A Model of PCB Bioaccumulation in the Lower Fox River and Green Bay: GBFood

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SECTION 1
INTRODUCTION

The bioaccumulation model GBFood is a mathematical description of PCB transfer within the food webs of Green Bay and the Lower Fox River, from the dam at DePere to the mouth. GBFood is comprised of two components; the model framework and model parameter values. The model framework is the set of mathematical equations that describes the process of bioaccumulation in aquatic food webs and forms the basis for the computer source code. The framework is written in FORTRAN, compiled using DIGITAL Visual Fortran v.6.0, and run on an Hewlett Packard Kayak (Intel Pentium II) using Windows NT. Values for the ecological, bioenergetic and toxicokinetic parameters specified in the framework are based upon site-, species- and chemical-specific data.

This modeling framework was originally developed approximately 20 years ago and has been updated several times, including as part of this project. It has been applied in a variety of aquatic systems to a variety of compounds, the most common of which has been polychlorinated biphenyls (PCBs) (Table 1-1). GBFood, the model of PCB bioaccumulation in Green Bay/Lower Fox River that is presented here, represents an update of an existing model that was first developed by Connolly et al. (1992) as part of the Green Bay Mass Balance Study (GBMBS) and later updated by HydroQual (1995), both on behalf of the U.S. Environmental Protection Agency (USEPA).

Table 1-1. Previous applications of the bioaccumulation model			
System	Chemical	Food Web Leading to	Reference
Lake Michigan	PCBs	lake trout	Thomann and Connolly, 1984
Lake Ontario	PCBs	lake trout	Connolly and Thomann, 1992
James River Estuary	Kepone	striped bass	Connolly and Tonelli, 1985
Hudson River Estuary	PCBs	striped bass	Thomann et al., 1989
New Bedford Harbor	PCBs, Cd, Cu, Pb	winter flounder, lobster	Connolly, 1991
Green Bay	PCBs	walleye, brown trout	Connolly et al., 1992; HydroQual 1995
Southern California Bight	PCBs, DDE	white croaker, kelp bass, Dover sole	HydroQual, 1994
Upper Hudson River	PCBs	largemouth bass	QEA, 1999

GBFood has been updated on behalf of Wisconsin Department of Natural Resources for use in the Fox River Remedial Investigation and Feasibility Study (RIFS) to estimate PCB concentrations in brown trout and walleye food webs in the Lower Fox River and Green Bay. Values for the pertinent physiological, bioenergetic, and toxicokinetic parameters in the model were derived from studies published in the peer-reviewed literature and/or site-specific data. The sediment and water column PCB concentrations to which the fish are exposed were provided by the Lower Fox River Model (wLFRM) and the Green Bay PCB fate and transport model (GBTOXe).

This document includes a discussion of the theoretical basis for the model framework (Section 2); the application of the framework to the Lower Fox River and Green Bay, including estimation of values for the parameters (Section 3); and a description of the calibration of the model (Section 4). The calibrated GBFood is used to evaluate the efficacy of several remedial alternatives in reducing PCB levels in fish of the Lower Fox River and Green Bay. Towards this end, 100-year model projections are performed as described in Section 5.

SECTION 2
BIOACCUMULATION MODEL FRAMEWORK

The accumulation of PCBs by aquatic animals is described by the following (Connolly 1991, Connolly et al. 1992):

$$\frac{dv_i}{dt} = K_{ui} c_d + \alpha_c \sum_{j=1}^{n} C_{ij} v_j - (K_i + G_i) v_i \qquad (2\text{-}1)$$

where:

i & j	=	indices for predator and prey, respectively
v_i	=	concentration of chemical in species i (µg/g wet)
v_j	=	concentration of chemical in species j (µg/g wet)
K_{ui}	=	rate constant for respiratory chemical uptake by species i (L/g wet-day)
K_i	=	rate constant for excretion of chemical by species i (1/day)
c_d	=	concentration of PCBs in the water (µg/L)
α_c	=	efficiency at which ingested chemical is assimilated from prey
C_{ij}	=	predation or consumption rate of species i on species j (g wet prey/g wet predator-day)
G_i	=	growth rate of species i (g wet/g wet-day)
n	=	number of species (including different year classes of a single species) preyed upon by species i

The first term in Equation 2-1 represents the direct uptake of PCBs by the animal from water. The second term represents the flux of PCBs into the animal through feeding. The third term represents the loss of chemical due to diffusion across the gill and the change in concentration due to growth. The gill is the major site of depuration; the fecal elimination rate is much less than the growth rate and is not included in the model. The dynamic bioaccumulation model is applied to each fish species, accounting for species-specific differences in growth rate, consumption rate and elimination rate. A brief discussion of the individual processes within

Equation 2-1 is provided below. A more detailed discussion can be found in Connolly (1991), Connolly et al. (1992), HydroQual (1996) and QEA (1999).

The uptake rate from water is a diffusive process that occurs at the gill surface. The rate is determined by the rate at which water passes over the gill, which is in turn estimated from the respiration rate (Equation 2-2):

$$K_{ui} = \frac{\varepsilon \kappa R_i}{c_{o_2}} \tag{2-2}$$

where:

ε	=	ratio of uptake efficiencies of PCBs/oxygen
κ	=	conversion factor (gO_2/kJ)
R_i	=	respiration rate of species *i* (kJ/g wet-day)
c_{O_2}	=	concentration of oxygen in the water (gO_2/L)

The bioenergetic component of the model computes the respiration rate, accounting for the metabolism in the absence of feeding (standard metabolism) and the added effects of specific dynamic action and swimming. The concentration of oxygen in water is calculated assuming saturation, incorporating corrections for temperature and salinity. The ratio of chemical to oxygen uptake efficiencies is estimated from experimental data.

The uptake rate from food is a function of the concentration of chemical in the prey (v_j), the consumption rate of the species on the prey (C_{ij}) and the efficiency at which ingested chemical is assimilated from the prey (α_c). The rate of consumption of food is calculated from the rate of energy usage, which in turn is estimated from the rates of production and metabolism (Equation 2-3):

$$C_{ij} = \frac{R_i + G_i}{\alpha_F} \frac{\lambda_i}{\lambda_j} \tag{2-3}$$

where:

G_i	=	growth rate of species *i* (g wet/g wet-day)
α_F	=	efficiency at which ingested energy is assimilated from prey species *j*
λ_i	=	energy density of species *i* (kJ/g wet)
λ_j	=	energy density of prey species *j* (kJ/g wet)

Several lines of evidence suggest the loss of chemical across the gill is a two-step process, the release of chemical from the storage compartment, lipid, followed by release to the environment. PCB elimination rates measured after long-term exposures are often much lower than rates measured after shorter exposure periods (de Boer et al., 1994; Lieb et al., 1974; O'Connor and Pizza, 1987; Sijm et al., 1992). This has been ascribed to the relatively slow equilibration of contaminant within the deeper compartments during chronic exposure (O'Connor and Pizza, 1987; de Boer et al., 1994; Spacie and Hamelink, 1982). In fact, the rate of elimination is likely limited by perfusion of the deep compartments, not diffusion across the gill (Gibaldi and Perrier, 1982). The model accounts for the additional resistance due to relatively slow transfer between storage compartments and blood by computing the elimination rate across the gill (assuming equilibrium between lipid and blood) and reducing this rate by a "resistance" factor, c_R (Equation 2-4):

$$K_i = K_{ui} c_R v_{Bi} = K_{ui} c_R \left(\frac{1}{f_B + \pi_{LB} f_{L_i}} \right) v_i \qquad (2\text{-}4)$$

where:

c_R	=	factor accounting for the slow transfer of PCBs from lipid to blood
v_{Bi}	=	concentration of chemical dissolved in blood (µg/L)
f_{Bi}	=	fraction aqueous blood of species *i* (g blood/g wet)
f_{Li}	=	fraction lipid of species *i* (g lipid/g wet)
π_{LB}	=	partition coefficient of chemical between lipid and blood (g blood/g lipid)

Finally, the model computes growth rates for individual species (G_i) based upon a relationship between age and weight (W_i) that is determined from data:

$$G_i = \frac{1}{W_i}\frac{dW_i}{dt} \tag{2-5}$$

SECTION 3
APPLICATION TO THE LOWER FOX RIVER/GREEN BAY

3.1 INTRODUCTION

The application of GBFood to the Lower Fox River and Green Bay was accomplished through the use of site-specific information, where available, to estimate model parameters. Published literature values were used for the estimation of the parameters for which site-specific information was not available.

3.2 MODELING ZONES

GBFood was parameterized and calibrated in Zones 1, 2, 3A, 3B, and 4 as defined in the GBMBS (Figure 3-1). Zone 1 is defined as the portion of the Lower Fox River between the dam at Depere and the mouth of the River. Zone 2 comprises the southern portion of Green Bay between the mouth of the Lower Fox River and a line that transverses the bay (parallel to latitude) at Little Tail Point. Zone 3 is defined as the portion of Green Bay extending from the Zone 2 boundary to Chambers Island. This zone is split between Zone 3A in the west and Zone 3B in the east. Zone 4 encompasses the portion of Green Bay located north of Chambers Island.

3.3 MODEL PARAMETERIZATION

3.3.1 Food Web Structure

A key component of the model is the structure of the food web which consists of a description of the diets of predatory fish, forage fish, and the invertebrates at the base of the food web that consume particulate material in the water column and sediment bed. The food web structures used in GBFood were derived from several sources:

- Information presented in Connolly et al., 1992;
- Published literature;
- Stomach content data for walleye and brown trout collected in Green Bay by Magnuson and Smith (1987); and
- Information presented in Technical Memorandum 7c (WDNR, 2001).

The food web contains species that can feed on three trophic levels: predatory fish, forage fish and invertebrates. Individual species can feed on more than one trophic level, and this is included, where appropriate, in the model food web structures. For the forage fish, the food web structure used in Connolly et al. (1992) was updated to include information published in more recent literature. As in Connolly et al. (1992), analysis of the stomach content data presented by Magnuson and Smith (1987) served as the basis for the food web structures for walleye and brown trout.

3.3.1.1 Bioaccumulation at the Base of the Food Web

The invertebrate fauna of Green Bay include species that feed within the water column and benthic species that feed on surface sediments. Feeding ecology studies conducted in the Great Lakes indicate that the fish species modeled in GBFood predominantly feed on zooplankton such as copepods and cladocera (Gannon, 1974). In addition, benthic invertebrates such as amphipods, chironomids, and oligochaetes are consumed. Two important organisms in the food webs within the study area are *Mysis relicta* and *Diporeia hoyi*. While the consumption of phytoplankton by copepods and cladocera is well documented (Pennak, 1978), the relative importance of sediment and water column particulates as food sources to the major benthic invertebrate species is less clear. The feeding strategies of several groups of invertebrates are discussed below.

M. relicta can be an important source of nutrition for forage fish (Grossnickle, 1982). *M. relicta* is found in Green Bay, although generally not present in the southern portion (Rades, 2000). In general, *M. relicta* feeds within the water column and can exert considerable influence over planktonic assemblages (Grossnickle, 1982; Bowers and Grossnickle, 1978; Bowers and

Vanderploeg, 1982). This invertebrate exhibits diurnal vertical migrations in the water column in response to the availability of food (Grossnickle, 1979), during which time it becomes available as food for forage fish. *M. relicta* can also feed upon sediment bed material, although Klump et al. (1991) considered sediments to be a secondary source of nutrition for this species.

D. hoyi is the dominant amphipod in the off-shore waters of the Great Lakes (Landrum and Nalepa, 1998). The habitat of *D. hoyi* in Green Bay is generally limited to the northern portions of the bay (WDNR, 2001). This amphipod is a benthic detritivore that consumes particulate material within the top 2 centimeters of the sediment bed, feeding primarily on bacteria-rich detritus and settled algae (Quigley, 1988). *D. hoyi* migrates into the water column, during which time it becomes available as food for forage fish. *D. hoyi* feeds selectively on particles that are rich in organic carbon, preferring freshly settled particles to aged sediment particulates (Dermott and Corning, 1988). In contrast to most other amphipods, *D. hoyi* appears to eat more intensively during algal blooms than during other times of the year (Gauvin et al., 1989; Dermott and Corning, 1988). For example, *D. hoyi* populations have been reported to consume a significant fraction of the spring diatom bloom in Lake Michigan (Fitzgerald and Gardner, 1993). Further, seasonal changes in growth rates and lipid levels suggest that *D. hoyi* rapidly assimilates newly settled detritus, when available, and is adapted to seasonally limited food (Gardner et al., 1985; Gauvin et al., 1989; Dermott and Corning, 1988). Finally, carbon, and PCB assimilation efficiencies are likely to be greater for freshly settled material than for aged sediment carbon (Landrum and Nalepa, 1998). Thus, due to a large component of freshly settled material in the diet, seasonal feeding on algal blooms, and high PCB assimilation efficiencies from freshly settled material, *D. hoyi* most likely accumulates PCBs primarily from water column particulates rather than sediment detritus.

Chironomids, or midge larvae, are associated with the sediments and are known to be an important resource for maintaining fish populations (Pennak, 1978). There are many species of chironomids with various feeding behaviors, consuming both water column or sediment particulates (Pennak, 1978).

Oligochaetes are deposit-feeders, ingesting whole sediment and digesting organic material as it passes through the alimentary canal (Pennak, 1978).

For the purpose of quantifying PCB transfer, the invertebrates are distinguished by their exposure source (water column vs. sediment) and the degree of bioaccumulation. GBFood includes two state variables: water column invertebrates (WCI) and benthic macroinvertebrates (BMI). The WCI represent the dominant species of zooplankton, cladocera and copepods, as well as *M. relicta*, and to the extent that they feed in the water column, *D. hoyi* and chironomids. The BMI represents oligochaetes, and to the extent that they feed in the sediments, *D. hoyi* and chironomids. Individual taxa are not modeled, primarily due to a lack of the data necessary to develop invertebrate models that would significantly improve the accuracy of the overall model. Overall, the information available on invertebrates in the Fox River/Green Bay system suggests that WCI are clearly dominant in the diets of the fish species of interest, and BMI have a relatively minor role.

Bioaccumulation in Benthic Macroinvertebrates (BMI)

GBFood computes food consumption by fish on an energy basis (in units of kJ/g-d). This permits the model to account for differences in energy density among prey and predators. Therefore, an energy-based biota-sediment accumulation factor (BSAF) was computed as follows:

$$BSAF_e = BSAF\left(\frac{f_L}{\lambda_{inv}}\right) \quad (3\text{-}1)$$

where:

$BSAF_e$	=	energy-based BSAF (g OC/kJ)
BSAF	=	lipid-based BSAF (g OC/g lipid)
λ_{inv}	=	energy density of the invertebrate sample (kJ/g wet)
f_L	=	Lipid content of invertebrate (glip/gwet)

A value of 1.5 gOC/glipid was selected for BSAF, based upon a review of field and laboratory studies performed by Tracey and Hansen (1996). The energy density of the invertebrates is equal to:

$$\lambda_{inv} = 20.08 f_P + 39.5 f_L \tag{3-2}$$

where:

f_P = fraction protein (g protein/g wet)

Furthermore, the dry weight of the invertebrates is essentially composed of lipid and protein:

$$f_D = f_P + f_L \tag{3-3}$$

Combining Equations 3-2 and 3-3, the inverse of the term in parentheses in Equation 3-1 is equal to:

$$\frac{\lambda_{inv}}{f_L} = 19.42 + 20.08\left(\frac{f_D}{f_L}\right) \tag{3-4}$$

Thus, the lipid content of the invertebrate prey on a dry weight basis (f_L/f_D, in units of glipid/gdry) is required. This was estimated from measurements performed in several species of invertebrates (Herbreteau et al., 1994; Nalepa et al., 1993; Wilcock et al., 1993; Oliver, 1984; Klump et al., 1987; Swindoll and Applehans, 1987; Leversee et al., 1982; Gerould et al., 1983; van de Guchte et al., 1988). From these data, the average energy density was computed for each of three major groups: crustacea, chironomids and annelids. An overall average energy density of the invertebrate prey was computed as the mean of the three group averages, yielding a value of 129 kJ/glipid. Thus, $BSAF_e$ equals 0.012 gOC/kJ (=1.5 gOC/glipid ÷ 129 kJ/glipid).

Bioaccumulation in Water Column Invertebrates (WCI)

Water column invertebrates accumulate their PCBs from particles associated with plant surfaces and particles in the water. In GBFood, PCB concentrations in WCI were set equal to the average PCB levels measured in zooplankton of the Lower Fox River and Green Bay as part of the GBMBS. In addition, bioaccumulation from water column particles to WCI was evaluated using paired PCB measurements in phytoplankton and zooplankton collected as part of the GBMBS. Using paired phytoplankton and zooplankton samples collected at numerous locations in the Lower Fox River and Green Bay, average trophic transfer factors ([µg PCB/glipid]/[µg PCB/gOC]) were determined for each paired sample and zone-specific averages were computed. These were used in support of model calibration, as described below.

3.3.1.2 Green Bay Zones 1 and 2

During the GBMBS, walleye, alewife and gizzard shad were collected from both Zones 1 and 2. Rainbow smelt were only captured in Lower Green Bay. WDNR (2001) included rainbow smelt in one food web structure that was considered representative of both Zones 1 and 2. For this model, we relied upon the data collected as part of the GBMBS. The presence of rainbow smelt in Lower Green Bay (Zone 2), but not in the Lower Fox River (Zone 1), necessitated the development of separate food web structures in each of these locations.

In GBFood, the diets of the forage fish present in both Zones 1 and 2 are identical. For walleye, the diets in Zones 1 and 2 differ only insofar as the diet of Zone 2 walleye includes a rainbow smelt component, whereas the diet of Zone 1 walleye does not. The food web structures used in GBFood for Zones 1 and 2 are discussed below and presented in Tables 3-1 and 3-2, respectively. A conceptual representation of these food webs is provided in Figure 3-2.

The average lengths of alewife, rainbow smelt and gizzard shad found in the stomachs of walleye indicate a relationship between walleye size and prey size (Magnuson and Smith, 1987). This relationship was integrated into GBFood using length/weight relationships developed during previous studies[1], along with weight/age relationships from Connolly et al. (1992). The prey size preferences for the six walleye age classes modeled for Zones 1 and 2 are presented in Tables 3-1 and 3-2, respectively.

Table 3-1. Dietary composition of prey consumed by receptors in the Lower Fox River (Zone 1)

Modeled Species/Age Class	Percent of Prey Consumed							
	Benthic Macroinvertebrates	Phytoplankton	Water Column Invertebrates	Gizzard Shad	Alewife			
				1	1	2	3	4
Benthic Macroinvertebrates*								
Water Column Invertebrates		100						
Gizzard Shad 1-2	10	20	70					
Alewife 1-4	5		95					
Walleye 1	10		10	30	50			
2				40	30	30		
3				40	15	20	25	
4				40		15	20	25
5				40		10	25	25
6				40			30	30
Notes	* Benthic macroinvertebrates feed on surface sediment particulates.							

[1] Brown trout and walleye weight estimates were computed from length/weight relationships presented in Magnuson and Smith (1987). The length/weight relationship presented in Connolly et al. (1992) was used to compute alewife weights. Rainbow smelt weights were estimated from a relationship presented in Lantry and Stewart (1993).

Table 3-2. Dietary composition of prey consumed by receptors in Lower Green Bay (Zone 2).												
Modeled Species/Age Class	Percent of Prey Consumed											
	Benthic Macroinvertebrates	Phytoplankton	Water Column Invertebrates	Gizzard Shad	Alewife				Rainbow Smelt			
				1	1	2	3	4	1	2	3
Benthic Macroinvertebrates*												
Water Column Invertebrates		100										
Gizzard Shad 1-2	10	20	70									
Rainbow Smelt 1	5		95									
2	5		75		20							
3-4	5		55		40							
Alewife 1-4	5		95									
Walleye 1	10		10	30	40				10			
2				40	25	25			5	5		
3				40	10	20	20		5	5		
4				40		10	20	20		5	5	
5				40		5	20	25		5	5	
6				40			25	25		5	5	
Notes	* Benthic macroinvertebrates feed on surface sediment particulates.											

Walleye

Prey preferences were based upon the stomach content analysis of walleye collected from the Lower Fox River below the dam at DePere and at the mouth of the river where it empties into Green Bay (Magnuson and Smith, 1987). An average diet consisting of 50 percent alewife, 40 percent gizzard shad and 10 percent rainbow smelt was computed from these data and used for Zone 2 walleye age classes 2 and older (Table 3-2). Because rainbow smelt are not found in Zone 1, a diet of 60 percent alewife and 40 percent gizzard shad was used for Zone 1 walleye (Table 3-1). Young-of-year (YOY) walleye (age class 1) consume invertebrates, especially early in the season. Therefore, water column invertebrates (WCI) and benthic macroinvertebrates (BMI) were added to the diet. In Zone 1, a YOY walleye diet consisting of 50 percent alewife, 30 percent gizzard shad, 10 percent WCI and 10 percent BMI was used (Table 3-1; Carlander, 1997; Wolfert and Bur, 1992; Graham and Sprules, 1992; Hartman and Margraf, 1992; Knight et al., 1984). In Zone 2, YOY walleye diet consisting of 40 percent alewife, 30 percent gizzard shad, 10 percent rainbow smelt, 10 percent WCI and 10 percent BMI was used (Table 3-2).

Rainbow Smelt

Great Lakes rainbow smelt feed primarily on invertebrates, but YOY fish are also consumed (Stedman and Argyle, 1985; Lantry and Stewart, 1993; Mills et al., 1995). Lantry and Stewart (1993) conducted an extensive analysis of rainbow smelt diets in the Great Lakes and found YOY smelt consume primarily zooplankton, *Mysis* and *Diporeia*. Age 1 smelt consumed roughly equal fractions of zooplankton, *Mysis* and *Diporeia* and age 2 fish consumed more fish and less zooplankton and *Diporeia*. *Mysis* and Diporeia are not generally present in Zones 1 and 2 (Rades, 2000) so it is presumed that other invertebrates that consume mostly particulate material associated with the water column dominate their diet (see Section 3.3.1.1). Therefore, YOY rainbow smelt consume 95 percent WCI and 5 percent BMI, age 1 smelt consume approximately 75 percent WCI, 20 percent fish and 5 percent BMI, and age 2 and older smelt consume approximately 55 percent WCI, 40 percent fish and 5 percent BMI. These fractions were used to represent the rainbow smelt diet in Zone 2.

Alewife

Feeding ecology studies conducted in the Great Lakes indicate that alewife primarily consume zooplankton and, to a lesser degree, invertebrates associated with sediments such as *Mysis* and *Diporeia* (Janssen and Brandt, 1980; Crowder and Binkowski, 1983; Urban and Brandt, 1993; Mills et al., 1995). For both Zones 1 and 2, the contribution of invertebrates feeding on sediment organic material to the diet of the alewife was set equal to 5 percent. Invertebrates feeding in the water column were considered to supply 95 percent of the alewife diet.

Gizzard shad

Gizzard shad are omnivorous, visually feeding on particulate material until they reach lengths of 25-35 millimeters, at which time they switch to filter-feeding (Mummert and Drenner, 1988; Roseman et al., 1996). The diet of small, visual-feeding gizzard shad consists almost exclusively of zooplankton, while larger filter-feeding shad also consume phytoplankton and detritus (Williamson and Nelson, 1985; Mummert and Drenner, 1988; Roseman et al., 1996). Roseman and coworkers (1996) found the gizzard shad diet primarily consisted of zooplankton, when abundant, but algae and detritus became important when zooplankton populations declined. Based on the above information, the gizzard shad was assigned a diet of 70 percent WCI, 20 percent phytoplankton and 10 percent BMI. This structure was maintained in both Zones 1 and 2.

3.3.1.3 Green Bay Zones 3A, 3B and 4

The food web structure used in GBFood for Zones 3A, 3B, and 4 is presented in Table 3-3 and Figure 3-3. The same approach used to define the food web structures for Zones 1 and 2 was used to develop the food web structure for outer Green Bay. The primary difference between the food web structure used by GBFood for these zones and the food web structure used for Zone 2 is the addition of another top predator, brown trout, and the removal of the forage fish, gizzard shad, which is not found in outer Green Bay.

Table 3-3. Dietary composition of prey consumed by receptors in Upper Green Bay (Zones 3A, 3B and 4).

Modeled Species/Age Class	Percent of Prey Consumed									
	Benthic Macroinvertebrates	Phytoplankton	Water Column Invertebrates	Alewife				Rainbow Smelt		
				1	2	3	4	1	2	3
Benthic Macroinvertebrates*										
Water Column Invertebrates		100								
Rainbow Smelt										
1	5		95							
2	5		75	20						
3-4	5		55	40						
Alewife										
1-4	5		95							
Walleye										
1	10		10	50				30		
2				30	30			20	20	
3				15	20	25		20	20	
4					15	20	25		20	20
5					10	25	25		20	20
6						30	30		20	20
Brown Trout										
1				35	35			15	15	
2					35	35		15	15	
3					35	35		15	15	
4						35	35		15	15
5						35	35		15	15
Notes	* Benthic macroinvertebrates feed on surface sediment particulates.									

Walleye

Prey preferences for walleye were based upon the stomach content analysis performed by Magnuson and Smith (1987). Because only one of the three locations surveyed during this study was in Green Bay proper (Zone 3; the southern third of Green Bay north of Point Sable and Long Tail Point), data from this location were used to determine prey preferences for GBFood Zones 3A, 3B and 4. Using these data, an average diet consisting of 60 percent alewife and 40 percent rainbow smelt was computed and used in the model for age classes 2 and older (Table 3-3). The same diet assigned to YOY walleye in Zones 1 and 2 were applied to Zones 3A, 3B and 4 (50 percent alewife, 30 percent rainbow smelt, 10 percent WCI and 10 percent BMI; Table 3-3).

The relationship between walleye size and prey size developed for Zones 1 and 2 was applied to walleye in Zones 3A, 3B and 4 (Table 3-3). These values are similar to those used in previous versions of GBFood (Connolly et al., 1992; HydroQual, 1995).

Brown Trout

Prey preferences for brown trout were also based upon the stomach content analysis performed by Magnuson and Smith (1987). In this study, brown trout were only collected from one location. These data were used directly to define brown trout prey preferences in GBFood, resulting in a diet consisting of 70 percent alewife and 30 percent rainbow smelt for all age classes in the model (Table 3-3).

The same approach used to define prey size preferences for walleye was applied to the brown trout stomach content data (Magnuson and Smith, 1987). The prey size preferences developed for the five brown trout age classes modeled in GBFood are presented in Table 3-3. These values are similar to those used in previous versions of GBFood (Connolly et al., 1992; HydroQual, 1995).

Rainbow Smelt and Alewife

The diets of rainbow smelt and alewife used for Zones 3A, 3B and 4 are identical to the diets used for these species in Zone 2.

3.3.2 Movement Between Green Bay and the Lower Fox River

Fish are found in the Lower Fox River below DePere throughout the year (Terry Lychwick, Wisconsin Department of Natural Resources biologist, personal communication). Their patterns of movement between the Lower Fox River and Southern Green Bay cannot be determined precisely, and probably include a range of behaviors and, therefore, a range of Lower Fox River exposures. Based on his experience, Mr. Lychwick indicated that there are likely four groups of walleye:

- Fish that spend the entire year in Zone 2 (southern Green Bay);
- Fish that enter the Lower Fox River in fall, remain through the winter, and leave after spawning;
- Fish that enter the Lower Fox River in spring and leave after spawning; and
- Fish that remain in the Lower Fox River all summer.

Mr. Lychwick has also indicated that there may be walleye that remain throughout the year in the Lower Fox River.

There is insufficient field information to determine the proportions of fish that exhibit each of these behaviors, and therefore the migration pattern of an "average" fish cannot be characterized. Therefore, the strategy taken in developing the bioaccumulation model was to simulate a range of realistic behaviors. In the model, groups of fish are assumed to:

- Spend the entire year in Zone 2;
- Enter the Lower Fox River in spring and leave after one month. This was the original condition simulated by Connolly et al. (1992);

- Enter the Lower Fox River in May, remain through the summer, and leave in October; and
- Remain in the Lower Fox River throughout the year, except for one week in winter[2].

For each scenario, the migratory behaviors of the forage fish species in the model were set the same as for walleye. Thus, the simulations provide bounding estimates of the impact of PCBs in the Lower Fox River to the fish, with exposure ranging from one month to almost the entire year.

3.3.3 Species Bioenergetics

Respiration

Respiration rates used in GBFood were determined from species-specific measurements of standard or active metabolism published in the available literature. Estimates of standard metabolism were adjusted, when appropriate, to account for the additional energy requirements associated with routine activity such as swimming, feeding and digestion. The bioenergetic parameters are the same as those used in previous versions of GBFood (HydroQual, 1995).

Growth

Growth rates used in GBFood were determined from weight-age relationships of fish collected for the Green Bay Mass Balance Study (GBMBS) in 1989 by the Wisconsin Department of Natural Resources (WDNR) and made available on the Great Lakes National Program Office (GLNPO) website. Data from all zones were used to estimate a single growth rate for each species.

[2] A one-week period in Zone 2 was kept for practical convenience as this required no change in the number of migratory species in the model input files (see Model Users Manual).

Predator Fish

Ages of walleye and brown trout were estimated from the measured age and the month of capture; their date of birth was subtracted from the month of capture and added to the measured age in years. A growth function was then fit to monthly averages of measured weights. Monthly average weights-at-age are presented with values used in the model for walleye and brown trout on Figures 3-4 and 3-5, respectively.

Forage Fish

Forage fish collected through the GBMBS program were classified as either YOY or adult. The ages of the collected fish were estimated based on the observed trends between length and month of capture presented in Connolly et al. (1992). Values used in the model are presented along with the data in Figures 3-6, 3-7, and 3-8 for alewife, rainbow smelt, and gizzard shad, respectively.

Body Composition

The lipid and dry weight fractions of each fish species were developed from the 1989 GBMBS data contained in the Fox River Database (FRDB). Annual average lipid and dry weight fractions were computed and used in GBFood for each species. Table 3-4 provides a summary of lipid and dry weight fractions used in GBFood.

Table 3-4. Lipid and dry weight contents used in GBFood.

Species	Zone 1		Zone 2		Zone 3A		Zone 3B		Zone 4	
	% Lipid	% Dry Weight	% Lipid	% Dry Weight	% Lipid	% Dry Weight	% Lipid	% Dry Weight	% Lipid	% Dry Weight
Walleye	9.5	30.0	10.7	30.0	12.2	32.3	11.2	33.8	12.7	32.7
Brown trout	-	-	-	-	14.2	33.2	11.4	30.9	15.2	35.2
Rainbow smelt	-	-	4.6	22.1	4.2	22.9	4.3	30.3	4.7	26.7
Alewife	5.6	23.9	10.0	27.8	7.1	25.4	12.3	21.2	8.5	21.2
Gizzard shad	7.9	26.6	6.4	26.3	-	-	-	-	-	-
Water Column Invertebrates*	0.4	7.5	0.9	11.4	0.9	11.9	1.1	11.3	1.4	11.8
Notes	* Zooplankton data used to define body composition parameters. Values are presented on whole-body basis.									

3.3.4 Toxicokinetics

Gut Transfer

The fraction of ingested contaminant that is transferred across the gut wall into the animal is termed the assimilation efficiency (α_C in Equation 2-3). A compilation of experimental estimates of assimilation efficiency of various PCB congeners has shown that values range from about 0.1 to 1.0 (Connolly et al., 1992; Parkerton, 1993). To develop a best estimate for total PCBs, multiple values from individual studies were averaged to give all studies equal weight; the data were then grouped into half log unit K_{OW} bins (e.g., 4.25 to 4.75) and displayed as box plots (Figure 3-9). Congeners with log K_{OW} values below 6.75 (generally mono- to pentachlorobiphenyl) have similar assimilation efficiencies, although a slight decline with increasing K_{OW} is evident. Median values range between 0.75 and 0.85. As log K_{OW} increases beyond 6.75 a more dramatic decline occurs.

The differences in assimilation efficiency among studies reflect various factors including measurement error, residence time in the gut, digestibility of the portion of the ingested prey that contains most of the contaminant (for hydrophobic organic chemicals this is fat tissue) and the physical-chemical mechanisms responsible for moving the chemical across the gut wall. Of the biological and chemical factors, the digestibility of the prey appears to have the greatest impact.

Studies indicate that the assimilation efficiency of hydrophobic contaminants is closely linked to dietary assimilation of lipids (Van Veld, 1990). This is supported by experimental studies with metals and radionuclides which indicate a direct correspondence between the uptake of contaminant by zooplankton and the fraction in the digestible component of the algal diet (Reinfelder and Fisher, 1991). In addition, previous modeling studies have suggested that assimilation efficiency of hydrophobic organics with log K_{OW} values below about 6.0 to 6.5 is similar to that of food energy and is perhaps equal. Based on the above information, equality between contaminant and food assimilation efficiency of PCBs was maintained. Note that the model requires only the ratio of these coefficients and not their absolute values (substitute Equation 2-3 into the second term in Equation 2-1). In GBFood, the food and PCB assimilation efficiencies are set equal to 0.6.

Gill Transfer

The rate of transfer of contaminants between blood and water across the gill epithelia is determined from the transfer rate of oxygen and a ratio between the uptake efficiencies of contaminant and oxygen (ε in Equation 2-2). Based upon laboratory studies summarized in Figure 3-10 (Connolly et al., 1992), the ratio of uptake efficiencies is approximately 1.0. This value was used in the model.

Computation of the elimination rate requires estimation of the lipid/blood partition coefficient, π_{LB}. K_{OW} is used as an estimate of π_{LB} in the model, resulting in the inverse relationship between log K_{OW} and log (elimination rate), as found by Erickson and McKim (1990). In Equation 2-4, $f_B \ll \pi_{LB} f_L$. Therefore, the average elimination rate for total PCBs is approximately equal to:

$$K_{gill} = K_u c_R v_B \approx \left(\frac{K_u c_R v}{f_{L_i}} \right) \sum_{c=1}^{n} \frac{f_c}{K_{OW,c}} \qquad (3\text{-}5)$$

where:

f_c	=	weight fraction that congener *c* comprises in fish
$K_{OW,c}$	=	octanol-water partition coefficient for congener *c*

Thus, estimation of the total PCB elimination rate requires the harmonic mean K_{OW}. This was calculated for each species in each modeling zone using the congener composition data from the Green Bay Mass Balance Study, along with the congener-specific K_{OW} values reported by Hawker and Connell (1988). Resulting K_{OW} values for each species are presented in Table 3-5.

Table 3-5. Log K_{ow} values derived from Green Bay Mass Balance Study data for each species.

Species	Zone 1	Zone 2	Zone 3A	Zone 3B	Zone 4
Walleye	5.73	5.73	5.84	5.81	5.74
Brown trout	-	-	5.80	5.75	5.81
Rainbow smelt	-	5.64	5.56	5.44	5.84
Alewife	5.62	5.62	5.65	5.54	5.34
Gizzard shad	5.56	5.56	-	-	-

The mass proportion of blood in the body (f_B) is set equal to 0.05. Uncertainty in this value has no significant impact on model calculations, because $f_B << \pi_{LB} f_L$ (Equation 2-4).

Due to the lack of sufficient experimental data, the factor that accounts for the reduction in elimination rates due to the slow transfer from storage tissues (c_R) was considered a calibration parameter.

3.3.5 Exposure Concentrations

The sediment and water column PCB exposure levels were provided by the PCB fate models developed for the Lower Fox River and Green Bay (wLFRM and GBTOXe, respectively). For each modeling zone, daily-average volume-weighted water column PCB concentrations (dissolved [µg/L] and particulate [mg/kgOC]) and area-weighted PCB concentrations in the top five centimeters of sediment (mg/kgOC) were provided and transferred directly into GBFood.

SECTION 4
GBFOOD CALIBRATION

4.1 CALIBRATION STRATEGY

The first step in calibrating GBFood was to match the computed zooplankton PCB concentrations to GBMBS data collected between April 1 and November 30, 1989 from each model zone. The same data were also used to set zooplankton average lipid content and dry weight fraction; these parameters determine the energy content of the zooplankton, which in turn determines the rate at which they are consumed by fish. Energy content, together with PCB concentration, controls the PCB dose to the fish. The computed zooplankton PCB concentrations were set equal to the average of the zooplankton data[3].

Calibration of fish PCB levels involved adjusting the minimum number of parameters necessary to produce the best fit between model and data. Parameters already constrained by site- or species-specific laboratory or field data were not adjusted. The elimination rate constant (c_R) cannot be well-defined by field or laboratory data, and therefore its value had to be constrained by calibration. One value of c_R was used for all species in all zones. No other parameters were adjusted for any fish in any Zone, with one exception. The time spent by fish that migrate from Zone 2 to Zone 1 for a brief period in spring is uncertain and therefore was adjusted to provide the best model/data comparison. Note that the migration periods were not adjusted for the fish that spend the summer and fish that spend nearly the entire year in the Fox River.

Calibration simulations were performed for a 10-year period. The first nine years of the model run enabled the fish to come to steady-state with exposure concentrations. During this spin-up period, the fish were exposed to average water column and sediment PCB concentrations calculated by averaging the wLFRM and GBTOXe results over the GBTOXe calibration period

[3] In GBFood, realistic values for the zooplankton net growth efficiency and food and chemical assimilation efficiencies were used, following HydroQual (1995). Calibration was achieved by adjusting the K_{ow} of the mixture of PCBs on a zone-specific basis.

(511 days). For the 10th year, the daily output provided by the fate models were used directly. The GBFood calibration results are presented for the 10th year of the model run.

Model results for the Lower Fox River and Green Bay were compared with 1989 GBMBS data[4] in two ways. First, the PCB concentrations computed by the model for each species in each zone were averaged over the period in which GBMBS data were available (April – November 1989) and compared with GBMBS data. Second, time courses of daily model output were compared with monthly-averaged GBMBS data for the same period. For migrating Zone 1 fish, the average PCB concentrations computed over the entire period spent within the Lower Fox River were compared with the average of the data for Zone 1.

GBFood computes PCB concentrations throughout the lifetime of each species. Data were compared with model results for age classes defined by the GBMBS data.

The calibration was performed to provide the best overall match between model and data for all species, on both a wet-weight and lipid-normalized basis.

4.2 CALIBRATION RESULTS

4.2.1 Outer Green Bay (Zones 3A, 3B and 4)

Computed zooplankton PCB concentrations in Zones 3A, 3B and 4 were matched to the average of the GBMBS data by adjusting the value used for K_{OW} (Figure 4-1 and 4-2; Table 4-1). A value of 0.15 for c_R provided the best overall fit to the fish data in all zones. No additional parameters were adjusted to match the Zone 3A, 3B or 4 data.

Model results for walleye, brown trout, rainbow smelt, and alewife in Zone 3A, on an annual average basis, compare well with PCB data (Figures 4-1 and 4-2). All model values lie within the error bars of the PCB data on both a wet-weight and lipid-normalized basis. The model results for brown trout, rainbow smelt and alewife in Zone 3A compare well with the data on a seasonal basis as well (Figures 4-3 and 4-4). For walleye, the model overestimates the average PCB concentrations in spring and summer and underestimates the average PCB concentrations in the fall.

Table 4-1. Final water column invertebrate log K_{ow} values used in GBFood.					
Zone 1 One-Month Residency	Zone 1 6 to 12-Month Resident	Zone 2	Zone 3A	Zone 3B	Zone 4
5.95	5.40	5.40	5.80	5.70	6.50

In Zone 3B, the computed PCB concentrations in walleye and brown trout lie within the error bars of the data on both wet-weight and lipid-normalized bases. The model underestimates the mean PCB concentration of the forage fish in this zone by 35 to 40%, with computed values lying below the error bars of the data. The time courses provide similar results; computed PCB concentrations in the predators lie within the range of the measured values, while nearly all of the model values for the forage fish lie below the monthly averages of the data (Figure 4-5 and 4-6). The potential reasons for the underestimation of the forage fish include inaccuracy in model parameters such as growth rate, which could not be specified on a zone-by-zone basis because of data limitations, and uncertainty in the zooplankton or fish PCB data due to small sample sizes.

In Zone 4, the model underestimates the mean PCB concentrations in all of the modeled species (Figures 4-1 and 4-2). Predators are underestimated by approximately a factor of 2; computed rainbow smelt values lie below the mean but within the error bars of the data on a wet-weight basis and close to them on a lipid basis; alewife is underestimated by a factor of 3. The model does fall within some of the error bars of the data on a seasonal basis (Figures 4-7 and 4-8); however, average monthly concentrations are generally underestimated. As all species are underestimated to some degree, an underestimation of exposure levels is a likely cause of the difference between observed and computed PCB levels. Therefore, we investigated the possibility that Zone 4 fish may be exposed to higher PCB levels than estimated in the fate

[4] The GBMBS fish and zooplankton PCB, lipid and dry weight data included in the FRDB were used to calibrate GBFood. GBMBS age data for fish were obtained directly from the GLNPO website.

model and in the zooplankton data for Zone 4. A sensitivity analysis was conducted, in which Zone 4 fish were exposed to water column and sediment PCB concentrations the same as observed in Zone 3A. Using these higher exposure concentrations, computed PCB concentrations are generally more consistent with the data (Figures 4-9 and 4-10). Thus, the results of this model are consistent with the exposure of Zone 4 fish to more contaminated water and sediment than measured in Zone 4. Whether this may be due to fish movement into a more contaminated section of Green Bay, or whether the exposure levels in Zone 4 are underestimated, is not known.

4.2.2 Inner Green Bay and the Lower Fox River (Zones 1 and 2)

Fish that remain in Zone 2 throughout the year

Computed zooplankton PCB concentrations in Zone 2 were matched to the average of the GBMBS data by adjusting the value used for K_{OW} (Figure 4-1 and 4-2; Table 4-1). PCB concentrations computed for fish resident in Zone 2 were compared with PCB concentrations measured in fish collected in Zone 2. As for Zones 3A, 3B and 4, no additional parameters were adjusted to model fish resident in Zone 2. The model results for walleye, alewife, rainbow smelt, and gizzard shad compare well with the annual and monthly average PCB data (Figures 4-1, 4-2, 4-11, and 4-12). Overall average walleye, alewife, and gizzard shad model results lie within the error bars of the data. The overall average rainbow smelt wet-weight and lipid-normalized PCB concentrations computed by the model lie at the low end of the error bars of the data, within 10-15 percent of the average of the 1989 data.

Fish that migrate into the Lower Fox River for one month in spring

In Zone 1, PCB concentrations in zooplankton vary through the year, being higher in spring than in summer and early fall (Figures 4-13 and 4-14). To provide realistic exposure levels for fish that enter the Lower Fox River in spring and leave after spawning, the model for Zone 1 was first calibrated to zooplankton concentrations measured in the spring (Figures 4-13 and 4-14). The time spent in the river by the fish was adjusted to provide the best overall fit to the data collected in the river. No other parameters were adjusted. With a one-month residency period, the model compares reasonably well with the PCB concentrations measured in walleye and alewife (Figures 4-1, 4-2, 4-13 and 4-14). The model results for walleye and gizzard shad in Zone 1 fall within the error bars of the data on both wet-weight and lipid-normalized bases. Zone 1 alewife fall near the lower error bars of the overall average of the data (Figures 4-1 and 4-2), but are consistent with monthly averages of the data collected during the period of migration (Figures 4-13 and 4-14).

Fish that remain within the Lower Fox River for 6 months and year-round

To provide realistic exposure levels for fish that remain in the Lower Fox River for the summer and for fish that remain in the River throughout the year, the model for Zone 1 was calibrated to zooplankton concentrations measured in summer and early fall (Figures 4-15 and 4-16). That this provides a realistic estimate of zooplankton bioaccumulation overall is supported by an analysis of computed and measured zooplankton/phytoplankton trophic transfer factors (TTFs). The TTF is the ratio of lipid-based PCB concentrations in zooplankton to organic carbon-normalized PCB concentrations in phytoplankton (units of g organic carbon/g lipid). With zooplankton PCB concentrations set equal to the values measured in Zone 1 in summer and fall, the computed trophic transfer factor is 3.2 g organic carbon/g lipid, which is within the range of trophic transfer factors computed from the GBMBS data for Zones 2 through 4 (range 3.1 to 4.0).

No other parameters were adjusted in the simulations of summer-resident and year-round-resident Zone 1 fish. Under both conditions, the average PCB concentrations computed by the model lie within the error bars of the data for both walleye and alewife (summer residency: Figures 4-15 through 4-18; year-round residency: Figures 4-19 through 4-22). For both simulations, concentrations computed in gizzard shad are 1.5 to 2 times greater than measured concentrations on a wet-weight basis but similar on a lipid basis. The difference in model/data comparisons performed on wet-weight and lipid bases is due to the variability in lipid content in the gizzard shad throughout the year, which ranges from 0.03 to 0.13 g lipid/g wet weight whole body[5].

