Evaluation of the Health Implications of Levels of Polychlorinated Dibenzo-p-Dioxins (dioxins) and Polychlorinated Dibenzofurans (furans) in Fish from Maine Rivers

2008 Update

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Executive Summary

- The Maine Center for Disease Control and Prevention (formally Bureau of Health), within the Maine Department of Health and Human Services, is responsible for recommending warnings on eating recreationally caught fish based on the presence of chemicals (22 MSRA § 1696 I).

- This document presents the Maine Center for Disease Control's (ME-CDC) update on the need for consumption advisories due to the presence of dioxin-like compounds in fish from Maine rivers. The evaluation is based on the 2003 through 2007 sampling data. The last update was provided in 2004 and based on sampling data for 2001 through 2003.

- Dioxin-like compounds refer to a collection of 29 individual compounds from three distinct families of chemicals: the polychlorinated dibenzo-p-dioxins (dioxins), the polychlorinated dibenzofurans (furans), and the coplanar polychlorinated biphenyls (coplanar PCBs). Because the chemicals are believed to exert cumulative toxicity, they are typically combined in risk assessments in a way that weights the individual chemicals by their relative toxic potencies (referred to as toxic equivalents or TEQs). The Dioxin Monitoring Program has largely focused on the presence of dioxins and furans in fish tissue. It has been left to another DEP funded program (e.g. SWAT) to support monitoring of coplanar PCBs. In this report, fish tissue data are presented as toxicity-weighted cumulative levels of dioxins and furans, as well as cumulative levels of dioxins, furans and coplanar PCBs.

- An evaluation of the need for fish consumption advisories due to the presence of dioxin-like compounds in fish requires a comparison to a health benchmark. The ME-CDC uses a health benchmark that is expressed as a toxicity-weighted concentration of dioxin-like compounds in fish tissue, referred to as a "Fish Tissue Action Level" or FTAL. For the present report, the ME-CDC compares the most recent data on contaminant levels to its current FTALs for dioxin-like compounds of 1.5 parts per trillion (ppt) for protection of cancer-related effects and a 0.4 parts per trillion FTAL for protection of noncancer related effects. The FTAL of 1.5 ppt for cancer related effects has been used by ME-CDC since 1990. The FTAL of 0.4 ppt for noncancer effects is based on the same toxicity data relied upon since 1990, but has been adjusted downward to account for the substantial background exposure we all get from the presence of these chemicals in most dietary foods. Much of this report discusses the rationale for accounting for this background dietary exposure.

- Substantial progress has been made from the days in the late 1980s when dioxin levels were as high as 20 ppt. We now have levels of dioxin-like compounds in fish that are generally less than 1 – 2 ppt range, and generally less than 1 ppt for gamefish.

- Despite this progress, there are a number of Maine rivers where levels of dioxin-like compounds in fish remain above ME-CDC's FTALs, primarily the new FTAL of 0.4 ppt , and sometimes only after the addition of coplanar PCBs.

- Androscoggin River / Androscoggin Lake: Levels of dioxins and furans remain at or above the FTAL of 0.4 ppt at virtually all sampling locations for gamefish, and exceeded this FTAL when coplanar PCBs were added. Suckers remain above the cancer FTAL of 1.5 ppt for most locations on the Androscoggin River. Levels of dioxins in furans have also remained above the 0.4 FTAL in white perch collected from Androscoggin Lake, and exceed this level in both perch and bass when coplanar PCBs and included.

- Kennebec River: Levels of dioxins and furans have generally remained below the FTAL of 0.4 ppt in both gamefish and suckers, but exceeded this action level when coplanar PCBs were added. The levels at Gardiner are particularly noteworthy due to the high coplanar PCB levels .

- Penobscot River: Levels of dioxins and furans have continued to remain below the FTAL of 0.4 ppt in gamefish. When coplanar PCBs are added, levels only exceeded the 0.4 ppt FTAL at Veazie, based on 2005 data. The situation for suckers is less clear, with levels generally being more variable and exceeding the 0.4 ppt FTAL in some years for dioxins and furans alone, and in other years only when coplanar PCBs are added.

- Sebasticook River: Levels of dioxins and furans in gamefish collected on the Sebasticook have tended to fluctuate around the 0.4 ppt FTAL on the Main Stem and West Branch, but have remained well above on the East Branch. The addition of coplanars causes this FTAL to be exceeded, considerably so for the Main Stem.

- Presumpscot River: Levels of dioxins and furans have continued to remain below the 0.4 ppt FTAL in game fish sampled in 2006 on the Presumpscot River. This is generally consistent with findings reported in 2001 and 2002. The addition of coplanar PCBs caused the 0.4 FTAL to be exceeded.

- Salmon Falls River: Levels of dioxins and furans continued to remain near, but below the 0.4 FTAL in gamefish sampled on the Salmon Falls River. Again, the addition of coplanar PCBs caused this action level to be exceeded.

- It needs to be emphasized that any formal changes in ME-CDC fish consumption advisories involves a comprehensive review of the levels of all measured contaminants in fish tissue from any given waterbody (e.g., methylmercury, PCBs, lead, and DDT in addition to dioxins & furans).

- Fish consumption advisories are based on the most limiting chemical contaminant. It is an unfortunate fact that a lessened need for consumption advisories due to lower levels of dioxins & furans in fish does not necessarily translate into changes in consumption advisories for a waterbody, primarily because all inland water bodies in Maine are covered by a restrictive statewide consumption advisory due to the presence of methylmercury in fish.

- Based on preliminary evaluations of the past several years of data of dioxins and coplanar PCBs in fish, it appears that for a number of sampling locations, levels of these contaminants do not result in advisories that are more restrictive of consumption than the statewide mercury advisory (though there is a potential exception to this general conclusion regarding advice to young and adolescent girls). Thus, it must be recognized that for a number of sampling locations, additional data on levels of dioxin-like compounds in fish may not materially change the fish consumption advice issued by the ME-CDC.

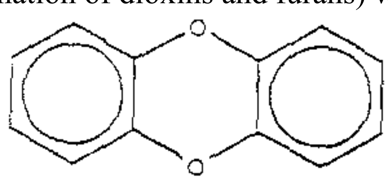
- This is not to say there is no need for continued monitoring of dioxin levels in these rivers. It is desirable from a public health perspective to know whether fish are below levels of concern for dioxin-like compounds, and monitoring data alone provides this information. There also remain some locations where dioxins and furans alone, or when combined with coplanar PCBs, reach levels requiring advisories more restrictive than that associated with the mercury advisory. With these considerations in mind, ME-CDC has made recommendations for future sampling of the above waters for dioxin-like compounds.

- While ME-CDC believes there remains a benefit to ongoing monitoring for dioxin-like compounds, we also believe it is appropriate to consider changes to its current design with its emphasis on testing a number of individual fish at every sampling location. Potential changes include monitoring on a subset of sampling locations on a given river ideally each year (to be selected based on inspection of historical monitoring data); using composite fish samples rather than individual fish analyses to decrease the number of samples to be analyzed while ideally increasing the number of rivers that can be sampled in a giver year.

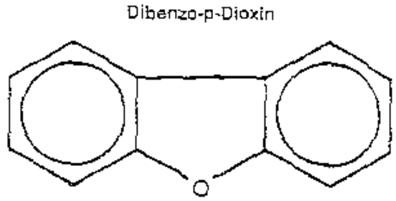
I. Background on Dioxins and Coplanar PCBs

Dioxins are a class of chemicals of which there are two main groups - polychlorinated dibenzodioxins (PCDDs or dioxins) and polychlorinated dibenzofurans (PCDFs or furans) that have similar chemical structures (Figure 1). These chemicals are not produced for any commercial use, but rather are typically byproducts of combustion or chemical manufacturing processes. The chlorine bleaching of pulp is an example of a chemical manufacturing process that inadvertently produced dioxins and furans that were then released into rivers along with wastewaters. These chemicals are very lipophilic, a term that means they have a very strong affinity for fatty substances. As a consequence, these chemicals are greatly bioaccumulated into the fatty tissue of animals, including fish. Dioxins and furans have become fairly ubiquitous in the environment and can detected in virtually all dietary sources of animal fat (NAS 2003).

There are many individual chemical compounds (referred to as congeners) that belong in this broad group of chemicals called dioxins and furans. They differ by where chlorine atoms are attached to the basic structure illustrated in Figure 1. Of these chemicals, there are 7 dioxins that are considered of primary concern because of their toxicity. There are 10 furans that are of primary concern. These 17 congeners are all believed to cause toxicity by a common mechanism. All these chemicals are typically collectively referred to as "dioxins" and will be referred to in that way in this report. While these chemicals all act in a similar manner, they do have differing potencies for causing toxic effects. To put these chemicals on a common toxicity scale, each dioxin congener can be multiplied by a "Toxic Equivalency Factor" or TEF - a value of 1 is assigned to the most toxic congeners (2,3,7,8-tetrachlorinated dibenzo-p-dioxin and 1,2,3,7,8-penta chlorinated dibenzo-p-dioxin) with all other congeners assigned a value that is a fraction of one. Once all chemicals have been put on a toxicologically equal metric, they are summed to produce a single concentration that can be compared to a health standard. This single metric is called "Toxic Equivalents" or TEQs. Concentrations of dioxins in this report (a combination of dioxins and furans) will be reported on this TEQ basis.



Dibenzo-p-Dioxin



Dibenzofuran

Figure 1 Structure of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans. The position of chlorine atoms on the benzene rings distinguishes the different compounds (congeners) from one another.

There is another set of chemicals that also act by the same toxicological mechanism. These chemicals are called coplanar polychlorinated biphenyls or coplanar PCBs (Figure 2). Unlike dioxins, PCBs were produced commercially, and had a variety of uses including placement in electrical equipment such as transformers. Their ability (like dioxins) to accumulate in fat and their toxicity caused them to be banned from production in the early 1970s. They are extremely stable and remain in the environment at toxicologically relevant concentrations even today – 30 years after they were banned. While PCBs include a large class of chemicals, the ones that act toxicologically like dioxins are limited to 12 individual chemicals. These 12 PCBs, called coplanar PCBs, also have toxic equivalency factors (TEFs) and can therefore be put on the same toxicological metric as dioxin and furans, and can be summed among themselves and with dioxins to produce a total TEQ. This TEQ is then compared to a health benchmark. Both dioxins and coplanar PCBs (collectively referred to as dioxin-like compounds) can be found in fish caught in Maine rivers. In this report, total TEQs are presented as both summed dioxins and furans, as well as summed to additionally include coplanar PCBs.

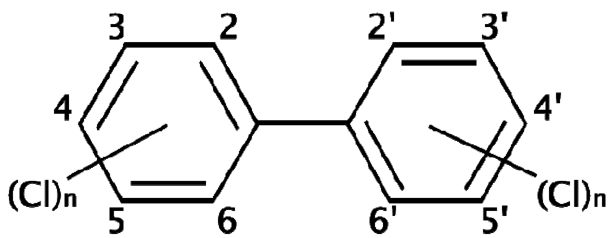


Figure 2 Structure of PCBs. Coplanar PCBs have chlorine atoms in locations that result in their acting toxicologically like dioxins.

