood of subsistence fishing. Why is it important to know whether and how many subsistence fishers are residents of the area? The USEPA and the DSHS believe it important to consider subsistence fishing as occurring at any water body because subsistence fishers (as well as recreational anglers and certain tribal and groups of certain ethnicities) may consume more locally caught fish than the general population. As shown by the above demographics, many Hidalgo County residents have characteristics of subsistence fishers. These groups sometimes harvest fish or shellfish from the same water body over many years to supplement caloric and protein intake. Should local water bodies contain chemically contaminated fish or shellfish, people who routinely eat fish from the water body 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. The DIS is a popular fishing "hole" for residents of the area. Subsistence fishing, while not explicitly documented by the DSHS, likely occurs along the Donna System. The DSHS assumes the rate of subsistence fishing to be similar to that estimated by the USEPA.[6]

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.*[9] The SALG bases its sampling and analysis protocols, in part, on procedures recommended by the USEPA in that agency's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1.*[10] Advice and direction are also received from the legislatively mandated *State of Texas Toxic Substances Coordinating Committee (TSCC) Fish Sampling Advisory Subcommittee (FSAS).*[11] 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 Method and Description of the Donna Irrigation System 2005-2006 Sample Set

In December 2005 and January 2006, the field collection team from SALG collected 30 fish samples from sites along the DIS. That system includes two small reservoirs and a canal from which irrigation water is drawn. The SALG selected six sample sites to provide spatial coverage of the study area (Figure 1). Sites 1, 2, and 3 were in the canal proper. Sites 4 and 5 were in the reservoirs: Site 4 in the West Reservoir and Site 5 in the East Reservoir. Table 1 also shows exact latitudes and longitudes for each site.

The collection team targeted species for collection from the DIS through fish-tissue sampling protocols developed over many years by the SALG. Species collected represent two 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 which anglers and their families commonly consume. The 30 fish collected from the DIS in December 2005 and January 2006 represented all species targeted for collection from this water body. Table 1 presents date collected, sample number, species, collection site, length and weight of each sample. The table lists the samples by site: largemouth bass (12), common carp (10), smallmouth buffalo (3), freshwater drum (3), and channel catfish (2).

During each day of sampling, staff set gill nets in late afternoon and fished those overnight, collecting samples from the nets early the following morning. Gill nets were set to maximize available cover and habitat. SALG staff stored captured fish retrieved from the nets on wet ice until processed. The staff returned to the reservoir or canal system any remaining live fish culled from the catch. Staff also properly disposed of fish found dead in the gill nets.

The SALG utilized a boat-mounted electrofisher to collect fish. SALG staff conducted electrofishing activities during daylight hours, using pulsed direct current (Smith Root 5.0 GPP electrofishing system settings: 4.0-6.0 amps, 60 pulses per second [pps], low range 360 volts, 80% 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 ensure interim preservation of tissues.

SALG staff processed fish from the DIS at the sites from which the samples came. Staff weighed each sample to the nearest gram on an electronic scale and measured total length (tip of nose to tip of tail fin) to the nearest millimeter. 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 the filleting knife cleaned with distilled water after each sample was processed, after which the fillet(s) was wrapped 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. At the end of each sampling trip, SALG staff transported tissue samples on wet ice to their Austin, TX, 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 the chain of custody remains intact while samples are in the possession of agency staff. The week following each collection trip, frozen fish tissue samples were shipped by commercial carrier (UPS next-day air) to the Geochemical and Environmental

Research Group (GERG) Laboratory, Texas A&M University, College Station, TX, for contaminant analysis.

Analytical Laboratory Information

The GERG laboratory notified the SALG when samples from the DIS arrived. Upon receipt of the samples, the laboratory recorded the DSHS sample number – assigned by the collection team – and noted the condition of each fillet.

Utilizing USEPA-sanctioned methodology, the laboratory analyzed the 30 samples for common inorganic and organic contaminants, including seven metals – cadmium (Cd), copper (Cu), lead (Pb), selenium (Se), zinc (Zn), total arsenic (As), and total mercury (Hg). The GERG laboratory analyzed each fish for total (inorganic arsenic + organic arsenic = total As) arsenic. Although the proportions of each form of arsenic may differ among species, under different water conditions, and, perhaps, with other variables, the literature suggests that well over 90% of arsenic in fish is likely organic arsenic – a form that is virtually non-toxic to humans. Taking a conservative approach, DSHS estimates that 10% of arsenic in a fish is inorganic arsenic and derives estimates of inorganic arsenic concentrations by multiplying total arsenic concentration in each fish by a factor of 0.1.[12] Virtually all mercury in upper trophic level fish three years of age or older is methylmercury.[5] Thus, total mercury concentration in a fish of legal size for possession in Texas serves well as a surrogate for methylmercury. Because methylmercury analyses are difficult to perform well and are more expensive than analysis of total mercury, 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 analyzed fish tissues for total mercury. In its risk characterizations, the DSHS may interchangeably utilize the terms "mercury", "methylmercury", or "organic mercury" to refer to methylmercury in fish.[13]

The laboratory analyzed tissues for several classes of pesticides such as organophosphates, organochlorines, and carbamates. The laboratory also analyzed 30 fish tissue samples for PCBs, while it analyzed five of the 30 for panels of semi-volatile organic compounds (SVOCs) and volatile organic compounds (VOCs).

PCB Analyses and the Measurement of PCB Congeners instead of Aroclors

The GERG laboratory reports the presence and concentrations of 209 PCB congeners using detection limits that are, typically, around 1 µg/kg. Although only about 130 congeners existed in mixtures commonly used in the U.S. (Aroclors®), it may be useful to have measured all 209 congeners for examining the effects of "weathering" on the PCB mixture presumed originally disseminated.

Despite USEPA's suggestion that the states analyze PCB congeners rather than Aroclor or homolog analyses, the toxicity literature does not reflect this state-of-the-art laboratory science. To handle this dilemma, DSHS empirically uses recommendations from the National Oceanic and Atmospheric Administration (NOAA)[14] and from McFarland and Clarke,[15] along with the USEPA's guidance documents for assessing contaminants in fish tissues[10,16] to address the toxicity of PCB congeners in fish tissues, summing concentrations of 43 PCB congeners to derive a "total" PCB concentration. The DSHS averages the summed congeners to derive a mean PCB concentration. The authors of the preceding references utilized congeners for their likelihood of occurrence in fish, the likelihood of significant toxicity – based on structure-activity relationships – and for the relative environmental abundance of those congeners.[14,15] Using only a few PCB congeners to determine "total PCBs" could underestimate PCB concentrations in fish tissue. Nonetheless, the above-described method complies with expert recommendations on evaluation of PCBs in fish. Therefore, SALG risk assessors compare average PCB concentrations with information in the USEPA's (Integrated Risk Information System) IRIS database.[17] IRIS currently contains systemic toxicity information for five Aroclor mixtures: Aroclor 1016, 1242, 1248, 1254, and 1260, as well as supplying one or more cancer potency factors (CPFs) – also known as slope factors (SFs) - for mixtures of PCBs, (not all information is available for all mixtures).[17] Systemic toxicity estimates in this document reflect comparisons with the Reference Dose (RfD) for Aroclor 1254 because IRIS contains an RfD for Aroclor 1254 but not for Aroclor 1260. As of yet, IRIS does not contain toxicity information on individual PCB congeners. Risk assessors may be unable to determine the originally-present Aroclor® mixture or whether the PCBs observed even originated from Aroclors® as U.S. companies used PCB mixtures imported from abroad as well as U.S.- produced PCBs. Additionally, airplanes and ships from foreign countries entered U.S. waters and may have discharged foreign-made PCB mixtures into U.S. portal waters.