Seasonal timing may be part of the reason for the model/data differences in gizzard shad: if the model results for gizzard shad are shifted by about one month, then the model results lie within the error bars of the data for the June and August samplings on a wet-weight basis (Figures 4-15 and 4-19). Such a difference in timing may be due in part to inaccurate characterization of the growth and food consumption patterns of the fish during the year. The available growth data are insufficient to further refine the within-year pattern.

The sensitivity of computed walleye PCB concentrations to uncertainty in gizzard shad PCB concentrations was evaluated. As the average wet-weight-based PCB concentration measured in the alewife in Zone 1 is within 10% of the average measured in gizzard shad (Figure 4-17), this sensitivity was performed by replacing the model gizzard shad in the walleye diet with model alewife; thus, for these simulations, only alewife was consumed by the walleye. The assumption behind these sensitivities is that the walleye are exposed to PCB concentrations characteristic of those measured in the gizzard shad and alewife data. These sensitivity analyses resulted in computed walleye concentrations that were between 10 and 20% lower than those presented here, and still within the error bars of the data. Thus, while it appears that the model overestimates PCB concentrations in the gizzard shad measured in Zone 1, this does not affect the walleye calibration significantly.

4.3 CONCLUSIONS

More than 90% of the average computed wet-weight and lipid-normalized PCB concentrations lie within a factor of 2 of the averages of the data (Figure 4-23, including all three Zone 1 scenarios). All of the average computed values lie within a factor of 3 of the observed

[5] The average measured lipid-based PCB concentration was calculated as the average of the individual lipid-based PCB concentrations measured during the GBMBS. In contrast, the model computes an average wet-weight-based PCB concentration and divides that by the average lipid content. The average of a ratio does not in general equal the ratio of averages, especially when the variability in the numerator or denominator is relatively large, as is the case for lipid content in gizzard shad. The usual practice is to present lipid-based PCB concentrations as the average of the individual lipid-based values, and that is how the data are presented here.

average values. This level of agreement is consistent with the model metrics proposed for PCBs in fish by Limno-Tech and WDNR (1998): mean predicted PCB concentrations in fish should be within a factor of 3 of observed values for short-term simulations and a factor of 5 for long-term simulations.

All 3 migration scenarios for Zone 1 fish are realistic representations of migratory behaviors, and therefore projections have been performed for all of the scenarios. Average future PCB levels in the fish collected in the Lower Fox River are likely to reflect some combination of the results for these scenarios.

Projections for Zone 4 are subject to uncertainty, as the model underestimates PCB levels in the predators from Zone by about a factor of 2. To the extent that this is due to exposure of the fish within more contaminated regions of the bay, fish PCB concentrations projected by GBFood for Zones 3A and/or 3B will provide a more reasonable representation of future Zone 4 fish PCB levels. If the fish collected in Zone 4 are truly exposed within Zone 4, then it is likely that the zooplankton data are not an accurate representation of the true average zooplankton concentration in this zone. In this case, the Zone 4 projections provide the best representation of future trends in these fish, with the understanding that the computed predator PCB concentrations will be underestimated by approximately a factor of 2.

Based on the calibration, GBFood, combined with realistic PCB concentrations in water and sediment projected by the fate and transport models, can provide realistic projections of PCB concentrations in Lower Fox River and Green Bay fish under natural recovery and alternative remediation scenarios, subject to the aforementioned uncertainty associated with Zone 4.

SECTION 5
GBFOOD PROJECTIONS

5.1 DEVELOPMENT OF THE PROJECTION

All parameter values estimated during GBFood calibration were used for the projections with the exception of lipid contents and the initial fish tissue PCB concentrations. The initial fish tissue PCB concentrations and lipid contents used in GBFood projections were calculated from the data available in the WDNR database. Lipid contents were calculated for each fish in each zone by averaging the annual averages of the whole-body lipid contents measured in the Lower Fox River and Green Bay between 1980 and 1998 (Table 5-1).

The projections were assumed to start some time after the calibration period (1989). Based on the initial sediment and water column PCB concentrations specified for wLFRM and GBTOXe, a precise starting date for GBFood could not be specified (see model documentation reports for the two fate models). Moreover, the final concentrations computed during the calibration could not be used to establish initial concentrations in the projections. For this reason, the most recent average whole-body PCB concentrations measured in each species in each zone were used as the initial PCB concentrations in GBFood (Table 5-2). A starting date of January 1, 1999 was chosen arbitrarily.

Table 5-1. Lipid fractions used in GBFood projections.

Species	Zone 1	Zone 2	Zone 3A	Zone 3B	Zone 4
Walleye	10.2	11.6	13.6	10.6	10.7
Brown trout	-	-	14.2	11.6	13.0
Rainbow smelt	-	4.6	5.4	4.3	4.7
Alewife	4.9	12.2	7.1	9.0	11.3
Gizzard shad	9.1	7.9	-	-	-

Table 5-2. Initial PCB concentrations used in GBFood projections.					
Species	Zone 1	Zone 2	Zone 3A	Zone 3B	Zone 4
Walleye	6.12	2.66	5.27	1.45	1.39
Brown trout	-	-	1.40	1.40	2.00
Rainbow smelt	-	0.40	0.56	0.56	0.56
Alewife	1.67	1.97	0.54	0.54	0.54
Gizzard shad	1.85	2.15	-	-	-
Notes:	Values represent µg total PCB/g whole body wet weight.				

The year length of wLFRM was assumed to be 365 days while the GBTOXe year length was assumed to be 364. This difference does not affect the calibration since the calibration period is only one year. However, after 100 years this year length discrepancy would cause the two exposures to be off by 100 days, thus affecting the synchronization of the two models. To correct for this discrepancy, the weekly wLFRM output was translated to daily output by assigning each day of the week with the weekly average value. Then the 365th day of each year was removed. wLFRM exposures were then collapsed back into weekly-average output and transferred directly into GBFood.

Remedial action levels for the Lower Fox River and Green Bay were developed in Section 5 of the Feasibility Study. The action level combinations used here were specified by WDNR. Fifteen 100-year remediation scenarios were provided by the fate models for each of the five zones. The scenarios can be placed into three groups. The first group combines No Action in Green Bay with eight Fox River remediation scenarios. The Fox River remediation scenarios include No Action and the remediation of sediments that contain greater than 5000, 1000, 500, 250, and 125 ppb total PCB. Additionally, the Green Bay No Action scenario was run with two Fox River remediation schedules (“H” and “I”); these schedules were not part of the RI/FS, but were requested by WDNR to support their selection of a proposed plan. Schedule “H” includes remediation of sediments greater than 500 ppb in Little Lake Butte de Morts (LLBdM), No Action in the Appleton to Little Rapids reach (AP-LR), and remediation of sediments greater than 250 ppb in the Little Rapids to DePere reach (LR-DP). Schedule “I” includes remediation of sediments greater than 1000 ppb in LLBdM, No Action in AP-LR, and remediation of sediments greater than 500 ppb in LR-DP. The second group of scenarios combines a Green Bay action level of 1000 ppb with Fox River action levels of 1000, 500, 250, and 125 ppb. The third group combines a Green Bay action level of 500 ppb with Fox River action levels of 500, 250, and 125 ppb.

5.2 PROJECTION RESULTS

The annual average PCB concentrations in the fish projected by GBFood for the Green Bay/Fox River No Action scenario are presented on Figures 5-1 through 5-7 for Zones 1, 2, 3A, 3B, and 4. These figures also include the average concentrations computed over the calibration period (large open circle), as well as the annual averages of the available data for whole-body fish (smaller symbols; individual data sets are indicated by different symbols). In many cases, PCB concentrations rise over the first two to five years of the simulation and then begin a long-term decline. The initial adjustments are a function of the initial PCB concentrations that were used. These were based on the most recent data, which generally were collected after the calibration period. To the degree that these were not consistent with exposure concentrations computed at the start of the projection, the initial "spin-up" was observed.

Figures presenting the annual average PCB concentrations for the remaining 14 scenarios are presented as Figures 5-8 through 5-98. In addition, the average whole-body wet-weight-based PCB concentrations computed over the final 10 years of each 100-year projection are provided in Tables 5-3 through 5-7, for each of the model species in each zone. Note that no Green Bay remediation scenarios were performed for the fish resident in the Lower Fox River.

Table 5-3. PCB concentrations in walleye (µg/g wet-weight whole body) computed by GBFOOD: Average over the final 10 years of each projection.								
Green Bay Action Level	**Fox River Action Level**	**Zone 1 One-Month Migration**	**Zone 1 Summer Migration**	**Zone 1 Resident**	**Zone 2**	**Zone 3A**	**Zone 3B**	**Zone 4**
No Action	No Action	2.39	3.92	4.96	2.28	1.10	0.57	0.79
	5000	1.13	0.461	0.204	1.39	0.90	0.46	0.76
	1000	1.07	0.331	0.028	1.34	0.89	0.45	0.76
	500	1.07	0.327	0.024	1.34	0.89	0.45	0.76
	250	1.07	0.321	0.016	1.34	0.89	0.45	0.76
	125	1.06	0.319	0.012	1.34	0.89	0.45	0.76
	Schedule H	1.06	0.324	0.025	1.32	0.85	0.42	0.72
	Schedule I	1.06	0.328	0.030	1.32	0.85	0.42	0.72
1000	1000	0.49	0.161	-	0.61	0.60	0.29	0.70
	500	0.49	0.158	-	0.60	0.59	0.29	0.70
	250	0.48	0.152	-	0.60	0.59	0.29	0.70
	125	0.48	0.149	-	0.60	0.59	0.29	0.70
500	500	0.47	0.147	-	0.58	0.58	0.28	0.69
	250	0.47	0.147	-	0.58	0.58	0.28	0.69
	125	0.47	0.145	-	0.58	0.58	0.28	0.69

Table 5-4. PCB concentrations in brown trout (µg/g wet-weight whole body) computed by GBFOOD: Average over the final 10 years of each projection.				
Green Bay Action Level	Fox River Action Level	Zone 3A	Zone 3B	Zone 4
No Action	No Action	0.60	0.35	0.48
	5000	0.49	0.28	0.46
	1000	0.48	0.28	0.46
	500	0.48	0.27	0.46
	250	0.48	0.27	0.46
	125	0.48	0.27	0.46
	Schedule H	0.46	0.26	0.43
	Schedule I	0.46	0.26	0.43
1000	1000	0.32	0.18	0.42
	500	0.32	0.18	0.42
	250	0.32	0.18	0.42
	125	0.32	0.18	0.42
500	500	0.31	0.17	0.42
	250	0.31	0.17	0.42
	125	0.31	0.17	0.42

Table 5-5. PCB concentrations in rainbow smelt (µg/g wet-weight whole body) computed by GBFOOD: Average over the final 10 years of each projection.					
Green Bay Action Level	Fox River Action Level	Zone 2	Zone 3A	Zone 3B	Zone 4
No Action	No Action	0.34	0.17	0.09	0.18
	5000	0.21	0.14	0.07	0.17
	1000	0.20	0.14	0.07	0.17
	500	0.20	0.14	0.07	0.17
	250	0.20	0.14	0.07	0.17
	125	0.20	0.14	0.07	0.17
	Schedule H	0.20	0.13	0.07	0.16
	Schedule I	0.20	0.13	0.07	0.16
1000	1000	0.09	0.09	0.04	0.15
	500	0.09	0.09	0.04	0.15
	250	0.09	0.09	0.04	0.15
	125	0.09	0.09	0.04	0.15
500	500	0.09	0.09	0.04	0.15
	250	0.09	0.09	0.04	0.15
	125	0.09	0.09	0.04	0.15

Table 5-6. PCB concentrations in alewife (µg/g wet-weight whole body) computed by GBFOOD: Average over the final 10 years of each projection.								
Green Bay Action Level	Fox River Action Level	Zone 1 One-Month Migration	Zone 1 Summer Migration	Zone 1 Resident	Zone 2	Zone 3A	Zone 3B	Zone 4
No Action	No Action	0.78	0.897	0.929	0.78	0.23	0.18	0.20
	5000	0.20	0.073	0.040	0.47	0.19	0.14	0.20
	1000	0.18	0.042	0.007	0.46	0.18	0.14	0.20
	500	0.18	0.041	0.006	0.46	0.18	0.14	0.20
	250	0.18	0.040	0.004	0.46	0.18	0.14	0.20
	125	0.18	0.039	0.004	0.45	0.18	0.14	0.20
	Schedule H	0.18	0.041	0.006	0.45	0.18	0.13	0.19
	Schedule I	0.18	0.042	0.007	0.45	0.18	0.13	0.19
1000	1000	0.08	0.022	-	0.21	0.12	0.09	0.18
	500	0.08	0.021	-	0.21	0.12	0.09	0.18
	250	0.08	0.020	-	0.21	0.12	0.09	0.18
	125	0.08	0.019	-	0.21	0.12	0.09	0.18
500	500	0.08	0.019	-	0.20	0.12	0.09	0.18
	250	0.08	0.019	-	0.20	0.12	0.09	0.18
	125	0.08	0.019	-	0.20	0.12	0.09	0.18

Table 5-7. PCB concentrations in gizzard shad (µg/g wet-weight whole body) computed by GBFOOD: Average over the final 10 years of each projection.					
Green Bay Action Level	Fox River Action Level	Zone 1 One- Month Migration	Zone 1 Summer Migration	Zone 1 Resident	Zone 2
No Action	No Action	1.16	2.07	1.80	0.70
	5000	0.29	0.092	0.072	0.45
	1000	0.25	0.025	0.012	0.43
	500	0.25	0.023	0.011	0.43
	250	0.25	0.020	0.008	0.43
	125	0.25	0.019	0.007	0.43
	Schedule H	0.25	0.023	0.011	0.43
	Schedule I	0.25	0.025	0.013	0.43
1000	1000	0.12	0.016	-	0.20
	500	0.12	0.015	-	0.20
	250	0.12	0.011	-	0.20
	125	0.12	0.010	-	0.20
500	500	0.11	0.011	-	0.19
	250	0.11	0.011	-	0.19
	125	0.11	0.010	-	0.19

SECTION 6
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FIGURES

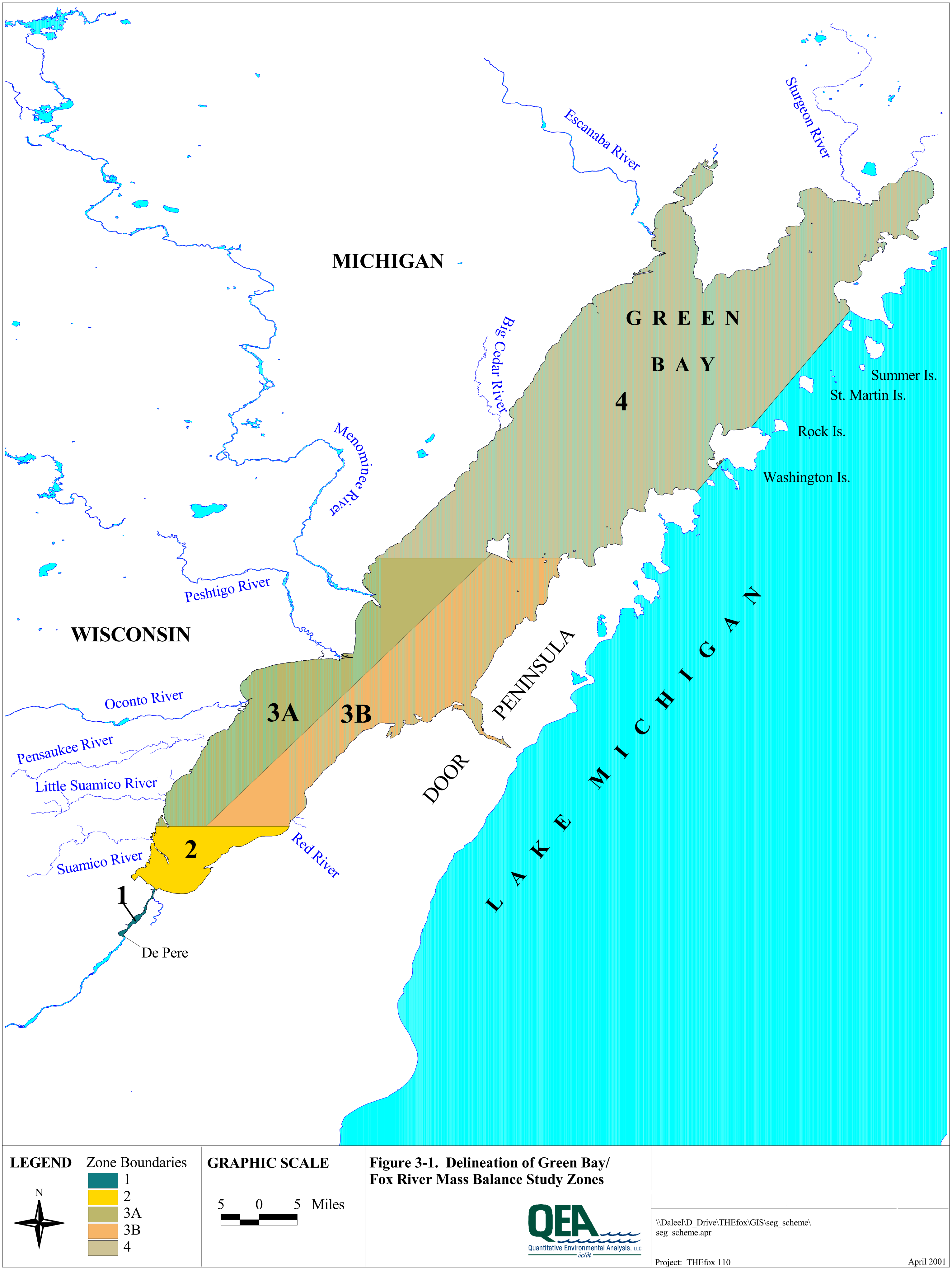

Figure 3-1. Delineation of Green Bay/ Fox River Mass Balance Study Zones

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April 2001

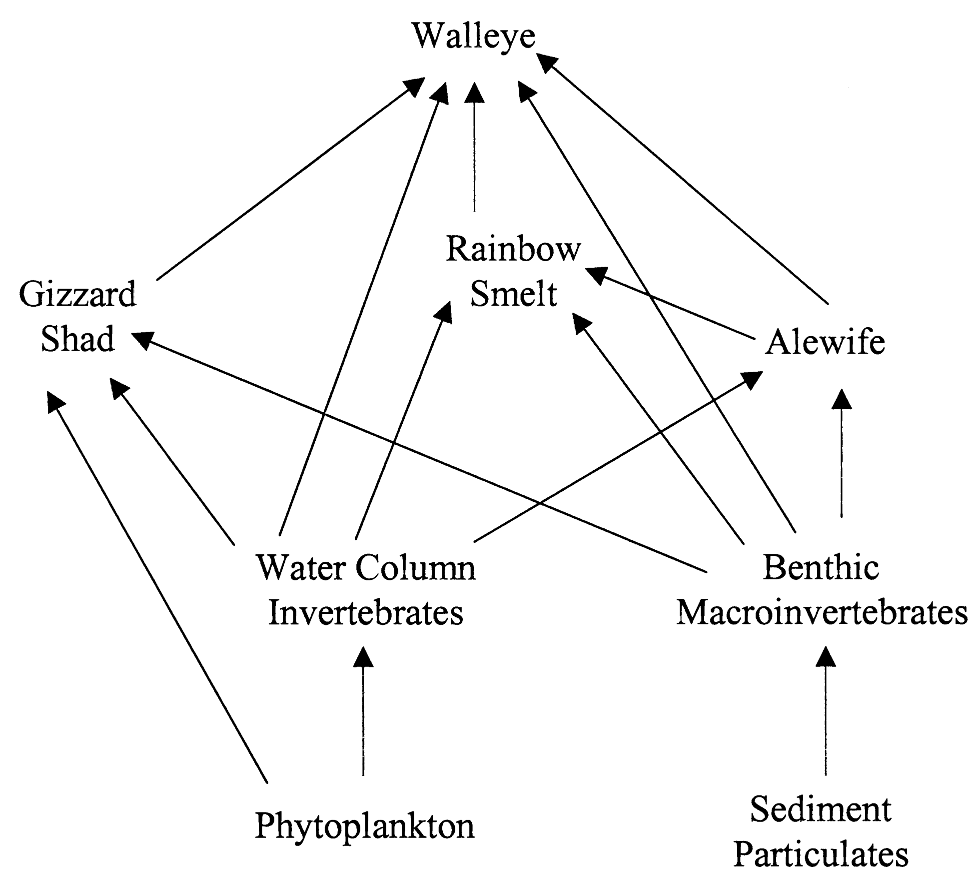

Figure 3-2. Conceptual representation of Zone 1 and Zone 2 food webs.

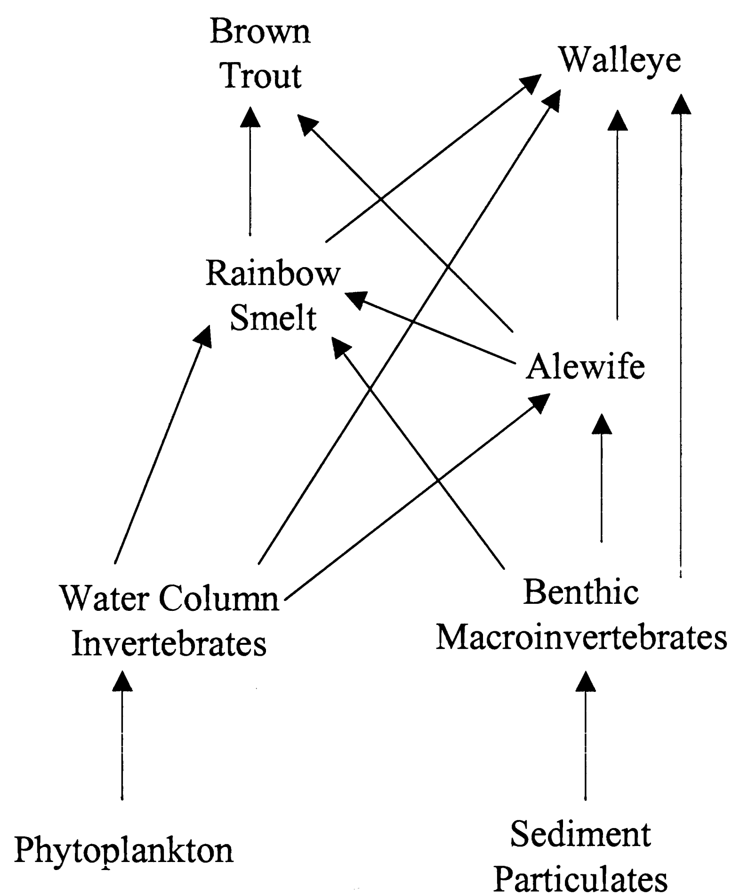

Figure 3-3. Conceptual representation of Zones 3A, 3B and 4 food webs.

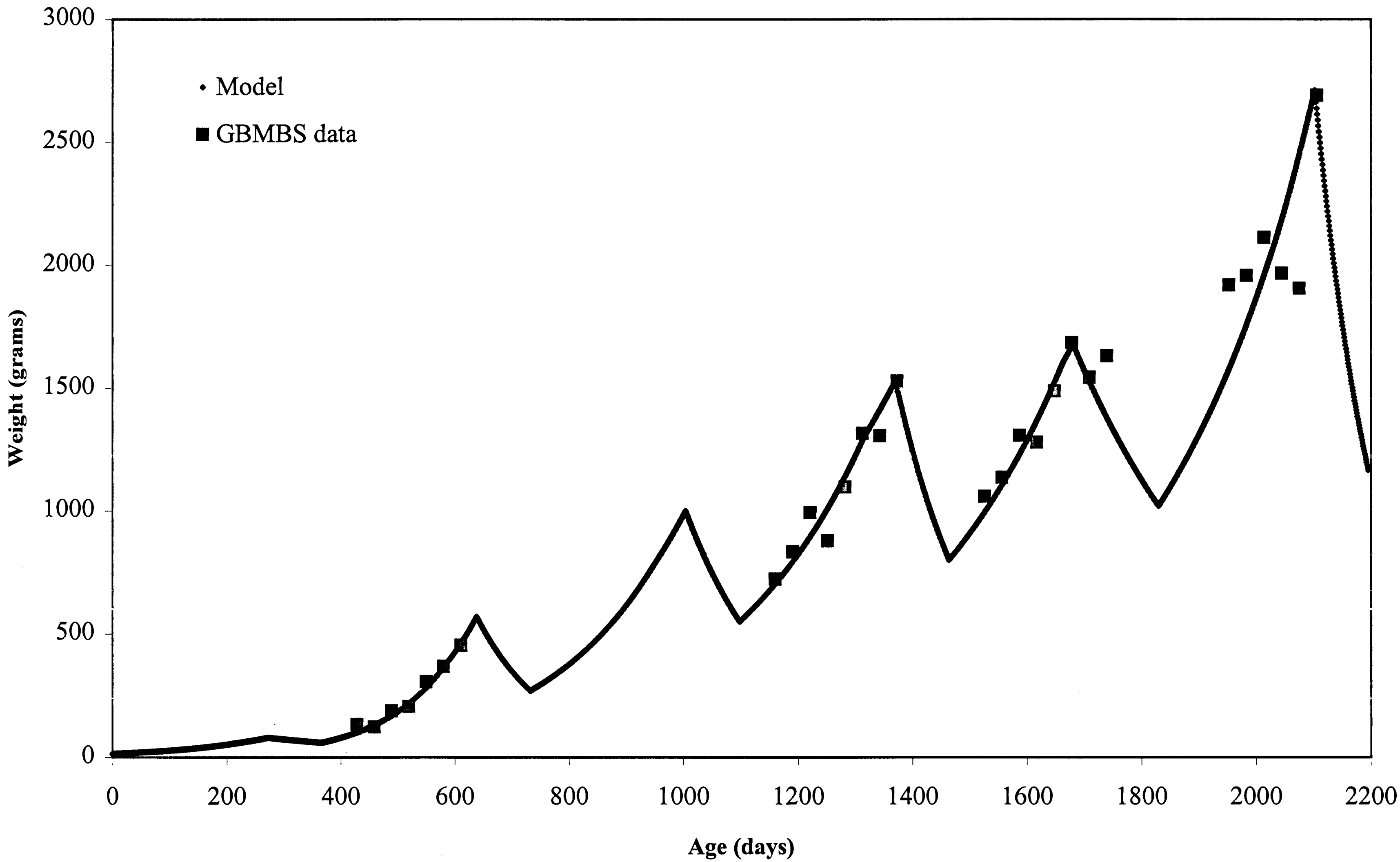

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Figure 3-4. Model growth rate for walleye compared with measured monthly average weights-at-age.

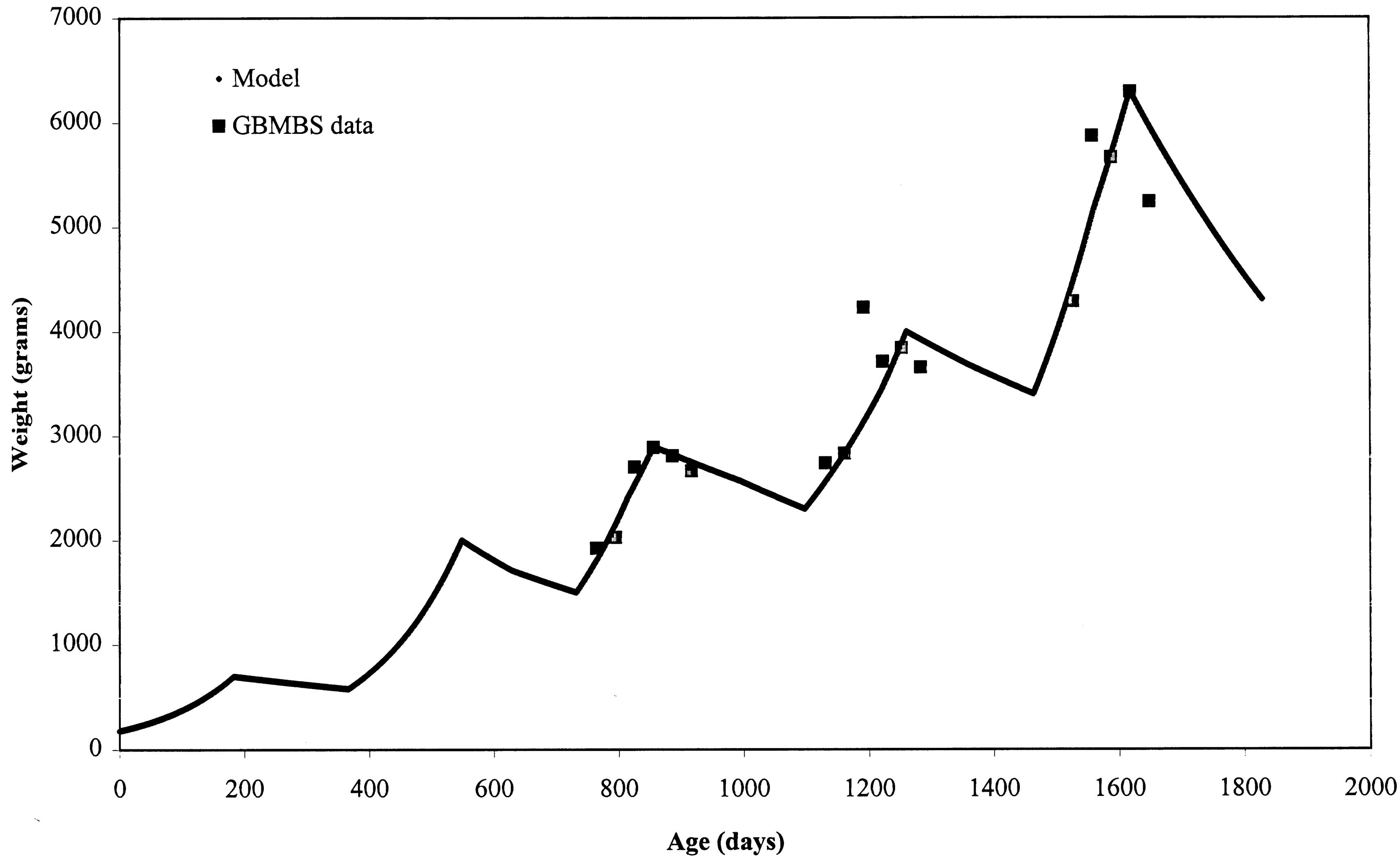

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Figure 3-5. Model growth rate for brown trout compared with measured monthly average weights-at-age.

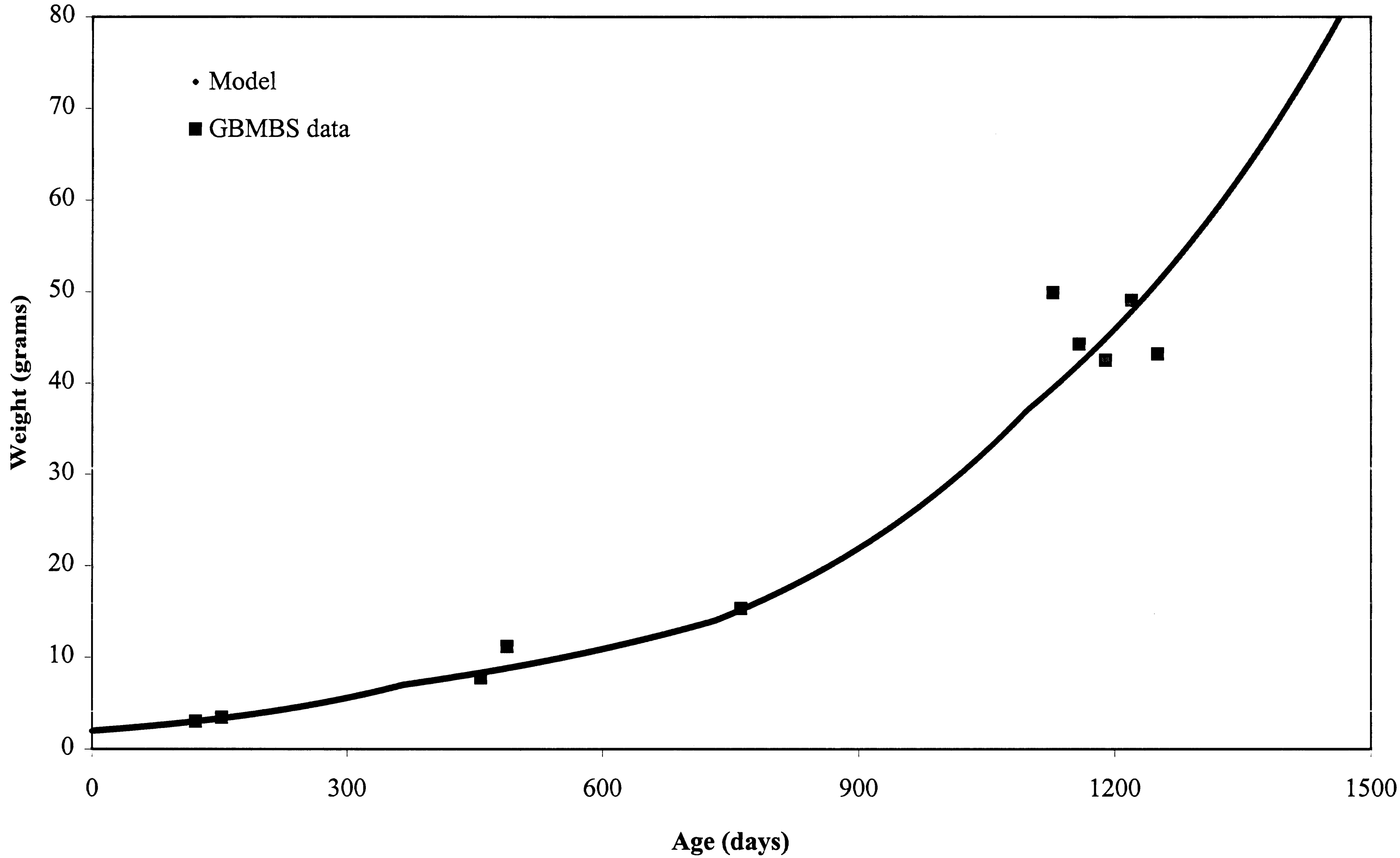

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Figure 3-6. Model growth rate for alewife compared with measured monthly average weights-at-age.

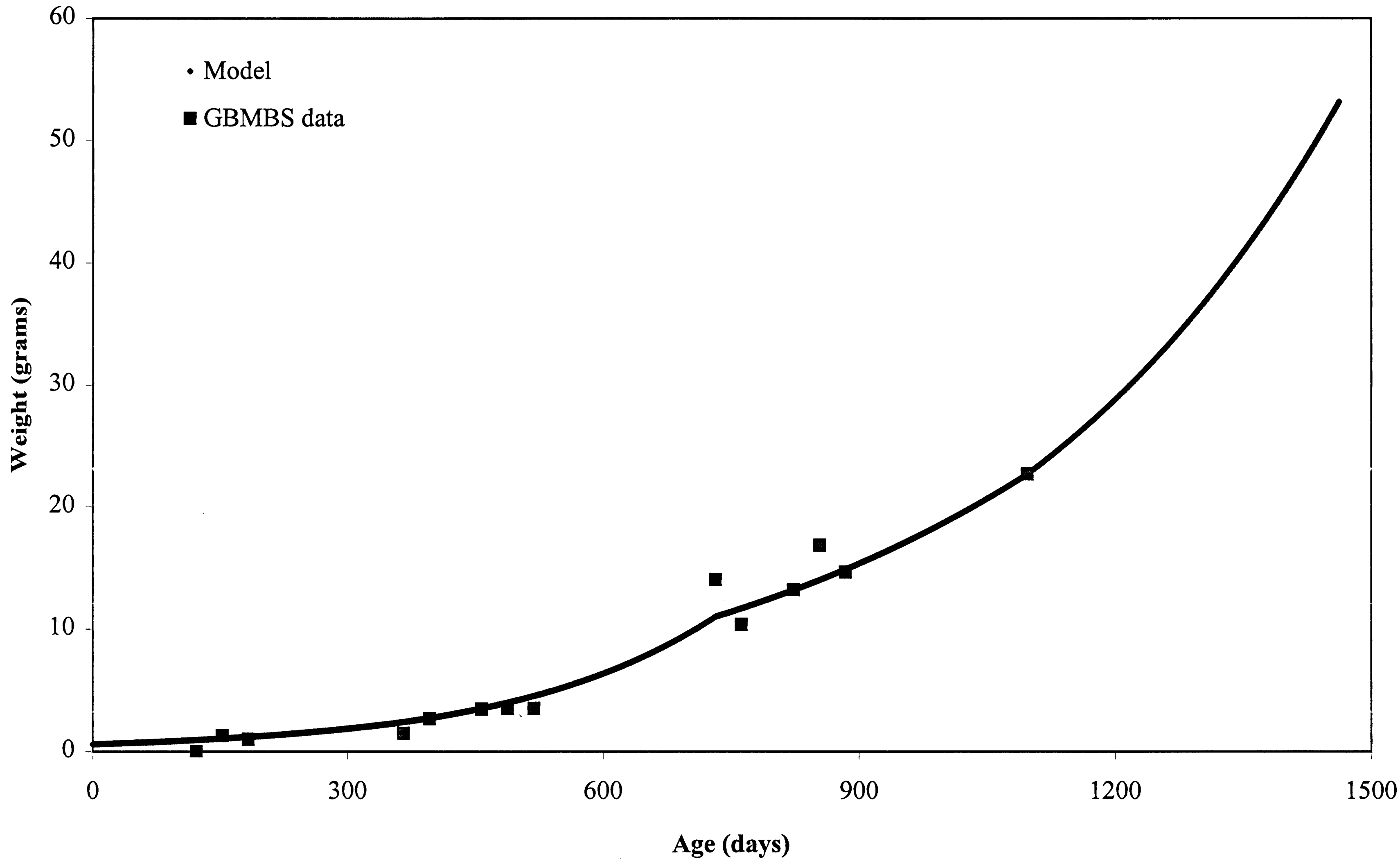

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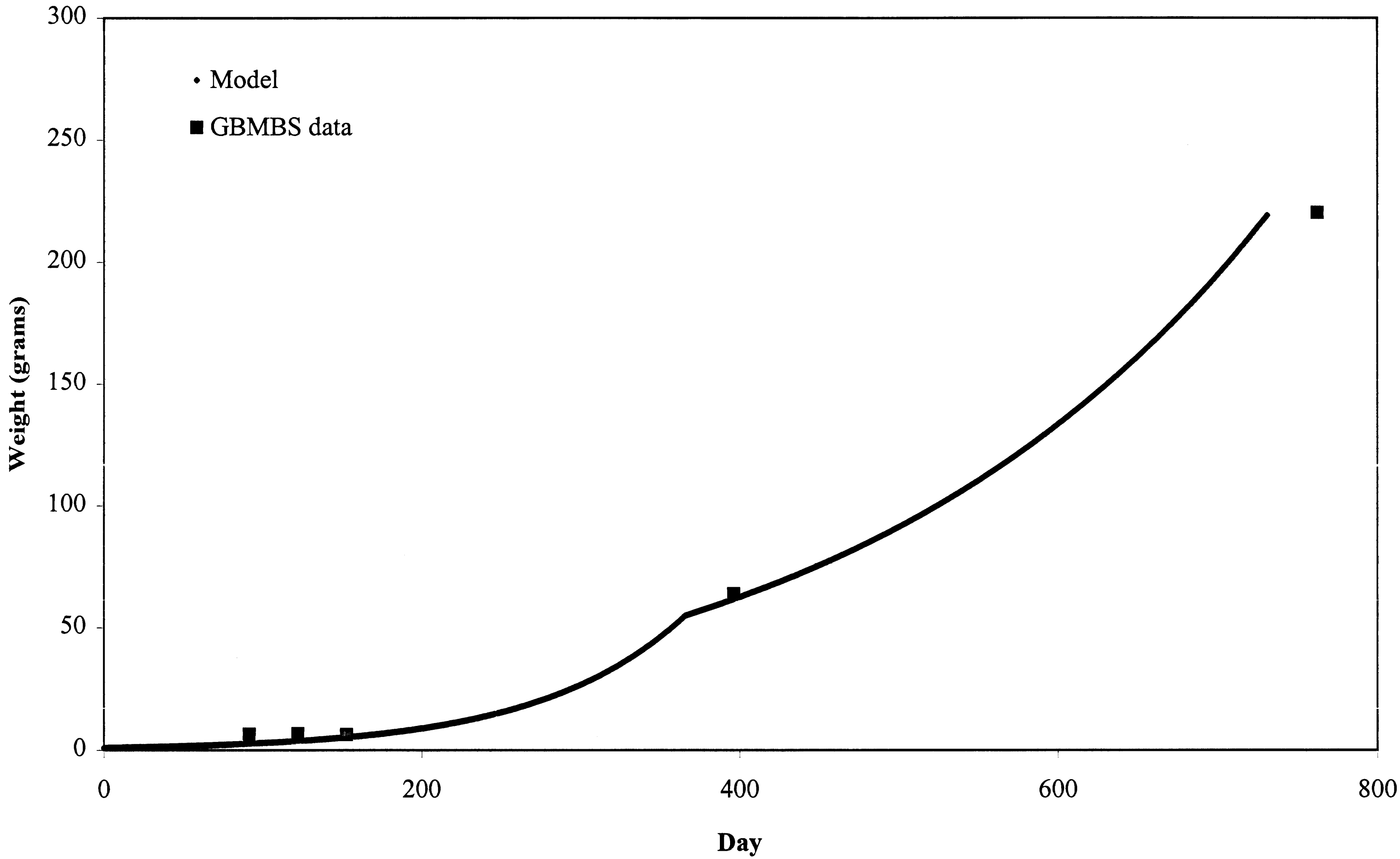
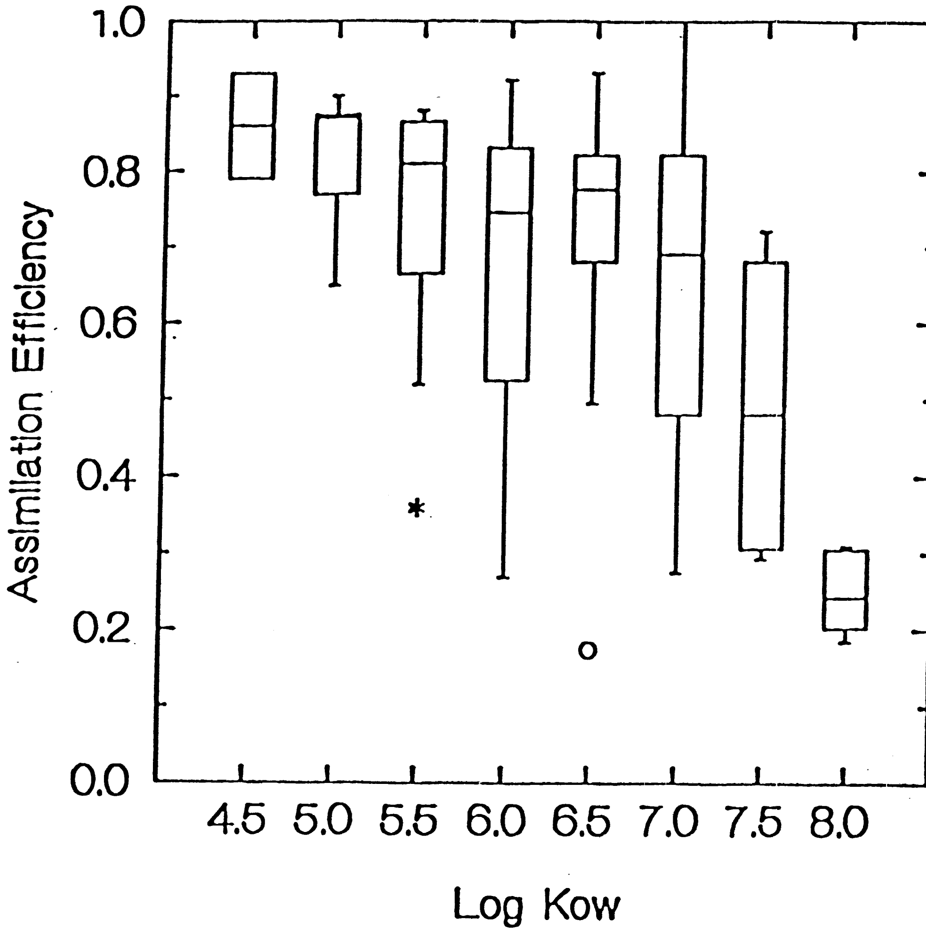
Figure 3-7. Model growth rate for rainbow smelt compared with measured monthly average weights-at-age.