Dioxins have been shown to cause a variety effects in animal studies at very low levels of exposure; effects such as cancer, liver damage, disruption of the endocrine system, weakening of the immune system, and reproductive damage. Studies of animals exposed to dioxins during pregnancy have reported miscarriages and the offspring of exposued animals had birth defects and neurodevelopmental effects. They are considered extremely toxic chemicals.

II. Brief History of Dioxin Fish Consumption Advisories in Maine

The Maine Center for Disease Control and Prevention (formally Bureau of Health) is responsible for recommending the warnings on eating fish based on the presence of chemicals (22 MSRA § 1696 I). Specifically, the statute states: “The Director of the Bureau of Health shall assess regularly whether any health threats exist for persons consuming freshwater and anadromous fish caught in state waters by noncommercial anglers. The assessment must be based on appropriate technical and scientific data and public health analyses and must include, but is not limited to, the risk of carcinogenic, mutagenic, teratogenic and reproductive effects and infectious disease.”

Historically, the first fish advisories for dioxins in Maine occurred on the Androscoggin River in 1985, and were limited to just one of the 17 dioxin and furan congeners (2,3,7,8-TCDD, one of the most toxic dioxin congeners). The Kennebec and Penobscot Rivers were added in 1987, and the Presumpscot River and West Branch of the Sebasticook River were added in 1990. In both these cases, the data collected and the advisories were based on only one dioxin congener – one of the most toxic congeners, 2,3,7,8-TCDD. The advisories on the Presumpscot and the West Branch of the Sebasticook River were dropped in 1992. There were significant changes to the fish consumption advisories in 1997. This was the first time that the monitoring data available on all dioxin and coplanar PCB congeners were considered in developing fish consumption advisories, and made use of the then current World Health Organization TEF scheme. The West and the East Branch of the Sebasticook River were re-added to the list of rivers with advisories due to the combined presence of both dioxins and PCBs. In 2000 the advisories were re-evaluated and minor revisions occurred regarding the extent of advisories on the various rivers. ME-CDC last review of dioxin and coplanar PCB levels in fish from Maine rivers was completed in 2004 (ME-CDC, 2004). The review in 2004 examined data on fish tissue levels of dioxins and coplanar PCBs collected between 2001 and 2003.

The concentrations of dioxins in fish from Maine rivers have decreased significantly over time. Concentrations of dioxins in Maine fish were in the 2 to 30 ppt level in the mid 1980s while today levels are much more commonly seen in the less than 1 to 2 ppt level.

III. Current Fish Tissue Action Levels for Dioxin and Dioxin-Like Compounds

To develop advisories, concentrations in fish must be compared to a health benchmark. The health benchmarks are called Fish Tissue Action Levels or FTALs. FTALs reflect the maximum level of a chemical in fish tissue that will allow consumption at a rate of one 8-ounce meal per week without exceeding an *Acceptable Daily Intake* (ADI) for the specific chemical. Daily Intakes (ADIs), referred to as Risk Specific Doses (RsDs) for cancer-causing chemicals and Reference Doses (RfDs) for toxic effects other than cancer by the U.S. Environmental Protection Agency (USEPA), are typically derived by federal or international health organizations (e.g., World Health Organization). They can also be derived by State Agencies. The process for deriving ADIs usually involves a comprehensive review of the scientific literature and are subject to internal and external scientific peer review. Dioxins can cause both cancer and non-cancer related toxic effects, and thus toxicity values have tended to be developed for both types of toxic effects.

Maine CDC has used the same estimates of ADIs since 1990. This is in part because the USEPA has been unable to finalize the development of more updated values (despite more than a decade of review). ADI's for the noncancer related effects of dioxins developed by other federal and international agencies have been numerically consistent with Maine's estimate. Maine's toxicity values were derived by former State Toxicologist, Dr. Robert Frakes, and were subject to review by an external Scientific

Advisory Panel (Frakes 1990). The cancer-related ADI used for dioxins is 0.7 picogram dioxin-TEQs per kilogram-body weight per day (pg/kg/day). This ADI is a lifetime daily dose that is believed to result in no more than an excess cancer risk of 1-in-100,000; this cancer risk level for issuing advisories is a policy decision (MeCDC 1999).[1] This ADI of 0.7 pg/kg/day results in a Fish Tissue Action Level (FTAL) of 1.5 parts per trillion (ppt).[2] It is noteworthy that in its 2000 draft reassessment, the U.S. Environmental Protection Agency (USEPA) estimated that this dose could be associated with a cancer risk as much as 100-fold higher than the cancer risk estimate derived by Maine in 1990. However, as the USEPA has yet to be able to finalize its own cancer estimate, Maine continues to rely upon its 1990 peer reviewed value.

The risk assessment paradigm for deriving ADIs for non-cancer related health effects differs from that for cancer-causing chemicals. For noncarcinogens, it is assumed that there is a threshold below which there is a negligible risk of a deleterious effect. ADI's are developed to be below this threshold. In 1990, Maine CDC derived a noncancer ADI of 1 pg/kg/day (Frakes 1990). The specific toxicity effect from which this estimate was derived was an increase in spontaneous abortions among dosed monkeys. This ADI of 1 pg/kg/day remains consistent with the most recent recommendations by the U.S. Agency for Toxic Substances and Disease Registry (ATSDR 1999) and the World Health Organization (WHO, 1998). ATSDR's value (called a chronic Minimal Risk Level) is based on behavioral developmental effects in offspring of monkeys dosed prior, during and post pregnancy. The World Health Organization's Acceptable Daily Intake is 1 to 4 pg/kg/day with recommendations that exposures should be reduced as much as possible. The ADI was developed looking at the body of available studies rather than one key study (hence the range for the ADI). The endpoints were all developmental or reproductive – namely in rats, decreased sperm count in offspring, immune suppression in offspring and increased genital malformations in offspring. In monkeys the effects seen included neurobehavioral effects in offspring and endometriosis in adult females.

The noncancer ADI of 1 pg/kg/day results in a FTAL of 1.8 ppt. Since this health benchmark is based on developmental and reproductive effects, ME-CDC has used this FTAL to develop fish consumption advisories targeted to women who may get pregnant, pregnant women, nursing women, and all girls (the latter due to concern over the build-up of body burdens over time). The focus on females of reproductive age and young girls is consistent with recommendations from the National Academy of Sciences (NAS, 1993).

[1] Note that under the conventional risk assessment paradigm for cancer-causing chemicals, it is assumed that there is some increased risk of cancer associated with any dose, i.e., a non-threshold mechanism of action. Excess lifetime cancer risk levels in the range of 1-in-10,000 to 1-in-1,000,000 are typically used by federal and state agencies as *de minimis* cancer risks.

[2] A part per trillion (ppt) refers to one part of dioxin-TEQ on mass basic per one-trillion parts of fish tissue on a mass basis. 1.5 ppt is equivalent to 1.5 picograms of dioxin per gram of fish tissue (pg/g).

IV. The Need to Account for Background Exposure to Dioxin-Like Compounds in Developing FTALs

Since 2004 the Maine CDC has been evaluating whether to revise the noncancer related FTAL of 1.8 ppt for dioxins, furans and coplanar PCBs (ME-CDC, 2004). The motivation has been a growing recognition of the need to account for the contribution of background dietary exposures toward the ADI. As noted above, it is assumed that there is a toxicological threshold for non-cancer effects. If exposures are below the threshold, the risk of a deleterious effect is considered negligible. Any additional intake to these chemicals from sources other than fish would result in cumulative exposures potentially above the assumed threshold. The current FTAL for the noncancer dioxin effects apportions 100% of the Acceptable daily intake for these chemicals from the consumption of a single fish-meal per week, and thus makes no allowance for concurrent exposures from other sources.

The publication of National Academy of Science (NAS) report “Dioxins and Dioxin-Like Compounds in the Food Supply” (NAS, 2003) provided a comprehensive compilation of data on dietary exposure to dioxin-like compounds. The NAS report estimated average dietary exposure to dioxin-like compounds at levels approaching a substantial fraction of the ADI of 1 pg/kg/day. Since dioxin-like compounds are pervasive in dietary animal fats (e.g., beef, pork, poultry, dairy in addition to fish), concurrent exposure to these dietary sources are difficult to avoid. ME-CDC thus believes in order to protect public health, it is necessary to account for non-fish related dietary exposures when developing FTALs and fish consumption advisories.

It has been standard practice for ME-CDC to account for contributions from non-water exposures to chemicals, namely air and non-water dietary sources, when developing Maximum Exposure Guidelines (MEGs) for drinking water contaminants (ME-CDC, 2000). This has been done in accordance with USEPA risk assessment guidelines for developing Drinking Water Exposure Limits (ME-CDC, 2000). Under this protocol, the fraction of total exposure typically accounted for by drinking water, referred to as the relative source contribution (RSC), is applied to the ADI to determine the maximum amount of the ADI “apportioned” to drinking water reflected by the MEG value. In using this fraction procedure, the protocol applies a ceiling level of 80 percent of the ADI and a floor level of 20 percent of the ADI. That is, the MEG can neither account for more than 80 percent of the ADI, nor less than 20 percent of the ADI. ME-CDC (and USEPA) usually takes a conservative approach to public health by applying an RSC factor of 20 percent to the ADI when adequate exposure data do not exist, assuming that the major portion (80 percent) of the total exposure comes from other sources, such as diet.

In 2000, USEPA published an updated “Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health”. This methodology considers consumption of fish and water as the major exposures in developing ambient water quality criteria. The 2000 updated guidance included methodology for accounting for non-water related exposures in the development of ambient water quality standards. The approach is called the Exposure Decision Tree. The USEPA's Exposure Decision Tree approach allows flexibility in the way the ADI can be adjusted to account for background exposure. When adequate data on background exposure are available, they are used to make protective exposure estimates for the population(s) of concern. The Decision Tree allows for use of either the subtraction method or percentage method to account for other exposures. In the subtraction method, an estimate of background exposure is subtracted directly from the ADI. In the percentage method, the ADI is multiplied by the fractional exposure to be apportioned to consumption of sport-caught fish. The Decision Tree provides an algorithm for choosing between the subtraction and percentage method, as well how to account for background exposure when only limited data are available. The key issue in selecting between the two methods is the availability of reliable data to quantify background exposure to the chemical of concern, as well as knowledge of other sources of exposure regulated under different programs (i.e., one's confidence that they have good knowledge of cumulative exposure).

Also in 2000, the USEPA published the third edition of "Volume 2 - Risk Assessment and Fish Consumption Limit" as part of a series of documents entitled: "Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories." This guidance states that USEPA is developing guidance on the use of a Relative Source Contribution (RSC) approach, and that the RSC concept could be used in fish advisory activities. The guidance further states that "If state agencies have information about other pathways that may contribute significantly to exposure, then risk assessors are encouraged to use this information to calculate an appropriate total exposure limit. Depending on the magnitude of the suspected nonfish exposure, the fish advisory intake limits may be set at a level that accounts for some fraction of the total allowable daily dose (e.g., 10, 20, or 30 percent). This allocates to the nonfish exposures the remaining percentage of the total exposure limit. The goal of these strategies is to ensure that the total pollutant exposure does not exceed the predetermined exposure limit."