Statistical Analysis

SALG risk assessors employed SPSS® statistical software, version 13.0 installed on IBM-compatible microcomputers (Dell, Inc) to generate descriptive statistics (mean, standard deviation, median, range, and minimum and maximum concentrations) on all measured compounds in each species of fish from each sample site.[18] SALG risk assessors utilized ½ the detection limit for all analytes not detected (ND) or estimated (J)[a] concentrations in computing descriptive statistics. SALG risk assessors imported previously edited Excel data files into SPSS® to generate means, standard deviations, median concentrations, and minimum and maximum concentrations of each measured analyte. SALG used the descriptive statistical results to generate the present report. SALG protocols do not require hypothesis testing. Nevertheless, when data are of sufficient quantity and quality, and, should it be necessary, the SALG utilizes SPSS® software to determine significant differences in contaminant concentrations among species and/or collection sites. The SALG risk assessors did not test hypotheses on differences among species from the DIS because all samples contained PCBs, and most were above the HAC_{nonca}. The SALG employed Microsoft Excel® spreadsheets to generate figures, to compute health-based assessment comparison values (HAC_{nonca}) for contaminants, and to calculate hazard quotients (HQ), hazard indices (HI), cancer risk probabilities, and meal consumption limits for fish from the DIS.[19] When lead data are of sufficient quality, concentration, and interest, the SALG utilizes the USEPA's Interactive Environmental Uptake Bio-Kinetic (IEUBK) model to determine whether consumption of lead-contaminated fish could cause children's blood lead (PbB) level to exceed the federally set 10 micrograms/deciliter.[20]

---

[a] "J-value" is standard laboratory nomenclature for analyte concentrations detected and reported, which reported concentration is 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.

Derivation and Application of Health-Based Assessment Comparison Values (HAC_{nonca} or HAC_{ca})

The effects of exposure to any hazardous substance depend on the dose, the duration of exposure, the manner in which one is exposed, one's personal traits and habits, and whether other chemicals are present.[21] People who regularly consume contaminated fish or shellfish conceivably suffer repeated exposures to relatively low concentrations of contaminants over extended times. Such exposures are unlikely to result in acute toxicity but may increase risk of subtle, chronic, and/or delayed adverse health effects that include cancer, benign tumors, birth defects, infertility, blood disorders, brain damage, peripheral nerve damage, lung disease, and kidney disease, to name but a few.[21] Presuming people to eat a diet of diverse fish or shellfish from a water body if species variety is available, the DSHS routinely collapses data across species and sampling sites to evaluate mean contaminant concentrations of toxicants in all samples. This approach intuitively reflects consumers' likely exposure over time to contaminants in fish or shellfish from a water body, but may not reflect reality at a specific water body. The agency thus reserves the right to examine risks associated with ingestion of individual species of fish or shellfish from separate collection sites or at higher concentrations (e.g., the upper 95 percent confidence limit on the mean concentration. Confidence intervals are derived from Monte Carlo simulation techniques with software developed by Dr. Richard Beauchamp, of the DSHS).[22] The DSHS evaluates contaminants in fish by comparing the mean, and – when appropriate – the 95% upper confidence limit on the mean concentration of a contaminant to its HAC value (measured in milligrams of contaminant per kilogram of edible tissue – mg/kg) derived for non-cancer or cancer endpoints. To derive HAC values for systemic (HAC_{nonca}) effects, the department assumes a standard adult weighs 70 kilograms and that adults consume 30 grams of edible tissue per day (about one 8-ounce meal per week). The DSHS uses USEPA's oral RfDs[23] or the Agency for Toxic Substances and Disease Registry's (ATSDR) chronic oral minimal risk levels (MRLs)[24] to generate HAC values used in evaluating systemic (noncancerous) adverse health effects. The USEPA defines a contaminant's 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.*[25]

EPA also states that an 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.*[25]

The ATSDR uses a similar technique to derive MRLs.[24] The DSHS compares the estimated daily dose (mg/kg/day) – derived from the mean of the measured concentrations of a contaminant – to the contaminant's RfD or MRL, using HQ methodology as suggested by the USEPA.

A HQ, defined by the EPA, is

> *…the ratio of the estimated exposure dose of a contaminant (mg/kg/day) to the contaminant's RfD or MRL (mg/kg/day).*[26]

Note that a linear increase in the hazard quotients for a site or species usually does *not* represent a linear increase in the likelihood or severity of systemic adverse effects (i.e., a substance having an HQ of 2 is not twice as toxic as if the substance had an HQ of 1.0. Similarly, a substance with a HQ of 4 does not imply that adverse events will be four times more likely than a HQ of 1.0). As stated by the USEPA, a HQ (or an HI) of less than 1.0 "is no cause for concern, whereas an HQ (or HI) greater than 1.0 should indicate some cause for concern." Thus, risk managers at the DSHS utilize a HQ of 1.0 as a "jumping-off point," not for decisions concerning likelihood of occurrence of adverse systemic events, but as a point of departure for management decisions that assume, in a manner similar to EPA decisions, that fish or shellfish having a HQ of less than 1.0 are unlikely to be cause for concern. Since the chronic oral RfD derived by the USEPA represents chronic consumption, eating fish with a toxicant-to-RfD ratio (the HQ) of less than 1.0 is not likely to result in adverse health effects, whereas routine consumption of fish where the HQ for a specific chemical exceeds 1.0 represents a qualitatively unacceptable increase in the likelihood of systemic adverse health outcomes.

Although DSHS preferentially utilizes an RfD derived by federal scientists for each contaminant, should no RfD be available for a specific contaminant, the USEPA advises risk assessors to consider using an RfD determined for a contaminant of similar molecular structure, or mode or mechanism of action. For instance, DSHS – as specifically directed by the USEPA – uses the published reference dose for Aroclor 1254 to assess noncarcinogenic effects of Aroclor 1260, for which no reference dose is available – the USEPA has derived one other reference dose for Aroclors – that of Aroclor 1016. However, Aroclor 1016 is not as clearly like Aroclor 1260 as is Aroclor 1254. In the past, when DSHS had access only to the relatively crude measurement of Aroclors, the agency did not attempt to determine the dioxin equivalent toxicity of coplanar PCBs found in fish. The SALG recently adopted PCB congener analysis, as is suggested by the USEPA. This change in methodology allows the agency to identify coplanar or dioxin-like PCBs and to apply toxicity equivalency factors (TEFs) to PCBs in fish should SALG staff consider this a priority.

The constants (RfDs, MRLs) the DSHS employs to calculate HAC_{nonca} values are derived by federal agencies from the peer-reviewed literature (which the federal agencies routinely re-examine). These values incorporate built-in margins of safety called "uncertainty factors" or "safety factors" as mentioned in EPA reference materials.[25] In developing an oral RfD or MRL, federal scientists review the extant literature on the toxicant to determine an experimentally-derived NOAEL, a LOAEL, or, in some cases, a benchmark dose (BMD). Once the NOAEL, LOAEL, or BMD is determined, the scientist then utilizes uncertainty factors to minimize potential systemic adverse health effects in people exposed through consumption of contaminated materials. The uncertainty factors account for certain conditions that are undetermined by the experimental data. The classic four uncertainty factors are (1) extrapolation from animals to humans (interspecies variability), (2) intra-human variability, (3) using a subchronic study rather than a chronic study to determine the NOAEL, LOAEL, or BMD, (4) using a LOAEL instead of a NOAEL to determine the RfD. Recently, a fifth uncertainty factor, (5) database insufficiencies for the toxicant, was added.[23] Vulnerable groups – women who are pregnant or lactating, women who may become pregnant, the elderly, infants, children, people with chronic illnesses, those with compromised immune systems, or those who consume exceptionally large servings, collectively called "sensitivities" by the EPA, also receive special consideration in calculations of the RfD.[25, 27]