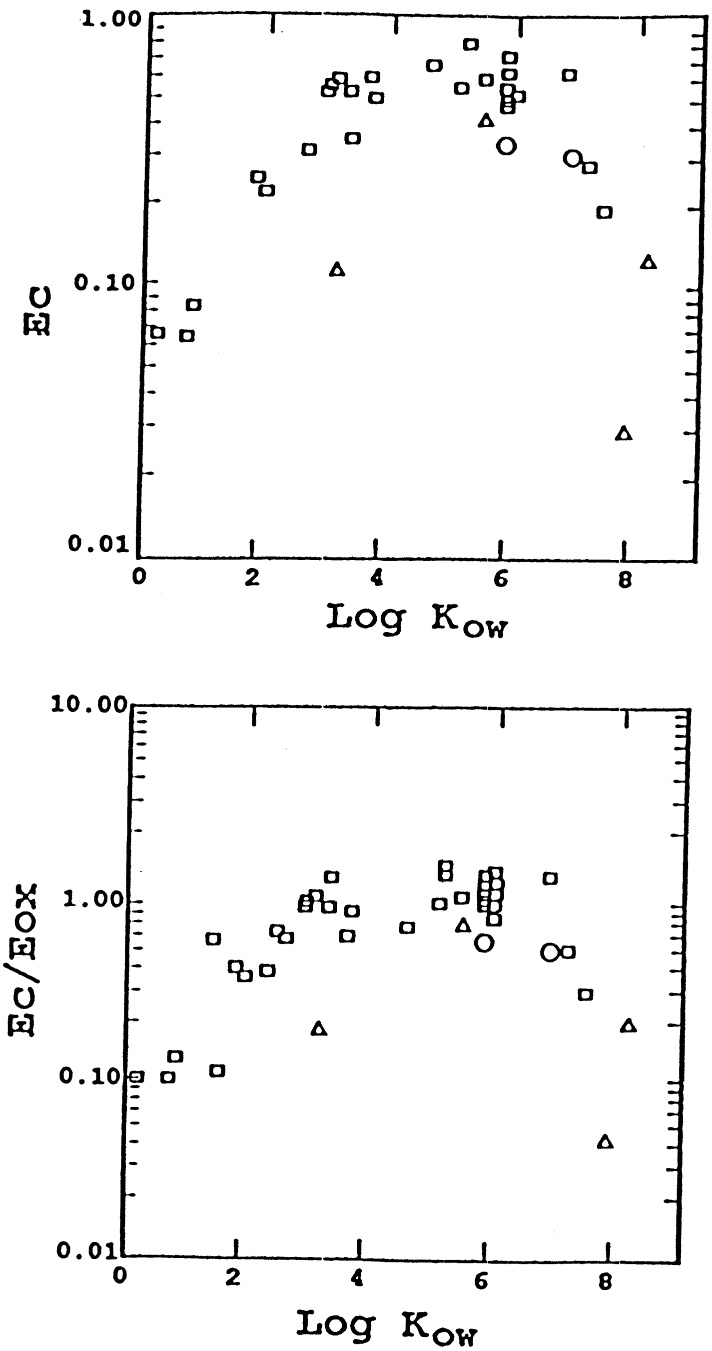
Data: monthly averages of GBMBS data from GLNPO website

Figure 3-8. Model growth rate for gizzard shad compared with measured monthly average weights-at-age.



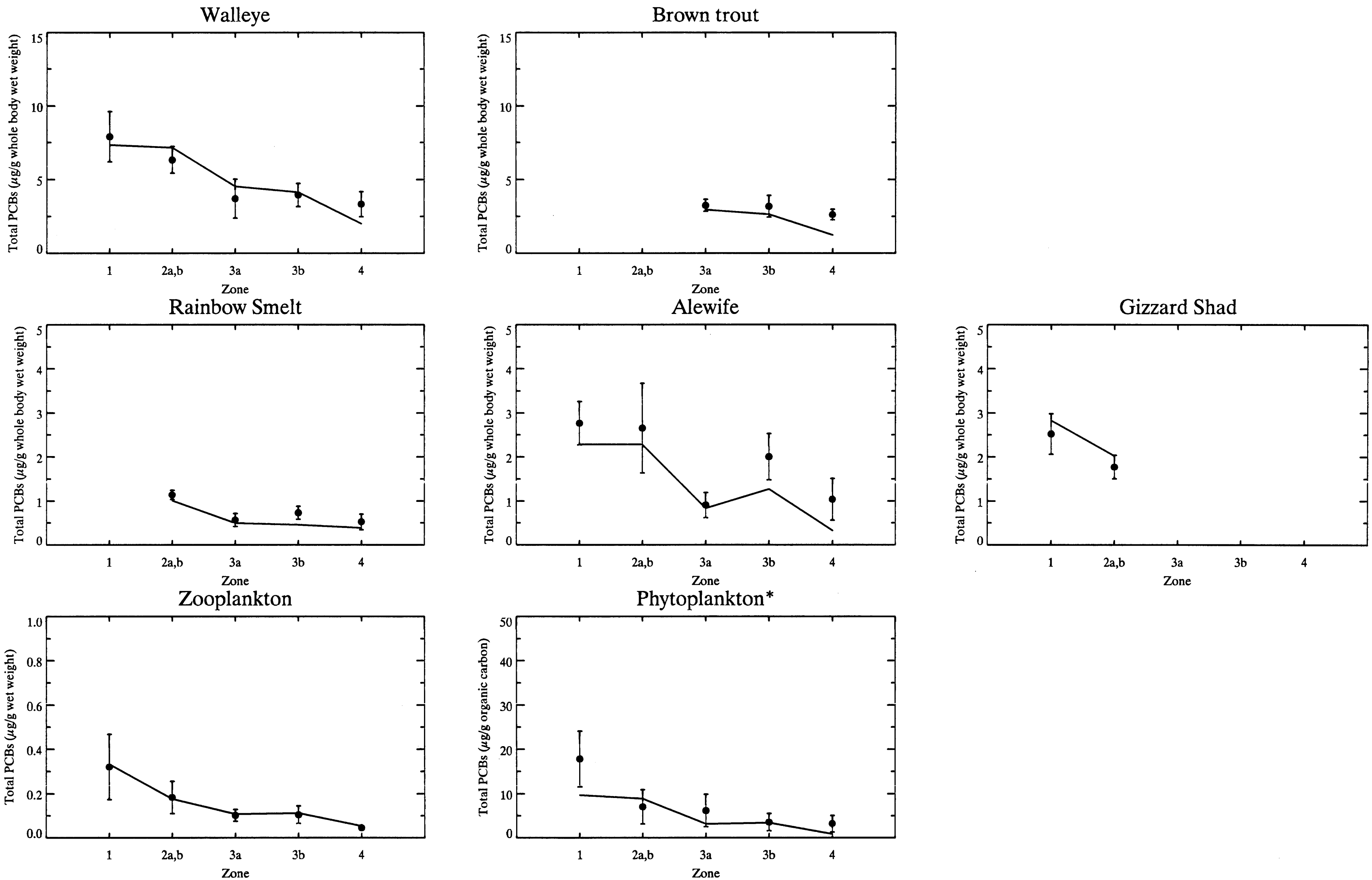
Data collected by Connolly et al. 1992, Parkerton 1993.

Figure 3-9. Dietary assimilation efficiencies of PCBs in fish (box plots).



Data collected by Connolly et al. 1992.
Symbols: Circles < 10 g, Triangles 10-100 g, Squares > 100 g.

Figure 3-10. Ratio of PCB:oxygen uptake efficiencies at the gill (E_c/E_{ox}).



Averaging period for model and data in Zones 2,3, and 4: April 1 to November 30; Zone 1: June 1 to June 30. *Phytoplankton data; carbon-normalized water column particulate model exposures.
DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Calibration Run #: Zones 1&2: 1989_rn34_z12; Zone 3a: 1989_rn29_z3a; Zone 3b: 1989_rn19_z3b; Zone 4: 1989_rn20_z4.

Figure 4-1. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish from the Lower Fox River and Green Bay. Fish are present in Zone 1 for one month of the year. Overall averages, wet-weight basis.

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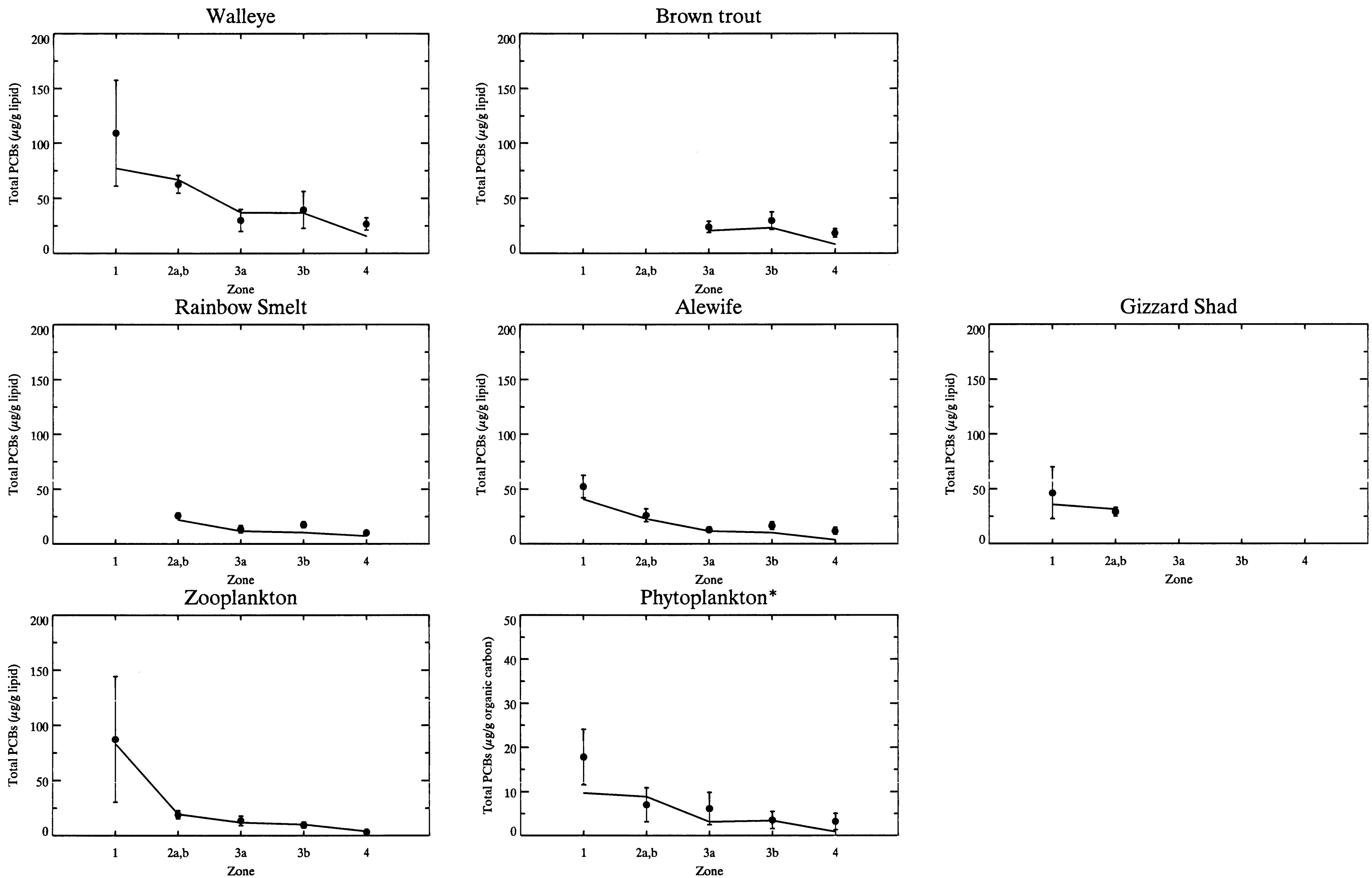

Averaging period for model and data in Zones 2,3, and 4: April 1 to November 30; Zone 1: June 1 to June 30. *Phytoplankton data; carbon-normalized water column particulate model exposures.
DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Calibration Run #: Zones 1&2: 1989_rn34_z12; Zone 3a: 1989_rn29_z3a; Zone 3b: 1989_rn19_z3b; Zone 4: 1989_rn20_z4.

Figure 4-2. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish from the Lower Fox River and Green Bay. Fish are present in Zone 1 for one month of the year. Overall averages, lipid basis.

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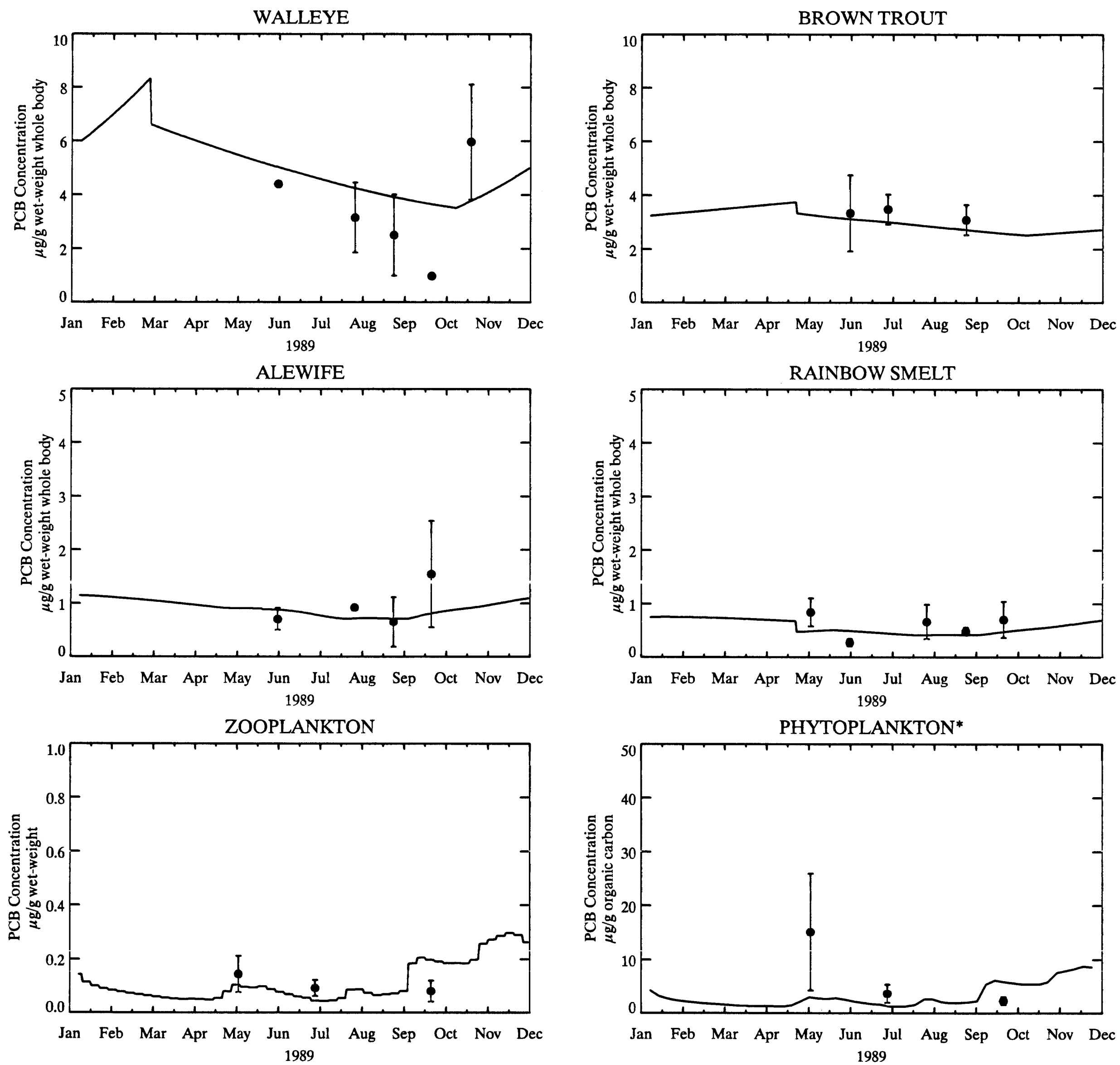

DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn29_z3a.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-3. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish from Zone 3A. Seasonal patterns, wet-weight basis.

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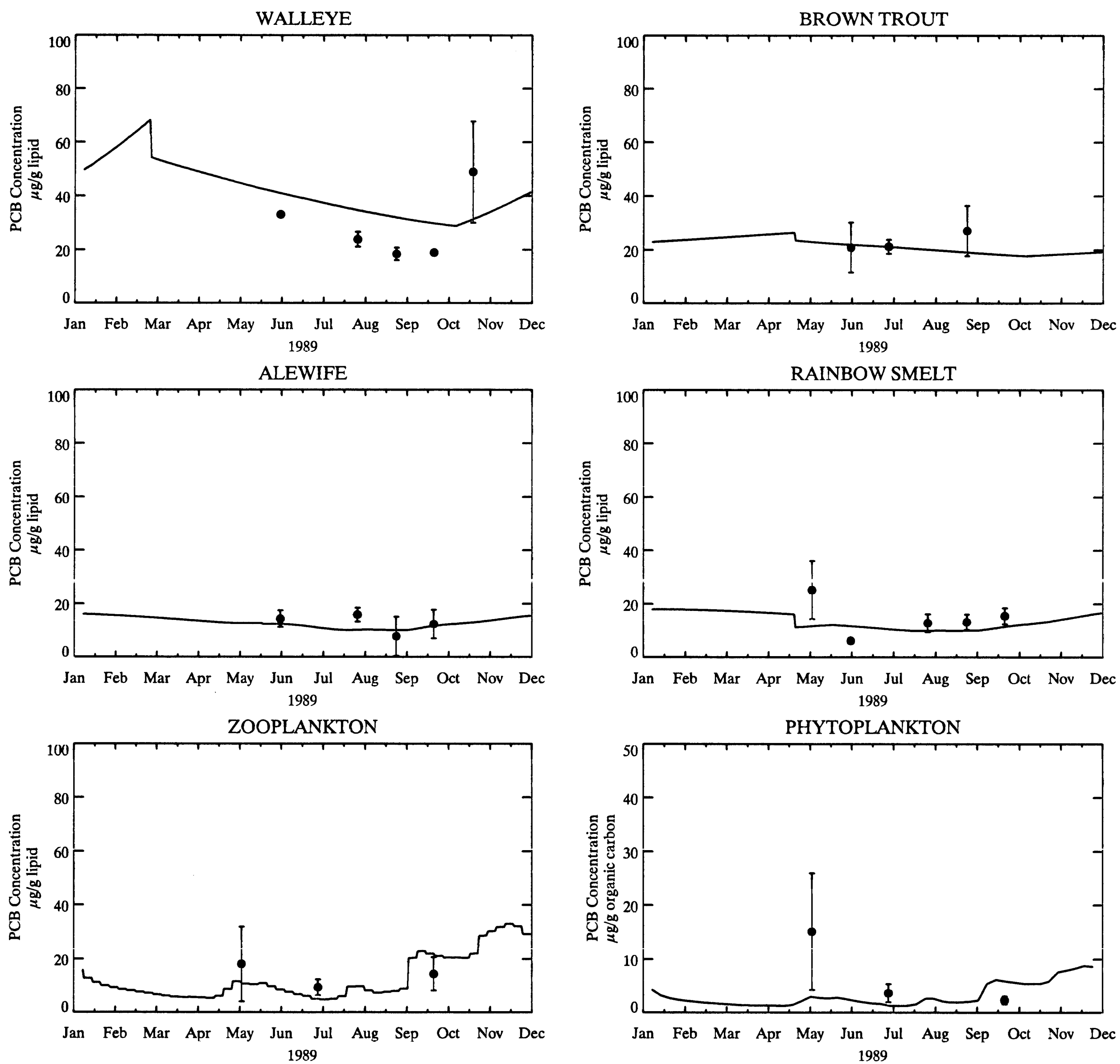

DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn29_z3a.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-4. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish from Zone 3A. Seasonal patterns, lipid basis.

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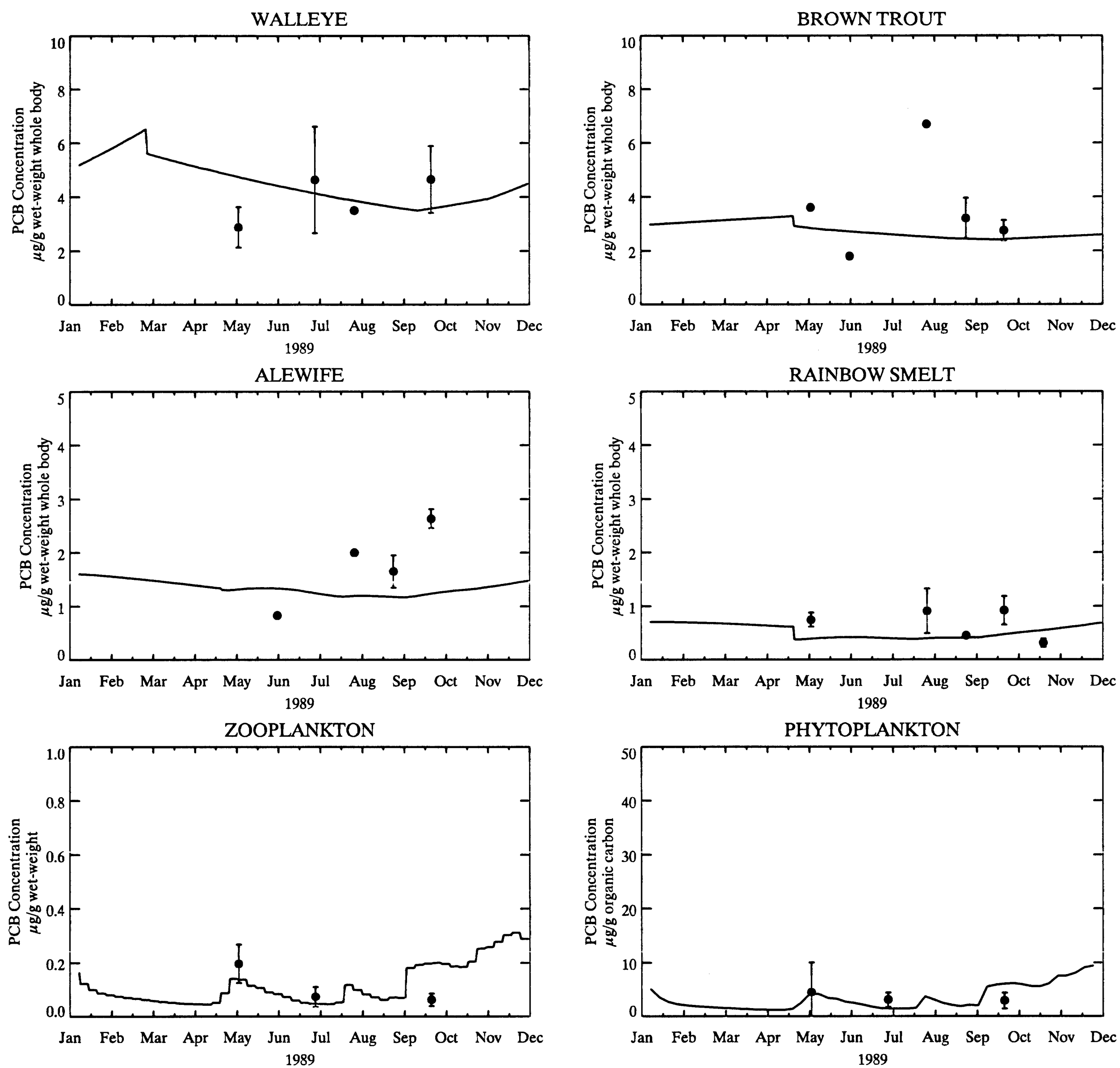

DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn19_z3b.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-5. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish from Zone 3B. Seasonal patterns, wet-weight basis.

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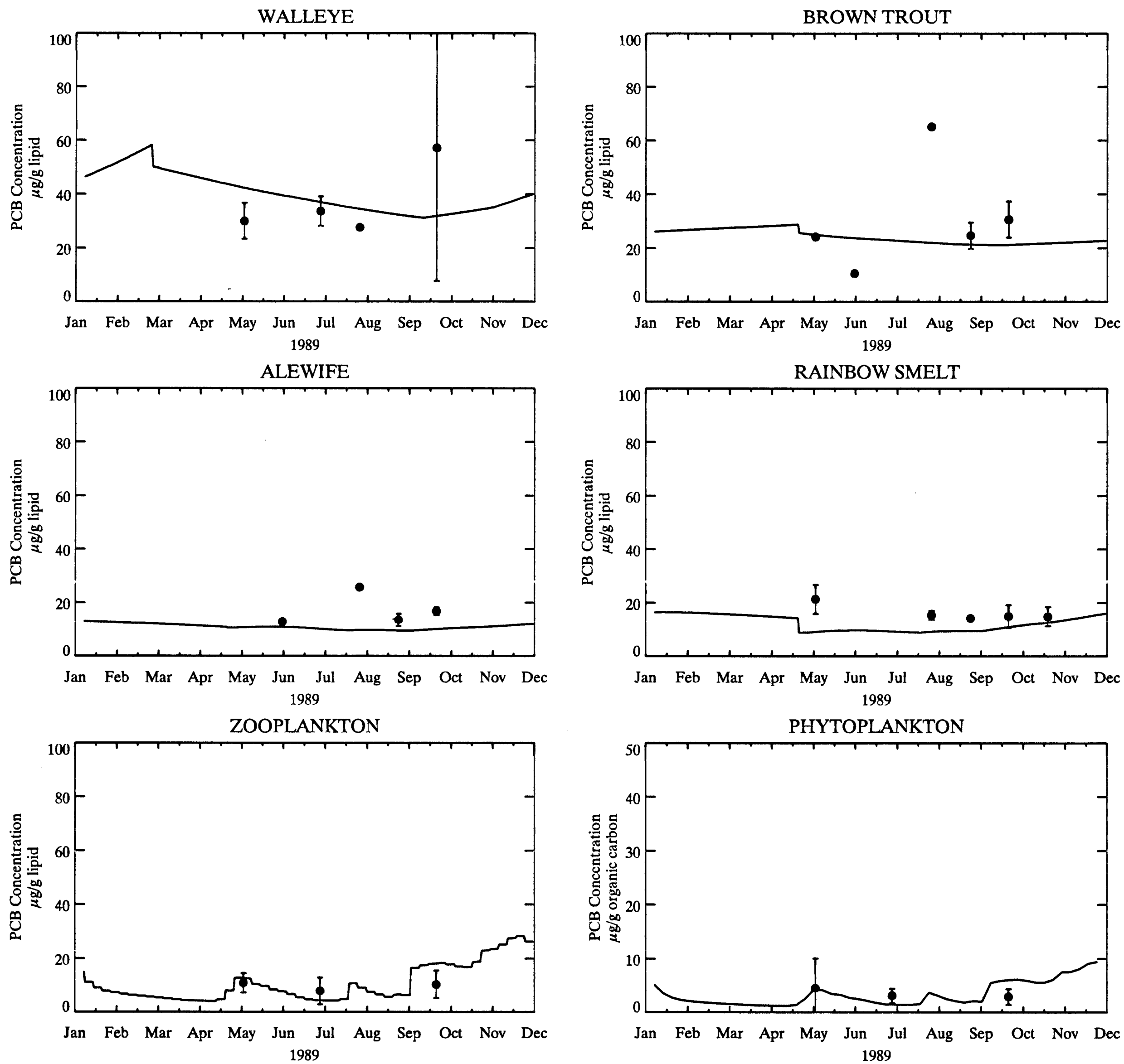

DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn19_z3b.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-6. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish from Zone 3B. Seasonal patterns, lipid basis.

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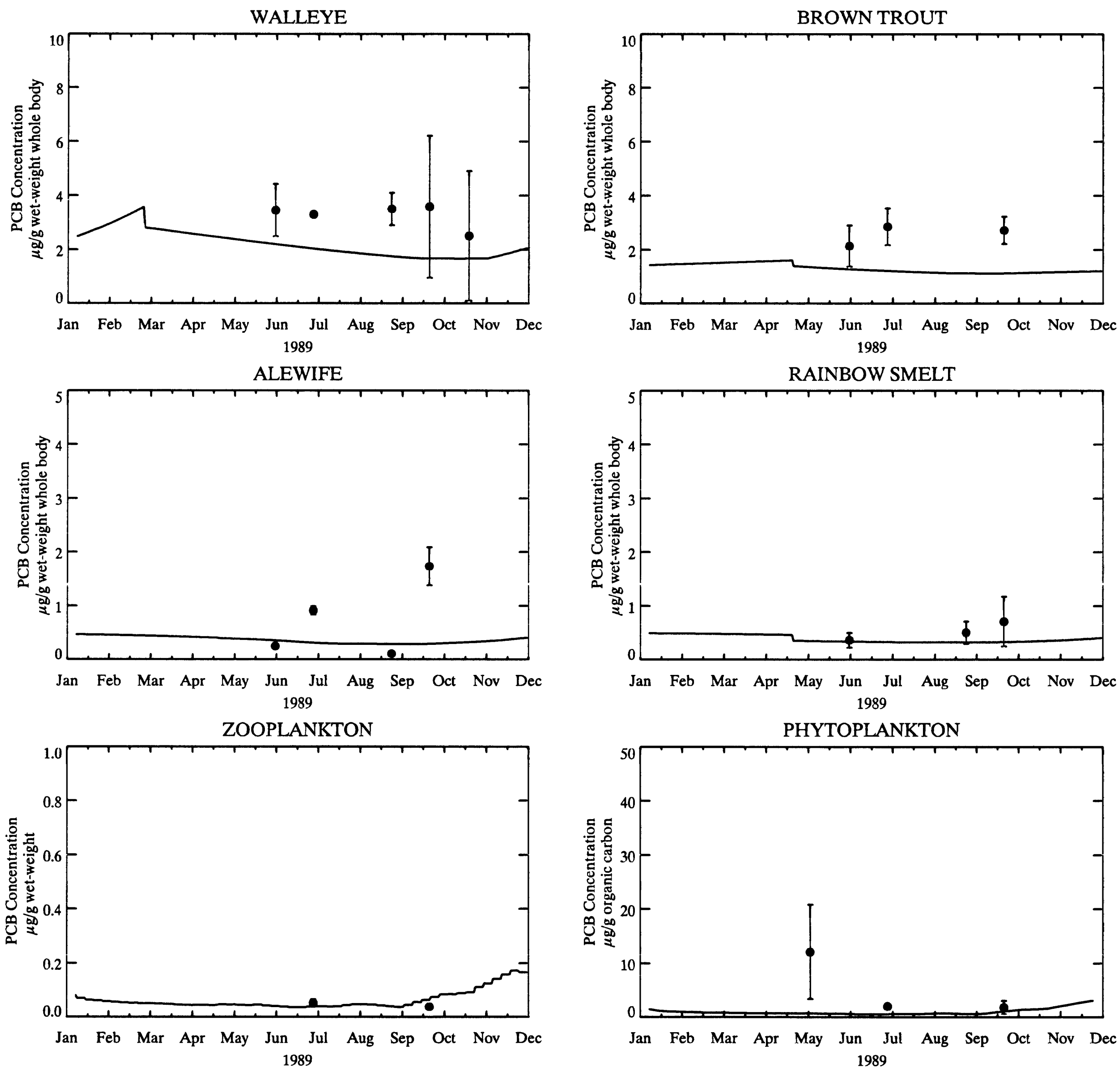

DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn20_z4.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-7. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish from Zone 4. Seasonal patterns, wet-weight basis.

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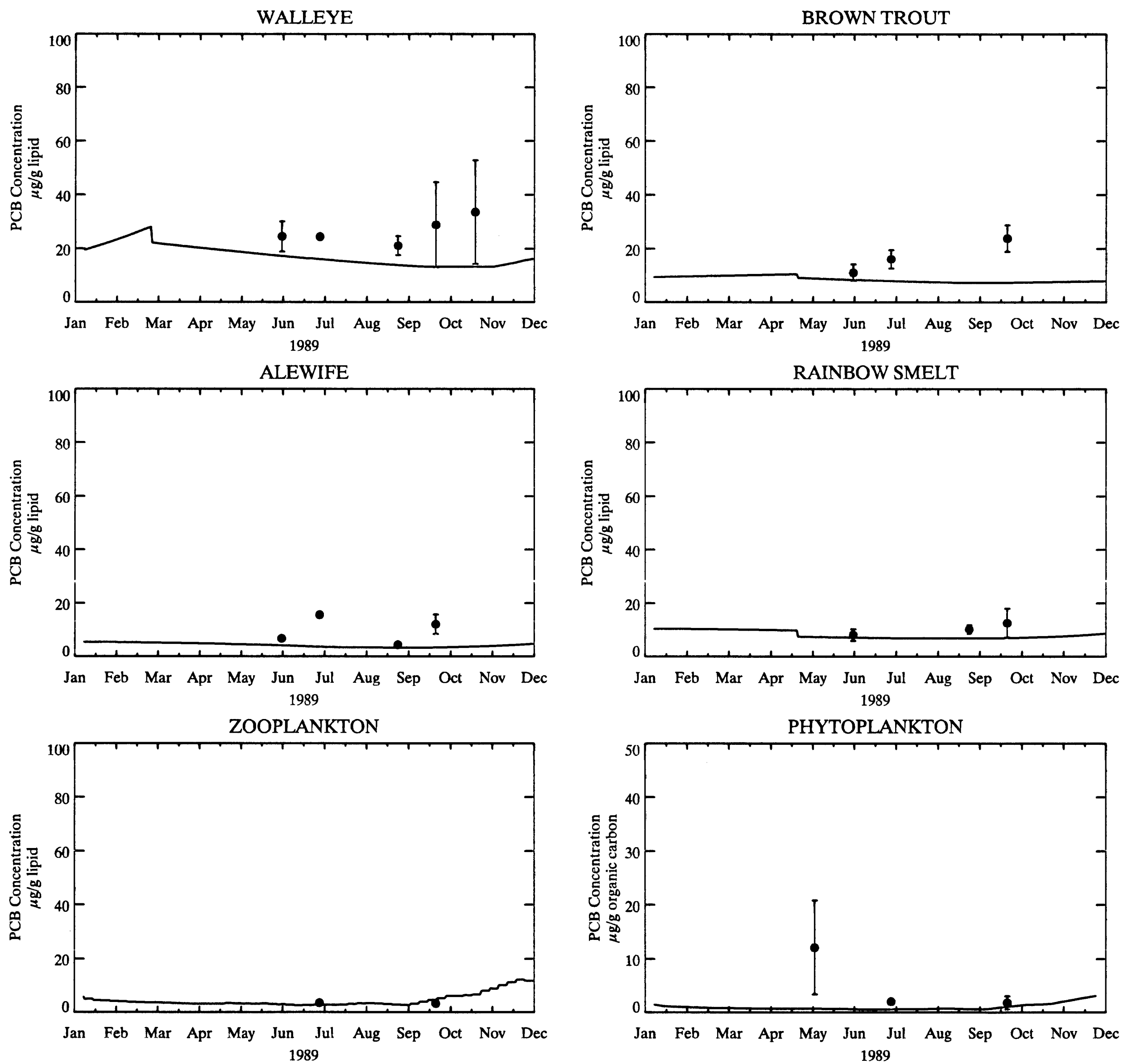

DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn20_z4.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-8. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish from Zone 4. Seasonal patterns, lipid basis.

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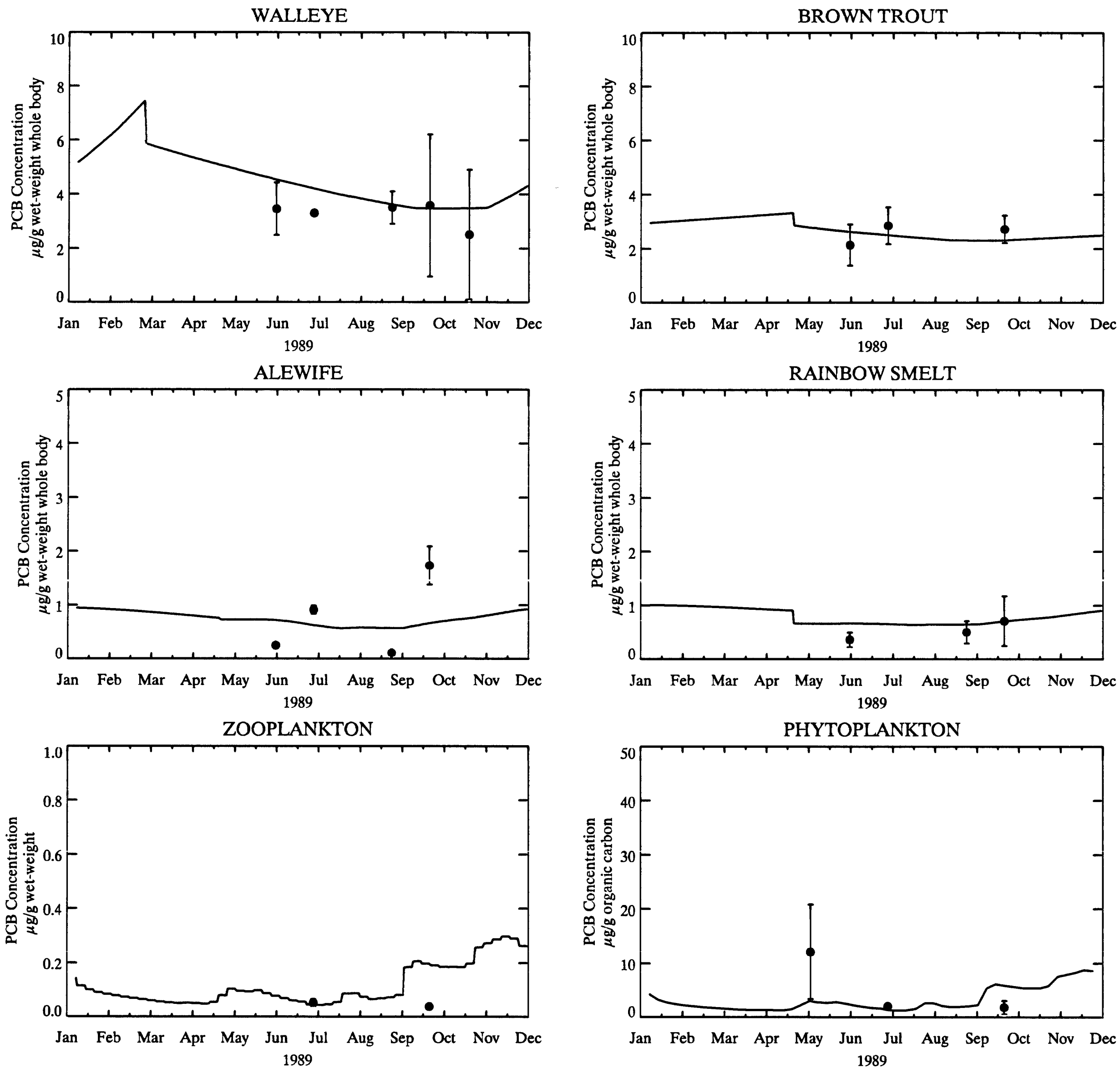

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Data are monthly averages.
Calibration Run #: 1989_rn21_z4.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-9. GBFood sensitivity analysis. Computed (line) and measured (symbols) total PCB concentrations in fish from Zone 4 exposed to water and sediment from Zone 3A. Seasonal patterns, wet-weight basis.

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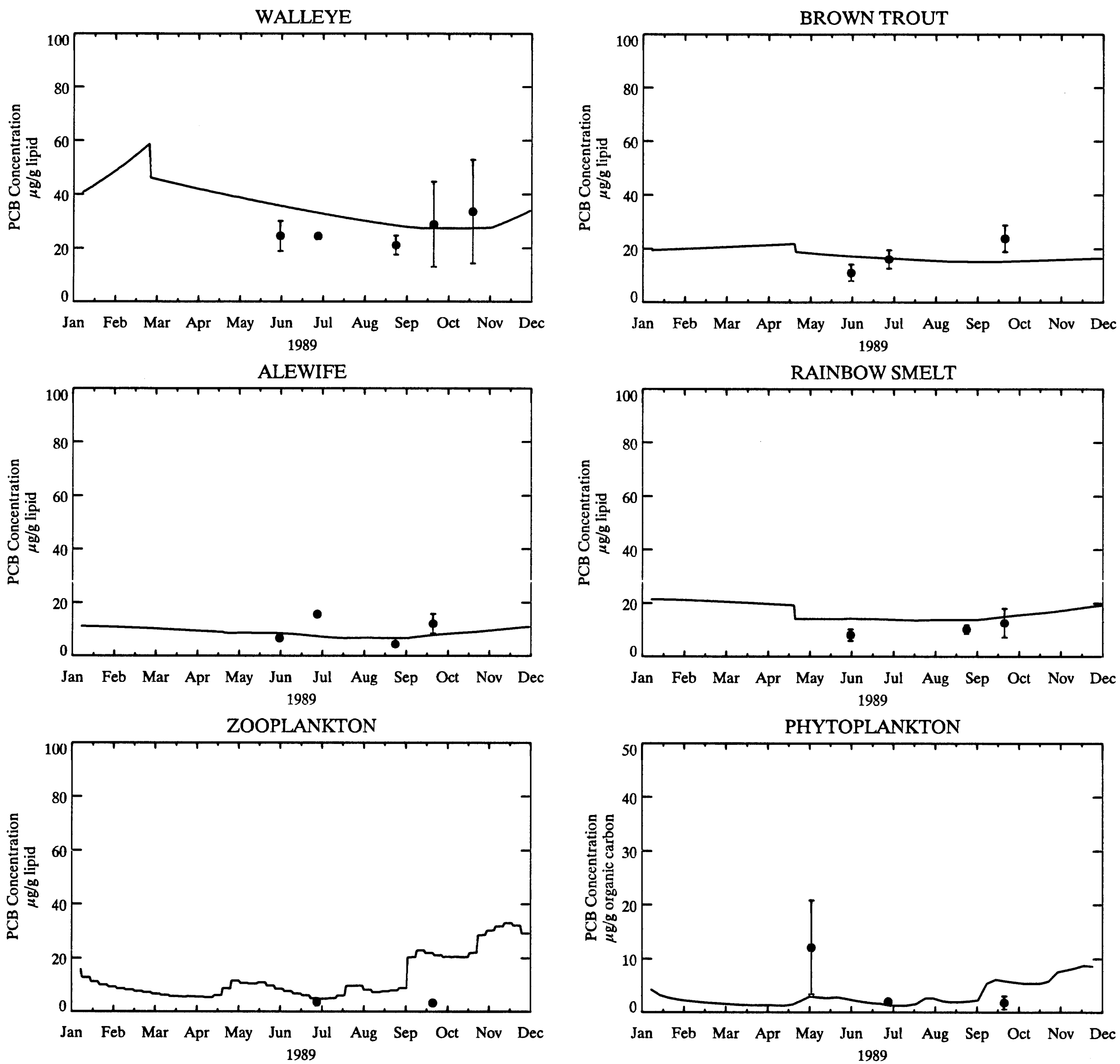

DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn21_z4.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-10. GBFood sensitivity analysis. Computed (line) and measured (symbols) total PCB concentrations in fish from Zone 4 exposed to water and sediments from Zone 3A. Seasonal patterns, lipid basis.

