West Virginia Sport Fish Consumption Advisory Guide

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West Virginia Interagency Technical Committee

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List of Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
BPH	Bureau for Public Health of the West Virginia Department of Health and Human Resources
CSF	Cancer slope factor
DEP	West Virginia Department of Environmental Protection
DEP-DWWM	West Virginia Department of Environmental Protection, Division of Water and Waste Management
DHHR	West Virginia Department of Health and Human Services
DNR	West Virginia Division of Natural Resources
EPA	United States Environmental Protection Agency
FDA	United States Food and Drug Administration
HEAST	Health Effects Assessment Summary Table
HPV	Health Protection Value
IRIS	Integrated Risk Information System
LOAEL	Lowest observed adverse effect level
Log K_{ow}	Octanol-water partition coefficient
mg/kg	milligram per kilogram
mg/kg/day	milligram per kilogram per day
MRL	Minimal risk level
ng/kg	nanogram per kilogram
NOAEL	No observed adverse effect level
ORSANCO	Ohio River Valley Water Sanitation Commission
OWR	West Virginia Department of Natural Resources, Office of Water Resources, now known as the Division of Water and Waste Management (DEP-DWWM)
PAD	Population adjusted dose
PAHs	Polycyclic aromatic hydrocarbons or polynuclear aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
RfD	Reference dose
TCDD TEQs or TEQs	2,3,7,8-tetrachlorodibenzo- para-dioxin toxic equivalents
USFWS	United States Fish and Wildlife Service

Forward

This is the second edition of the West Virginia Sportfish Consumption Advisory Guide, (the "WV Guide") The first edition of this document was prepared by William Warnick in 2000 for the West Virginia Interagency Technical Committee.

The purpose of the *WV Guide* is to

- provide background information about the West Virginia Interagency Technical Committee (the Advisory Committee),
- outline the background for meal consumption limits,
- provide the basis for the calculations of the meal consumption limits, and
- provide information about the development of fish advisories using fish tissue data and meal consumption limits.

A number of factors prompted this revision. There was a desire for a more user-friendly format. Additional chemicals needed to be added to the *WV Guide*. New toxicological risk information was available.

Some of the notable changes are:

- The document is in a more concise and readable format.
- A new meal consumption category (two meals/month) was added to allow more choices for people who eat sport-caught fish.
- Reference doses and cancer slope factors have been updated for chlorpyrifos, diazinon, dicofol, dioxin, lindane, terbufos, and toxaphene.
- Meal consumption limits have been added for arsenic, oxyfluorfen, and tributyltin.
- Minor adjustments were made to the formulas used to determine meal advice.
- Children's advisories have been dropped. Fish advisories are currently based on a ratio of body weight to meal size that uses the same meal consumption limits for both adults and children.
- The Introduction and Chemical Summaries have been revised.

A glossary can be found in Appendix D.

Introduction

West Virginia has a number of resident and nonresident fishermen and women. The state's rural heritage and low per capita income may provide for a resident population with the inclination and incentive to catch and keep fish for food. West Virginia had a total population of 1,808,344 with an average per capita income of $10,520 in 2000 (Bureau of the Census 2000). Rural residents constituted 64% of West Virginia's total population as compared to 20% for rural residents in the United States. In 2001 the U.S. Fish and Wildlife Service (USFWS) estimated that 273,000 of West Virginia residents age 16 and greater accounted for 4.3 million days of fishing and $146 million in fishing expenditures. Another 318,000 nonresidents spent an estimated 4.2 million days fishing and $102 million on fishing activities. Forty percent of West Virginia anglers had an annual household income of less than $30,000. Fifty-seven percent of the anglers in West Virginia were men (U.S. Fish and Wildlife Service 2002).

Human activities have allowed the discharge of chemicals, trace metals, and other contaminants into the waters of West Virginia. Our history of industry, mining and oil and gas extraction and the lack of wastewater treatment have resulted in the pollution of portions of West Virginia's waters. Fish and other aquatic organisms accumulate and bio-concentrate these contaminants to levels much higher than those in the water and sediments.

Fish are naturally equipped to adapt to changes in the aquatic environment in order to thrive and survive. However, fish are not able to avoid chemicals introduced into their environment.

Although not all contaminants will be harmful or occur in doses high enough to have adverse effects, many chemicals do pose a health threat to humans, fish, and other wildlife. Many of these chemicals are those that accumulate in tissues and thus increase in concentration throughout the food chain.

The chemicals reviewed in this guide fall into several categories:

- Metals – arsenic, cadmium, mercury, selenium;
- Organic metal – tributyltin oxide;
- Organochlorine pesticides – chlordane, DDT, dicofol, dieldrin, endosulfan, endrin, heptachlor epoxide, hexachlorobenzene, lindane, mirex, toxaphene;
- Organophosphate pesticides – chlorpyrifos, diazinon, disulfoton, ethion, terbufos;
- Chlorophenoxy herbicides – oxyfluorfen;
- Polycyclic aromatic hydrocarbons (PAHs);
- Polychlorinated biphenyls (PCBs); and
- Dioxins/furans.

Among the chemicals evaluated here are chemicals that are persistent and can bioaccumulate and biomagnify in the food chain. They are: aldrin, chlordane, DDT,

dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene, PCBs, dioxins, and furans.

Bioaccumulation is the uptake and retention of chemicals by living organisms. A chemical bioaccumulates if the rate of intake into the living organisms is greater than the rate of excretion or metabolism. This results in chemical concentrations in tissues that are higher than that in the environment. Consequently, analysis of fish tissue can reveal the presence of chemicals in waterbodies that may not be detected from testing the water alone.

Contaminants in fish not only indicate pollution impact on aquatic life and other wildlife through biomagnification up the food chain, but also can represent a significant route of human exposure to toxic chemicals through consumption of fish and shellfish.

Chemicals that bioaccumulate in the bodies of organisms can pass from one species to the next through the food chain. This process is called biomagnification. When contaminants found in small amounts at the bottom of the food chain biomagnify, they can pose a hazard to predators that feed at the top of the food chain. This means that even small releases of some chemicals can have impacts out of proportion to the release.

Sediments can serve as reservoirs or "sinks" for some chemicals that are not water soluble. Many chemicals can remain in undisturbed sediments for a long time. If the sediments are disturbed, however, they can be reintroduced into the ecosystem and food chain, potentially becoming a source of contamination.

Human consumption of sport-caught fish represents a significant route of exposure to aquatic contaminants (Humphrey 1987). Scientists in West Virginia and across the nation have long suspected that fish contaminated with certain chemicals may pose health risks to those who frequently consume these fish. This concern has heightened as scientists learn more about the levels of contamination in fish and toxicological characteristics of these contaminants. The U.S. Environmental Protection Agency (EPA) encourages states to monitor contaminant levels in fish.

In 1997, EPA conducted a survey of the states regarding the development of fish consumption advisories. The results showed that 23 states were using risk-based protocols, 16 used a combination of risk-based and U.S. Food and Drug Administration (FDA) guidelines, nine used FDA guidelines only, and two states had no fish consumption advisories. The five states bordering West Virginia used the following guidelines:

- Ohio – Great Lakes Protocol for PCBs. A different risk-based procedure for all other contaminants unless FDA action levels were exceeded.
- Kentucky and Pennsylvania – Great Lakes Protocol for PCBs and FDA action levels for other contaminants.
- Maryland and Virginia – Risk-based procedures (no written protocols) and FDA action levels.

The different risk-assessment protocols can result in conflicting fish consumption advisories in waters that are shared by different states. Conflicting information can be confusing to anglers and cause them to ignore an advisory altogether. The states

adjoining the Great Lakes were aware of such a problem, which prompted the formation of the Great Lakes Sport Fish Advisory Task Force. This group's efforts resulted in the *Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory* (GLSFATF 1993). West Virginia also acknowledges the need for uniform consumption advisories on the Ohio River when issuing consumption advisories.

Fish advisories help people make informed choices about eating fish caught in West Virginia. The goal of fish consumption advisories is to reduce the consumption of chemicals that may be in edible fish tissue to levels that are unlikely to cause adverse health effects during a lifetime of exposure.

History and Background of the West Virginia Interagency Technical Committee

West Virginia Department of Health and Human Resources (DHHR), through an interagency agreement (WVBPH 2000), partners with the West Virginia Department of Environmental Protection (DEP) and the West Virginia Division of Natural Resources (DNR) to develop consumption advisories for fish caught in West Virginia.[1] The West Virginia Interagency Technical Committee (the Advisory Committee) reviews fish advisories and updates these advisories as needed to protect the public health.

In the late 1970s the W.V. Department of Natural Resources' Office of Water Resources (OWR)[2] conducted whole-fish contaminant studies to determine levels of bioaccumulation. This effort was initiated from a pollution-control perspective and was not intended for evaluating safe fish consumption. However, these studies revealed that some contaminants were present in significant levels in the whole-fish samples. Therefore, OWR began testing edible-portions (fillets) to evaluate the level of contamination and potential risks to consumers of sport-caught fish.

In the 1980s West Virginia began issuing fish consumption advisories based on U.S. Food and Drug Administration (FDA) Action Levels. The Bureau for Public Health (BPH), DNR, and OWR were involved in preparing press releases.

As scientific assessment methods improved, the EPA began to encourage states to adopt risk-based fish consumption advisories. Risk-based advisories were developed to protect recreational and subsistence-level anglers, who may consume fish from the same waterbody on a regular basis. By contrast, the FDA Action Levels were designed to protect consumers of supermarket fish. The initial EPA documents offered guidance for deriving advisories, but did not specify precise consumption limits. Individual states were allowed to determine such factors as risk level, average meal size, and other variables.

The Ohio River Valley Water Sanitation Commission (ORSANCO) formed a fish advisory committee, consisting of Ohio River states, to develop consistent fish consumption advisories for states along the Ohio River mainstem.[3] The Ohio River states agreed to adopt risk-based advisories for polychlorinated biphenyls (PCBs) following the

[1] The interagency agreement
[2] The agency is currently known as the Division of Water and Waste Management (WVDEP-DWWM).
[3] Pennsylvania, Ohio, West Virginia, Kentucky, Illinois, and Indiana

protocol established by the Great Lakes Fish Consumption Advisory Task Force.[4] West Virginia issued its first risk-based advisory for the Ohio River in 1996.

In 1998, EPA began to question mercury contamination in West Virginia fish. At that time, all states surrounding West Virginia, except Maryland, had mercury-based consumption advisories. When the FDA Action Level was applied to the existing West Virginia fish tissue data, no mercury advisory was necessary. However, these data suggested the need for restricted consumption if risk-based principles were applied. OWR, BPH, and DNR initiated discussions to move toward risk-based mercury advisories.

The Advisory Committee was officially created by Executive Order No. 16-00 on September 11, 2000. This committee is represented by three agencies (BPH, DNR, DEP-DWWM). The objectives of the committee were finalized in the Interagency Agreement on November 8, 2000. The Interagency Agreement sets objectives, obligations, fish consumption advisory principles, agency roles and responsibilities, funding needs and policies for developing and publicly disseminating fish consumption advisories. The agreement states that the BPH chairs the committee and has statutory authority for matters affecting or potentially affecting the public health of the state's citizens.

The objectives of the Advisory Committee are as follows.

- Collect and evaluate fish tissue contamination.
- Maintain a fish contaminant database.
- Adopt risk-based protocols and develop consumption guidelines for the public.
- Develop and modify fish consumption advisories, based upon but not limited to, the fish consumption advisory principles set forth in the Interagency Agreement.
- Annually review the existing advisories and recommend needed changes.
- Develop and implement an advisory communication policy.

OWR secured a grant for a West Virginia University researcher to develop risk-based consumption guidelines for 23 contaminants. This research was completed in 2000 and was presented in the 2000 version of the *WV Guide*.

The 2nd edition of the *WV Guide* sets meal consumption limits for 26 contaminants based on fish tissue testing results and the formulas and assumptions outlined below. Assumptions used are from the Great Lakes Protocol (GLSFATF 1993) and EPA (USEPA, 2000).

DEP-DWWM secured a federal grant in 2001 to conduct statewide sampling and analysis of fish tissue for mercury and PCB contaminants. That project has been completed. A total of 395 samples were collected from 56 waterbodies. The data from this project were received and reviewed by the Advisory Committee in 2004.

At the same time, the Advisory Committee reviewed the assumptions used to calculate the meal consumption limits in the *WV Guide*. This resulted in changes in the procedures

[4] PCBs are the predominant fish-tissue contaminant in the Ohio River.

used to establish the meal consumption limits that are outlined in the 2nd edition of the *WV Guide*. The 2005 West Virginia Fish Advisories were based on these changes.

In 2004 the U.S. Food and Drug Administration and the U.S. Environmental Protection Agency released a joint national advisory that covers sport fish. Information about this advisory and the FDA guidelines is in Appendix A. The advisory said that women who may become pregnant, pregnant women, nursing mothers, and young children should check with local fish advisories or, if no advice is available, could eat up to 6 ounces (one average meal) per week of fish caught from local waters while not consuming any other fish during that week.

Benefits of Eating Fish

Fish are nutritious and good to eat. Eating fish is part of a healthy diet. Fish is high in quality protein, low in saturated fats, and provides valuable vitamins and minerals. Fish contain omega-3 fatty acids which reduce blood clotting and plaque from forming in your arteries. Recent studies have shown eating as little as one meal of fish a week can significantly reduce the risk of a fatal heart attack. Many doctors suggest that eating 8 ounces of fish each week helps to prevent heart disease. When properly prepared, fish provide numerous health benefits. The American Heart Association recommends eating two to three fish meals each week. Another study linked a significantly lower risk of stroke for those who ate more than one meal of fish a week. Fish contain nutrients essential for proper development of infants. Eating fish may also lower lung disease in smokers and may help relieve symptoms of arthritis. Other benefits of eating fish include:

- Fish offer high-quality protein with fewer calories than a similar-sized portion of meat. For example, both catfish and ground beef are about 18 percent protein. But for an eight-ounce meal, catfish has 232 calories while the ground beef has 640 calories.
- Fish are low in sodium and are a good source of potassium, vitamins, and other minerals.
- Fish are generally low in cholesterol and saturated fats which have been associated with heart disease.
- While the health benefits of fish are still being studied, much of the current research is focused on various kinds of beneficial fats in fish, particularly omega-3 fatty acids. Some studies have indicated that these fatty acids have favorable effects on health conditions such as hardening of the arteries and high cholesterol.

Fish Preparation and Cooking Advice

Fish should be cleaned and dressed as soon as possible.

Eat smaller fish (within the legal size limit). As a general rule, larger, older fish may be more contaminated than smaller, younger fish.

Vary the kind of fish you eat. Trout and sunfish, such as bluegill, eat insects and other aquatic life that are less likely to contain high levels of contaminants. Top predators like bass and walleye may have higher levels of contaminants. If you eat a lot of these top

predators, eat smaller fish to minimize your exposure. Follow the fish consumption advisories, for types and sizes of fish.

Some contaminants accumulate in the fat of fish. Choose leaner fish. Catfish and carp have a higher fat content. Yellow perch, sunfish, and crappie are examples of lean fish.

Clean and cook fish properly. How you clean and cook fish can reduce the level of contaminants by as much as half in some fish. Some contaminants concentrate in the fatty tissues and internal organs of fish. Filleting the fish, removing the skin and internal organs, and trimming the fat along the back, side, and belly of the fish helps reduce the contaminants.

While cooking does not destroy contaminants, heat from cooking melts some of the fat and allows some of the contaminated fat to drain away. Broil, grill, or bake the trimmed, skinned fish on a rack so that the fat drips away. Deep-fat frying removes some of the contaminants, but you should discard the oil after you cook the fish. Pan frying does not remove much of the contaminants. Mercury levels cannot be reduced by trimming because mercury binds to protein (the meat portion) of the fish.

The drippings or broth, which usually contains higher levels of contaminants should not be included in the meal. Frying and deep frying fish will remove fewer contaminants and may seal contaminants in the fish. Fish should be filleted and skinned before smoking.

Establishing Meal Consumption Limits

Comparing fish tissue data to meal consumption limits is one of the tools used to establish fish advisories in West Virginia. Meal consumption limits recommend restrictions on the frequency of fish meals based on chemical concentrations found in fish tissue. Meal consumption limits are set to keep amounts of chemicals eaten in fish at or below levels believed to cause no adverse health effects.

These meal consumption limits use:

- reference concentrations for the amount of chemicals that can be in the body without being likely to cause adverse health effects,
- the number of fish meals eaten per year,
- the amount of fish eaten per meal,
- the amount of chemical remaining in the fish after preparing the fish for eating,
- the weight of the person eating the fish, and
- for those chemicals that have calculations for carcinogenic risk, a cancer risk factor.

A summary of the assumptions used for establishing meal consumption limits is in Table 1 of Appendix B.

What reference concentrations are used?

The reference concentrations that set the amount of chemical that can be in the body without being likely to cause adverse health effects are set by various governmental agencies. These reference concentrations are set by the EPA, the Great Lakes Protocol, or the Agency for Toxic Substances and Disease Registry (ATSDR). The reference concentrations for noncarcinogenic effects are expressed in terms of milligrams of chemical per kilogram of body weight per day (mg/kg/day). The reference concentrations for carcinogenic effects are expressed in terms of $(mg/kg/day)^{-1}$.

Reference Dose (RfD)

Reference Doses (RfDs) are developed by the EPA and are used here for all chemicals with noncarcinogenic effects, except for polychlorinated biphenyls, chlorpyrifos (special population), and dioxins. A RfD is an estimate of a daily exposure to humans that is likely to be without an appreciable risk of deleterious noncarcinogenic effects during a lifetime (ATSDR 2005). RfDs take into account the effects on people who are particularly sensitive to the chemical such as children.

RfDs are calculated by first reviewing the literature and determining the proper no observed adverse effects level (NOAEL) or lowest observed adverse effects level (LOAEL) from a significant study. The process uses factors that take into account the uncertainties of extrapolating from animals to humans, data gaps, or other unknown factors. These factors can range from 1 to 10,000. Some RfDs incorporate modifying factors which are assigned based on professional judgment concerning varying chemical tolerances, absorption rates, and critical endpoints of studies. The NOAEL or LOAEL is then divided by the product of the uncertainty factors and any modifying factor, resulting in the RfD.

Reference doses determined by the EPA will be used to calculate fish consumption advisories when available, except for the health protection value used for PCBs.