The SALG calculates cancer-risk comparison values (HAC_{ca}) from the EPA's CPFs – also known as SFs – derived through mathematical modeling of 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) [25] of one excess cancer case in 10,000 persons whose average daily exposure is equal and (2) daily exposure for 30 years. Comparison values used to assess the probability of cancer, thus, do not contain "uncertainty" factors as such. However, conclusions drawn from those probability determinations infer substantial safety margins for all people by virtue of the models utilized to derive the slope factors (cancer potency factors). For instance, the USEPA suggests the use of a tiered approach to determine the potency of PCB mixtures to cause cancer in exposed individuals. This approach depends on information available from the IRIS database.[17] Three tiers of carcinogen slope factors (SFs) used to assess the impact of environmental PCBs exist. The first tier, with an upper bound slope factor of 2.0 and a central tendency slope factor of 1.0, is used for PCBs with "high risk and persistence." Criteria for using this most restrictive slope factor include (1) exposure via food, (2) ingestion of sediment or soil, (3) inhalation of dust or aerosols (4) dermal exposure – if an absorption factor was applied – (5) the presence of dioxin-like, tumor-promoting, or persistent PCB congeners, and, perhaps most importantly, (6) the possibility of early-life exposure. Because the potential implications of early-life exposures include factors such as possibly greater perinatal sensitivity, or the likelihood of interactions between PCBs and normal functions (such as PCB-mediated depletion of thyroid hormones, an effect that can result in irreparable damage to the developing brain) of development, the USEPA concludes that early-life exposures may be associated with increased risks.[17] The DSHS, in agreement with the federal agency, utilizes the upper bound slope factor of the "high risk" tier for all exposures to PCBs in fish.

The calculated comparison values (HAC_{nonca} and HAC_{ca}) are quite conservative, so adverse systemic or carcinogenic health effects are unlikely to occur, even if exposures are consistently greater or last longer than those used to calculate comparison values. Moreover, comparison values for adverse health effects (systemic or carcinogenic) do not represent sharp dividing lines (bright-line divisions) between safe and unsafe exposures. The *perceived* strict demarcation between acceptable and unacceptable exposures or risks is primarily a tool to assist risk managers to make decisions that ensure protection of the public's health. For instance, 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 even though most such exposures are unlikely to result in adverse health effects. The department further 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. DSHS aims to protect vulnerable subpopulations with its consumption advice. The DSHS assumes that advice protective of vulnerable subgroups will also minimize the impact to the general population of consuming 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.[28, 29] 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 pregnancy, infancy, childhood, or adolescence – indeed, at any time during development – times when toxicants can impair or alter the structure or function of susceptible systems.[30] Unique early sensitivities may exist because organs and body systems are structurally or functionally immature – even 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 which factors could alter the concentration of biologically effective toxicant at the target organ(s) or that could modulate target organ response to the toxicant. Children's exposures to toxicants may be more extensive than adults' exposures because, in proportion to their body weights, children consume more food and liquids than adults do, another factor that might alter the concentration of toxicant at the target. 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. Women are encouraged to continue breastfeeding and to limit exposure of their infants by limiting intake of the contaminated foodstuff). Children's behaviors (i.e., hand to mouth behaviors) might expose them to more toxicants or higher concentrations of a toxicant than adults.[31]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.[32] In any case, if a chemical – or a class of chemicals – is observed to be – or is thought to be – more toxic to the fetus, infants, or children than to adults, the constants (e.g., RfD, MRL, or CPF) are usually further modified to assure protection of the immature system's potentially greater susceptibility.[23] Additionally, in accordance with the ATSDR's *Child Health Initiative*[33] and the USEPA's *National Agenda to Protect Children's Health from Environmental Threats,*[34] (In recognition of the possibly greater vulnerability of children to harmful substances, USEPA has established the Office of Children's Health Protection (OCHP). The OCHP ensures that all standards set by USEPA will protect children from any heightened risks and that newly developed policies address children's health concerns)[35]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, 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 suggests consumption of no more than two meals per month of a contaminated species, those children should eat no more than 24 meals of the contaminated fish or shellfish per year and, ideally, should not eat such fish or shellfish more than twice per month.

RESULTS

Laboratory Analytical Results

The GERG laboratory submitted electronic copies of the analytical results on fish from the DIS (Donna Canal and Donna Reservoir) to the SALG between December 2005 and February 2006. As SALG requested, the laboratory analyzed 30 fish for pesticides, metal-like constituents and for PCBs. The laboratory reported data for VOCs and SVOCs measured in five samples. Information about the samples is presented in Table 1.

Inorganic Contaminants

Arsenic, Cadmium, Copper, Mercury, Lead, Selenium, Zinc

Samples from the DIS contained no detectable arsenic or cadmium (data not shown). Inorganic contaminants present at measurable levels in one or more fish from the DIS included copper, mercury, lead, selenium, and zinc (Table 2). Six of 30 fish contained some level of lead. Four fish contained measurable quantities of lead; two contained estimated concentrations. The remaining 24 fish were reported only as “less than the reporting limit” for the sample.

The laboratory reported mercury in 30 fish tissues (Table 2). The average mercury concentration in all fish combined was 0.229±0.112 mg/kg. The highest mercury value in the sample data set was 0.467 mg/kg (Table 2). One sample contained an estimated concentration of mercury (a J-value).

Copper, selenium, and zinc are all essential nutrients. Thirty of 30 samples contained copper. The mean copper concentration for all fish was 0.271±0.258 mg/kg. The minimum concentration of copper (reported below the detection limit as a J-value) was 0.041 mg/kg and the maximum concentration was.0.916 mg/kg. Selenium and zinc were present in all fish, as is often observed (Table 2). Average selenium concentration across all fish was 0.547±0.135 mg/kg, ranging from 0.268-0.931mg/kg (Table 2). The mean zinc concentration was 5.766±2.601 mg/kg with a spread of 2.364 to 13.261 mg/kg (Table 2).

Organic Contaminants

The GERG laboratory analyzed 30 fish tissue samples from the DIS for commonplace and/or legacy pesticides and PCBs. The laboratory also analyzed five of the samples for SVOCs and VOCs.

<u>Pesticides</u>

The laboratory analyzed fish tissue from the DIS for 34 pesticides representing legacy and/or major pesticide groups such as organochlorines, organophosphates, and carbamates. The following pesticides were observed at some levels in one or more fish.

Organophosphates were reported present in fish from the DIS. All but one sample from the 2005-2006 DIS dataset contained trace quantities of 4,4'-DDD; 22 samples had estimated concentrations (J-values) below the laboratory's reporting limit. Seven fish had measurable concentrations of 4,4'-DDD. One sample contained no detectable 4,4'-DDD. All samples contained 4,4'-DDE (minimum value to maximum value = 0.005 mg/kg-1.432 mg/kg). Four samples contained 4,4'-DDT, two at estimated (J-value) concentrations and two as measured concentrations. Other samples (26 fish) did not contain detectable 4,4'-DDT, according to the laboratory report. 2,4'-DDD, DDE, and DDT were present in a number of samples but are not addressed in this report because EPA has not established RfDs or cancer slope factors for these isomers of DDT, it's metabolites, or breakdown products. The procedural blanks revealed no 4,4'-DDT, 4,4'-DDE, or 4,4'-DDT.

Measurable concentrations of chlordane were reported present in seven samples (0.014 mg/kg± 0.021 mg/kg). Fourteen samples contained chlordane at detectable concentrations below the analytical method detection limit (MDL). Nine samples had detectable, but not quantifiable chlordane (reported only as < the MDL). The laboratory does not utilize chlordane in its quality control (QC) procedure.