ME-CDC has not previously accounted for non-water related exposures in developing FTALs and Fish Consumption Advisories. This is partly because ME-CDC has not made a major update or revision to freshwater fish consumption advisories since 2000, neither has ME-CDC updated its protocol for developing FTALs since 2000 nor USEPA its guidance to address background exposure. In this document, ME-CDC updates its FTAL for dioxins and coplanar PCBs using the same approach it uses to account for background exposures when developing MEGs (i.e., the Relative Source Contribution method).

1. Methodology for Accounting for Background Dietary Exposure in the Derivation of Fish Tissue Action Levels for Noncarcinogenic Toxicological

The methodology for deriving Fish Tissue Action Levels (FTALs) is described in MeCDC guidance (MeCDC 1999) and supported by EPA Guidance (EPA 1997 & 2000). As noted above, FTALs for noncarcinogenic toxicological endpoints are set at a level believed to represent a minimal risk of a deleterious effect from lifetime exposure even for sensitive subpopulations. It is assumed that such noncarcinogenic endpoints have a threshold response (i.e., there is a dose below which the toxic effects will not occur). Fish Consumption Advisories are set such that total exposure from eating on average one 8 ounce fish meal per week will result in a daily dose below the threshold.

The equation for determining FTALs for noncancer toxicological endpoint is:

$$FTAL = \frac{(ADI \times BW)}{FC} \qquad (1)$$

Where,

FTAL = Action Level (pg/kg)
ADI = Acceptable Daily Intake
BW = Body Weight
FC = Fish Consumption Rate

To account for background exposure, equation (1) is modified to include a relative source contribution term that represents the fraction of allowable daily intake that will be apportioned to consumption of recreationally caught fish:

$$FTAL = \frac{(ADI \times BW)}{FC} \times RSC \qquad (2)$$

As is done in the development of drinking water guidelines, ME-CDC will impose a ceiling level of 80 percent of the ADI and a floor level of 20 percent of the ADI. That is, the exposure associated with the FTAL cannot account for more than 80 percent of the ADI, nor less than 20 percent of the ADI. To determine the appropriate magnitude of the RSC (i.e., where, between 20 and 80 percent, it should be) it is necessary to evaluate the available data on background exposure to dioxins and coplanar PCBs and compare estimates of the magnitude of these exposures to the ADI.

2. Data on Background Exposures to Dioxins and Coplanar PCBs for Use in Estimating the Relative Source Contribution

Dioxins: The publication of National Academy of Science (NAS) report "Dioxins and Dioxin-Like Compounds in the Food Supply" (NAS, 2003) provided a comprehensive compilation of data on dietary exposure to dioxin compounds. Estimates of exposure are based on data on concentrations of dioxins in measured in foods and dietary consumption habits of those foods. The dioxin food concentration data was based on the US Food and Drug Administrations Total Diet Study. The Total Diet Study is an ongoing evaluation of contaminants in food and has been in place since the early 1960s. Estimates of food consumption rates were based on Continuing Survey of Food Intakes by Individuals (CSFII) a study between 1994 and 1996 and in 1998 to evaluate consumption rates of foods.

The NAS report identifies that dietary sources of animal fat are by far the largest source of dioxin exposure to the general population, with 90% of total exposure being due to consumption of food – namely animal products and their associated animal fats (beef, pork chicken, fish, fats (butter), and dairy products. Figure 4 shows an estimate prepared by the NAS of the fractional contribution of various dietary foods to average U.S. exposure to dioxins & furans from this report. This particular figure was generated using typical dietary food intakes averaged over a lifetime. The fractional contributions would look somewhat different for other averaging periods (e.g., infants, young children, adolescents, adults).

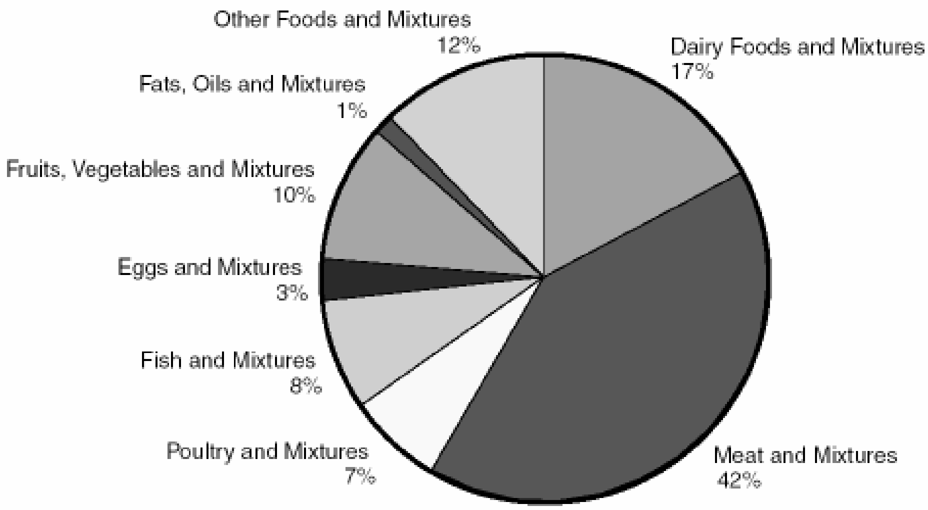


Figure 4. Estimated percent contribution of various dietary foods to lifetime cumulative exposure to dioxin-like compounds for males & females averaged over lifetime exposure. Non-detects are equal to zero. *Reproduced from NAS (2003).*

NAS prepared estimates of background dietary intake of dioxins for several distinct populations. Background dietary exposure levels of dioxins for females pregnant and lactating are presented in Appendix B of the NAS report. The estimates range from 0.38 pg/kg/day when the detection limit is treated as zero, and 0.64 pg/kg/day when non detects are assumed to be present at ½ the detection limit. The estimates for background exposure to similar populations (e.g., women of childbearing age) are very similar.

A few comments are in order about treatment of laboratory analyses reported as less than the detection limit – which is an issue that must be dealt with when reviewing Maine's sport fish tissue data. When a laboratory analysis does not detect dioxins in a sample (e.g., food, soil, water) it does not confirm the chemical's complete absence, but rather its absence at a concentration above the detection limit for the analytical instrument. It has been the health protective policy of ME-CDC (ME-CDC, 1999) – and a policy used by many state and federal agencies – to assume that chemicals reported as undetected in a laboratory analysis, are assumed present at a concentration equal to ½ the detection limit (i.e., ND = 1/2 DL). This policy is followed in this document as well. This policy is especially relevant with dioxins as current laboratory analyses can only detect dioxins in samples at levels slightly below levels of concern.

Coplanar PCBs: There is not nearly as much published literature on background concentrations and exposure to coplanar PCBs. Since coplanar PCBs act toxicologically like dioxins, all recent evaluations of dioxin-like compound exposure include some estimate of coplanar PCB exposure (e.g., NAS 2003 and EPA 2000). A common "rule of thumb" cited in NAS (2003) is to double dioxin exposure to estimate total exposure to dioxins and coplanar PCBs. That method, however, was derived from European Union (EU) estimates and is quite qualitative (AEA 1999, Fiedler et al. 2000). In that analysis, dioxin and coplanar PCB concentrations in foodstuffs were evaluated across EU countries. Three countries had data on both dioxin/furan concentrations and coplanar PCB concentrations, however, the number of congeners evaluated and how data reported as below detection limits were handled varied significantly from country to country. These studies reported estimates of coplanar PCB contribution to total dioxin-TEQs ranging from 37% to 57%, and concluded that 50% is a reasonable estimate to apply in general.

EPA's 2000 Draft Dioxin Reassessment (EPA 2000) summarized the available data on background concentrations in foods for the United States. Using that data and standard assumptions for intake or contact rates, they developed an estimate of general background exposure to coplanar PCBs. The estimates assume concentrations in food reported as nondetected are present at ½ the detection limit. EPA did not breakdown the population groups in a similar manner to NAS. EPA estimated an adult general population background exposure of dioxins and furans at 0.61 pg/kg/day, and an adult general population background exposure from coplanar PCBs was estimated at 0.34 pg/kg/day. Based on EPA's analysis, coplanar PCBs account for approximately one-third of total dioxin-TEQs, which is in the low range of values reported.

Given EPA's estimate for dioxin exposure in the general adult population (0.61 pg/kg/day) is roughly equivalent to the dioxin exposure estimates presented for the sensitive population in the NAS report for pregnant women (0.64 pg/kg/day), ME-CDC believes it is appropriate to use EPA's general adult population estimate for coplanar PCB-TEQ intake for pregnant women as well (i.e., 0.34 pg/kg/day). Moreover, given that coplanar PCBs are generally found in food samples at concentrations above the detection limits of laboratory analysis, this estimate is valid regardless of assumptions regarding treatment of samples with concentrations reported as non-detect.

Total estimates of dioxin TEQs (i.e., dioxins, furans, and coplanar PCBs) range from 0.72 to 0.98 pg/kg/day, depending of treatment of data reported as non-detect. In accordance with ME-CDC risk assessment policies, the estimate of 0.98 pg/kg/day is used as an estimate of background dietary exposure to dioxin TEQs. This estimate suggests less than 20% of the ADI (1 pg/kg/day) may be available for apportioning to sport fish consumption. However, it has been the policy of ME-CDC with its derivation of drinking water guidelines (and the policy of USEPA both with drinking water guidelines and ambient water quality criteria) to set a floor of 20% for relative source contribution. The 20 percent floor has been traditionally rationalized to prevent a situation where small fractional exposures are being controlled. That is, below that point, it is more appropriate to reduce other sources of exposure, rather than promulgating standards or guidelines for *de minimus* reductions in overall exposure (USEPA, 2000).

Table 1. Estimates of Background Dietary Exposure to Dioxins and Coplanar PCBs on a Toxic Equivalents (TEQs) Basis.

Chemical	Estimated Exposure Assuming NDs = 0 (pg/kg/day)	Estimated Exposure Assuming NDs = ½ DL (pg/kg/day)
Dioxins/Furans TEQs	0.38	0.64
Coplanar PCB TEQs	0.34	0.34
Total TEQ	0.72	0.98
% Contribution of Coplanar PCBs to Total TEQs	47%	35%

3. Revised FTAL for Noncarcinogenic Effects of Dioxin-Like Compounds

Using the above information, a revised FTAL for use in evaluating the noncarcinogenic effects of dioxin TEQs can be calculated using equation (2), where:

$$FTAL = \frac{(ADI \times BW)}{FC} \times RSC$$

FTAL = Action Level (pg/kg, parts-per-trillion)
ADI = Acceptable Daily Intake (1 pg/kg/day)
BW = Body Weight (60 Kg for average woman)
FC = Fish Consumption Rate (32.4 grams fish/day, one 8-oz meal per week)
RSC = 20 % (fraction of 0.2)

yielding an FTAL of 0.37 picograms dioxin TEQs per gram of edible fish tissue (pg/g), or 0.37 parts per trillion (ppt, as the more commonly reported units) – which is rounded to 0.4 ppt.