Health Protection Value (HPV)

The health protection value (HPV) set by the Great Lakes Sport Fish Advisory Task Force is used for polychlorinated biphenyl (PCB) meal consumption limits. The task force used a weight of evidence procedure and evaluated many values and studies involving PCBs. The HPV was created by considering data for both carcinogenic and noncarcinogenic effects. The HPV for PCBs is a consensus of the best professional judgment based on all available PCB studies (GLSFATF 1993). This process is significantly different from the process used to develop an RfD.

Cancer Slope Factor (CSF)

The Cancer Slope Factors (CSFs) for chemicals in food are all oral slope factors. The CSFs are extrapolated by the EPA from high doses used in animal experiments or from studies of people exposed at work to the lower doses than the public is more likely to encounter. Dosing is estimated by using the ratio of animal to human surface area. The surface area is converted to a dose in milligrams per kilogram per day assuming surface area equals 2/3 power of body weight. The EPA uses an average body weight of 70 kilograms when calculating CSFs. The extrapolation process and the various assumptions

used add significant uncertainty to the number. These uncertainties may add an order of magnitude to the actual risk.

Population Adjusted Dose (PAD)

The EPA recommends that a Population Adjusted Dose (PAD) be used for infants, children to the age of 6, and women of childbearing age for chlorpyrifos (USEPA 2000). Meal consumption limits were calculated for this sensitive subpopulation using a PAD for Chlorpyrifos only.

Minimal Risk Level (MRL)

The Agency for Toxic Substances and Disease Registry (ATSDR) sets Minimal Risk Levels (MRLs). An MRL is an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse health effects (noncarcinogenic) over a specified duration of exposure (ATSDR 2005). The duration of exposure can be a few days to more than a year. Chronic MRLs are used instead of RfDs or HPVs when reference concentrations are not available from other sources.

How does one's body weight relate to the size of a fish meal?

The meal consumption limit calculations use a body weight of 70 kilograms (about 154 pounds) for a person eating a 227 gram (8 ounce) fish meal. These are assumptions recommended by the EPA for an adult. The 70 kilogram weight for an adult was used by the EPA to derive cancer slope factors and is recommended for fish consumption advisories by the EPA (USEPA 1997). The 70 kilogram average body weight is used by 28 states, while three use a average weight of 60 kilograms (Reinert 1991).

The 227 gram adult meal size used in the *WV Guide* is used by 20 states, 170 grams is used by 12 states, and 114 grams is used by seven states in developing fish consumption advisories (Reinert 1991).

It should be noted, however, that people are assumed to eat fish in proportion to their body weight. The fish consumption advisories established using these meal consumption limits assume that the portion size of fish is proportional to a person's body weight. So, for instance, a child weighing 24-32 kilograms (51-70 pounds) is advised to eat an 85 gram (3 ounce) portion of fish at a meal. It is important to ensure that this assumption is explained to the fish consuming public, to protect children and smaller consumers.

A summary of the body weight and portion size relationship used when establishing fish advisories is in Table 2 of Appendix B.

What conversion factors were used in the calculations?

The meal consumption limit formulas use a conversion factor of 1,000 milligrams per gram. This factor is used to convert the grams per day portion of the formula to milligrams per day.

The maximum allowable chemical concentrations for meal consumption limits are reported in nanograms per kilogram, or parts per trillion. Calculations were made for milligrams per kilogram (or parts per million) and the multiplied by one million to convert the amount to parts per trillion.

What are the meal categories?

The meal consumption limits are divided into six meal categories. Five of these are from the Great Lakes Protocol. The "2 meal per month" category was added in 2005. Previous to this addition, the meal consumption limits used the 5 categories used in the Great Lakes Protocol to maintain uniformity between states bordering the Ohio River.

The West Virginia meal categories are:

Group 1: Up to 225 meals per year.

Group 2: Up to 1 meal per week or 52 meals per year.

Group 3: Up to 2 meals per month or 24 meals per year.

Group 4: Up to 1 meal per month or 12 meals per year.

Group 5: Up to 6 meals per year.

Group 6: Do not eat.

How much of the chemical is removed by trimming and cooking?

The preparation dose reduction factor estimates the amount of fat removed from edible fish tissue during trimming and cooking. Chemicals that accumulate in fat may be reduced by trimming fat and skin from the fish fillets as well as allowing the fat to melt and drain away during the cooking process. The assumption is made that the fat drained away during the cooking process will not be eaten.

The preparation dose reduction factor was used in the calculations assuming that a proportion of some of the chemicals tested in raw fish would not be eaten. A meal preparation factor of 0.5 was applied to fish tissue that was analyzed with the skin on. A meal preparation factor of 0.7 was applied to fish tissue that was analyzed with the skin off.

If the chemical does not accumulate in fat, then cooking and trimming cannot reduce the amount of chemical in the fish tissue. Then the preparation dose reduction factor used in the formula is "1."

There is wide variation in the literature about the amount of reduction in lipophilic chemicals during trimming and cooking. Taken as a whole, the literature indicates a contaminant reduction factor for lipophilic chemicals of 50% due to trimming and cooking (GLSFATF 1993; Zabik 1995). The source of these preparation dose reduction factors used in this guide is the Great Lakes Protocol. The Great Lakes Protocol reviewed only PCBs. However, other lipophilic chemicals, those that accumulate in fat, would partition into fat in a similar manner to PCBs, as indicated by their octanol-water partition (Log K_{ow}). Therefore, it is assumed that the lipophilic chemicals reviewed in this guide will have the same preparation dose reduction as that for PCBs.

What cancer risk factor is used?

The cancer risk factor of 1 in 10,000 is used for the meal consumption limit calculations. It predicts that no more than one person in 10,000 would develop cancer from eating chemical residues in fish tissue. This theoretical prediction is based on several assumptions. Cancer risks are calculated based on exposures to animals that are well above the exposure doses that people receive from eating fish. Estimates are made about the exposure doses that would cause cancer in humans, which are much lower than that studied in animals. These estimates assume that any level of exposure to a chemical that causes cancer has some risk.

Some contaminants cause cancer in laboratory animals and may increase the lifetime risk of cancer. However, eating contaminated fish may or may not increase an individual's risk of cancer. While cancer affects about 1 out of 4 people by age 70, it is impossible to estimate how much of this risk is due to exposure to chemicals from eating fish. The two leading causes of cancer in the United States are smoking and nutrition-related effects.

How much of the chemical in the fish tissue is absorbed into the body?

Contaminant absorption, uptake, and transport are highly variable. Little quantitative data is available concerning distribution, metabolism, and excretion of individual contaminants. Meal consumption limits assume 100% absorption of contaminants. In most cases this assumption provides an added margin of safety.

What formulas are used to calculate the maximum allowable amount of chemical in fish tissue for each meal category?

The maximum chemical concentration in fish tissue that can be consumed within a meal category is calculated using the following formulas. The formulas calculate the contaminants concentrations in raw fish tissue in unit of milligrams of chemical per kilogram of fish tissue (mg/kg, or ppm). Levels of dioxin, however, are reported in terms of nanograms of chemical per kilogram of fish tissue (ng/kg, or ppt).

The minimum chemical concentration in fish tissue for each meal category is determined by the cut-off point for the next meal category.

Calculation for non-carcinogenic health effects

Concentration of a contaminant in fish tissue (mg contaminant / kg fish tissue) =

$$\frac{\text{RfD}_O \text{ (mg/kg/day)} \times 365 \text{ (days/year)} \times \text{Body Weight (kg)}}{\text{Fish Meal Size (kg/meal)} \times \text{No. of Meals/year} \times \text{Preparation Dose Reduction Factor}}$$

Where:

- RfD_o, the chemical-specific oral reference dose
- For fish meal size, see table 2, Appendix B.
- For body weight, see table 2, Appendix B.
- No. of meals /year, is determined by fish meal category, as indicated in the examples below.
- Preparation dose reduction factor
  - For lipophilic chemicals (chemicals that accumulated in fat and skin, which is mostly removed during the fish meal preparation)
    - 0.5 is for fish tissue samples with skin-on
    - 0.7 is for fish tissue samples with skin-off
  - For non-lipophilic chemicals (chemicals that are not accumulated in fat)
    - no adjustment for meal preparation needed

Please refer to Appendix C for detailed examples of how to calculate and determine the maximum acceptable concentration range for each contaminant.

Calculation for carcinogenic health effects

In contrast to the RfD_o, which is an exposure limit of contaminants for non-carcinogenic health, the cancer slope factor (CSF) defines an actual cancer risk that is associated with a unit daily exposure dose (usually mg/kg/day) over a lifetime. Thus, CSF can be used to derive the exposure dose at a defined level of acceptable risk. The WV Interagency Agreement has set the acceptable cancer risk level at 1/10,000 (0.0001). At the risk level of 1/10,000 (0.0001), the exposure dose for a carcinogenic contaminant is:

$$\text{Exposure doses for a carcinogenic health effects} = \frac{\text{Risk Level}}{\text{CSF}}$$

$$= \frac{0.0001}{\text{CSF (mg/kg/day)}^{-1}}$$

The concentration of carcinogenic contaminants in fish tissue sample can be calculated using following formula:

Concentration of a contaminant in fish tissue (mg contaminant / kg fish tissues) =

$$\frac{\textbf{0.0001 x 365(days/year) x body weight (kg)}}{\textbf{CSF (mg/kg/day)}^{-1}\ \textbf{x Fish meal size (kg/meal) x No. of meals/year x Preparation dose reduction factor}}$$

Where:

- CSF, chemical specific cancer slope factor
- 1/10,000 (0.0001) is the acceptable cancer risk level decided by WVDHHR
- For fish meal size, see table 2, Appendix B.
- For body weight, see table 2, Appendix B.

- No. of meals /year, is determined by fish meal category, as indicated in the examples below.
- Preparation dose reduction factor
  - For lipophilic chemicals (chemicals that accumulated in fat and skin, which is mostly removed during the fish meal preparation)
    - 0.5 is for fish tissue samples with skin-on,
    - 0.7 is for fish tissue samples with skin-off.
  - For non-lipophilic chemicals (chemicals that are not accumulated in fat)
    - no adjustment for meal preparation needed

Please refer to Appendix C for detailed examples of how to calculate and determine the maximum acceptable concentration range for each contaminant.

How are the health effects of multiple contaminants taken into account?

Not much information is available on interactions of chemicals within fish tissue. Chemical contaminants of a similar nature, such as organochlorines, are considered to have additive effects unless the toxicological literature states differently. These effects can be calculated by summing the standard used (RfDs, etc) times the concentrations of chemical in the fish tissue for all the chemicals involved and multiplying the sum by the body weight. This gives the maximum allowable fish consumption rate per day (in kilograms per day).

Presently there are no methods to combine effects of contaminant mixtures of chemicals with different modes of action. These chemicals are calculated and presented separately.

How does this method for establishing meal consumption limits differ from that used by the EPA?

The method for setting meal consumption limits in the *WV Guide* is similar to that used by the EPA in the "Guidance for Assessing Chemical Contamination Data for use in Fish Advisories"(USEPA 2000). This is also consistent with The *Clean Water Action Plan: Restoring and Protecting America's Waters* released by President Clinton in February 1998.

There are several differences between the method used in the *WV Guide* and that used by the EPA to calculate the meal consumption limits. The EPA;

- uses different meal categories,
- does not use a preparation dose reduction factor, and
- uses a cancer risk factor of 10E5 (or 1 cancer in 100,000 people) while the *WV Guide* uses a cancer risk factor of 10E4 (or 1 cancer in 10,000 people).

How are fish contaminant data and meal consumption limits used to establish advisories?

Fish are categorized into groups containing closely related species and/or having similar food habits. Categories are further separated by length if the contamination levels suggest that larger fish are more highly contaminated than smaller fish. The species groupings are as follows, and may be subcategorized by size.

- channel catfish
- flathead catfish
- carp
- sauger
- walleye and saugeye
- white bass and hybrid striped bass
- largemouth, smallmouth, and spotted bass
- suckers
- sunfish
- rainbow trout
- all other species

Composited fish samples consist of fillets from three to six individual fish. The concentration of chemicals in each composite determines which meal category is selected. The number of composites and the resulting percentage of total composites that fall within each meal category are tabulated. A cumulative percentage of composite samples for each meal category is tabulated for each fish group for the state or for a specific waterbody. The Advisory committee decided that a meal category containing at least 80% of the composites with an adequate sample size (6 or more composites) meets the criteria for use. If fewer than six composite samples are available, the meal category containing a cumulative percentage of 100 is considered for an advisory. These groupings serve as the basis for the general state advisory.

Examples of this selection process follow in Figures 1 and 2.

Specific advisories, more restrictive than the general advisory, are established for species from individual water bodies if clearly warranted by contamination concentrations and other factors, such as goals for consistency with other state's fish advisories.

This approach allows fish advisories to be set for fish from most state waters at one level while providing protection from uniquely contaminated waters or species.

Figure 1: Profile of 17 composite samples whose cumulative percentage of more than 80 was in the "Do not eat" category*

	Meal Categories						
	Unlimited	One meal/ week	Two meals/ week	One meal/ month	Six meals/ year	Do not eat	Totals
# composites in each category	0	1	1	2	6	7	17
% of the composites in each category	0	6	6	12	35	41	100%
Cumulative %	0	6	12	24	59	**100**	

**Data from Ohio River channel catfish >17 inches long*

Figure 2: Profile of 18 composite samples whose cumulative percentage of more than 80 was in the "One meal/month" category*

	Meal Categories						
	Unlimited	One meal/ week	Two meals/ week	One meal/ month	Six meals/ year	Do not eat	Totals
# composites in each category	1	1	8	7	1	0	18
% of the composites in each category	6	6	44	38	6	0	100%
Cumulative %	6	12	56	**94**	100	0	

**Data from Ohio River buffalo and drum*

Chemical Summaries and Meal Consumption Limit Tables

Chemical summaries and meal consumption limit tables for 25 chemicals follow. A summary of the meal consumption limit tables can be found in Tables 3 and 4 of Appendix B.

The meal consumption limit tables for noncarcinogenic effects list the maximum tissue concentration for a chemical assuming chronic, long term, exposures to a chemical. The meal consumption limit tables for carcinogenic effects list the maximum tissue concentration for a chemical at a 1 in 10,000 risk level.

The chemical summaries mention adverse health effects over a wide spectrum of exposures. The adverse health effects that the meal consumption limits are established to prevent, are called critical health effects. Critical health effects are significant health effects that occur at the lowest exposure level over a range of observed exposures.

The critical effects are listed on the meal consumption limit table pages. Other adverse health effects observed at higher doses or under short-term exposures (acute) are mentioned in the summary pages.

Arsenic

CAS Number 7440 – 38 - 2

What is it? Arsenic is a relatively common element that occurs naturally in air, water, soil, tissues, and in the Earth's crust. It is the 20th most abundant element in the Earth's crust, 14th in seawater, and 12th in the human body.

Where does it come from? Inorganic arsenic is released into the air by volcanoes, the weathering of arsenic-containing minerals and ores, and by commercial or industrial processes, such as metal smelting, and from power generation using fossil fuels. Large quantities are released each year as a result of agricultural and industrial activities. It is present in water contaminated by mine tailings and smelter wastes, and affected by naturally occurring minerals.

How is it used? The major use for inorganic arsenic is in wood preservation. Most arsenic produced domestically is used in the manufacture of agricultural products such as insecticides, herbicides, fungicides, algaecides, wood preservatives, and growth stimulants for plants and animals.

How might a person be exposed to arsenic in fish? For most people, food is the largest source of inorganic arsenic exposure, with lower amounts coming from drinking water and air. Arsenic is accumulated by fish and other organisms, but is not biomagnified in the food chain.

It is important to understand that although fish can accumulate arsenic in their tissues, most of the arsenic is stored in an organic form of arsenic which is relatively nontoxic. The usual organic arsenic compound, arsenobetaine, is excreted quickly from humans and does not appear to be harmful. Note that the meal consumption limits are based on the amount of inorganic, not organic, arsenic.

What are the health effects? Ingesting inorganic arsenic increases the risk of skin cancer and tumors of the bladder, kidney, liver, and lung. EPA has classified inorganic arsenic as a human carcinogen. Although it is carcinogenic in humans, evidence for arsenic-induced carcinogenicity in other mammals is scarce.

Arsenic can produce fetal death and malformations in many species of mammals.

Paradoxically, evidence is accumulating that arsenic is nutritionally essential or beneficial. Arsenic deficiency effects, such as poor growth, reduced survival, and inhibited reproduction, have been recorded in mammals fed diets containing <0.05 milligrams arsenic per kilogram, but not in those fed diets with 0.35 milligrams arsenic per kilogram. At comparatively low doses, arsenic stimulates growth and development in various species of plants and animals.

EPA has classified inorganic arsenic as a human carcinogen based on sufficient evidence from epidemiologic studies (Class A).

Last revised on: October 15, 2005

ARSENIC
NONCARCINOGENIC EFFECTS

Fish tissue should be analyzed for total inorganic arsenic.

Reference Dose (RfD)	0.0003 mg/kg/day
The RfD is based on the critical effect of skin changes (darkening and development of growths called keratoses) and possible vascular complications from a study by Tseng in 1977. An uncertainty factor of three was applied when developing the RfD.	

When the concentration of arsenic reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.15	1	Up to 225 meals per year (no restrictions)
0.15	0.65	2	Up to 1 meal per week
>0.65	1.41	3	Up to 2 meals per month
>1.41	2.82	4	Up to 1 meal per month
>2.82	5.63	5	Up to 6 meals per year
>5.63		6	DO NOT EAT

Last revised on: October 15, 2005

ARSENIC
CARCINOGENIC EFFECTS

Fish tissue should be analyzed for total inorganic arsenic.

Cancer Slope Factor (CSF)	1.5 $(mg/kg/day)^{-1}$
The cancer slope factor was based on a study by Tseng et al, 1968 and Tseng, 1977 that showed increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and increased incidence of skin cancer in humans exposed to inorganic arsenic in drinking water.	