Three fish tissues contained estimated concentrations of the organochlorine pesticide chlorpyrifos. One sample had a measurable 0.0146 mg/kg chlorpyrifos. Twenty-six samples contained chlorpyrifos at some concentration below the laboratory MDL.

Another organochlorine, dacthal, was also present in fish from the DIS. All 30 samples contained some level of dacthal. Twenty samples contained estimated (J-values) of dacthal, while ten samples contained measurable concentrations of Dacthal (0.015±0.024 mg/kg, ranging from 0.0012 to 0.062 mg/kg). Twenty samples contained Dacthal at levels below the laboratory's reporting limit.

One sample (DIC15, a common carp) contained traces of 1,2,3,4-tetrachlorobenzene and 1,2,3,5-tetrahlorobenzene. The laboratory reported no other pesticides in any sample from the DIS.

Volatile Organic Compounds (VOCs)

Four of five fish tested for VOCs contained acetone at levels below the laboratory's MDL; one fish, a common carp contained a quantifiable level of acetone (5.22 mg/kg; MDL = 0.200 mg/kg). Four of five samples contained quantifiable methylene chloride. Although the reporting limit for methylene chloride is 0.050 mg/kg, these levels were around 0.032 mg/kg – below the MDL. One fish contained an estimated concentration of a magnitude similar to those reported as firm measurements. A single fish contained a trace of benzene (0.001 mg/kg, MDL=0.020 mg/kg). Toluene was present at estimated levels (below the MDL) in four fish. All five fish contained naphthalene, three at levels above the MDL (0.020 mg/kg).The average concentration of naphthalene in the five fish was 0.031 mg/kg However, acetone, methylene chloride, and naphthalene were also identified in the procedural blanks, an indication, perhaps, of handling or laboratory contamination. When these contaminants were identified in the samples, they were usually equal to, or higher than those of the procedural blank were. It is possible these contaminants could have been byproducts of sample necrosis (data not presented).

Semi-volatile Organic Compounds (SVOCs)

No SVOCs were present in any fish at levels above the laboratory's MDL, although some SVOCs occurred sporadically at levels below the MDLs. All five fish contained one or more phthalate esters: diethylphthalate, di-n-butyl phthalate, and/or di-(2-ethylhexyl) phthalate, albeit at low levels. The procedural blank contained all three phthalates at levels similar to or higher than the samples. Three fish contained traces of dibenz(a,h)anthracene. The procedural blank contained this substance at a level higher than the sample concentrations. One fish also contained a trace of 3-methylcholanthrene, as did the procedural blank. Both compounds are polycyclic aromatic hydrocarbons (PAHs), common sources of which include asphalt sealers, shampoos, medications, roofing materials, and other tar-like materials. Finally, four fish contained marginal levels of phenol (estimated concentrations below the MDL for phenol). The laboratory reported no phenol in the procedural blank. The authors did not present data for these sporadic and low SVOCs.

Polychlorinated Biphenyls (PCBs)

For the DIS, the present study marks the first analysis of PCB congeners instead of analysis of samples for Aroclors®. Thus, the reader should not compare PCB levels among this and previous risk characterizations for the DIS. As described in the methods section, the survey team collected fish for PCBs from five sites within the DIS: Three sites were within the canal system and two were within Donna Reservoirs, one in the West Reservoir and one in the East Reservoir.

Representatives of five fish species were collected from five sites within the DIS. Survey staff did not collect all species from each site. Table 3 presents PCB concentration in each species at each site. Table 3 also gives the average concentration of PCBs at each site. SALG staff noted that the highest PCB concentrations tended to cluster about Canal Site 2. Canal Sites 1 and 3, Reservoir West Site 4, and Reservoir East Site 5 had much lower concentrations of PCBs than did Canal Site 2.

The PCB data from this site could be further partitioned to illustrate species at each site contained the highest PCB concentrations. Risk assessors cannot know a person is fishing sites or how many different species a fisher might collect from each site. However, most species at each site contained some level of PCBs. Therefore, any fisher could choose to eat any number of species from any site recently sampled. Nonetheless, visual inspection of the data suggested that PCBs were at their highest concentrations in fish collected near Canal Site 2, with a gradient in both directions from this site. Canal Site 1, closest to the Rio Grande, has the lowest average concentration of PCBs. The gradient is as follows- from highest PCB concentrations to lowest: Canal Site 2 > Canal Site 3 > Reservoir Site 4 >Reservoir Site 5> Canal Site 1.

Assuming fish containing the highest concentrations of PCB to have accumulated those PCBs from areas having the highest PCB concentrations in dissolved solids,[3] the partitioned data could assist the USGS[3] and other agencies to definitively locate the elusive source of PCBs in the DIS.

DISCUSSION

Risk Characterization

The actual risk of adverse health outcomes from exposure to toxicants based on experimental or epidemiological data is subject to the known variability of individual and population responses. Thus, calculated risks can be orders of magnitude above or below the actual risks of systemic or local effects of toxicants. The variability depends upon many factors: the target organ; the species of animal used in the study; different exposure periods; different doses; or other variations in conditions.[23] Nevertheless, the DSHS calculated a number of risk parameters for potential toxicity to humans who consume contaminated fish from the DIS. Conclusions and recommendations predicated upon the stated goal of the DSHS to protect human health follow this discussion of findings.

Characterization of Possible Systemic (Noncancerous) Health Effects Related to Consumption of Fish from the Donna Irrigation System

The RfD for PCBs – the primary contaminant of concern in the DIS – comes from the findings of ocular exudates, inflamed and prominent Meibomian glands, distorted growth of finger and toenails, decreased antibody (IgG and IgM) response to sheep erythrocytes in clinical and immunologic studies conducted in monkeys.[36] The LOAEL was 0.005 mg/kg-day. Researchers applied several uncertainty factors: a full factor of 10 for intra-human variability (sensitive subgroups), a factor of three to account for extrapolation to humans from monkeys. To account for use of a subchronic study (approximately 25% of the animal's life); an uncertainty factor (UF) of three was used. Risk assessors at the federal level used a minimal LOAEL to determine the RfD, using a partial uncertainty factor of approximately 3.3. The composite uncertainty factor was 300. The modifying factor was 1.0. To calculate the RfD for Aroclor 1254, use the following:

$$RfD = LOAEL \div UFs * MF$$

Therefore, the RfD for Aroclor 1254 is

$$0.005 \div 300 * 1.0 = 0.00002 \text{ mg/kg-day (2E-05 mg/kg-day).}$$

Using the SALG's assumptions, the HAC_{nonca} for systemic effects for Aroclor 1254 is 0.047 mg/kg (mg Aroclor per kg of edible tissue). Risk assessors derive hazard quotients from the toxic substance's RfD or MRL and that substance's measured concentration in tissue, as described earlier. Table 4 contains hazard quotients for each species of fish examined at the DIS. Since PCBs were the only contaminants of concern in fish collected in 2005 from the DIS to exceed a HAC value, the HQs in Table 4 refer only to PCBs. Even though one cannot assume a linear relationship for HQs, one observes from this table that HQs are greater than 1.0 by a large margin for some fish (smallmouth buffalo, channel catfish, and common carp), while for others (largemouth bass, freshwater drum) the margin is not so different from 1.0. Nonetheless, all HQs are greater than 1.0, suggesting that all species from this reservoir have some potential to harm those who regularly consume fish from the DIS. The DSHS interprets this table as evidence of a continuing danger to those who regularly eat fish from the DIS and for continuing the possession ban in force for this water body.