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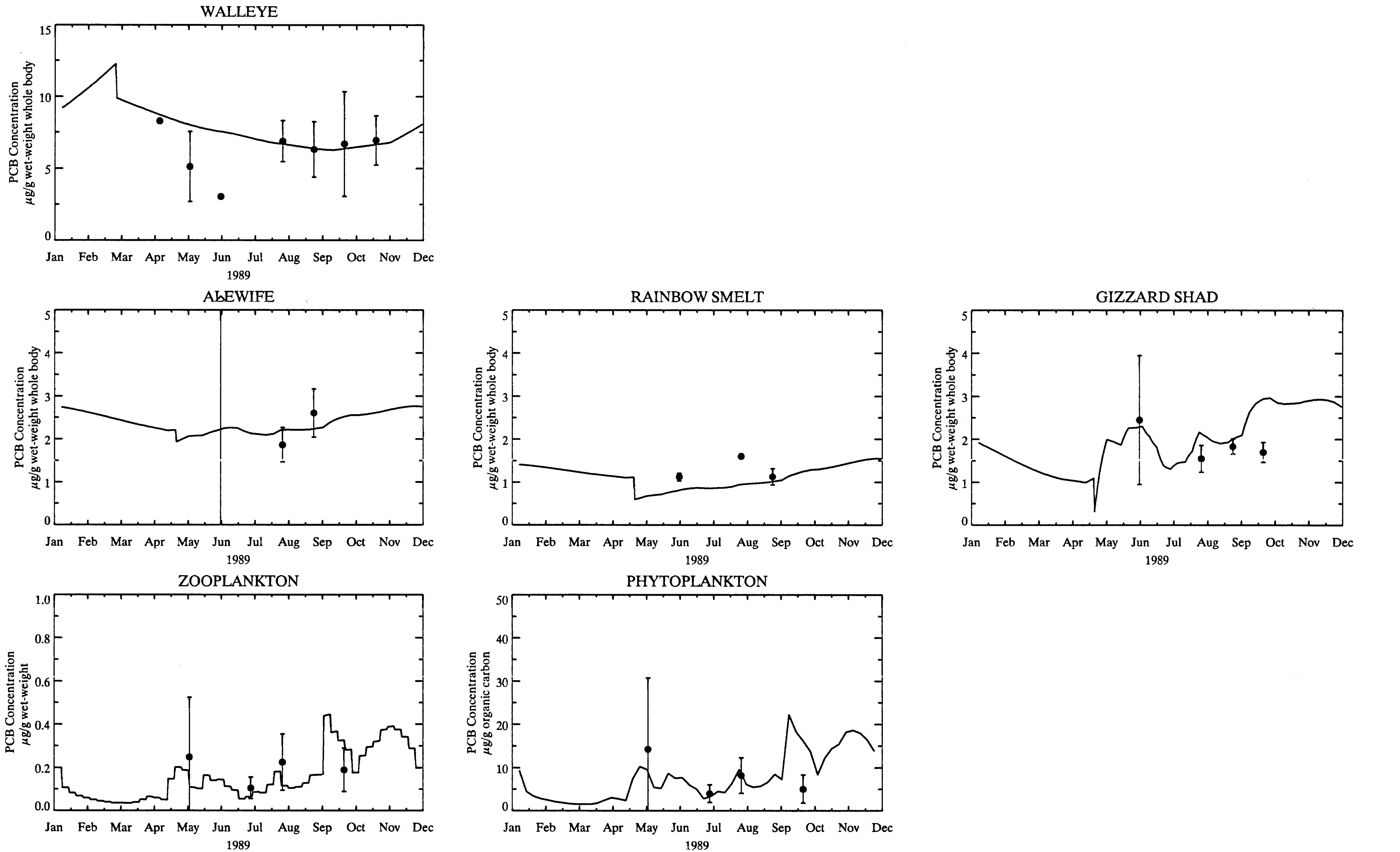

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Data are monthly averages.
Calibration Run #: 1989_rn34_z12.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-11. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish resident in Zone 2. Seasonal patterns, wet-weight basis.

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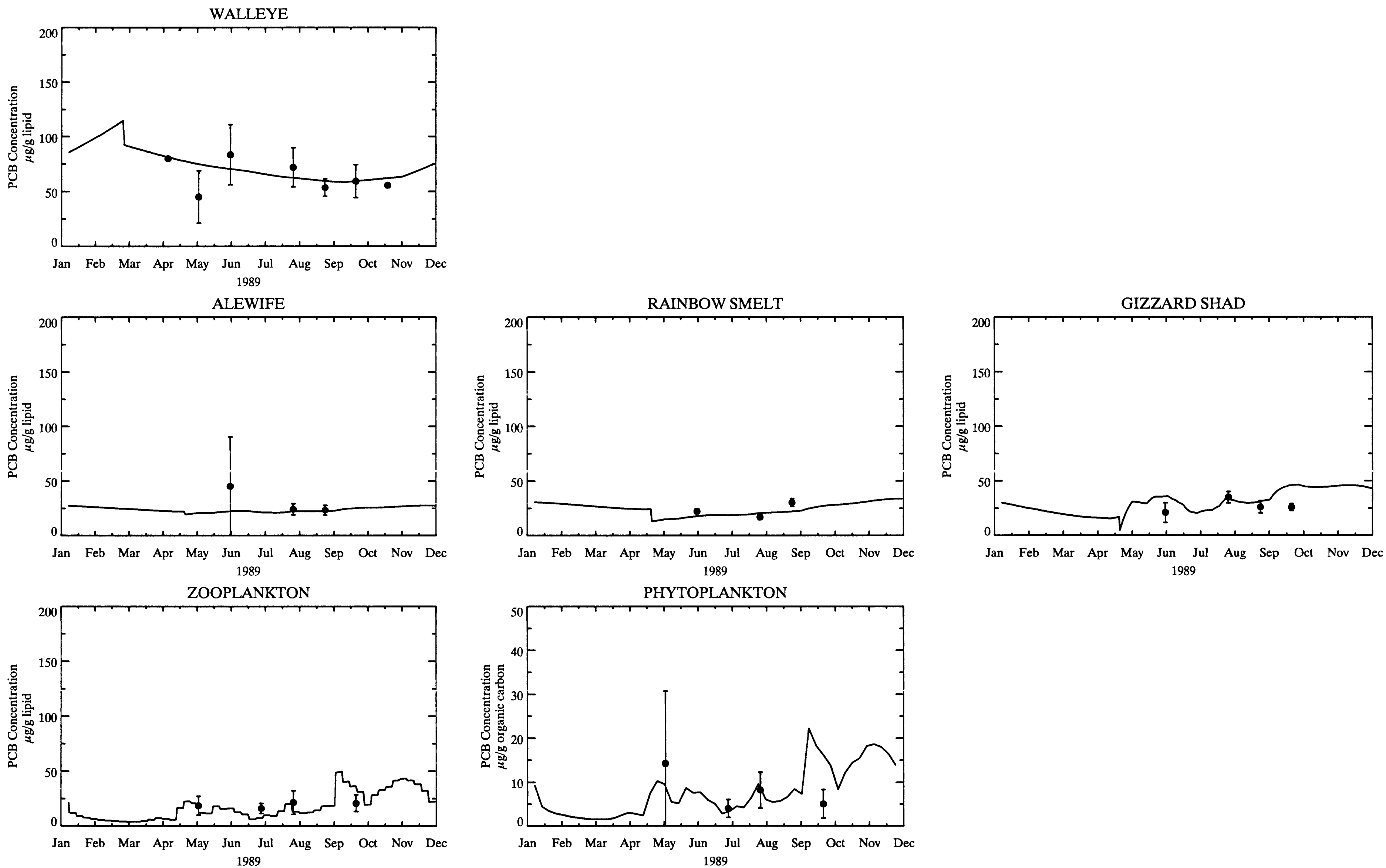

DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn34_z12.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-12. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish resident in Zone 2. Seasonal patterns, lipid basis.

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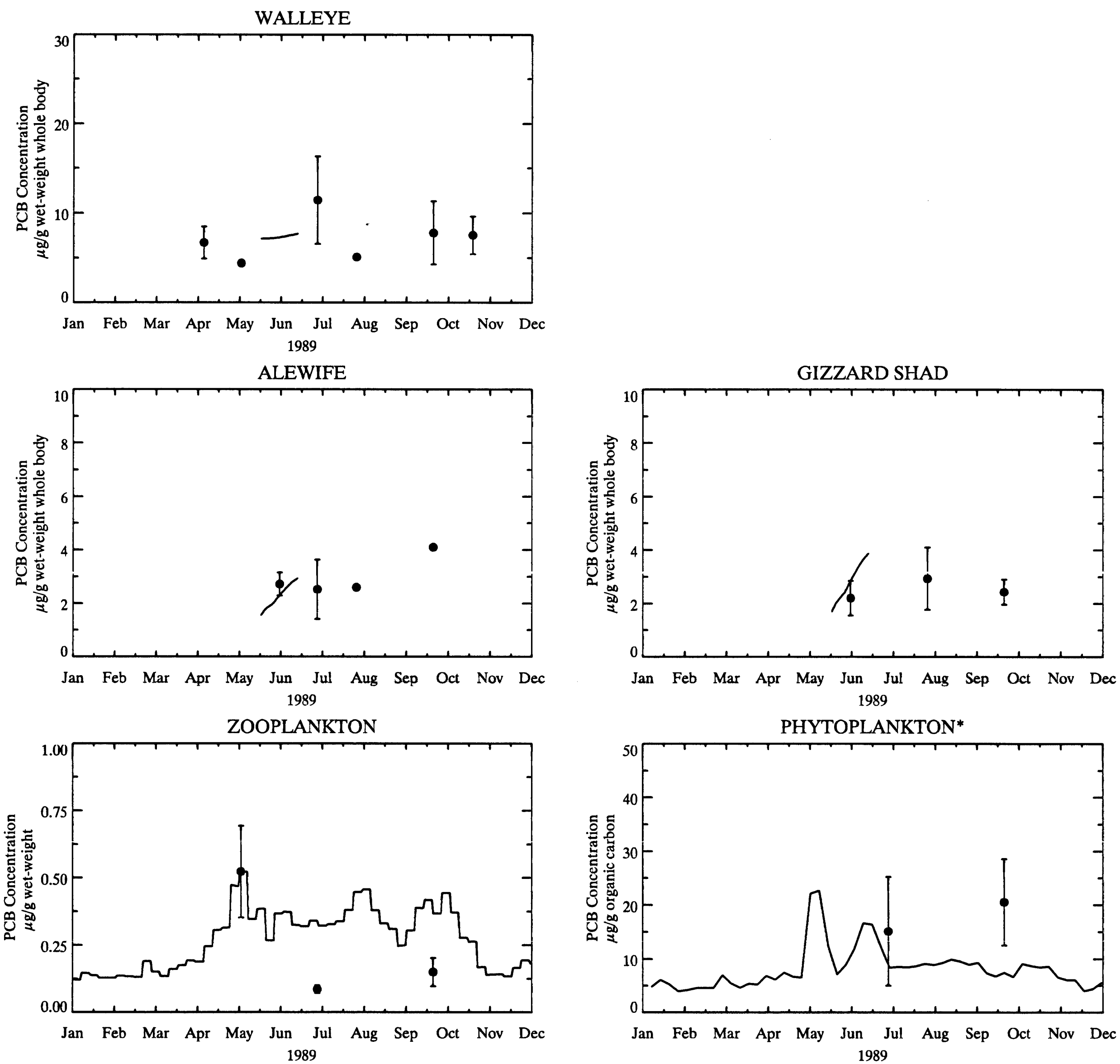

DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn34_z12.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-13. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish present in Zone 1 for one month each year. Seasonal patterns, wet-weight basis.

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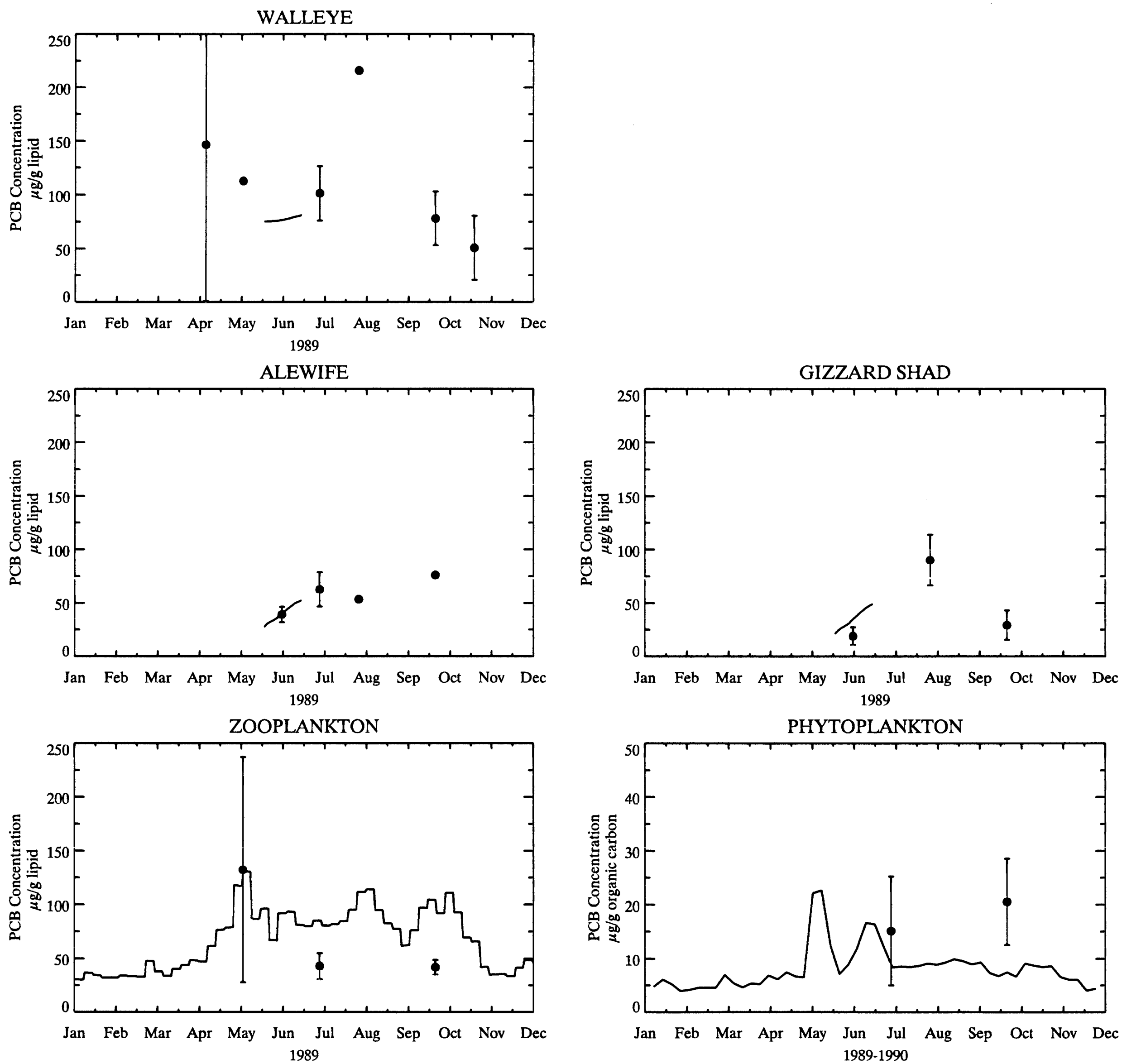
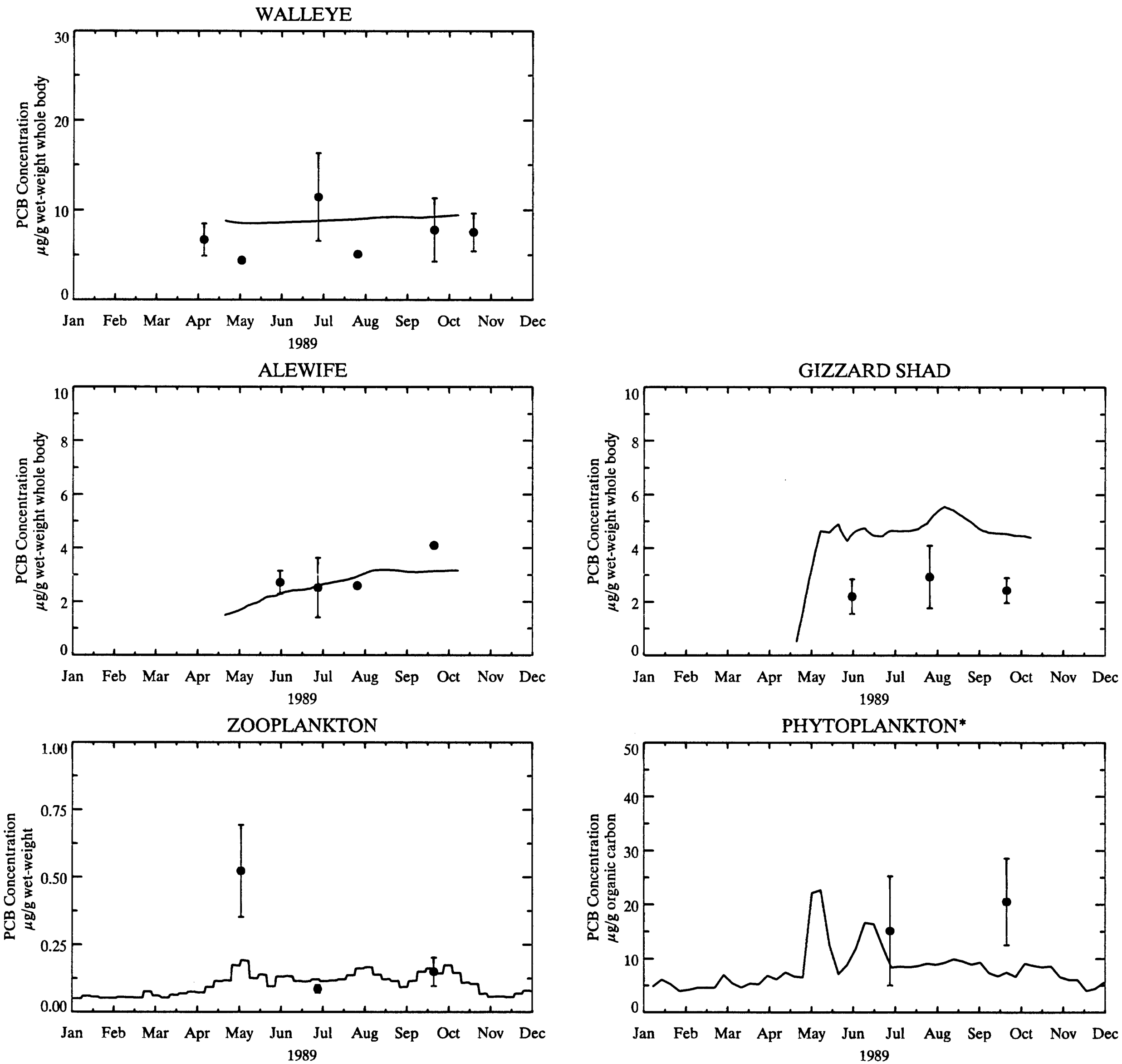


DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn34_z12.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-14. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish present in Zone 1 for one month each year. Seasonal patterns, lipid basis.

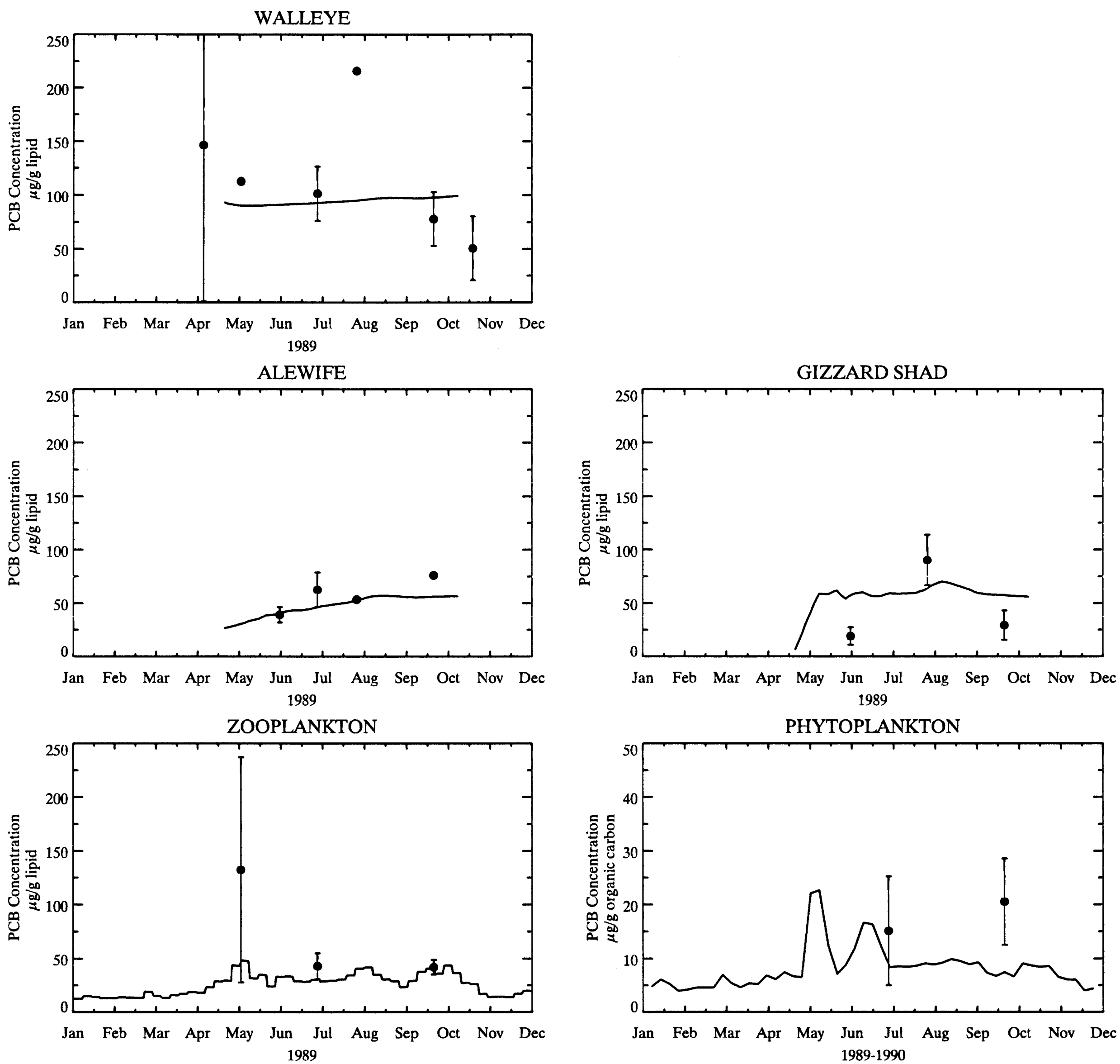


DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn48_z12.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-15. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish present in Zone 1 from May through October each year. Seasonal patterns, wet-weight basis.

beth - D:\THEfox\model\Biota\CON_EXP_DATA\Zones12\Plots\z1_1989_model_data_comp_sum.pro
Fri May 11 11:48:14 2001



DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn48_z12.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-16. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish present in Zone 1 from May through October each year. Seasonal patterns, lipid basis.

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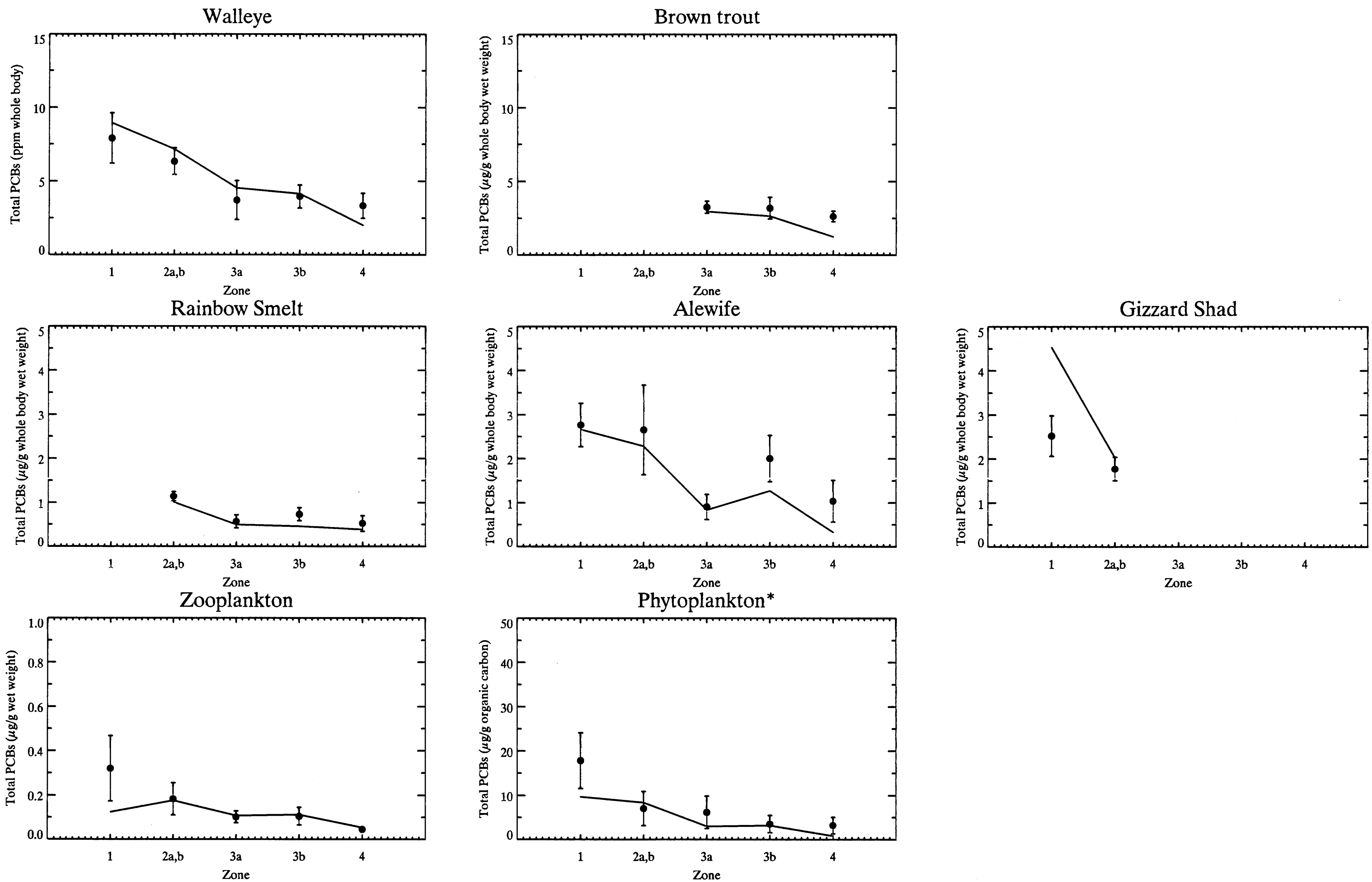
Fri May 11 11:50:37 2001



Averaging period for model and data in Zones 2,3, and 4: April 1 to November 30; Zone 1: June 1 to June 30. *Phytoplankton data; carbon-normalized water column particulate model exposures.
DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Calibration Run #: Zones 1&2: 1989_rn48_z12; Zone 3a: 1989_rn29_z3a; Zone 3b: 1989_rn19_z3b; Zone 4: 1989_rn20_z4.

Figure 4-17. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish from the Lower Fox River and Green Bay. Fish are present in Zone 1 from May through October. Overall averages, wet-weight basis.

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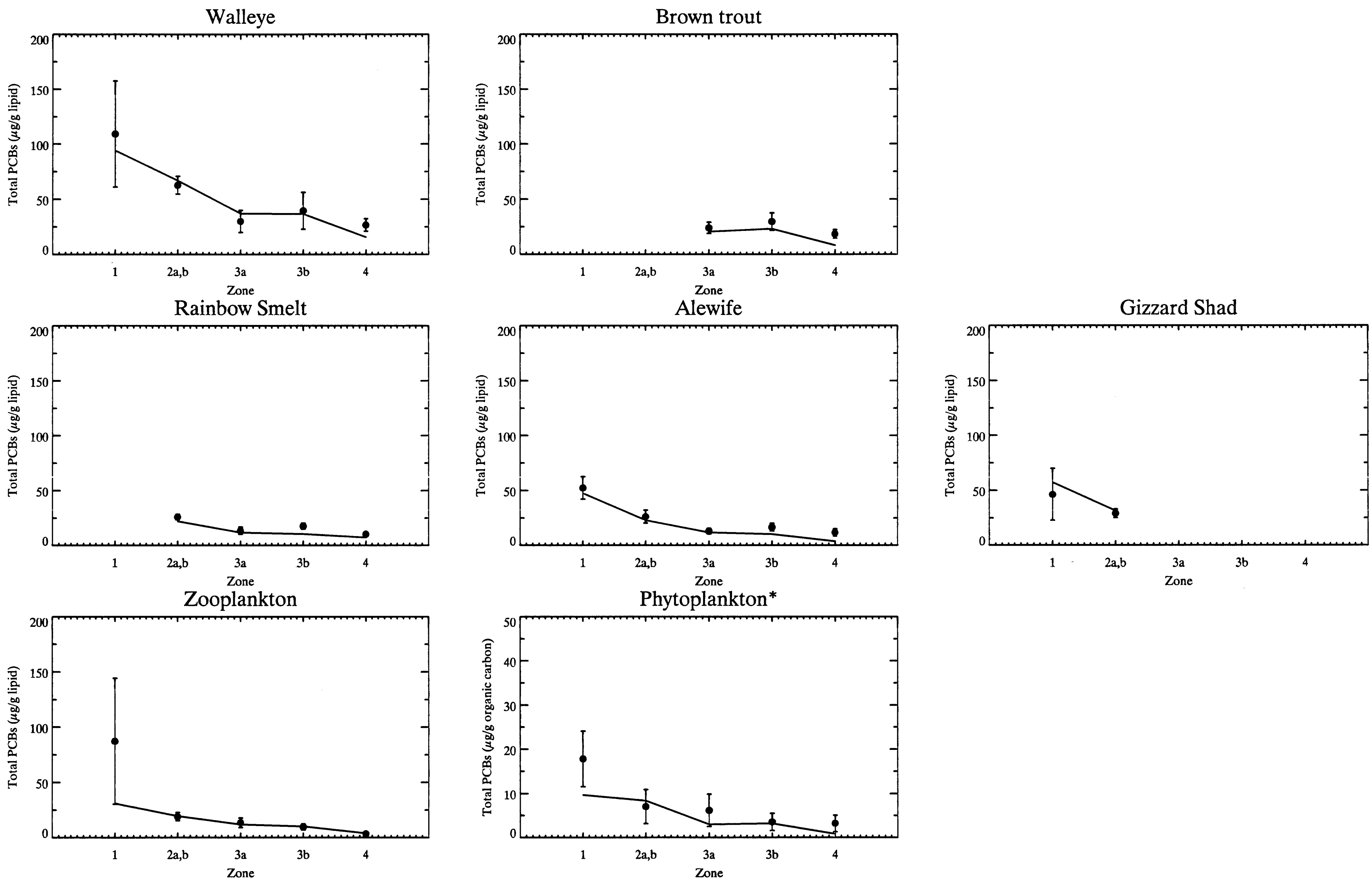
Fri May 11 12:04:39 2001



Averaging period for model and data in Zones 2,3, and 4: April 1 to November 30; Zone 1: June 1 to June 30. *Phytoplankton data; carbon-normalized water column particulate model exposures.
DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Calibration Run #: Zones 1&2: 1989_rn48_z12; Zone 3a: 1989_rn29_z3a; Zone 3b: 1989_rn19_z3b; Zone 4: 1989_rn20_z4.

Figure 4-18. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish from the Lower Fox River and Green Bay. Fish are present in Zone 1 from May through October. Overall averages, lipid basis.

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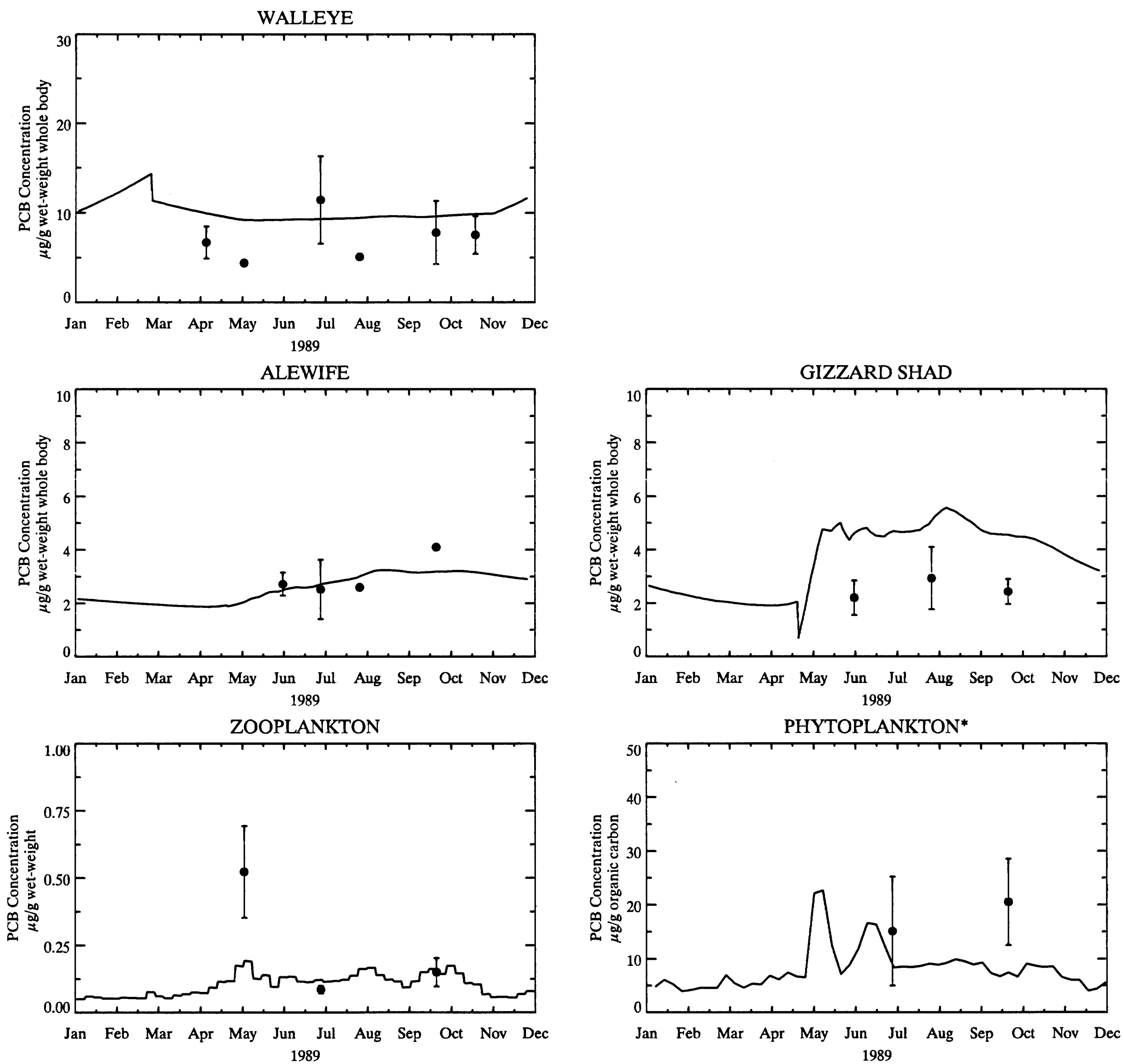
Fri May 11 12:09:40 2001



DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn47_z12.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-19. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish present in Zone 1 for 11 months +3 weeks of the year. Seasonal patterns, wet-weight basis.

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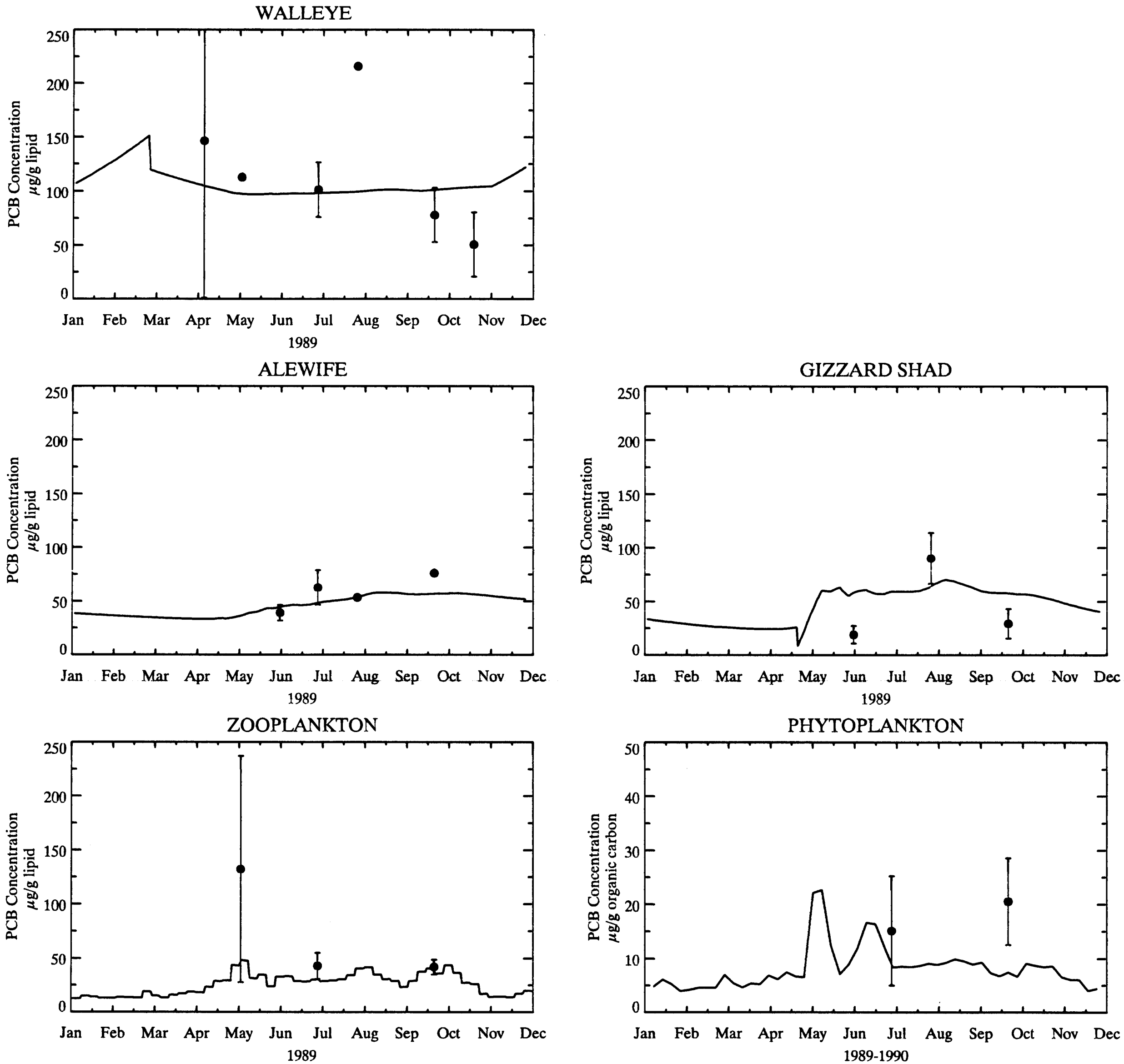
Fri May 11 11:55:56 2001



DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Data are monthly averages.
Calibration Run #: 1989_rn47_z12.

*Phytoplankton data; carbon-normalized water column particulate model exposures.

Figure 4-20. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish present in Zone 1 for 11 months +3 weeks of the year. Seasonal patterns, lipid basis.

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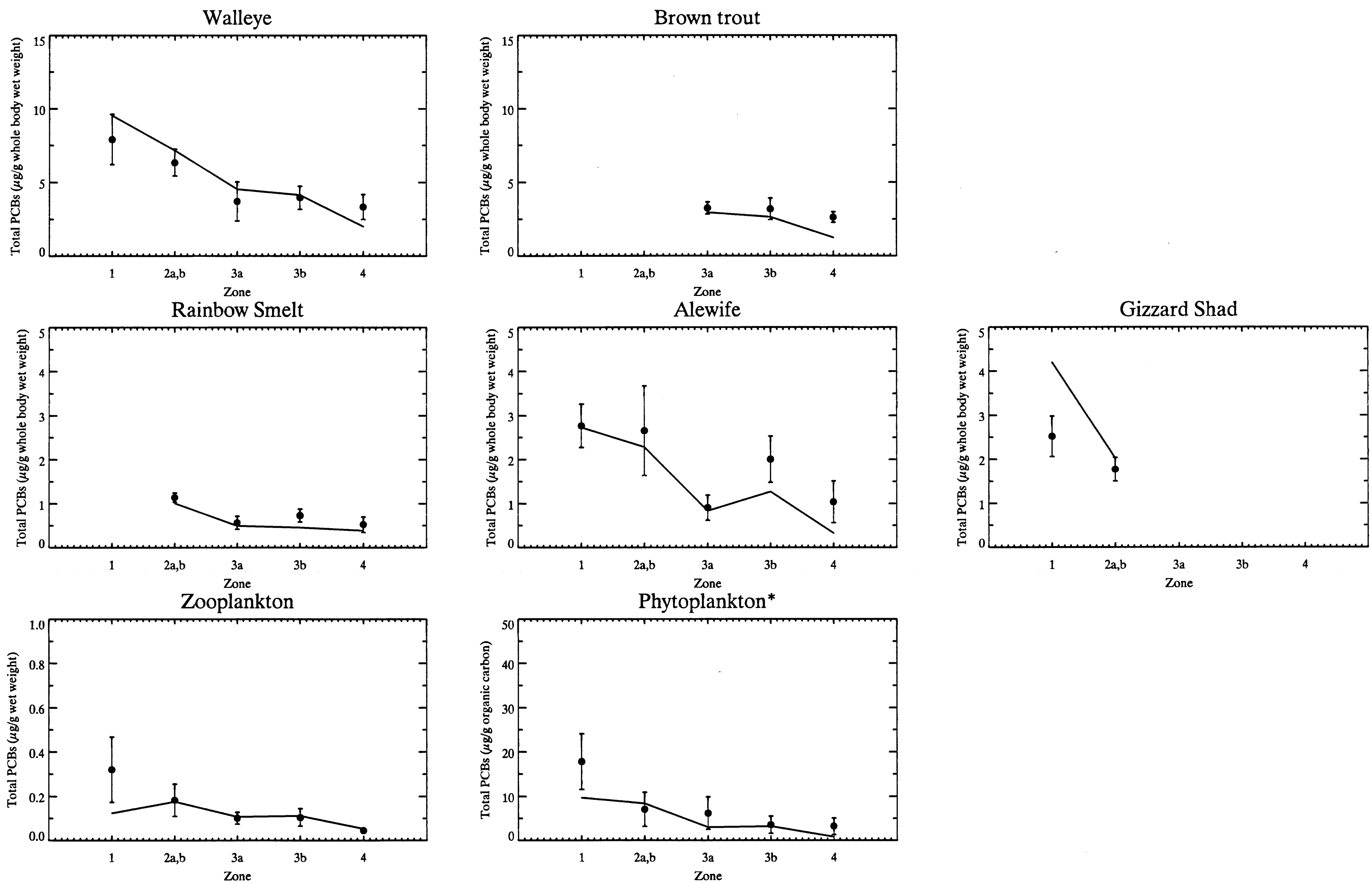
Fri May 11 11:53:12 2001



Averaging period for model and data in Zones 2,3, and 4: April 1 to November 30; Zone 1: June 1 to June 30. *Phytoplankton data; carbon-normalized water column particulate model exposures.
DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Calibration Run #: Zones 1&2: 1989_rn47_z12; Zone 3a: 1989_rn29_z3a; Zone 3b: 1989_rn19_z3b; Zone 4: 1989_rn20_z4.

Figure 4-21. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish from the Lower Fox River and Green Bay. Fish are present in Zone 1 for 11 months +3 weeks each year. Overall averages, wet-weight basis.

