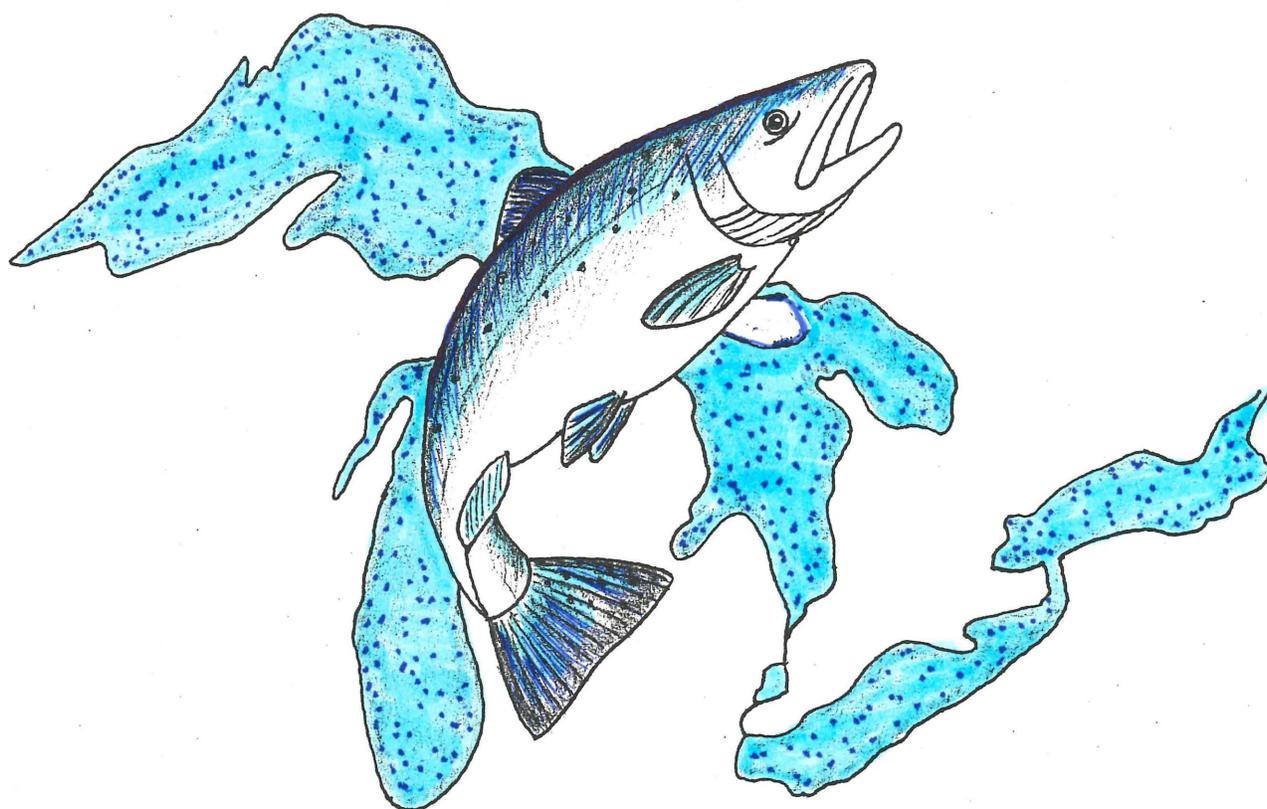# Protocol
for a
Uniform Great Lakes Sport Fish
Consumption Advisory

Great Lakes Sport Fish Advisory Task Force
September 1993

Protocol
for a
Uniform Great Lakes Sport Fish
Consumption Advisory

Great Lakes Fish Advisory Task Force
Protocol Drafting Committee

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September 1993

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Executive Summary

The Great Lakes Sport Fish Consumption Advisory Task Force

The Great Lakes Sport Fish Consumption Advisory Task Force (Task Force) was created on an ad hoc basis in the early 1980's. The informal meetings attempted to share monitoring data and coordinate Lake Michigan consumption advisories on a lake-wide basis. The Task Force was formally established on a basin-wide basis by the Great Lakes Governors' Toxics Agreement in 1986. Task Force membership includes one representative from each Public Health and Environmental or Natural Resources Agency in the eight states bordering the Great Lakes (New York, Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, and Minnesota). Additional participants have included the Canadian Province of Ontario, the USEPA and Native American organizations. The Task Force is charged with developing a uniform sport fish consumption advisory protocol applicable to all the Great Lakes. Since its inception, the Task Force has met once or twice each year to share environmental sampling results, coordinate future sampling protocols and review the appropriateness of the placement of fish in each Lake's advisory.

The advisory goals are to: 1) maintain the health benefit of fish consumption, 2) minimize the potential for angler toxic chemical exposure, 3) use credible and understandable science and, 4) present the information in a manner conducive to maximal voluntary compliance.

Many of the sport caught species in the Great Lakes are also available in commercial fish markets (lake trout, walleye, catfish, smelt, perch, buffalo, carp). Experience has shown that maximum voluntary compliance is achieved when advisories provide a reference to publicly accepted regulatory standards. Thus, when initiated in the 1970s, sport fish consumption advisories provided anglers with a qualitative comparison of their catch to the FDA tolerances for marketplace fish. However, now there is general agreement that the current FDA tolerances for market fish are not adequately protective of public health, particularly those who consume sport fish.

Recent angler surveys have found that the frequency of fish consumption among anglers far exceeds the frequencies assumed by the FDA when they established the tolerances.[44,53,64] Such consumers are not adequately protected by the FDA tolerances.[18] In addition, anglers tend to concentrate their fishing in specific geographical locations which eliminates the nationwide contaminant dilution factor assumed in FDA tolerance setting. Angler sport fish consumers deserve advice that provides adequate protection and can accommodate their desire to selectively eat sport fish as often as they wish.

In 1989, the Task Force began an in-depth review of the existing advisory protocol to assure that it met the Task Force charge and goals and utilized the most effective risk reduction communication methods available to maximize voluntary compliance. In this protocol, the Task

Force places more explicit emphasis upon quantitative methods of assessment of human health risks.

The Task Force has spent considerable time reviewing and discussing the risk of adverse health effects from consumption of contaminated sport fish. While the review and discussion has been comprehensive, priority was placed upon understanding reproductive, developmental effects and cancer risk. The Task force chose to focus the advisory protocol on PCBs, the chemical contaminant most frequently encountered in Great Lakes fish which necessitates guidance.

The advisory utilizes a weight-of-evidence derived individual health protection value (HPV) of 0.05 ug/kg/day for PCBs residue ingested from fish tissue. The HPV is intended to encompass acceptable cancer and reproductive/developmental risk. To assist in the process, the Task Force sent the final draft protocol out for peer review. The reviewers were a spectrum of scientists who had no association with the development of the HPV or protocol. The reviewer comments were helpful to the Task Force.

A risk analysis shows that this protection value is reasonable and within the margins of exposure for no observed adverse effect levels (NOAEL) for both laboratory animal and human effects (Table 2 & 3). Careful consideration has been given to the uncertainties in cancer risk estimates for PCBs in fish tissue and to the assumptions used in their derivation. Reference is made to the conventional range of acceptable cancer risk utilized for USEPA regulatory programs.

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Overview

Polychlorinated Biphenyls (PCBs) are a family of 209 individual compounds each referred to as a congener. Commercially, PCBs were sold as mixtures. In the United States the most widely used mixtures frequently contained 50 or more congeners and were marketed under the trade name Aroclor.[5] The laboratory animal toxicity testing upon which current regulations are based was done using these commercial mixtures.[28] The pattern of PCB congeners in environmental media, biota and in human tissues differ from the commercial product mixtures.[88] This is explained by differing individual congener environmental persistence and, once absorbed from the environment, differing organism efficiency in metabolizing and/or excreting the different congeners.[21] Current toxicological evaluation efforts are directed toward assessing the toxicity of individual congeners to better understand the risks posed by the mixtures found in the environment and human tissues.[29,127]

All the commercial PCBs mixtures tested have been found to cause reproductive and developmental effects in laboratory animals.[5] Ingestion no observable adverse effect levels (NOAEL), lowest observable adverse effect levels (LOAEL) and reference doses (RfD) can be calculated from these studies. Studies of wild mammals and birds have correlated the observation of adverse effects to the presence of PCBs and pesticide related residues in tissues.[105,114,115] Human investigations have confirmed that PCBs present in maternal blood cross the placenta and enter the fetal circulation.[42] PCBs are effectively excreted via lactation. Human epidemiologic studies have correlated maternal and fetal cord blood PCBs and Lake Michigan sport fish consumption with reproductive effects and infant developmental delays.[11,51,67,69] These human data have been used to estimate LOAEL and NOAEL and human RfDs.[95]

Laboratory animal studies have demonstrated that Aroclor 1260 and Aroclor 1254 cause benign and malignant liver nodules to occur.[28,125,126] However, review of these studies to re-characterize the tumors using current pathologic criteria have resulted in statistically significant excesses of tumors being described only in the studies with PCBs having 60% or greater chlorination.[119]

Assessment of human cancer risk experience has been limited to occupational exposure studies.[19,71] The results are considered equivocal for demonstrating a human cancer risk. The USEPA has categorized the whole family of PCBs on the basis of the Aroclor 1260 studies.[28] PCBs have been given a carcinogen category of B-2 by the USEPA, probable human carcinogen, sufficient evidence for animal carcinogenicity, insufficient evidence for human carcinogenicity.[28]

This report is organized to first discuss the sport fish consumption advisory protocol elements and then, using the proposed advisory protocol, present model advisories for each of the Great Lakes.

Please note that the model tables and specific advice for each of the Great Lakes are preliminary in nature and will be revised and updated to reflect the most current data prior to final advisory issuance.

Protocol Structure Components

The Task Force spent considerable time debating the components that would make up a uniform advisory protocol and would address the risk assessment and risk management issues. First and foremost was the selection of a health protection value on which to base the advisory. An appropriate value is needed to ensure a consistent and scientifically defensible human health endpoint for the protection of public health.

Each state can tailor the advisory language to fit their needs. Consistency in the overall messages that are sent to the fish consuming public is important. The Introductory Advisory Components selected by the Task Force present general information that the public needs in order to make an informed choice about fish consumption. Because the advisory is based on a weight-of-evidence human health protection value that considers all adverse health risks, including the possible link of contaminants to reproductive and cancer risk, the Task Force identified the need for a consistent statement regarding cancer risk.

A Cornell University study[46] identified specific advisory communication techniques that help effectively disseminate advisory information. The study recommendations included the preferred reading level as well as presentation style (cajoling vs. commanding language) and the use of diagrams. These suggestions have been incorporated into the advisory.

The method and statistics involved in the placement of fish into advisory categories is an integral part of an advisory. A consistent protocol is needed in order to ensure that all states use the same methods and so that there are not major fluctuations in advice from year to year.

Because a consistent advisory protocol requires a uniform sampling program, the Task Force felt it important to outline the basic components such as sample preparation and analysis.

The major advisory components which the Task Force identified and which are incorporated into the proposed protocol procedure are as follows.

Advisory Introduction Components

1. A general statement about contaminants, benefits and hazards.
2. A statement on cancer risk.
3. A statement on benefits of fish consumption.
4. Preparation and cooking advice.

Consumption Advice Components

5. Determine whether a meal unit dose reduction is appropriate to convert the raw fish residue data to a delivered dose.
6. Utilize a uniform meal size.
7. Utilize easily understood meal frequencies as Advisory Groups.

Hazard Identification Components

8. Select a fish flesh sample collection protocol for laboratory residue analysis.
9. Select uniform limits of detection for residues in tissues.
10. Establish whole fish size and species contaminant residue concentrations for use in placing fish into consumption categories.

Risk Assessment Components

11. Select a risk assessment procedure for assigning fish to consumption frequency groups.
12. Address issue of multiple contaminants.

Prospective Advisory Items

13. Develop a uniform method for deciding when to shift a size/species class into a higher or lower advisory category.
14. Coordinate the release of each state/province's annual advisory update.

The Task Force reached agreement on the specific components and the discussions on each item are summarized in the following sections. More detailed discussions of some of the issues can be found in the **Appendices I-V.**

1. A general statement about contaminants, benefits and hazards

Summary

The Task Force agreed on the use of a general hazard statement. This component is intended to provide a general overview of contaminants in fish, to give reasons as to why the public should be aware of the risks, and to serve as an introduction to the advisory. The Task Force agreed to the use of the following statement:

"Fish are good for you and good to eat. But some fish may take in contaminants from the water they live in and the food they eat. Some of these contaminants build up in the fish -- and you -- over time. These contaminants could harm the people who eat them, so it is important to keep your exposure to these contaminants as low as possible. This advisory helps you plan what fish to keep as well as how often and how much sport fish to eat. This advisory is not intended to discourage you from eating fish, but should be used as a guide to eating fish low in contaminants."

2. Statement includes cancer risk

Summary

While this advisory protocol is based on a weight-of-evidence health protection value, the Task Force acknowledges the studies linking cancer and exposure to certain contaminants and also the use of cancer risk assessment as the benchmark for regulatory programs. **Appendix I** contains a discussion of the potential cancer risks. The Task Force agreed to the use of the following cancer risk statement:

"Although this advisory is primarily based on effects other than cancer, some contaminants cause cancer in animals. Your risk of cancer from eating contaminated fish cannot be predicted with certainty. Cancer currently affects about one in every four people by the age of 70; primarily due to smoking, diet and hereditary risk factors. Exposure to contaminants in the fish you eat may not increase your cancer risk at all. If you follow this advisory over your lifetime, you will minimize your exposure and reduce whatever cancer risk is associated with those contaminants. At worst, using Environmental Protection Agency (EPA) methods, it is estimated that approximately one additional cancer case may develop in 10,000 people eating contaminated fish over their lifetime."

3. Statement includes benefits of fish consumption

Summary

In order for consumers to make an informed choice about fish consumption, the Task Force agreed that a statement regarding the health benefits from eating fish should be included. Based upon a review of the literature,[72,74,76,77,96] the Task Force agreed to the use of the following statement:

"When properly prepared, fish provide a diet high in protein and low in saturated fats. Many doctors suggest that eating a half-pound of fish each week is helpful in preventing heart disease. Almost any kind of fish may have real health benefits when it replaces a high-fat source of protein in the diet. You can get the health benefits of fish and reduce unwanted contaminants by following this advisory."

4. Provide preparation and cooking advice

Summary

The Task Force recognizes that skinning and trimming the fish and cooking it in the proper fashion can remove much of the fat from fish and therefore significantly reduce the levels of organic contaminants. Many anglers already skin and trim their fish. **Appendix II** includes a review of the literature on the impact of cleaning and cooking on the residue of contaminants in fish. The Task Force agreed to the use of the following statement in the advisory:

"Many contaminants are found at higher levels in the fat of fish. You can reduce the amount of these contaminants in a fish meal by properly trimming, skinning, and cooking your catch. Remove the skin and trim all the fat from the areas shown on the diagram below: the belly flap, the line along the sides of the fish, fat along the back, and under the skin.