Characterization of Excess Lifetime Cancer Risk from Consumption of Fish from the Donna Irrigation System

Table 5 outlines the probability of cancer from regular, long-term, or, perhaps, repeatedly large meals of one or more fish species collected from the DIS, containing the calculated probability of one excess cancer in X number of people exposed to PCBs in different species of fish from the DIS. The probability that DSHS utilizes to make risk management decisions about fish or shellfish contaminated with chemicals that have carcinogenic potential is 1 excess cancer in 10,000 equally exposed people. Only largemouth bass and freshwater drum do not exceed a 1 in 10,000 calculated theoretical lifetime risk of cancer (Table 5). This finding indicates that three fish species from the DIS contain PCBs at concentrations that may be capable of causing or contributing to cancer in people who regularly consume these fish. Although two species that do not exceed the cancer risk level used by the DSHS to ensure protection of public health (largemouth bass and freshwater drum), these species may already pose a hazard to health from the noncarcinogenic or systemic effects of long-term, low-level consumption of PCBs present in these fish.

Characterization of Cumulative Systemic Health Effects and Cumulative Excess Lifetime Cancer Risk from Consumption of Fish from the Donna Irrigation System

Because only one contaminant (PCBs) occurred in fish from the DIS at concentrations approaching or exceeding DSHS' health-based guidelines for protection of human health, the SALG determined it neither necessary nor possible to accurately predict or determine cumulative effects from consuming multiple chemicals in one or more species of fish from the DIS. If more than one contaminant of concern acting on the same target organ, by the same mode or mechanism of action, or that caused cancer had reached biological or toxicological significance, SALG risk assessors would have discussed those cumulative effects in this document.

CONCLUSIONS

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, and – if indicated – may suggest strategies for reducing risk to the health of those who eat contaminated fish or seafood to risk managers at DSHS, including the Texas Commissioner of Health.

The primary reason for conducting this study was to re-assess the potential risks to public health from consuming fish from the DIS, a body of water that has a long history of PCB contamination, only one example of which is PCB-contaminated fish. Risk assessors from the SALG and the Environmental and Injury Epidemiology and Toxicology Branch (EIETB) confirmed that PCBs in several species from the DIS exceed the HAC_{nonca} or the HAC_{ca} for PCBs. All samples contained some PCBs. Fish from the DIS contained no other contaminants at concentrations that would be expected to be of importance to human health if consumed over the long term or in large quantities. Thus, risk assessors from the SALG and the EIETB conclude from this characterization of risks possibly associated with consuming fish from the DIS

1. That all fish sampled species from the DIS contain PCBs at levels exceeding those concentrations used by the DSHS to ensure protection of public health from adverse systemic health effects of these contaminants. Although some species from some sites appear not to contain high concentrations of PCBs, this finding is not consistent, meaning the fish could previously been in waters the sediment of which were heavily contaminated with PCBs, having lately traveled to the collection site. Therefore, consumption of any of the sampled fish species and, presumably all fish species from the DIS continues to **pose an apparent hazard to human health**, systemic adverse health effects being the more sensitive endpoint in the SALG calculations of the likelihood of adverse health outcomes from consuming contaminated fish or shellfish. Additionally, consumption of channel catfish, common carp, and smallmouth buffalo from the DIS, heavily contaminated with PCBs, markedly increases the calculated lifetime excess risk of cancer in people eating these fish.

2. That cumulative adverse health effects from consuming fish from the DIS are not likely. Fish from the DIS do not contain concentrations of metal-like contaminants, VOCs, or SVOCs at concentrations in excess of DSHS guidelines for protection of human health. In fact, with the exception of metallic contaminants – which frequently were present in low, presumably nontoxic concentrations – contaminants of other chemical classes were present only sporadically and in low concentrations. Therefore, consumption of fish containing these compounds in addition to PCBs should not increase the risk to human health already posed by the PCBs. To reiterate: metalloid contaminants, VOCs and SVOCs observed in fish from the DIS are not likely to **pose no apparent human health hazard**, even when consumed along with PCBs in fish from the DIS.

3. That fish from the DIS do not appear to contain organochlorine pesticides at concentrations of significance to human health. Therefore, consumption of fish

containing only these pesticides at levels observed in sample tissues – were that possible – would **pose no apparent human health hazard.**

RECOMMENDATIONS

Risk managers at the DSHS have established criteria for issuing fish consumption advisories based on approaches suggested by the USEPA.[10, 16] If a risk characterization confirms that people can eat four, or fewer than four, meals per month (adults: eight ounces per meal; children: four ounces per meal) of fish or shellfish from the water body under investigation could lead risk managers at DSHS to recommend consumption advice for fish or shellfish from that water body. Alternatively, the department may ban 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).[37]. Declarations of prohibited harvesting areas are enforceable under the Texas Health and Safety Code, Subchapter D, parts 436.091 and 436.101.[37] DSHS consumption advice carries no penalty for noncompliance. Consumption advisories, instead, inform the public of potential health hazards from consuming contaminated fish or shellfish from Texas waters. With this information, members of the public can make informed decisions about whether – and how much – contaminated fish or shellfish they wish to consume. Risk assessors from the SALG and the EIETB conclude from this risk characterization that consuming fish from the DIS apparently **poses a continuing public health hazard**. Based on these observations, the SALG and the EIETB recommend

1. That the DSHS continues to enforce AL-9 – which bans possession of fish from the DIS and that is currently in force for this water body because every sampled fish species contained PCBs in concentrations that could increase the likelihood of experiencing adverse systemic health outcomes. Additionally, several sampled species contained PCBs at concentrations high enough to increase the theoretical lifetime excess risk of cancer if eaten regularly or in bulk.

2. That the DSHS continues to monitor fish from the DIS for PCBs until these contaminants decrease to a level, consumption of which would likely not interfere with the health of those consuming such fish.

3. That the DSHS analyze fish from the DIS for dioxins and furans.

PUBLIC HEALTH ACTION PLAN

Communication to the public of new and continuing possession bans or consumption advisories – or the removal of either – are essential to effective management of risk from consuming contaminated fish. In fulfillment of the responsibility for communication, the Texas Department of State Health Services (DSHS) takes several steps. The agency irregularly publishes fish consumption advisories and bans in a booklet available to the public through the Seafood and Aquatic Life Group (SALG). To receive the booklet and/or the data, please contact the SALG at 1-512-834-6757.[38] The SALG also posts the most current information about advisories, bans, and the repeal of such on the Internet at http://www.dshs.state.tx.us/seafood. The SALG regularly updates this web site. The Texas Department of State Health Services also provides the U.S. Environmental Protection Agency (http://epa.gov/waterscience/fish/advisories/), the Texas Commission on Environmental Quality (TCEQ; http://www.tceq.state.tx.us), and the Texas Parks and Wildlife Department (TPWD; http://www.tpwd.state.tx.us) with information on all consumption advisories and possession bans. Each year, the TPWD informs the fishing and hunting public of consumption advisories and fishing bans on it's Web site and in an official hunting and fishing regulations booklet available at many state parks and at all establishments selling Texas fishing licenses.[39] Readers may direct questions about the scientific information or recommendations in this risk characterization to risk managers at the (SALG) at 512-834-6757 or may find the information at the SALG's website (http://www.dshs.state.tx.us/). Secondarily, one may address inquiries to the Environmental and Injury Epidemiology and Toxicology Branch of the Department of State Health Services (512-458-7269). The EPA's IRIS Web site (http://www.epa.gov/iris/) contains much information on environmental contaminants found in food and environmental media. The Agency for Toxic Substances and Disease Registry (ATSDR), Division of Toxicology (888-42-ATSDR or 888-422-8737 or the ATSDR's Web site (http://www.atsdr.cde.gov) supplies brief information via ToxFAQs.® ToxFAQs are available on the ATSDR website in either English http://www.atsdr.cdc.gov/toxfaq.html) or Spanish (http://www.atsdr.cdc.gov/es/toxfaqs/es _toxfaqs.html). The ATSDR also publishes more in-depth reviews of many toxic substances in its *Toxicological Profiles.* To request a copy of available *Toxicological Profiles*, readers may telephone the ATSDR at 1-404-498-0261 or email requests to atsdric@cdc.gov. Many *Toxicological Profiles* are also available for downloading at ATSDR's website.