Since this health benchmark continues to be based on the developmental and reproductive toxic effects of dioxin-like compounds, ME-CDC will use this FTAL to develop fish consumption advisories targeted to women who may get pregnant, pregnant women, nursing mothers, and all girls (the latter due to concern over the very long residence time of these chemicals in the human body and the potential for build-up of body burdens over time). The focus on females of reproductive age and young girls is consistent with recommendations from the National Academy of Sciences (NAS, 1993).

V. Comparison of Dioxin TEQ Levels in Fish from Maine Rivers to Health Benchmarks

1. Background on Data on Dioxin-Like Compounds in Fish Tissue

The following section will describe the concentrations of dioxins and coplanar PCBs found in fish from Maine Rivers. The Dioxin Monitoring Program (DMP) was enacted in 1987 (38 MRSA §420-A) to include monitoring of all dioxin and furan congeners in fish below known or likely sources of dioxin. That included any and all rivers where discharges of dioxin were suspected, including the Androscoggin, Kennebec, Penobscot, Sebasticook, Salmon Falls, Presumpscot, St. Croix, St John. Table 2 lists the sample locations for each River that was sampled during the 2003 – 2007 period.

Table 2. Fish Sampling Locations on Androscoggin, Kennebec and Penobscot Rivers

Androscoggin River	Kennebec River	Penobscot River
Lisbon Auburn Livermore Livermore Falls Riley Rumford Rumford Point Gilead	Gardiner Sidney Waterville Fairfield Norridgewock	Veazie Costigan Lincoln Mattawamkeag Woodville Grindstone
Sebasticook River	**Salmon Falls River**	**Presumpscot River**
Burnham (MainStem) Palmyra (West Branch) Newport (East Branch) Sebasticook Lake (East Branch)	South Berwick Spaulding Pond	Windham Westbook

As dioxins alone are the concern of the Dioxin Monitoring Program, they will be discussed first and separately from the coplanar PCBs. From the perspective of advisories, however, coplanar PCBs need to be considered because of their contribution to total dioxin TEQs and consequently, need for fish consumption advisories. Therefore, levels of total TEQs (dioxin and coplanar PCB concentrations) will additionally be compared to the noncancer FTAL of 0.4 ppt.

In 2004, ME-CDC reported on an evaluation of dioxin-like compounds in fish from Maine rivers (ME-CDC, 2004). That report focused on data on fish collected during the sampling seasons of 2001 through 2003. The present report focuses on data collected from 2003 through 2007. It should be noted that due to limited funds, not all locations were sampled for each year, not all fish species were sampled for each year, and coplanar PCBs were not always analyzed for the same samples as the dioxin samples.

The Department of Environmental Protection targets a game species of fish and a bottom feeding species of fish when doing sampling. The game fish is typically smallmouth bass, though when other game fish species are abundant, they may be collected (e.g., trout). The bottom feeding species of fish has always been white sucker. Both dioxins and coplanar PCBs are highly lipophilic (i.e., they have a very strong affinity for fatty materials), and thus tend to be present at higher levels in fish that have a higher fat content (e.g., both trout and white suckers have higher concentrations of fat in their tissue as compared to smallmouth bass, so they typically have higher levels dioxins and coplanar PCBs). All species of fish are filleted prior to analysis, so the dioxin and coplanar PCB concentrations represent levels that would be consumed by someone eating the fish. At most sampling locations, 5 to 10 individual fish are caught and analyzed for dioxins and coplanar PCBs.

The figures that follow summarize the available fish tissue data on individual fish by reporting the 95th percentile upper confidence limit on the mean.[3] It is ME-CDC policy to rely on this summary statistic (i.e., the 95th percentile upper confidence limit on the mean) as a health protective measure given uncertainty about the true population mean levels due to limited numbers of individual fish sampled (ME-CDC, 2000). As sample size increases or inherent variability in measured levels lessens, the difference between the upper 95th percentile confidence limit on the mean and the estimate of the mean itself becomes smaller. For purposes of performing analyses with fish tissue data, all measured levels reported as non-detect for individual congeners are assumed present at one-half the detection limit as per ME-CDC policy (ME-CDC, 2000). This is another health protection measure given uncertainty about whether a dioxin congener may in fact be present at levels less than a particular laboratory's method for analyzing for these chemicals. In 2004, however, the coplanar PCB data had unusually high detection limits; following standard treatment of non-detects resulted in estimates that were typically substantially higher than in both prior and following years. Consequently, ME-CDC has not included these data in present analyses. A final data quality issue regards treatment of measured values flagged by the laboratory as "EMPC" or "Estimate Maximum Possible Concentration". For these samples, a peak was detected, but not all quantification criteria were met by the laboratory; hence the data are flagged. It has been the standard procedure to treat these values at their estimated level since 1997 for the purposes of developing advisories, rather than as non-detects.

[3] Fish tissue data for Androscoggin Lake are an exception to this way of summarizing the data. For most years, only two composite samples of a given fish species were collected for chemical analyses. When this was the case, the maximum of the two composites was used in preparing figures summarizing the data. For most years, however, there was little difference in dioxin levels between the two composite samples.

The fish tissue data are summarized as bar graphs, where the height of bar reflects the 95th upper confidence limit on the estimated mean of the individual data. Hence, there is a single bar for each sampling location on a river. There are several sets of figures. The first set illustrates how the dioxin levels alone have varied over the past several years; one figure illustrates levels in game fish (primarily smallmouth bass), the other suckers. The second set illustrates the cumulative dioxin TEQ levels when coplanar PCBs are added, again with separate figures for game fish and suckers. As coplanar PCB data are not available every year for which there are dioxin data, these figures reflect a subset of the dioxin data.

The data on fish tissue levels of dioxins and coplanar PCBs can be compared to both the cancer FTAL of 1.5 ppt (dioxins and coplanar PCBs treated separately) and the newly derived non-cancer FTAL of 0.4 ppt (dioxins and coplanar PCBs combined on a TEQ basis). The new non-cancer FTAL, it should be remembered, only applies to the sensitive population – namely, pregnant women, women who may get pregnant, and young girls for whom cumulative exposure to dioxin-like compounds would be relevant when they become pregnant. The rest of the population (predominantly males) would typically be compared to the cancer action level.

2. Dioxin Concentrations in Fish from Maine Rivers

Figure 5 summarizes the average levels of dioxins & furans in smallmouth bass and trout (gamefish) collected from the Androscoggin, Kennebec and Penobscot Rivers during the 2003 through 2007 field seasons. Over this time period, dioxin concentrations have repeatedly exceeded the 0.4 ppt FTAL at Gilead, Rumford Point, Rumford and Auburn for gamefish. Only in 2004, and only at Rumford Point, did dioxin concentrations exceed the cancer FTAL of 1.5 ppt. For the most recent sampling data (2007), exceedances in FTALs were limited to Auburn (smallmouth bass) and Gilead (trout). The Kennebec River was last sampled for dioxins in 2006, and in general has had only limited sampling since 2003. Levels have been at or below the 0.4 ppt FTAL. It is noteworthy that the apparent increase in dioxin TEQ levels on the Kennebec at Fairfield was primarily associated with the detection of the dioxin congener 2,3,7,8-TCDD in 2006 – it was not detected in 2005. The Penobscot River was last sampled for dioxins in gamefish in 2005. Measured concentrations between 2003 and 2005 have been consistently less than the 0.4 FTAL.

Figure 6 summarizes the average levels of dioxins & furans in white suckers collected from the Androscoggin, Kennebec and Penobscot Rivers during the 2003 through 2007 field seasons. Over this time period, dioxin concentrations have remained above the 0.4 ppt FTAL at all sampling locations on the Androscoggin River. Levels have remained above the cancer FTAL of 1.5 ppt at Livermore Falls, Riley, and Auburn (albeit with only 2007 data available at the latter). Rumford and Rumford Point have not been resampled since 2004. White suckers at Fairfield on the Kennebec River were sampled for dioxins every year between 2004 and 2007. All results since 2005 have indicated dioxin levels below the 0.4 FTAL. With the exception of Norridgewock in 2004 (which was less than the 0.4 FTAL), no other locations above or below Fairfield have been sampled for this fish species. On the Penobscot River, sampling has been most extensive at Veazie, Lincoln, and Woodville. Dioxin levels have hovered around 0.4 ppt in suckers collected at Veazie, as has also been the case at Lincoln since 2005. Levels at Woodville have been highly variable, bouncing between 0.8 ppt and < 0.4 ppt every other year. Notably, there is substantial fish-to-fish variability in dioxin levels at Woodville within a given year, resulting in substantial differences between the mean and the 95th percentile upper limit on the mean.[4]

Figure 7 summarizes the average levels of dioxins & furans in smallmouth bass collected from the Sebasticook, Salmon Falls, and Presumpscot Rivers during the 2003 through 2007 field seasons. With the exception of the West Branch and main stem of the Sebasticook, sampling has been limited. Over this time period, dioxin concentrations on the East Branch of the Sebasticook remained above the 0.4 ppt FTAL at Newport, and were above this level at Sebasticook Lake when last sampled in 2004. At Palmyra on the West Branch, levels appeared to drop substantially after 2004 and have remained around 0.4 ppt, whereas on the Main Stem, levels varied between 0.4 and 0.7 ppt in a more or less random way. Dioxin levels in gamefish collected in 2006 from the Salmon Falls and Presumpscot Rivers were at or below the 0.4 ppt FTAL.

3. Contribution of Coplanar PCB to Total TEQ Concentrations in Fish from Maine Rivers.

In Figures 8 through 10, coplanar PCB levels are presented as added to dioxin levels on a total TEQ basis. Figure 8 summarizes the total TEQs in smallmouth bass and trout (gamefish) collected from the Androscoggin, Kennebec and Penobscot Rivers during the 2003 through 2007 field seasons. The addition of coplanar PCB TEQs to dioxin TEQs results in levels consistently above the 0.4 FTAL for all sampling locations on the Androscoggin River. This is also generally the case for the Kennebec River (sampled in 2006), albeit with far less years of sampling data. For the Penobscot River (sampled in 2005), only gamefish from Veazie has total TEQs above the 0.4 FTAL. The Kennebec and Penobscot Rivers were sampled for coplanar PCBs in 2002, at which time total TEQ levels were generally between 0.5 and 1.0 ppt (ME-CDC, 2004).[5] Noteworthy are the coplanar PCB levels in smallmouth bass caught in Kennebec River at Gardiner. The represent the highest coplanar PCB levels in this data set, and the first time fish have been sampled for coplanar PCBs at this location. On average, coplanar PCBs represent 30 to 50% of the total TEQ levels.