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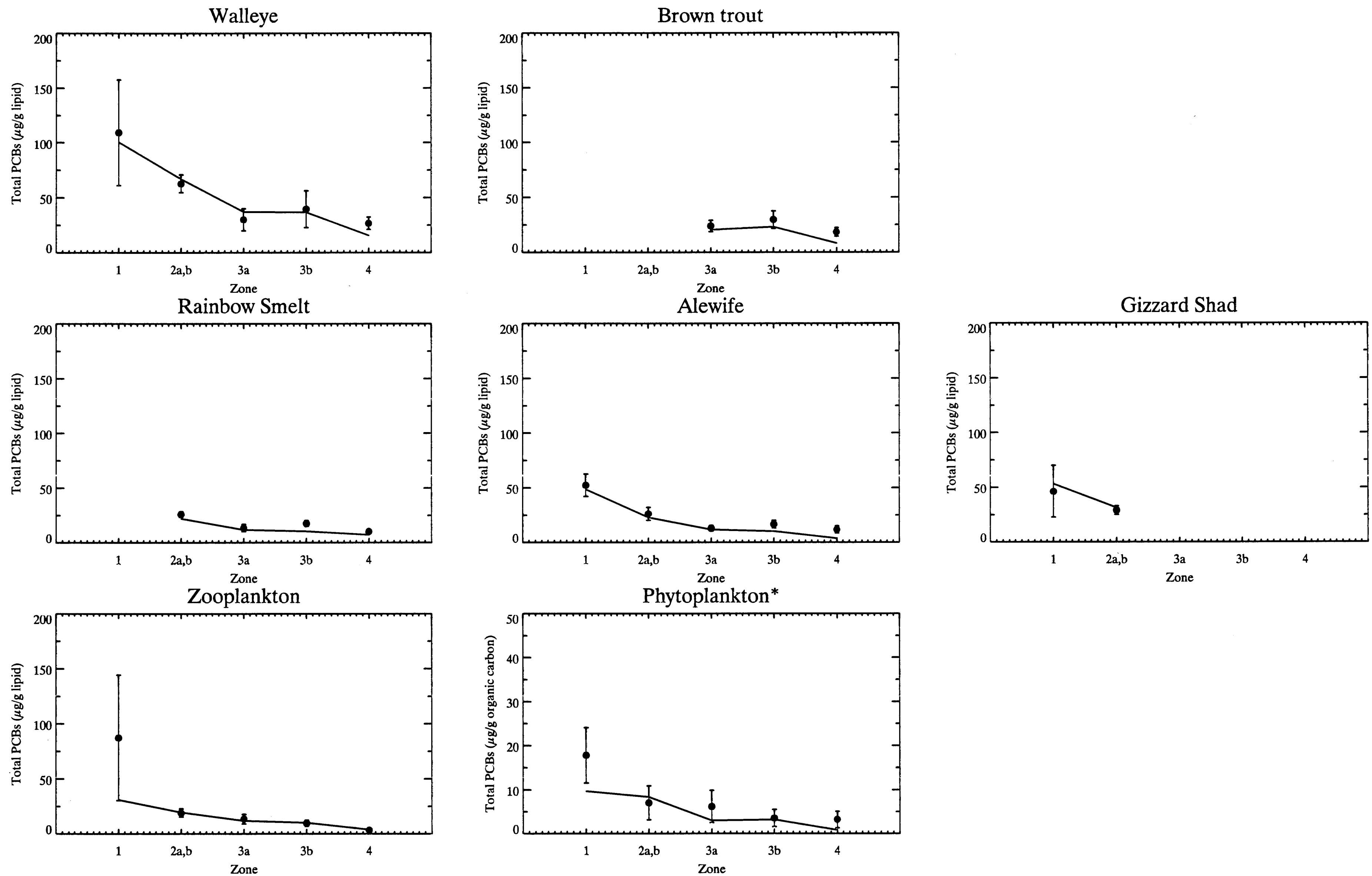
Fri May 11 12:15:57 2001



Averaging period for model and data in Zones 2,3, and 4: April 1 to November 30; Zone 1: June 1 to June 30. *Phytoplankton data; carbon-normalized water column particulate model exposures.
DATA: GBMBS data from QEA database compiled from FRDB received from Ecochem
Calibration Run #: Zones 1&2: 1989_rn47_z12; Zone 3a: 1989_rn29_z3a; Zone 3b: 1989_rn19_z3b; Zone 4: 1989_rn20_z4.

Figure 4-22. GBFood calibration results. Computed (line) and measured (symbols) total PCB concentrations in fish from the Lower Fox River and Green Bay. Fish are present in Zone 1 for 11 months +3 weeks each year. Overall averages, lipid basis.

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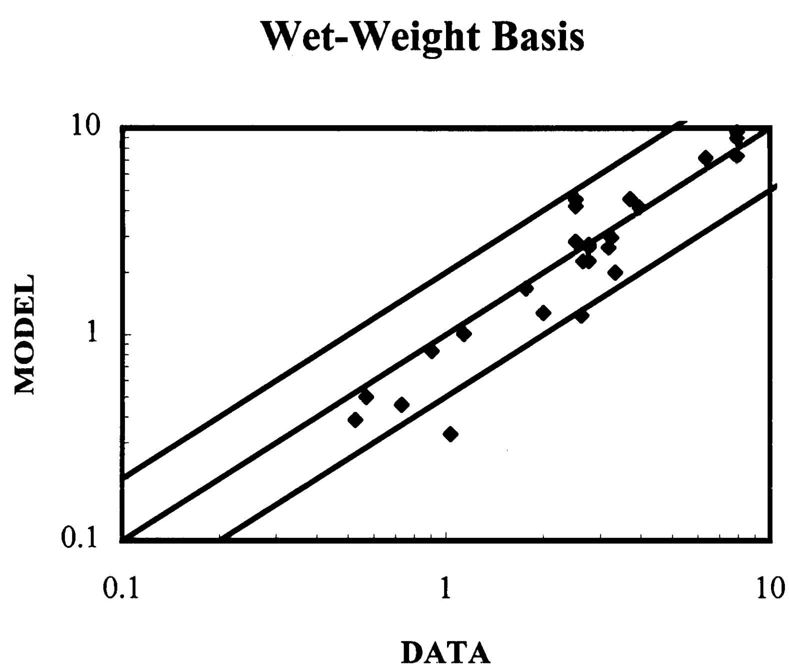

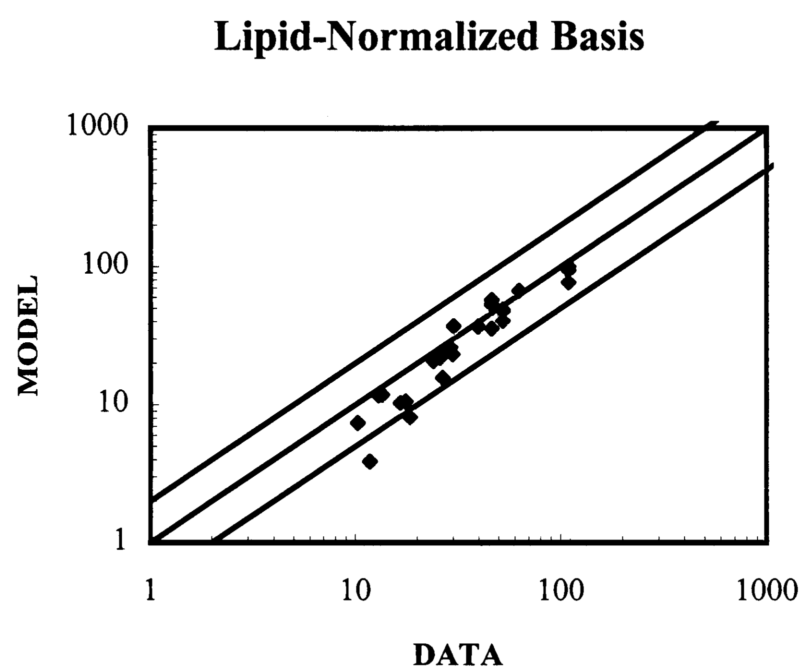

Figure 4-23. GBFood calibration results. Comparison of average computed and observed total PCB concentrations in fish from the Fox River and Green Bay. 1:1, 2:1, and 1:2 lines are provided for comparison. All species and all zones, including Zone 1 scenarios, are represented.

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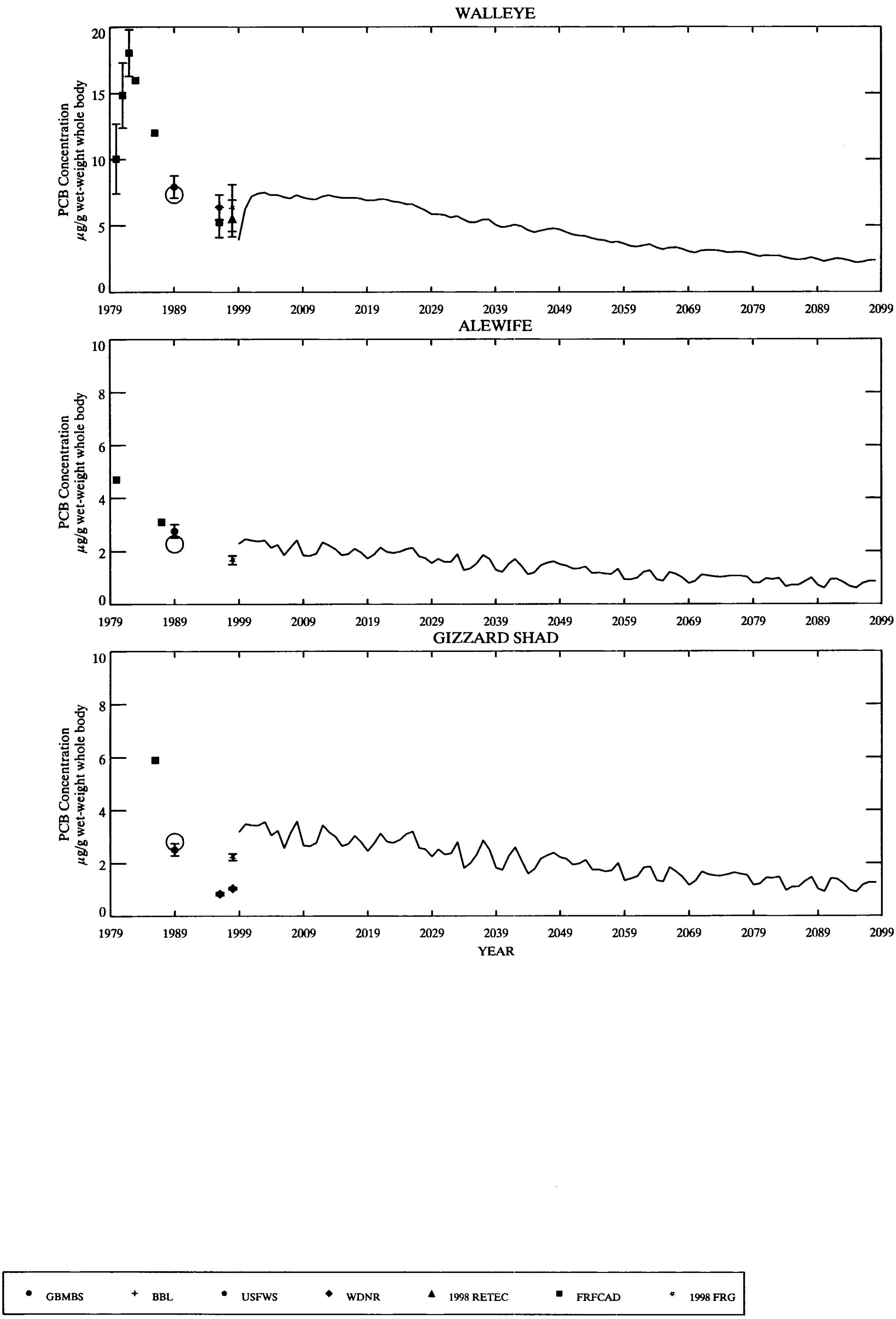
\\Beth\THEfox\model\con_exp_data\model_results.xls

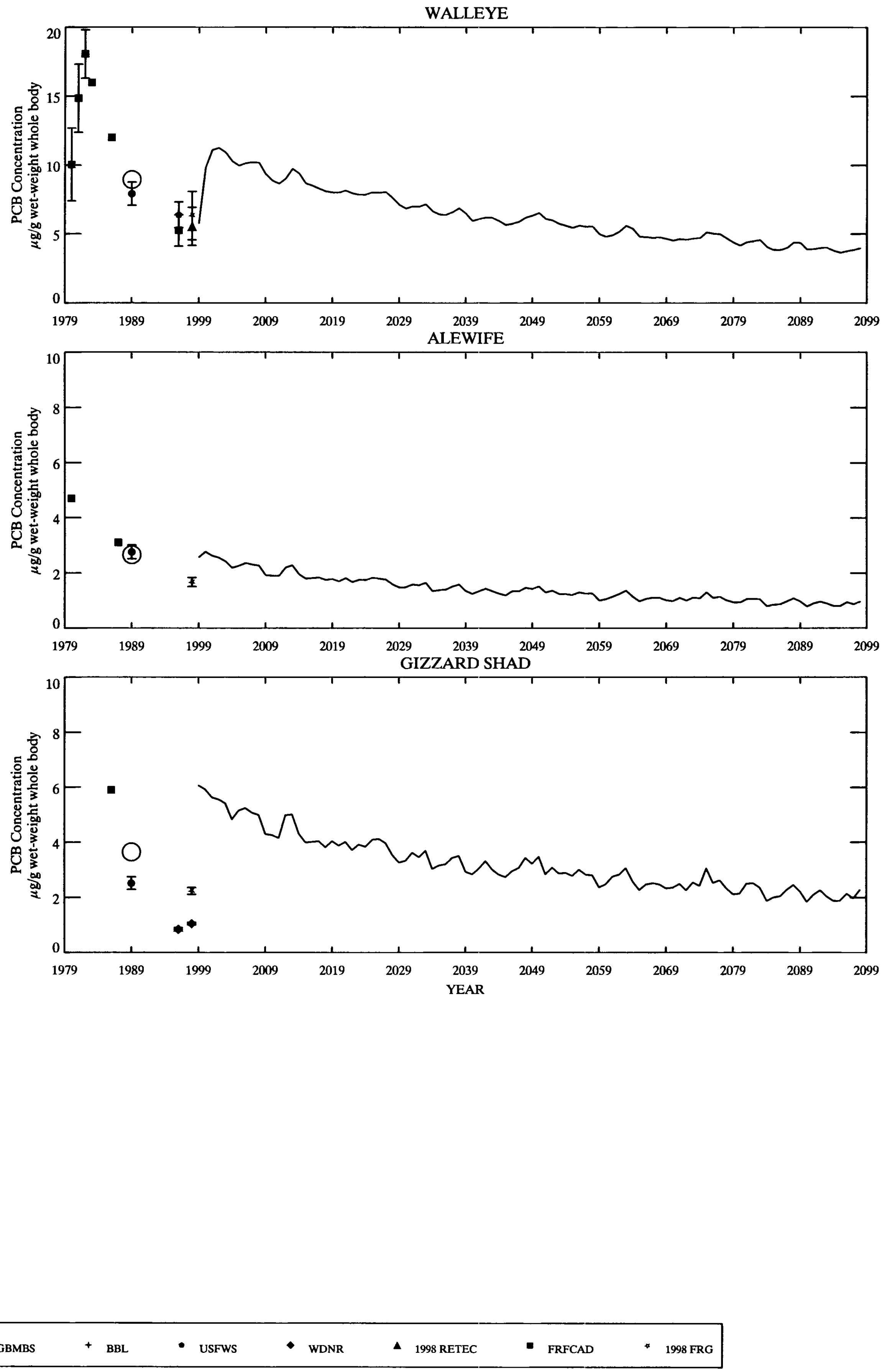


Whole fish data; annual averages (of dataset) +/-2 standard errors. Source: QEA database compiled from FRDB received from Ecochem
Calibration: 1989_rn34_z12 (open circle). Projection: frNOACz1_gbNOAC-frNOACz2_rn34_z12 (line): Annual averages.

Figure 5-1. GBFood projection results. Average computed and observed total PCB concentrations fish present in Zone 1 for one month each year based on Fox River: No Action; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_calproj_wet_ann_avg.pro

Fri May 11 17:19:55 2001



Whole fish data; annual averages (of dataset) +/-2 standard errors. Source: QEA database compiled from FRDB received from Ecochem
Calibration: 1989_rn48_z12 (open circle). Projection: frNOACz1_gbNOAC-frNOACz2_rn48_z1sum (line): Annual averages.

Figure 5-2. GBFood projection results. Average computed and observed total PCB concentrations fish present in Zone 1 from May through October each year based on Fox River: No Action; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_calproj_wet_ann_avg_sum_res.pro
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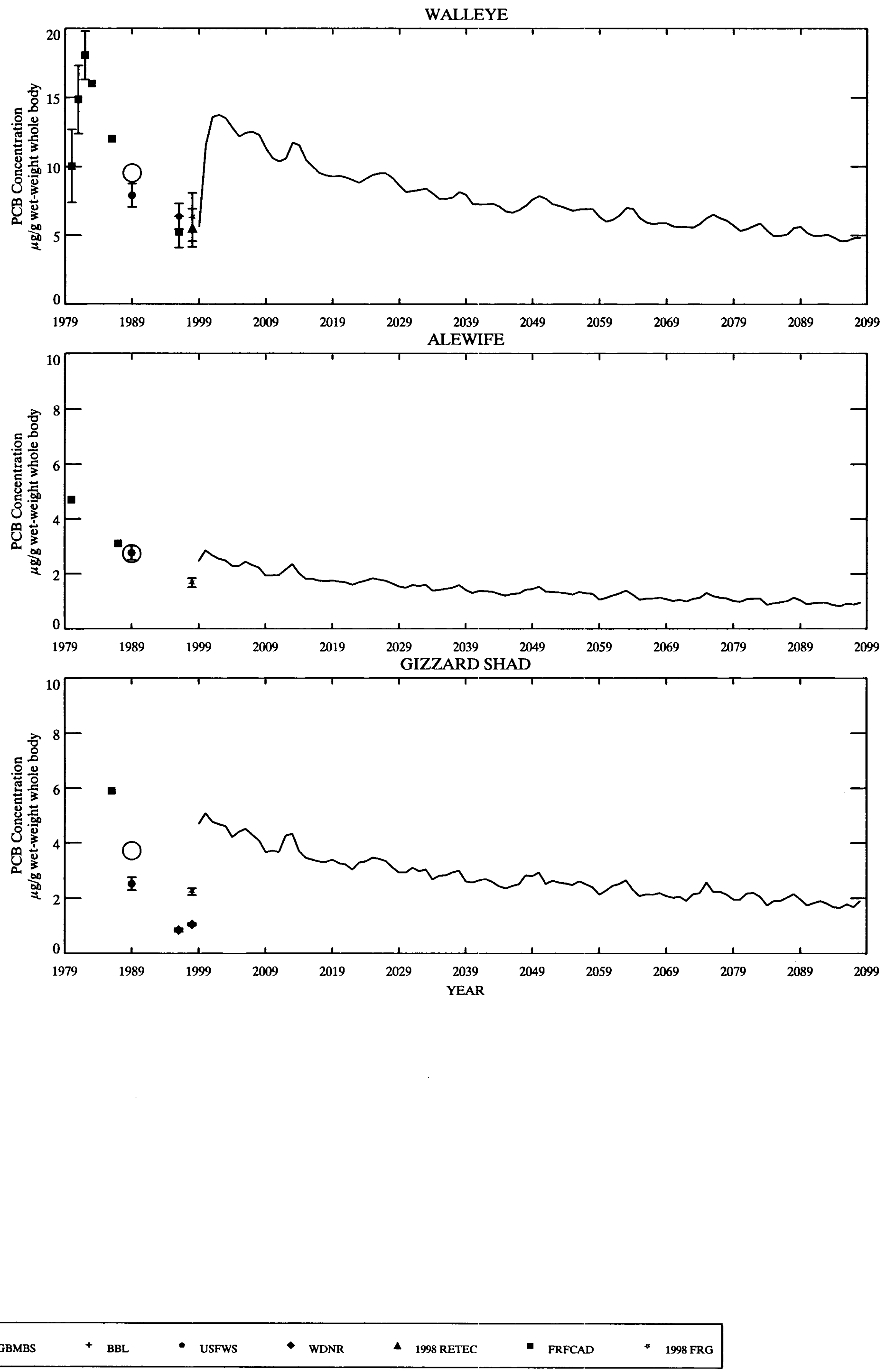
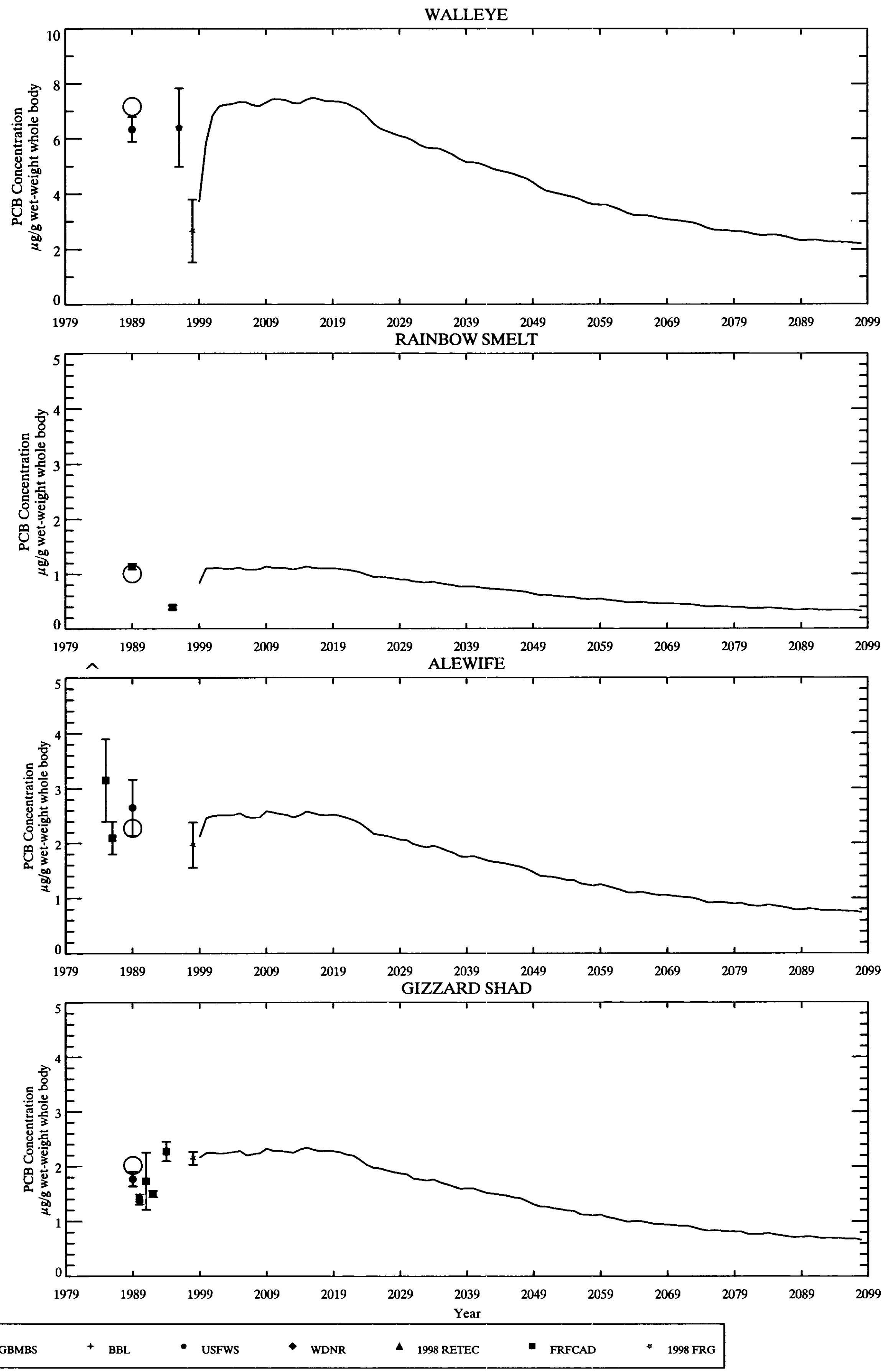


Whole fish data; annual averages (of dataset) +/-2 standard errors. Source: QEA database compiled from FRDB received from Ecochem
Calibration: 1989_rn47_z12 (open circle). Projection: frNOACz1_gbNOAC-frNOACz2_rn47_z1res (line): Annual averages.

Figure 5-3. GBFood projection results. Average computed and observed total PCB concentrations fish present in Zone 1 for 11 months +3 weeks each year based on Fox River: No Action; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_calproj_wet_ann_avg_res.pro

Fri May 11 17:31:26 2001

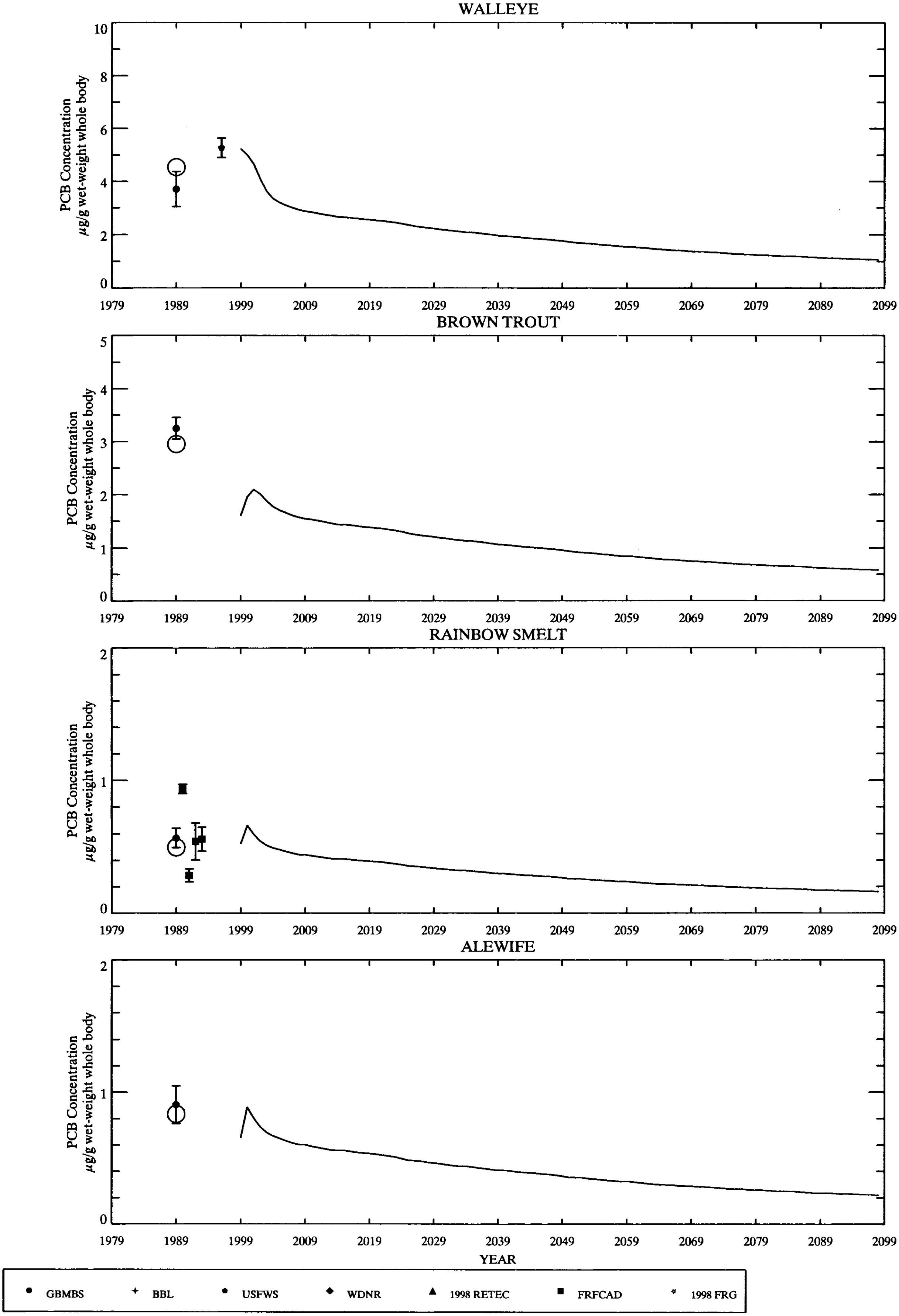


Whole fish data; annual averages (of dataset) +/-2 standard errors. Source: QEA database compiled from FRDB received from Ecochem
Calibration: 1989_rn34_z12 (open circle). Projection: frNOACz1_gbNOAC-frNOACz2_rn34_z12 (line). Projections are annual averages.

Figure 5-4. GBFood projection results. Average computed and observed total PCB concentrations in fish resident in Zone 2 based on Fox River: No Action; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_calproj_wet_ann_avg.pro

Mon May 14 12:19:15 2001



Whole fish data; annual averages (of dataset) +/-2 standard errors. Source: QEA database compiled from FRDB received from Ecochem
Calibration: 1989_rn29_z3a (open circle). Projection: gbNOAC-frNOAC_0-5_0-10_rn29_z3a (line). Projections are annual averages.

Figure 5-5. GBFood projection results. Average computed and observed total PCB concentrations in fish from Zone 3A based on Fox River: No Action; Green Bay: No Action.

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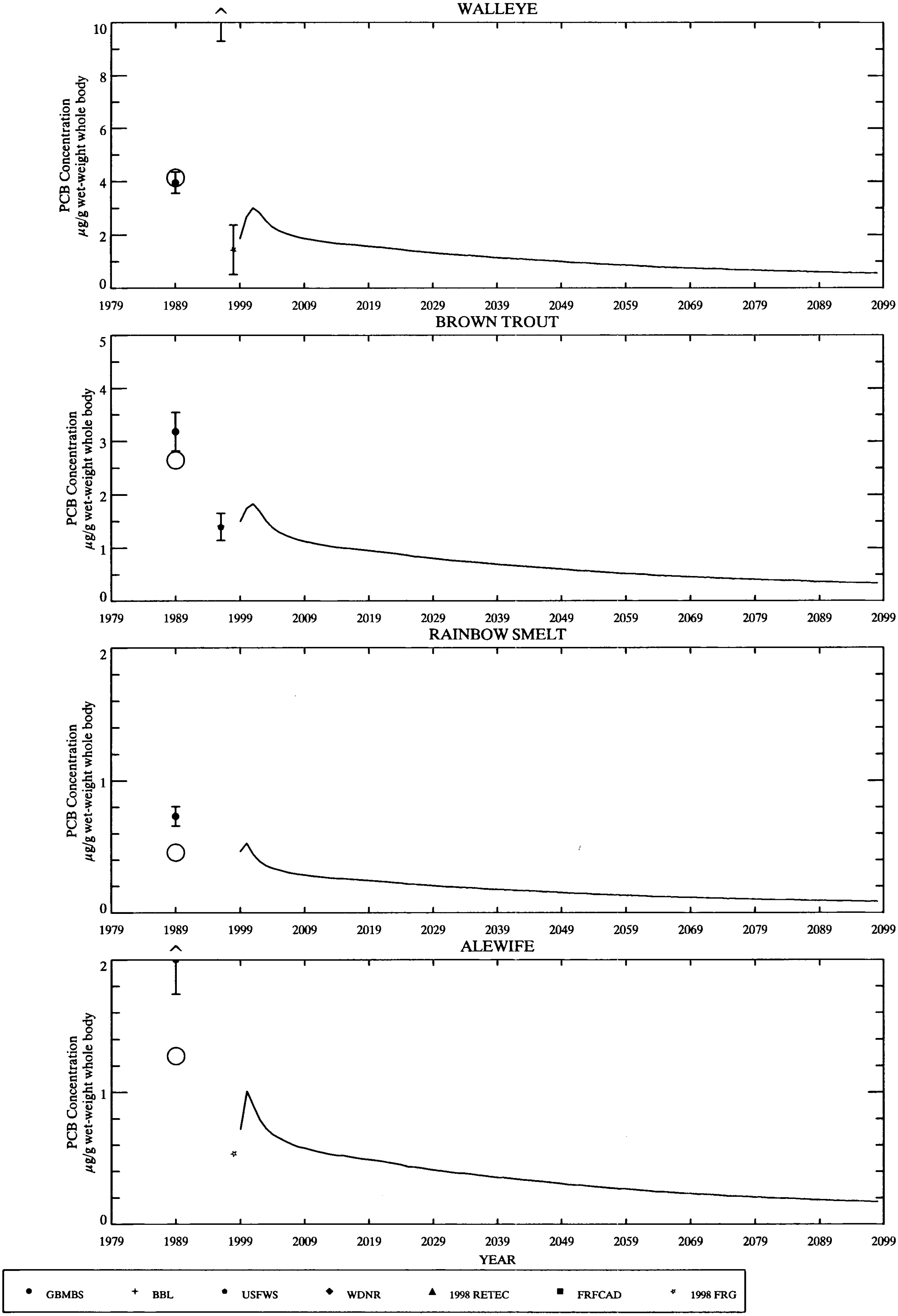
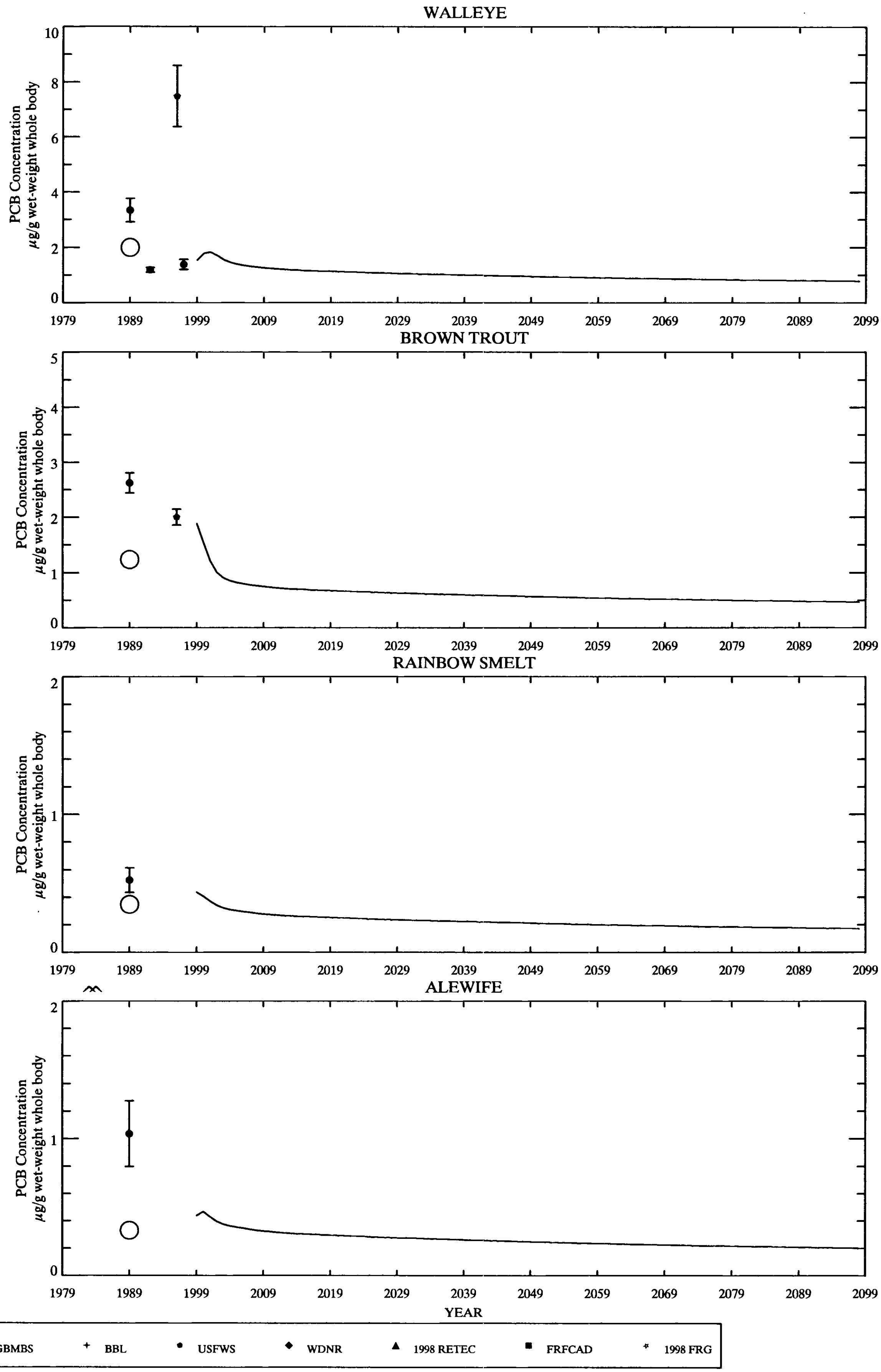


Whole fish data; annual averages (of dataset) +/-2 standard errors. Source: QEA database compiled from FRDB received from Ecochem
Calibration: 1989_rn19_z3b (open circle). Projection: gbNOAC-frNOAC_0-5_0-10_rn19_z3b (line). Projections are annual averages.

Figure 5-6. GBFood projection results. Average computed and observed total PCB concentrations in fish from Zone 3B based on Fox River: No Action; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\Z3b_calproj_wet_ann_avg.pro
Mon May 14 13:06:53 2001



Whole fish data; annual averages (of dataset) +/-2 standard errors. Source: QEA database compiled from FRDB received from Ecochem
Calibration: 1989_rn20_z4 (open circle). Projection: gbNOAC-frNOAC_0-5_0-10_rn20_z4 (line). Projections are annual averages.

Figure 5-7. GBFood projection results. Average computed and observed total PCB concentrations in fish from Zone 4 based on Fox River: No Action; Green Bay: No Action.

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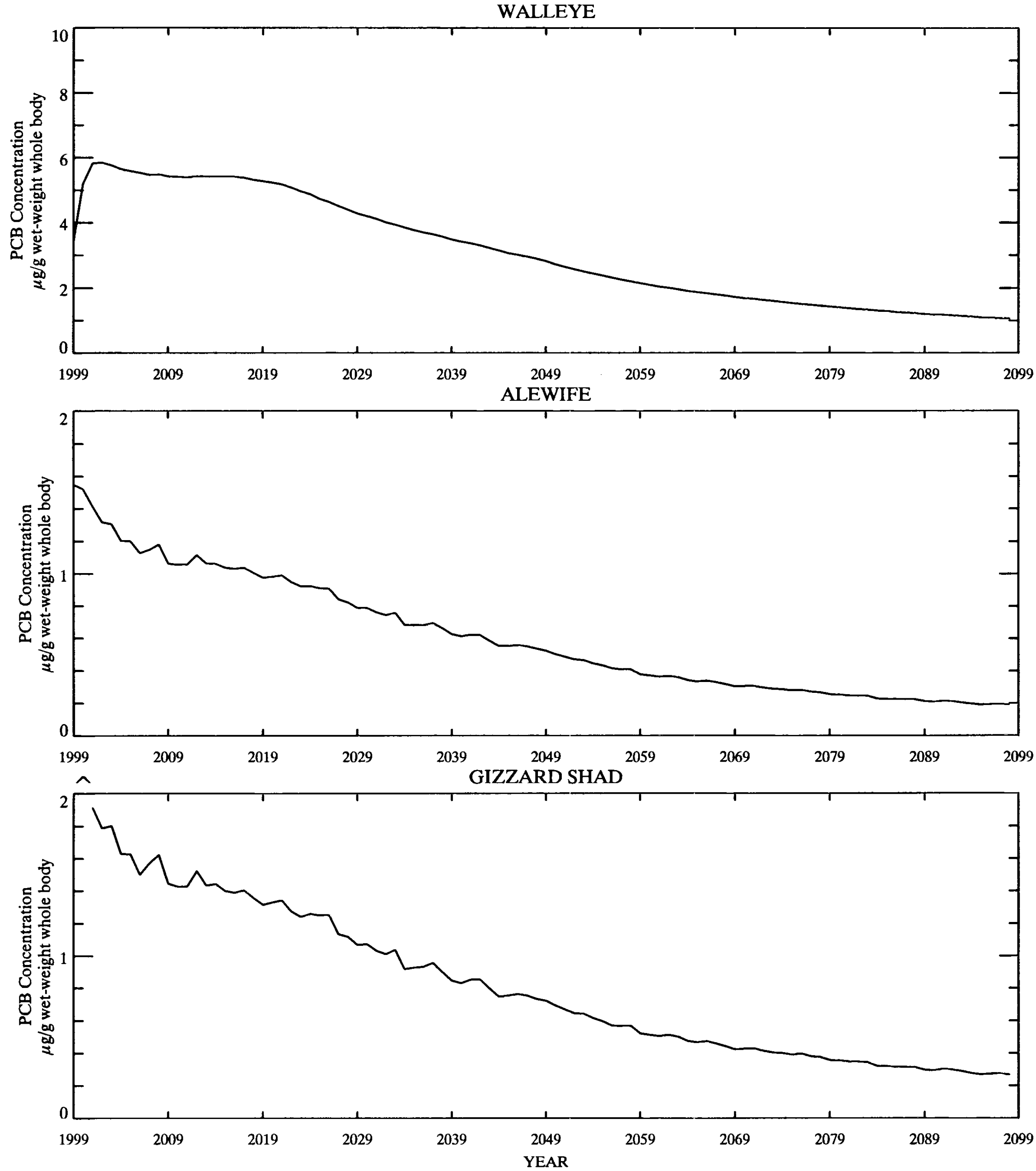
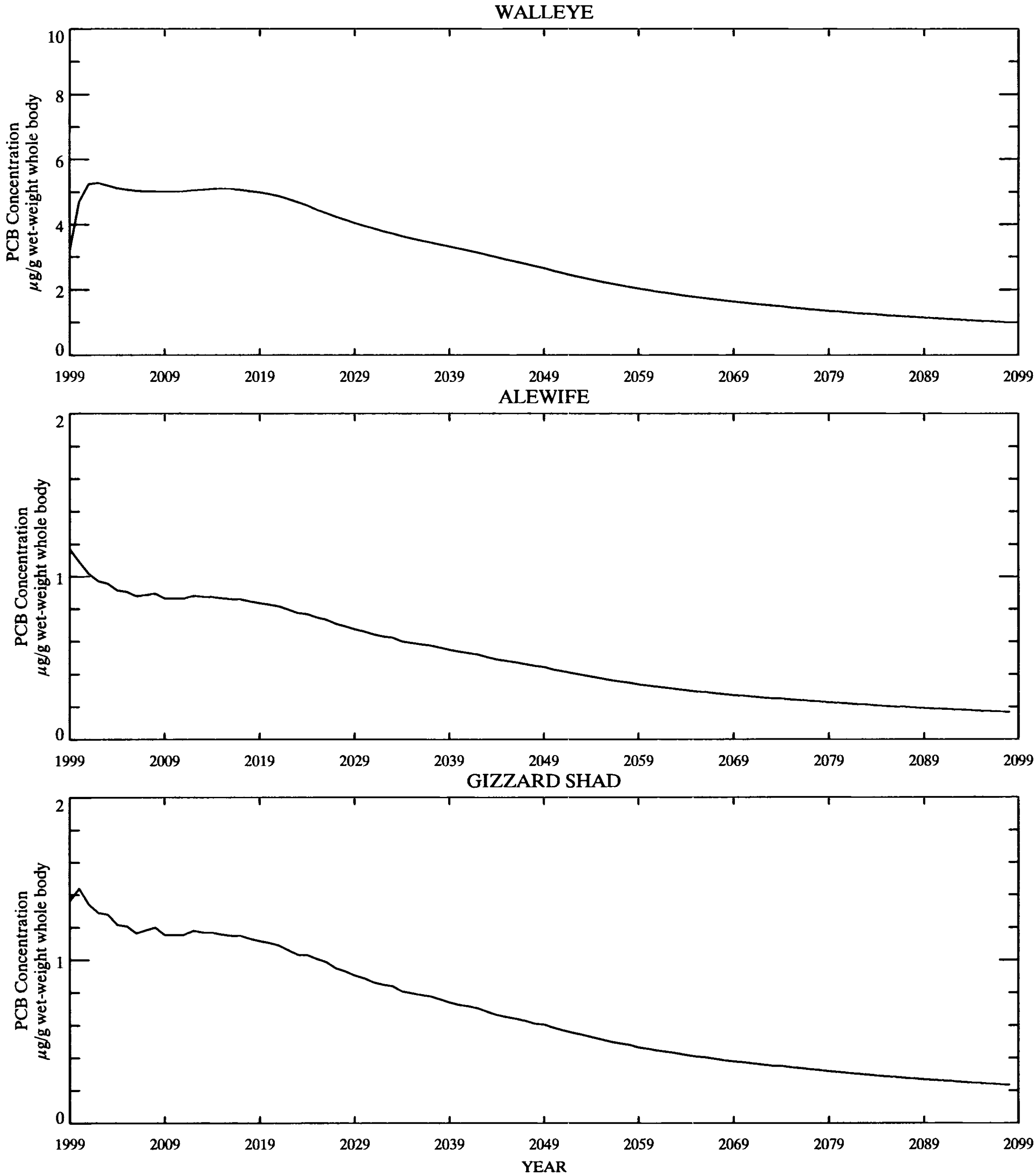


Projection: 5000z1_gbNOAC-fr5000z2_rn34_z12: Annual averages.