Remove all skin

Cut away all fat along the back

Cut away a V-shaped wedge to remove the dark fatty tissue along the entire length of the fillet

Slice off the belly fat
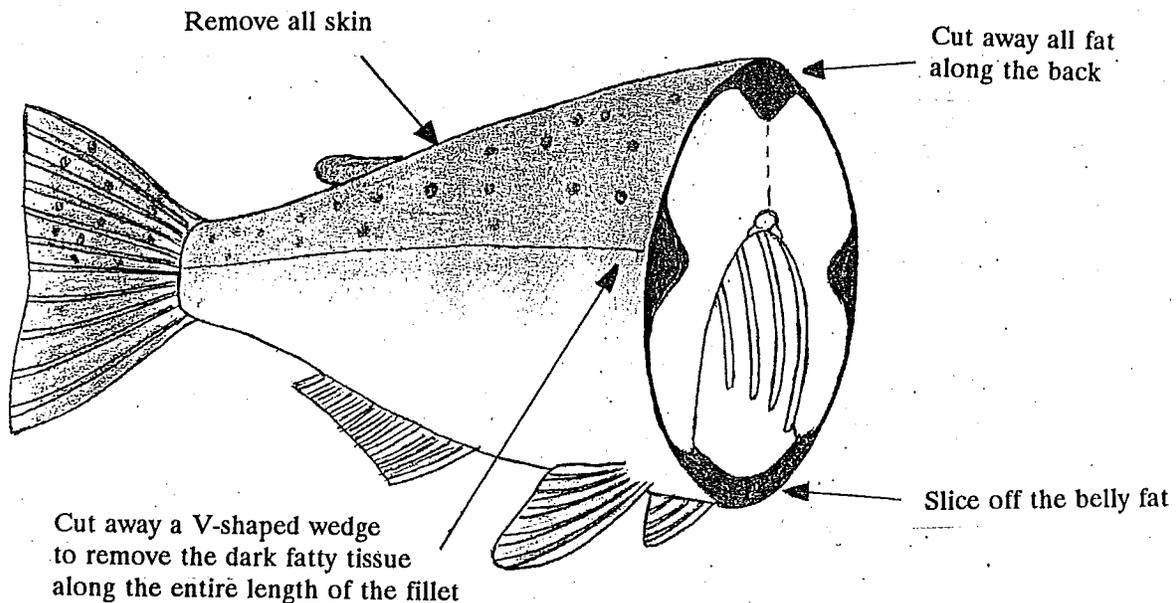
Cooking does not destroy contaminants in fish, but heat from cooking melts some of the fat in fish and allows some of the contaminated fat to drip away. Broil, grill, or bake the trimmed, skinned fish on a rack so the fat drips away. Do not use the drippings to prepare sauces or gravies.

These precautions will not reduce the amount of mercury or other metals in a meal. Mercury is distributed throughout a fish's muscle tissue (the part you eat) rather than in the fat and skin. Therefore, the only way to reduce mercury intake is to reduce the amount of contaminated fish you eat.

IMPORTANT: Follow these cleaning and cooking directions. <u>The meal advice that follows is for eating trimmed and skinned fish</u>."

5. **Determine whether a meal unit dose reduction is appropriate to convert the raw fish residue data to a delivered dose**

Summary

The states agreed to the use of a 50% reduction factor for most species. The Task Force reviewed a number of documents related to contaminant reduction through various preparation methods (See **Appendix II**) The Task Force realizes that there may be inter-species variances in contaminant reduction by following the suggested guidelines, but feel the 50% reduction factor provides adequate representation of the various species encountered by consumers of sport fish. The standing committee will review this factor annually as more species specific reduction factors for cooking and cleaning methods become known.

NOTE: A 30% (0.3) reduction factor[157] will apply to species that are analyzed as skin-off fillets or skin-off steak (See **Appendix III**).

6. **Utilize a uniform meal size**

Summary

The Task Force agreed to the use of a 1/2 pound of raw fish per 70 kg body weight as the uniform meal size. It will be assumed that the meal size will change proportionally with body weight.

Most dietitians consider the best predictor of meal size to be the body mass of the individual. The meal size ratio for fish is commonly given as 227 gm/70 kg body weight. Smaller people generally eat smaller meal sizes. The 227 gm (1/2 pound) meal appears to be the most widely used for exposure assessment, often with the caveat that any overestimate provides an additional "margin of safety."

7. **Use easily understood meal frequencies as advisory groups**

Summary

The Task Force agreed to the use of the following five advisory categories which are used and commonly understood by anglers:

Unrestricted Consumption

One Meal a Week (52 meals/year)

One Meal a Month (12 meals/year)

One Meal every 2 Months (6 meals/year)

No Consumption (Do Not Eat)

A further discussion of the various ingestion rates found in the literature is provided in **Appendix IV**. **Figure 1** shows the relationship between these ingestion rate assumptions and the Task Force categories.

Figure 1

Comparison of Assumed Fish Consumption Rates
(Typical meal size assumed to be 0.5 pounds)
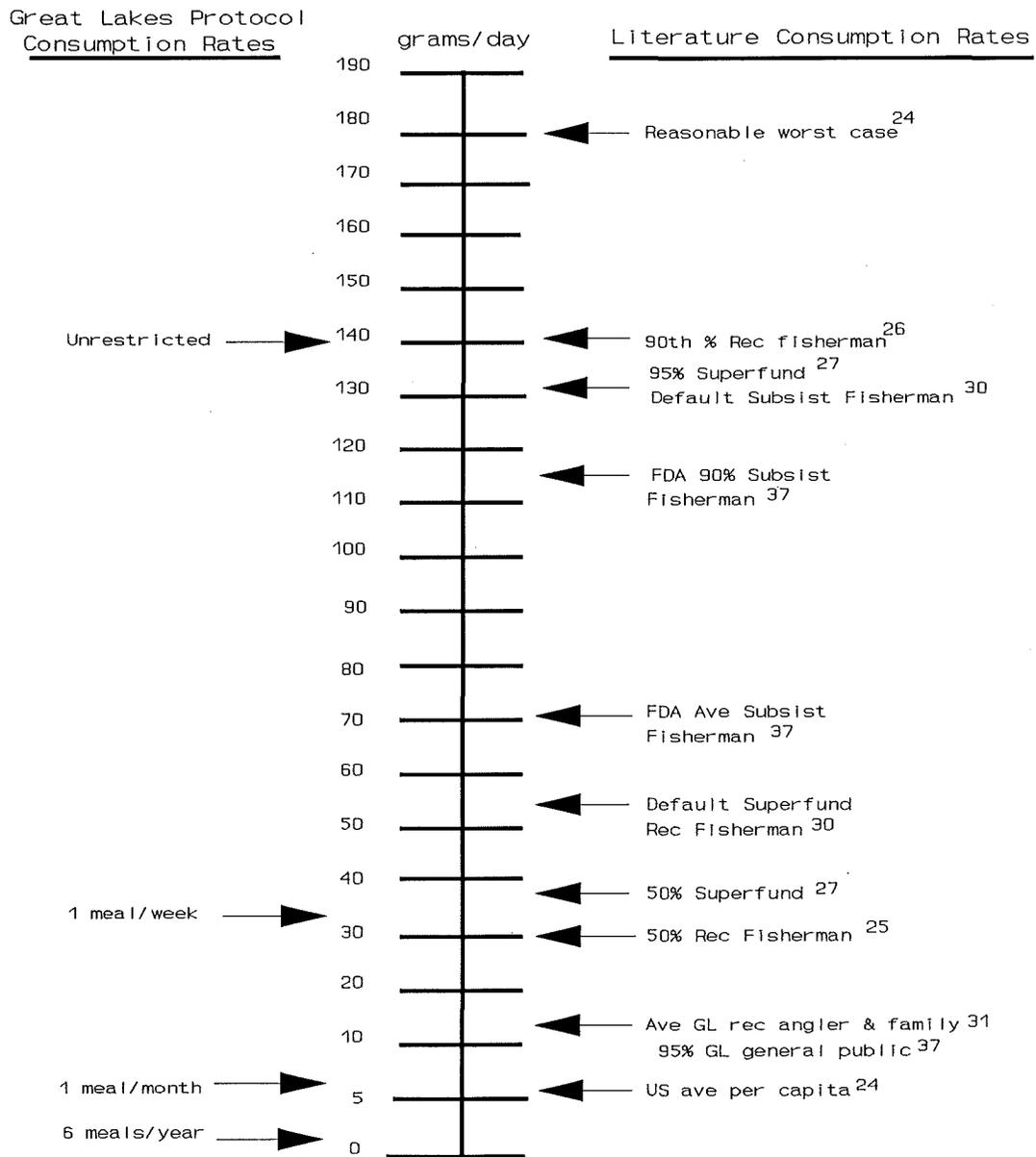
Adapted from Cox JP. TVA/WR-92/27, 1992[6]

8.   Select a fish flesh sample collection protocol for laboratory residue analysis

Summary

A raw, skin-on, fillet will be the primary sample to be analyzed for contaminants. The fish should be scaled, then filleted so as to include all flesh from the back of the head to the tail and from the top of the back down to **and including** the belly flap area of the fish. Remove all fins, the tail, head, viscera, and major bones (backbone and ribs).

The only exceptions to this sample type would be as follows: the skin will be removed from black bullhead, brown bullhead, yellow bullhead, channel catfish, flathead catfish and burbot, but fillets would still remain untrimmed. Sturgeon would be analyzed as a skin-off cross section (steak). Smelt should be gutted and the head removed. See **Appendix III** for a listing of species and associated analysis portion.

While some states use whole fish samples for trend monitoring, **whole fish samples will not be used for the purpose of issuing consumption advisories.**

9.   Select uniform limits of detection for residues in tissues

Summary

The Task Force realizes that there are certain problems with current laboratory inconsistencies in detection limits. However, the group does not feel this should alter the advisory process, but rather, the advisory process should be used to foster the development of lower detection limits, method sharing, and greater consistency among laboratories.

Therefore, an interim approach for dealing with values below current detection limits is described in **Appendix V**. However, laboratories participating in the state monitoring programs should be encouraged to achieve a PCB detection limit of at least 0.05 ppm within the next 2 years.

10.   Establish whole fish size and species contaminant residue concentrations for use in placing fish into consumption categories

Summary

Regression analysis will be the primary method used to determine placement of fish sizes into advisory groups. See **Appendix V** for a discussion of listing criteria, establishment of size ranges, compositing samples and shifting size ranges between consumption categories.

The standing committee members representing each state will meet annually to discuss new data, listing of new species/sites, and shifting of fish and/or size ranges to different consumption advice categories.

Data from so called "hot-spots" would be excluded from consideration for a lakewide advisory if it

is determined, by weight of evidence and as judged by the standing committee, that the "hot-spot" data shows significant difference from overall lakewide data.

11.   Select a risk assessment procedure for assigning fish to consumption frequency groups

Summary

The Task Force spent considerable time reviewing and discussing the selection of an appropriate adverse health endpoint(s) to use as a reference for the advisory. Instead of the usual single effect reference endpoint, a "weight-of-evidence" approach was chosen which would represent a composite of possible endpoints. However, adverse reproductive and neuro-development studies were given the most weight and included both human experience and controlled laboratory animal studies. After much discussion, a health protection value of 0.05 ug/kg/day PCB residue in sport fish was selected. The technical discussion document "Selection of a Health Protection Value for Regular Consumption of Great Lakes Sport Fish" is attached to this protocol as **Appendix I**. This document describes and summarizes the process used to select the health protection value.

A summary of the resulting risk calculations, and subsequent advisory groupings is discussed below.

Calculations for Protocol Groupings

Assumptions:

1.   Health Protection Value = 0.05 ug PCB/kg/day
2.   Average meal = 227 g (1/2 lb) uncooked fish
3.   Representative target consumer is a 70 kg adult
4.   Five advisory groups - meal rates = unrestricted (225/yr); 1/wk; 1/mo; 6/yr; none)
5.   Assume skinning/trimming/cooking reduces residues 50% from raw, skin-on filet used to assess PCB residue level.

Calculation of Maximum Daily PCB Ingestion When Following Advisory

0.05 ug/kg/day X 70 kg body weight = 3.5 ug PCB/day.   The goal of the advisory is to keep the sport fish associated dietary PCB ingestion below 3.5 ug PCB per day.

Advisory Calculations

Group 1

For unrestricted consumption or up to 225 meals/year (140 g sport fish/day)
3.5 ug/day PCB / 140 g/day fish / .5 (cleaning reduction)

0.05 ppm PCB in raw fish filet

Group 2

For consumption up to one meal a week (32 g sport fish/day)
3.5 ug/day PCB / 32 g/day fish / .5 (cleaning reduction)

0.22 ppm PCB in raw fish filet

Group 3

For consumption up to 1 meal per month (7.4 g sport fish/day)
3.5 ug/day PCB / 7.4 g/day fish / .5 (cleaning reduction)

0.95 ppm PCB in raw fish filet

Group 4

For vacationer consumption up to 6 meals/yr (3.7 g sport fish/day)
3.5 ug/day PCB / 3.7 g/day fish / .5 (cleaning reduction)

1.89 ppm PCB in raw fish filet

Group 5

Do not eat

Greater than 1.89 ppm PCB in raw fish filet

Model Advisory Groupings

Placement of fish species/size classes into consumption advice groups based upon fish tissue concentration of PCB.

<center>

Group 1
(Unrestricted Consumption)
raw fish filet with

0 - 0.05 ppm PCB

Group 2
(1 meal/week - 52 meals/year)
raw fish filet with

0.06 - 0.2 ppm PCB

Group 3
(1 meal/month- 12 meals/year)
raw fish filet with

0.21 - 1.0 ppm PCB

Group 4
(6 meals/year)
raw fish filet with

1.1 - 1.9 ppm PCB

Group 5
(No consumption)
raw fish filet with
> 1.9 ppm PCB

</center>

12.   Address the issue of multiple contaminants

Summary

The Task Force agreed that the health protection value developed for the PCBs would in most instances account for the majority of the potential health risk from the mixture of chemicals present in the fish. For areas where other contaminants are present but not predominant, the health protection value for PCBs would be protective even considering possible additive effects. In areas where other compounds are predominant (i.e., mirex, chlordane, mercury) the most stringent health advice for a given compound would be calculated using new health protection values and advisories based on that compound.

The Task Force plans to develop new health protection values for other chemicals as needed. To establish priorities for developing new health protection values in addition to PCB, the Task Force will compare the existing fish monitoring results with the RfDs developed by USEPA (IRIS). The currently available IRIS RfDs are: Aldrin (3×10^{-5} mg/kg/day), Chlordane (6×10^{-5}

mg/kg/day), DDT (5×10^{-4} mg/kg/day), Dieldrin (5×10^{-5} mg/kg/day) and Mirex (2×10^{-6} mg/kg/day). Chemicals responsible for the advisory in specific species/waterbodies will be listed in the advisory next to the subject species.

The Task Force will consider whether the next protocol revision should explicitly include a procedure to devise an health protection value index that will include the risks from all chemicals present in each species and lake monitored.

13. Develop a uniform method for deciding when to shift a size/species class into a higher or lower advisory category

Summary

The Task Force agreed there should be a documented method for shifting species and/or size classes of fish as the monitoring data warrants. **Appendix V** provides the detailed description of the method proposed.

14. Coordinate the release of each state/province's annual advisory update

The Task Force recognizes that coordination of advisory releases may not be entirely feasible since the states differ on the methods of distribution and mode of communication. Advisories that are printed in fishing regulation pamphlets would be dependent upon each individual state's fishing season. However, the standing committee for the Fish Advisory Task Force will meet annually in October to discuss new data, possible changes in advisory categories, and to coordinate advisories for the following year.

Model Advisory

A Guide to Your Health

Fish are nutritious and good to eat. But some fish may take in contaminants from the water they live in and the food they eat. Some of these contaminants build up in the fish - and you - over time. These contaminants could harm the people who eat them, so it is important to keep your exposure to these contaminants as low as possible. This advisory helps you plan what fish to keep as well as how often and how much sport fish to eat. This advisory is not intended to discourage you from eating fish, but should be used as a guide to eating fish low in contaminants.

Health Benefits

When properly prepared, fish provide a diet high in protein and low in saturated fats. Many doctors suggest that eating a half-pound of fish each week is helpful in preventing heart disease. Almost any kind of fish may have real health benefits when it replaces a high-fat source of protein in the diet. You can get the health benefits of fish and reduce unwanted contaminants by following this advisory.

Contaminants in Fish

Long lasting contaminants such as PCBs, DDT, and mercury build up in your body over time. It may take months or years of regularly eating contaminated fish to build up amounts which are a health concern. Health problems which may result from the contaminants found in fish range from small changes in health that are hard to detect to birth defects and cancer. Mothers who eat highly contaminated fish for many years before becoming pregnant may have children who are slower to develop and learn. The meal advice in this advisory is intended to protect children from these potential developmental problems. Adults are less likely to have health problems at the low levels that affect children.

Although this advisory is primarily based on effects other than cancer, some contaminants cause cancer in animals. Your risk of cancer from eating contaminated fish cannot be predicted with certainty. Cancer currently affects about one in every four people by the age of 70; primarily due to smoking, diet and hereditary risk factors. Exposure to contaminants in the fish you eat may not increase your cancer risk at all. If you follow this advisory over your lifetime, you will minimize your exposure and reduce whatever cancer risk is associated with those contaminants. At worst, using Environmental Protection Agency (EPA) methods, it is estimated that approximately one additional cancer case may develop in 10,000 people eating contaminated fish over their lifetime.