TABLES

Table 1. Fish samples collected from five sites within the Donna Irrigation System in December 2005 and January 2006.

Sample Number	Species	Length (mm)	Weight (g)
Site 1 Donna Irrigation Canal			
DIC40	Common Carp	647	3501
DIC41	Common Carp	520	2283
DIC42	Largemouth Bass	358	737
DIC43	Largemouth Bass	362	723
DIC44	Smallmouth Buffalo	673	5244
Site 2 Donna Irrigation Canal			
DIC24	Largemouth Bass	406	1163
DIC25	Common Carp	553	2294
DIC26	Largemouth Bass	382	858
DIC27	Largemouth Bass	364	717
DIC12	Largemouth Bass	445	1127
DIC15	Common Carp	535	1919
DIC28	Channel Catfish	399	684
DIC29	Smallmouth Buffalo	735	6612
DIC30	Common Carp	647	3640
DIC31	Smallmouth Buffalo	655	4902
Site 3 Donna Irrigation Canal			
DIC18	Freshwater Drum	450	1133
DIC20	Largemouth Bass	371	698
DIC21	Common Carp	582	2905
DIC22	Common Carp	550	2237
DIC23	Largemouth Bass	368	882
Site 4 Donna Irrigation Canal			
DIC1	Channel Catfish	357	405
DIC2	Largemouth Bass	434	1479
DIC3	Largemouth Bass	415	1498
DIC4	Largemouth Bass	397	1278
DIC5	Common Carp	660	4082
Site 5 Donna Irrigation Canal			
DIC6	Largemouth Bass	438	1445
DIC7	Freshwater Drum	487	1783
DIC8	Freshwater Drum	455	1268
DIC9	Common Carp	595	2179
DIC10	Common Carp	622	3410

Table 2. Inorganic Contaminants (mg/kg) in Fish Collected in December 2005 and January 2006 from the Donna Irrigation System.

Contaminant	# Detected/ # Sampled	Mean Concentration ± S.D. (Min-Max)	Health Assessment Comparison Value (mg/kg)[b]	Basis for Comparison Value
Copper				
Channel catfish	2/2	0.202±0.073 (0.150, 0.253)	333	National Academy of Science Upper Limit: 0.143 mg/kg–day
Common carp	10/10	0.479±0.232 (0.157-0.811)		
Freshwater drum	3/3	0.061±0.026 (BDL[c]-0.091)		
Largemouth bass	12/12	0.149±0.246 (BDL-0.916)		
Smallmouth buffalo	3/3	0.317±0.091 (0.231-0.413)		
All Fish Combined	30/30	0.271±0.258 (BDL-0.916)		
Lead				
Channel catfish	1/2	0.076±0.047 (ND[d]-0.109)	0.6	USEPA IEUBKwin
Common carp	2/10	0.070±0.076 (ND-0.285)		
Freshwater Drum	0/3	ND		
Largemouth bass	1/12	0.045±0.003 (ND-BDL)		
Smallmouth buffalo	2/3	0.324±0.327 (ND-0.692)		
All fish combined	6/30	0.083±0.127 (ND-0.692)		
Mercury				
Channel catfish	2/2	0.126±0.126 (0.108,0.143)	0.7	ATSDR chronic oral MRL: 0.0003 mg/kg–day
Common carp	10/10	0.212±0.137 (BDL-0.467)		
Freshwater drum	3/3	0.158±0.053 (0.098-0.194		
Largemouth bass	12/12	0.246±0.084 (0.165-0.453)		
Smallmouth buffalo	3/3	0.358±0.093 (0.252-0.427)		
All Fish Combined	30/30	0.229±0.112 (BDL-0.467)		
Selenium				
Channel catfish	2/2	0.315±0.066 (0.268,0.361)	6	EPA chronic oral RfD: 0 .005 mg/kg–day
Common carp	10/10	0.666±0.113 (0.496-0.931)		

[b] *Derived from the MRL or RfD for noncarcinogens or the USEPA 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].*
[c] *BDL: Below Detection Limit — Estimated concentrations reported were less than the laboratory's method detection limit (J-values).*
[d] *ND: Not Detected above the method detection limit or reporting limit (method specific).*

Table 2. Inorganic Contaminants (mg/kg) in Fish Collected in December 2005 and January 2006 from the Donna Irrigation System.

Contaminant	# Detected/ # Sampled	Mean Concentration ± S.D. (Min-Max)	Health Assessment Comparison Value (mg/kg)[b]	Basis for Comparison Value
Selenium, continued				
Freshwater drum	3/3	0.504±0.042 (0.457-0.538)		ATSDR chronic oral MRL: 0.005 mg/kg–day NAS 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) to account for other sources of selenium in the diet
Largemouth bass	12/12	0.476±0.074 (0.379-0.640)		
Smallmouth buffalo	3/3	0.632±0.064 (0.573-0.700)		
All Fish Combined	30/30	0.547±0.135 (0.268-0.931)		
Zinc				
Channel catfish	2/2	5.312±0.599 (4.888, 5.735)	700	EPA chronic oral RfD: 0.3 mg/kg–day
Common carp	10/10	8.391±2.845 (5.140-13.261)		
Freshwater drum	3/3	3.193±0.742 (2.364-3.797)		
Largemouth bass	12/12	4.516±.0.9269 (3.220-6.138)		
Smallmouth buffalo	3/3	4.894±1.053 (3.838-5.943)		
All Fish Combined	30/30	5.766±2.601 (2.364-13.261)		

Table 3. Polychlorinated Biphenyls (PCBs) (mg/kg) in Fish by Species and Site from Donna Irrigation System, 2005-2006.

Contaminant	# Detected/ # Sampled	Mean Concentration ± S.D. (Min-Max)	Health Assessment Comparison Value (mg/kg)[b]	Basis for Comparison Value
Site 1 (Donna Canal SH 281)				
Common carp	2/2	0.012 ± 0.003 (0.010-0.014)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Largemouth bass	2/2	BDL[c]		
Smallmouth buffalo	1/1	**0.049**		
All Sampled Fish, Site 1	5/5	0.018 ± 0.018 (BDL-0.049)		
Site 2 (Donna Canal Siphon Outlet)				
Channel catfish	1/1	**2.509**	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Common carp	3/3	**3.777** ± 5.202 (0.129-9.733)		
Largemouth bass	4/4	**0.195** ± 0.159 (BDL-0.401)		
Smallmouth buffalo	2/2	**13.782** ± 9.002 (7.417-20.148)		
All Sampled Fish, Site 2	10/10	**4.219**± 6.553 (BDL-20.148)		
Site 3 (Donna Canal FM 1423)				
Common carp	2/2	**1.276** ± 1.063 (0.524-2.027)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Freshwater drum	1/1	**0.175**		
Largemouth bass	2/2	**0.056** ± 0.035 (0.032-0.081)		
All Sampled Fish, Site 3	5/5	**0.568** ±0.838 (0.032-2.027)		
Site 4 (Donna Reservoir West)				
Channel catfish	1/1	**0.057**	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Common carp	1/1	0.043		
Largemouth bass	3/3	**0.052** ± 0.012 (0.039-0.063)		
All Sampled Fish, Site 4	5/5	**0.051** ± 0.010 (0.039-0.063)		
Site 5 (Donna Reservoir East)				
Common carp	2/2	0.031 ± 0.010 (0.024-0.038)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Freshwater drum	2/2	BDL		
Largemouth bass	1/1	0.023		
All Sampled Fish, Site 5	5/5	0.025 ± 0.007 (BDL-0.038)		

Table 3 continued. Polychlorinated Biphenyls (PCBs) (mg/kg) in Fish by Species from Donna Irrigation System, 2005-2006.