[4] e.g., For 2005, the mean dioxin TEQ level was 0.53 ppt, while the 95th percentile upper limit on the mean was 0.80 ppt; for 2007, mean was 0.55 ppt and the 95th percentile upper limit on the mean is 0.85 ppt.

[5] Coplanar PCB data is available for 2004 as well. ME-CDC has decided not to use these data to support fish consumption advisories due to unusually high detection limits for this batch of data and its attendant consequences for estimated total TEQs when assuming non-detects are present at ½ the detection limit.

Figure 9 summarizes the average levels of total TEQs in white suckers collected from the Androscoggin, Kennebec and Penobscot Rivers during the 2003 through 2007 field seasons. With the exception of Grindstone on the Penobscot River, suckers from all sampling locations had total TEQ levels above the 0.4 FTAL. On average, coplanar PCBs in suckers represent 30% of the total TEQ levels.

Figure 10 summarizes the average levels of total TEQs in smallmouth bass for the Sebasticook, Salmon Falls and Presumpscot Rivers. The addition of coplanar PCBs results in total TEQs above the 0.4 FTAL at all sampling locations, though only moderately so on the West Branch of the Sebasticook River and the Presumpscot River.

4. Dioxin and Coplanar PCB concentrations in Fish from Androscoggin Lake

The Dead River connects the Androscoggin Lake to the Androscoggin River. It has been estimated that 2 to 3 times a year, Androscoggin River water overtops a floodgate on the Dead River and flows into Androscoggin Lake. For this reason, levels of dioxins and coplanar PCBs have been monitored in fish collected from Androscoggin Lake for a number of years. Figure 11 shows dioxin results from sampling smallmouth bass and white perch since 2003. No sampling season was associated with average levels of dioxins & furans above the cancer FTAL of 1.5 ppt. Since 2004, levels of dioxins have been below the 0.4 ppt FTAL for smallmouth bass, however, this has not been the case for white perch. White perch levels have been variable with levels above the 0.4 ppt FTAL for three of the past five years. The addition of coplanar PCBs (Figure 12) results in total TEQs about 0.4 FTAL for both smallmouth bass and suckers.

VI. Implications for Fish Consumption Advisories

Substantial progress has been made from the days in the late 1980s when dioxin levels were in the 2 – 20 ppt range. We now have levels of dioxin-like compounds in fish that are generally less than 1 – 2 ppt range, and generally less than 1 ppt for gamefish. It needs to be emphasized, however, that any formal changes in ME-CDC fish consumption advisories involves a comprehensive review of the levels of all measured contaminants in fish tissue from any given waterbody (e.g., methylmercury, PCBs, lead, and DDT in addition to dioxins & furans). Fish consumption advisories are based on the most limiting chemical contaminant. It is an unfortunate fact that a lessened need for consumption advisories due to lower levels of dioxins & furans in fish does not necessarily translate into changes in consumption advisories for a waterbody. This is especially the case given the restrictive statewide consumption advisory due to the presence of methylmercury in fish tissue. The statewide fish consumption advisory for methylmercury in fish is:

- **Pregnant and nursing women, women who may get pregnant, and children under age 8** SHOULD NOT EAT any freshwater fish from Maine's inland waters. Except, for brook trout and landlocked salmon, 1 meal per month is safe.

- **All other adults and children older than 8** CAN EAT 2 freshwater fish meals per month. For brook trout and landlocked salmon, the limit is 1 meal per week.

Based on preliminary evaluations of the past several years of data of dioxins and coplanar PCBs in fish, it appears that for a number of sampling locations, levels of these contaminants do not result in advisories that are more restrictive of consumption than the statewide mercury advisory. There is, however, an exception to this general conclusion. The NAS (2003) recommends that young girls should limit their intake of dioxin-like compounds because of the ability of these chemicals to build up in body tissues over time resulting in higher exposure to the fetus during pregnancy and the infant during nursing. Young girls between the age of 8 and when they become of childbearing age, are not included in the sensitive population for the statewide mercury advisory. Thus, for those areas where fish tissue levels of total dioxin TEQs warrant advice more restrictive than the general population 2-meal per month recommendation (i.e., where fish tissue levels for total TEQs average above 0.8 ppt), the statewide methylmercury advice will not be most limiting for this specific population. This situation applies to the Androscoggin River (Auburn, Livermore Falls, Gilead for gamefish, all sampling locations for suckers), gamefish from Gardiner on the Kennebec River (though mostly due to presence of coplanar PCBs), suckers on the Penobscot, gamefish from the Sebasticook (Main Stem and East Branch), and possibly gamefish from Androscoggin Lake.

Regardless of whether the statewide mercury advice becomes the limiting advice, dioxin-like compounds certainly remain a concern on all waters where total dioxin-like TEQs exceed 0.4 ppt in fish tissue. They remain above these levels at virtually all sampling locations on the Androscoggin River for both gamefish and suckers. They remain of concern on Androscoggin Lake. They remain of concern for suckers on the Penobscot, and possibly for gamefish at Veazie on the Penobscot. They clearly remain a concern on the Kennebec at Gardiner, and most recent data suggests a continued concern regarding trout caught at Waterville and Fairfield. These locations all have dioxin or total TEQ levels that continue to exceed the 0.4 ppt FTAL. For the Androscoggin River, suckers even exceed the 1.5 ppt cancer FTAL.

Yet it must be recognized that for a number of sampling locations, additional data on levels of dioxin-like compounds in fish may not materially change the fish consumption advice issued by the ME-CDC; again, due to the statewide mercury advisory. This is not to say there is no need for continued monitoring of dioxin levels in these rivers. It is desirable from a public health perspective to know whether fish are below levels of concern for dioxin-like compounds even if they do not determine consumption limits and even if our risk assessment methods do not yet consider the cumulative effects of different classes of chemicals with similar targets (e.g., both dioxins and mercury have developmental toxicity).

While there remains a benefit to ongoing monitoring, it is appropriate to consider changes to its design with its current emphasis on testing a number of individual fish at every sampling location. Such data have been desirable for understanding variability between individual fish, analyzing congener profiles, and providing more robust data for statistical analyses. Yet having collected such data for years, it is appropriate to consider using the information collected to date to support decisions to focus monitoring on a subset of sampling locations on a given river each year (e.g., Auburn and Gilead on the Androscoggin River; Gardiner and Fairfield on the Kennebec; Lincoln or Veazie and Woodville on the Penobscot). It is also appropriate to consider using composite fish samples rather than individual fish analyses to decrease the number of samples to be analyzed (and thus costs), yet still provide a reliable estimate of average levels and ideally increase the number of rivers that can be sampled in a giver year. The latter point – increasing the number of rivers sampled in a given year, would more quickly bring us to the point of having sufficient data to assess averages and trends, both of use in the lifting of advisories. With these considerations in mind, Maine CDC makes the following recommendations for future sampling of fish for dioxin-like compounds.

VII. Recommendations for Future Sampling of Fish for Dioxin-Like Compounds

Androscoggin River: Annual monitoring at Auburn (Gulf Island Pond) for both gamefish (smallmouth bass) and suckers. This station is representative of levels seen at all other sampling locations below Rumford Point, represents a potential high use area (Gulf Island Pond), and has total TEQs around 0.8 ppt. Continued annual monitoring of trout at Gilead. This station is representative of conditions of water coming into the state and of Rumford Point; it has been historically high in dioxin levels; it is a significant trout fishery; and it is one of several areas where the statewide mercury advisory would not be sufficiently protective for consumption of gamefish. Sampling could change from individual fish to composite samples, with only two samples being submitted for chemical analysis for any sampling location – fish species combination. All analyses should be for total TEQs (i.e., dioxins, furans and coplanar PCBs)

Kennebec River: Annual monitoring of gamefish at Gardiner (smallmouth bass) and Fairfield (brown trout). The coplanar PCB levels in gamefish at Gardiner are among the highest seen and should be confirmed; it may be appropriate to sample immediately above and below this sampling location (e.g., Augusta, Richmond) to bound this potential hot spot. This is another location where the statewide mercury advisory would not be sufficiently protective of the sensitive population. The levels of dioxins in trout at Fairfield have been variable in recent years and there are insufficient data to obtain a reliable estimate of average levels. This is also a popular fishery. Again, sampling could change from individual fish to composite samples as discussed above. All analyses should be for total TEQs (i.e., dioxins, furans and coplanar PCBs).

Penobscot River: Annual monitoring of suckers at Woodville and possibly smallmouth bass as well. The primary concern is the continued variability in total TEQ levels in suckers, and insufficient data to know if the variability exists with smallmouth bass as well. Continue annual monitoring of both gamefish and suckers at either Veazie (our preference) or Lincoln. Both have similar levels of total TEQs in suckers; the most recent data for Veazie had levels in gamefish approaching 0.8 ppt. After two years of additional data on total TEQ levels, the frequency of monitoring should be reevaluated and could be lessened. Again, sampling could change from individual fish to composite samples as discussed above. All analyses should be for total TEQs (i.e., dioxins, furans and coplanar PCBs).

Sebasticook River: Annual monitoring of gamefish at Burnham (Main Stem) and Newport (East Branch). Most recent data for both stations have total TEQs above 0.8 ppt and thus the statewide mercury advisory would not be sufficiently protective. We do not have any recent data on suckers for these locations; sampling is recommended if possible. Again, sampling could change from individual fish to composite samples as discussed above. All analyses should be for total TEQs (i.e., dioxins, furans and coplanar PCBs).

Salmon Falls River: Annual monitoring of gamefish at South Berwick. Most recent data show total TEQs above 0.8 ppt and thus the statewide mercury advisory would not be sufficiently protective. We do not have any recent data on suckers for these locations; sampling is recommended if possible. Again, sampling could change from individual fish to composite samples as discussed above. All analyses should be for total TEQs (i.e., dioxins, furans and coplanar PCBs).

Presumpscot River: One or two years of additional sampling of gamefish at Windham and Westbrook to confirm levels are remaining below 0.8 ppt on a total TEQ basis, after which less frequent sampling to monitor levels are either stable or decreasing. We do not have any recent data on suckers for these locations; sampling is recommended if possible. Again, sampling could change from individual fish to composite samples as discussed above. All analyses should be for total TEQs (i.e., dioxins, furans and coplanar PCBs).

Androscoggin Lake: Two years of additional sampling of white perch to confirm levels are remaining below 0.8 ppt, after which less frequent sampling to monitor levels are either stable or decreasing. Again, sampling could change from individual fish to composite samples as discussed above. All analyses should be for total TEQs (i.e., dioxins, furans and coplanar PCBs).