How to Use This Advisory

Measure your fish from the tip of the nose to the end of the tail. Find the location, species and size of fish you've caught in the tables that follow. The tables show each kind of fish which has been tested for contaminants. If a species is not listed, it has not been tested.

At the top of the tables, find the meal advice for the size fish you've caught. "No Restrictions" means you can eat as many meals as you like. "Do Not Eat" means no one should eat those fish because of very high contamination. The other three groups ("One Meal a Week", "One Meal a Month", "One Meal Every Two Months") are advice for how often to eat a fish meal. The amount of contaminants in a fish listed in the "One Meal a Month" group is four times higher than the amount of contaminants in a fish listed in the "One Meal a Week" group.

People who regularly eat sport fish, women of childbearing age, and children, are particularly susceptible to contaminants that build up over time. If you fall into one of these categories, you should be especially careful to space fish meals out according to the advisory table that follows. Your body can get rid of some contaminants, such as mercury, over time. Spacing the meals out helps prevent the contaminants from building up to harmful levels in the body. For example, if the fish you eat is in the "One Meal a Month Group", wait a month before eating another meal of fish from **any** restricted category.

Women beyond their childbearing years and men face fewer health risks from contaminants such as mercury. However, if you are in this group you should also follow the advisory to reduce your total exposure to contaminants. For these groups, it is the **total** number of meals that you eat during the year that becomes important and many of those meals can be eaten during a few months of the year. If most of the fish you eat are from the "One Meal a Week" category, you should not exceed 52 meals per year, likewise, if most of the fish you eat are in the "One Meal a Month" category, you should not exceed 12 meals per year. Remember, eating one meal of fish from the "One Meal a Month" group is comparable to eating four fish meals from the "One Meal a Week Group".

One meal is assumed to be one-half pound of fish (weight before cooking) for a 150 pound person. This meal advice is equally protective for larger people who eat larger meals, and smaller people who eat smaller meals.

Cleaning and Cooking Your Fish

Many contaminants are found at higher levels in the fat of fish. You can reduce the amount of these contaminants in a fish meal by properly trimming, skinning, and cooking your catch. Remove the skin and trim all the fat from the areas shown on the diagram below: the belly flap, the line along the sides of the fish, fat along the back, and under the skin.

Remove all skin

Cut away all fat along the back

Cut away a V-shaped wedge to remove the dark fatty tissue along the entire length of the fillet

Slice off the belly fat
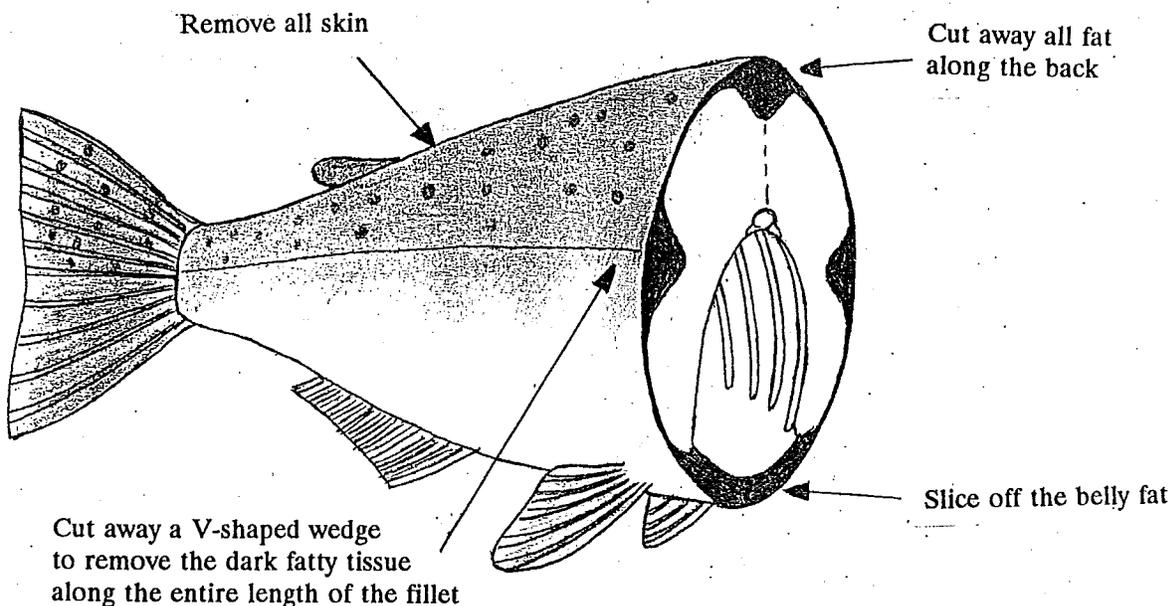
Cooking does not destroy contaminants in fish, but heat from cooking melts some of the fat in fish and allows some of the contaminated fat to drip away. Broil, grill, or bake the trimmed, skinned fish on a rack so the fat drips away. Do not use the drippings to prepare sauces or gravies.

These precautions will not reduce the amount of mercury or other metals. Mercury is distributed throughout a fish's muscle tissue (the part you eat) rather than in the fat and skin. Therefore, the only way to reduce mercury intake is to reduce the amount of contaminated fish you eat.

IMPORTANT: You must follow these cleaning and cooking directions. <u>The meal advice that follows is for eating trimmed and skinned fish.</u>

Model Advisory Tables for Each Great Lake

Task Force Proposed
Meal Advice for Eating Sport Fish from **Lake Michigan**

DRAFT   DRAFT   DRAFT   DRAFT   DRAFT   DRAFT   DRAFT

Fish	No Restriction	One Meal a Week (52 meals/year)	One Meal a Month (12 meals/year)	One Meal every 2 Months (6 meals/year)	Do NOT Eat
Carp					All Sizes
Catfish					All Sizes
Chinook Salmon			< 26"	> 26"	
Coho Salmon		< 17"	17-28"	>28"	
Brown Trout			< 18"	18-27"	> 27"
Lake Trout			< 21"	21-26"	> 26"
Walleye		< 17"	17 - 26"	> 26"	
Whitefish			< 23"	> 23"	
Yellow Perch	< 9"	> 9"			
Brook Trout			All Sizes		
Pink Salmon			All Sizes		
Rainbow Trout			< 22"	> 22"	
Smelt	All Sizes				

NOTE: This is a DRAFT advisory table proposed by the Task Force. Categories for specific fish are subject to change as new data becomes available.

Task Force Proposed
Meal Advice for Eating Sport Fish from **Lake Superior**

DRAFT   DRAFT   DRAFT   DRAFT   DRAFT   DRAFT   DRAFT

Fish	No Restriction	One Meal a Week (52 meals/year)	One Meal a Month (12 meals/year)	One Meal every 2 Months (6 meals/year)	Do NOT Eat
Lake Trout (Leans)		< 20"	20 - 27"	>27"	
Siscowet (Fats)				<20"	>20"
Chinook Salmon			All Sizes		
Coho Salmon		All Sizes			
Whitefish		All Sizes			
Rainbow Trout		All Sizes			
Brown Trout			All Sizes		
Smelt	All Sizes				

NOTE: This is a DRAFT advisory table proposed by the Task Force. Categories for specific fish are subject to change as new data becomes available.

Meal Advice for Eating Sport Fish from **Lake Erie**

DRAFT   DRAFT   DRAFT   DRAFT   DRAFT   DRAFT   DRAFT

Fish	No Restrictions	One Meal a Week (52 meals/year)	One Meal a Month (12 meals/year)	One Meal every 2 Months (6 meals/year)	Do NOT Eat
Carp			< 20"	> 20"	
Channel Catfish				All Sizes	
Coho			All Sizes		
Lake Trout				All Sizes	
Rainbow Trout (Steelhead)			All Sizes		
Walleye*		< 24"	>24"		
Yellow Perch	All Sizes				
Chinook		< 19"	> 19"		
Smallmouth Bass			All Sizes		
White Bass			All Sizes		
Freshwater Drum		All Sizes			
White Perch			All Sizes		
Maumee Bay (also follow Lake Erie advisories for species not listed below)					
Carp				All Sizes	
Channel Catfish					All Sizes

* <u>All sizes</u> of **walleye** caught in the **Michigan waters of Lake Erie** should be consumed no more than once a month and not to exceed 12 meals/year

NOTE: This is a DRAFT advisory table proposed by the Task Force. Categories for specific fish are subject to change as new data becomes available.

Task Force Proposed
Meal Advice for Eating Sport Fish from **Lake Huron**

DRAFT   DRAFT   DRAFT   DRAFT   DRAFT   DRAFT   DRAFT

Fish	No Restrictions	One Meal a Week (52 meals/year)	One Meal a Month (12 meals/year)	One Meal every 2 Months (6 meals/year)	Do NOT Eat
Chinook Salmon			< 32"	> 32"	
Coho Salmon			All Sizes		
Brown Trout			< 22"	> 22"	
Lake Trout			< 25"	> 25"	
Rainbow Trout			All Sizes		
Burbot		< 20"	> 20"		
Walleye		<21"	> 21"		
Saginaw Bay (also follow Lake Huron advisories for species not listed below)					
Carp				< 23"	> 23"
Catfish			< 15"	15 - 21"	> 21"
Walleye		< 16"	> 16"		
Yellow Perch	< 8"	> 8"			
White Sucker		< 15"	> 15"		
Thunder Bay (also follow Lake Huron advisories for species not listed below)					
Carp					All Sizes

NOTE: This is a DRAFT advisory table proposed by the Task Force. Categories for specific fish are subject to change as new data becomes available.

Task Force Proposed
Meal Advice for Eating Sport Fish from **Lake Ontario**

DRAFT   DRAFT   DRAFT   DRAFT   DRAFT   DRAFT   DRAFT

Fish	No Restrictions	One Meal a Week (52 meals/year)	One Meal a Month (12 meals/year)	One Meal every 2 Months (6 meals/year)	Do NOT Eat
Chinook Salmon			< 15"	15-38"	> 38"
Coho Salmon				All Sizes	
Lake Trout		< 14"	14-17"	17-22"	> 22"
Rainbow Trout		< 16"	16-21"	21-27"	> 27"
Brown Trout		< 14"	14-18"	18-24"	> 24"
Smallmouth Bass			All Sizes		

NOTE: This is a DRAFT advisory table proposed by the Task Force. Categories for specific fish are subject to change as new data becomes available.

APPENDIX I

Selection of a Health Protection Value
for Regular Consumption of
Great Lakes Sport Fish

Selection of a Health Protection Value
for Regular Consumption of
Great Lakes Sport Fish

Background

In 1987 and 1989 the Task Force systematically surveyed methodologies used by each of the nine Great Lakes jurisdictions for issuing fish consumption advisories. The goal was to identify common advisory criteria as well as any inconsistencies. At the May 1990 Task Force meeting the survey results were presented.[61] The results highlighted improvement in coordination, but that the goal of a truly uniform protocol had not been achieved. A strategy to achieve such a common protocol was proposed.[34] Since that time, procedures to advance toward that goal and a plan for implementation have been developed.

The decision to renew efforts to resolve jurisdictional differences of policy and scientific opinion was facilitated by the publication of the USEPA ambient water quality criteria under Section 304(a) of Clean Water Act[23], the USEPA Guidance Manual for Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish[25], the availability of the ATSDR Toxicological Profiles[1,2,3,4,5], the publication of the Technical Support Document from the National Wildlife Federation Lake Michigan Sport Fish Consumption Advisory Project[18], and the commitment of the Great Lakes Protection Fund to support research to fill data gaps.[90] A similar toxicologic review and research process was occurring concurrently in Canada.[16] These Great Lakes Basin related activities provide an excellent opportunity to achieve international and State jurisdictional agreement on a Great Lakes sport fish consumption advisory protocol.

Central to action to resolve the jurisdictional policy and procedural differences was the recognition that the existing Great Lakes fish consumption advisory protocols, which used the FDA "tolerances" and "action levels"[8] for commercial fish as a guide for advising sport angler's on fish consumption, were no longer appropriate.[18,48,54]

Some were cautious about abandoning the proven advisories. While the existing advisory protocol process was no longer considered "state-of-the-art" risk assessment as employed by the USEPA, the existing advisories were well recognized and accepted by anglers.[44,45,46,53] Documented voluntary compliance was reducing angler exposures and being reflected in reduced body burdens of contaminants in at least one state[47]. At issue was whether a significant public health risk remained for those carefully following these advisories and whether that residual risk was sufficient to warrant more restrictive advice.[18,48,54] Many states expressed concern that any change in their advisory needed to result in a significant public health gain to offset any possible increase in risk due to a decrease in compliance with a new and unfamiliar advisory. On the other hand, other states expressed optimism that compliance would increase with a new advisory that the public understood, was consistently applied across the Great Lakes. Despite these concerns about compliance, a Task Force consensus was reached that a more refined, clearly enunciated, science-based protocol was needed. However, a significant public health gain would likely occur because adoption by all Great Lakes jurisdictions would assure public confidence in the validity of the revised advice. An international agreement with Canada would complete unification and thus, resolve existing public confusion.

Introduction

From 1990 through 1992, The Task Force toxicology working sub-group, with the assistance of each jurisdictions scientific staff, systematically reviewed and discussed the risk of adverse human health effects from ingestion of the chemical contaminants present in Great Lakes sport fish. To facilitate the most efficient use of available time and resources, the toxicology group decided to focus in a stepwise fashion on different contaminants, beginning with an evaluation of PCBs.

PCBs were chosen first because: 1) they are the principal contaminant responsible for placement of fish on the current Great Lakes advisories; 2) they are the most ubiquitous contaminant and are monitored in all jurisdictions; 3) they have the largest multi-lake fish tissue data base; 4) they have been studied extensively in laboratory animals and wildlife and; 5) human exposure and health outcome data are available.

Having made the decision to no longer use the FDA tolerances as the comparison value for sport fish consumption guidance, the Task Force needed to develop an appropriate replacement. The Task Force decided to designate the new comparison an individual health protection value (HPV).

The Task Force considered utilizing alternative existing values developed by the USEPA to replace the FDA tolerance. These included the Human Cancer Potency Factor for PCBs ($q1^*$) with a selected risk level determination, and the non-cancer oral risk reference dose (RfD) approach. However, it was felt that conflict with regulatory programs would complicate adoption should the Task Force select one of these values as the HPV. For instance, a 10^{-5} risk level would be more restrictive for sport fish consumption than the 10^{-4} risk level used in the public drinking water program PCB MCL. Alternatively, a 10^{-4} choice as acceptable individual lifetime cancer risk could be interpreted to undermine a jurisdiction's Clean Water Act Section 304(a) enforcement program that utilized a more restrictive 10^{-5} or 10^{-6} criterion target for fish. Some states have a very structured process to adopt RfDs and thus could not support use of a PCB RfD that did not conform to their own methodology or already adopted values.

The complexities of the existing inter-jurisdictional regulatory differences and policies regarding cancer risk methodologies, acceptable risk levels, and RfD development could easily intrude upon the advisory process, unacceptably delaying implementation of the advisory until all the ramifications were considered and resolved.

Health Protection Value Derivation

The Task Force decided to use a weight-of-evidence approach which would consider all the existing toxicologic values and studies to develop an individual health protection value (HPV) that would be uniquely derived for the Great Lakes Sport Fish Advisory Process.

It was intended that by considering all the available information and distilling it into a single HPV the most robust and stable HPV possible would emerge. While new toxicologic information is being published regularly and the cancer risk assessment process and RfD development remain fluid, a composite HPV would be provide greater stability and be less likely to need to change

precipitously should federal science policy or individual cancer potency factors be revised, or new RfDs adopted by USEPA.

The Task Force did not develop and utilize a quantitative method to assign "weights" to specific studies which could then be combined to derive the HPV. The Task Force process represented an expert committee approach. The Task force did not make judgements or weight decisions on individual studies. Thus, as one of the Peer Reviewers pointed out, it is difficult for non-task force members to fully understand how each study affected the final HPV.