Contaminant	# Detected/ # Sampled	Mean Concentration ± S.D. (Min-Max)	Health Assessment Comparison Value (mg/kg)[b]	Basis for Comparison Value
All Sites (Sample Sites Combined)				
Channel catfish	2/2	**1.283** ± 1.734 (0.057-2.509)		
Common carp	10/10	**1.401** ± 3.012 (0.010-9.733)		
Freshwater drum	3/3	**0.072** ± 0.089 (BDL – 0.175)	0.047	EPA chronic oral RfD: 0.00002 mg/kg–day
Largemouth bass	12/12	**0.090** ± 0.115 (BDL-0.401)	0.272	EPA slope factor: 2.0 per mg/kg–day
Smallmouth buffalo	3/3	**9.205** ± 10.168 (0.049-20.148)		
All Sampled Fish, All Sites	30/30	**1.516** ± 4.152 (BDL-20.148)		

Table 4. Hazard quotients (HQ) for PCBs in fish Collected from Lake The Donna Irrigation System in 2005-2006 along with suggested consumption rates for adults eating fish (8-oz per meal) containing PCBs at concentrations near those found in these samples.[e]

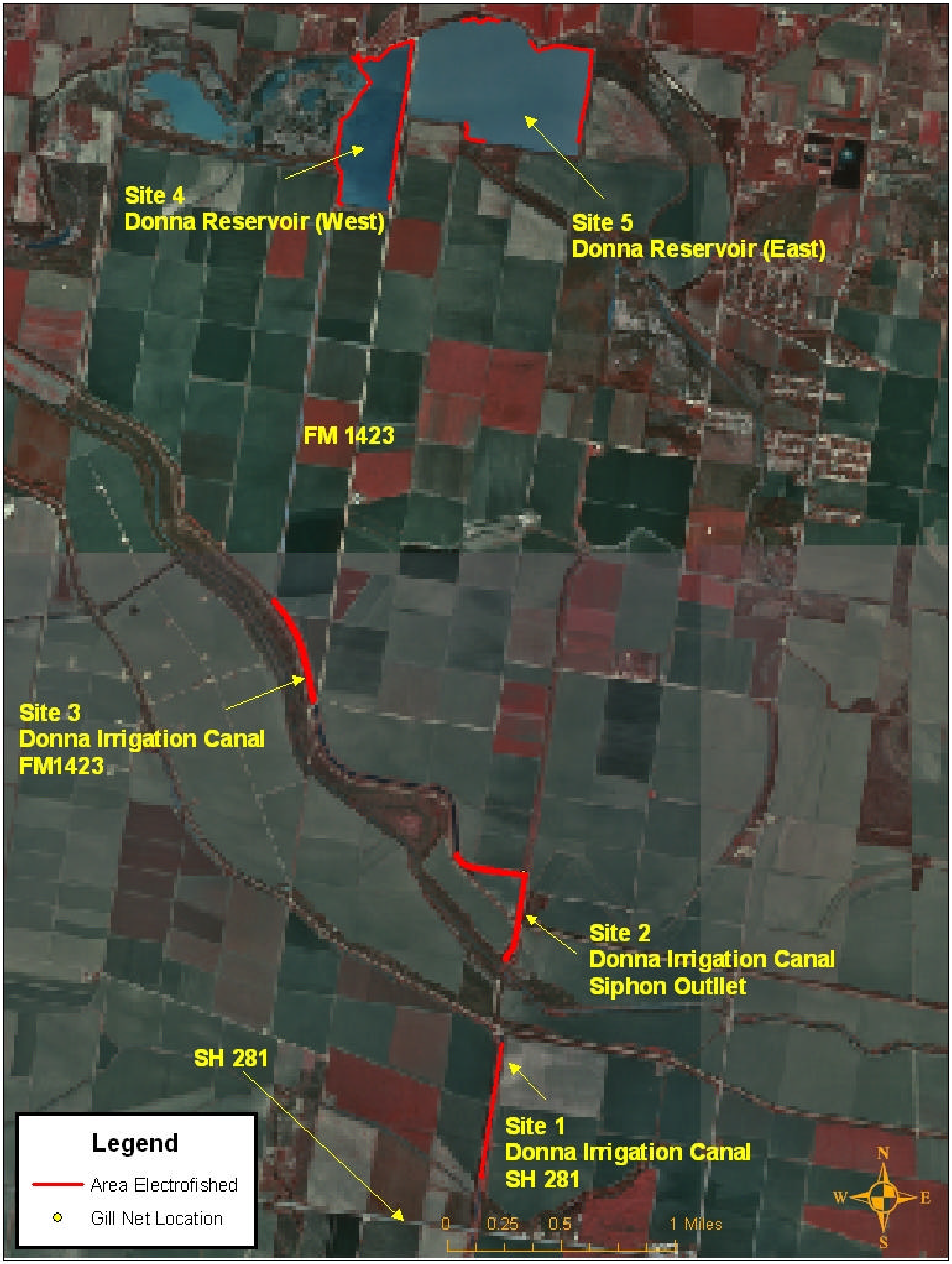
Species	Hazard Quotient	Meals per Week
Channel catfish	**27.5**	**0.0**
Common carp	**30.0**	**0.0**
Freshwater drum	**1.5**	**0.6**
Largemouth bass	**1.9**	**0.5**
Smallmouth buffalo	**197.2**	**0.0**
All Fish Combined	**32.5**	**0.0**

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

Table 5. Theoretical lifetime excess cancer risk for each PCB-contaminated species collected in 2005 from the Donna Irrigation System along with suggested weekly (8 oz per meal) consumption rates for 70-kg adults who eat each species of fish.[e]

Species/Contaminant	Theoretical Lifetime Excess Cancer Risk		Meals per Week
	Risk	1 excess cancer per number of people exposed	
Channel catfish	**4.7E-04**	**2122**	**0.2**
Common carp	**5.1E-04**	**1943**	**0.2**
Freshwater drum	2.6E-05	37809	3.5
Largemouth bass	3.3E-05	30047	2.8
Smallmouth buffalo	**3.4E-03**	**296**	**0.0**
All Fish Combined	**4.4E-03**	**226**	**0.2**

Figure 1. Donna Irrigation System Sample Site Map



LIITERATURE CITED

[1] Donna Reservoirs and Irrigation System Location. Google Maps http://maps.google.com/maps?q=26.15,-98.06667+(Donna%20Reservoirs)&hl=en (Accessed April 19, 2007).

[2]History of PCBs in the Donna Reservoir, as recited by Mr. G. Kirk Wiles to Dr. Jerry Ann Ward on March 22, 2007.

[3] USGS report from http://pubs.usgs.gov/fs/fs01602/pdf/FS_016-02.pdf (Accessed March 22, 2007)

[4] [TDH] Texas Department of Health. Seafood Safety Division. Fish Consumption Advisories & Bans, 2004. Regulatory Action on Donna Irrigation System (AL-9), Issued February 4, 1994.

[5] Clean Water Act. 33 USC 125 *et seq.* 40CFR part 131: Water Quality Standards.

[6] http://www.epa.gov/waterscience/316b/econbenefits/b6.pdf (Accessed October 3, 2005).