When the concentration of arsenic reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.03	1	Up to 225 meals per year (no restrictions)
0.03	0.14	2	Up to 1 meal per week
>0.14	0.31	3	Up to 2 meals per month
>0.31	0.63	4	Up to 1 meal per month
>0.63	1.25	5	Up to 6 meals per year
>1.25		6	DO NOT EAT

Last revised on: October 15, 2005

Cadmium

CAS Number 7440 - 43 - 9

What is it? Cadmium is a relatively rare metal that is commonly found in zinc, lead, and copper deposits. Cadmium has been found to bioaccumulate in freshwater fish and shellfish tissues. Past studies have shown higher mean concentrations of cadmium in bottom feeders (e.g., carp, suckers, and catfish) compared to predator fish (e.g., trout, walleye, and largemouth bass).

What are the sources and uses of this chemical? Cadmium is released into the environment in a variety of ways. About half of the cadmium released into the environment comes from natural weathering of rocks. Mining and burning of fossil fuels and household waste also release cadmium into the environment.

What are the health effects? Cadmium that enters the body goes to the kidney and liver and can remain there for many years. A small portion of the cadmium that enters the body leaves slowly in urine and feces. It is known to cause defects in embryos and fetuses and is suspected to cause mutations. It has been implicated as the cause of severe deleterious effects on fish and wildlife. Freshwater biota is particularly sensitive to cadmium.

There is no evidence that cadmium is biologically essential or beneficial.

Effects of cadmium poisoning in birds include bone damage, suppressed egg production, eggshell thinning, and kidney damage.

Potential health effects in humans include kidney dysfunction, decreased mental ability, weakness, headache, abdominal cramps, diarrhea, and anemia. Cadmium also affects blood-forming mechanisms and the peripheral nervous systems. Other known health effects from exposure include: anxiety, irritability, dizziness, disturbed equilibrium, tremor, and convulsions; liver toxicity and permanent kidney damage.

EPA has classified cadmium as a carcinogen only if it is inhaled. There is no evidence that cadmium ingested from food, including fish, can cause cancer.

Last revised on: October 15, 2005

CADMIUM
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)	0.001 mg/kg/day
The RfD is based on the critical effect to the kidney (excess protein in the urine) from a study by the EPA in 1985. An uncertainty factor of 10 was applied when developing the RfD.	

When the concentration of cadmium reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.5	1	Up to 225 meals per year (no restrictions)
0.5	2.17	2	Up to 1 meal per week
>2.17	4.69	3	Up to 2 meals per month
>4.69	9.39	4	Up to 1 meal per month
>9.39	18.77	5	Up to 6 meals per year
>18.77		6	DO NOT EAT

Last revised on: October 15, 2005

Chlordane

CAS Number 57 – 74 - 9

What is it? Chlordane represents a group of approximately 140 chlorinated hydrocarbon compounds. Active ingredients of technical grade chlordane include chlordane, *cis*-chlordane, *trans*-chlordane, *cis*-nonachlor, *trans*-nonachlor, and heptachlor.

What are the sources and uses of this chemical? Chlordane was used in the United States between 1948 and 1988. Chlordane was once used as an insecticide on crops such as vegetables, small grains, potatoes, sugarcane, sugar beets, corn, grapes, strawberries, nuts, citrus, and cotton. Chlordane was used on home lawn and garden pests and used extensively to control termites.

Past chlordane use, coupled with atmospheric transport as the major route of dissemination, produced global contamination of fish and wildlife resources and human populations. The chemical and its metabolites were frequently detected in all species examined, but usually at low concentrations.

Chlordane is moderately volatile, binds moderately to soil. It has a high potential for bioaccumulation because it accumulates in fats and fatty tissue. Chlordane can biomagnify in aquatic ecosystems because once in the body it resists metabolism and excretion.

What are the health effects? Chlordane is readily absorbed by warm-blooded animals through skin, diet, and inhalation. Once inside the body chlordane is widely distributed in the tissues, however concentrations are generally highest in fat and liver. In humans, most of the chlordane that enters the body is excreted within a few days. The remainder is stored in body fat.

Acute (short-term, high-dose) poisoning in chlordane affects the nervous system. Results can be hyperexcitability, convulsions, depression, muscle tremors, coma, and possible death.

Chronic (long-term, low-dose) exposure can result in liver toxicity and blood disorders such as anemia.

Children may be at greater risk for harm from chlordane exposure than adults.

Animal studies have shown that prenatal exposure causes damage to the developing nervous and immune systems. Chronic chlordane exposure causes liver disease in rats, mice, and dogs. Tests with chlordane in cultured mammalian cells have shown chlordane to be mutagenic.

EPA has classified chlordane as a probable human carcinogen based on sufficient evidence in animals and inadequate or no data in humans (Class B2). Chlordane administered orally has been shown to cause liver carcinomas in male and female mice and rats.

Last revised on: October 15, 2005

CHLORDANE
NONCARCINOGENIC EFFECTS

It is recommended that the total chlordane (sum of *cis* and *trans* - chlordane, *cis* and *trans* - nonachlor and oxychlordane) be used to determine the chlordane amount. The RfD is derived from studies using technical grade chlordane.

Reference Dose (RfD)	0.0005 mg/kg/day
The RfD was derived from studies using technical grade chlordane. The RfD is based on the critical effect of tissue death of mouse liver from a study by Khasawinah and Grutsch in 1989. An uncertainty factor of 300 was applied when developing the RfD.	

For fish tissue that was tested as SKIN-OFF filets
(a meal preparation reduction factor of 0.7 was applied)

When the concentration of chlordane reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.36	1	Up to 225 meals per year (no restrictions)
0.36	1.55	2	Up to 1 meal per week
>1.55	3.35	3	Up to 2 meals per month
>3.35	6.70	4	Up to 1 meal per month
>6.70	13.41	5	Up to 6 meals per year
>13.41		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets
(a meal preparation reduction factor of 0.5 was applied)

When the concentration of chlordane reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.50	1	Up to 225 meals per year (no restrictions)
0.50	2.17	2	Up to 1 meal per week
>2.17	4.69	3	Up to 2 meals per month
>4.69	9.39	4	Up to 1 meal per month
>9.39	18.77	5	Up to 6 meals per year
>18.77		6	DO NOT EAT

Last revised on: October 15, 2005

CHLORDANE
CARCINOGENIC EFFECTS

It is recommended that the total chlordane (sum of *cis* and *trans* - chlordane, *cis* and *trans* - nonachlor and oxychlordane) be used to determine the chlordane amount.

Cancer Slope Factor (CSF)	0.35 $(mg/kg/day)^{-1}$
The CSF was based on a study of benign or malignant liver tumors in several strains of mice by Khasawinah and Grutsch, 1989.	

For fish tissue that was tested as SKIN-OFF filets
(a meal preparation reduction factor of 0.7 was applied)

When the concentration of chlordane reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.20	1	Up to 225 meals per year (no restrictions)
0.20	0.88	2	Up to 1 meal per week
>0.88	1.92	3	Up to 2 meals per month
>1.92	3.83	4	Up to 1 meal per month
>3.83	7.66	5	Up to 6 meals per year
>7.66		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets
(a meal preparation reduction factor of 0.5 was applied)

When the concentration of chlordane reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.29	1	Up to 225 meals per year (no restrictions)
0.29	1.24	2	Up to 1 meal per week
>1.24	2.68	3	Up to 2 meals per month
>2.68	5.36	4	Up to 1 meal per month
>5.36	10.73	5	Up to 6 meals per year
>10.73		6	DO NOT EAT

Last revised on: October 15, 2005

Chlorpyrifos

CAS Number 2921 – 88 - 2

What is it? Chlorpyrifos is an organophosphate pesticide. It was first introduced in 1965 as a replacement to the more persistent organochlorine pesticides (e.g., DDT). Chlorpyrifos is a chemical that sticks tightly to soil particles. It is found in water in only small amounts. Chlorpyrifos will evaporate in water. In organisms, degradation time is comparatively short--usually less than nine hours in fishes, and probably the same in birds and invertebrates.

What are the sources and uses of this chemical? Chlorpyrifos is used extensively in a variety of formulations to control a broad spectrum of agricultural and other insects. Chlorpyrifos is used by the general public in the home and on lawns and gardens. A significant amount of this chemical has been used to control termites.

The agricultural uses of chlorpyrifos control root-infesting and boring insects on a variety of fruits (e.g., citrus crops, apples, bananas, peaches, grapes, and nectarines), nuts (e.g., almonds, and walnuts), vegetables (e.g., beans, broccoli, brussel sprouts, cauliflower, soybeans, cabbage, and peas) and field crops (e.g., alfalfa and corn).

What are the health effects? Chlorpyrifos is highly lipophilic and accumulates in fat.

Exposure to milligram amounts of chlorpyrifos orally can cause dizziness, fatigue, runny nose or eyes, salivation, nausea, intestinal discomfort, sweating, and changes in heart rate. Exposure to much higher amounts may cause paralysis, seizures, loss of consciousness, and death. Sometimes short term exposure to chlorpyrifos can cause muscle weakness weeks after the original symptoms have disappeared.

Infants and children may be at special risk for toxicity. Animal studies suggest that this chemical is absorbed through the skin more easily in the young. In addition children are more sensitive to the central nervous system effects from this chemical. Based on animal studies, there is concern that developing fetuses may be particularly sensitive to chlorpyrifos.

Accidental or careless applications of chlorpyrifos have resulted in the death of many species of non-target organisms such as fish, aquatic invertebrates, birds, and humans.

It is not known to increase the incidence of cancer in feeding studies of rats and mice.

Last revised on: October 15, 2005

CHLORPYRIFOS
NONCARCINOGENIC EFFECTS

These limits are for people <u>not</u> in the population subgroup of infants, children to the age of 6, and women of childbearing age.

Reference Dose (RfD)	0.003 mg/kg/day
The RfD is based on the critical effect of decreased plasma ChE activity in the blood after nine days from a study by Dow Chemical in 1972. An uncertainty factor of 10 was applied when developing the RfD.	

<u>For fish tissue that was tested as SKIN-OFF filets</u>
(a meal preparation reduction factor of 0.7 was applied)

When the concentration of chlorpyrifos reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<2.15	1	Up to 225 meals per year (no restrictions)
2.15	9.28	2	Up to 1 meal per week
>9.28	20.11	3	Up to 2 meals per month
>20.11	40.23	4	Up to 1 meal per month
>40.23	80.45	5	Up to 6 meals per year
>80.45		6	DO NOT EAT

<u>For fish tissue that was tested as SKIN-ON filets</u>
(a meal preparation reduction factor of 0.5 was applied)

When the concentration of chlorpyrifos reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<3.00	1	Up to 225 meals per year (no restrictions)
3.00	13.00	2	Up to 1 meal per week
>13.00	28.16	3	Up to 2 meals per month
>28.16	56.32	4	Up to 1 meal per month
>56.32	112.63	5	Up to 6 meals per year
>112.63		6	DO NOT EAT

Last revised on: October 15, 2005

CHLORPYRIFOS
NONCARCINOGENIC EFFECTS

These limits are for people in the population subgroup of infants, children to the age of 6, and women of childbearing age because of neurological effects.

Population Adjusted Dose (PAD)	0.00003 mg/kg/day
The PAD is 100 times less than the RfD for this sensitive subpopulation. The PAD is from Table 3.1 of the EPA Guidance.	

For fish tissue that was tested as SKIN-OFF filets
(a meal preparation reduction factor of 0.7 was applied)

When the concentration of chlorpyrifos reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.02	1	Up to 225 meals per year (no restrictions)
0.02	0.09	2	Up to 1 meal per week
>0.09	0.2	3	Up to 2 meals per month
>0.2	0.4	4	Up to 1 meal per month
>0.4	0.8	5	Up to 6 meals per year
>0.8		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets
(a meal preparation reduction factor of 0.5 was applied)

When the concentration of chlorpyrifos reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.03	1	Up to 225 meals per year (no restrictions)
0.03	0.13	2	Up to 1 meal per week
>0.13	0.28	3	Up to 2 meals per month
>0.28	0.56	4	Up to 1 meal per month
>0.56	1.13	5	Up to 6 meals per year
>1.13		6	DO NOT EAT

Last revised on: August 3, 2006

DDT/DDD/DDE

DDT CAS Number 50 – 29 - 3

DDD CAS Number 72 – 54 - 8

DDE CAS Number 72 – 55 - 9

What is it? DDT (dichlorodiphenyltrichloroethane) is an organochlorine insecticide. The terms DDT or DDTs are often used to refer to a family of isomers (p,p'-DDT and o,p'-DDT) and their breakdown products (p,p'-DDE; o,p'-DDE; p,p'-DDD; and o,p'-DDD). DDT data are often expressed as the sum of these six components.

DDE and DDD are products of the metabolic breakdown of DDT within an organisms' body.

What are the sources and uses of this chemical? DDT was first synthesized in 1873 by a German graduate student. However, it was not recognized as an insecticide until 1938. It was extremely effective against flies and mosquitoes. In the United States, DDT was used extensively on agricultural crops, particularly cotton, from 1945 to 1972. DDT was also used to protect soldiers from malaria and typhus during World War II.

The use of DDT was banned by EPA on January 1, 1973, due to its long residual life and tendency to accumulate in food chains. The heavy use of this highly persistent chemical, however, has resulted in widespread environmental contamination and the accumulation of DDT in humans and wildlife. DDT continues to be a major chemical of concern in agricultural, suburban/urban, and industrial areas.

The U.S. Department of Agriculture and U.S. military continue to store and use DDT for public health emergencies. Public health officials in developing countries still rely on DDT to control malaria-causing mosquitoes. The United States still manufactures DDT for export.

What are the health effects? Based on the information obtained from a recent developmental study that found neurotoxicity and structural brain alterations at relatively low exposures (approximately 50-fold less than in adults), children may be at greater risk from DDT exposure than adults. Evidence of DDT's estrogen-like action was first noted in 1950. One major problem related to contaminants identified in fish-eating birds is the thinning of eggshells.

Acute symptoms of DDT poisoning include apprehension, irritability, dizziness, disturbed equilibrium, tremors, and convulsions.

EPA has classified DDT, DDE, and DDD as probable human carcinogens based on sufficient evidence in animals and inadequate or no data in humans (Class B2). p,p'-DDE has been shown to induce liver tumors (hepatocellular carcinomas) in mice. It is also weakly mutagenic in mouse lymphocytes.

Last revised on: October 15, 2005

DDT/DDD/DDE
NONCARCINOGENIC EFFECTS

It is recommended that the total concentration of the p,p' and o,p' isomers of DDT and its metabolites, DDE and DDD be determined.

Reference Dose (RfD)	0.0005 mg/kg/day (for DDT)
The RfD is based on a critical effect of lesions of the liver from a study by Laug et al. in 1950. An uncertainty factor of 100 was applied when developing the RfD.	

For fish tissue that was tested as SKIN-OFF filets
(a meal preparation reduction factor of 0.7 was applied)

When the concentration of DDT/DDD/DDE reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.36	1	Up to 225 meals per year (no restrictions)
0.36	1.55	2	Up to 1 meal per week
>1.55	3.35	3	Up to 2 meals per month
>3.35	6.70	4	Up to 1 meal per month
>6.70	13.41	5	Up to 6 meals per year
>13.41		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets
(a meal preparation reduction factor of 0.5 was applied)

When the concentration of DDT/DDD/DDE reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.50	1	Up to 225 meals per year (no restrictions)
0.50	2.17	2	Up to 1 meal per week
>2.17	4.69	3	Up to 2 meals per month
>4.69	9.39	4	Up to 1 meal per month
>9.39	18.77	5	Up to 6 meals per year
>18.77		6	DO NOT EAT

Last revised on: August 3, 2006

DDT/DDD/DDE
CARCINOGENIC EFFECTS

It is recommended that the total concentration of the p,p' and o,p' isomers of DDT and its metabolites, DDE and DDD be determined.

Cancer Slope Factor (CSF)	0.34 $(mg/kg/day)^{-1}$ (for DDT and DDE)
The CSF was calculated based on studies of hepatocellular carcinomas, hepatomas, and liver tumors in mice in multiple studies.	

For fish tissue that was tested as SKIN-OFF filets
(a meal preparation reduction factor of 0.7 was applied)

When the concentration of DDT/DDD/DDE reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.21	1	Up to 225 meals per year (no restrictions)
0.21	0.91	2	Up to 1 meal per week
>0.91	1.97	3	Up to 2 meals per month
>1.97	3.94	4	Up to 1 meal per month
>3.94	7.89	5	Up to 6 meals per year
>7.89		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets
(a meal preparation reduction factor of 0.5 was applied)

When the concentration of DDT/DDD/DDE reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.29	1	Up to 225 meals per year (no restrictions)
0.29	1.27	2	Up to 1 meal per week
>1.27	2.76	3	Up to 2 meals per month
>2.76	5.52	4	Up to 1 meal per month
>5.52	11.04	5	Up to 6 meals per year
>11.04		6	DO NOT EAT

Last revised on: August 3, 2006

Diazinon

CAS Number 333 – 41 – 5

What is it? Diazinon (phosphorothioic acid o,o-diethyl-o-(6-methyl-2-(1-methylethyl)-4-pyrimidinyl) ester) is an organophosphate pesticide . It falls into the subcategory of a phosphorothiate pesticide. It has been used to control nematodes (microscopic, worm-like organisms that feed on plant roots) since 1952.

What are the sources and uses of this chemical? Diazinon usually degrades rapidly in the environment, with a half-life usually less than 14 days. However, under some conditions (low temperature, low moisture, high alkalinity, and lack of suitable microbial degraders) diazinon may remain biologically active in soils for six months or longer.

It is used extensively to control flies, cockroaches, lice, and soil insects (e.g., grubs, nematodes), pests of fruits, vegetables, tobacco, forage, field crops, range, pasture, grasslands, and ornamental plants. It is also used as a seed treatment. It is used as an insecticide in homes and on lawns, gardens and farms.

What are the health effects? There is no evidence that long-term exposure to low levels of diazinon causes any harmful health effects in humans.

Most cases of adverse health effects have occurred when people who use the chemical do not properly protect themselves and when they have inhaled, swallowed, or contaminated their skin with a large amount of diazinon. In some cases, people have been exposed by living in a home that has been treated for pests with this chemical. Mild symptoms of exposure are headache, dizziness, weakness, feelings of anxiety, constriction of the pupils of the eye and not being able to see clearly. However, if you experience these symptoms from an exposure to diazinon medical treatment should be obtained.

Diazinon is moderately toxic to mammals, but highly toxic to birds, fish, and other aquatic invertebrates. There is limited experimental evidence that diazinon accumulates in trout. At recommended treatment levels, diazinon-related kills have been noted for songbirds, honeybees, and especially waterfowl that consume diazinon-treated grass. These incidents may be underreported.