A quantitative weight-of-evidence method is being developed for the Task Force by Sielken, Inc. under a Great Lakes Protection Fund grant. This project's deliverables will provide the means to explicitly assign weights to issues and studies. The set of computer programs will address carcinogenicity separately from non-cancer endpoints. This approach will allow the user to evaluate the impact of specific weighting decisions.

The Task Force had several broad parameters which guided the HPV development. The first was that the HPV should fall within the one in 10^4 - 10^6 life-time cancer risk range. The second was that toxicologic and epidemiologic studies of adverse reproductive and neuro-developmental end-points were given greater evaluation time and therefore consideration in the HPV selected than other toxicologic endpoints.

After completing the review process and discussing the strengths and weaknesses of the toxicologic data, the Task Force adopted a weight-of-evidence derived health protection value (HPV) of 0.05 ug/kg/day total PCBs residue from fish, as the basis for advice to anglers on consumption of their Great Lakes sport fish. While individually nearly all of the studies considered and referenced in this discussion had identified weaknesses and flaws, taken collectively the Task Force felt the data supported the selected HPV.

While a small residual exposure above background remains (less than an order of magnitude), the Task Force believes this HPV provides reasonable protection from adverse health effects from PCBs ingested as a consequence of consuming Great Lakes sport fish and that the HPV is soundly supported by the scientific evidence reviewed.

NOTE:

Some may view, and wish to use this HPV as an RfD. Those choosing to do so must keep in mind that, unlike the traditional RfD process which usually selects a single critical study to derive the RfD, this HPV uniquely represents a consensus of Task Force expert professional judgement on the adverse effect weight-of-evidence and is intended only for deriving the fish consumption advisory. The HPV is not intended as an acceptable "total dietary" PCB exposure as it only addresses that part of the total exposure that comes from sport fish. The HPV is not dependent upon an individual animal or human study, or a single adverse outcome endpoint.

The Task Force recognizes that State and USEPA derived RfDs and Cancer Potency Factors are valuable in risk assessment and risk management and do not advocate that our HPV supplant their validity and continued use.

Adverse Health Effects

The Task force believes that whenever possible it is preferable to base risk assessments on human epidemiologic data. Because of the inherent exposure assessment weaknesses and·potential for confounding, such human data has seldom been used as the principle support for quantitative risk assessment. With these caveats in mind, the Task Force placed emphasis upon review of the human epidemiologic studies and specifically those most relevant to ingestion of sport fish, but not to the exclusion of traditional toxicologic evidence from animal studies. There have been many reviews of the published literature on the observed adverse effects of PCB ingestion by laboratory animals and humans.

The published literature contains hundreds of articles detailing the toxicology of PCBs as well as pesticide residues commonly identified in Great Lakes fish species.[5,11,18,21,25,71,95,118,127] The Task Force was not charged with the task of providing a comprehensive written review of this literature. Many excellent reviews are available and, for those wishing more detailed information, the Task Force has provided selected summary references **(references 1 -31)**, key individual human epidemiologic studies specifically reviewed by the Task Force **(references 32 - 99)**, and laboratory animal toxicologic studies **(references 100 - 138)**, and studies related to toxicant reduction from trimming, other preparation and cooking techniques **(references 139 - 157)** in **Appendix VI.**

The following sections are intended to outline the scientific conceptual framework for the Task Force derived health protection value (HPV).

Cancer Risk

Quantitative carcinogen risk assessment has become the standard methodology utilized in the United States to model potential human cancer risk from specific exposure circumstances.[22] The regulation of most carcinogens is based upon the results of such assessments coupled with the selection of an acceptable lifetime cancer risk, usually between 1×10^{-7} and 1×10^{-4}. While conceptually simple, the multiplicity of animal to man extrapolation models, default assumptions, and toxicologic uncertainties in the predictive value of the results have led to risk estimates, based upon the same animal study, which differ by several orders of magnitude.[75] For this methodology to meet the regulatory programmatic needs of the USEPA, that agency developed a policy statement which provided a uniform approach to consistent, comparable risk estimates.[22] Scientific advances, especially in toxicology and laboratory science since the policy was implemented, have led to careful scrutiny and re-evaluation of the current carcinogen risk assessment practices.

Unfortunately, the two federal agencies with programs related to fish residues (FDA[8] and USEPA[22]), historically and currently, continue to utilize different cancer risk estimate methodologies. For instance, to extrapolate the small laboratory animal dose to a human dose the USEPA uses a surface area scaling factor (body weight to the 2/3 power) and the FDA utilizes a body weight scaling factor. This single difference, one of several, produces risk estimates nearly an order of magnitude different when applied to data generated from the Norback et al. rat bioassay.[126] Differences such as this cause public confusion. When these and other agency policy differences are carried through to final regulatory standards, the differences between agencies

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become even greater. The current draft of the USEPA document "Fish Sampling and Analysis: A Guidance Document for Issuing Fish Advisories"[31] recommends a fish tissue screening value of 0.01 ppm PCBs. The FDA PCBs tolerance for commercial fish is 2.0 ppm. The Task Force has repeatedly encouraged the agencies to resolve their differences and adopt a single methodology.

In response to the state's priority for a uniform scaling factor, the USEPA, FDA and Consumer Products Safety Commission published a compromise consensus method for cross-species scaling on the basis of body weight raised to the 3/4's power.[116] Application of this technical adjustment would reduce the current EPA Human Cancer Potency Factor (q1*) from 7.7 $(mg/kg/day)^{-1}$ to 4.95 $(mg/kg/day)^{-1}$.

Laboratory Animal Toxicology

Despite the 1992 interagency agreement to use the new scaling factor, the USEPA Human Cancer Potency Factor (q1*) as listed in the USEPA Integrated Risk Information System (IRIS)[28] remains 7.7 $(mg/kg/day)^{-1}$ and the FDA has not begun to re-evaluate their PCB tolerance for commercial fish. The IRIS value is derived from the 1985 study by Norback and Weltman[126] which reported an excess of both benign and malignant liver tumors among female Sprague-Dawley rats chronically fed Aroclor 1260.

In 1991 a review of four of the 2-year oral exposure rat bioassay studies was completed.[119] The criteria for classifying hepatic proliferative lesions in the rat had been revised by the National Toxicology Program[123] since the four bioassay results had been published. The review confirmed the carcinogenicity of Aroclor 1260 (no changes in classification of lesions in the Norback and Weltman study) and in the other two 60% chlorination of PCBs studies.[120,128] Reclassification of some lesions seen in the Aroclor 1254 bioassay[125] resulted in the loss of statistical significance for either increased benign or malignant tumors.

The IEHR[119] report proposed a new methodology for calculating a Human Cancer Potency Factor for PCBs with 60% chlorination. They recommended using the geometric mean of the cancer potency factors derived using the results from the new pathology review classification of the four study groups. This methodology would yield a Human Cancer Potency Factor of 1.9 $(mg/kg/day)^{-1}$.[119]

Human Epidemiological Studies

All the human cohort mortality studies of exposure to PCBs involve occupational settings.[19,36,39,40,59,71,86] In an industrial setting, the route of exposure is predominantly via inhalation and/or skin absorption rather than ingestion. The human cancer experience data is inconsistent and as a whole inconclusive as to cancer risks identified.[5] These and other studies have not been used to quantitatively develop human cancer unit risk estimates. The Task Force agrees with the USEPA conclusion that the existing human occupational mortality data, while supportive of the animal studies, does not lend itself to cancer risk extrapolations.[28]

Because PCBs and some chlorinated pesticides such as DDT/DDE have been shown to have cancer promotor and estrogen-like activity, associations with other cancers have also been

investigated.[12] A recent study suggested PCBs may play a role in the development of breast cancer.[50] Another, larger case-control study able to control for more confounding risk factors found a statistically increasing risk of breast cancer for women as their serum DDT/DDE residues increased. PCBs, while showing an upward risk trend, did not reach statistical significance.[99]

Conclusion

PCBs have been given a carcinogen category of B-2 by the USEPA, probable human carcinogen, sufficient evidence for animal carcinogenicity, insufficient evidence for human carcinogenicity.[28] Considerable uncertainties in estimating human cancer risk from prolonged consumption of sport fish contaminants exist. The observation that PCBs in fish and human tissues do not have the same congener pattern as the commercial grade 60% chlorinated PCB found to be carcinogenic in small laboratory animals, adds further uncertainty to using human cancer risk estimation as the sole basis for a sport fish consumption advisory. These issues led to the Task Force decision to not base the advisory HPV solely upon a Human Cancer Potency Factor ($q1^*$) but rather utilize a weight-of-evidence derived value and discuss the range of possible life-time cancer risks for that value.

Non-cancer Risk

To predict human health effects from laboratory animal exposure to non-carcinogenic chemicals, toxicologists rely upon the concept that a threshold dose exists below which no effects are observed and that predictably humans respond to chemicals in a similar fashion to laboratory animals. Animal bioassays with multiple exposure levels are specifically designed to determine the dose of a chemical at which no observable adverse effects occur. This dose is known as the NOAEL. If a NOAEL can not be identified from the study (all exposures cause an adverse effect) then the lowest dose causing an adverse effect is called the lowest observable adverse effect level (LOAEL). While laboratory animal bioassays are most commonly utilized to establish LOAEL and NOAELs, human epidemiological studies can sometimes be utilized.

A Reference Dose (RfD)[49] can be determined from the NOAEL or LOAEL by dividing by uncertainty factors. Uncertainty factors to account for differences between species, differing sensitivity within a species, experiment duration or using a LOAEL instead of a NOAEL.[28] When uncertainty factors (up to 10X each) are combined, typical total adjustments for uncertainty ranges from 100X to 1000X. The RfD is thus based on the assumption that thresholds exist for certain toxic effects. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.[28]

Table 2 and Table 3 summarize some of the NOAELs and LOAELs derived from published studies and RfDs which others have developed and used. These are offered for comparative purposes.

Laboratory Animal Toxicology

The USEPA is currently reviewing all available animal bioassay data with the goal of establishing RfDs for as many individual Aroclor mixtures as possible. To date they have proposed one RfD for Aroclor 1016.[28]

In the past they have used the NOAEL for Rhesus monkey (Aroclor 1248 exposure) postnatal decreased body weight (14 ug/kg/day) and an uncertainty factor of 100 to generate an oral Rfd of 0.1 ug/kg/day. This RfD was used in the development of a PCBs drinking water advisory level of 3.5 ug/L for adults.[15,24,109]

Preliminary USEPA reviews suggest an oral RfD for Aroclor 1254 in the range of 0.05 ug/kg/day based on the Rhesus monkey studies showing immunological and menstrual/endocrine abnormalities and applying an uncertainty factor of 100. These effects occurred at a LOAEL of 5 ug/kg/day.[134]

The USEPA also intends to derive an RfD for PCB congener mixtures most commonly found in the environment. Such an RfD is likely to be a composite of multiple non-cancer bioassays.

IRIS Summary Aroclor 1016 RfD

The IRIS Aroclor 1016 RfD has been controversial and is the subject of a pending lawsuit. Many

of the studies reviewed by USEPA during the development of the RfD were considered by the Task Force. Because the IRIS review is concise the Task Force felt it was appropriate to present it. The review is presented for its study summaries not for its conclusions.

Since 1/1/93 the USEPA has listed on IRIS a reference dose (RfD) for Aroclor 1016. The USEPA review for Aroclor 1016 used a monkey reproductive bioassay to derive a reduced birth weights LOAEL of 28 ug/kg/day and a NOAEL 7 ug/kg/day.[107,121,130,131] An uncertainty factor of 100 was used to derive an Aroclor 1016 oral RfD of 0.07 ug/kg/day.

RfD Summary Table From IRIS

IRIS

Topic: AROCLOR 1016

Critical Effect	Experimental Doses*	UF	MF	RfD
Reduced birth weights	NOAEL: 0.25 ppm in feed (0.007 mg/kg-day)	100	1	7E-5 mg/kg-day
Monkey Reproductive Bioassay	LOAEL: 1 ppm in feed (0.028 mg/kg-day)			
Barsotti and van Miller, 1984[107]; Levin et al., 1988[121]; Schantz et al., 1989, 1991[130,131]				

*Conversion Factors: Dams received a total average intake of 4.52 mg/kg (0.25 ppm) or 18.41 mg/kg (1 ppm) throughout the 21.8-month (654 days) dosing period. These doses are equivalent to 0.007 mg/kg-day and 0.028 mg/kg-day for the identified NOAEL and LOAEL respectively.

Toxicology Summary from IRIS[28]

These are a series of reports that evaluated perinatal toxicity and longterm neurobehavioral effects of Aroclor 1016 in the same groups of infant monkeys.[107,121,130,131] Aroclor 1016 is a commercial mixture of polychlorinated biphenyls (PCBs) devoid of chlorinated dibenzofurans.[107] Analysis of the commercial feed used for this study revealed contamination with congeners specific for Aroclor 1248, present in the parts per billion range. These congeners were present in the control as well as test diets.

Aroclor 1016 was administered to groups of 8 adult female rhesus monkeys via diet in concentrations of 0, 0.25 or 1.0 ppm for approximately 22 months. Based on a reported total Aroclor intake of 4.52 and 18.41 mg/kg over the 22 month exposure period,[130,131] the low- and high-doses are estimated to be 0.007 and 0.028 mg/kg-day, respectively. Exposure began 7 months prior to breeding and continued until offspring were weaned at age 4 months. No exposure-related effects on maternal food intake, general appearance, hematology, serum chemistry (SGPT, lipid, and cholesterol analyses) or number of breedings were observed.[107]

All monkeys had uncomplicated pregnancies, carried their infants to term and delivered viable offspring. Teratologic examinations were not performed. Mean birth weights of the infants in the control, 0.007 and 0.028 mg/kg-day dose groups were 521 g, 491 g and 442 g, respectively.[107] The

decrease in birth weight in the high-dose group was significantly ($p < 0.01$) lower than in controls. Further statistical analysis of the infant birth weight data by the Agency indicated that gestation length did not significantly affect birth weight and the distribution of male and female infants in the various dose groups could not account for the difference in birth weights among the dose groups. Agency reanalysis of the data confirmed the significant decrease in body weight for the high-dose infants, although slightly different average values were obtained.

Males that had sired some infants were exposed to Aroclor 1248, so the birth weight data were also analyzed excluding these infants. The results for this adjusted data indicated that control infants weighed 528 g, low-dose infants weighed 486 g, and high-dose infants weighed 421 g. Even with this adjustment there was still a significant difference ($p < 0.01$) in birth weight for the high-dose group when compared with controls.

No significant differences between treatment and control groups were detected in neonatal head circumference or crown-to-rump measurements. Both exposure groups showed consistent weight gains, but infant weights in the high-dose group were still lower (864 g) at weaning, although not significantly different from the controls (896g).

Hyperpigmentation was present at birth in the low- and high-dose infants but did not persist once dosing was stopped. This clinical change was determined not to be a critical adverse effect. The concentration of Aroclor 1016 in breast milk was higher than the maternal dose. No exposure-related hematologic effects were observed in the infants during the nursing period.[107] One of the offspring in the high-dose group went into shock and died on the day following weaning for unknown reasons.[130,131]

Behavioral testing of the infant monkeys was first performed at age 14 months and no overt signs of PCB toxicity were observed.[130,131] Two-choice discrimination-reversal learning was assessed using simple left-right spatial position, color and shape discrimination problems, with and without irrelevant color and shape cues. One of the offspring in the low-dose group stopped responding early in testing for an unknown reason and could not be induced to resume; therefore, test results were obtained using 6, 7 and 6 infants in the control, low- and high-dose groups, respectively. The offspring in the high-dose (0.028 mg/kg-day) group were significantly ($p < 0.05$) impaired in their ability to learn the spatial position discrimination problem (i.e., achieved 9 correct choices in 10 trials), requiring more than 2.5 times as many trials as their age-matched controls. There were no significant learning differences between these groups on this problem during overtraining (ability to achieve greater than or equal to 90% correct choices in two consecutive daily sessions) or position reversals.