[7] [USCB] Hidalgo County, TX, Fact Sheet, 2000 and 2005: http://factfinder.census.gov/servlet/ACSSAFFFacts?_event=&geo_id=05000US48215&_geoContext=01000US%7C04000US48%7C05000US48215&_street=&_county=Hidalgo+County&_cityTown=Hidalgo+County&_state=04000US48&_zip=&_lang=en&_sse=on&ActiveGeoDiv=&_useEV=&pctxt=fph&pgsl=050&_submenuId=factsheet_1&ds_name=null&_ci_nbr=null&qr_name=null&reg=null%3Anull&_keyword=&_industry= (Accessed April 19, 2007).

[8] 2005 American Community Survey Hidalgo County TX. http://factfinder.census.gov/servlet/ACSSAFFFacts?_event=&geo_id=05000US48215&_geoContext=01000US%7C04000US48%7C05000US48215&_street=&_county=Hidalgo+County&_cityTown=Hidalgo+County&_state=04000US48&_zip=&_lang=en&_sse=on&ActiveGeoDiv=&_useEV=&pctxt=fph&pgsl=050&_submenuId=factsheet_1&ds_name=null&_ci_nbr=null&qr_name=null&reg=null%3Anull&_keyword=&_industry= (Accessed April 19, 2007).

[9] [DSHS] Texas Department of State Health Services, Seafood and Aquatic Life Group Survey Team Standard Operating Procedures and Quality Assurance/Quality Control Manual. Austin, Texas. 2007.

[10] [USEPA] United States Environmental Protection Agency. Guidance for assessing chemical contaminant data for use in fish advisories. Vol. 1, Fish sampling and analysis, 3rd ed. Washington D.C. 2000.

[11] [TSCC] Toxic Substances Coordinating Committee URL: http://www.tscc.state.tx.us/dshs.htm (Accessed August 29, 2006).

[12] [USDHHS] United States Department of Health & Human Services. Public Health Service. [ATSDR] Agency for Toxic Substances and Disease Registry. Toxicological Profile for Arsenic (update). Atlanta, GA., September 2000.

[13] [USDHHS] United States Department of Health & Human Services. Public Health Service. [ATSDR] Agency for Toxic Substances and Disease Registry. Toxicological Profile for Mercury (update). Atlanta, GA: 1999 March.

[14] Lauenstein, G.G. & Cantillo, A.Y. 1993. Sampling and Analytical Methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects 1984-1992: Overview and Summary of Methods - Vol. I. NOAA Tech. Memo 71. NOAA/CMBAD/ORCA. Silver Spring, MD. 157pp.http://www.ccma.nos.noaa.gov/publications/tm71v1.pdf (accessed October 3, 2005).

[15] McFarland, V.A. & Clarke, J.U. 1989. Environmental occurrence, abundance, and potential toxicity of polychlorinated biphenyl congeners: considerations for a congener-specific analysis. Environmental Health Perspectives. 81:225-239.

[16] [USEPA] United States Environmental Protection Agency. Guidance for assessing chemical contaminant data for use in fish advisories. Vol. 2, Risk assessment and fish consumption limits. 3rd ed. Washington, D.C.: 2000.

[17] [IRIS} Integrated Risk Information System, maintained by the USEPA. Polychlorinated biphenyls (PCBs) (CASRN 1336-36-3), Part II,B.3. Additional Comments (Carcinogenicity, Oral Exposure http://www.epa.gov/iris/subst/0294.htm (Accessed by Jerry Ann Ward on March 15, 2007).

[18] SPSS 13 for Windows©. Release 13.0.1. 12 December 2004. Copyright SPSS, Inc., 1989-2004. http://www.spss.com (Accessed August 29, 2006).

[19] Microsoft Corporation. Microsoft Excel® 2000. Copyright© Microsoft Corporation 1985-1999.

[20] CDC's Lead Standard for Children

[21] Casarett and Doull's Toxicology: The Basic Science of Poisons. 5th ed. Ed. CD Klaassen. Chapter 2, pp. 13-34. McGraw-Hill Health Professions Division, New York, NY, 1996.

[22] Beauchamp, Richard. 1999. Personal Communication. *Monte Carlo Simulations in analysis of fish tissue contaminant concentrations and probability of toxicity*. Department of State Health Services.

[23] [USEPA] United States Environmental Protection Agency. Office of Research and Development, National Center for Environmental Assessment. Integrated risk information system (IRIS). Human Health Risk Assessments. Background Document 1A. 1993, March. http://www.epa.gov/iris/rfd.htm (Accessed August 29, 2006).

[24] [ATSDR] Agency for Toxic Substances and Disease Registry. Minimal Risk Levels for Hazardous Substances. http://www.atsdr.cdc.gov/mrls.html (Accessed August 29, 2006).

[25] [USEPA] United States Environmental Protection Agency. Glossary of risk assessment-related terms. Washington, D.C.: 1999. Information available at URL: http://www.epa.gov/iris/gloss8.htm (Accessed August 29, 2006).

[26] [USEPA] United States Environmental Protection Agency. Technology Transfer Network. National Air Toxics Assessment. Glossary of Key Terms. Washington, D.C.: 2002. Information available at URL: http://www.epa.gov/ttn/atw/nata/gloss1.html (Accessed August 29, 2006)

[27] [USEPA] United States Environmental Protection Agency. Guidelines for Carcinogen Risk Assessment and Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. Federal Register Notice posted April 7, 2005.

[28] Thompson, KM. *Changes in Children's Exposure as a Function of Age and the Relevance of Age Definitions for Exposure and Health Risk Assessment*. MedGenMed. 6(3), 2004. http://www.medscape.com/viewarticle/480733. (Last accessed August 22, 2005).

[29] University of Minnesota. Maternal and Child Health Program *Healthy Generations: Children's Special Vulnerability to Environmental Health Risks*. http://www.epi.umn.edu/mch/resources/hg/hg_enviro.pdf (accessed August 29, 2005).

[30] Selevan, SG, CA Kimmel, P Mendola. *Identifying Critical Windows of Exposure for Children's Health.* Environmental Health Perspectives Volume 108, Supplement 3, June 2000.

[31] [USEPA] The United States Environmental Protection Agency. Children's Health Protection http://yosemite.epa.gov/ochp/ochpweb.nsf/content/homepage.htm (Accessed 04-30-07).

[32] Schmidt, C.W. *Adjusting for Youth: Updated Cancer Risk Guidelines*. Environ. Health Perspectives. 111(13):A708-A710.

[33] [USDHHS] United States Department of Health & Human Services. Public Health Service. Agency for Toxic Substances and Disease Registry (ATSDR). Office of Children's Health. Child health initiative. Atlanta Ga.: 1995.

[34] [USEPA] United States Environmental Protection Agency. Office of Research and Development (ORD). Strategy for research on environmental risks to children, Section 1.2. Washington D.C.: 2000.

[35] [USEPA] The United States Environmental Protection Agency. Children's Health http://www.epa.gov/ebtpages/humachildrenshealth.html (Accessed 04-30-07).

[36] [IRIS] Integrated Risk Information System maintained by the USEPA. Authors reviewed for the IRIS databases include Arnold et al., 1994a,b; Tryphonas et al., 1989, 1991a,b.

[37] Texas Statutes: Health and Safety, Chapter 436, Subchapter D, § 436.011, §436.061 and others.

[38] [DSHS] Department of State Health Services, Austin, TX. Fish Consumption Advisories and Bans. Seafood Safety Division. Austin, Texas: 2004.

[39] [TPWD] Texas Parks and Wildlife Department. 2006-2007 Outdoor Annual: hunting and fishing regulations. Ed. J. Jefferson. Texas Monthly Custom Publishing, a division of Texas Monthly, Inc. 2006.