Last revised on: October 15, 2005

DIAZINON
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)*	0.0007 mg/kg/day
The RfD is based on a critical effect of decreased cholinesterase activity (an enzyme) in rat blood from a study by the EPA in 1984. An uncertainty factor of 100 was applied when developing the RfD. * The RfD is from Table 3.1 of the EPA Guidance. The source listed in this table is the Office of Pesticide Program and Office of Water of the EPA.	

When the concentration of diazinon reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.35	1	Up to 225 meals per year (no restrictions)
0.35	1.52	2	Up to 1 meal per week
>1.52	3.29	3	Up to 2 meals per month
>3.29	6.57	4	Up to 1 meal per month
>6.57	13.14	5	Up to 6 meals per year
>13.14		6	DO NOT EAT

Last revised on: October 15, 2005

Dicofol

CAS Number 115 – 32 - 2

What is it? Dicofol is an organochlorine pesticide used to control mites that was first registered for use in 1957. Technical-grade dicofol is manufactured from DDT; however, modern manufacturing processes can produce technical grade dicofol which contains less than 0.1% DDT.

What are the sources and uses of this chemical? It is primarily used on cotton, apples, and citrus crops, mostly in California and Florida. Dicofol is less commonly used on turf, ornamental plants, pears, apricots, cherries, and vegetables.

Dicofol is moderately persistent in soil, with a half-life of 60 days. It is susceptible to chemical breakdown in moist soil and is subject to degradation by UV light. It is practically insoluble in water and adsorbs very strongly to soil particles. It is therefore nearly immobile in soils and unlikely to infiltrate groundwater.

What are the health effects? Dicofol is preferentially stored in fatty tissue.

Dicofol has been shown to be toxic to the nervous system in rats and to cause changes in muscle function as well as weight loss under acute high dose conditions. No developmental toxicity has been observed in rats exposed to dicofol. There is some indication that dicofol may be mutagenic to human cells of the lymph system.

In July 1993, EPA withdrew its cancer assessment of dicofol pending further review. Dicofol, therefore, has no current classification for its potential to cause cancer.

Last revised on: October 15, 2005

DICOFOL
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)*	0.0004 mg/kg/day
The RfD is from Table 3.1 of the EPA Guidance. This table lists the source as the Registration Eligibility Decision of the EPA. The RfD is based on a study of dogs that found changes in hormones, specifically the inhibition of the adrenocortical trophic hormone (ACTH).	

When the concentration of dicofol reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.20	1	Up to 225 meals per year (no restrictions)
0.20	0.87	2	Up to 1 meal per week
>0.87	1.88	3	Up to 2 meals per month
>1.88	3.75	4	Up to 1 meal per month
>3.75	7.51	5	Up to 6 meals per year
>7.51		6	DO NOT EAT

Last revised on: October 15, 2005

Dieldrin

CAS Number 60 – 57 - 1

What is it? Dieldrin belongs to a class of organochlorine insecticides called chlorinated cyclodienes.

What are the sources and uses of this chemical? Dieldrin is a product of aldrin metabolism, a structurally similar organochlorine pesticide which is also no longer in use. Sunlight and bacteria change aldrin to dieldrin, so dieldrin is more widely found in the environment. Both dieldrin and aldrin bind tightly to soil and slowly evaporate to the air.

Dieldrin is a major chemical of concern in agricultural, suburban/urban, and industrial areas. From 1950-1974, aldrin and dieldrin were popular pesticides for crops like corn, citrus, and cotton. Dieldrin was also used as a broad spectrum pesticide on soil-dwelling insects and termites. Because of concerns about damage to the environment and the potential harm to human health, EPA banned all uses of aldrin and dieldrin in 1974 except to control termites. In 1987, EPA banned all uses of dieldrin.

What are the health effects? Dieldrin has been shown to be toxic to the neurological system in humans after both chronic and acute exposures. One group of people exposed to wheat contaminated with lindane and aldrin developed muscle jerks, memory loss, irritability, and abnormal EEGs. It was assumed that these effects were due to the aldrin, which was metabolized to dieldrin in the body.

Dieldrin is stored in body fat and leaves the body very slowly.

EPA has classified dieldrin as a probable human carcinogen based on sufficient evidence in animals and inadequate or no data in humans (Class B2).

Last revised on: October 15, 2005

DIELDRIN
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)	0.00005 mg/kg/day
The RfD is based on a critical effect of lesions of rat livers from a study by Walker et al. in 1969. An uncertainty factor of 100 was applied when developing the RfD.	

For fish tissue that was tested as SKIN-OFF filets
(a meal preparation reduction factor of 0.7 was applied)

When the concentration of dieldrin reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.04	1	Up to 225 meals per year (no restrictions)
0.04	0.15	2	Up to 1 meal per week
>0.15	0.34	3	Up to 2 meals per month
>0.34	0.67	4	Up to 1 meal per month
>0.67	1.34	5	Up to 6 meals per year
>1.34		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets
(a meal preparation reduction factor of 0.5 was applied)

When the concentration of dieldrin reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.05	1	Up to 225 meals per year (no restrictions)
0.05	0.22	2	Up to 1 meal per week
>0.22	0.47	3	Up to 2 meals per month
>0.47	0.94	4	Up to 1 meal per month
>0.94	1.88	5	Up to 6 meals per year
>1.88		6	DO NOT EAT

Last revised on: October 15, 2005

DIELDRIN
CARCINOGENIC EFFECTS

Cancer Slope Factor (CSF)	16.0 $(mg/kg/day)^{-1}$
The critical carcinogenic effect is liver carcinomas in mice.	

For fish tissue that was tested as SKIN-OFF filets
(a meal preparation reduction factor of 0.7 was applied)

When the concentration of dieldrin reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.0045	1	Up to 225 meals per year (no restrictions)
0.0045	0.019	2	Up to 1 meal per week
>0.019	0.04	3	Up to 2 meals per month
>0.04	0.084	4	Up to 1 meal per month
>0.084	0.17	5	Up to 6 meals per year
>0.17		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets
(a meal preparation reduction factor of 0.5 was applied)

When the concentration of dieldrin reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.0063	1	Up to 225 meals per year (no restrictions)
0.0063	0.027	2	Up to 1 meal per week
>0.027	0.06	3	Up to 2 meals per month
>0.06	0.12	4	Up to 1 meal per month
>0.12	0.23	5	Up to 6 meals per year
>0.23		6	DO NOT EAT

Last revised on: October 15, 2005

Dioxin

CAS number for 2,3,7,8-tetrachlorodibenzo-para-dioxin or TCDD is 1746-01-6

What is it? Dioxin is the popular name for a class of organochlorines known as polychlorinated dibenzo-p-dioxins (PCDDs) or dibenzofurans (PCDF). The entire "dioxin" family consists of 75 different dioxins and 135 different furans. The word "dioxin" will be used to refer to these compounds.

The toxicity of these compounds varies widely. In some cases the toxicity of the particular compounds is unknown.

The most toxic and most extensively studied PCDD isomer is 2,3,7,8-tetrachlorodibenzo-para-dioxin (2,3,7,8-TCDD). The toxicity of mixtures of dioxins and furans is usually expressed in terms of "2,3,7,8-TCDD toxic equivalents" (TCDD EQs or TEQs) which is the concentration of 2,3,7,8-TCDD that would be expected to produce the same type and degree of response as the chemicals involved.

The most toxic PCDF is 2,3,7,8-TCDF.

What are the sources and uses of this chemical? Dioxins are unintentionally produced during various processes. Some chemical processes produce dioxins, such as the manufacture of some pesticides, PCB mixtures, wood preservatives, and the chlorine bleaching process used in some pulp and paper mills. Dioxins are also formed from incomplete burning of materials. They are formed during forest fires, medical and municipal waste incineration, and the "backyard" burning of trash.

In general, wherever high levels of PCDDs have been detected, the source has been a hazardous waste dump, an industrial discharge, or an application of PCDD-contaminated herbicide. Although they are most often associated with industrial activities, some natural occurrences, such as forest fires, are believed to make a small contribution to the presence of dioxins and furans in the environment.

Dioxins have been detected in the environment in part because of their environmental stability and their tendency to accumulate in fatty tissues.

What are the health effects? There is a wide range of health effects from exposure to dioxins. In some animals, exposure to even small amounts may cause death. Other systems affected in some animals exposed to dioxins over a long period are the liver, digestive, nervous, skin, endocrine, immune, reproductive, and developmental systems. However, in humans adverse health effects have generally been observed in people exposed to a substantial amount of dioxins. Some studies in humans have shown that dioxins may cause effects on immune, respiratory, cardiovascular, and liver systems. The most common adverse health effect associated with exposure to high levels of dioxin in humans is chloracne, a skin condition that resembles acne.

EPA has classified 2,3,7,8- TCDD and 2,3,7,8-TCDF as probable human carcinogens based on sufficient evidence in animals and inadequate or no data in humans (Class B2). Oral exposure causes increased incidence of tumors in liver, tongue, hard palate, and lungs in rats, and in thyroid and adrenal glands in mice.

Last revised on: October 15, 2005

DIOXIN
NONCARCINOGENIC EFFECTS

Minimal Risk Level (MRL)	0.001 nanograms/kg/day
The MRL was based on a study of rhesus monkeys and based on changes in behavior (social interactions, vocalization, and environmental exploration) by Schantz et al. in 1992. An uncertainty factor of 90 was used to derive the MRL.	

For fish tissue that was tested as SKIN-OFF filets
(a meal preparation reduction factor of 0.7 was applied)

When the concentration of dioxin reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (nanograms/kg)	Maximum (nanograms/kg)	Group	Meal Restriction
	<0.72	1	Up to 225 meals per year (no restrictions)
0.72	3.09	2	Up to 1 meal per week
>3.09	6.70	3	Up to 2 meals per month
>6.70	13.41	4	Up to 1 meal per month
>13.41	26.82	5	Up to 6 meals per year
>26.82		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets
(a meal preparation reduction factor of 0.5 was applied)

When the concentration of dioxin reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (nanograms/kg)	Maximum (nanograms/kg)	Group	Meal Restriction
	<1.00	1	Up to 225 meals per year (no restrictions)
1.00	4.33	2	Up to 1 meal per week
>4.33	9.39	3	Up to 2 meals per month
>9.39	18.77	4	Up to 1 meal per month
>18.77	37.54	5	Up to 6 meals per year
>37.54		6	DO NOT EAT

nanogram = 0.000001 milligram
ng/kg = nanograms per kilogram = parts per trillion

Last revised on: October 15, 2005

DIOXIN
CARCINOGENIC EFFECTS

The CSF is for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). It is recommended that the 17 2,3,7,8-substituted tetra- through octa-chlorinated dibenzo-p-dioxins and dibenzofurans and the 12 dioxin-like PCBs be determined and a toxicity-weighted total concentration be calculated for each sample, using the method for estimating Toxicity Equivalency Concentrations (TEQs).

Cancer Slope Factor (CSF)	0.156 (nanograms/kg/day)$^{-1}$
The CSF was calculated based on a review of respiratory system tumors in rats by the EPA in 1989. The CSF is from Table 3.1 of the EPA Guidance. The table lists the source as the CSF for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin in the EPA's HEAST Table.	

For fish tissue that was tested as SKIN-OFF filets
(a meal preparation reduction factor of 0.7 was applied)

When the concentration of dioxin reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (nanograms/kg)	Maximum (nanograms/kg)	Group	Meal Restriction
	<0.46	1	Up to 225 meals per year (no restrictions)
0.46	1.98	2	Up to 1 meal per week
>1.98	4.30	3	Up to 2 meals per month
>4.30	8.60	4	Up to 1 meal per month
>8.60	17.19	5	Up to 6 meals per year
>17.19		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets
(a meal preparation reduction factor of 0.5 was applied)

When the concentration of dioxin reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (nanograms/kg)	Maximum (nanograms/kg)	Group	Meal Restriction
	<0.64	1	Up to 225 meals per year (no restrictions)
0.64	2.78	2	Up to 1 meal per week
>2.78	6.02	3	Up to 2 meals per month
>6.02	12.03	4	Up to 1 meal per month
>12.03	24.07	5	Up to 6 meals per year
>24.07		6	DO NOT EAT

nanogram = 0.000001 milligram
ng/kg = nanograms per kilogram = parts per trillion

Last revised on: October 15, 2005

Disulfoton

CAS Number 298 – 04 - 4

What is it? Disulfoton is a manufactured substance used on many field and vegetable crops to control a variety of harmful pests. It does not occur naturally. Pure disulfoton is a colorless oil with an unidentifiable odor and taste. It takes about seven days for half of disulfoton to break down in water.

What are the sources and uses of this chemical? Disulfoton is used to protect small grains, sorghum, corn, and other field crops; some vegetables, fruit, and nut crops; and ornamental and potted plants against certain insects. Although it is used mostly in agriculture, small quantities are used on home and garden plants, and for mosquito control in swamps. The use of disulfoton has decreased in recent years.

What are the health effects? Fish accumulate disulfoton in their bodies. In humans, disulfoton mainly causes harmful effects to the nervous system. Depending on the amount of disulfoton that enters the body, effects on the nervous system, such as narrowing of the pupils, vomiting, diarrhea, drooling, difficulty in breathing, tremors, convulsions, and even death may occur.

Disulfoton eaten in food over a long period of time may cause nearsightedness. Ingesting high levels of disulfoton can cause similar nervous system (neurologic) effects in animals. Some animals that ingested disulfoton during pregnancy had newborns with underdeveloped bones, damaged livers and kidneys, and underdeveloped testes. Reproductive or birth defect effects of disulfoton in people are not known.

Last revised on: October 15, 2005

DISULFOTON
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)	0.00004 mg/kg/day
The RfD is based on a critical effect of cholinesterase (an enzyme) inhibition and optic nerve degeneration in rats from a study by Mobay Chemical in 1985. An uncertainty factor of 1000 was applied when developing the RfD.	

When the concentration of disulfoton reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.02	1	Up to 225 meals per year (no restrictions)
0.02	0.09	2	Up to 1 meal per week
>0.09	0.19	3	Up to 2 meals per month
>0.19	0.38	4	Up to 1 meal per month
>0.38	0.75	5	Up to 6 meals per year
>0.75		6	DO NOT EAT

Last revised on: October 15, 2005

Endosulfan

CAS Number 115 – 29 - 7

What is it? Endosulfan is a pesticide. It is a cream- to brown-colored solid that may appear in the form of crystals or flakes. It smells like turpentine, but does not burn. It does not occur naturally in the environment.

There are two forms of endosulfan. They are endosulfan I and II. They have similar toxicities.

What are the sources and uses of this chemical? Endosulfan does not dissolve easily in surface water and is mostly found attached to soil particles floating in water or adsorbed to sediment. Endosulfan can build up in the bodies of animals that live in endosulfan-contaminated water. People can be exposed by eating endosulfan-contaminated food, but levels in foods are very low.

Endosulfan is used to control insects on food and non-food crops. It is also used on seed, soil, and wood to kill insects.

What are the health effects? Endosulfan affects the central nervous system and prevents it from working properly. Hyperactivity, nausea, dizziness, headache, or convulsions have been observed in adults exposed to high doses. Severe poisoning may result in death.

Studies of the effects of endosulfan on animals suggest that long-term exposure can also damage the kidneys, testes, and liver and may possibly affect the body's ability to fight infection. However, it is not known if these effects also occur in humans.

The sensitivity of children to endosulfan has not been established. However, some birth defects have been seen in the offspring of animals ingesting endosulfan during pregnancy.

Last revised on: October 15, 2005

ENDOSULFAN
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)	0.006 mg/kg/day
The RfD is based on a critical effect of decreased body weight gain, increased marked progressive glomrulonephrosis (shown by presence of albumin in the urine), and blood vessel abnormalities (aneurysms) in rats from a study by Hoechst Celanese Corp. in 1989. An uncertainty factor of 100 was applied when developing the RfD.	

When the concentration of endosulfan I or II reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<3.00	1	Up to 225 meals per year (no restrictions)
3.00	13.00	2	Up to 1 meal per week
>13.00	28.16	3	Up to 2 meals per month
>28.16	56.32	4	Up to 1 meal per month
>56.32	112.63	5	Up to 6 meals per year
>112.63		6	DO NOT EAT

Last revised on: October 15, 2005

Endrin

CAS Number 72 – 20 - 08

What is it? Endrin is a solid, white, almost odorless substance. It belongs to the cyclodiene group of organochlorine insecticides.

Where does it come from? Endrin is a major chemical of concern in agricultural and industrial areas. It was used as a pesticide to control insects, rodents, and birds. It was also used on crops such as cotton and grains, but has not been produced or sold for general use in the United States since 1986.

Endrin does not dissolve very well in water. It has been found in groundwater and surface water, but only at very low levels. It is more likely to cling to the bottom-sediments of rivers, lakes, and other bodies of water.

What are the health effects? No long-term effects have been noted in workers who have been exposed to endrin by breathing or touching it. There are no human data on birth defects, although some have been noted in animal studies.

Endrin poisoning (swallowing large amounts) can cause various harmful effects including death and severe nervous system (brain and spinal cord) injury. Symptoms that may result from endrin poisoning are headaches, dizziness, nervousness, confusion, nausea, vomiting, and convulsions.

Endrin levels can build up in the tissues of organisms that live in water. Studies in animals confirm that endrin's main target is the nervous system.

No significant excess cancer risk has been found in people who work with endrin and animal studies do not show that endrin causes cancer.

Last revised on: August 3, 2006

ENDRIN
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)	0.0003 mg/kg/day
The RfD is based on a critical effect of mild lesions of liver tissue and occasional convulsions in dogs from a study by Velsicol Chemical in 1969. An uncertainty factor of 100 was applied when developing the RfD.	