The only other exposure related effect was significantly facilitated learning ability ($p < 0.05$) on the shape discrimination problem at 0.028 mg/kg-day. Performance on delayed spatial alternation (a spatial learning and memory task) was assessed in the offspring monkeys at age 4-6 years.[121,131] The two Aroclor-exposed groups were not significantly different from controls ($p < 0.05$) in test performance. However, the exposed groups did significantly ($p < 0.05$) differ from each other. The difference between the two exposed groups was due to a combination of facilitated performance at the low-dose (0.007 mg/kg-day) and impaired performance at the high-dose (0.028 mg/kg-day). Although these data are insufficient for establishing an exposure-effect relation due to the lack of difference between exposed and control groups, the investigators suggested that the performance deficit at 0.028 mg/kg-day may have been exposure related.

The investigators noticed that a paradoxical biphasic effect occurred on the same test when comparing low-dose and high-dose infants. This same effect has been observed for lead-exposed monkeys. To summarize the above, adult monkeys that ingested 0.007 or 0.028 mg/kg/day doses of Aroclor 1016 for approximately 22 months showed no evidence of overt toxicity. Effects occurring in the offspring of these monkeys consisted of hairline hyperpigmentation at greater than or equal to 0.007 mg/kg-day, and decreased birth weight and possible neurologic impairment at 0.028 mg/kg-day. Based on the reduced birth weights of prenatally-exposed monkeys, the 0.007 mg/kg-day dose is the NOAEL and the 0.028 mg/kg-day dose is a LOAEL in monkeys.

The results of the neurobehavioral tests in the monkey offspring at 14 months and 4-6 years of age indicate adverse learning deficits at the 0.028 mg/kg-day maternal dose. Evaluation of these data is complicated by possible inconsistencies in the outcome of both the discrimination-reversal learning tests (learning was impaired and facilitated on different problems) and the delayed spatial alternation test (performance significantly differed between the two exposed groups, but not between either test group and the control). However, there is evidence suggesting that deficits in discrimination-reversal learning and delayed spatial alternation are related to decreased brain dopamine,[131] which has been observed in monkeys orally exposed to Aroclor 1016.[132,133]

Behavioral dysfunctions, including deficits in visual recognition and short-term memory, also have been observed in infants of human mothers who consumed fish contaminated with PCB mixtures of unknown composition.[51,52,56,67,70]

Uncertainty Factor Discussion from IRIS[28]

A 3-fold factor is applied to account for sensitive individuals. The results of these studies, as well as data for human exposure to PCBs, indicate that infants exposed transplacentally represent a sensitive subpopulation.

A factor of 3 is applied for extrapolation from rhesus monkeys to human. A full 10-fold factor for interspecies extrapolation is not considered necessary because of similarities in toxic responses and metabolism of PCBs between monkeys and humans and the general physiologic similarity between these species. In addition, the rhesus monkey data are predictive of other changes noted in human studies such as chloracne, hepatic changes, and effects on reproductive function.

A factor of 3 is applied because of limitations in the data base. Despite the extensive amount of animal laboratory data and human epidemiologic information regarding PCBs, the issue of male reproductive effects is not directly addressed and two-generation reproductive studies are not available. As the study duration was considered as somewhat greater than subchronic, but less than chronic, a partial factor of 3 is used to account for extrapolation from a subchronic exposure to a chronic RfD.

Other Federal Agency RfD or Equivalent Values

Table 1 summarizes RfDs adopted or recommended by various groups. The **Agency for Toxic Substances and Disease Registry** (ATSDR) in their Toxicological Profile for Selected PCBs[5] summarized the NOAEL, LOAEL results from 118 studies in Table 2-2 of that document. They organized the adverse effects into six outcome groups; death, systemic effects, immunological, developmental, reproductive and cancer.

Although similar to an RfD, the ATSDR derives a value they refer to as the Minimal Risk Level (MRL). The MRL for PCBs is 0.005 ug/kg/day. ATSDR concluded immunological effects appear to be the most sensitive health endpoint and chose the Tryphonas et al.[135], 27 month, 7 days per week Aroclor 1254 gavage of monkeys study as the basis for deriving their MRL. In that study decreased IgG and IgM response to sheep red blood cells was seen at the lowest exposure dose of 0.005 mg/kg/day. This LOAEL was divided by an uncertainty factor of 1000 to derive the MRL.

The **Tennessee Valley Authority** (TVA) in their evaluation of their fish tissue contaminant data[6] developed and utilized a RfD for PCBs of 0.05 ug/kg/day.

The Biological Water Quality Subcommittee of the **Ohio River Valley Sanitation Commission** (ORSANCO) in their 1989 draft proposed an RfD of 0.1 ug/kg/day for low chlorinated PCBs such as Aroclor 1016 and 1242[20] based upon the same monkey study[107] used by the USEPA in 1988 to derive the RfD used in the water quality criteria document. The adverse heath endpoint was low infant birth weight with a NOAEL of 0.01 mg/kg/day and an uncertainty factor of 100.

They proposed a separate RfD for the higher chlorinated PCBs such as Aroclor 1254 and Aroclor 1260. The reference dose was an order of magnitude lower at 0.01 ug/kg/day.

The **Joint FAO/WHO Expert Committee on Food Additives** evaluated PCBs in 1990. They concluded that they could not establish a precise numerical value for tolerable intake in humans. They identified the monkey bioassay as the most appropriate animal model for estimating human risks from PCBs. From the monkey studies they considered, they concluded that 0.04 mg/kg/day was the no effect level.[7]

After completing their 1989 review of the PCB literature, the **National Wildlife Federation** utilized three oral RfDs of 0.05 ug/kg/day (thyroid/endocrine dysfunction in rats), 0.2 ug/kg/day (liver function abnormality) and 0.01 ug/kg/day (behavior/neuro-development delay) when calculating their hazard index.[18]

For the thyroid/endocrine RfD the NWF relied upon two studies. The first[112] exposed groups of 10 female Sprague-Dawley rats to Aroclor 1254 for five months and observed a significant depression in serum T_4 levels at the lowest dose (0.05 mg/kg/day). This dose did not result in significant liver toxicity. The second study[113] exposed groups of 10 Sprague-Dawley rats to Aroclor 1254, 1242 and 1016 for five months and observed decreased adrenal weight and decreased serum adrenal hormone levels at the lowest dose (0.05 mg/kg/day). The NWF applied an uncertainty factor of 1000 to the LOAEL derived from these studies (0.05 mg/kg/day) to derive this RfD.

The NWF selected the study by Bruckner et al.[111] as the basis for their liver toxicity based RfD. This study fed groups of six Sprague-Dawley rats Aroclor 1242 containing diets for up to six months. At the lowest dose (0.2 mg/kg/day) liver lipid levels were elevated and urinary coproporphyrin excretion significantly increased. Mixed function oxidase activity was induced in a dose dependant fashion with induction occurring at the lowest administered dose. A LOAEL of 0.2 mg/kg/day) was identified. An uncertainty factor of 1000 was applied with the result of an oral RfD of 0.2 ug/kg/day.

The Allen et al[101] study of Rhesus monkeys fed Aroclor 1248 containing diets three times a week for 18 months formed the basis for the NWF RfD for developmental/behavior abnormality. Abnormal behavior patterns were seen at the lowest dose (0.01 mg/kg/day). This LOAEL of 0.01 mg/kg/day was divided by an uncertainty factor of 1000 to derive the RfD of 0.01 ug/kg/day.

Table 1

Organization
Reference Doses (RfD)

ATSDR (MRL)
0.005 ug/kg-day (neuro)

NWF
0.01 ug/kg-day (neuro)
0.05 ug/kg-day (liver)
0.2 ug/kg-day (endocrine)

ORSANCO
0.01 ug/kg-day (1254/60)
0.1 ug/kg-day (1016/1242)

TVA
0.05 ug/kg-day

IRIS (Aroclor 1016)
0.07 ug/kg-day

FAO\WHO Estimate
0.04 - 0.4 ug/kg-day

Table 2

Human and Monkey Bioassay Derived NOAELs and LOAELs for PCBs

HUMAN DATA

			Margins of Exposure over 0.05 ug/kg/day[*]
NOAEL[95] (Visual recognition memory)	=	0.027 ug/kg/day	0.5
NOAEL[95] (Brazelton/Bayley motor function)	=	0.093 ug/kg/day	2.
NOAEL[85] Reproductive/behavior	=	0.05 ug/kg/day	1.
NOAEL[a] (Visual recognition memory)	=	0.048 ug/kg/day	1.
NOAEL[a] (Brazelton/Bayley motor function)	=	0.16 ug/kg/day	3.
NOAEL[b] (Visual recognition memory)	=	0.095 ug/kg/day	2.
NOAEL[b] (Brazelton/Bayley motor function)	=	0.32 ug/kg/day	6.
NOAEL[c] (Visual recognition memory)	=	0.16 ug/kg/day	3.
NOAEL[c] (Brazelton/Bayley motor function)	=	0.54 ug/kg/day	11.
NOAEL[d] (Visual recognition memory)	=	0.47 ug/kg/day	9.
NOAEL[d] (Brazelton/Bayley motor function)	=	1.61 ug/kg/day	32.

ANIMAL DATA

NOAEL[109] (Monkey - Aroclor 1248 fetal body weight)	=	14. ug/kg/day	280.
LOAEL[109] (Monkey - 1248 learning/memory)	=	1.4 ug/kg/day	28.
LOAEL[134] (Monkey - 1254 reprod/immune)	=	5.0 ug/kg/day	100.
LOAEL[107] (Monkey - 1016 learning defects)	=	28.0 ug/kg/day	560.
NOAEL[28] (Monkey 1016 body weight	=	7.0 ug/kg/day)	140.

a = PCBs half-life assumed to be 10 yrs
b = PCBs half-life assumed to be 5 yrs
c = PCBs half-life assumed to be 3 yrs
d = PCBs half-life assumed to be 1 yr

* Task Force exposure level chosen for evaluating sport fish consumption 0.05 ug/kg/day

Table 3

Human and Laboratory Bioassay Derived RfDs for PCBs

HUMAN DATA

Source	NOAEL/LOAEL	Uncertainty Factor	RfD
Tilson[95] (Visual recognition memory)	0.027 ug/kg/day	10	0.0027 ug/kg/day
Tilson[95] (Brazelton/Bayley motor function)	0.093 ug/kg/day	10	0.0093 ug/kg/day
Minnesota[85] Reproductive/behavior	0.5 ug/kg/day (LOAEL)	10	0.05 ug/kg/day

ANIMAL DATA

Source	NOAEL/LOAEL	Uncertainty Factor	RfD
USEPA[28] Monkey 1016 body weight	7.0 ug/kg/day)	100	0.07 ug/kg/day
Monkey - Aroclor 1248 body weight[109]	14. ug/kg/day	100	0.14 ug/kg/day
Monkey - 1248 learning/memory[109]	1.4 ug/kg/day (LOAEL)	100	0.01 ug/kg/day
Monkey - 1254 reprod/immune[134]	5.0 ug/kg/day (LOAEL)	100	0.05 ug/kg/day
Monkey - 1016 learning defects[107]	28.0 ug/kg/day (LOAEL)	1000	0.028 ug/kg/day
NWF[18] - rat thyroid	50. ug/kg/day (LOAEL)	1000	0.05 ug/kg/day
NWF[18] - rat liver	200. ug/kg/day (LOAEL)	1000	0.2 ug/kg/day
NWF[18] - monkey behavior	10. ug/kg/day	1000	0.01 ug/kg/day

Human Epidemiological Studies

Intuitively, the most appropriate data for assessing the non-cancer human health risks should come from human epidemiologic study. However, the strengths and advantages to the use of human data are often outweighed by inherent study design weaknesses, difficulty in determining actual exposure doses and in establishing reliable and reproducible dose-response relationships. When more than one study is available, the results are often inconsistent. Thus, animal data is often judged most appropriate for primary support of RfD development and epidemiologic data in a secondary support role.

The human health consequences of chronic, low level ingestion exposure to PCBs are not well understood. Because adverse reproductive effects are among the most sensitive effects in animal bioassays, researchers have focused investigation of possible human health effects upon adverse reproductive effects and infant and child developmental delays. Two acute PCBs poisoning episodes, one in Japan[60] and one in Taiwan[83] have been studied carefully over several decades.[73] In these instances prenatal exposure to complex mixtures of degraded PCBs produced infant developmental delay as measured by motor and mental function tests. These abnormalities persisted into the early school ages (last time examined). All the mothers had been clinically ill and many of the children also had signs and symptoms of illness. A major confounder to the study observation was the presence of heat degradation products of PCBs including highly toxic polychlorinated dibenzofurans.[73]

An occupationally PCB exposed group of female capacitor workers was studied by Taylor et al.[93] After controlling for some possible confounding factors such as twinning, sex, maternal genetic factors and illness during pregnancy, they found a statistically significant decrease in mean birth weight and gestational age. However, other confounding factors such as cigarette smoking and alcohol consumption were not assessed and the mean decrease in birth weight was small (-30 grams) and the clinical significance of the decrease questionable.

A prospective study of 856 breast fed infants in North Carolina were identified at birth and followed periodically for up to 60 months has been reported in a series of publications.[56,57,81,82] Higher in utero PCB exposure, assessed as maternal breast milk fat PCBs concentration, was associated with hypotonicity and hyporeflexia on the Brazelton Neonatal Behavioral Assessment Scales[38]. No association was seen with birth weight, head circumference or gestational age. Maternal serum, maternal breast milk, placenta and cord serum were tested. Most of the PCB levels in cord serum were below the laboratory limit of detection.

At six and 12 month followup examination, Bayleys Scales of Infant Development were used and the psychomotor index showed a downward trend with increasing transplacental exposure to PCBs.[56] Mental index scores were not associated with PCBs exposure. DDE was included in the laboratory analyses performed on breast milk fat but was not related to psychomotor scores. At subsequent examination the observed behavioral effects were not seen.[57]

A prospective study of 1112 women in Green Bay, Wisconsin who were seen at the time of a positive pregnancy test evaluated potential associations between adverse reproductive outcomes and historic Lake Michigan sport fish consumption habits.[47] The typical effects of known confounders were seen; negative associations between birth size measures and cigarette smoking, consumption of alcohol and caffeine, and positive associations with gestational age, birth order,

weight gain during pregnancy, male babies, and rural residence. Contrary to expectations, PCB exposure (sport fish consumption) was positively associated with birth weight for most women (the exception being those women who gained more than 34 lb during pregnancy). Serum PCBs concentrations were performed on 106 women and correlated positively with local sport fish consumption (Pearson correlation of 0.666). The PCBs concentration was based upon the sum of 13 individual PCB congeners. Serum PCBs sums were low (only 23% had PCBs above the detection limit of 0.6 ng/ml for each congener). The highest congener sum was 5.0 ng/ml. Consumption of highly contaminated sport fish was quite low in this population. This study suggests that if adverse reproductive effects occur due to sport fish consumption, there is likely a threshold for such effects.

A series of papers have reported prospective observation of Michigan children born to women who consumed contaminated fish from Lake Michigan.[51,52,66,67,68,69,70,84] Reduced birth weight, head circumference, gestational age and developmental behavioral changes were noted in the exposed children when compared to a group of children born to non-sport fish consuming women. The children were assessed at birth, 7 months of age and at 4 years. These studies attempted to correlate maternal sport fish consumption, serum PCBs, breast milk PCBs and cord serum PCBs with reproductive and developmental outcome observations and assess dose-response relationships. The women had consumed Lake Michigan fish for an average of 16 years, averaging 6.7 kg of fish per year, the median being two 1/2 lb meals per month. The contamination levels in the different fish species were estimated based upon research monitoring performed at the Large Lakes Research Station (USEPA) at Grosse Ile, Michigan. Actual species specific meals consumed were standardized to the equivalent contaminant level in Lake Trout. Maternal serum PCBs concentration (as Aroclor 1260) for all women averaged 5.5 ng/ml (ppb). The exposed group averaged 6.1 ng/ml and the unexposed group 4.1 ng/ml.

Dose-response analyses[52] indicated that the greatest decrease in birth weight and head circumference were seen in infants of mothers who consumed 6.6 - 41.7 kg/year. Effects were observed at consumption rates as low as 2-3.4 kg/yr. The mean birth weight was 190 grams less in the exposed group compared to the unexposed.