Figure 5-8. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: remediate >5000 ppb; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg.pro

Mon May 14 13:26:47 2001

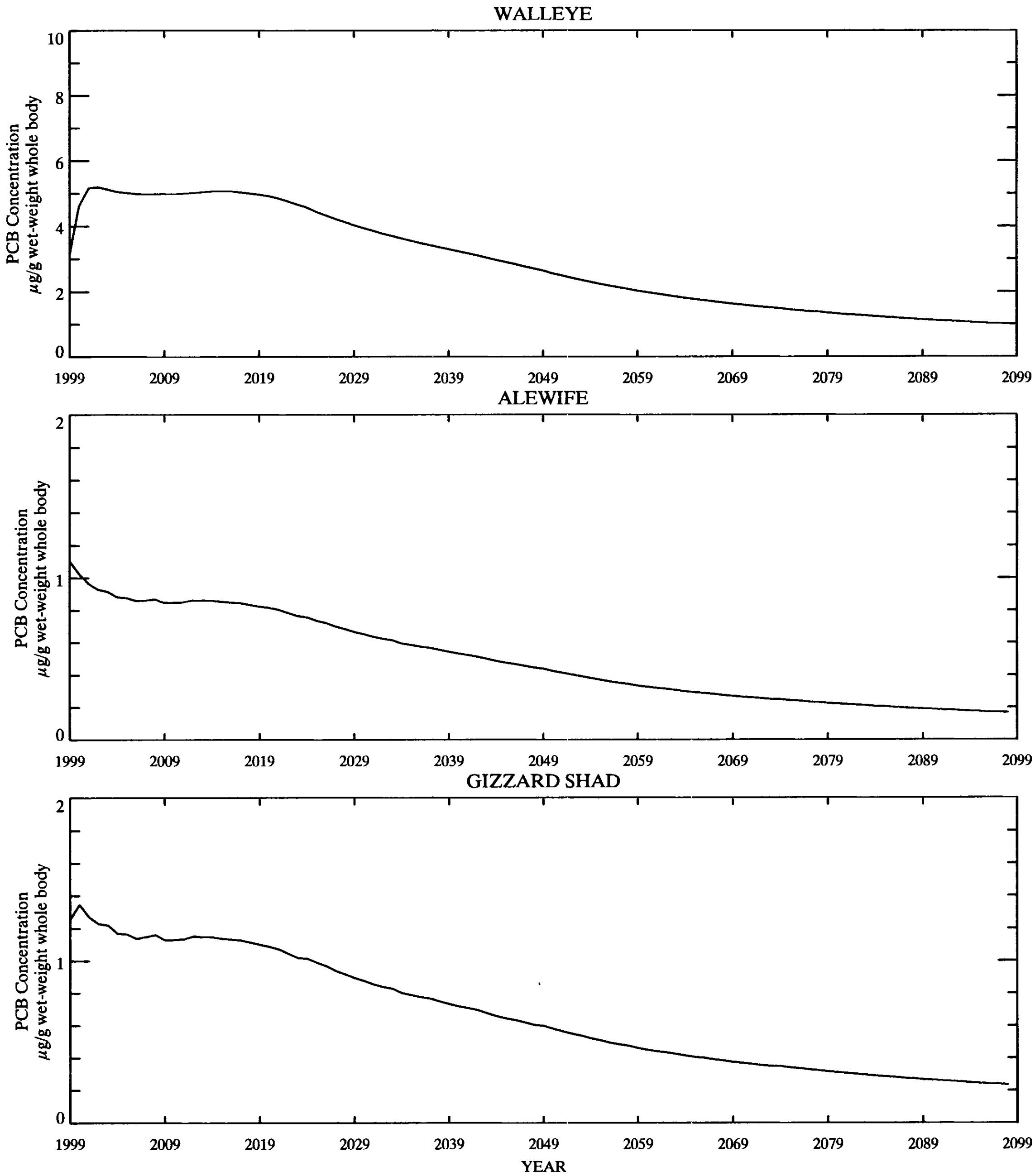


Projection: 1000z1_gbNOAC-fr1000z2_rn34_z12: Annual averages.

Figure 5-9. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: remediate >1000 ppb; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg.pro

Mon May 14 13:28:31 2001

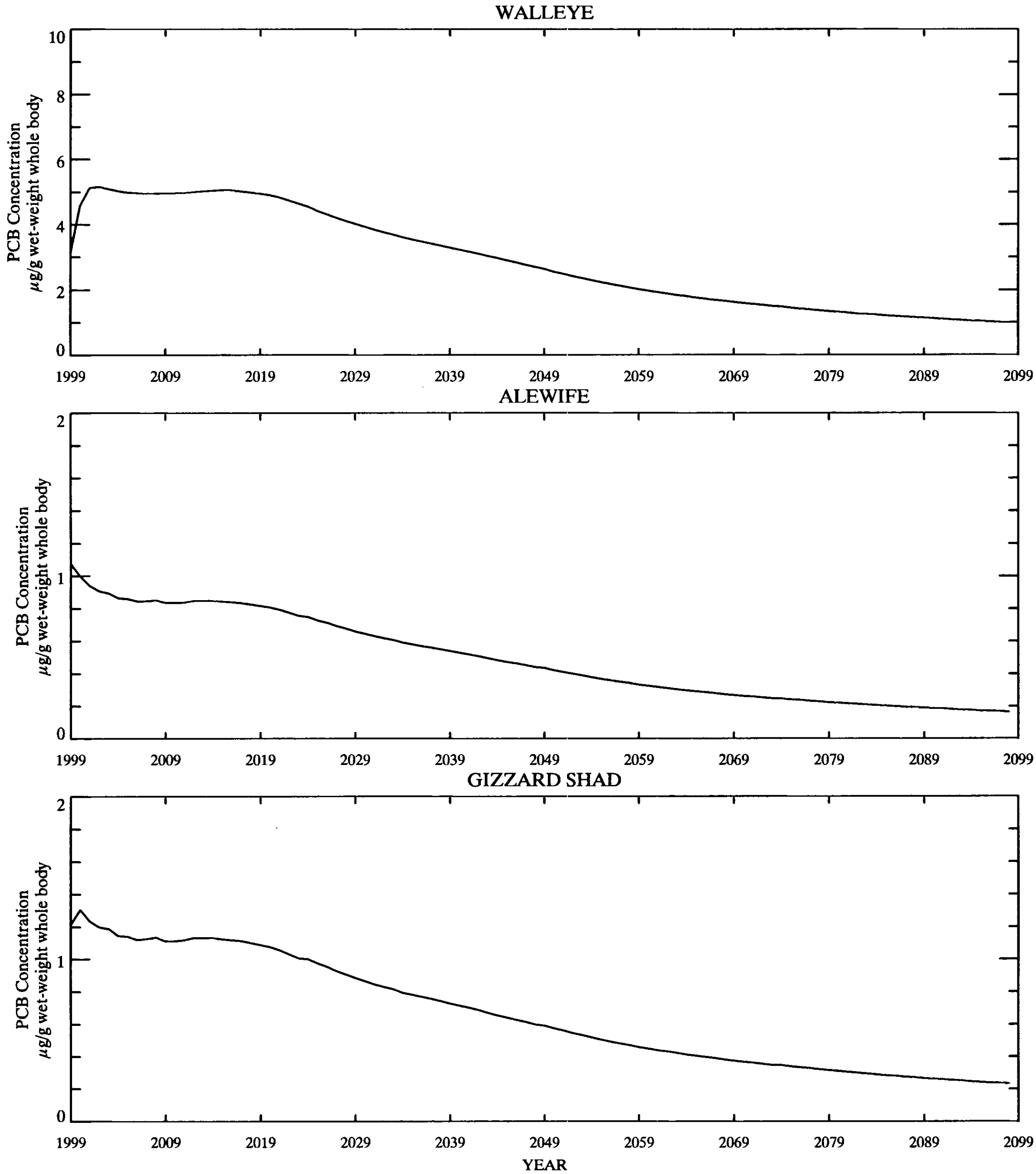


Projection: 0500z1_gbNOAC-fr0500z2_rn34_z12: Annual averages.

Figure 5-10. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: remediate >500 ppb; Green Bay: No Action..

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg.pro

Mon May 14 13:30:17 2001



Projection: 0250z1_gbNOAC-fr0250z2_rn34_z12: Annual averages.

Figure 5-11. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: remediate >250 ppb; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg.pro
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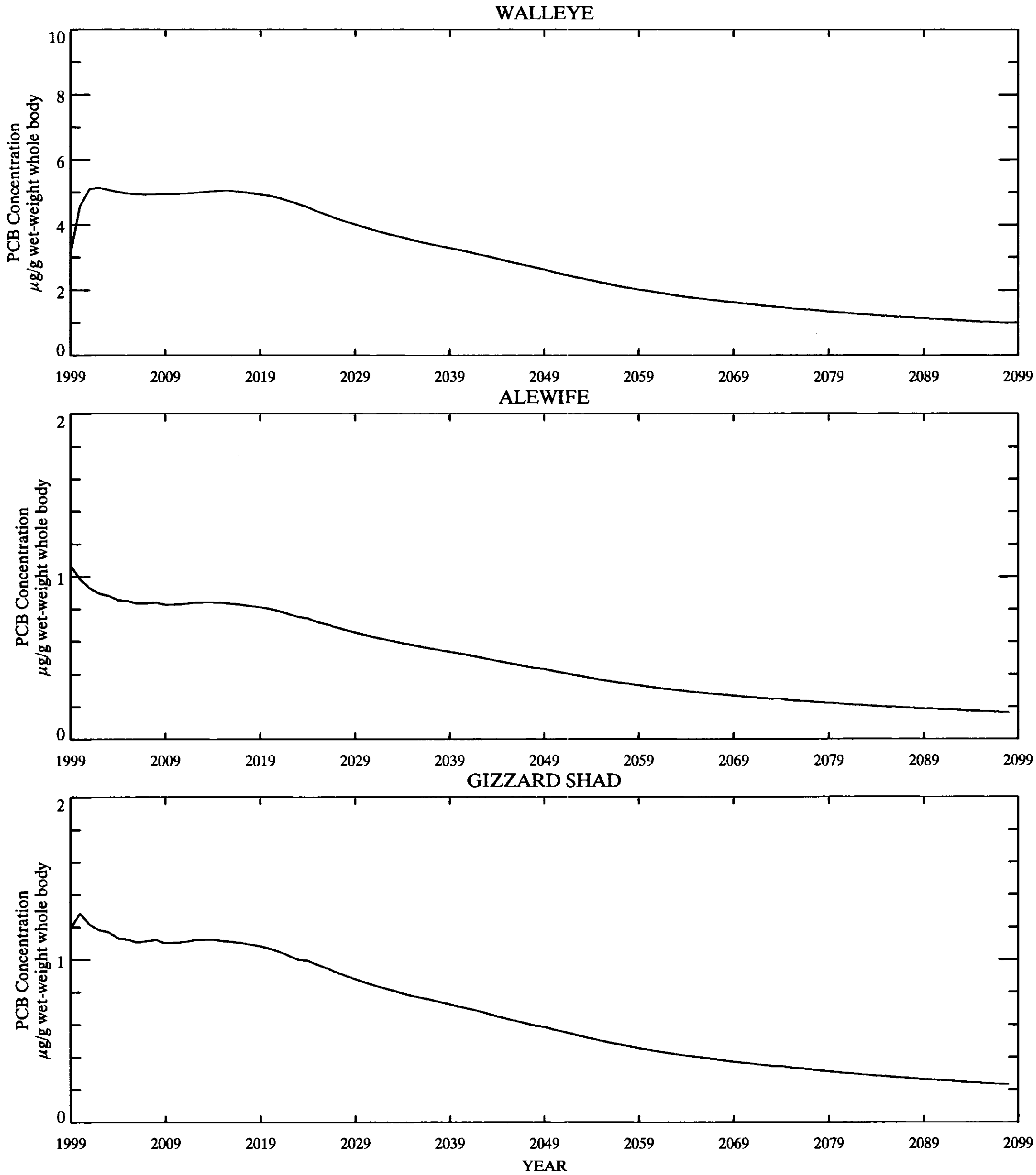
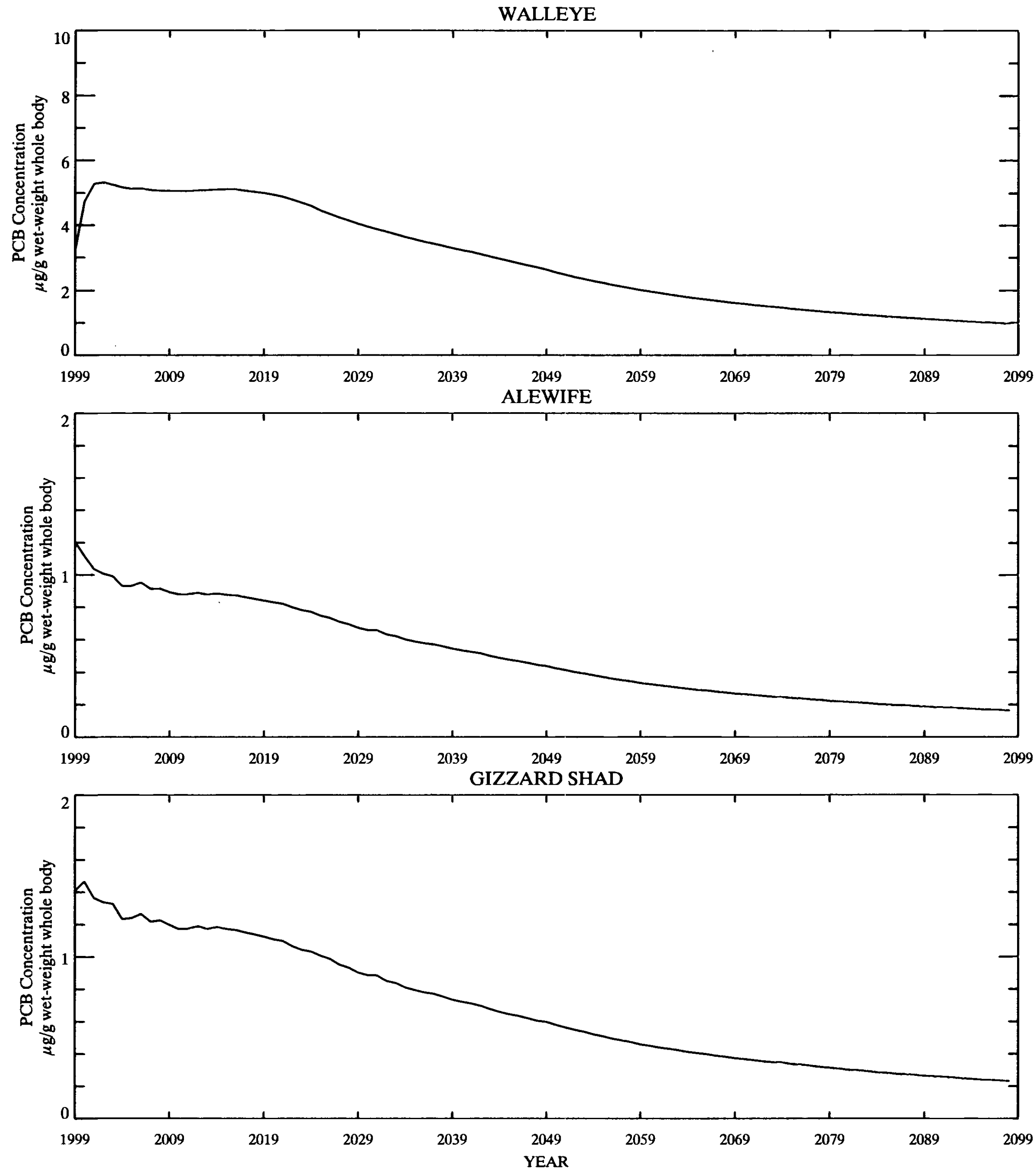


Projection: 0125z1_gbNOAC-fr0125z2_rn34_z12: Annual averages.

Figure 5-12. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: remediate >125 ppb; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg.pro

Mon May 14 13:33:38 2001



Projection: 000Hz1_gbNOAC-fr000Hz2_rn34_z12: Annual averages.

Figure 5-13. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: Schedule "H"; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg.pro

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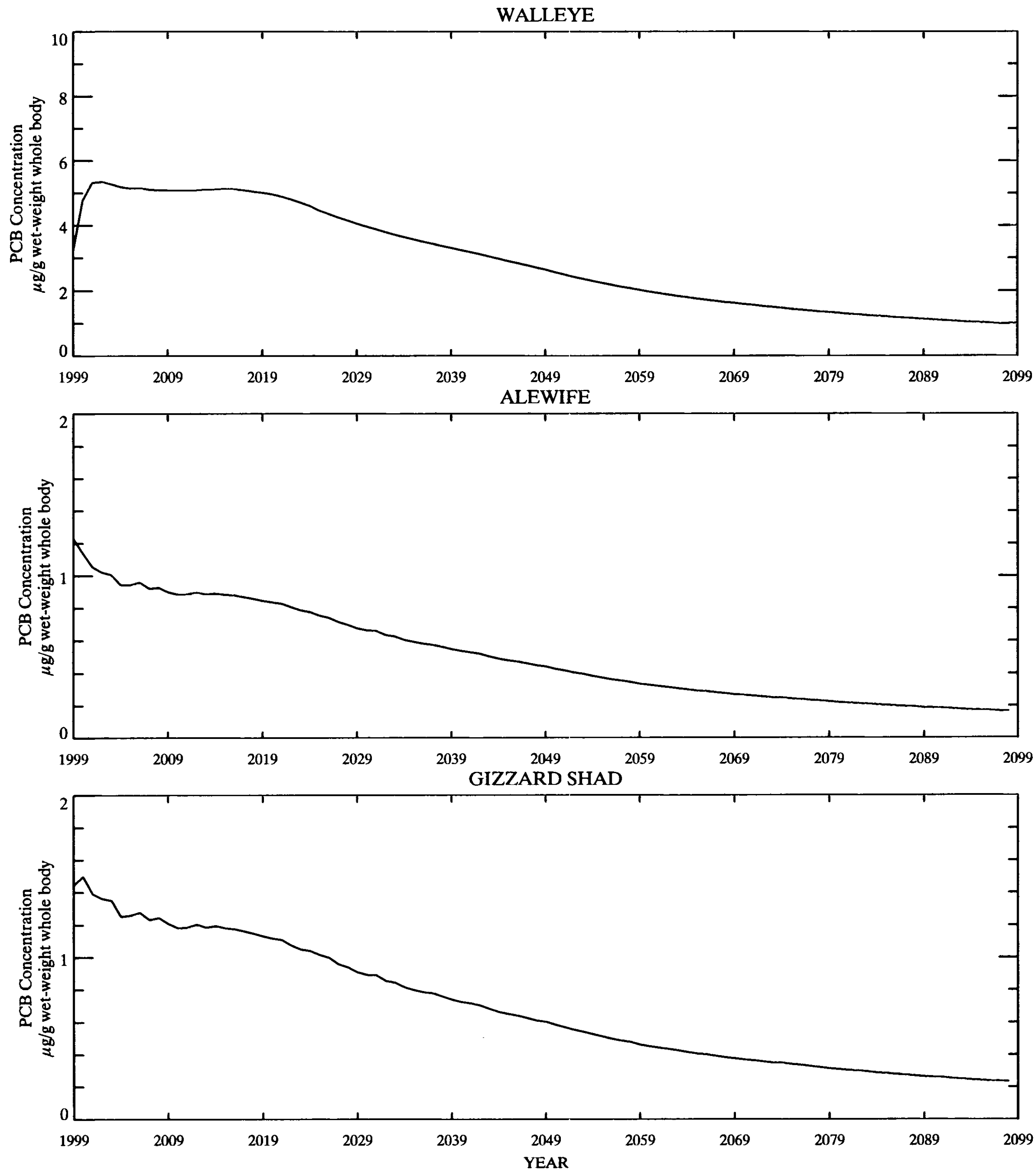

Projection: 000Iz1_gbNOAC-fr000Iz2_rn34_z12: Annual averages.

Figure 5-14. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: Schedule "I"; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg.pro
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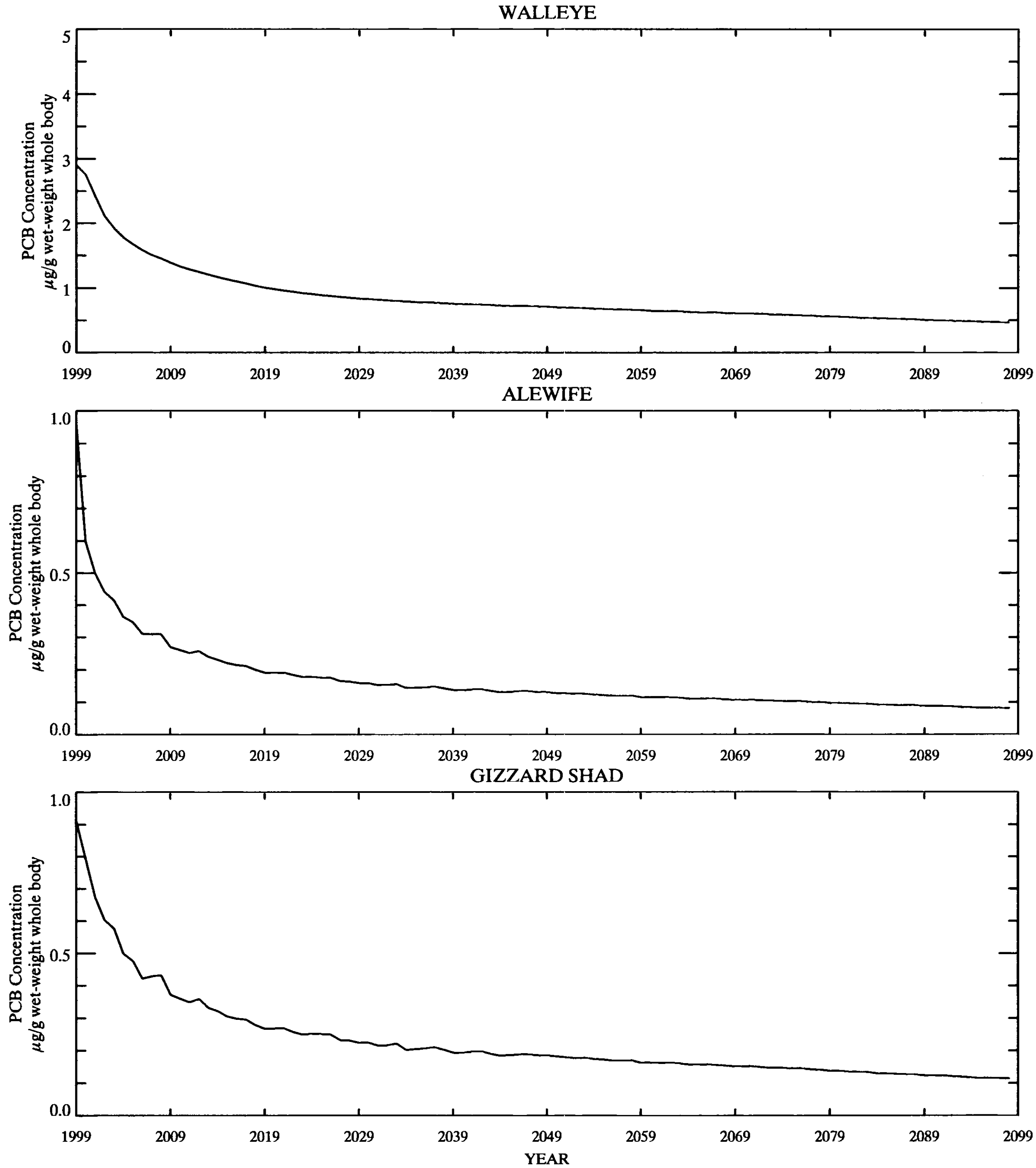

Projection: 1000z1_gb1000-fr1000z2_rn34_z12: Annual averages.

Figure 5-15. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: remediate >1000 ppb; Green Bay: remediate >1000 ppb.

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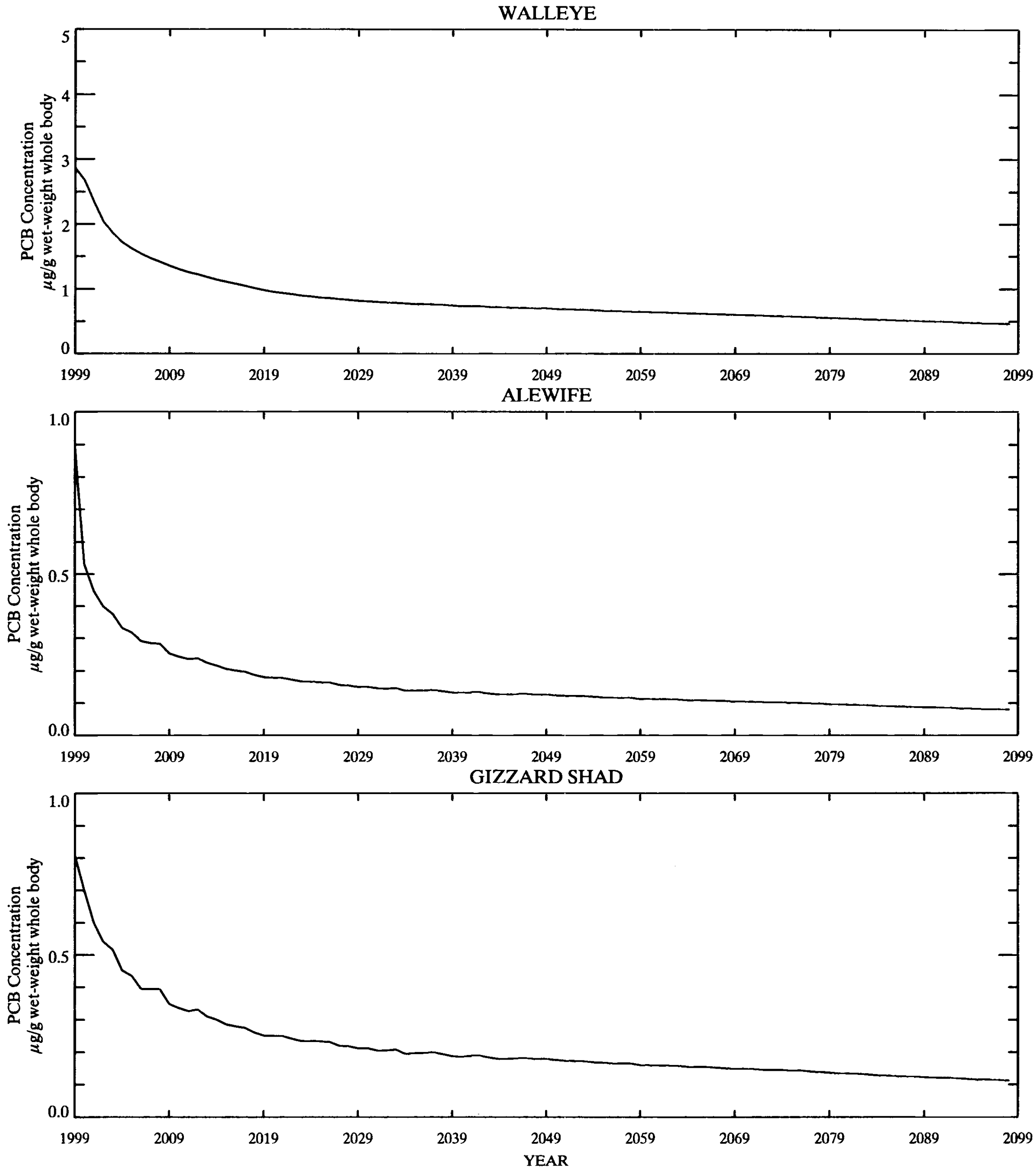

Projection: 0500z1_gb1000-fr0500z2_rn34_z12: Annual averages.

Figure 5-16. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: remediate >500 ppb; Green Bay: remediate >1000 ppb.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg.pro

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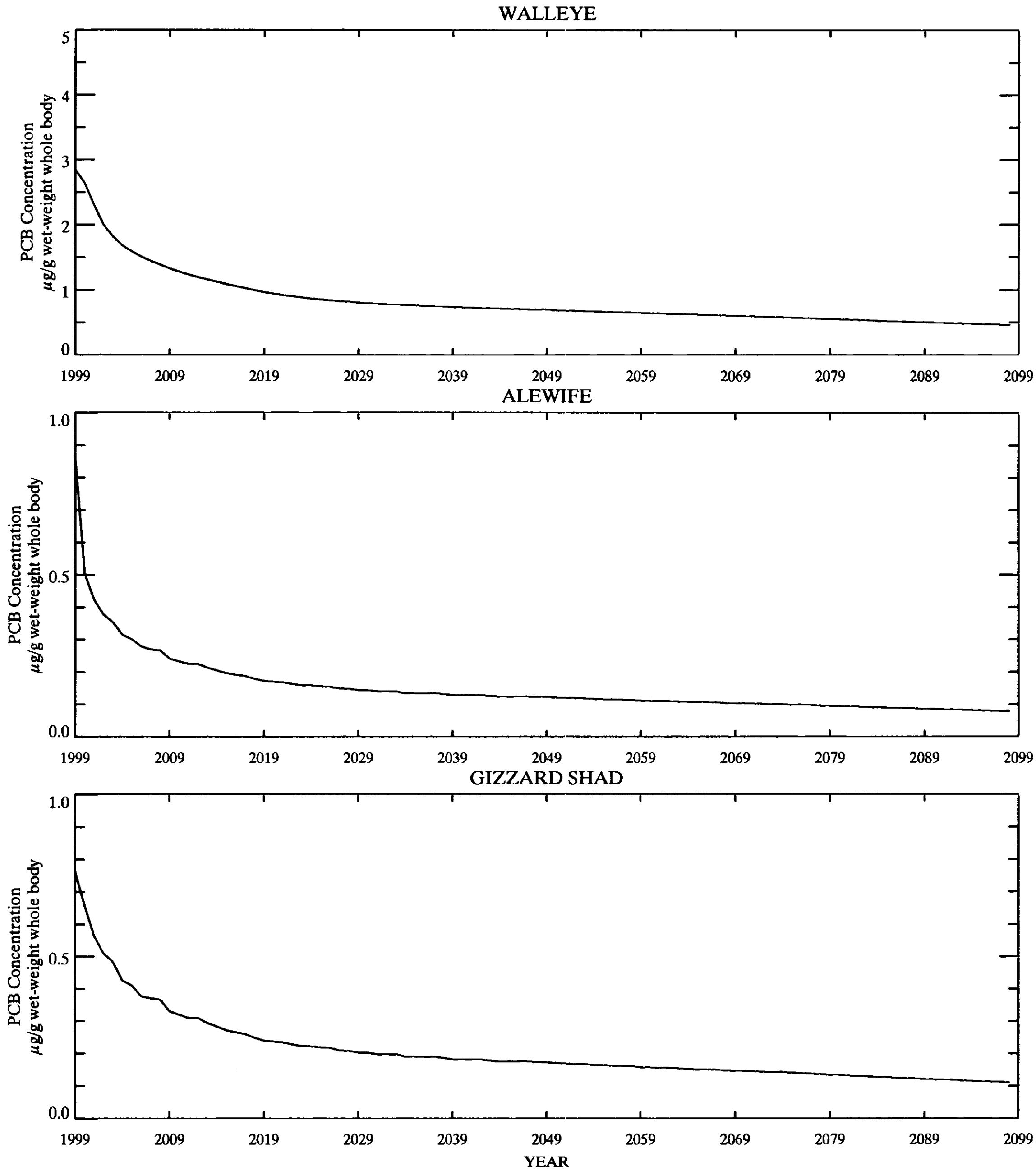

Projection: 0250z1_gb1000-fr0250z2_rn34_z12: Annual averages.

Figure 5-17. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: remediate >250 ppb; Green Bay: remediate >1000 ppb.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg.pro

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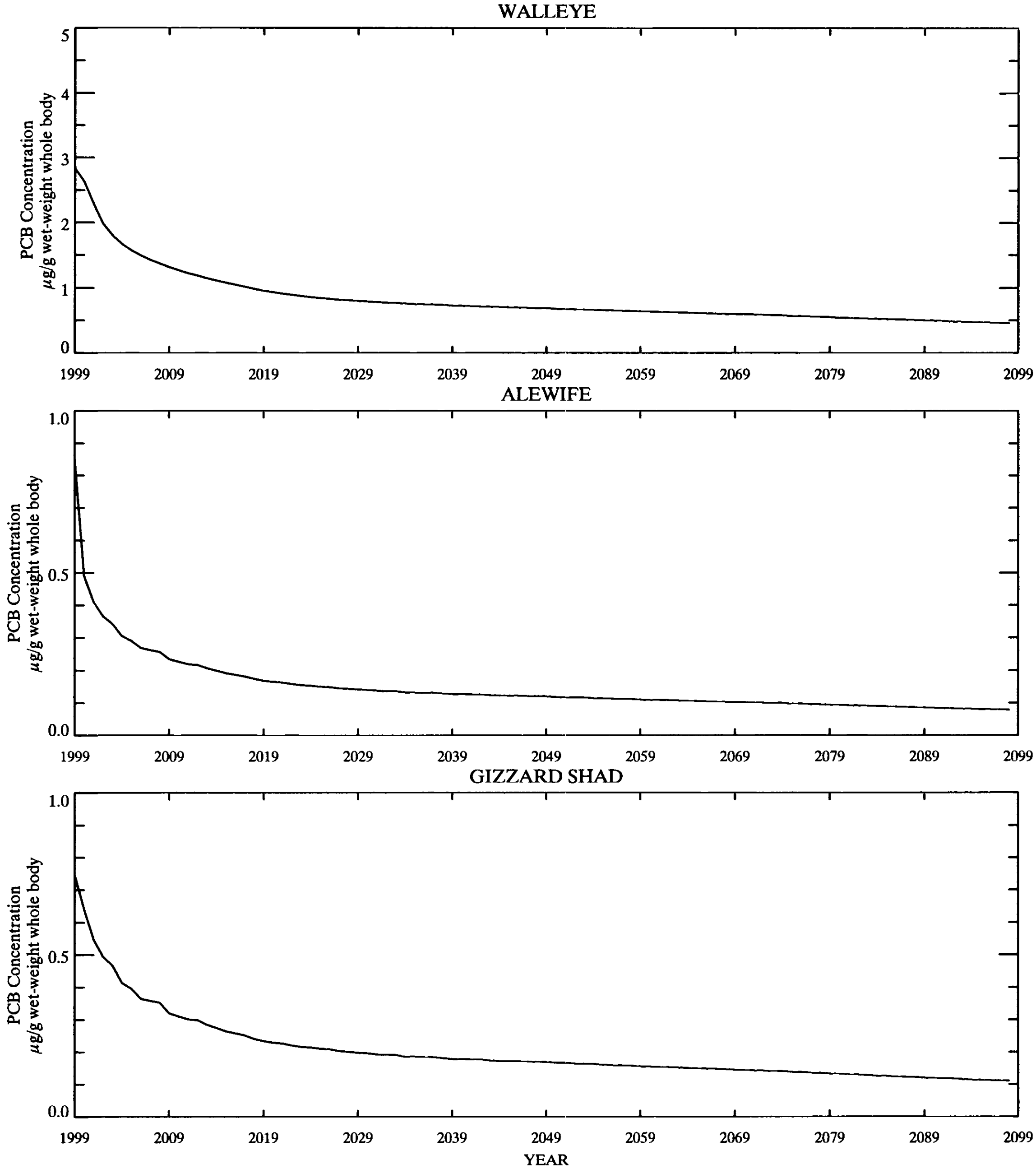

Projection: 0125z1_gb1000-fr0125z2_rn34_z12: Annual averages.

Figure 5-18. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: remediate >125 ppb; Green Bay: remediate >1000 ppb.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg.pro
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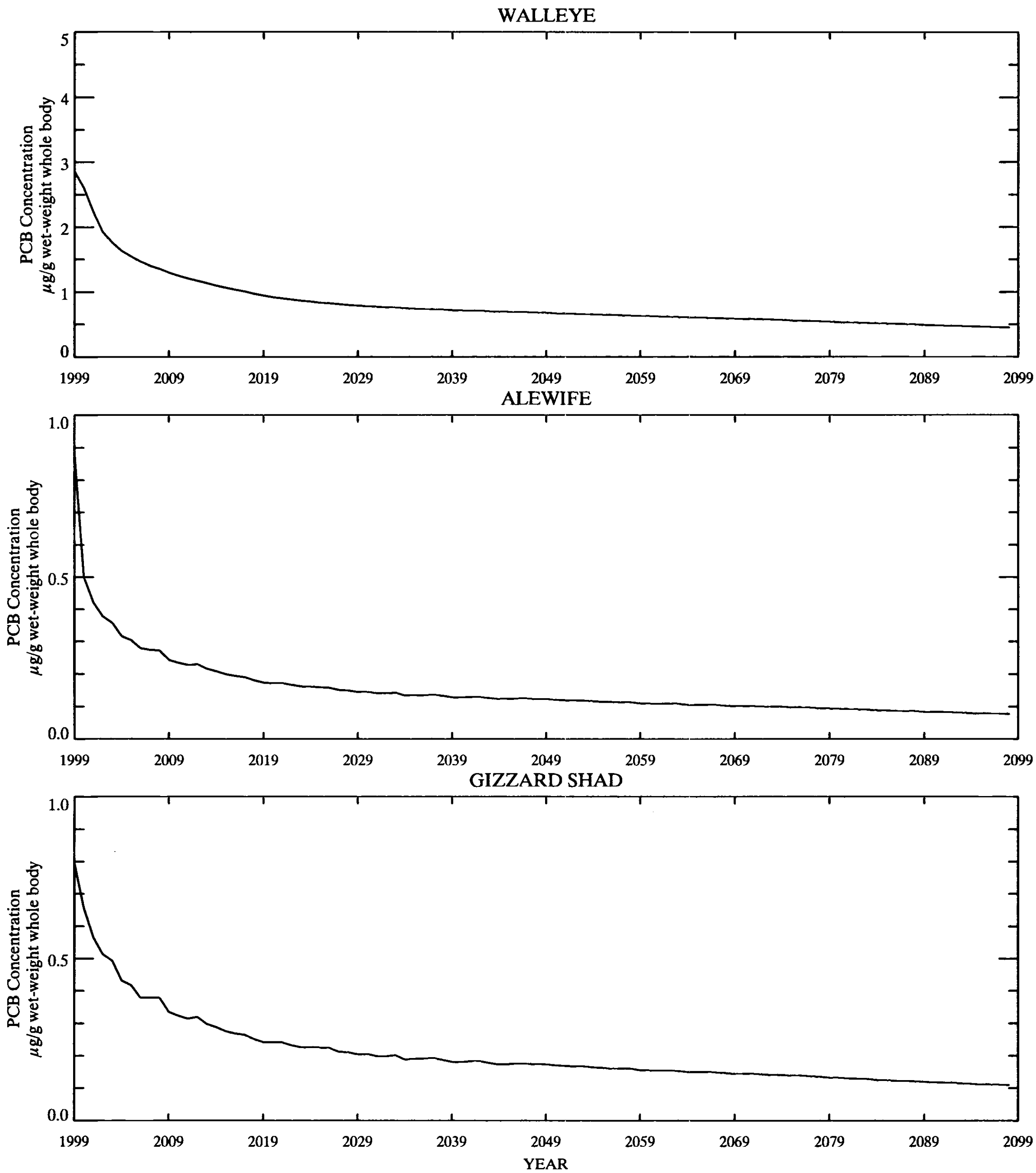

Projection: 0500z1_gb0500-fr0500z2_rn34_z12: Annual averages.

Figure 5-19. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: remediate >500 ppb; Green Bay: remediate >500 ppb.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg.pro

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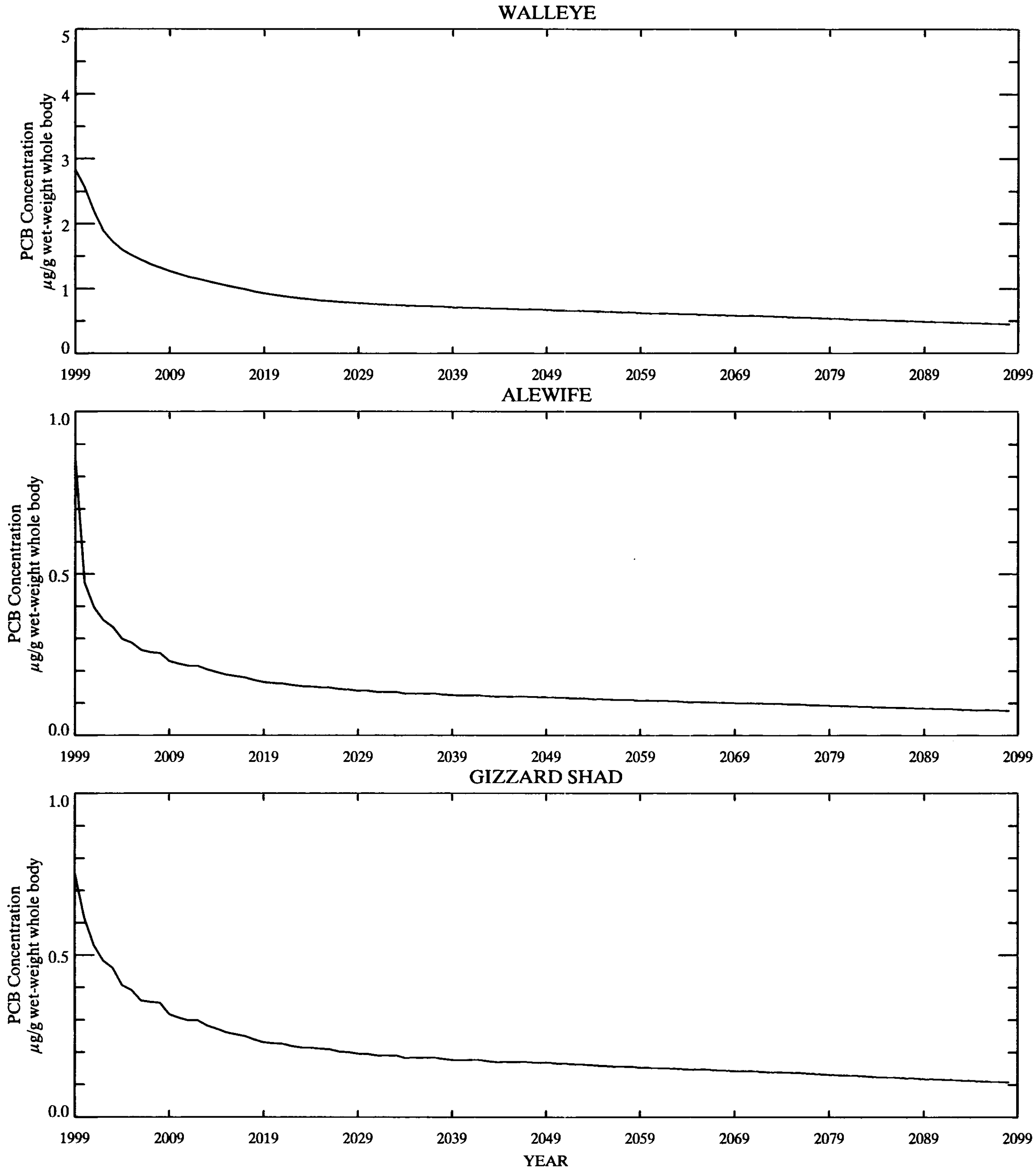
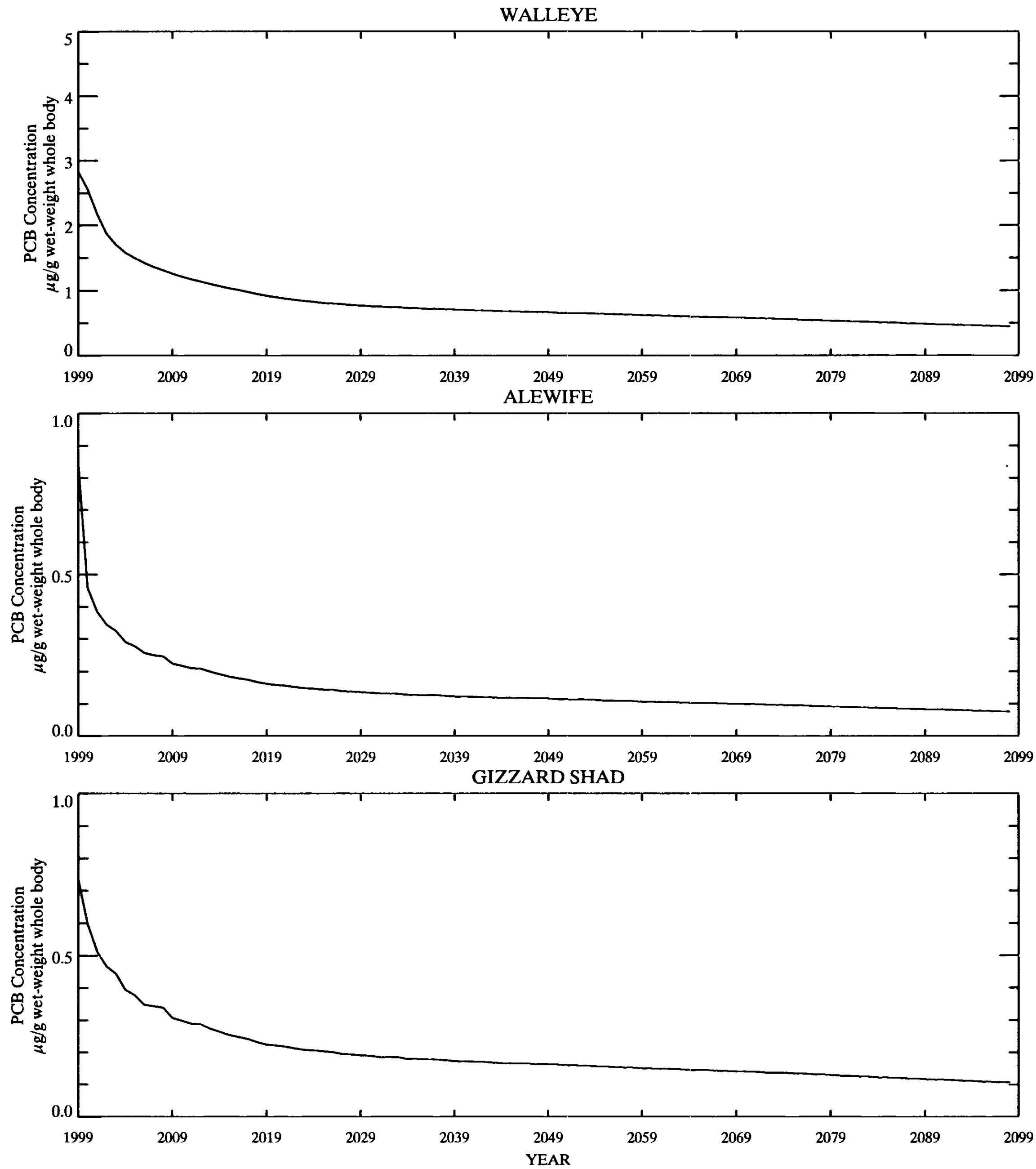


Projection: 0250z1_gb0500-fr0250z2_rn34_z12: Annual averages.