For fish tissue that was tested as SKIN-OFF filets
(a meal preparation reduction factor of 0.7 was applied)

When the concentration of endrin reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.21	1	Up to 225 meals per year (no restrictions)
0.21	0.93	2	Up to 1 meal per week
>0.93	2.01	3	Up to 2 meals per month
>2.01	4.02	4	Up to 1 meal per month
>4.02	8.05	5	Up to 6 meals per year
>8.05		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets
(a meal preparation reduction factor of 0.5 was applied)

When the concentration of endrin reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.30	1	Up to 225 meals per year (no restrictions)
0.30	1.30	2	Up to 1 meal per week
>1.30	2.82	3	Up to 2 meals per month
>2.82	5.63	4	Up to 1 meal per month
>5.63	11.26	5	Up to 6 meals per year
>11.26		6	DO NOT EAT

Last revised on: October 15, 2005

Ethion

CAS Number 563 – 12 - 2

What is it? Ethion is an organophosphate pesticide. Pure ethion is a clear to yellowish liquid with an unpleasant sulfur-like smell. It does not occur naturally in the environment.

Where does it come from? Ethion is used in agriculture, mainly to control insects on citrus trees, but also on cotton, fruit and nut trees, and some vegetables. It may also be used on lawns and turf grasses.

It is not known if ethion levels can build up in fish.

What are the health effects ? Exposure to ethion happens mostly from skin contact or breathing contaminated air, but may also occur from eating contaminated food or drinking contaminated water.

Ethion affects the function of the central nervous system and at high doses can cause nausea, blurring or dimness of vision, muscle tremors, and labored breathing. It is not known how much ethion is necessary to cause harmful effects in humans.

No cancer was seen in animals that ate ethion over a long period. There is no evidence that exposure to ethion increases the risk of cancer in people.

Last revised on: October 15, 2005

ETHION
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)	0.0005 mg/kg/day
The RfD is based on a critical effect of plasma cholinesterase (an enzyme) inhibition of the blood from a study by FMC Corp. in 1970. An uncertainty factor of 100 was applied when developing the RfD.	

When the concentration of ethion reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.25	1	Up to 225 meals per year (no restrictions)
0.25	1.08	2	Up to 1 meal per week
>1.08	2.35	3	Up to 2 meals per month
>2.35	4.69	4	Up to 1 meal per month
>4.69	9.39	5	Up to 6 meals per year
>9.39		6	DO NOT EAT

Last revised on: October 15, 2005

Heptachlor Epoxide

CAS Number 1024 – 57 - 3

What is it? Hepatchlor epoxide is not a formulated pesticide but rather a product of the metabolic degradation of the pesticides heptachlor and chlordane. It is also found as a contaminant in heptachlor and chlordane formulations.

Where does it come from? Heptachlor has been used for the control of termites and in the cotton industry. It has been used as a persistent, non-systemic contact and ingested insecticide in soils (particularly for termite control) and seeds and as a household insecticide. EPA suspended the major uses of heptachlor in 1978.

Chlordane, the other compound that is a parent of heptachlor epoxide, is discussed under its own section.

What are the health effects? Heptachlor epoxide is more toxic than either of its parent compounds (chlordane and heptachlor). Acute exposures to high doses of heptachlor epoxide can cause central nervous system effects (e.g., irritability, dizziness, muscle tremors, and convulsions). Liver, kidney, and blood disorders can occur in animals.

EPA has classified heptachlor epoxide as a probable human carcinogen based on sufficient evidence in animals and inadequate or no data in humans (Class B2). Exposure to this compound produced an increased incidence of liver carcinomas in rats and mice and hepatomas (a type of malignant liver tumor) in female rats.

Last revised on: October 15, 2005

HEPTACHLOR EPOXIDE
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)	0.000013 mg/kg/day
The RfD is based on a critical effect of increased liver to body weight ratio in dogs by Dow Chemical Co. in 1958. An uncertainty factor of 1000 was applied when developing the RfD.	

For fish tissue that was tested as SKIN-OFF filets

(a meal preparation reduction factor of 0.7 was applied)

When the concentration of heptachlor epoxide reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.01	1	Up to 225 meals per year (no restrictions)
0.01	0.04	2	Up to 1 meal per week
>0.04	0.09	3	Up to 2 meals per month
>0.09	0.17	4	Up to 1 meal per month
>0.17	0.35	5	Up to 6 meals per year
>0.35		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets

(a meal preparation reduction factor of 0.5 was applied)

When the concentration of heptachlor epoxide reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.01	1	Up to 225 meals per year (no restrictions)
0.01	0.06	2	Up to 1 meal per week
>0.06	0.12	3	Up to 2 meals per month
>0.12	0.24	4	Up to 1 meal per month
>0.24	0.49	5	Up to 6 meals per year
>0.49		6	DO NOT EAT

Last revised on: October 15, 2005

HEPTACHLOR EPOXIDE
CARCINOGENIC EFFECTS

Cancer Slope Factor (CSF)	9.1 $(mg/kg/day)^{-1}$
The CSF was calculated based on a study by Velsicol in 1973 that reviewed hepatocellular liver carcinomas (cancer in the liver cells that secrete bile) in rats from oral exposures to heptachlor epoxide.	

For fish tissue that was tested as SKIN-OFF filets

(a meal preparation reduction factor of 0.7 was applied)

When the concentration of heptachlor epoxide reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.008	1	Up to 225 meals per year (no restrictions)
0.008	0.034	2	Up to 1 meal per week
>0.034	0.07	3	Up to 2 meals per month
>0.07	0.15	4	Up to 1 meal per month
>0.15	0.29	5	Up to 6 meals per year
>0.29		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets

(a meal preparation reduction factor of 0.5 was applied)

When the concentration of heptachlor epoxide reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.011	1	Up to 225 meals per year (no restrictions)
0.011	0.048	2	Up to 1 meal per week
>0.048	0.10	3	Up to 2 meals per month
>0.10	0.21	4	Up to 1 meal per month
>0.21	0.41	5	Up to 6 meals per year
>0.41		6	DO NOT EAT

Last revised on: October 15, 2005

Hexachlorobenzene

CAS Number 118 – 74 – 1

What is it? Hexachlorobenzene (HCB) is a man-made pesticide that was used in the United States until 1985.

Where does it come from? It has been used extensively as a fungicide (to control fungus) for the protection of grain in storage or seed treatment.

Hexachlorobenzene was also used as an industrial chemical to make fireworks, ammunition, synthetic rubber, nitroso-rubber for tires, and other substances.

It served as a chemical intermediate in the production of many other organochlorine pesticides (pentachloronitrobenzene [PCNB], dacthal, chlorothalonil, and picloram).It may occur as a contaminant in the production of other chlorinated solvents (e.g., carbon tetrachloride and chlorobenzenes). Hexachlorobenzene is also unintentionally produced as fugitive emissions during the combustion and manufacture of certain chemicals.

What are the health effects? The most studied exposure of people to hexachlorobenzene was to bread contaminated with hexachlorobenzene. The bread was eaten for a long time before it was discovered. Some of the adverse health effects observed were shortening of fingers and toes due to osteoporosis, painless arthritis, muscle weakness, enlargement of the thyroid, skin lesions, and changes to liver that affected hemoglobin in the body. There was a high death rate in young children of mothers who ate the contaminated bread and in children who ate it themselves.

EPA has classified hexachlorobenzene as a probable human carcinogen based on sufficient evidence in animals and inadequate or no data in humans (Class B2). Studies in animals suggest that eating hexachlorobenzene causes cancer in the liver, kidney, and thyroid.

Last revised on: October 15, 2005

HEXACHLOROBENZENE
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)	0.0008 mg/kg/day
The RfD is based on liver effects (hepatic centrilobular basophilic chromogenesis) in rats from a study by Arnold et al. in 1985. An uncertainty factor of 100 was applied when developing the RfD.	

For fish tissue that was tested as SKIN-OFF filets

(a meal preparation reduction factor of 0.7 was applied)

When the concentration of hexachlorobenzene reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.57	1	Up to 225 meals per year (no restrictions)
0.57	2.48	2	Up to 1 meal per week
>2.48	5.36	3	Up to 2 meals per month
>5.36	10.73	4	Up to 1 meal per month
>10.73	21.45	5	Up to 6 meals per year
>21.45		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets

(a meal preparation reduction factor of 0.5 was applied)

When the concentration of hexachlorobenzene reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.80	1	Up to 225 meals per year (no restrictions)
0.80	3.47	2	Up to 1 meal per week
>3.47	7.51	3	Up to 2 meals per month
>7.51	15.02	4	Up to 1 meal per month
>15.02	30.04	5	Up to 6 meals per year
>30.04		6	DO NOT EAT

Last revised on: October 15, 2005

HEXACHLOROBENZENE
CARCINOGENIC EFFECTS

Cancer Slope Factor (CSF)	1.6 $(mg/kg/day)^{-1}$
The CSF was calculated based on a study by Erturk et al. in 1986 that reviewed hepatocellular carcinomas (cancer in the liver cells that secrete bile) in rats from oral exposures to hexachlorobenzene.	

For fish tissue that was tested as SKIN-OFF filets

(a meal preparation reduction factor of 0.7 was applied)

When the concentration of hexachlorobenzene reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.045	1	Up to 225 meals per year (no restrictions)
0.045	0.19	2	Up to 1 meal per week
>0.19	0.42	3	Up to 2 meals per month
>0.42	0.84	4	Up to 1 meal per month
>0.84	1.68	5	Up to 6 meals per year
>1.68		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets

(a meal preparation reduction factor of 0.5 was applied)

When the concentration of hexachlorobenzene reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.063	1	Up to 225 meals per year (no restrictions)
0.063	0.27	2	Up to 1 meal per week
>0.27	0.59	3	Up to 2 meals per month
>0.59	1.17	4	Up to 1 meal per month
>1.17	2.35	5	Up to 6 meals per year
>2.35		6	DO NOT EAT

Last revised on: October 15, 2005

Lead

CAS Number 7439 – 92 – 1

What is it? Lead is a blue-white to grey metal which shines when cut. It has been used by humans for nearly 7,000 years. Lead has many uses and is the fifth most used metal in the United States.

What are the sources of this chemical? Sources of lead in the environment include mining, smelting, lead shot and sinkers, lead-based paint, and until recently, lead-containing gasoline. Lead is used primarily in manufacturing lead acid storage batteries, as well as ammunition, pigments, and solder.

What are the health effects? Lead accumulates in the body at the same places as calcium. Lead that is not excreted from the body accumulates in bone. There is no evidence that lead is biologically essential or useful.

Lead causes problems with behavior, development, growth, learning, metabolism, and survival. Lead poisoning was first recognized 2,500 years ago.

In addition to causing multiple health effects, some studies show that there is no amount of lead below which some effects on children's development cannot be found. Because of this, no RfD has been established for lead.

Acute lead poisoning can occur at low doses and can affect the central nervous system, delayed mental and physical development, attention deficits, hearing loss, learning disabilities, and increased blood pressure.

Chronic lead poisoning can cause inflammation of the brain and kidney disease.

Why are no meal consumption limits established for lead? Without a RfD, no meal consumption limits can be calculated. However, lead does not accumulate significantly in fish tissue.

If a meal consumption limit could be calculated, the preparation dose reduction factor would be "1" because this chemical does not accumulate in the fatty portion of fish tissue.

Last revised on: October 15, 2005

Lindane (γ-Hexachlorocyclohexane)

CAS Number 58 – 89 - 9

What is it? Hexachlorocyclohexane (HCH) is a manufactured chemical that exists in eight chemical forms called isomers. Lindane, commonly referred to as benzene hexachloride, is a mixture of the chemical forms of HCH, whose major component is the gamma (γ) isomer.

What are the sources and uses of this chemical? Lindane has been primarily used in seed treatments, soil treatments for tobacco transplants, foliage applications on fruit and nut trees and vegetables, and wood and timber protection. Lindane is also available as a prescription (lotion, cream, or shampoo) to treat head and body lice and scabies. It has not been produced in the Unites States since 1976, but is imported for insecticide use. Many of its uses have been banned or restricted since 1985.

What are the health effects? Lindane can accumulate in the fatty tissue of fish. Accidentally eating high amounts of lindane can kill a child. However, the most likely source of exposure for children is from the use of shampoos and lotions containing HCH for the treatment of lice. Very little HCH residue is found in food products.

Lindane is toxic to the nervous system and has been found to cause aplastic anemia (an anemia that is caused by defects in the blood-forming organs) in humans.

Acute symptoms of exposure to lindane include apprehension, irritability, dizziness, disturbed equilibrium, tumors, and convulsions.

The EPA has determined that there is suggestive evidence that lindane is carcinogenic, but the evidence is not sufficient to assess its human carcinogenic potential. Although the EPA does not place lindane in a cancer class, the US Department of Health and Human Services has determined that lindane may reasonably be anticipated to cause cancer in humans. Long-term oral administration of the various forms of HCH to laboratory animals produced liver cancer.

Last revised on: October 15, 2005

LINDANE
(gamma (γ)-hexaclorocylohexane or gamma (γ)-HCH)
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)	0.0003 mg/kg/day
The RfD is based on a critical effect of liver and kidney toxicity in rats from a study by Zoecon Corp. in 1983. An uncertainty factor of 1000 was applied when developing the RfD.	

For fish tissue that was tested as SKIN-OFF filets

(a meal preparation reduction factor of 0.7 was applied)

When the concentration of lindane reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.21	1	Up to 225 meals per year (no restrictions)
0.21	0.93	2	Up to 1 meal per week
>0.93	2.01	3	Up to 2 meals per month
>2.01	4.02	4	Up to 1 meal per month
>4.02	8.05	5	Up to 6 meals per year
>8.05		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets

(a meal preparation reduction factor of 0.5 was applied)

When the concentration of lindane reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.30	1	Up to 225 meals per year (no restrictions)
0.30	1.30	2	Up to 1 meal per week
>1.30	2.82	3	Up to 2 meals per month
>2.82	5.63	4	Up to 1 meal per month
>5.63	11.26	5	Up to 6 meals per year
>11.26		6	DO NOT EAT

Last revised on: October 15, 2005

LINDANE
(gamma (γ)-hexachlorocyclohexane or gamma (γ)-HCH)
CARCINOGENIC EFFECTS

Cancer Slope Factor (CSF)	1.3 $(mg/kg/day)^{-1}$
The CSF was calculated based on a study by the EPA in 1987 that reviewed mouse liver tumors from oral exposures to γ-(gamma) hexachlorocyclohexane. The CSF was obtained from Table 3.1 of the EPA Guidance.	

For fish tissue that was tested as SKIN-OFF filets

(a meal preparation reduction factor of 0.7 was applied)

When the concentration of lindane reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.055	1	Up to 225 meals per year (no restrictions)
0.055	0.24	2	Up to 1 meal per week
>0.24	0.52	3	Up to 2 meals per month
>0.52	1.03	4	Up to 1 meal per month
>1.03	2.06	5	Up to 6 meals per year
>2.06		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets

(a meal preparation reduction factor of 0.5 was applied)

When the concentration of lindane reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.077	1	Up to 225 meals per year (no restrictions)
0.077	0.33	2	Up to 1 meal per week
>0.33	0.72	3	Up to 2 meals per month
>0.72	1.44	4	Up to 1 meal per month
>1.44	2.89	5	Up to 6 meals per year
>2.89		6	DO NOT EAT

Last revised on: August 3, 2006

Methylmercury

CAS Number 22967 – 92 - 6

What is it? Mercury is a naturally-occurring element that can exist in a range of organic and inorganic forms with varying degrees of toxicity. Mercury recycles between land, water, and air and enters plant and animal tissue. Microorganisms and other processes can change mercury in the environment to organic forms. The most common of these is methylmercury.

What are the sources and uses of this chemical? Mercury enters the environment as a result of natural weathering of rocks and soil. Human activity can also release mercury into the environment. Mining and the burning of fossil fuels have been the major sources of mercury due to human activity. Lesser sources of mercury in the environment are from fertilizers, fungicides, and municipal solid waste.

Methylmercury in water can remain a long time, particularly if it attaches to small particles in the water and settles into the sediment. Methylmercury can accumulate in the food chain and older, larger, fish are more likely to have more methylmercury in their bodies than younger, smaller fish. In addition, fish that eat other fish are more likely to have higher levels of methylmercury in their tissues.

Measured mercury concentrations are usually higher in the fillet samples than in the whole-body samples. This is because, unlike other organic chemicals, organic mercury compounds are taken up and stored in muscle rather than fatty tissue.

What are the health effects? The nervous system is the very sensitive to mercury. One of the adverse health effects observed is decreased mental ability.

Exposures to methylmercury are more dangerous for young children because more methylmercury moves into the brain of developing fetuses and children. The effects range from small decreases in IQ or effects on the brain that can only be measured by professional testing to, at much higher doses, mental retardation, incoordination, and inability to move.

Higher exposures to mercury may cause a decrease in the ability to walk, talk, see, and hear.

EPA has classified methylmercury as a possible human carcinogen based on limited evidence of carcinogenicity in animals and no human data (Class C). There is no cancer slope factor for methylmercury. Therefore, no meal consumption limits for carcinogenic effects were calculated.

Last revised on: October 15, 2005

METHYLMERCURY
NONCARCINOGENIC EFFECTS

It is recommended that the total mercury be analyzed and the conservative assumption be made that nearly all mercury is present as methylmercury. This approach is deemed to be most protective of public health and most cost effective.

Reference Dose (RfD)	0.0001 mg/kg/day
The RfD is based on a critical effect of developmental changes in the central nervous system in humans from a study by Grandjean et al. in 1997 and Budtz-Jorgensen et al. in 1999. An uncertainty factor of 10 was applied when developing the RfD.	

When the concentration of methylmercury reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.05	1	Up to 225 meals per year (no restrictions)
0.05	0.22	2	Up to 1 meal per week
>0.22	0.47	3	Up to 2 meals per month
>0.47	0.94	4	Up to 1 meal per month
>0.94	1.88	5	Up to 6 meals per year
>1.88		6	DO NOT EAT

Last revised on: October 15, 2005

Mirex

CAS Number 2385 – 85 - 5

What is it? Mirex is a man-made, organic compound that was produced in the United States between 1959 and 1975. All registered uses of mirex were cancelled in 1977. In 1978, EPA banned all further use of mirex, partly because of the hazards it imposed on marine crustaceans, such as shrimp and crabs.

What are the sources and uses of this chemical? Mirex has been used to control fire ants (*Solenopsis invicta*) in eight southeastern states as well as the pineapple mealy-bug in Hawaii. Mirex has also been used to combat termites and as a flame retardant in electronic components, plastics, rubber, paint, paper, and fabrics.

Mirex is thermally and chemically very stable and resistant to biodegradation. The products of its breakdown are also toxic. Mirex can move through aquatic and terrestrial environmental compartments and is persistent in the aquatic environment. Mirex becomes more concentrated as it moves up the food chain.