At seven months of age some of the children were re-evaluated and found to have decreased scores on a visual recognition memory test.[67] The decreased performance was associated with increasing cord serum PCBs concentrations but not maternal fish consumption. Maternal fish consumption was not correlated with cord serum PCBs concentration. At four years of age, cord serum PCBs levels greater than 1.5 ng/ml were associated with lowered scores on another short-term memory test (McCarthy Scale)[69], but not on the long-term memory component of the test battery. This group of children continues to be followed.

As with many human epidemiologic studies, results are difficult to evaluate. While statistically significant differences between study groups were seen, the clinical significance of the differences is difficult to assess. The actual Lake Michigan fish related PCB exposure of the women was only indirectly assessed. Despite the reports of high fish consumption, maternal serum PCBs concentrations were not markedly elevated when compared to the controls (6.1 ng/ml vs 4.1 ng/ml) far from the median 50 ng/ml serum levels seen in the frequent fish consuming anglers studied by Humphrey.[63] The dose-response relationships are not established or consistent between exposure measures. While the studies focused upon PCBs, the fish consumed were likely to contain a mix of other toxic chlorinated chemicals such as DDE, Aldrin and Dieldrin and

perhaps metals such as mercury and lead. While the PCBs concentration is likely to be a good indicator for all the chemicals present, how much of the risk described is due solely to the PCBs is unknown. While attempts were made to statistically control for other maternal risk factors known to affect the outcomes measured, not all potential confounding issues could be considered (alcohol, caffeine, maternal weight and drug usage).

Utilization of Epidemiologic Data to Estimate RfDs

Central to the ability to utilize epidemiologic health outcome data to estimate RfDs is the accuracy of the chemical dose estimation. Two options exist to estimate human NOAEL and LOAEL PCBs values from the Michigan and North Carolina cohort studies. The first is to use the available biomarker data (serum PCBs or adipose/fat PCBs concentration) and pharmacokinetics data to estimate the past exposures necessary to achieve the observed body burdens. The second method utilizes sport fish monitoring information and dietary recall of sport fish consumption to estimate the delivered dose of chemical. Both of these methods have been used to estimate RfDs.

RfD Based Upon Dose Estimation From Body Burden Residues

Human NOAELs were developed by Tilson et al. in 1990.[95] They used decreased infant motor development and infant visual recognition memory thresholds identified in a combined array of the Michigan and North Carolina reproductive study data.

For the percent abnormal on the Brazelton[38] (mean score on Bayleys) test results (primarily motor function), visual inspection of the test score data points arrayed by breast milk PCBs residue was used to identify the threshold where the effects seemed to begin. This occurred at a maternal breast milk fat PCBs residue level of 3.4 ppm (95% percentile level in the North Carolina general population data[82]). For abnormal visual recognition memory, studied only in the Michigan infants[67], a PCBs residue level of 1.0 ppm in breast milk was identified as the threshold (mean breast milk of the subset of women tested in the Michigan group was 0.8 ppm).

It was necessary to convert these breast milk PCBs threshold concentration into a mg/kg/day NOAEL before use as an RfD. Tilson did this by applying the following assumptions.

Assumptions

1. Average women is age 25.
2. Body weight 60 kg.
3. Average 60 kg women has 25% body fat.
4. Threshold for decreased infant motor function seen at 3.4 ppm PCBs in maternal breast milk fat of primiparous, 25 year old women; or at 1.0 ppm PCBs for decreased infant visual recognition memory score.
5. PCBs are equally distributed in all adipose tissue.
6. Breast milk fat PCBs concentration = body adipose tissue PCBs.
7. Once ingested, PCBs remain in the adipose tissue, ie no appreciable metabolism or excretion occurs - except via breast feeding.

Formula

PCBs NOAEL in mg/kg body weight/day = (% body fat) X (Threshold PCBs level in mg/kg breast milk fat)

(Maternal age in days)

NOAELs and resulting RfDs Proposed by Tilson

Infant Motor Function

NOAEL = 0.093 ug/kg/day
RfD   = NOAEL / uncertainty factor 10X for intra-species = 0.0093 ug/kg/day

Infant Visual Recognition Memory

NOAEL = (0.027 ug/kg/day)
RfD   = NOAEL / uncertainty factor 10X for intra-species = 0.0027 ug/kg/day

Impact on RfD of PCB Excretion/metabolism Pharmacokinetics

The Tilson approach, assuming no PCBs excretion/metabolism converts the breast milk fat NOAEL body burden to the lowest possible NOAEL expressed as a daily dose for a women of a given age. The Task Force felt modifying the Tilson model to include a PCBs mixture half-life would better fit the available pharmacokinetics information. Estimates of the kinetics of PCBs elimination from humans have been made and range from 3 months for some of the lower chlorination to 9 years for higher chlorinated congeners.

The study by Buhler et al.[41], using a single bolus oral dose of ^{13}C labeled PCBs (329 ug/kg bw) given orally to a single, 50 year old male volunteer, followed isomer specific elimination for 260 days. This study used only a single subject. Buhler found that congener 153 and 138 had half-lives of slightly less than a year (321 and 338 days) and congener 180 a shorter 124 days. Elimination of congeners followed first order kinetics.

The USEPA (Milt Clark personal communication) has concluded that this study should not be used as a basis for pharmacokinetic determinations. Their comments can be summarized as follows. The single bolus dose is quite different from the chronic low dose dietary exposures which should lead to a near equilibrium state. There are other potential confounders in this study which may have biased the results toward shortening the estimated half-lives. Little is known about the health status of the subject (ie AHH induction status). During the observation period, food was not restricted or analyzed for PCB content. The data was analyzed as the ratio of $^{13}C/^{12}C$. Other uncontrolled dietary sources of ^{12}C PCB would affect the ratio to make it appear that the rate of elimination was greater and thus shorten the half-life estimation by an unknown period. No internal laboratory standard was used to correct for extraction efficiency.

Chen attempted to estimate congener specific elimination rates of PCBs by studying the group acutely poisoned in Taiwan.[42] They reported that serum concentrations of congener #153 decreased less than 10% over 300-500 days. This data suggests a half-life of 5.4 - 9.9 years.

Congeners 153 and 138 are the two most prevalent isomers found in the Lake Michigan anglers and isomer 180 is the third most prevalent.[88]

The other studies assessing metabolism/excretion have been based upon occupational cohort studies and provide estimates specific to the Aroclor types. Phillips et al.[80] described a median half-live for Aroclor 1242 of 2.6 yrs and median of 4.8 years for Aroclor 1254.

Steele[89], and Taylor[94] calculated a mean half-life of 1.8 years for Aroclor 1242, 3.3 years for Aroclor 1254 and 4.1 years for Aroclor 1260.

Based upon these studies, it is apparent that Tilson's assumption of no metabolism or excretion was overly conservative. The impact of first order kinetic half-lives of one, three, five and 10 years upon the conversion of the PCBs breast milk fat concentration to NOAEL daily doses was considered by the Task Force.

The following summarizes the analyses performed by the Task Force.

Assumptions from Tilson et al.

1.   Average 60 kg women has 25% body fat
2.   Decreased infant motor function threshold of 3.4 ppm PCBs in maternal breast milk fat; or at 1.0 ppm PCBs for decreased infant visual recognition memory score.
3.   PCBs are equally distributed in all adipose tissue
4.   Breast milk fat PCBs concentration = body adipose tissue PCBs concentration

Additional Assumptions

1.   Theoretical mother PCBs body burden has reached a steady state equilibrium
2.   Metabolism/excretion of PCBs mixture half-life = 1 yr (365 days), 3 yrs (1095 days), 5 yrs (1825 days), or 10 years (3650 days)

Adding a half-life assumption to the Tilson model and assuming near steady state equilibrium, maternal age at time of infant birth drops out of the formula. The model estimates the annual daily dose needed to maintain the target breast milk fat PCBs body burden.

Modified Formula for Estimating NOAELs from PCBs in Breast Milk Fat

PCBs NOAEL in mg/kg body weight/day =
$$\frac{(\% \text{ body fat}) \times (\text{PCBs in mg/kg breast fat}) \times .693 \text{ (1st order kinetics)}}{(1/2 \text{ life in days})}$$

Assumption of 1/2 life = one year (365 days)

Infant Motor Function NOAEL   = 1.61 ug/kg/day
Visual Recognition Memory NOAEL   = 0.475 ug/kg/day

<u>Assumption of 1/2 life = three years (1095 days)</u>

Infant Motor Function NOAEL   = 0.54 ug/kg/day
Visual Recognition Memory NOAEL   = 0.16 ug/kg/day

<u>Assumption of 1/2 life = five years (1825 days)</u>

Infant Motor Function NOAEL   = 0.32 ug/kg/day
Visual Recognition Memory NOAEL   = 0.095 ug/kg/day

<u>Assumption of 1/2 life = ten years (3650 days)</u>

Infant Motor Function NOAEL   = 0.16 ug/kg/day
Visual Recognition Memory NOAEL   = 0.048 ug/kg/day

Comparing the NOAELs proposed by Tilson with those derived using the half-life estimate method suggests that Tilson may have underestimated the NOAELs based on a 25 year old female by a factor of 2 - 6 fold depending on the elimination kinetic assumed.

RfD Based Upon Dose Estimation From Diet

In 1990 the Minnesota Department of Health[85] completed an analysis of the non-cancer human epidemiologic data and derived an human RfD using a methodology which estimated a PCBs Lowest Observed Adverse Effect Level (LOAEL) from the dietary sport fish consumption history information in the study of Michigan sport fish consumers.[51,65,67,68,69]

<u>Assumptions Utilized in Minnesota Model Development</u>

1.   Reproductive/developmental effects were seen in the lowest exposure group
2.   7.4 g/day = fish consumption mid-point of lowest exposure group
3.   4.12 ug/g = average fish tissue PCBs residue (year of study)
4.   62 kg = average pre-pregnancy weight of study women

<u>Calculation of LOAEL</u>

1.   7.4 g/day X 4.12 ug/g = 30.5 ug/day PCBs
2.   30.5 ug/day / 62 kg = 0.5 ug/kg/day (LOAEL)

<u>Calculation of RfD</u>

A human RfD for the reproductive/ developmental effects seen in the Michigan study was derived by Minnesota by applying an uncertainty factor of 10 (conversion of LOAEL to NOAEL).

Minnesota RfD = 0.05 ug/kg/day

Conclusion

The RfDs developed by other expert groups (Table 1) ranged from 0.005 ug/kg/day to 0.4 ug/kg/day (FAO/WHO applying an uncertainty factor of 100 instead of 1000 from their NOEL of 40 ug/kg/day).

The animal bioassay derived RfDs summarized in Table 3 range over more than an order of magnitude from a low of 0.01 ug/kg/day to 0.2 ug/kg/day. The uncertainty factors used to derive the RfDs were either 100 or 1000. The RfDs clustered near the high end of the range.

NOAEL estimates from the human data range from 0.027 ug/kg/day to 1.61 ug/kg/day. RfD estimates based upon the human epidemiologic data ranged from 0.0027 ug/kg/day to 0.05 ug/kg/day. An uncertainty factor of 10 was used to derive each RfD.

The Task Force concluded that no single NOAEL or RfD was most appropriate for advisory use. A weight-of-evidence derived value that integrated all the reviewed data was the conclusion. Even though the health protection value (HPV) chosen (0.05 ug/kg/day) is the same value as some of the NOAELs and RfDs summarized, these values and the studies they were derived from should not be given or assumed to have more weight than any of the other reports reviewed.

Sensitivity Analysis

A major Task Force consideration in the decision to develop a new protocol was whether a significant public health risk remained for those carefully following the existing advisories and whether that residual risk was sufficient to warrant more restrictive advice. Any change in the advisories needed to result in a significant public health gain.

To assess the public health gain from following the new protocol, it is possible to compare the expected annual dose of PCBs anglers would accrue under the existing advisories to the target under the new protocol. The new protocol is specifically designed to limit the dose of PCBs from sport fish to less than 0.05 ug/kg/day. For a 70 kg person this would allow 3.5 ug PCBs per day or 1.3 mg PCBs per year. The current advisory does not set a target dose. However such a dose can be estimated by considering the PCBs concentration in existing sport fish and assuming consumption rates.

As an example, the most recent Wisconsin and Michigan monitoring results for coho salmon from Lake Michigan indicate the average PCBs contamination is about 0.8 mg/kg (ppm). None of the recently sampled fish exceeded 2.0 mg/kg and over the past 5 years less than 10% exceeded 2.0 mg/kg. Thus these fish fit into the "lowest" category of all current fish advisories (except Minnesota). Anglers are advised only to trim and cook fish before eating them and would allow consumption up to once a week or more.

Angler surveys indicate average consumption is about one meal per week (about 30 g/day). A 70 kg angler consuming 52 meals (1/2 lb per meal, 227 g/meal, 32 g/day) of trimmed, cooked fish would consume about 4.7 mg of PCBs per year, or roughly 4 times the target of the current

advisory. However, a recreational angler consuming at the 90th percentile[26] (140 g /day) but following advisory warnings to trim and cook fish to reduce PCBs would receive about 20,000 ug PCBs over a years time, or 16 times the new protocol's target. Therefore, depending on the advice a state gives and angler consumption patterns, anglers may be exceeding the HPV by 4 (for average angler or 50% consumption rate) to 20 times (top 10% of anglers). This exceedence could be even greater, up to 32-fold higher than the HPV, if anglers do not trim and cook the fish to minimize PCBs. For all states other than Minnesota, the new protocol does provide significant public health exposure reduction over the current advisories.

A state, such as Minnesota, that now gives maximal advice to reduce consumption could also make potential exposure reductions from the new protocol by way of increased compliance. The Minnesota advisory lists Lake Superior fish with 0.8 mg/kg PCBs in the 5 meal per year category, and assumes fish are not trimmed and cooked to maximize contaminant loss. Anglers following the current Minnesota advisory would receive 0.9 mg PCBs per year or roughly 0.75 of the target dose. This example shows that a state which already gives maximal current advice to reduce consumption will, under the new protocol continue to maintain approximately the same level of exposure. The potential public health benefit for such a state to adopt the uniform advisory is not in reducing an individual's PCB exposure but in having greater angler compliance because the uniform advisory has greater credibility.

Residual Risk

Even closely following the Task Force protocol, PCBs from sport fish will be the predominant dietary source of PCBs for anglers. The most recent 1982-1984[58,78] estimates of average PCBs dietary intake in the United States from the USFDA are 0.042 ug/day or 15.33 ug per year (1% of protocol target). This is down from the 1980-1982[55] estimate of 0.19 ug/day or 69.35 ug/year (5% of protocol target).

Estimate of Serum PCB Levels Associated With Protocol

Anglers who have had their serum PCBs level determined want to have the results interpreted. While the Task Force can not attribute an individual level of risk to such numbers or predict the likelihood of an adverse health event occurring, it is possible to estimate the contribution to serum PCBs levels under the various sport fish consumption examples discussed. The formula developed by the Task Force to evaluate the epidemiology based RfDs can be used to estimate steady-state serum PCBs.

PCBs NOAEL in mg/kg body weight/day =

$$\frac{(\% \text{ body fat}) \times (\text{mg/kg PCBs breast milk fat}) \times .693 \text{ (1st order kinetics)}}{(1/2 \text{ life in days})}$$

Solving the formula for PCBs in mg/kg breast milk fat results in the following formula which can be used to estimate the PCBs equilibrium body burden contribution under the consumption and individual parameters chosen.

$$\text{PCBs mg/kg fat} = \frac{(\text{PCBs exposure in mg/kg/day}) \times (1/2 \text{ life in days})}{(\% \text{ body fat}) \times .693 \text{ (1st order kinetics)}}$$

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<u>Additional Assumption</u>

1.   Breast milk fat PCB residue = body adipose tissue PCB.
2.   Serum = .5% lipid/fat ie PCB serum = PCB adipose/200
3.   1/2 life = 10 years (3650 days)
4.   body fat = 25% of body mass

Applying these assumptions and assuming a steady-state, long-term consumption of 3.5 ug PCBs per day, the estimate of the contribution of sport fish consumption to serum PCBs concentration is 0.36 ng/ml (ppb).

Using the 90th percentile recreational consumption rate of sport fish averaging 0.8 mg/kg (112 ug PCBs per day) the resulting contribution to serum PCBs estimate is 11.8 ng/ml.