Figure 5-20. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: remediate >250 ppb; Green Bay: remediate >500 ppb

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg.pro

Mon May 14 13:57:12 2001



Projection: 0125z1_gb0500-fr0125z2_rn34_z12: Annual averages.

Figure 5-21. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for one month each year based on Fox River: remediate >125 ppb; Green Bay: remediate >500 ppb.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg.pro

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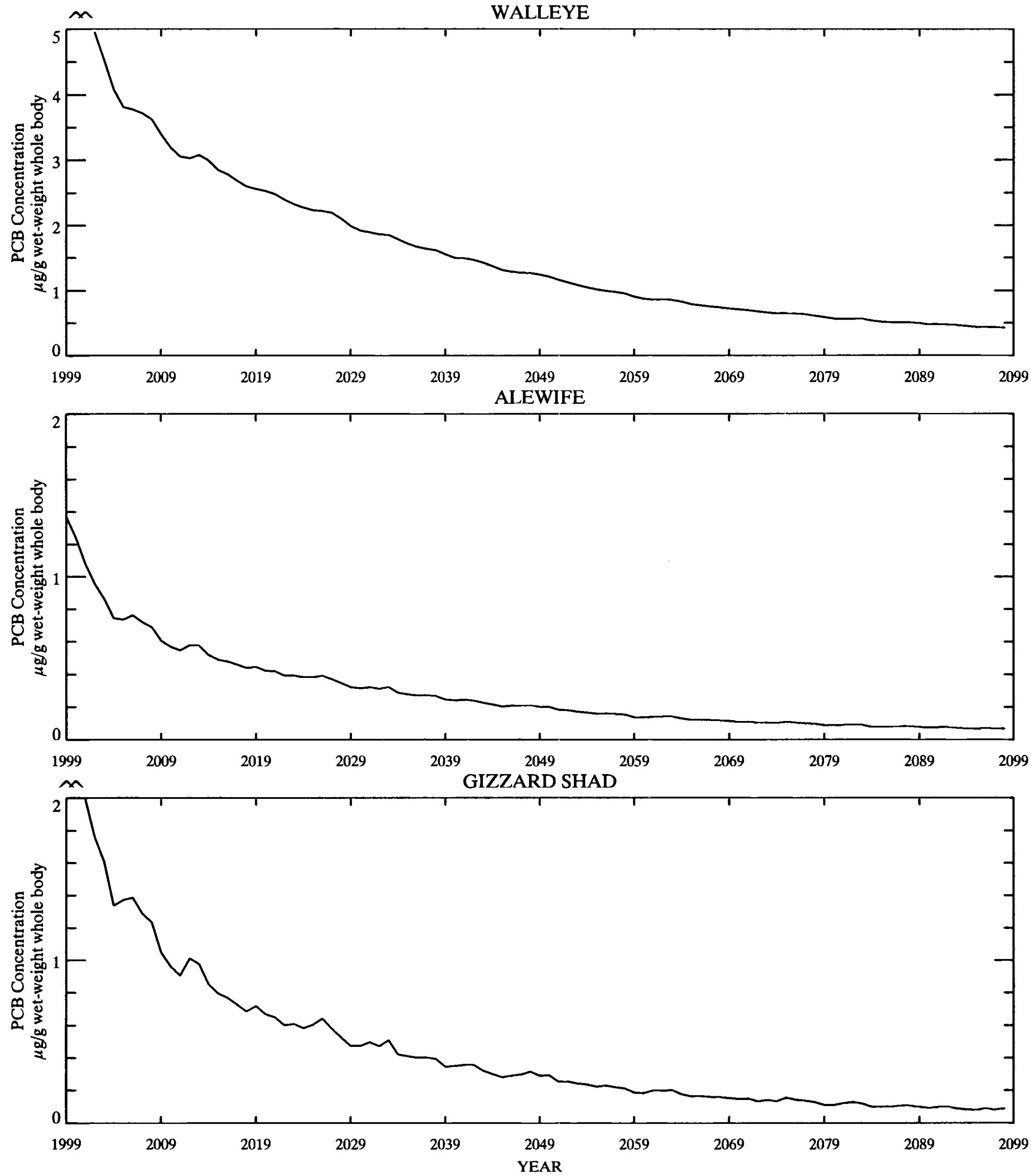
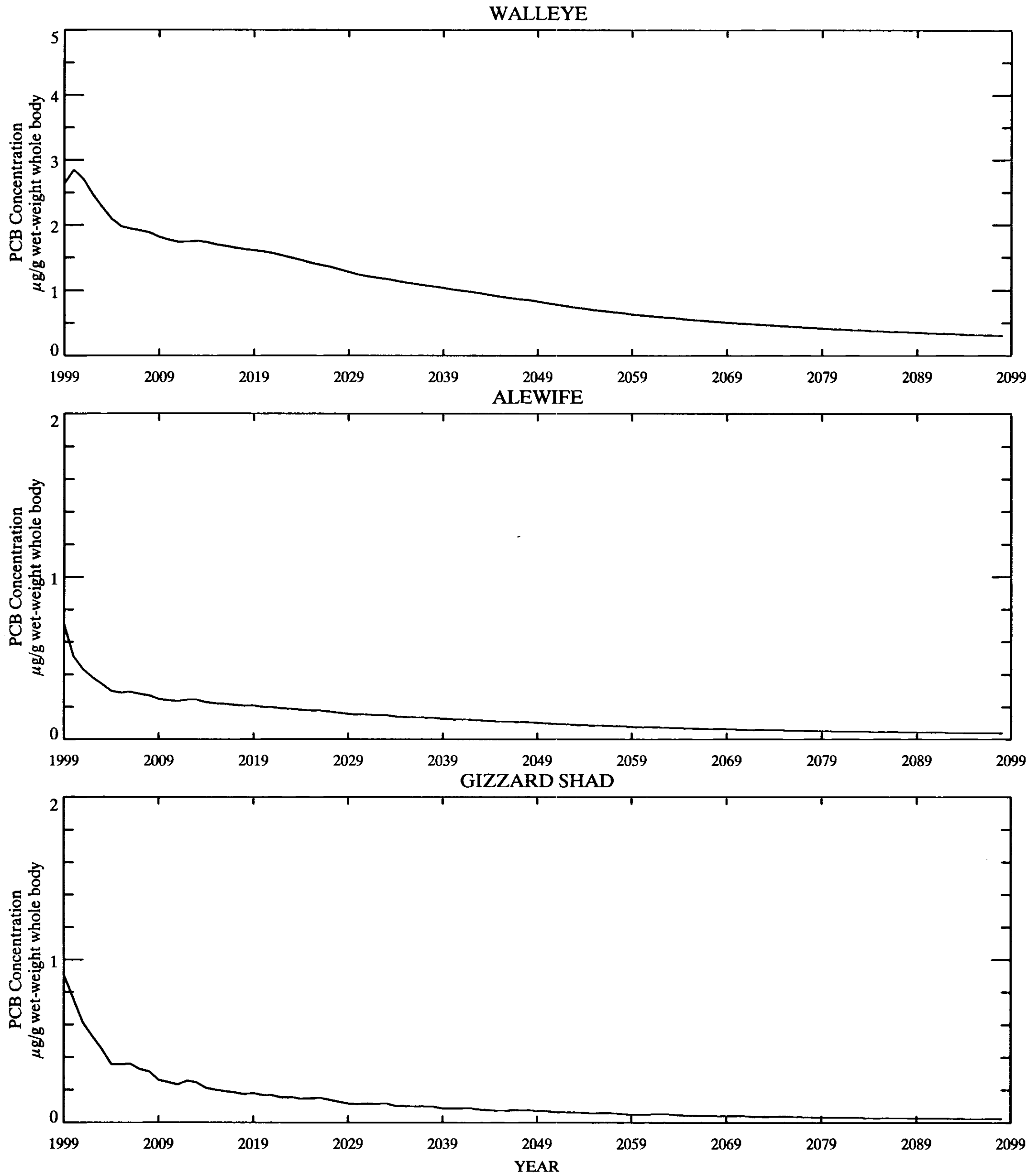


Projection: 5000z1_gbNOAC-fr5000z2_rn48_z1sum: Annual averages.

Figure 5-22. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: remediate >5000 ppb; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg_sum.pro

Mon May 14 14:15:21 2001



Projection: 1000z1_gbNOAC-fr1000z2_rn48_z1sum: Annual averages.

Figure 5-23. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: remediate >1000 ppb; Green Bay: No Action.

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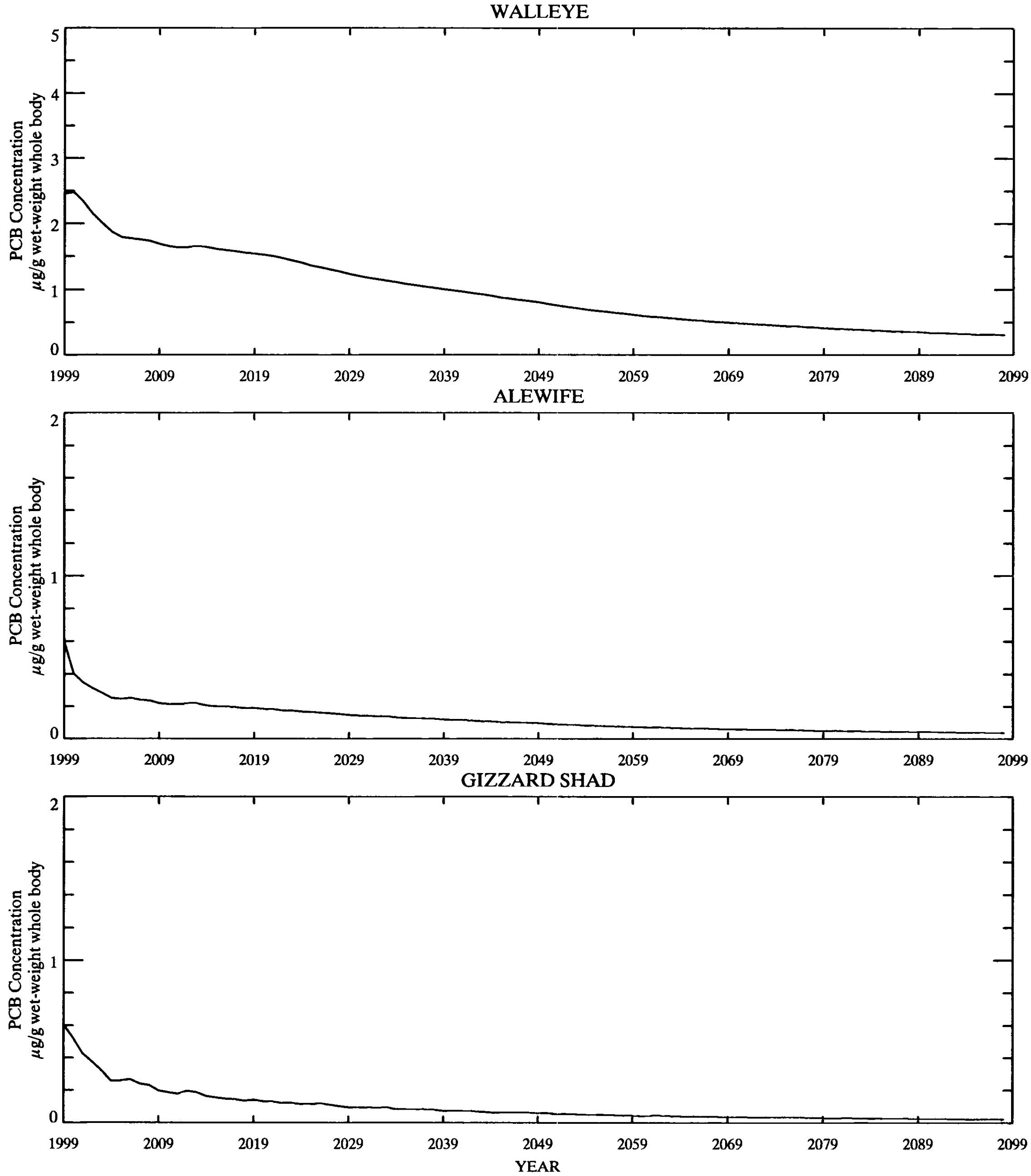

Projection: 0500z1_gbNOAC-fr0500z2_rn48_z1sum: Annual averages.

Figure 5-24. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: remediate >500 ppb; Green Bay: No Action..

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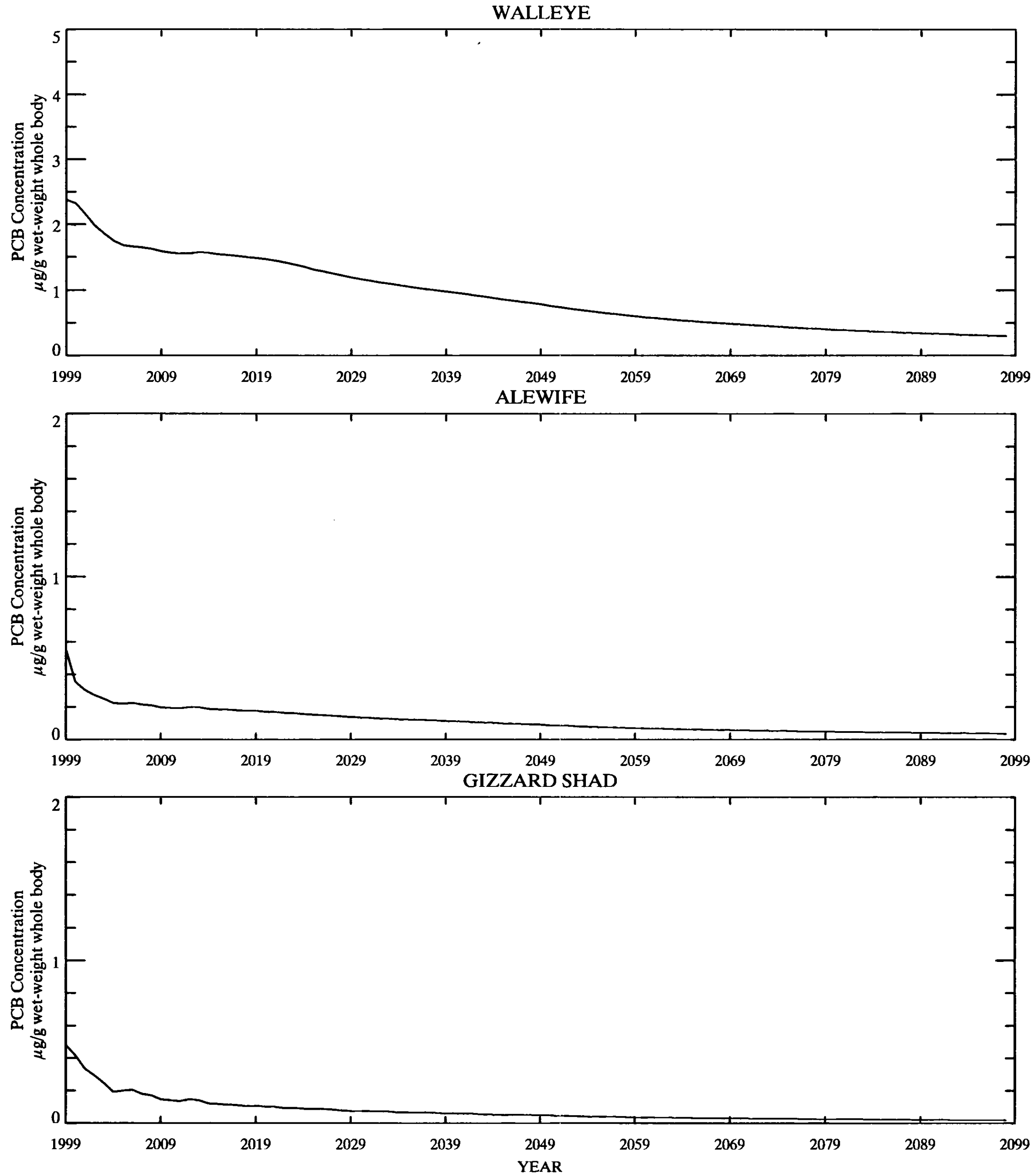

Projection: 0250z1_gbNOAC-fr0250z2_rn48_z1sum: Annual averages.

Figure 5-25. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: remediate >250 ppb; Green Bay: No Action.

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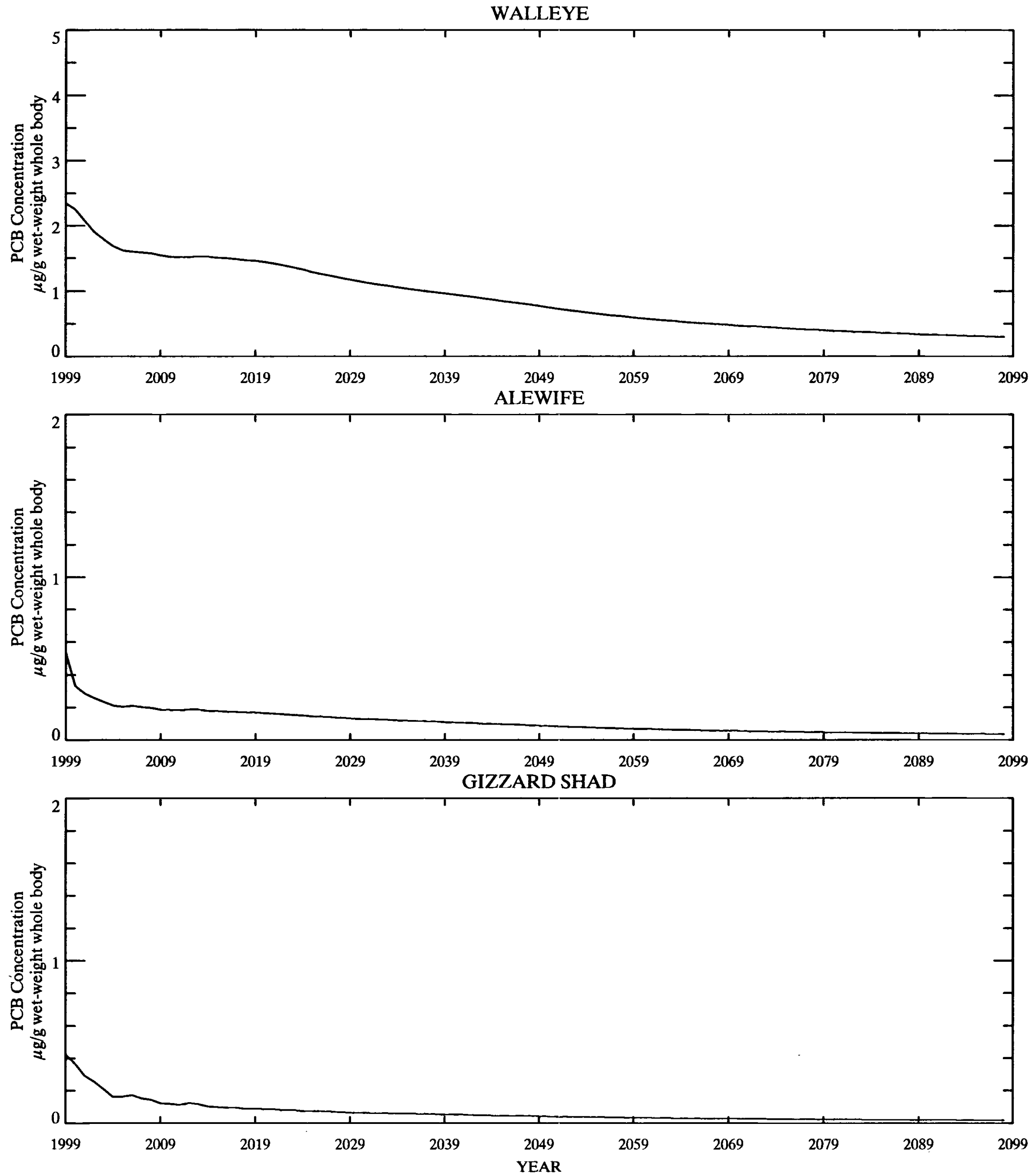
Mon May 14 14:20:04 2001



Projection: 0125z1_gbNOAC-fr0125z2_rn48_z1sum: Annual averages.

Figure 5-26. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: remediate >125 ppb; Green Bay: No Action.

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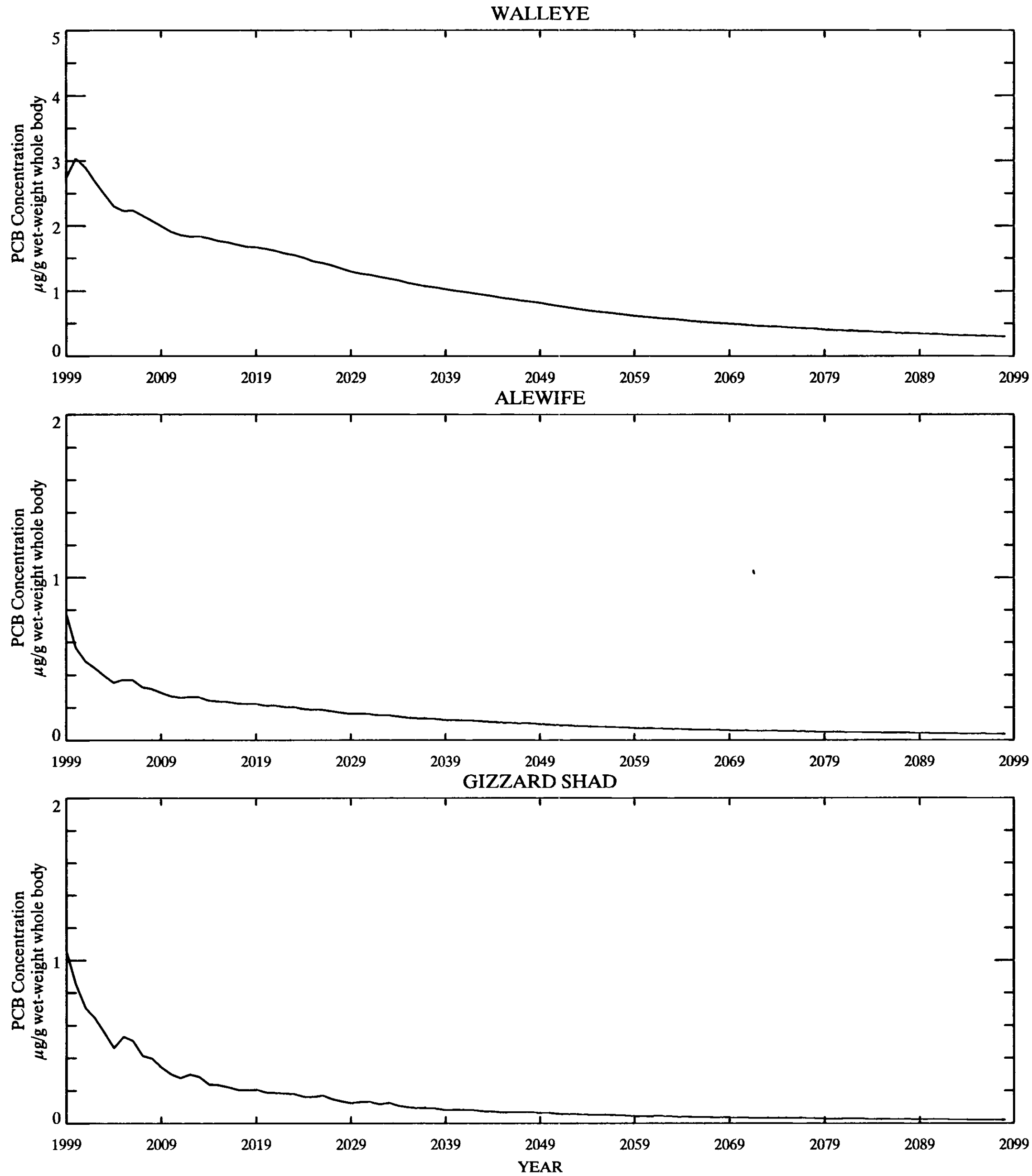

Projection: 000Hz1_gbNOAC-fr000Hz2_rn48_z1sum: Annual averages.

Figure 5-27. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: Schedule "H"; Green Bay: No Action.

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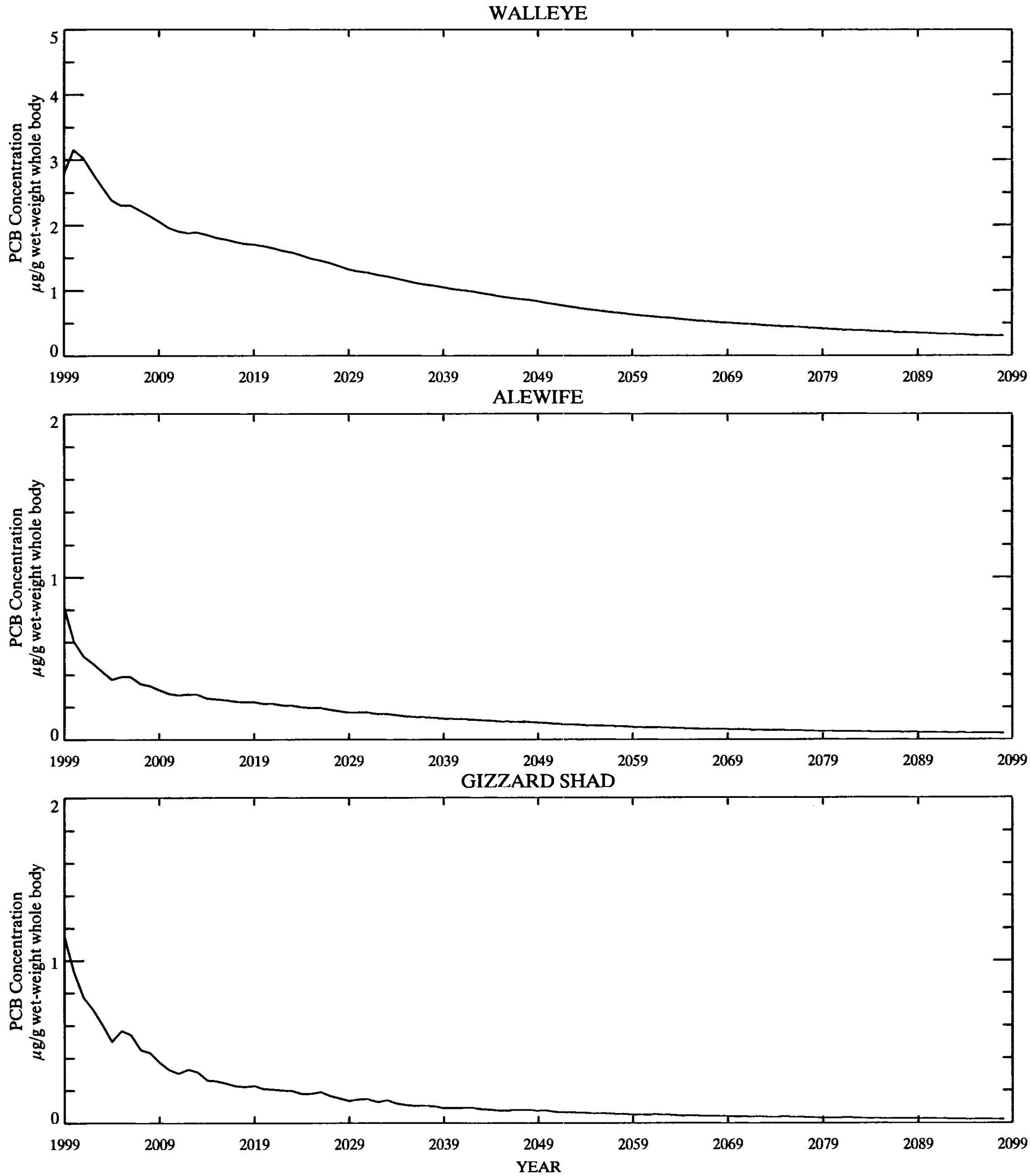
Mon May 14 14:23:15 2001



Projection: 000Iz1_gbNOAC-fr000Iz2_rn48_z1sum: Annual averages.

Figure 5-28. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: Schedule "I"; Green Bay: No Action.

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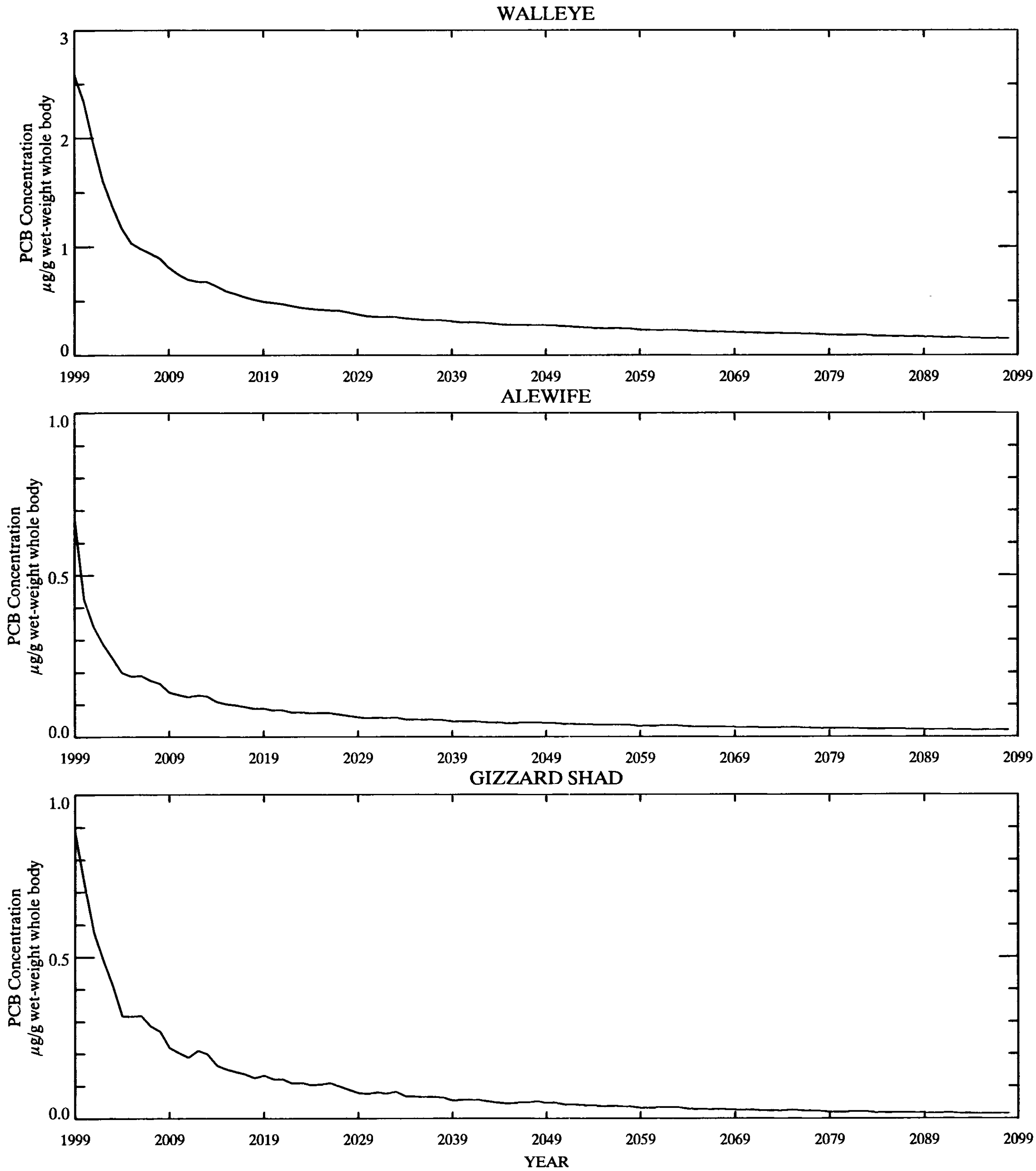

Projection: 1000z1_gb1000-fr1000z2_rn48_z1sum: Annual averages.

Figure 5-29. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: remediate >1000 ppb; Green Bay: remediate >1000 ppb.

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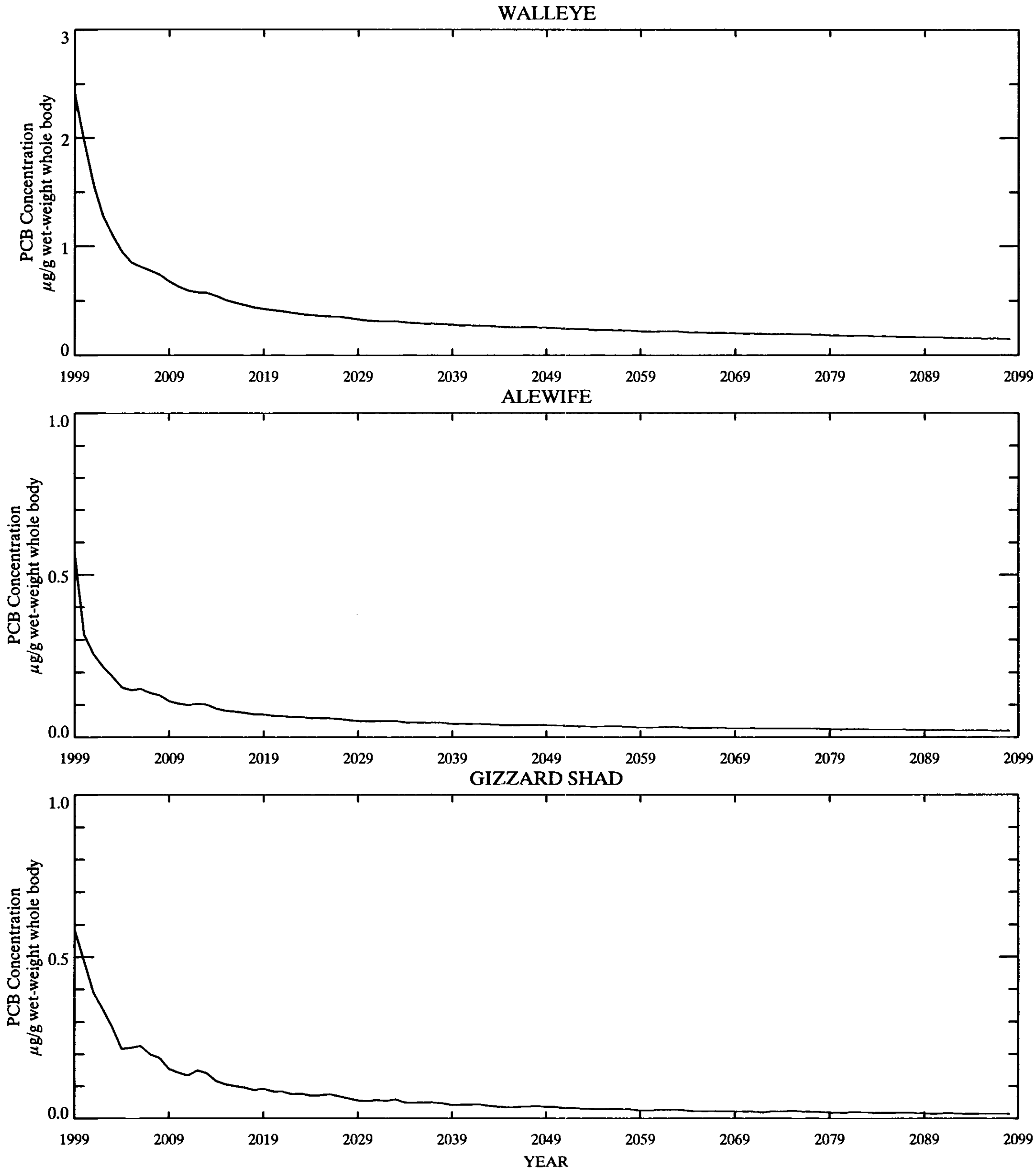

Projection: 0500z1_gb1000-fr0500z2_rn48_z1sum: Annual averages.

Figure 5-30. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: remediate >500 ppb; Green Bay: remediate >1000 ppb.

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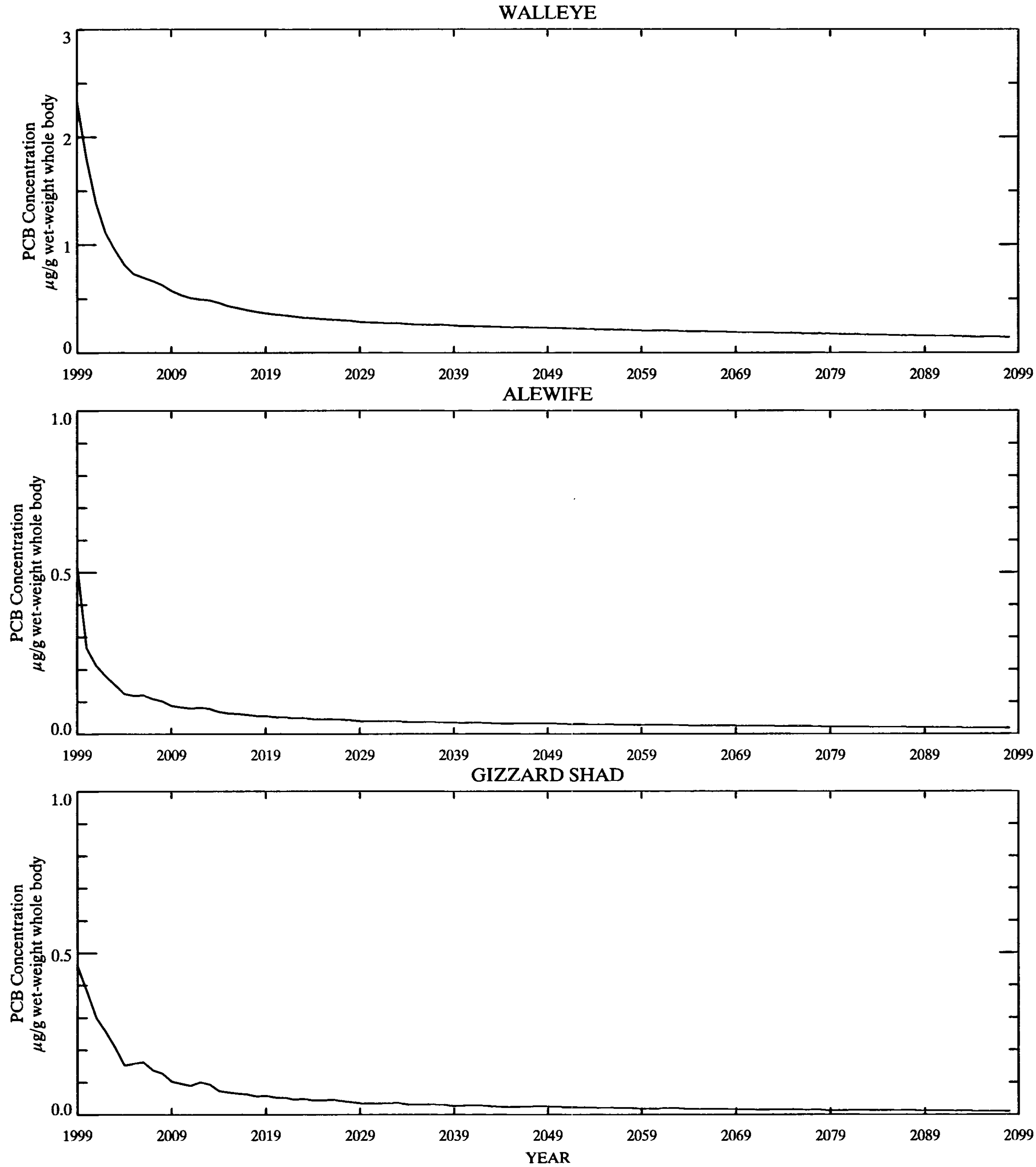
Mon May 14 14:49:39 2001



Projection: 0250z1_gb1000-fr0250z2_rn48_z1sum: Annual averages.

Figure 5-31. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: remediate >250 ppb; Green Bay: remediate >1000 ppb.

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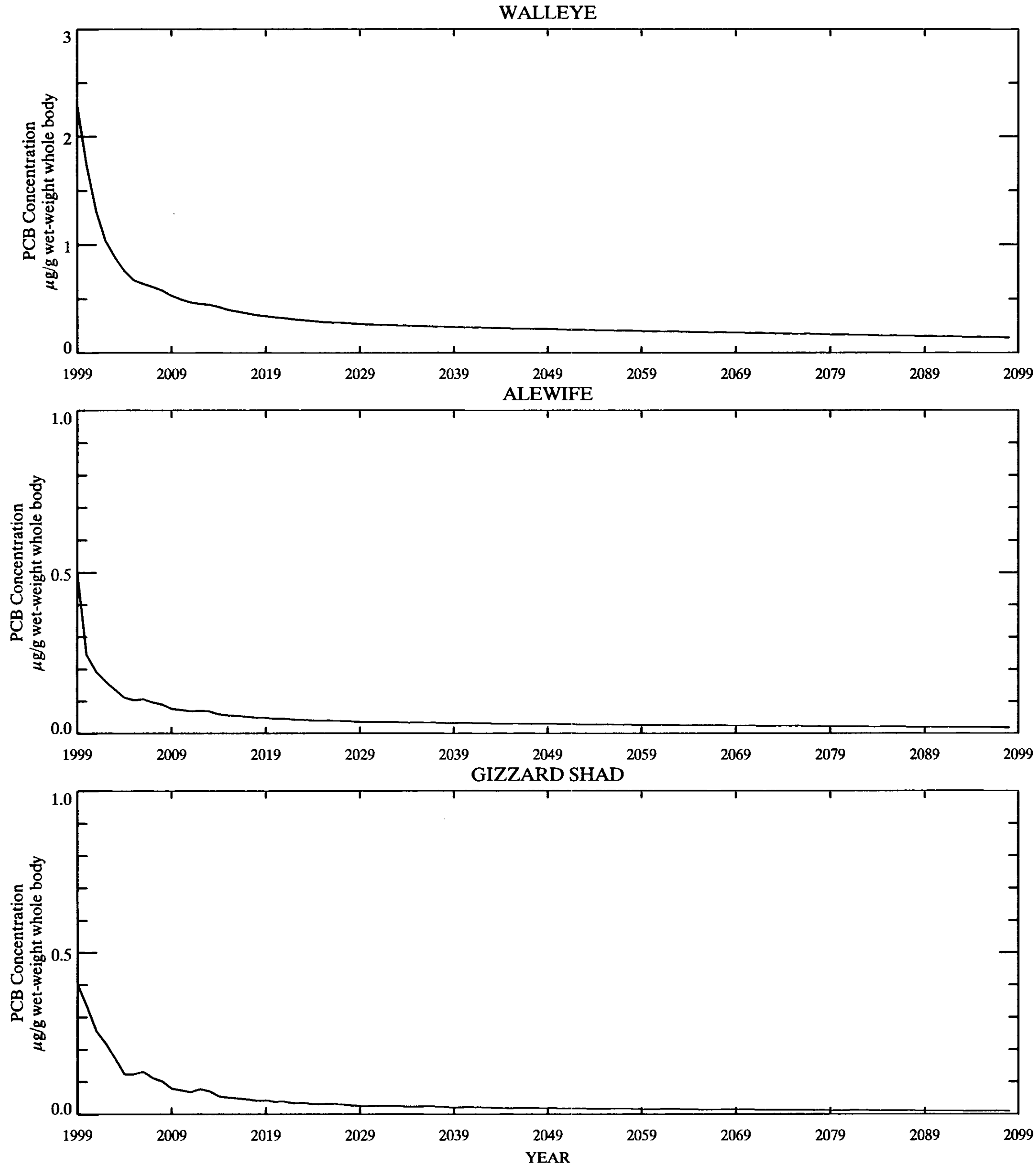
Mon May 14 14:51:14 2001



Projection: 0125z1_gb1000-fr0125z2_rn48_z1sum: Annual averages.