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FIGURES

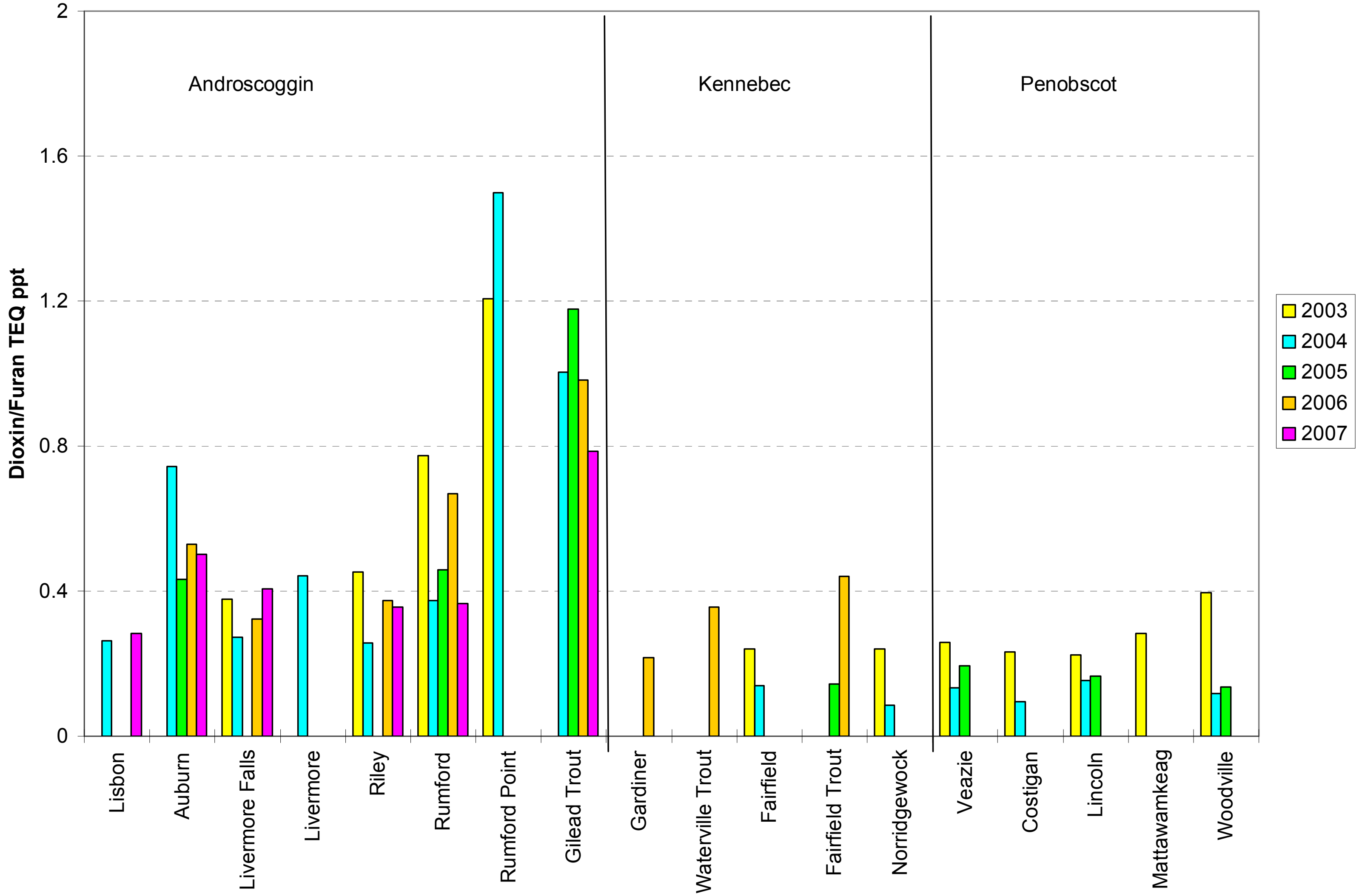
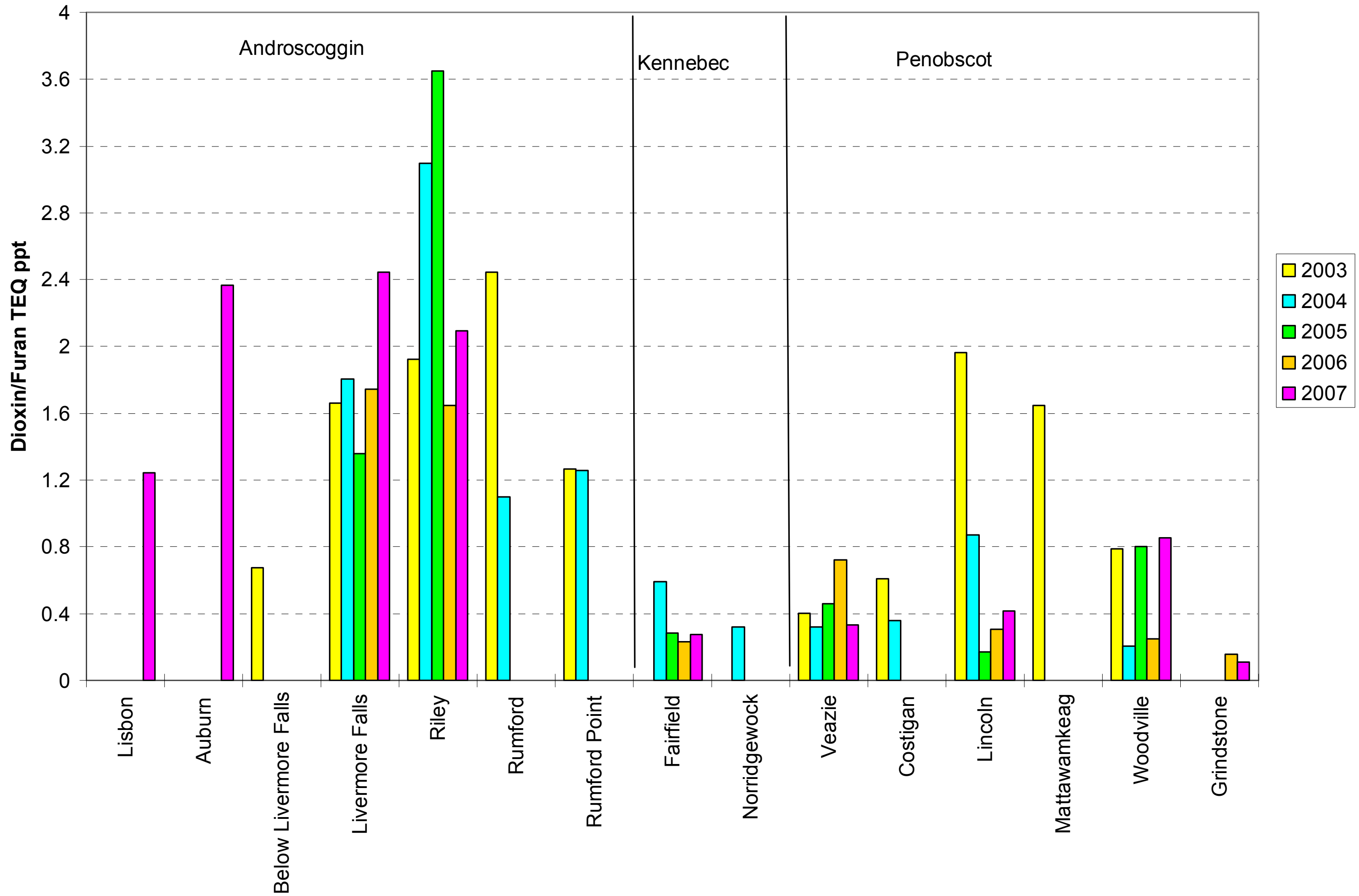


Figure 5. Average levels of dioxins & furans in game fish for sampling locations along three Maine Rivers. Levels are reported on a toxic equivalency basis in parts per trillion (ppt), and are computed assuming congeners below analytical detection limits are present at ½ the detection limit. To account for sample size limitations, the 95th percentile upper confidence limit on the sample mean is shown, rather than the sample mean itself.



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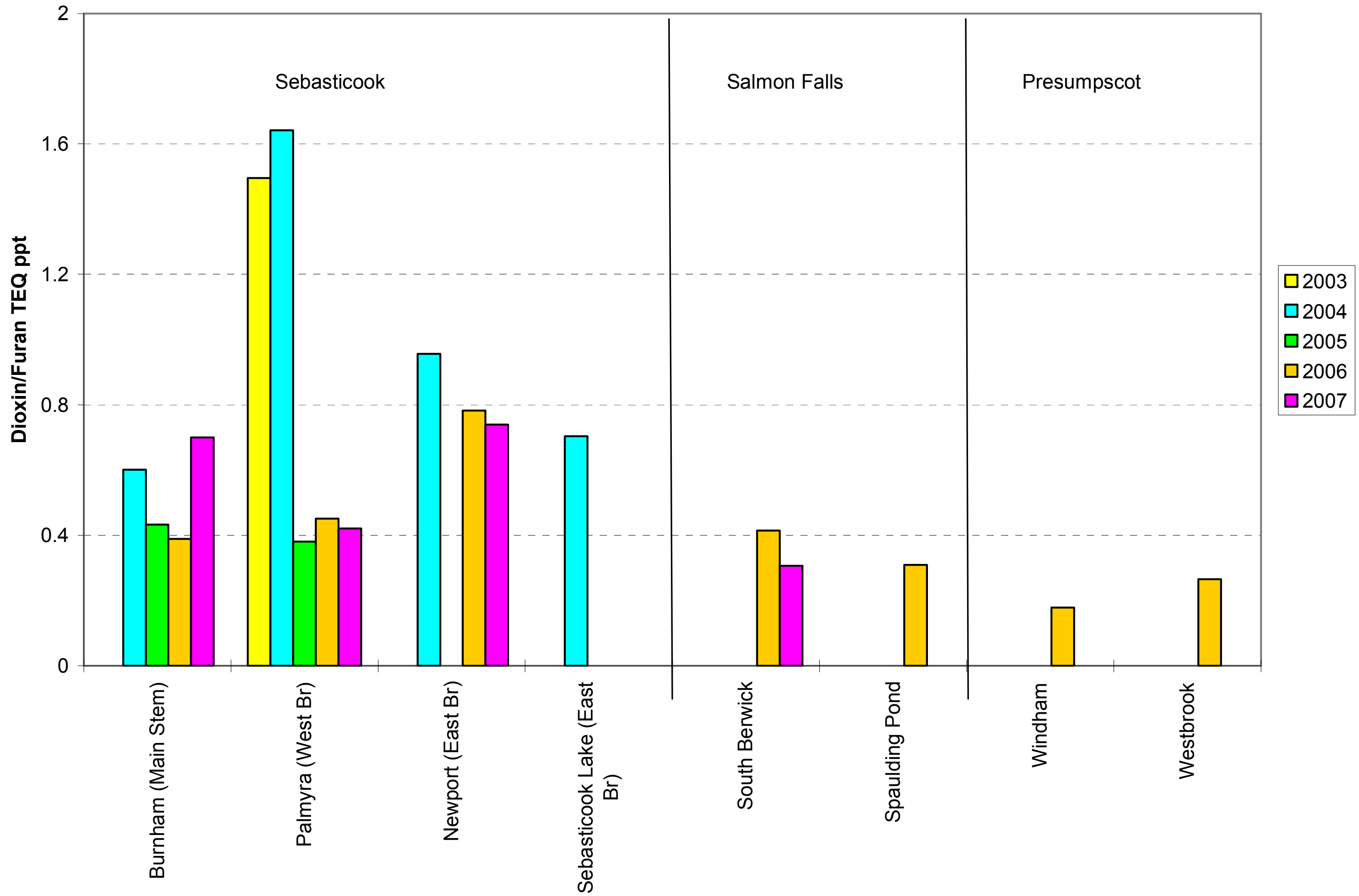


Figure 7. Average levels of dioxins & furans in game fish for the years 2003 through 2007 for the Sebasticook, Salmon Falls and Presumpscot Rivers. Levels are reported on a toxic equivalency basis in parts per trillion (ppt), and are computed assuming congeners below analytical detection limits are present at ½ the detection limit. To account for sample size limitations, the 95th percentile upper confidence limit on the sample mean is shown, rather than the sample mean itself.