An angler who consumes one meal a week of the 0.8 mg/kg PCBs contaminated sport fish (25.9 ug PCBs per day) would have such a diet contribute 2.7 ng/ml PCBs.

The most recent followup of the long-term fish-eaters study in Michigan found the anglers averaged 38 sport fish meals per year and their serum PCBs averaged 19.0 ng/ml. The control population who ate very little sport fish averaged 6.8 ng/ml PCBs.[62]

A recently completed survey of 108 charterboat captains in Wisconsin found average consumption of 33 sport fish meals per year. The mean serum PCBs was 9.67 ng/ml (M. O'Brien personal communication).

It must be kept in mind that the above estimates of dietary contribution to PCBs body burdens do not account for higher exposure to PCBs in the past and the slow excretion of PCBs accumulated under exposure circumstances that may have been more than an order of magnitude higher (fish contaminant levels have declined nearly 80% over the past decade). It may be a decade or more before the measured body burdens approximate the estimates.

Risk Analysis of Task Force Health Protection Value (HPV)

One method to assess the appropriateness of the health protection value is to consider the margins of exposure (MOE) around the value. Typically the MOE is the ratio of a NOAEL to the value in question. The resulting number can be compared to the uncertainty factors applied to a NOAEL to derive an RfD.

Cancer Risk

Cancer risk estimates for PCBs at the Task Force proposed HPV of 0.05 ug/kg/day using the USEPA $q1^*$ of (7.7 mg/kg/day)$^{-1}$ (95% upper bound confidence level estimate) and (5.5 mg/kg/day)$^{-1}$ (most likely estimate) are 3.8×10^{-4} and 2.7×10^{-4} respectively. These estimated cancer risks may overestimate risk by an order of magnitude given that scaling factors have changed and reanalysis of the data used to calculate the current $q1^*$ may occur. These estimates may over- or under- estimate risks given that not all PCBs mixtures have caused cancer in animals and PCBs mixture in fish do not generally match Aroclor 1260.

Although these estimated cancer risks are slightly above the 1×10^{-4} cancer risk, the upper end of the normally acceptable range for regulatory programs, the uncertainties in these cancer risk estimates specific for fish residues were recognized in the Task Force evaluation and in the selection of the HPV.

Non-cancer Risk

Table 2 includes the Margins-of-Exposure (MOE) over the NOAEL values reviewed by the Task Force proposed sport fish tissue PCBs residue dose of 0.05 ug/kg/day. For the human calculations these range from 0.5 to 32 for the NOAELs and 10 for the LOAEL. The margins of exposure over the PCBs reproductive / developmental health endpoints from the animal data ranged from 28 to 600. The margins of exposure for reproductive/developmental effects, reviewed in conjunction with the specific health endpoints and studies, are within the range normally considered acceptable by regulatory agencies and scientific advisory groups.

Peer Review of HPV

The Task Force sent the Protocol to a spectrum of scientists not associated with the development of HPV for comment specifically on the process and "weight-of-evidence" approach used by the Task Force. Five reviews were received and carefully considered by the Task Force. The reviewers provided comprehensive comments. The Task Force is grateful and appreciative that the reviewers were willing to donate their time and expertise to assist. The reviewers reaffirmed the Task Force conclusion that many of the studies considered had shortcomings. Nearly all of the reviewer comments detailed issues of which the Task Force were aware and which the Task Force had discussed at length.

This document remains a "working paper" and may well undergo further refinement. However, the Task Force felt the HPV and advisory protocol which is based upon the HPV was sufficiently complete to forward to the Council of Great Lakes Governors for further consideration.

APPENDIX II

Reduction in Lipophilic Chemicals
as a Consequence of
Sport Fish Preparation and Cooking Advice

Reduction in Lipophilic Chemicals due to Sport Fish Preparation and Cooking Advice

The proposed Great Lakes States' sport fish advisory calls for a standard raw, skin-on fillet to be used as the analytical sample. Exceptions to this include catfish, bullheads, burbot, and sturgeon for which the skin is removed. The concentration of contaminants found in the standard sample (expressed as mg/kg tissue wet weight) is utilized to place fish into the sport fish consumption advisory matrix.

To estimate the risk from consuming a standard sample of fish, it is necessary to estimate the delivered dose of chemical (usually expressed as mg/kg body weight/day.) Typically the dose is converted into units of exposure, which for sport fish consumption, is a "standard" meal. A "standard" meal is usually considered to be 1/2 lb (227 gm) of raw "standard fish fillet." Thus, a meal of 1 mg PCB/kg standard fish fillet could maximally deliver 0.227 mg PCB.

The Great Lakes Fish Advisory Task Force has decided to make quantitative risk assessment a more prominent component in the development of its sport fish consumption advisory. Each component of the risk assessment methodology is being reviewed.

In recognition that contaminants can be reduced from those found in the standard fillet, all advisories routinely highlight exposure reduction actions. These include instructions on how to trim away fatty tissue and skin and recommendations on cooking methods. The appropriateness of the risk assessment default assumption that 100% of the contaminants in the raw, skin-on fillet are ingested is being reviewed. The published literature references on the reduction of contaminants as a result of trimming of the raw fillet and/or during cooking was reviewed.

Effects of Trimming

Lipophilic chemicals preferentially concentrate in the fat of fish. In general, fish which contain high concentrations of lipid are likely to have higher concentrations of lipophilic chemicals. Lipid content of fish tissues vary with higher concentrations in skin, dorsal fat, lateral line fat and dark muscle, belly area and viscera.[149] Whole fish analyses for lipid content invariably exceed the lipid content of edible fillet portions. Trimmed edible fillets (skin, belly fat, lateral and dorsal fat and dark muscle removed) contain less lipid than the untrimmed fillet.[140,145,148,149,153] As the lipid content of the edible portion rises, there is a disproportionate rise in the total fish lipid content indicating increased lipid deposition in belly, viscera and skin. Thus it has been reported in a "fatty" fish such as lake trout the ratio of lipid content in edible portion (7.2% lipid) to whole fish (17.1% lipid) was .42 compared to a "lean" fish such as cod where the same ratio was .93 (.65% lipid vs .70% lipid).[147] This suggests that selective removal of high lipid tissues from the edible portion of a fish fillet (trimming) will be most effective at reducing lipid content (and lipophilic contaminants) the higher the lipid content in the fish.

Lipid and contaminant reduction from trimming fat and removing skin has been investigated for species relevant to the Great Lakes (lake trout,[145,146,147,149,154,155] brown trout,[143,144,148,149,153] rainbow trout,[144,147] coho salmon,[144,146,149,154] chinook salmon,[149,150] smallmouth bass,[148,149] carp,[142,151,156] perch[146]). Saltwater species (bluefish,[140,152] striped bass,[139,149] white croaker[145]) have also been tested. Representative results are summarized in **Table 1.**

Table 1

Summary of Contaminant Reductions Reported due to Trimming

Species	Activity	Contaminant	Reduction	Reference
lake trout	trimming	DDT	54%	# 146
	dressing	DDT	0%	# 146
coho	trimming	DDT	62%	# 146
	dressing	DDT	0%	# 146
brown trout	trimming	PCB,mirex	46,44%	# 153
	trimming	PCB,mirex,DDE	43,45,52%	# 148
smallmouth bass	trimming	PCB,mirex,DDE	64,64,54%	# 148
perch	dressing	DDT	90%	# 146
bluefish	trimming	PCB	59%	# 140

Effects of Cooking

Cooked-weight fish is always less than the uncooked-weight. On average, a 1/2 lb raw weight sample reduces to 1/3 lb cooked weight. During cooking weight is reduced due to loss of water, liquefying of fats and volatilization.[148,149,152,155] Different cooking methods result in different weight losses.[149,152,155] Loss of fat is usually proportional to water loss. In the studies reviewed, weight loss ranged from 15-50% depending on the cooking method. Microwave cooking resulted in the least weight loss and broiling/baking the highest.[155]

In most studies the contaminant concentration (on a mg/kg basis) after cooking was most often the same as before cooking. There was considerable variation with some tests actually resulting in higher levels in cooked than raw samples (most often broiled samples).

When weight loss and oil loss is factored in, total delivered contaminant dose per meal was consistently, significantly reduced. **Table 2** summarizes the reduction in total delivered contaminants reported due to cooking.

Table 2

Summary of Contaminant Reductions Reported
due to Cooking

Species	Activity	Contaminant	Reduction	Reference
lake trout	broiling	DDT	64 - 72%	# 146
	frying	DDT	64 - 72%	# 146
	broiling	PCB,dieldrin,DDT	53,48,39%	# 156
	Roasted	PCB,dieldrin,DDT	34,25,30%	# 156
	Microwave	PCB,dieldrin,DDT	26,47,54%	# 156
	baking	PCB	10 - 17%	# 157
	charbroiling	PCB	12 - 59%	# 157
	salt boiling	PCB	10%	# 157
brown trout	smoking	PCB,mirex,DDE	27,39,27%	# 148
	broiling	PCB,mirex,DDE	0,26,20%	# 148
smallmouth bass	baking	PCB,mirex,DDE	16,21,16%	# 148
	frying	PCB,mirex,DDE	74,75,75%	# 148
bluefish	baking	PCB	8%	# 140
	broiling	PCB	8%	# 140
	frying	PCB	8%	# 140
	poaching	PCB	8%	# 140
	baking	PCB	27%	# 152
carp	deep fat frying	PCB	32 - 42%	# 157
	pan frying	PCB	18 - 32%	# 157
chinook	baking	PCB	32 - 43%	# 157
	charbroiling	PCB	33 - 56%	# 157
	charbroiling/ scoring	PCB	42 - 51%	# 157
	canning	PCB	33 - 39%	# 157
siscowet	baking	PCB	19%	# 157
	charbroiling	PCB	30%	# 157
	salt boiling	PCB	19%	# 157

Several studies reported the combined effects of careful trimming and cooking. These are summarized in **Table 3.**

Table 3

Summary of Contaminant Reductions Reported due to Combining Trimming and Cooking

Species	Activity	Contaminant	Reduction	Reference
brown trout	trim,cook	PCB,mirex	78,74%	# 148
smallmouth bass	trim,cook	PCB,mirex	80%	# 148
bluefish	trim,cook	PCB	67%	# 140

Discussion

Taken as a whole, the literature indicates a contaminant reduction factor of 50% due to trimming and cooking is a realistic expectation for all the lipophilic contaminants of concern in the Great Lakes. From the literature it is clear that a reduction in delivered dose of contaminant is greatest when careful trimming includes skin and fat removal. This appears to apply to the full gamut of lipophilic chemicals commonly identified in Great Lakes sport fish. While skin removal prior to cooking appears preferable, simply discarding the skin after cooking also increases the reduction from the standard fillet. While the most data exists for brown trout and lake trout, other freshwater species such as smallmouth bass and salt water species such as bluefish also exhibit similar body lipid distributions and contaminants can be reduced via trimming procedures. Carp has been less well studied and trimming/cooking reductions may be less, although study methodology may have accounted for the lower reductions reported.[156]

All manner of cooking reduces the delivered contaminant dose. Cooking alone has a greater range of reductions reported. The variation is somewhat dependent on the type of raw sample. On average, cooking offers nearly the same reduction factor as trimming when the beginning raw sample is the untrimmed fillet. Zabik, et al.[157] showed an average loss of 30% PCBs in five Great Lakes fish species prepared with five cooking methods starting with skin off, trimmed fillets. An average loss of 33% occurred regardless of cooking method.

When the starting sample is a skinned and trimmed fillet, the reduction due to cooking is less. This reduction occurs less from a selective loss of contaminants than loss of contaminated fat during the cooking process. On a mg/kg basis, little change in tissue contaminant concentration occurs because water loss is proportional to fat loss. Since the cooked sample weight is significantly lower than the uncooked weight, when the tissue contaminant concentration remains the same, the total contaminants in the consumed meal portion is less. Not all the losses can be

accounted for via water and fat loss. Some authors indicate that the heat of cooking volatilizes contaminants and may account for up to 10% of the reduction in contaminants. Deep frying fish appears to further reduce contaminants via transfer from fish fat to cooking oil.

The combination of trimming and cooking offers the greatest reductions, reported to be at 60-80%.

Recommendation

Most, but not all anglers report routinely trimming their catch. Separately accounting for trimming reduction would under-estimate the risk for those not routinely trimming their catch of the most highly contaminated species. Virtually all Great Lakes sport fish caught is consumed after cooking. While different cooking methods result in a range of reductions, cooking of untrimmed fillets resulted in the greatest cooking reduction which was only sightly less on average than that from trimming alone.

It is recommended that a single contaminant reduction factor of 50% be utilized in converting the dose present in a 1/2 lb raw standard, skin-on fillet meal to the dose remaining after the meal is cooked. This factor is most appropriate for the salmonid species and other species evaluated as skin-on fillets. For other species commonly analyzed with the skin-off, a reduction factor of 30% should be used in order to take into account for the loss of contaminants due only to cooking.[157] For other species, particularly those consumed whole, these reduction factors should be evaluated.

APPENDIX III

Species Associated Analysis Portion and Compositing of Samples

Species Associated Analysis Portion and Compositing of Samples

Uniform Tissue Sample

A raw, skin-on, fillet will be the primary sample to be analyzed for contaminants. The fish should be scaled, then filleted so as to include all flesh from the back of the head to the tail and from the top of the back down to **and including** the belly flap area of the fish. Remove all fins, the tail, head, viscera, and major bones (backbone and ribs).

The only exceptions to this sample type would be as follows: the skin will be removed from black bullhead, brown bullhead, yellow bullhead, channel catfish, flathead catfish and burbot, but still remain untrimmed. Sturgeon would be analyzed as a skin-off cross section (steak). Smelt should be gutted and the head removed.

Whole fish samples should never be used for the purpose of issuing consumption advisories.

Sample Type

Individual samples are **preferred**. However, if composites are used, the length of the smallest fish should be within 90% of the largest fish. In conducting the regression analysis, each fish in the composite would be described by individual data points representing the individual lengths of fish within the composite and the projected corresponding contaminant concentration as determined by the contaminant concentration of the composite and the slope of the regression line at that point. Therefore it is very important that the length of each fish in the composite sample be recorded.

If the smallest fish is not within 90% of the largest fish, the composite will be represented by a single data point using the average length and average contaminant concentration for the composite.

Under **no** circumstances should a composite be made up of fish with a size difference (largest to smallest) greater than 75%.

Standard Portions for Analysis for Consumption Advisories

Standard Sample	Common Name	Scientific Name
	Yellow Perch	*Perca flavescens*
	Walleye	*Stizostedion vitreum*
	Sauger	*Stizostedion canadense*
	Largemouth Bass	*Micropterus salmonides*
	Smallmouth Bass	*Micropterus dolomieui*
	Bluegill	*Lepomis macrochirus*
	Pumpkinseed	*Lepomis gibbosus*
	Rock Bass	*Ambloplites rupestris*
	White Bass	*Morone chrysops*
	Black Crappie	*Pomoxis nigromaculatus*
	White Crappie	*Pomoxis annularis*
Skin - on	Green Sunfish	*Lepomis cyanellus*
Fillet	Longear Sunfish	*Lepomis megalotis*
	Warmouth	*Lepomis gulosus*
	Muskellunge	*Esox masquinongy*
	Northern Pike	*Esox lucius*
	Sucker Family	*Catastomidae*
	Carp	*Cyprinus carpio*
	Freshwater Drum (Sheepshead)	*Aplodinotus grunniens*
	Bigmouth Buffalo	*Ictiobus cyprinellus*
	Smallmouth Buffalo	*Ictiobus bubalus*
	Redhorse family	*Moxostoma* spp.
	Lake Whitefish	*Coregonus clupeaformis*
	Round Whitefish	*Prosopium cylindraceum*
	Lake Herring	*Coregonus artedii*
	Bloater Chub	*Coregonus hoyi*
	Lake Trout (lean and (Siscowett)	*Salvelinus namaycush*
	Rainbow Trout (Steelhead)	*Oncorhynchus mykiss*
	Brown Trout	*Salmo trutta*
	Brook Trout	*Salvelinus fontinalis*
	Splake	*S. fontinalis* X *S.namaykush*
	Atlantic salmon	*Salmo salar*
	Chinook salmon	*Oncorhynchus tschawytscha*
	Coho Salmon	*Oncorhynchus kisutch*
	Pink Salmon	*Oncorhynchus gorbuscha*
	Striped Bass	*Morone saxatilis*
	Black Bullhead	*Ictalurus melas*
	Brown Bullhead	*Ictalurus nebulosus*
Skin - off	Yellow Bullhead	*Ictalurus natalis*
Fillet	Channel Catfish	*Ictalurus punctatus*
	Flathead Catfish	*Pylodictis olivaris*
	Burbot	*Lota lota*
Skin - off	Lake Sturgeon	*Acipenser fulvescens*
Steak	Shovelnose Sturgeon	*Scaphirynchus platorynchus*
Headless, gutted	Rainbow Smelt	*Osmerus mordax*

APPENDIX IV

Fish Consumption Rate Estimates

The following is a summary of the consumption data put together by the Tennessee Valley Authority (TVA)[6];

A National Ocean Pollution Program Office report estimated that average annual fish consumption increased fifty percent between 1980 and 1988 from 10 pounds to 15 pounds per person.[17]

Some studies averaged the intakes of "fish eaters" with "non fish eaters" to get a per capita average that is misleading for both categories of consumers.