One environmental consequence of mirex was the severe damage recorded to fish and wildlife in nine southeastern states and the Great Lakes, especially Lake Ontario. These hazards included delayed mortality and numerous birth defects in aquatic and terrestrial fauna; tumor formation; histopathology; wildlife population alterations; adverse effects on reproduction, early growth and development; disrupted mammalian energy metabolism; and detection of residues in human milk and fatty tissues.

What are the health effects? Little data exists on the human health effects of mirex exposures. Workers who were exposed to high levels of chlordecone (a chemical similar to mirex) for more than one year, showed harmful effects on the nervous system, skin, liver, and male reproductive system. These workers were probably exposed mainly through touching this chemical, and not by ingestion.

Animal studies with chlordecone have shown harmful effects on the nervous system, skin, liver, kidney, and reproductive system as well as developmental effects. High doses of mirex can also affect the stomach, intestine, liver, kidneys, eyes, thyroid, and nervous and reproductive systems in animals.

Last revised on: October 15, 2005

MIREX
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)	0.0002 mg/kg/day
The RfD is based on a critical effect of enlarged liver cells and development of a fatty liver, gross dilation of blood or lymph vessels, and thyroid cysts in rats from a study by NTP in 1990. An uncertainty factor of 300 was applied when developing the RfD.	

For fish tissue that was tested as SKIN-OFF filets

(a meal preparation reduction factor of 0.7 was applied)

When the concentration of mirex reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.14	1	Up to 225 meals per year (no restrictions)
0.14	0.62	2	Up to 1 meal per week
>0.62	1.34	3	Up to 2 meals per month
>1.34	2.68	4	Up to 1 meal per month
>2.68	5.36	5	Up to 6 meals per year
>5.36		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets

(a meal preparation reduction factor of 0.5 was applied)

When the concentration of mirex reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.20	1	Up to 225 meals per year (no restrictions)
0.20	0.87	2	Up to 1 meal per week
>0.87	1.88	3	Up to 2 meals per month
>1.88	3.75	4	Up to 1 meal per month
>3.75	7.51	5	Up to 6 meals per year
>7.51		6	DO NOT EAT

Last revised on: October 15, 2005

Oxyfluorfen

CAS Number 42874 – 03 - 3

What is it? Oxyfluorfen, also called "GOAL," is a man-made, chlorophenoxy herbicide.

What are the sources and uses of this chemical? Oxyfluorfen has been registered since 1979 to control a wide spectrum of annual broadleaf weeds and grasses in apples, artichokes, corn, cotton, jojoba, tree fruits, grapes, nuts, soybeans, spearmint, peppermint, and certain tropical plantation and ornamental crops.

Experimental evidence indicates that this herbicide accumulates in bluegill sunfish.

What are the health effects? Oxyfluorfen is of low toxicity to mammals. Oxyfluorfen is practically nontoxic by ingestion in rats and dogs. Studies in dogs and mice found that the health effects observed occur in the liver.

Because of its chemical nature, oxyfluorfen may accumulate in fatty tissues.

EPA has not classified oxyfluorfen as to its carcinogenicity. No cancer slope factor is listed on the EPA IRIS system. Meal consumption limits for carcinogenic effects were calculated using the cancer slope factor from a 1998 EPA memo.

Last revised on: October 15, 2005

OXYFLUORFEN
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)	0.003 mg/kg/day
The RfD is based on studies of increased absolute liver weight and liver tumors in mice by Rohm and Haas in 1997. An uncertainty factor of 100 was applied to this RfD.	

When the concentration of oxyfluorfen reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<1.50	1	Up to 225 meals per year (no restrictions)
1.50	6.50	2	Up to 1 meal per week
>6.50	14.08	3	Up to 2 meals per month
>14.08	28.16	4	Up to 1 meal per month
>28.16	56.32	5	Up to 6 meals per year
>56.32		6	DO NOT EAT

Last revised on: October 15, 2005

OXYFLUORFEN
FOR CARCINOGENIC EFFECTS

Cancer Slope Factor (CSF)	0.0732 $(mg/kg/day)^{-1}$
The CSF is from Table 3.1 of the EPA Guidance. The table states that this value was from a memo dated 9/24/98: REVISED Oxyfluorfen (Goal) Quantitative Risk Assessment (Q1*) based on CD-1 Male Mouse Dietary Study with 3/4s Interspecies Scaling Factor. HED Document No. 012879. The critical carcinogenic effect of oxyfluorfen is evidence of carcinogenicity (liver tumors) in mice.	

When the concentration of oxyfluorfen reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.68	1	Up to 225 meals per year (no restrictions)
0.68	2.96	2	Up to 1 meal per week
>2.96	6.41	3	Up to 2 meals per month
>6.41	12.82	4	Up to 1 meal per month
>12.82	25.64	5	Up to 6 meals per year
>25.64		6	DO NOT EAT

Last revised on: October 15, 2005

Polychlorinated Biphenyls (PCBs)

CAS Number 1336 – 36 – 3 (for PCBs)

What is it? Polychlorinated biphenyls or PCBs are a family of man-made oils. PCBs are also unintentionally produced during combustion. Commercial products can be mixtures of up to 209 different compounds called congeners. PCBs are nonflammable, very stable, and highly resistant to extreme conditions of temperature and pressure, and can travel long distances in the environment.

PCBs were first introduced into commerce by the Monsanto Corporation in 1929. They were initially used as plasticizers in rubber and plastic products, lubricants in hydraulic fluids, and as an ink carrier, among other uses. After 1974, PCBs were produced as Arochlors and used primarily as a dielectric fluid in capacitors and electrical transformers. PCBs were also once widely used as coolants and lubricants, in flame retardants, in paint, varnish, pesticides, cosmetics, for general weatherproofing, and fire-resistant coatings to wood and plastic.

The U.S. government banned the production of PCBs in 1977.

What are the sources and uses of this chemical? PCBs are distributed worldwide, with measurable concentrations reported in aquatic organisms, wildlife, and in oceans. The highest PCB levels in biota are most often found in fish.

PCBs have the potential to remain in water and lake sediments for years. Subsistence fishermen or avid sport fishermen and their families may be exposed to very high dietary levels of PCBs, primarily through consumption of freshwater fish. Some studies have suggested that sport fishermen may have higher body burdens of PCBs than the general public. Saltwater fish generally do not have high PCB residues.

What are the health effects? PCBs are highly soluble in fat and can bioaccumulate and biomagnify within the food chain. As a result, everyone is exposed to a few hundred nanograms of PCBs each day, primarily through diet. It may take months or years of regularly eating contaminated fish to accumulate levels that are a health concern because PCBs build up in the body over time. Since the PCB ban, environmental levels and body burdens have been slowly declining.

PCBs elicit a variety of biologic and toxic effects. The primary effects associated with high level, short-term exposures in the workplace are eye and skin irritation. Some babies born to women who ate fish contaminated with PCBs before or during pregnancy have been born with low birth weight and have measurable changes in behavior. PCBs also cause changes in human blood, liver, and immune function in adults.

The major toxic effect after chronic exposure to PCBs in animals is liver damage. Other effects in animals include stomach, thyroid, and kidney damage, porphyria, and immunosuppressive effects, reproductive failure, and a wasting syndrome. PCBs administered orally have been shown to cause liver tumors in rats and mice. Animals chronically exposed to PCBs have shown a variety of effects including dermatologic, hepatic, immunologic, reproductive, and carcinogenic. Since these tests were often carried out at doses thousands of times higher than those to which humans are exposed, their significance to humans is uncertain.

Studies in monkeys have shown that the lowest dose of PCBs with a health effect when administered over a long period caused changes in the immune system (decreased antibody response to sheep red blood cells.)

EPA has classified PCBs as a probable human carcinogen based on sufficient evidence in animals and inadequate or no data in humans (Class B2). The critical carcinogenic effects include carcinomas and abnormal nodules in one strain of female rats.

POLYCHLORINATED BIPHENYLS
NONCARCINOGENIC AND CARCINOGENIC EFFECTS

Health Protection Value (HPV)	0.00005 mg/kg/day
The HPV is from the Great Lakes Protocol. It was determined by considering both noncarcinogenic and carcinogenic effects. The method used is different from that used to set Reference Doses.	

For fish tissue that was tested as SKIN-OFF filets
(a meal preparation reduction factor of 0.7 was applied)

When the concentration of polychlorinated biphenyls reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.036	1	Up to 225 meals per year (no restrictions)
0.036	0.15	2	Up to 1 meal per week
>0.15	0.34	3	Up to 2 meals per month
>0.34	0.67	4	Up to 1 meal per month
>0.67	1.34	5	Up to 6 meals per year
>1.34		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets
(a meal preparation reduction factor of 0.5 was applied)

When the concentration of polychlorinated biphenyls reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.05	1	Up to 225 meals per year (no restrictions)
0.05	0.22	2	Up to 1 meal per week
>0.22	0.47	3	Up to 2 meals per month
>0.47	0.94	4	Up to 1 meal per month
>0.94	1.88	5	Up to 6 meals per year
>1.88		6	DO NOT EAT

Last revised on: October 15, 2005

Polycyclic Aromatic Hydrocarbons (PAHs)

Benzo(a)pyrene CAS Number 50 – 32 – 8

What is it? Polychlorinated aromatic hydrocarbons (PAHs) belong to a family of base/neutral organic compounds that consist of hydrogen and carbon arranged in the form of two or more fused benzene rings. Another name for PAHs is polynuclear aromatic hydrocarbons. PAHs with two to five benzene rings are generally of greatest concern for environmental and human health effects.

What are the sources and uses of this chemical? PAHs are widespread in the environment and usually occur as complex mixtures with other toxic chemicals. They are components of crude and refined petroleum and coal products, waste incineration, wood preservatives, creosote, coal tar, coal coking, urban runoff from asphalt, automobile tires and exhaust emissions, petroleum spills, coal gasification sites, and petroleum refineries.

PAHs are major chemicals of concern in suburban/urban and industrial areas. They have been detected in sediments, soils, air, surface waters, and plant and animal tissues--primarily as a result of natural processes such as forest fires, microbial synthesis, and volcanic activities.

Anthropogenic activities associated with significant production of PAHs include high-temperature (>700 °C) combustion of organic materials typical of some processes used in the iron and steel industry, heating and power generation, and petroleum refining.

Major sources of PAHs found in marine and freshwaters include natural formation in sediments without the presence of oxygen, spillage and seepage of fossil fuels, discharge of domestic and industrial wastes, atmospheric deposition, and runoff. Urban stormwater runoff contains PAHs from leaching of asphalt roads, wearing of tires, deposition from automobile exhaust, and oiling of roadsides and unpaved roadways with crankcase oil. Solid PAH-containing residues from activated sludge treatment facilities have been disposed of in landfills or in the ocean. Liquid domestic sludge and industrial sewage also contribute PAHs to the environment.

Aquatic environments may receive PAHs from accidental releases of petroleum and its products, from sewage effluents, and from other sources. Sediments heavily contaminated with industrial PAH wastes have directly caused elevated PAH body burdens and increased frequency of abnormal growths on the liver in fishes.

What are the health effects? The PAH compounds with larger chemical structures tend to bioaccumulate in organisms living in water. In general, however, PAHs show little tendency to biomagnify in food chains. The reason for this may be that although they are highly soluble in fats or fatty tissue, they are rapidly metabolized.

The metabolites of many of the high-molecular-weight PAHs have been shown in laboratory test systems to be carcinogens, substances that increase the carcinogenic effect of another substance, substances that causes defects in embryos and fetuses and/or mutagenic. Biotransformation of PAHs in fish liver can result in the formation of carcinogenic and mutagenic intermediates, and exposure to PAHs has been linked to the development of tumors in fish.

EPA has classified PAHs as probable human carcinogens based on sufficient evidence in animals and inadequate or no data in humans (Class B2). Evidence for the carcinogenicity of PAHs in humans comes primarily from epidemiologic studies that have shown an increased mortality due to lung cancer in humans exposed to PAH-containing coke oven emissions, roof-tar emissions, and cigarette smoke.

Last revised on: October 15, 2005

POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)
CARCINOGENIC EFFECTS

It is recommended that tissue samples be analyzed for benzo(a)pyrene and 14 other PAHs and that the order-of-magnitude relative potencies given for these PAHs be used to calculate a potency equivalency concentration (PEC) for each sample.

Cancer Slope Factor (CSF)	7.3 $(mg/kg/day)^{-1}$ [for benzo(a)pyrene]
The CSF was based on a study of forestomach squamous cell warts and carcinomas in mice by Neal and Rigdon in 1967.	

For fish tissue that was tested as SKIN-OFF filets

(a meal preparation reduction factor of 0.7 was applied)

When the concentration of PAHs reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.010	1	Up to 225 meals per year (no restrictions)
0.010	0.042	2	Up to 1 meal per week
>0.042	0.09	3	Up to 2 meals per month
>0.09	0.18	4	Up to 1 meal per month
>0.18	0.37	5	Up to 6 meals per year
>0.37		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets

(a meal preparation reduction factor of 0.5 was applied)

When the concentration of PAHs reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.014	1	Up to 225 meals per year (no restrictions)
0.014	0.059	2	Up to 1 meal per week
>0.059	0.13	3	Up to 2 meals per month
>0.13	0.26	4	Up to 1 meal per month
>0.26	0.51	5	Up to 6 meals per year
>0.51		6	DO NOT EAT

Last revised on: October 15, 2005

Selenium

CAS Number 7782 – 49 - 2

What is it? Selenium is a naturally occurring mineral element that is distributed widely in nature in most rocks and soils, particularly in the western and southwestern United States.

What are the sources and uses of this chemical? Most processed selenium is used in the electronics and glass industries. Selenium is a component of pigments in plastics, paints, enamels, inks, and rubber. Selenium is used in the preparation of pharmaceuticals, pesticides, and rubber. Selenium is an ingredient in some anti-dandruff shampoos.

Selenium can be released into the environment during combustion of fossil fuels, and when metals are smelted. It is present in leachate from coal fly ash disposal areas. Selenium also enters the environment when rocks weather.

What are the health effects? Selenium is an essential nutrient but is toxic to both humans and animals at high concentrations. Selenium is used as a nutritional supplement for humans and animals.

Long-term adverse effects from ingestion by humans have not been studied thoroughly. Selenium has the ability to bioaccumulate in aquatic food chains and may thereby contaminate the diet and induce reproductive effects in fish and birds.

EPA has determined that one specific form of selenium, selenium sulfide, is a probable human carcinogen. However, selenium sulfide is not present in foods or the environment.

Last revised on: October 15, 2005

SELENIUM
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)	0.005 mg/kg/day
The RfD is based on a critical effect of clinical selenosis (hair loss, nail brittleness, numbness and other odd sensations in hands and feet) in humans based on a study by Yang et al. in 1989. An uncertainty factor of three was applied when developing the RfD.	

When the concentration of selenium reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<2.50	1	Up to 225 meals per year (no restrictions)
2.50	10.83	2	Up to 1 meal per week
>10.83	23.47	3	Up to 2 meals per month
>23.47	46.93	4	Up to 1 meal per month
>46.93	93.86	5	Up to 6 meals per year
>93.86		6	DO NOT EAT

Last revised on: October 15, 2005

Terbufos

CAS Number 13071 – 79 – 9

What is it? Terbufos is a systemic organophosphate pesticide. It is used to control insects and nematodes.

What are the sources and uses of this chemical? Terbufos was registered in 1974 principally for use on corn, sugar beets, and grain sorghum.

Terbufos is moderately persistent in soils. It is generally immobile and is unlikely to leach into groundwater. Terbufos degrades rapidly. In a field-study, only 1.5% of terbufos was detectible 60 days after its application.

Experimental evidence indicates that this compound accumulates in fish.

What are the health effects? Terbufos is highly toxic to humans, birds, fish, and aquatic invertebrates under acute exposure conditions. Limited information is available on the toxic effects of terbufos under chronic exposure conditions.

Based on current environmental data, people in this country do not ingest enough terbufos in water or food to cause adverse health effects. Misuse and poisoning are the avenues where exposures to terbufos might cause adverse health effects.

Acute poisoning in humans can disrupt the nervous system and cause nausea, dizziness, and confusion. Large doses result in respiratory failure.

Last revised on: October 15, 2005

TERBUFOS
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)*	0.00002 mg/kg/day
The RfD is based on a critical effect of cholinesterase (an enzyme) inhibition in dogs from a study by EPA in 1987. An uncertainty factor of 100 was applied when developing the RfD. * The RfD is from Table 3.1 of the EPA Guidance. The Table references a memorandum dated September 25, 1997; Terbufos-FQPA Requirement Report of the Hazard Identification Review.	

When the concentration of terbufos reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.01	1	Up to 225 meals per year (no restrictions)
0.01	0.04	2	Up to 1 meal per week
>0.04	0.09	3	Up to 2 meals per month
>0.09	0.19	4	Up to 1 meal per month
>0.19	0.38	5	Up to 6 meals per year
>0.38		6	DO NOT EAT

Last revised on: October 15, 2005

Toxaphene

CAS Number 8001 – 35 - 2

What is it? Toxaphene is a man-made, broad-spectrum insecticide which, until recently, was one of the most heavily-used agricultural chemicals on a global scale, especially against pests of cotton. It was also used on other crops, livestock, and to kill unwanted fish in lakes. Toxaphene is a mixture of over 670 chemicals. All registered uses of toxaphene were cancelled in 1990.

What are the sources and uses of this chemical? Toxaphene is extremely persistent in soil and water, with documented half-lives of nine to eleven years. In air and in warm-blooded organisms, toxaphene degradation is rapid with half-times of 15 and three days, respectively.

What are the health effects? Estimates of environmental exposure levels indicate that people and animals toxaphene exposure is not likely to cause adverse health effects. Wildlife typically contain low or no detectable levels of toxaphene, except for some species of fish-eating birds.

However, because toxaphene accumulates in the body and can be found in breast milk, the exposure to children and breast feeding women is of particular concern.

Animal studies have shown changes to the immune system and behavioral changes during development. Other animal studies have shown that chronic exposure to toxaphene may damage the liver, kidney, adrenal, immunological, and neurological systems. Changes in hormones may occur.

EPA has classified toxaphene as a probable human carcinogen based on sufficient evidence in animals and inadequate or no data in humans (Class B2).