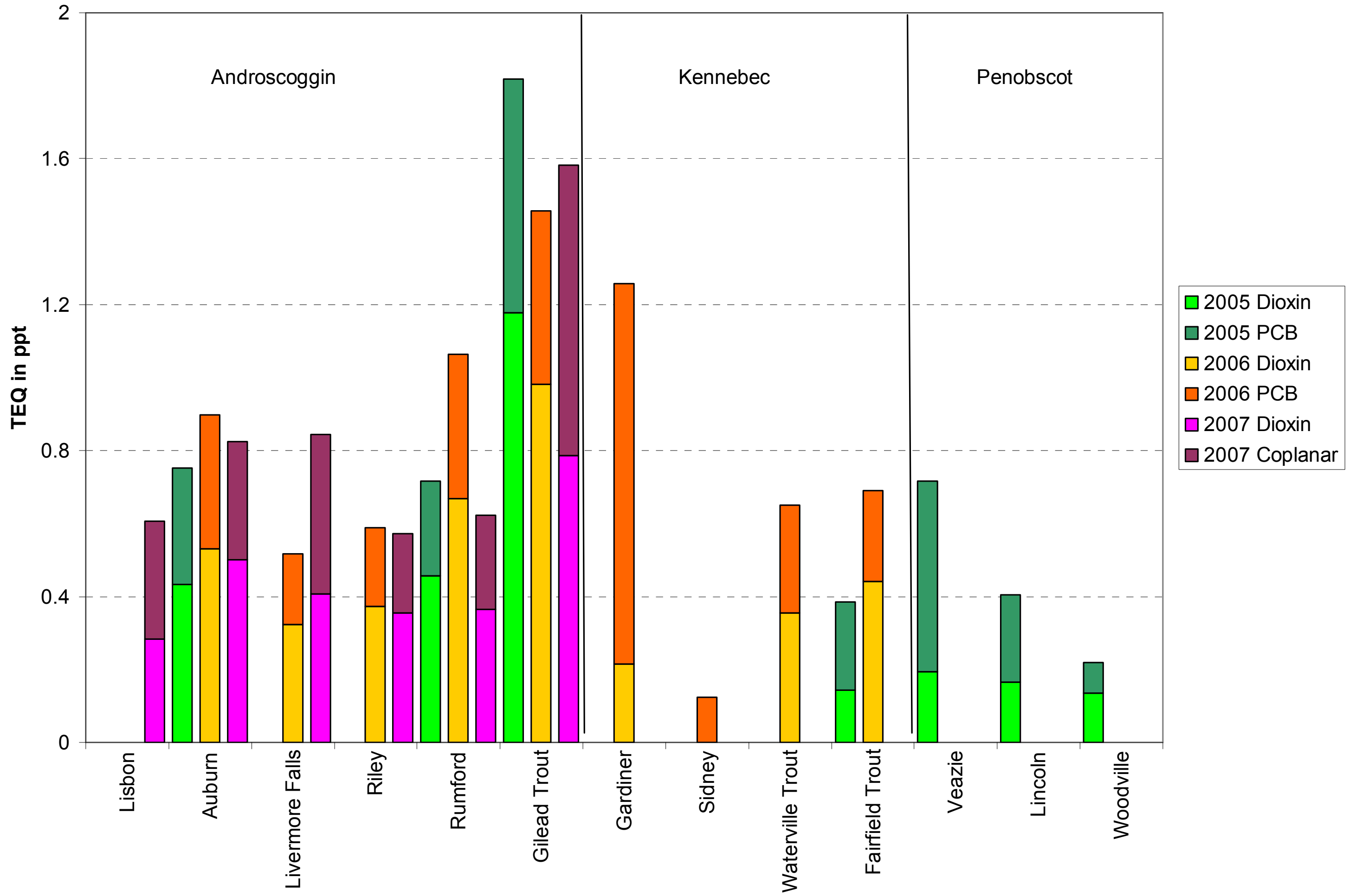
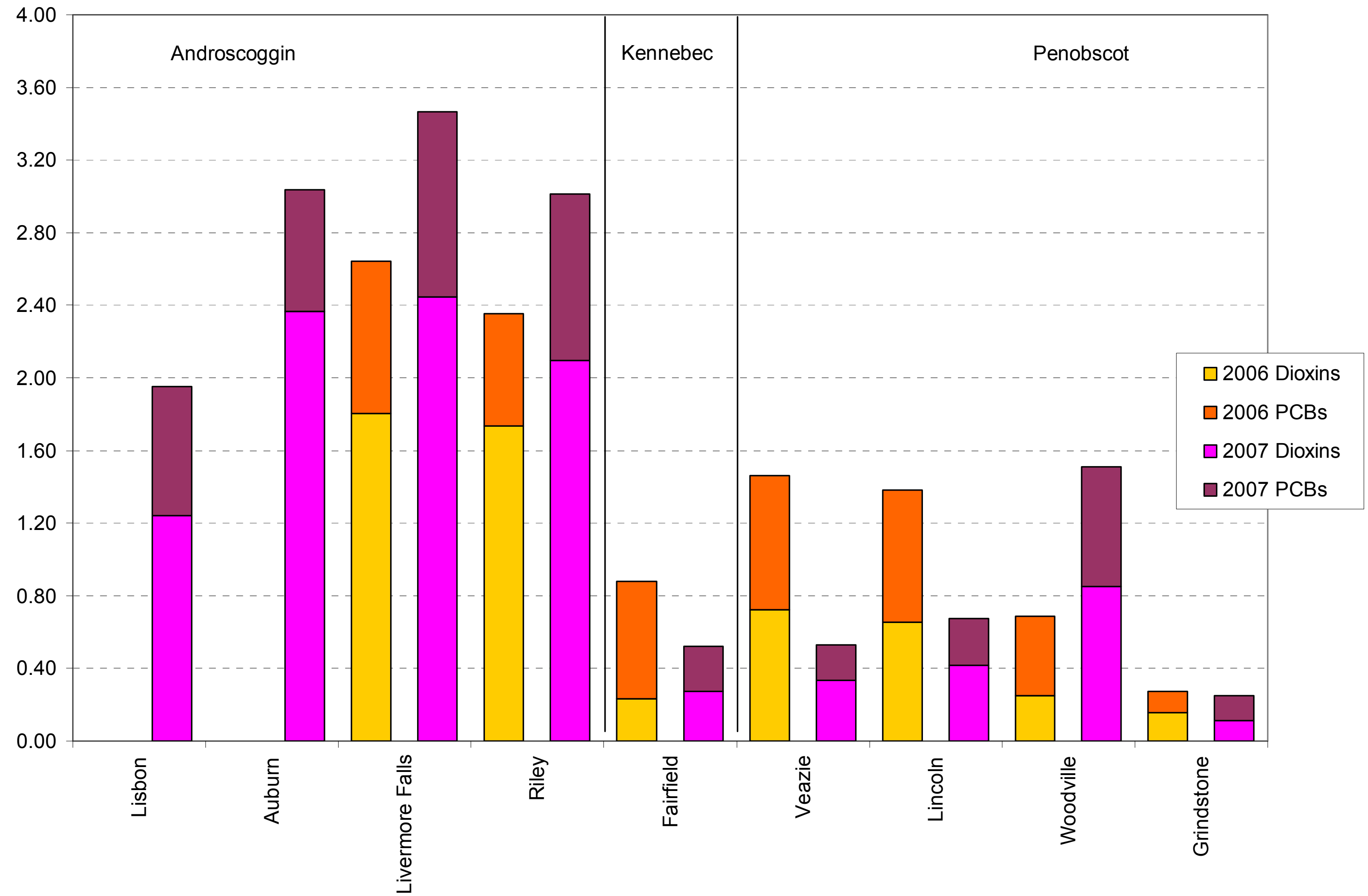


Figure 8. Average levels of dioxins and coplanar PCBs in game fish for sampling locations along three Maine Rivers. Levels are reported on a toxic equivalency basis in parts per trillion (ppt), and are computed assuming congeners below analytical detection limits are present at ½ the detection limit. To account for sample size limitations, the 95th percentile upper confidence limit on the sample mean is shown, rather than the sample mean itself.