Fish consumption varies with demographic variables such as age, sex, ethnic group and region of the country. The most commonly cited studies of recreational anglers were done on the west coast.

Federal Agencies have made various recommendations for default assumptions:

(1) Exposure Factors Handbook[26] recommends use of the following values for fish consumption rates among recreational anglers:

50th percentile - 30 g/day
90th percentile - 140 g/day

(2) Risk Assessment Guidance for Superfund[27] recommends use of the following values for fish consumption rates in evaluating residential exposure:

50th percentile - 38 g/day
95th percentile - 132 g/day

(3) Risk Assessment Guidance Document for Superfund: Supplemental Guidance "Standard Default Exposure Factors"[30] requires the following assumptions about fish consumption rates:

subsistence fishers - 132 g/day
recreational anglers - 54 g/day

(4) Guidance Manual for Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish[25] makes no general recommendations, but discusses values from 6.5 g/day (U.S. per capita average) to 180 g/day (reasonable worst case).

(5) The FDA Center for Food Safety and Applied Nutrition has evaluated the potential intake of subsistence fishers by assuming that fish is substituted for red meat and poultry in a normal diet. Using information from the Market Research Corporation of America Menu Census VI (1977-78), FDA derived the following assumptions[37]:

mean for subsistence fishers - 69 g/day
90th percentile for subsistence fishers - 116 g/day

(6) Bolger et al. (1990) cite a U.S. Department of the Interior survey of fishing in 1985 which assumed that one fishing trip lead to consumption of 8 ounces of fish. Their estimate of fish consumption rates of recreational fishers - based on the number of recreational fishing trips they

make were:

> average 13.1 g/day
> 90th percentile estimated at 26 to 40 g/day

(7) U.S. EPA "Proposed Water Quality Guidance for the Great Lakes System" cites 15 g/day as the average consumption rate of regionally caught fish by sport anglers and their families.This same consumption rate of 15g/day approximates at least the 90% consumption level of regionally caught fish for the regional population as a whole, i.e., anglers as well as non-anglers.[31]

The Task Force agreed to the use of the following five advisory categories which are used and commonly understood by anglers:

> Unrestricted Consumption
>
> One Meal a Week (52 meals/year)
>
> One Meal a Month (12 meals/year)
>
> One Meal every 2 Months (6 meals/year)
>
> No Consumption (Do Not Eat)

Figure 1 shows the relationship between these ingestion rate assumptions and the Task Force categories.

Figure 1

Comparison of Assumed Fish Consumption Rates
(Typical meal size assumed to be 0.5 pounds)

Great Lakes Protocol
Consumption Rates

grams/day

Literature Consumption Rates

190

180 — Reasonable worst case[24]

170

160

150

140 — Unrestricted — 90th % Rec fisherman[26]

130 — 95% Superfund[27]
Default Subsist Fisherman[30]

120

110 — FDA 90% Subsist Fisherman[37]

100

90

80

70 — FDA Ave Subsist Fisherman[37]

60

50 — Default Superfund Rec Fisherman[30]

40 — 50% Superfund[27]

30 — 1 meal/week — 50% Rec Fisherman[25]

20

10 — Ave GL rec angler & family[31]
95% GL general public[37]

5 — 1 meal/month — US ave per capita[24]

0 — 6 meals/year
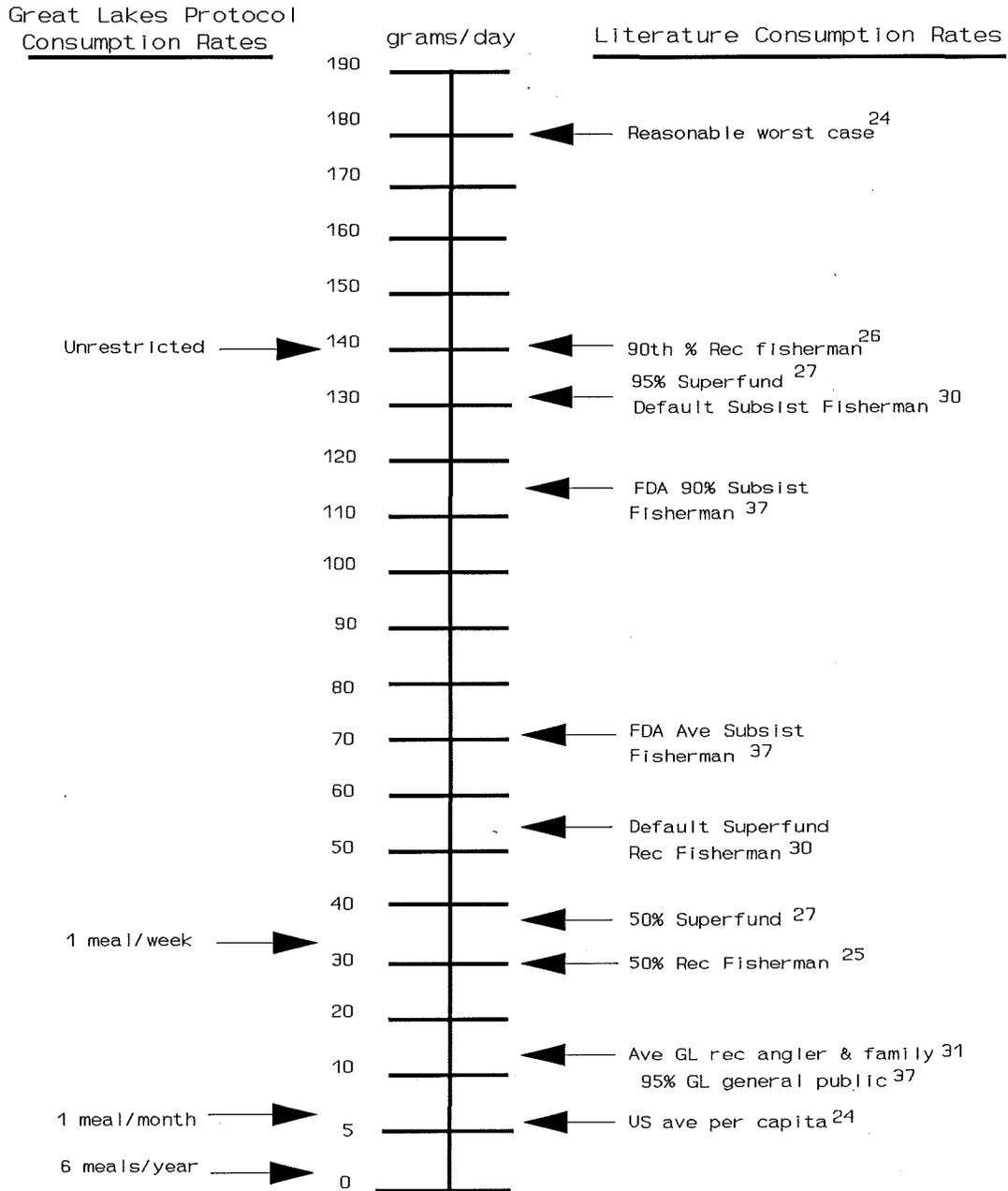
Adapted from Cox JP. TVA/WR-92/27, 1992[6]

APPENDIX V

Listing and Delisting Criteria and Establishment of Size Ranges

Method for Listing Sites or Shifting Size Ranges into Different Consumption Categories

The standing committee members representing each state will meet annually to discuss new data, listing of new species/sites, and shifting of size ranges to different consumption advice categories.

Listing Criteria

In the interest of protecting public health, a minimum of one year of data would be needed to place a site and/or species on an advisory. The annual meeting of the standing committee would be used as the forum for the proposed change. The strength of the data and confidence in the data will be considered.

However, if an emergency arises where it is felt there is an imminent impact to human health, an advisory can be initiated by any state as long as each jurisdiction is contacted by the state issuing the advisory to ensure a consistent public communication effort.

Establishment of Fish Size Ranges for Placement in Consumption Groups

Regression models will be used to examine the relationship between fish length and PCB concentrations. Fish will be placed in consumption categories by using a best fit regression based on the r^2 value. In addition, the biological plausibility and weight of evidence will be considered by the standing committee, given the understanding that a regression approach must remain consistent for a specific species from a given waterbody in order to have continuity from year-to-year for determining changes in the advisory.
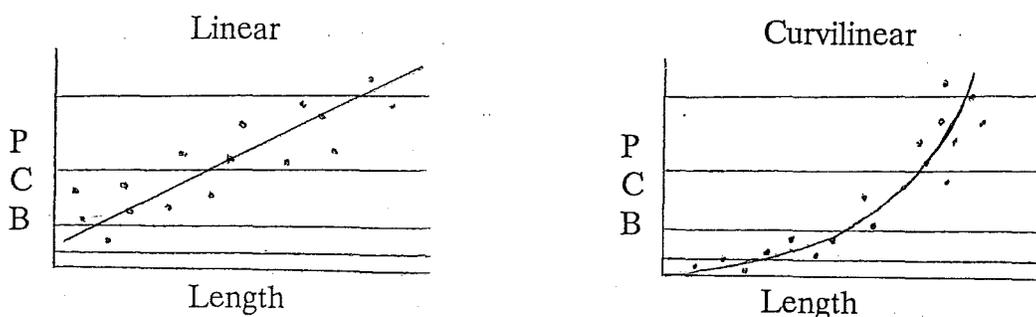
The relationship between fish length and PCB concentration will be analyzed using a regression analysis to determine the equation which best describes this relationship. The equation with the highest r^2, with a minimum of 0.6, will be used taking into consideration the statistical significance of the regression equations examined.

If the data set contains concentration values which are reported as less than the level of detection, the preferred approach will be to use a regression method which deals with censored observations. However, the appropriate regression methods are not well known or available. There are statistical methods for treatment of less than detectable concentrations, but these methods are primarily for determining the mean of a set of data and not for determining the best fit equation. These methods include assigning all than detected values equal to 1/2 of the LOD or assigning values based on an assumed or extrapolated distribution.
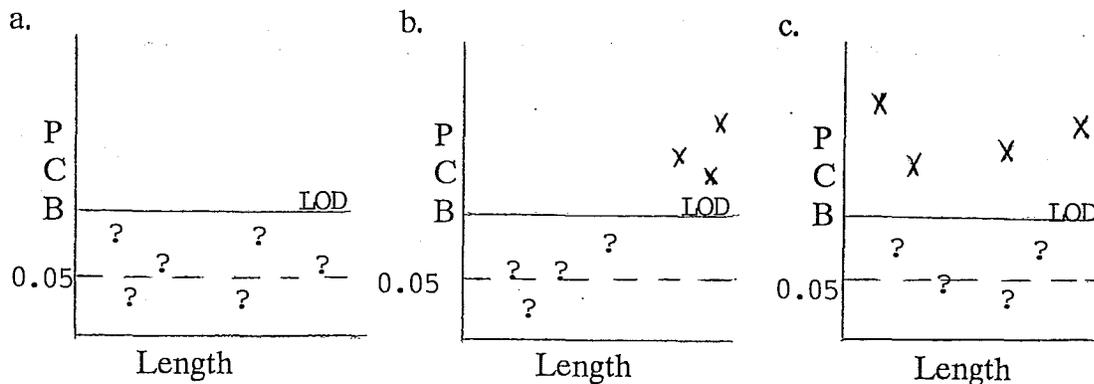
Until a method of conducting a regression analysis which automatically deals with censored data in an appropriate manner can be incorporated, the following procedures will be used for determining a regression equation to describe the relationship between length and PCB concentration:

a. If an initial regression analysis indicates that the relationship between PCB concentration and length is a linear relationship, a regression analysis will be conducted using the data reported at greater than the LOD. If this procedure derives an equation with an r^2 of 0.6 or greater and the level of significance is acceptable, this equation will be used to describe the relationship between fish length and PCB concentration. The appropriate consumption category will be determined by extrapolating the equation to size ranges corresponding to concentrations less than detection limits. Although extrapolation beyond the data set is not technically recommended, it is one way of estimating the values of the censored data.

b. In some cases the initial regression analysis will indicate that the relationship between PCB concentration and length is more appropriately described with a nonlinear equation. In these cases, a nonlinear regression analysis using only the data which is reported at greater than the level of detection will be used to determine the best fit equation. The size ranges corresponding to concentrations less than detection limits will be extrapolated from this equation. It may be necessary to examine the lower part of the curve separately and determine two regression equations to describe the relationship between PCB concentration and fish length.

In some cases, available data will not be sufficient to enable an equation to be generated with an r^2 of greater than 0.6. Also, in some cases the ability of laboratories to detect low concentrations of PCBs (the level of detection) will not allow determination of which category the fish should be placed. For those cases with below level of detection values, the following procedures will be used depending on the amount of data above the level of detection:

a. 100% of the data for a species from a given waterbody is below the level of detection. Fish will be placed in the category corresponding to a value of 1/2 of the LOD. For example, if all fish are below the detection limit of 0.1 ppm, they will be assigned the value of 0.05 ppm and therefore fall into Category 1 of the advisory.

b. Larger fish in the species have concentrations greater than the LOD: this provides evidence that contaminant levels are approaching the LOD and therefore a more conservative approach is warranted. Fish of the larger size will be placed in the category corresponding to the mean value of the detectable concentrations. Smaller fish (with undetectable concentrations) will be placed in the consumption category that is one group less restrictive than the category defined by the detectable values.

c.   The concentration data is scattered both above and below the LOD: calculate the mean concentration of all fish, giving undetectable data a value of 1/2 the LOD and calculating a mean using all data. All fish, regardless of size, would then be placed in that advisory category. The same method would be used if all data is above the detection limit, but no correlation is evident, the mean value of the data will be taken and fish placed into that advisory category.

a.

```
P
C
B  _____ LOD
      ?         ?
0.05 —  — ? —    —   — ? —
         ?        ?
```
Length

b.

```
                          X
P                      X
C                         X
B  _____ LOD
           ?
0.05  — ? ? — — — — —
           ?
```
Length

c.

```
      X                X
P                   X
C           X
B  _____ LOD
         ?         ?
0.05  —  — ? —  —  — —
                ?
```
Length

Shifting Size Ranges between Consumption Categories

A weight of evidence approach will be used to determine whether or not to shift sizes in consumption categories for a given species. To be considered, a jurisdiction wishing to change a lakewide advisory would be required to submit to the standing committee, a minimum of two separate years of data (three separate years of data is preferred) taken over a maximum of (the last) 5 years. The committee will then decide whether the change is warranted based on the weight of evidence such as the data presented, trends in that species as well as other species (i.e. the forage base), biological considerations and other environmental factors such as water/sediment data.

The Task Force can be utilized as a peer review body should states seek advice on hotspots or intrastate waterbodies.

"Hot Spots"

Data from so called "hot-spots" would be excluded from consideration for a lakewide advisory if it is determined, by weight of evidence and as judged by the standing committee, that the "hot-spot" data shows significant difference from overall lakewide data.

APPENDIX VI

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