Last revised on: October 15, 2005

TOXAPHENE
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)*	0.00025 mg/kg/day
* The RfD is from Table 3.1 of the EPA Guidance. The Table states that the RfD is from the Office of Pesticide Program's Reference Dose Tracking Report and has been agreed upon by the Office of Pesticide Programs and the Office of Water. The critical effect was slight changes in liver (granularity and vacuolization of hepatocytes.)	

For fish tissue that was tested as SKIN-OFF filets

(a meal preparation reduction factor of 0.7 was applied)

When the concentration of toxaphene reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.18	1	Up to 225 meals per year (no restrictions)
0.18	0.77	2	Up to 1 meal per week
>0.77	1.68	3	Up to 2 meals per month
>1.68	3.35	4	Up to 1 meal per month
>3.35	6.70	5	Up to 6 meals per year
>6.70		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets

(a meal preparation reduction factor of 0.5 was applied)

When the concentration of toxaphene reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.25	1	Up to 225 meals per year (no restrictions)
0.25	1.08	2	Up to 1 meal per week
>1.08	2.35	3	Up to 2 meals per month
>2.35	4.69	4	Up to 1 meal per month
>4.69	9.39	5	Up to 6 meals per year
>9.39		6	DO NOT EAT

Last revised on: October 15, 2005

TOXAPHENE
FOR CARCINOGENIC EFFECTS

Cancer Slope Factor (CSF)	1.1 $(mg/kg/day)^{-1}$
The critical carcinogenic effects of toxaphene are cancer of the liver cells that secrete bile (heptocellular carcinomas) and abnormal growths in one strain of male mice.	

For fish tissue that was tested as SKIN-OFF filets

(a meal preparation reduction factor of 0.7 was applied)

When the concentration of toxaphene reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.065	1	Up to 225 meals per year (no restrictions)
0.065	0.28	2	Up to 1 meal per week
>0.28	0.61	3	Up to 2 meals per month
>0.61	1.22	4	Up to 1 meal per month
>1.22	2.44	5	Up to 6 meals per year
>2.44		6	DO NOT EAT

For fish tissue that was tested as SKIN-ON filets

(a meal preparation reduction factor of 0.5 was applied)

When the concentration of toxaphene reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.091	1	Up to 225 meals per year (no restrictions)
0.091	0.39	2	Up to 1 meal per week
>0.39	0.85	3	Up to 2 meals per month
>0.85	1.71	4	Up to 1 meal per month
>1.71	3.41	5	Up to 6 meals per year
>3.41		6	DO NOT EAT

Last revised on: August 3, 2006

Tributyltin oxide

CAS Number 56 – 35 - 9

What is it? Tributyltin oxide (tributyltin) is an organic tin.

What are the sources and uses of this chemical? Organic chemicals that include the element tin (organotin compounds) have been used as biocides and disinfectants. Tributyltin compounds are used in paints applied to boat and ship hulls as well as to crab pots, fishing nets, and buoys to retard the growth of fouling organisms. These compounds were also registered for use as wood preservatives, disinfectants, and biocides in cooling waters, pulp and paper mills, breweries, leather processing facilities, and textile mills.

Background concentrations of organotin compounds (which include tributyltin oxide) are frequently elevated--occasionally to dangerous levels--in aquatic organisms collected near shipyards, marinas, and other locales where organotin-based antifouling paints are extensively used. However, more information is needed on background concentrations of organotins, especially those from terrestrial ecosystems.

What are the health effects? There are no studies on the chronic, developmental, or reproductive effects of tributyltin oxide in humans.

Tributyltin compounds are acutely toxic to aquatic organisms at concentrations below 1 part-per-billion (ppb). It is toxic to aquatic organisms at concentrations as low as 0.002 ppb under chronic exposure conditions.

Synthetic organotin may present a variety of problems to animals, including impaired behavior and reduced growth, survival, and reproduction.

All evidence to date indicates that organotin compounds are not carcinogenic.

Last revised on: October 15, 2005

TRIBUTYLTIN OXIDE
NONCARCINOGENIC EFFECTS

Reference Dose (RfD)	0.0003 mg/kg/day
The RfD is based on a critical effect of decreases in the immune system in rats from a study by Vos et al. in 1990. An uncertainty factor of 100 was applied when developing the RfD.	

When the concentration of tributyltin reaches these levels in fish tissue,		the recommended fish consumption advice should restrict intake amounts to:	
Minimum (mg/kg or ppm)	Maximum (mg/kg or ppm)	Group	Meal Restriction
	<0.15	1	Up to 225 meals per year (no restrictions)
0.15	0.65	2	Up to 1 meal per week
>0.65	1.41	3	Up to 2 meals per month
>1.41	2.82	4	Up to 1 meal per month
>2.82	5.63	5	Up to 6 meals per year
>5.63		6	DO NOT EAT

Last revised on: October 15, 2005

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APPENDIX A. FDA and EPA Advisories

Guidelines set by the FDA

Safety regulations and advisories for fish in the market place are the responsibility of the United States Food and Drug Administration (FDA). The FDA sets the maximum allowable contaminant in fish and fishery products in interstate commerce. FDA tolerances were formulated for the general population who purchase fish, not the sub-population of recreational fishermen and women. This results in a considerable underestimation of the fish consumption level and of the health risk by fishermen.

There are differences in the methods used by the FDA and the EPA to determine their fish advisories. Many of the discrepancies come from differing assumptions. The EPA uses a ratio of animal to human surface area to extrapolate from small animals to humans and the FDA uses a ratio of the body weights (Reinert et al. 1991). The FDA authority and regulations are aimed at fish in interstate commerce. The FDA considers the economic impact on the commercial fishing industry, while the EPA and Great Lakes Task Force are concerned only with recreationally caught fish. For example, the FDA has set a limit of 2 ppm PCB in the edible portion of all fish species, a level that will result in regulatory action. The EPA set levels of concern at 2.0 ppm PCB per day for carcinogenicity.

United States FDA/EPA joint advisory for commercial fish consumption

In 2004, the FDA and EPA issued a joint advisory for women of childbearing age and children. Most kinds of fish on the market are safe and the FDA encourages consumption of up to 12 ounces of fish per week.

The FDA and EPA recommend that women of childbearing age and children limit their intake of fish, including store bought fish and tuna, to two to three meals per week (12 oz. of fish per week for an adult woman). The following species of fish could pose health problems for some individuals and should be avoided by people who are concerned about their exposure to chemical contaminants; shark, swordfish, king mackerel, and tilefish (also called golden snapper or golden bass).

For more information, see http://www.fda.gov/bbs/topics/news/2004/NEW01038.html.

APPENDIX B. Tables

Table 1. Assumptions used in calculations.	
Factor	Source
Body weight	EPA Manual Vol. II page 29 Also in Great Lakes Protocol Used 70 kilograms, the average for adult males and females in the United States
Meal size	EPA Manual Vol. II page 30 Also in Great Lakes Protocol Used a meal size of 227 gm or 8 oz. for adults
Meal Frequency Categories	All from Great Lakes Protocol, except for Group 3. Group 1: 225 meals per year (unrestricted) Group 2: 1 meal per week (52/year) Group 3: 2 meal per month (24/year) Group 4: 1 meal per month (12/year) Group 5: 6 meals per year Group 6: Do not eat
Reference concentrations used	Reference Doses. Population Adjusted Dose and Cancer Slope Factors are from the Integrated Risk Information System (IRIS) (www.epa.gov/iris) or Table 3.1 (U.S. EPA 2000) Health Protection Value (HPV) (GLSFATF 1993) Minimal Risk Level (MRL) pg 264 (ATSDR 1998)
Contaminant Absorption	All chemicals are assumed to be 100% absorbed.
Cancer Risk Factor	1 in 10,000 (the Interagency Agreement)
Preparation Dose Reduction	50% reduction from raw, skin-on fillets for lipophilic chemicals 30% reduction from raw, skin-off fillets for lipophilic chemicals pg 55 (GLSFATF 1993)

Table 2. Body weight and portion size chart				
Body Weight (kilograms)	Body Weight (pounds)	Average Meal Size (ounces)	Average Meal Size (grams)	Meal Size (grams per kilogram)
9 or less	20 or less	1.0	28	3.11
10 - 16	21 - 35	1.5	43	4.3 – 2.69
17 - 23	36 - 50	2.0	57	3.35 – 2.47
24 - 32	51 - 70	3.0	85	3.54 – 2.66
33 - 41	71 - 90	4.0	114	3.45 – 2.78
42 - 50	91 - 110	5.0	142	3.38 – 2.84
51 - 60	111 - 130	6.0	170	3.33 – 2.83
61 - 69	131 - 150	7.0	199	3.26 – 2.88
70 and up	151 and up	8.0	227	3.24

Table 3. Meal consumption limits for chemicals with noncarcinogenic effects								
Chemical	Skin on/off	Standard	Group 1 225 meal/year	Group 2 1 meal/week	Group 3 2 meal/month	Group 4 1 meal/month	Group5 6 meal/year	Group 6.... Do not eat
		mg/kg/day	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Arsenic		0.0003	<0.15	0.15-0.65	>0.65-1.41	>1.41-2.82	>2.82-5.63	>5.63
Cadmium		0.001	<0.5	0.5-2.17	>2.17-4.69	>4.69-9.39	>9.39-18.77	>18.77
Chlordane	on	0.0005	<0.50	0.50-2.17	>2.17-4.69	>4.69-9.39	>9.39-18.77	>18.77
Chlordane	off	0.0005	<0.36	0.36-1.55	>1.55-3.35	>3.35-6.70	>6.70-13.41	>13.41
Chlorpyrifos	on	0.003	< 3.00	3.00–13.00	>13.00-28.16	>28.16–56.32	>56.32-112.63	>112.63
Chlorpyrifos	off	0.003	< 2.15	2.15–9.28	>9.28–20.11	>20.11– 40.23	>40.23– 80.45	>80.45
Chlorpyrifos (sensitive population)	on	0.00003	<0.03	0.03–0.13	>0.13–0.28	>0.28–0.56	>0.56–1.13	>1.13
Chlorpyrifos (sensitive population)	off	0.00003	< 0.02	0.02–0.09	>0.09–0.2	>0.2–0.4	>0.4–0.8	>0.8
DDT/DDD/DDE	on	0.0005	<0.50	0.50-2.17	>2.17-4.69	>4.69-9.39	>9.39-18.77	>18.77
DDT/DDD/DDE	off	0.0005	<0.36	0.36-1.55	>1.55-3.35	>3.35-6.70	>6.70-13.41	>13.41
Diazinon		0.0007	<0.35	0.35-1.52	>1.52-3.29	>3.29-6.57	>6.57-13.14	>13.14

Table 3. Meal consumption limits for chemicals with noncarcinogenic effects								
Chemical	Skin on/off	Standard	Group 1 225 meal/year	Group 2 1 meal/week	Group 3 2 meal/month	Group 4 1 meal/month	Group5 6 meal/year	Group 6.... Do not eat
		mg/kg/day	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Dicofol		0.0004	<0.20	0.20-0.87	>0.87-1.88	>1.88-3.75	>3.75-7.51	>7.51
Dieldrin	on	0.00005	<0.05	0.05-0.22	>0.22-0.47	>0.47-0.94	>0.94-1.88	>1.88
Dieldrin	off	0.00005	<0.04	0.04-0.15	>0.15-0.34	>0.34-0.67	>0.67-1.34	>1.34
Dioxin	on	0.001 (ng/kg/day)	<1.00 (ng/kg)	1.00-4.33 (ng/kg)	>4.33-9.39 (ng/kg)	>9.39-18.77 (ng/kg)	>18.77-37.54 (ng/kg)	>37.54 (ng/kg)
Dioxin	off	0.001 (ng/kg/day)	<0.72 (ng/kg)	0.72-3.09 (ng/kg)	>3.09-6.70 (ng/kg)	>6.70-13.41 (ng/kg)	>13.41-26-82 (ng/kg)	>26.82 (ng/kg)
Disulfoton		0.00004	<0.02	0.02-0.09	>0.09-0.19	>0.19-0.38	>0.38-0.75	>0.75
Endosulfan		0.006	<3.00	3.00-13.00	>13.00-28.16	>28.16-56.32	>56.32-112.63	>112.63
Endrin	on	0.0003	<0.30	0.30-1.30	>1.30-2.82	>2.82-5.63	>5.63-11.26	>11.26
Endrin	off	0.0003	<0.21	0.21-0.93	>0.93-2.01	>2.01-4.02	>4.02-8.05	>8.05
Ethion		0.0005	<0.25	0.25-1.08	>1.08-2.35	>2.35-4.69	>4.69-9.39	>9.39
Heptachlor Epoxide	on	0.000013	<0.01	0.01-0.06	>0.06-0.12	>0.12-0.24	>0.24-0.49	>0.49

Table 3. Meal consumption limits for chemicals with noncarcinogenic effects								
Chemical	Skin on/off	Standard	Group 1 225 meal/year	Group 2 1 meal/week	Group 3 2 meal/month	Group 4 1 meal/month	Group5 6 meal/year	Group 6.... Do not eat
		mg/kg/day	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Heptachlor Epoxide	off	0.000013	<0.01	0.01-0.04	>0.04-0.09	>0.09-0.17	>0.17-0.35	>0.35
Hexachlorobenzene	on	0.0008	<0.80	0.80-3.47	>3.47-7.51	>7.51-15.02	>15.02-30.04	>30.04
Hexachlorobenzene	off	0.0008	<0.57	0.57-2.48	>2.48-5.36	>5.36-10.73	>10.73-21.45	>21.45
Lindane	on	0.0003	<0.30	0.30-1.30	>1.30-2.82	>2.82-5.63	>5.63-11.26	>11.26
Lindane	off	0.0003	<0.21	0.21-0.93	>0.93-2.01	>2.01-4.02	>4.02-8.05	>8.05
Methylmercury		0.0001	<0.05	0.05-0.22	>0.22-0.47	>0.47-0.94	>0.94-1.88	>1.88
Mirex	on	0.0002	<0.20	0.20-0.87	>0.87-1.88	>1.88-3.75	>3.75-7.51	>7.51
Mirex	off	0.0002	<0.14	0.14-0.62	>0.62-1.34	>1.34-2.68	>2.68-5.36	>5.36
Oxyfluorfen		0.003	<1.50	1.50-6.50	>6.50-14.08	>14.08-28.16	>28/16-56.32	>56.32
Polychlorinated Biphenyls (PCBs)*	on	0.00005	<0.05	0.05-0.22	>0.22-0.47	>0.47-0.94	>0.94-1.88	>1.88
Polychlorinated Biphenyls (PCBs)*	off	0.00005	<0.036	0.036-0.15	>0.15-0.34	>0.34-0.67	>0.67-1.34	>1.34

Table 3. Meal consumption limits for chemicals with noncarcinogenic effects								
Chemical	Skin on/off	Standard	Group 1 225 meal/year	Group 2 1 meal/week	Group 3 2 meal/month	Group 4 1 meal/month	Group5 6 meal/year	Group 6.... Do not eat
		mg/kg/day	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Selenium		0.005	<2.50	2.50-10.83	>10.83-23.47	>23.47-46.93	>46.93-93.86	>93.86
Terbufos		0.00002	<0.01	0.01-0.04	>0.04-0.09	>0.09-0.19	>0.19-0.38	>0.38
Toxaphene	on	0.00025	<0.25	0.25-1.08	>1.08-2.35	>2.35-4.69	>4.69-9.39	>9.39
Toxaphene	off	0.00025	<0.18	0.18-0.77	>0.77-1.68	>1.68-3.35	>3.35-6.70	>6.70
Tributyltin Oxide		0.0003	<0.15	0.15-0.65	>0.65-1.41	>1.41-2.82	>2.82-5.63	>5.63
mg/kg = milligram per kilogram or parts per million								
ng/kg = nanograms per kilogram or parts per trillion								
* The standard for PCBs, the HPV, takes into account noncarcinogenic and carcinogenic effects.								