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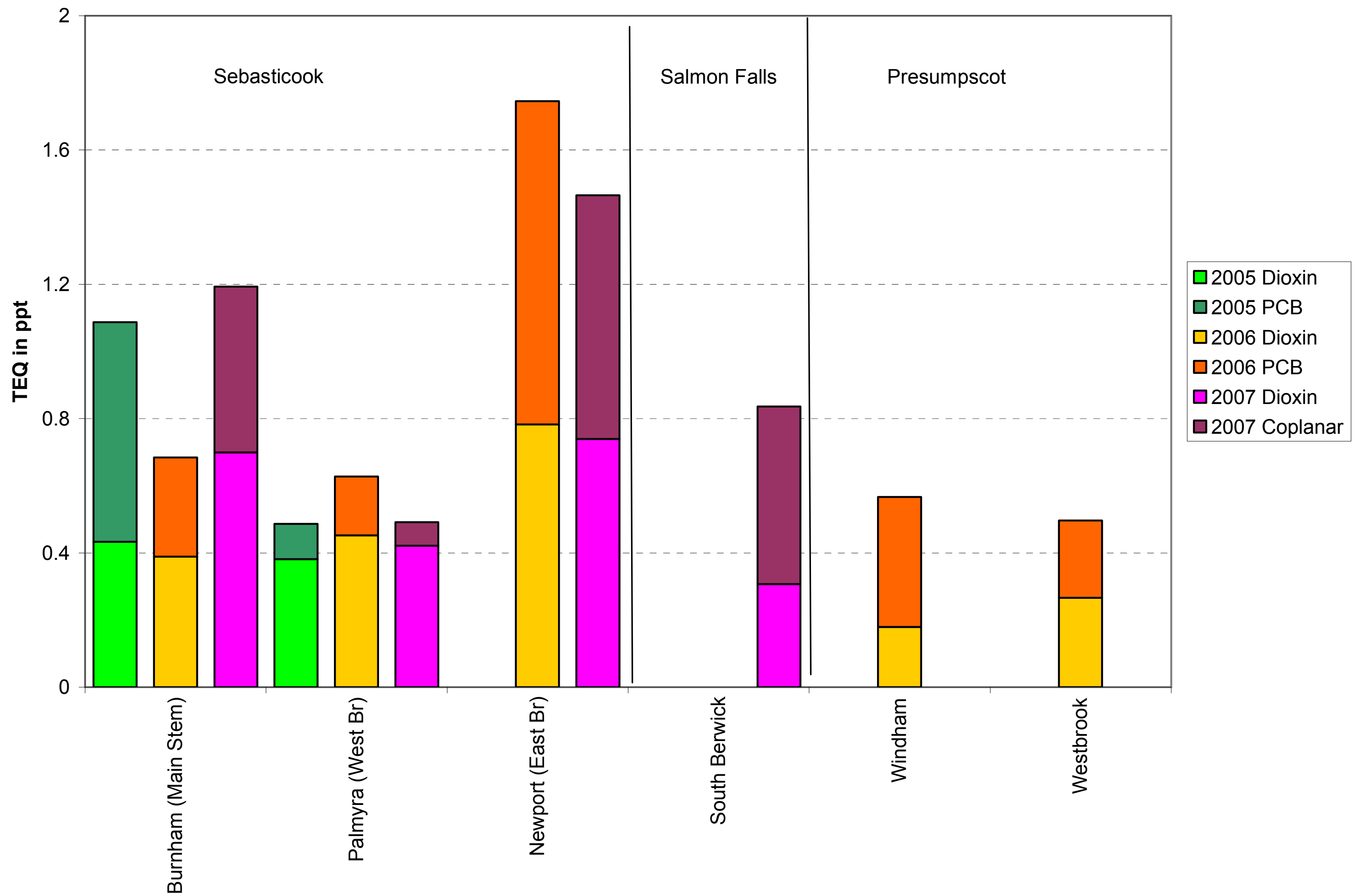

Figure 10: Average levels of dioxins and coplanar PCBs in game fish for the years 2003 through 2007 for the Sebasticook, Salmon Falls and Presumpscot Rivers. Levels are reported on a toxic equivalency basis in parts per trillion (ppt), and are computed assuming congeners below analytical detection limits are present at ½ the detection limit. To account for sample size limitations, the 95th percentile upper confidence limit on the sample mean is shown, rather than the sample mean itself.

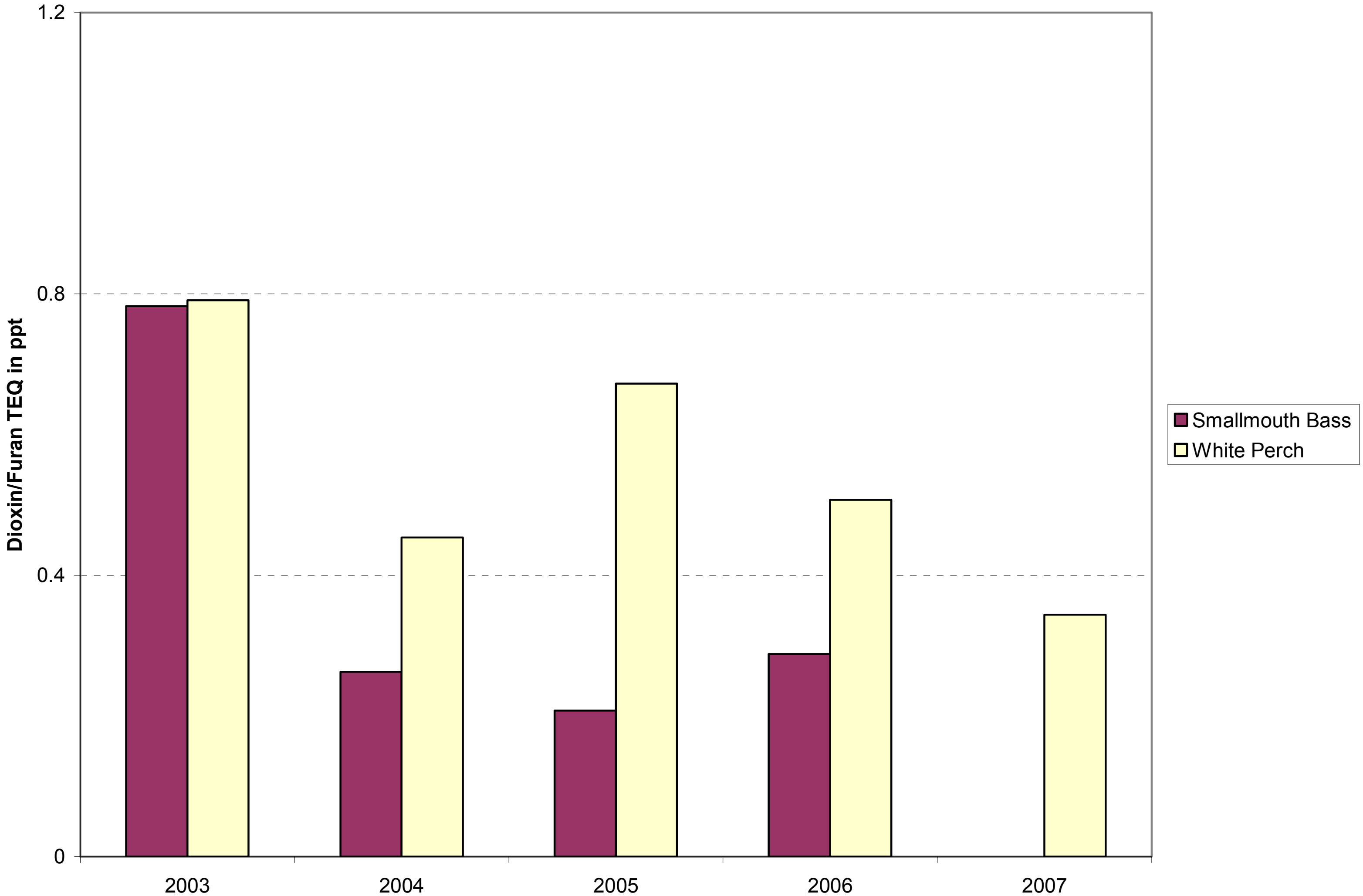

Figure 11 Average levels of dioxins & furans in game fish for the years 2003 through 2007 for Androscoggin Lake. Levels are reported on a toxic equivalency basis in parts per trillion (ppt), and are computed assuming congeners below analytical detection limits are present at ½ the detection limit. To account for sample size limitations, the 95th percentile upper confidence limit on the sample mean is shown if there are sufficient data points (only 2003), rather than the sample mean itself. For most years, only 1 or 2 fish were sampled, hence the maximum value is reported.

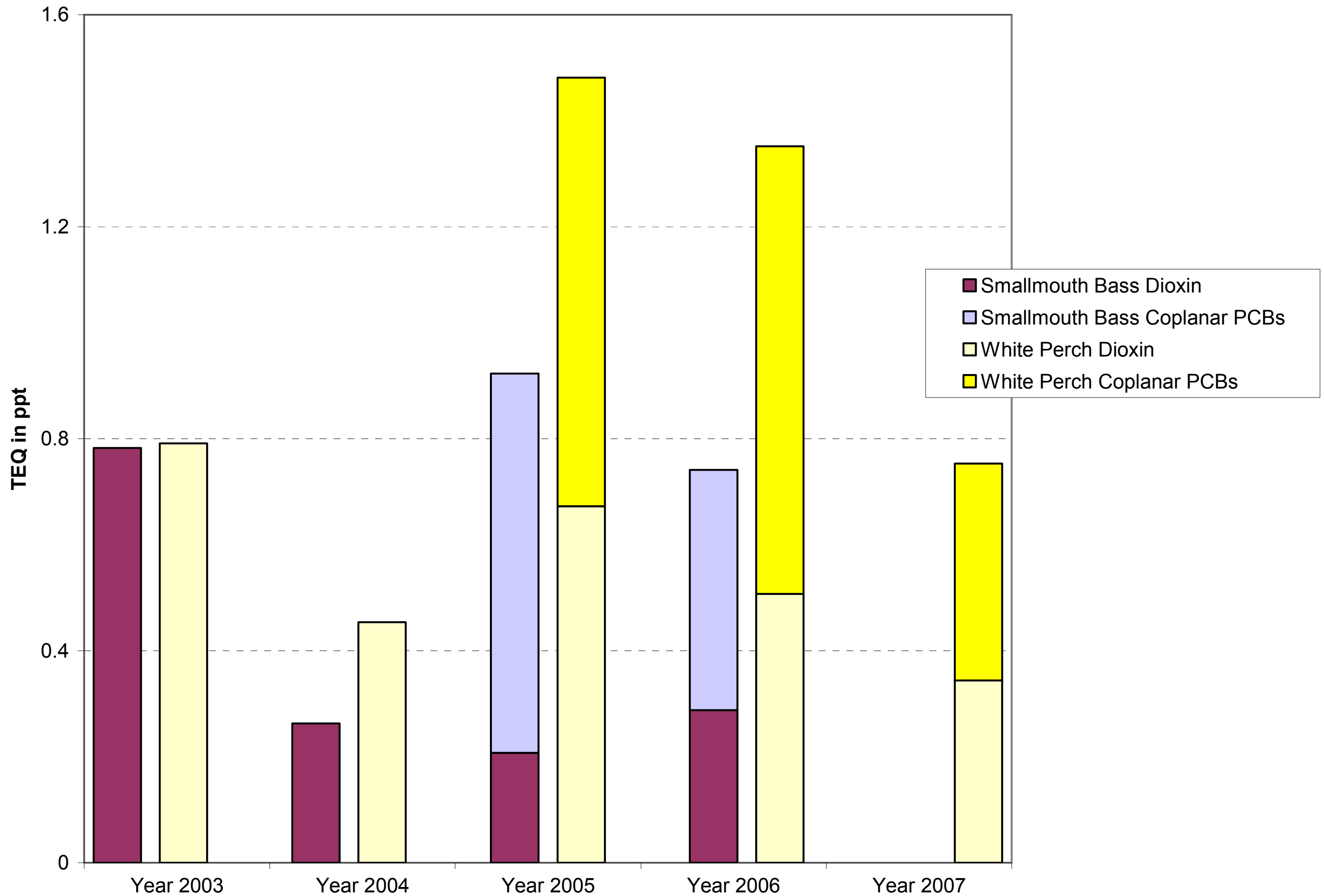

Figure 11: Average levels of dioxins and coplanar PCBs in game fish for the years 2003 through 2007 for Androscoggin Lake. Levels are reported on a toxic equivalency basis in parts per trillion (ppt), and are computed assuming congeners below analytical detection limits are present at ½ the detection limit. To account for sample size limitations, the 95th percentile upper confidence limit on the sample mean is shown if there are sufficient data points (only 2003), rather than the sample mean itself. For most years, only 1 or 2 fish were sampled, hence the maximum value is reported.