Table 4. Meal consumption limits for chemicals with carcinogenic effects								
Chemical	Skin on/off	CSF	Group 1 225 meal/year	Group 2 1 meal/week	Group 3 2 meal/month	Group 4 1 meal/month	Group5 6 meal/year	Group 6 Do not eat
		$(mg/kg/day)^{-1}$	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Arsenic		1.5	<0.03	0.03-0.14	>0.14-0.31	>0.31-0.63	>0.63-1.25	>1.25
Chlordane	on	0.35	<0.29	0.29-1.24	>1.24-2.68	>2.68-5.36	>5.36-10.73	>10.73
Chlordane	off	0.35	<0.20	0.20-0.88	>0.88-1.92	>1.92-3.83	>3.83-7.66	>7.66
DDT/DDD/DDE	on	0.34	<0.29	0.29-1.27	>1.27-2.76	>2.76-5.52	>5.52-11.04	>11.04
DDT/DDD/DDE	off	0.34	<0.21	0.21-0.91	>0.91-1.97	>1.97-3.94	>3.94-7.89	>7.89
Dieldrin	on	16.0	<0.0063	0.0063-0.027	>0.027-0.06	>0.06-0.12	>0.12-0.23	>0.23
Dieldrin	off	16.0	<0.0045	0.0045-0.019	>0.019-0.04	>0.04-0.084	>0.084-0.17	>0.17
Dioxin	on	0.156 $(ng/kg/day)^{-1}$	<0.64 (ng/kg)	0.64-2.78 (ng/kg)	>2.78-6.02 (ng/kg)	>6.02-12.03 (ng/kg)	>12.03-24.07 (ng/kg)	>24.07 (ng/kg)
Dioxin	off	0.156 $(ng/kg/day)^{-1}$	<0.46 (ng/kg)	0.46-1.98 (ng/kg)	>1.98-4.30 (ng/kg)	>4.30-8.60 (ng/kg)	>8.60-17.19 (ng/kg)	>17.19 (ng/kg)
Heptachlor Epoxide	on	9.1	<0.011	0.011-0.048	>0.048-0.10	>0.10-0.21	>0.21-0.41	>0.41

Table 4. Meal consumption limits for chemicals with carcinogenic effects								
Chemical	Skin on/off	CSF	Group 1 225 meal/year	Group 2 1 meal/week	Group 3 2 meal/month	Group 4 1 meal/month	Group5 6 meal/year	Group 6 Do not eat
		$(mg/kg/day)^{-1}$	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Heptachlor Epoxide	off	9.1	<0.008	0.008-0.034	>0.034-0.07	>0.07-0.15	>0.15-0.29	>0.29
Hexachlorobenzene	on	1.6	<0.063	0.063-0.27	>0.27-0.59	>0.59-1.17	>1.17-2.35	>2.35
Hexachlorobenzene	off	1.6	<0.045	0.045-0.19	>0.19-0.42	>0.42-0.84	>0.84-1.68	>1.68
Lindane	on	1.3	<0.077	0.077-0.33	>0.33-0.72	>0.72-1.44	>1.44-2.89	>2.89
Lindane	off	1.3	<0.055	0.055-0.24	>0.24-0.52	>0,52-1.03	>1.03-2.06	>2.06
Oxyfluorfen	on	0.0732	<0.68	0.68-2.96	>2.96-6.41	>6.41-12.82	>12.82-25.64	>25.64
Polycyclic Aromatic (PAHs) Hydrocarbons	on	7.3	<0.014	0.014-0.059	>0.059-0.13	>0.13-0.26	>0.26-0.51	>0.51
Polycyclic Aromatic (PAHs) Hydrocarbons	off	7.3	<0.010	0.010-0.042	>0.042-0.09	>0.09-0.18	>0.18-0.37	>0.37
Toxaphene	on	1.1	<0.091	0.091-0.39	>0.39-0.85	>0.85-1.71	>1.71-3.41	>3.41
Toxaphene	off	1.1	<0.065	0.065-0.28	>0.28-0.61	>0.61-1.22	>1.22-2.44	>2.44

Table 4. Meal consumption limits for chemicals with carcinogenic effects								
Chemical	Skin on/off	CSF	Group 1 225 meal/year	Group 2 1 meal/week	Group 3 2 meal/month	Group 4 1 meal/month	Group5 6 meal/year	Group 6 Do not eat
		$(mg/kg/day)^{-1}$	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
mg/kg = milligram per kilogram or parts per million								
ng/kg = nanograms per kilogram or parts per trillion								
Note that the meal consumption limits for PCBs listed in Table 3 incorporates both noncarcinogenic and carcinogenic effects								

APPENDIX C. Examples of How to Calculate and Determine the Maximum Acceptable Concentration Range for Each Contaminant

Contaminant concentration limits for non-carcinogenic health effects

The oral reference dose (RfD_o) is defined as the maximum amount (mg) of a contaminant that may be ingested per day, per kilogram of body weight, over a lifetime without causing a non-carcinogenic adverse impact to health. In order to assure that fish consumers are not exposed to a contaminant at a rate that exceeds its RfD_o, the contaminant concentration in fish meals must satisfy the following equation (or condition). In the case that no RfD_o is available for a certain contaminant, the Health Protection Value (HPV) or Minimal Risk Level will be used instead of RfD_o.

Concentration of a contaminant in fish tissue (mg contaminant / kg fish tissue) =

$$\frac{RfD_O \text{ (mg/kg/day)} \times 365 \text{ (days/year)} \times \text{Body Weight (kg)}}{\text{Fish Meal Size (kg/meal)} \times \text{No. of Meals/year} \times \text{Preparation Dose Reduction Factor}}$$

Where:

- RfD_o, the chemical-specific oral reference dose
- For fish meal size, see table 2, Appendix B.
- For body weight, see table 2, Appendix B.
- No. of meals /year, is determined by fish meal category, as indicated in the examples below.
- Preparation dose reduction factor
  - For lipophilic chemicals (chemicals that accumulated in fat and skin, which is mostly removed during the fish meal preparation)
    - 0.5 is for fish tissue samples with skin-on,
    - 0.7 is for fish tissue samples with skin-off.
  - For non-lipophilic chemicals (chemicals that are not accumulated in fat)
    - no adjustment for meal preparation needed

Examples: (for non-carcinogenic health effects)

Non-Lipophilic contaminant (no adjustment for preparation reduction needed):

Arsenic is a non-lipophilic contaminant. Its RfD_o of is 0.0003 mg/kg/day. The maximum allowable concentration of Arsenic in fish tissue with skin-on or skin-off for each fish meal group is calculated as follows:

Group 1, 225 meals / year, (about 4 meals / week)

$$\text{Conc.(G1)} = \frac{0.0003 \text{ mg/kg/day} \times 365 \text{ days/year} \times 70 \text{ kg}}{0.227 \text{ kg} \times \textbf{225 meals/year}} = 0.15 \text{ mg/kg (ppm)}$$

Group 2, **52 meals/year** (1 meal / week),

$$\text{Conc.(G2)} = \frac{0.0003 \text{ mg/kg/day} \times 365 \text{ days/year} \times 70 \text{ kg}}{0.227 \text{ kg} \times \textbf{52 meals/year}} = 0.65 \text{ mg/kg (ppm)}$$

Group 3, 24 meals/year (2 meals / month),

$$\text{Conc.(G3)} = \frac{0.0003 \text{ mg/kg/day} \times 365 \text{ days/year} \times 70 \text{ kg}}{0.227 \text{ kg} \times \textbf{24 meals/year}} = 1.41 \text{ mg/kg (ppm)}$$

Group 4, 12 meals/year (1 meal / month),

$$\text{Conc.(G4)} = \frac{0.0003 \text{ mg/kg/day} \times 365 \text{ days/year} \times 70 \text{ kg}}{0.227 \text{ kg} \times \textbf{12 meals}/\text{year}} = 2.81 \text{ mg/kg (ppm)}$$

Group 5, 6 meals/year, (1 meal / 2 months)

$$\text{Conc.(G5)} = \frac{0.0003 \text{ mg/kg/day} \times 365 \text{ days/year} \times 70 \text{ kg}}{0.227 \text{ kg} \times \textbf{6 meals/year}} = 5.63 \text{ mg/kg (ppm)}$$

Group 6, 0 meals/year, Conc. (G6) > 5.63 mg/kg

The resultant maximum allowable concentration ranges for Arsenic in fish tissue (with skin-on or skin-off) for each fish meal group are listed below:

	Group 1 225 meals / yr	Group 2 1meal / wk	Group 3 2 meals / mo
Conc.	Up to 0.15 ppm	0.15-0.65ppm	0.65-1.41 ppm

	Group 4 1meal / mo	Group 5 6 meals / yr	Group 6 Do not eat
Conc.	1.41-2.82 ppm	2.82 – 5.63 ppm	>5.63 ppm

<u>Lipophilic Contaminant</u> (preparation dose reduction factor is needed):

Chlordane is a lipophilic contaminant. Its RfD_o is 0.0005 mg/kg/day

1) Contaminant concentration in the fish tissue samples with skin-on

The maximum allowable concentration of chlordane in fish tissue samples with skin-on in each fish meal group is calculated with the same formula used in non-lipophilic contaminants. The only difference is that the preparation dose reduction factor of 0.5 is applied as a denominator in the formula.

For example:

Group 1, 225 meals / year, (about 4 meals / week)
Preparation dose reduction factor of 0.5 is applied for the fish tissue samples with skin-on

$$\text{Conc.(G1)} = \frac{0.0005 \text{ mg/kg/day} \times 365 \text{ days/year} \times 70 \text{ kg}}{0.227 \text{ kg} \times 225 \text{ meals/year} \times \mathbf{0.5}} = 0.5 \text{ mg/kg (ppm)}$$

The resultant maximum allowable concentration ranges for chlordane in fish tissue sample **with skin-on** in each fish consumption group are tabulated below:

	Group 1 225 meals / yr	Group 2 1meal / wk	Group 3 2 meals / mo
Conc.	Up to 0.50 ppm	0.50 - 2.17ppm	2.17 - 4.69 ppm

	Group 4 1meal / mo	Group 5 6 meals / yr	Group 6 Do not eat
Conc.	4.69 -9.39 ppm	9.39 -18.77 ppm	>18.77 ppm

2) Contaminant concentration in the fish tissue samples with skin-off

The only difference in calculation between "skin-on" and "skin-off" is the preparation dose reduction factor. In the case of "skin-off", the preparation dose reduction factor of 0.7 is used instead of 0.5.

For example:

Group 2, 52 meals/year (1 meal / week),
Preparation dose reduction factor of 0.7 is applied for the fish tissue samples with skin-off

$$\text{Conc.(G2)} = \frac{0.0005 \text{ mg/kg/day} \times 365 \text{ days/year} \times 70 \text{ kg}}{0.227 \text{ kg} \times 52 \text{ meals/year} \times \mathbf{0.7}} = 1.55 \text{ mg/kg (ppm)}$$

The resultant maximum allowable concentration ranges of chlordane in fish tissue samples **with skin-off** for each fish meal group are listed below:

	Group 1 225 meals / yr	Group 2 1meal / wk	Group 3 2 meals / mo
Conc.	Up to 0.36 ppm	0.36 - 1.55 ppm	1.55 - 3.35 ppm

	Group 4 1meal / mo	Group 5 6 meals / yr	Group 6 Do not eat
Conc.	3.35 - 6.70 ppm	6.70 - 13.41 ppm	> 13.41 ppm

Contaminant concentration limits for carcinogenic health effects

In contrast to the RfD_o, which is an exposure limit of contaminants for non-carcinogenic health, the cancer slope factor (CSF) defines an actual cancer risk that is associated with a unit daily exposure dose (mg/kg/day) over a lifetime. Thus CSF can be used to derive the exposure dose at a defined acceptable risk level. The WV Interagency Agreement has set the acceptable cancer risk level at 1/10,000 (0.0001). At the risk level of 1/10,000, the exposure dose for a carcinogenic contaminant is:

$$\text{Exposure doses for a carcinogenic health effects} = \frac{\text{Risk Level}}{\text{CSF}}$$

$$= \frac{0.0001}{\text{CSF (mg/kg/day)}^{-1}}$$

The concentration of carcinogenic contaminants in fish tissue sample can be calculated using following formula:

Concentration of a contaminant in fish tissue (mg contaminant / kg fish tissues) =

$$\frac{0.0001 \times 365(\text{days/year}) \times \text{body weight (kg)}}{\text{CSF (mg/kg/day)}^{-1} \times \text{Fish meal size (kg/meal)} \times \text{No. of meals/year} \times \text{Preparation dose reduction factor}}$$

Where:

- CSF, chemical specific cancer slope factor

- 1×10^{-4} is the acceptable cancer risk level decided by WVDHHR
- For fish meal size, see table 2, Appendix B.
- For body weight, see table 2, Appendix B.
- No. of meals /year, is determined by fish meal category, as indicated in the examples below.
- Preparation dose reduction factor
  - For lipophilic chemicals (chemicals that accumulated in fat and skin, which is mostly removed during the fish meal preparation)
    - 0.5 is for fish tissue samples with skin-on,
    - 0.7 is for fish tissue samples with skin-off.
  - For non-lipophilic chemicals (chemicals that are not accumulated in fat)
    - no adjustment for meal preparation needed

Examples: (for carcinogenic health effects)

Non-Lipophilic contaminant: (no adjustment for preparation reduction needed)

Arsenic is a non-lipophilic contaminant. Its CSF is 1.5 $(mg/kg/day)^{-1}$. The maximum allowable concentration of Arsenic in fish tissue with skin-on or skin-off for each fish meal group is calculated as follows:

Group 1, 225 meals / year, (about 4 meals / week)

$$\text{Concentration (Group 1)} = \frac{0.0001 \times 365 \text{ days/year} \times 70 \text{ kg}}{1.5 \text{ (mg/kg/day)}^{-1} \times 0.227 \text{ kg} \times \mathbf{225 \text{ meals/year}}}$$

$$= 0.033 \text{ (mg of Arsenic / kg of fish tissue)}$$

Group 2, 52 meals / year (1 meal/week)

$$\text{Concentration (Group 2)} = \frac{0.0001 \times 365 \text{ days/year} \times 70 \text{ kg}}{1.5 \text{ (mg/kg/day)}^{-1} \times 0.227 \text{ kg} \times \mathbf{52 \text{ meals/year}}}$$

$$= 0.144 \text{ (mg of Arsenic / kg of fish tissue)}$$

The resultant maximum allowable concentration ranges for Arsenic in fish tissue sample in each fish consumption group are tabulated below:

	Group 1 225 meals / yr	Group 2 1meal / wk	Group 3 2 meals / mo
Conc.	Up to 0.033 ppm	0.033 - 0.14 ppm	0.14 - 0.31 ppm

	Group 4 1meal / mo	Group 5 6 meals / yr	Group 6 Do not eat
Conc.	0.31 - 0.63 ppm	0.61 - 1.25 ppm	> 1.25 ppm

Lipophilic Contaminant (preparation dose reduction factor is needed)

Chlordane is a lipophilic contaminant. Its CSF is 0.35 $(mg/kg/day)^{-1}$

1) Contaminant concentration in the fish tissue samples with skin-on

For example:

Group 1, 225 meals / year, (about 4 meals / week)
Preparation dose reduction factor of 0.5 is applied for the fish tissue samples with skin-on

$$\text{Concentration (Group 1)} = \frac{0.0001 \times 365 \text{ days/year} \times 70 \text{ kg}}{0.35 \ (mg/kg/day)^{-1} \times 0.227 \text{ kg} \times \mathbf{225 \text{ meals/year}} \times \mathbf{0.5}}$$

$$= 0.29 \text{ (mg of Chlordane / kg of fish tissue)}$$

The resultant maximum allowable concentration ranges for chlordane in fish tissue sample **with skin-on** in each fish consumption group are tabulated below:

	Group 1 225 meals / yr	Group 2 1meal / wk	Group 3 2 meals / mo
Conc.	Up to 0.29 ppm	0.29-1.24 ppm	1.24 – 2.68 ppm

	Group 4 1meal / mo	Group 5 6 meals / yr	Group 6 Do not eat
Conc.	2.68 – 5.36 ppm	5.36 – 10.73 ppm	>10.73 ppm

3) Contaminant concentration in the fish tissue samples with skin-off

The only difference in calculation between "skin-on" and "skin-off" is the preparation dose reduction factor. In the case of "skin-off", the preparation dose reduction factor of 0.7 is used instead of 0.5.

For example:

Group 2, 52 meals/year (1 meal / week),
Preparation dose reduction factor of 0.7 is applied for the fish tissue samples with skin-off

$$\text{Concentration (Group 2)} = \frac{0.0001 \times 365 \text{ days/year} \times 70 \text{ kg}}{0.35 \text{ (mg/kg/day)}^{-1} \times 0.227 \text{ kg} \times \mathbf{52 \text{ meals/year}} \times \mathbf{0.7}}$$

$$= 0.88 \text{ (mg of Arsenic / kg of fish tissue)}$$

The resultant maximum allowable concentration ranges of chlordane in fish tissue samples **with skin-off** for each fish meal group are listed below:

	Group 1 225 meals / yr	Group 2 1meal / wk	Group 3 2 meals / mo
Conc.	Up to 0.20 ppm	0.20 – 0.88 ppm	0.88 – 1.92 ppm

	Group 4 1meal / mo	Group 5 6 meals / yr	Group 6 Do not eat
Conc.	1.92 – 3.83 ppm	3.83 – 7.66 ppm	>7.66 ppm

APPENDIX D. Glossary

Acute - Occurring over a short time, up to 14 days [compare with chronic].

Adverse health effect - A change in body function or cell structure that might lead to disease or health problems.

Advisory Committee – The West Virginia Interagency Committee established by Interagency Agreement between the West Virginia Bureau for Public Health, Division of Natural Resource, and Department of Environmental Protection on November 8, 2000.

Algaecide – A pesticide used to control algae.

Bioaccumulation – the uptake and retention of chemicals by living organisms. Bioaccumulation can result in a higher chemical concentration in an organism than is in the environment.

Biomagnification – the movement of bioaccumulated chemicals from one species to another within the food chain.

Biota - Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden - The total amount of a substance in the body.

Cancer - Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Carcinogen - A substance that causes cancer.

C**arcinogenic -** Capable of causing cancer.

Carcinoma – A type of cancer of epithelial origin. One of the four major types of cancer.

Chronic - Occurring over a long time, more than one year [compare with acute].

Concentration - The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Critical health effects – Significant health effects that occur at the lowest exposure level over a range of exposures observed.

Dose (for chemicals that are not radioactive) - The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Exposure - Contact with a substance by swallowing, breathing, or contacting the substance on the skin or in the eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Fillet – The edible, muscular, portion of fish.

Forestomach – The cardiac part of the stomach.

Fungicide - A pesticide used to control fungi.

Herbicide - A pesticide designed to control or kill plants, weeds, or grasses.

Histopathology – Abnormal or adverse changes in tissue that is found with certain diseases.

Hyperexcitability - Excitability over and above that which is considered normal in a given situation or circumstance.

Immunotoxic – A substance that damages the immune system.

Ingestion - The act of swallowing something through eating, drinking, or mouthing objects.

Inhalation - The act of breathing.

Insecticide - A pesticide used to control insects.

Meal consumption limits – Recommended restrictions on the frequency of fish meals based on chemical concentrations found in fish tissue. Meal consumption limits are set to keep amounts of chemicals eaten in fish at or below levels believed to cause no adverse health effects.

Metabolism - The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite – A substance formed in the body as a result of processing another substance in the body.

Mutagenic - A substance that causes changes in DNA or the physical arrangement of the chromosomes in cells (genetic damage).

Neurotoxic - Able to chemically produce an adverse effect on the nervous system: such effects may be subdivided into effects on the central nervous system and the peripheral nervous system.

Noncarcinogenic – Not cancer causing.

Pesticide - Substances intended to repel, kill, or control any species designated a "pest" including weeds, insects, rodents, fungi, nematodes, or algae. The family of pesticides includes insecticides, rodenticides, fungicides, nematocides, and algaecides.

Prenatal – Occurring before birth.

Risk - The probability that something will cause injury or harm.

Sport fish - Game fish as defined in the DNR 2005 Fishing Regulations. They are: brook trout, brown trout, rainbow trout, golden rainbow trout, black bass (largemouth, smallmouth, spotted), striped bass, chain pickerel, muskellunge, northern pike, sauger,

walleye, white bass, rock bass, crappie, bluegill, other sunfish, channel catfish, flathead catfish, and all game fish hybrids.

Teratogenic – Of or relating to a substance that causes defects in an embryo or fetus that results in death or birth defect.

Toxicant - Agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

Tumor - An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

WV Guide – West Virginia Sportfish Consumption Advisory Guide.