Figure 5-32. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: remediate >125 ppb; Green Bay: remediate >1000 ppb.

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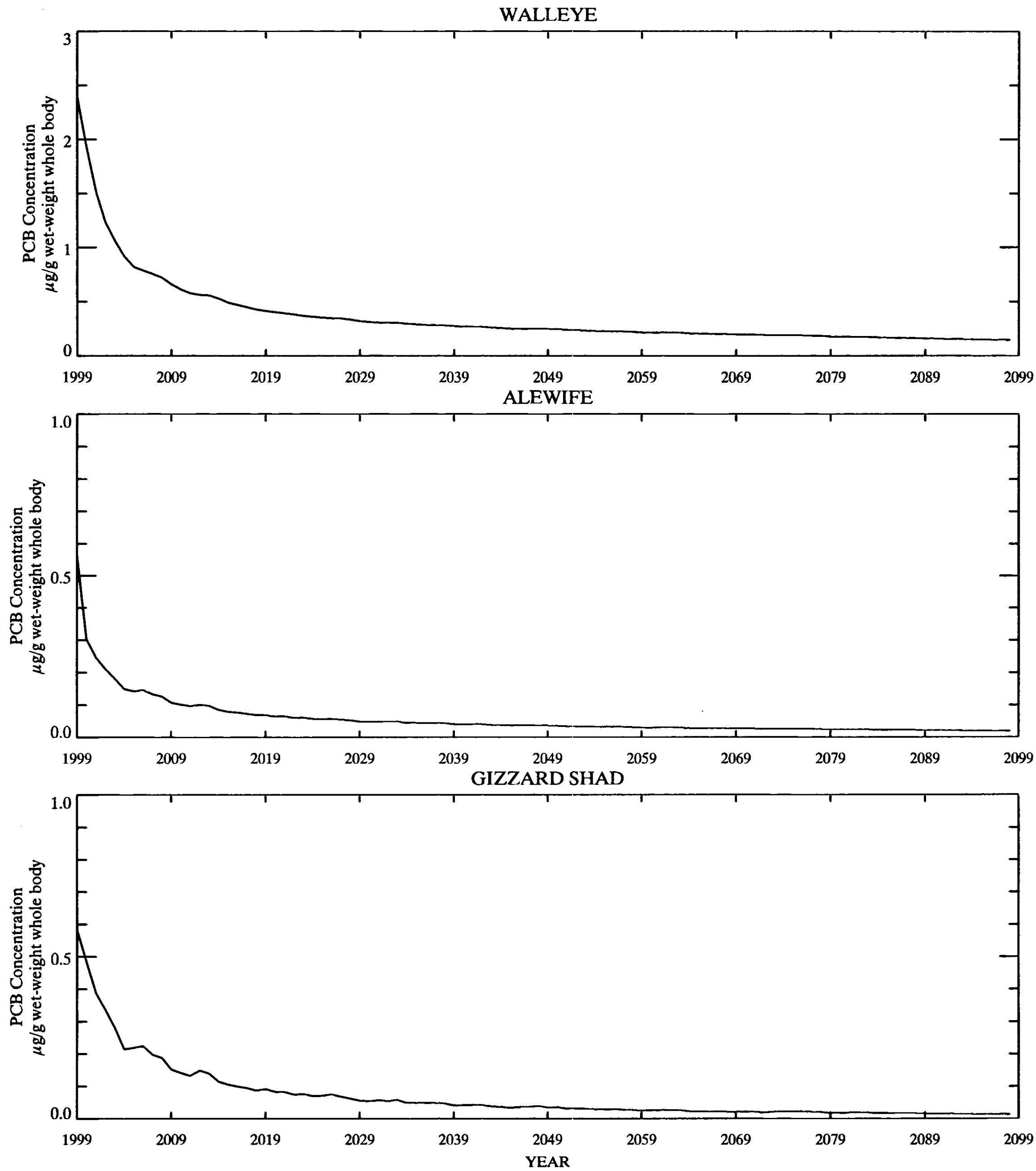

Projection: 0500z1_gb0500-fr0500z2_rn48_z1sum: Annual averages.

Figure 5-33. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: remediate >500 ppb; Green Bay: remediate >500 ppb.

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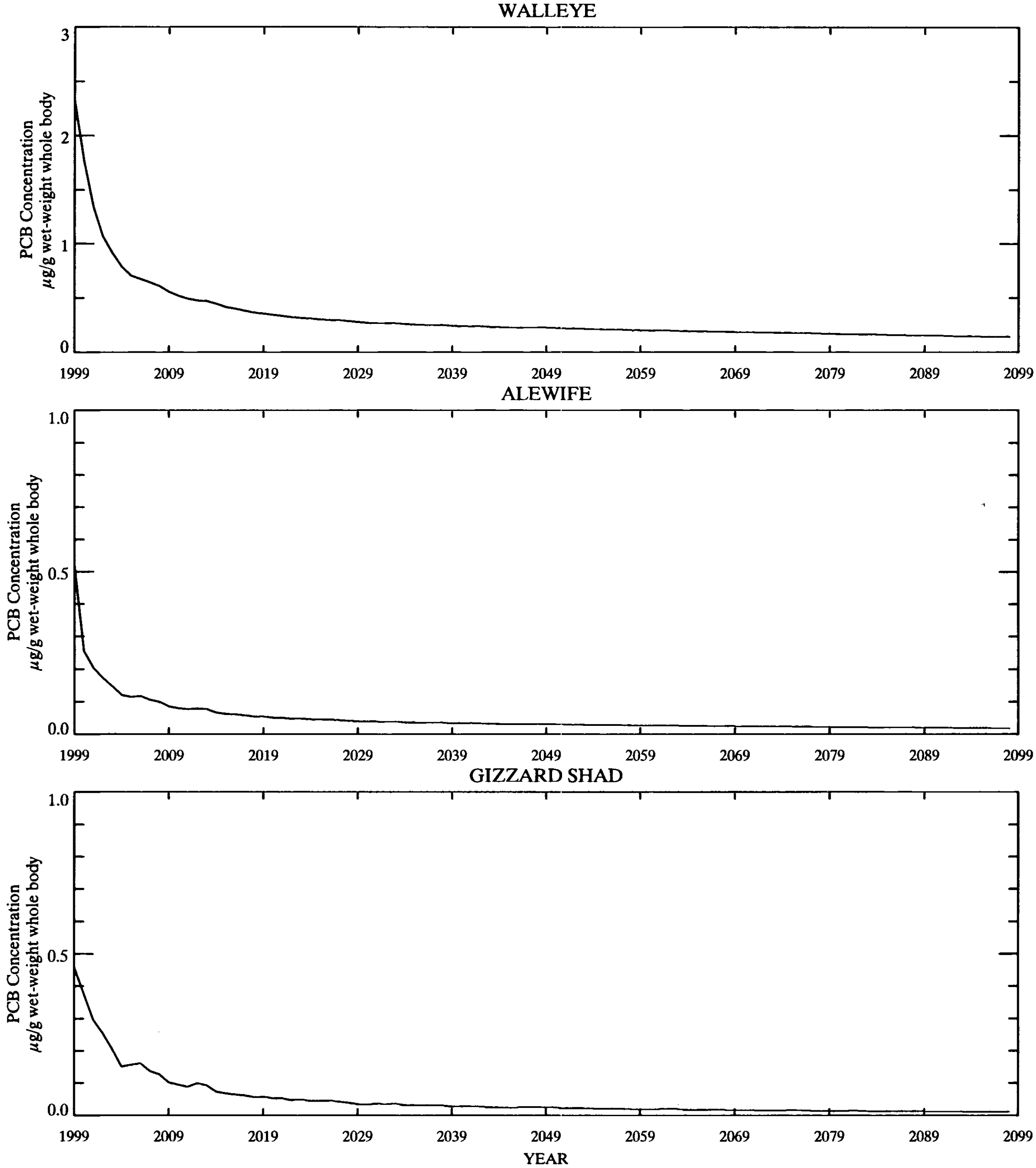

Projection: 0250z1_gb0500-fr0250z2_rn48_z1sum: Annual averages.

Figure 5-34. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: remediate >250 ppb; Green Bay: remediate >500 ppb

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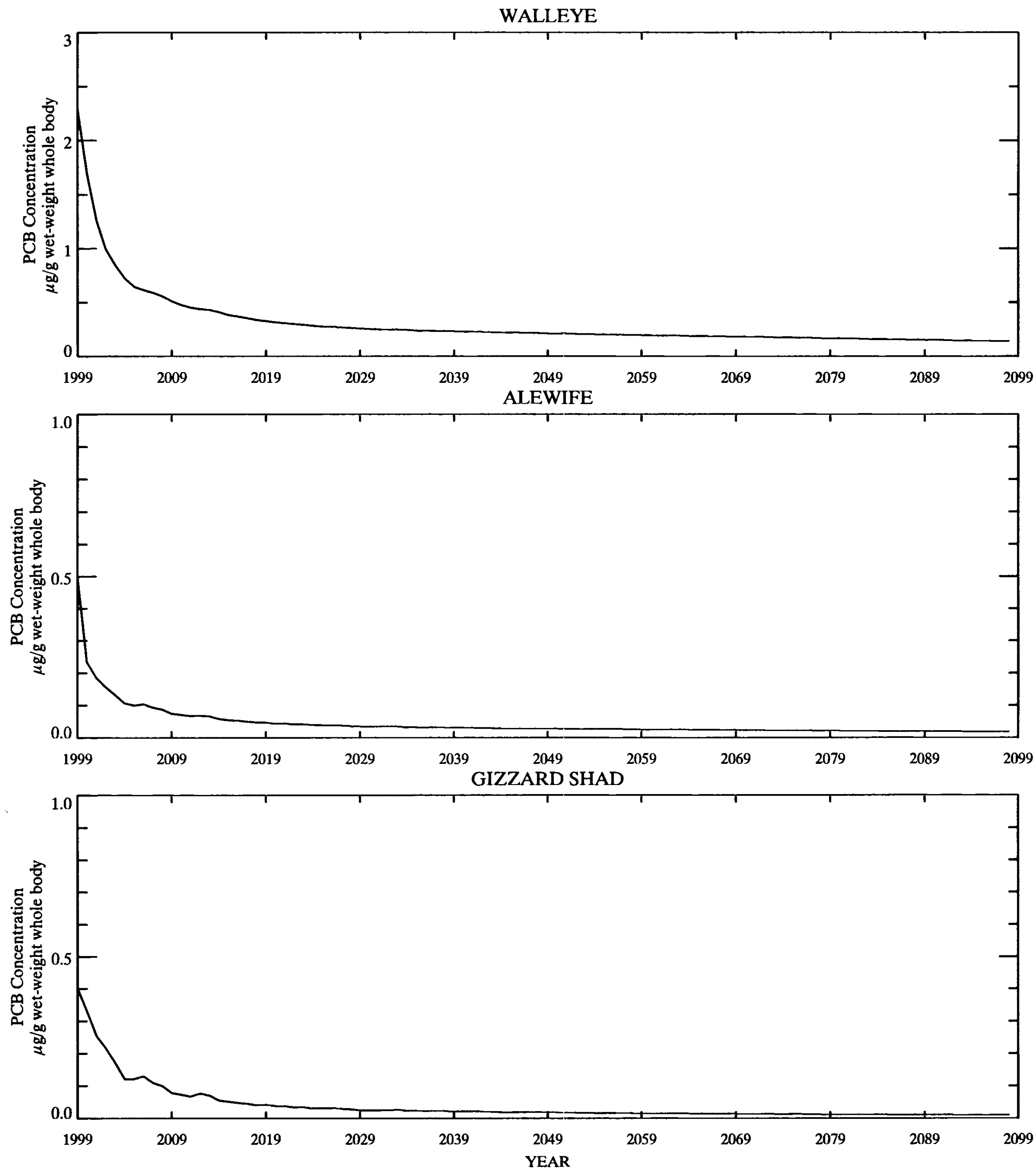

Projection: 0125z1_gb0500-fr0125z2_rn48_z1sum: Annual averages.

Figure 5-35. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 from May through October year based on Fox River: remediate >125 ppb; Green Bay: remediate >500 ppb.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg_sum.pro

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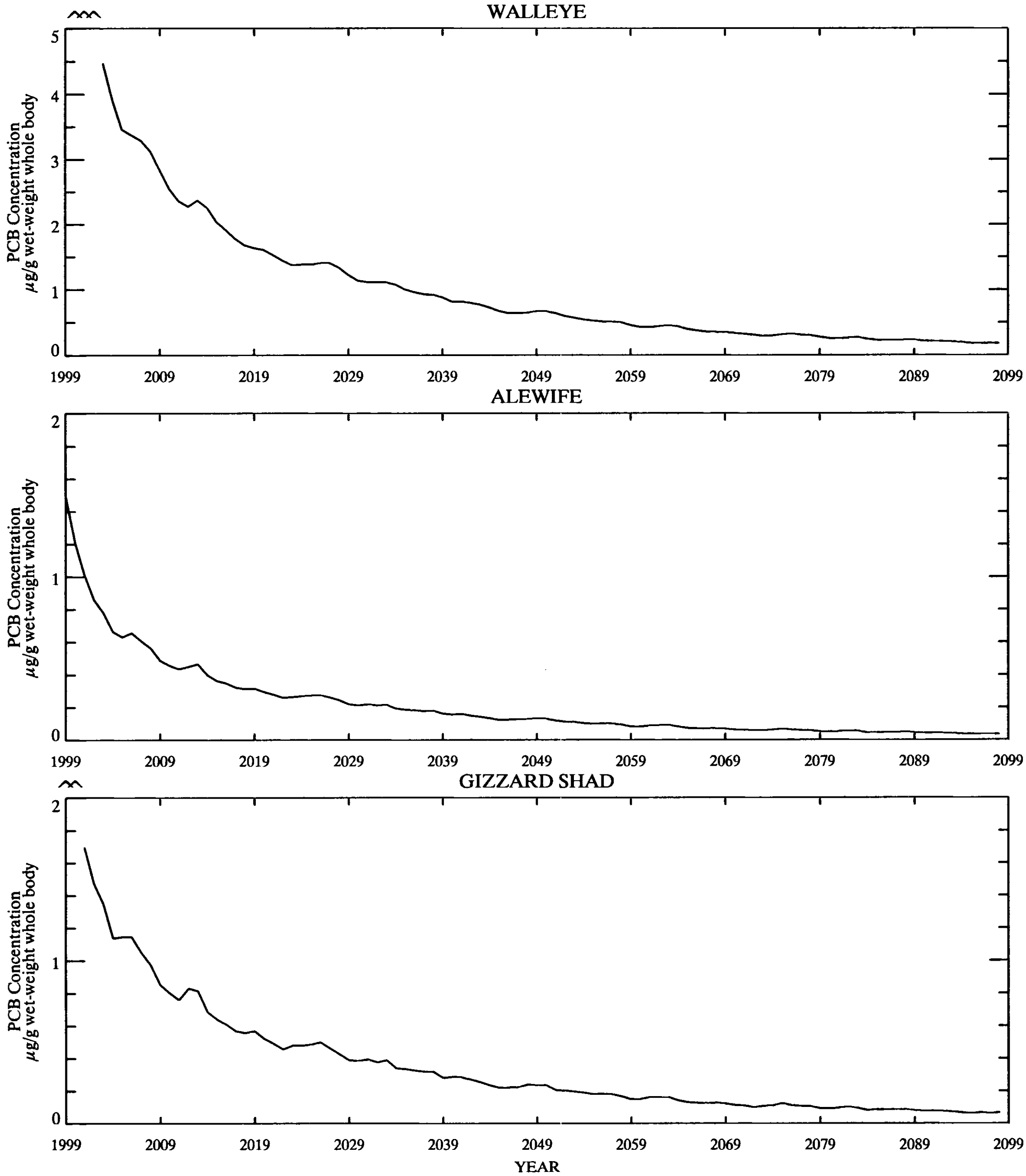

Projection: 5000z1_gbNOAC-fr5000z2_rn47_z1res: Annual averages.

Figure 5-36. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for 11 months +3 weeks each year based on Fox River: remediate >5000 ppb; Green Bay: No Action.

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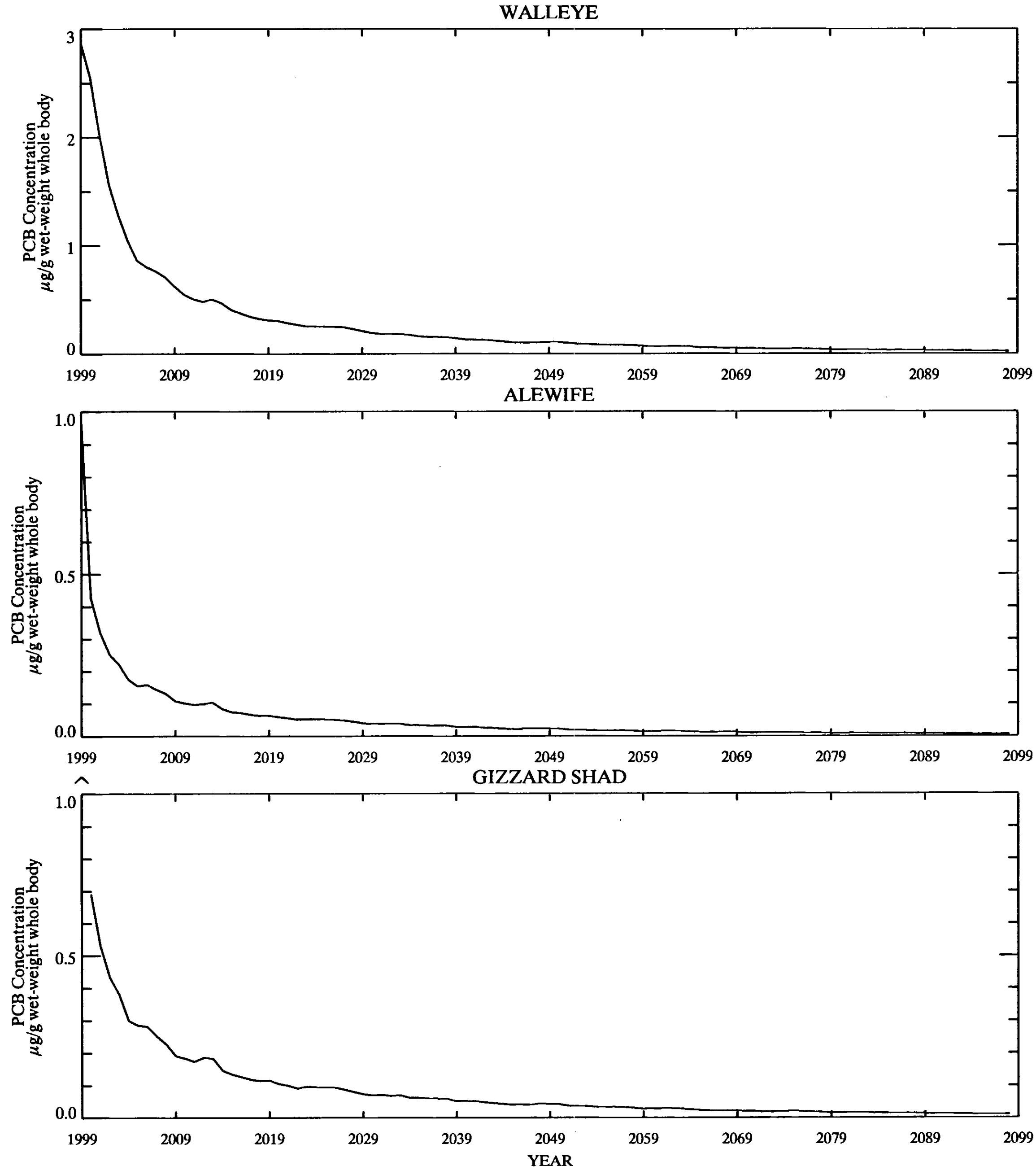

Projection: 1000z1_gbNOAC-fr1000z2_rn47_z1res: Annual averages.

Figure 5-37. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for 11 months +3 weeks each year based on Fox River: remediate >1000 ppb; Green Bay: No Action.

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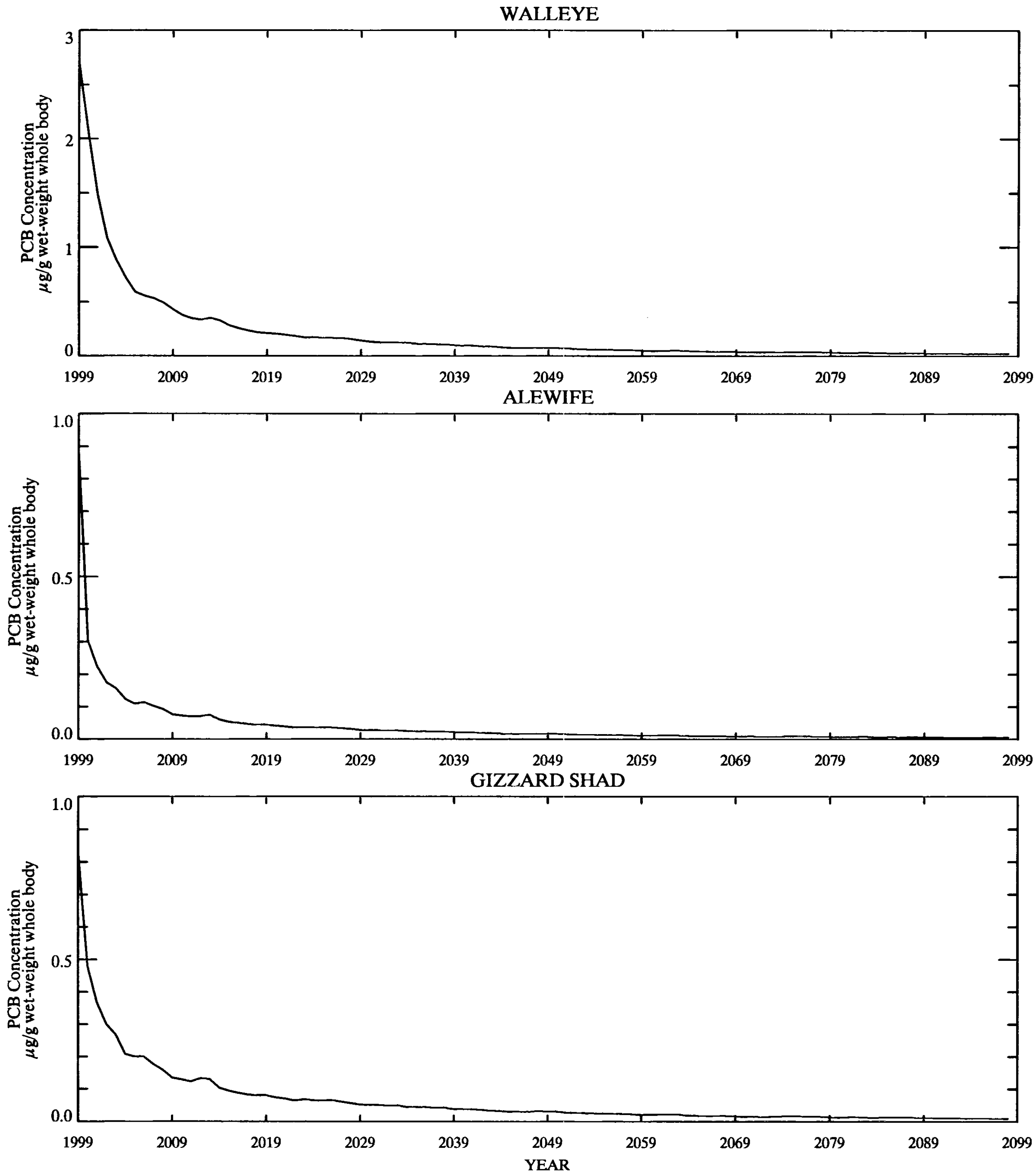

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Figure 5-38. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for 11 months +3 weeks each year based on Fox River: remediate >500 ppb; Green Bay: No Action.

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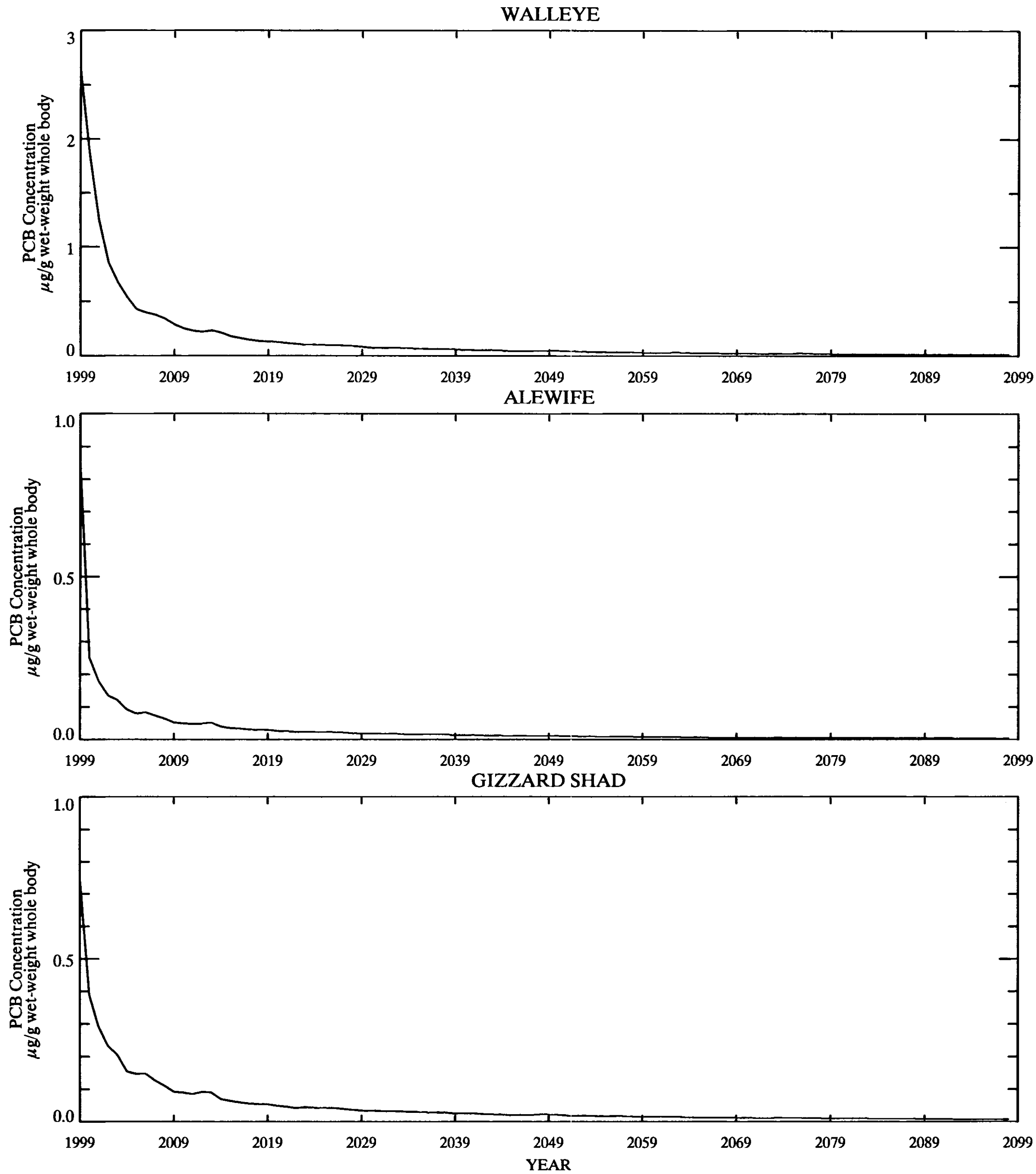

Projection: 0250z1_gbNOAC-fr0250z2_rn47_z1res: Annual averages.

Figure 5-39. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for 11 months +3 weeks each year based on Fox River: remediate >250 ppb; Green Bay: No Action.

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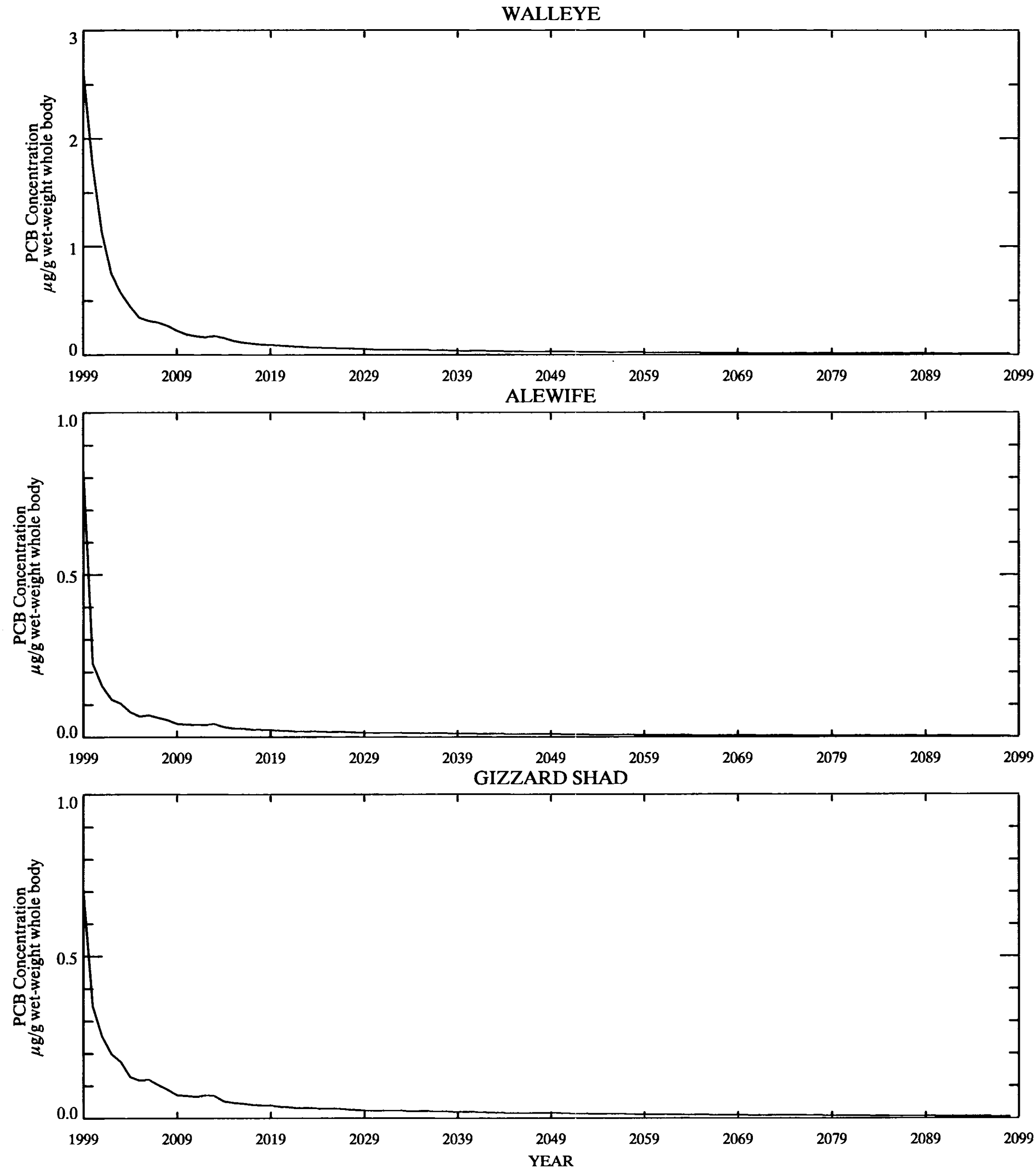

Projection: 0125z1_gbNOAC-fr0125z2_rn47_z1res: Annual averages.

Figure 5-40. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for 11 months +3 weeks each year based on Fox River: remediate >125 ppb; Green Bay: No Action.

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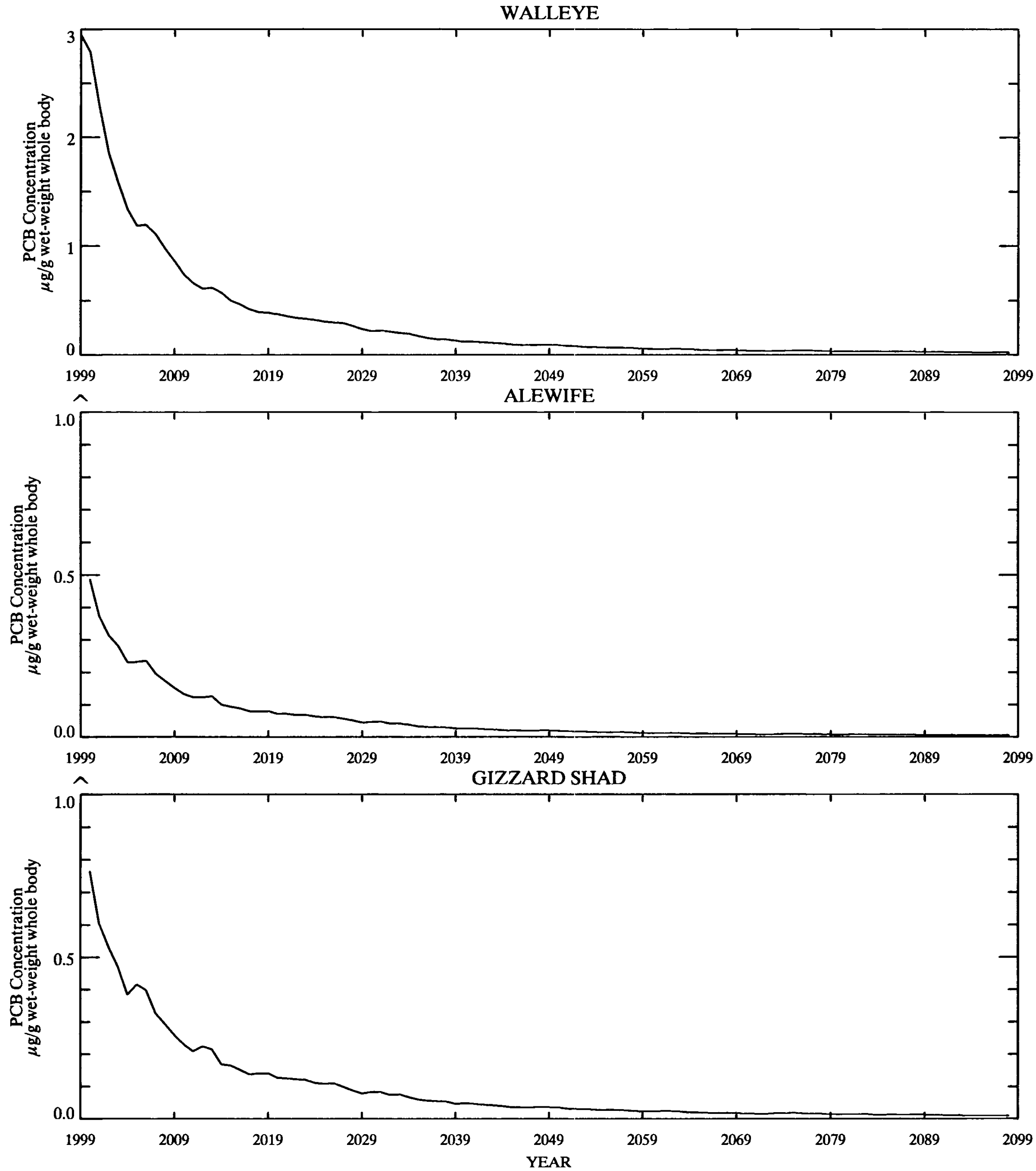

Projection: 000Hz1_gbNOAC-fr000Hz2_rn47_z1res: Annual averages.

Figure 5-41. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for 11 months +3 weeks each year based on Fox River: Schedule "H"; Green Bay: No Action.

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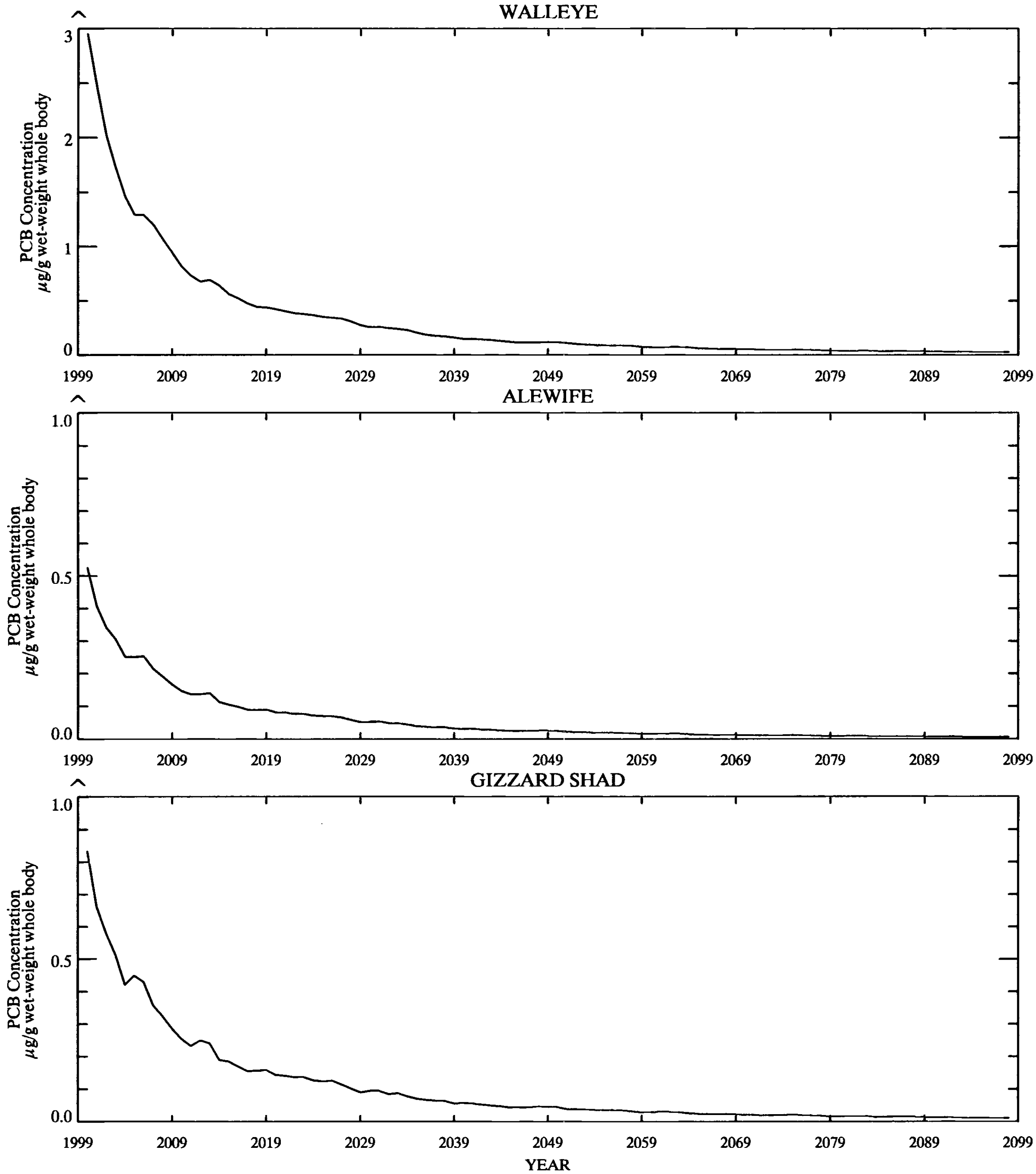
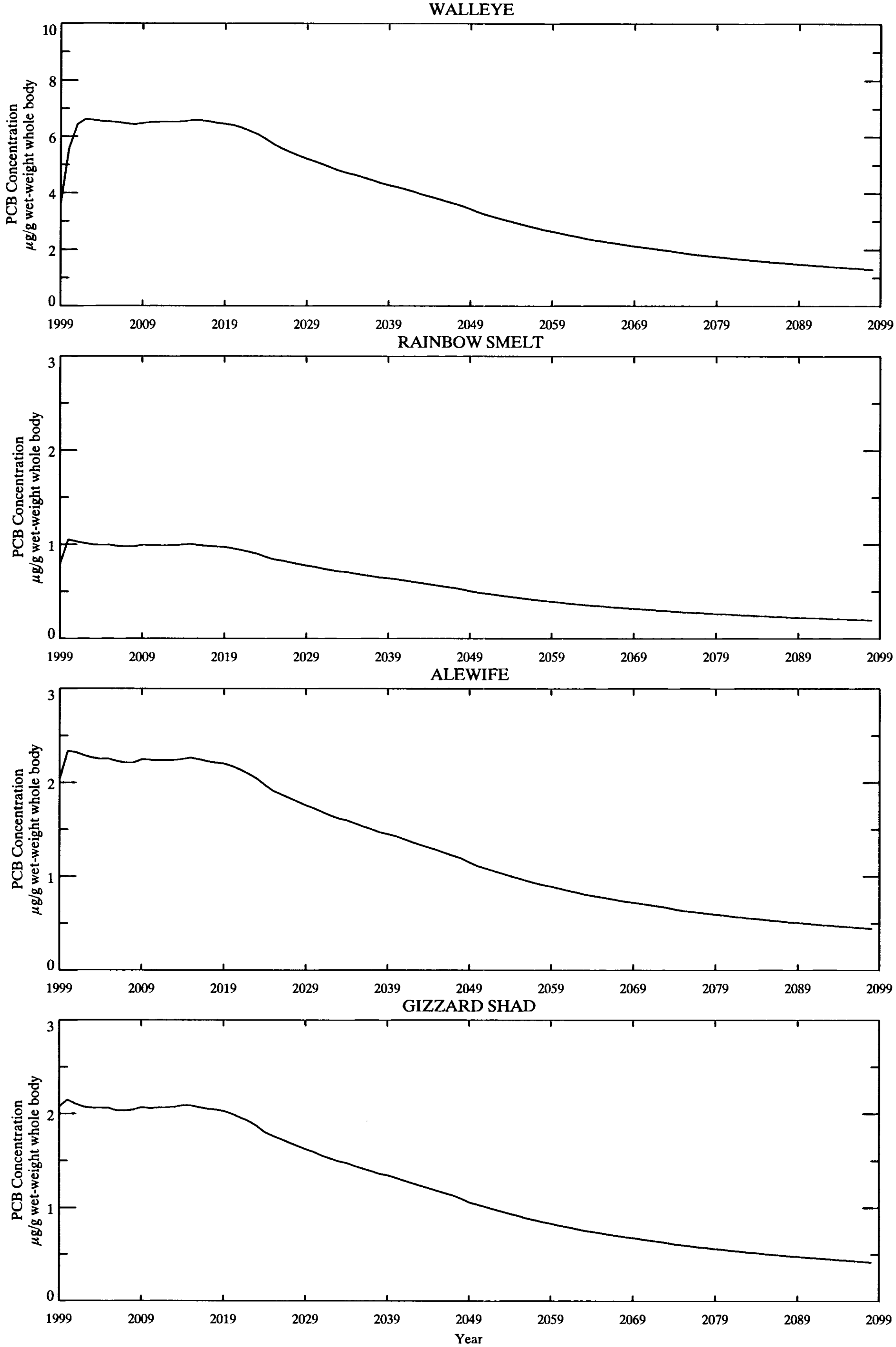


Projection: 000Iz1_gbNOAC-fr000Iz2_rn47_z1res: Annual averages.

Figure 5-42. GBFood projection results. Average computed total PCB concentrations in fish present in Zone 1 for 11 months +3 weeks each year based on Fox River: Schedule "I"; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zones12\plots\z1_proj_wet_ann_avg_res.pro

Mon May 14 14:15:11 2001



Projection: 5000z1_gbNOAC-fr5000z2_rn34_z12: Annual averages.

Figure 5-43. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: remediate >5000 ppb; Green Bay: No Action.

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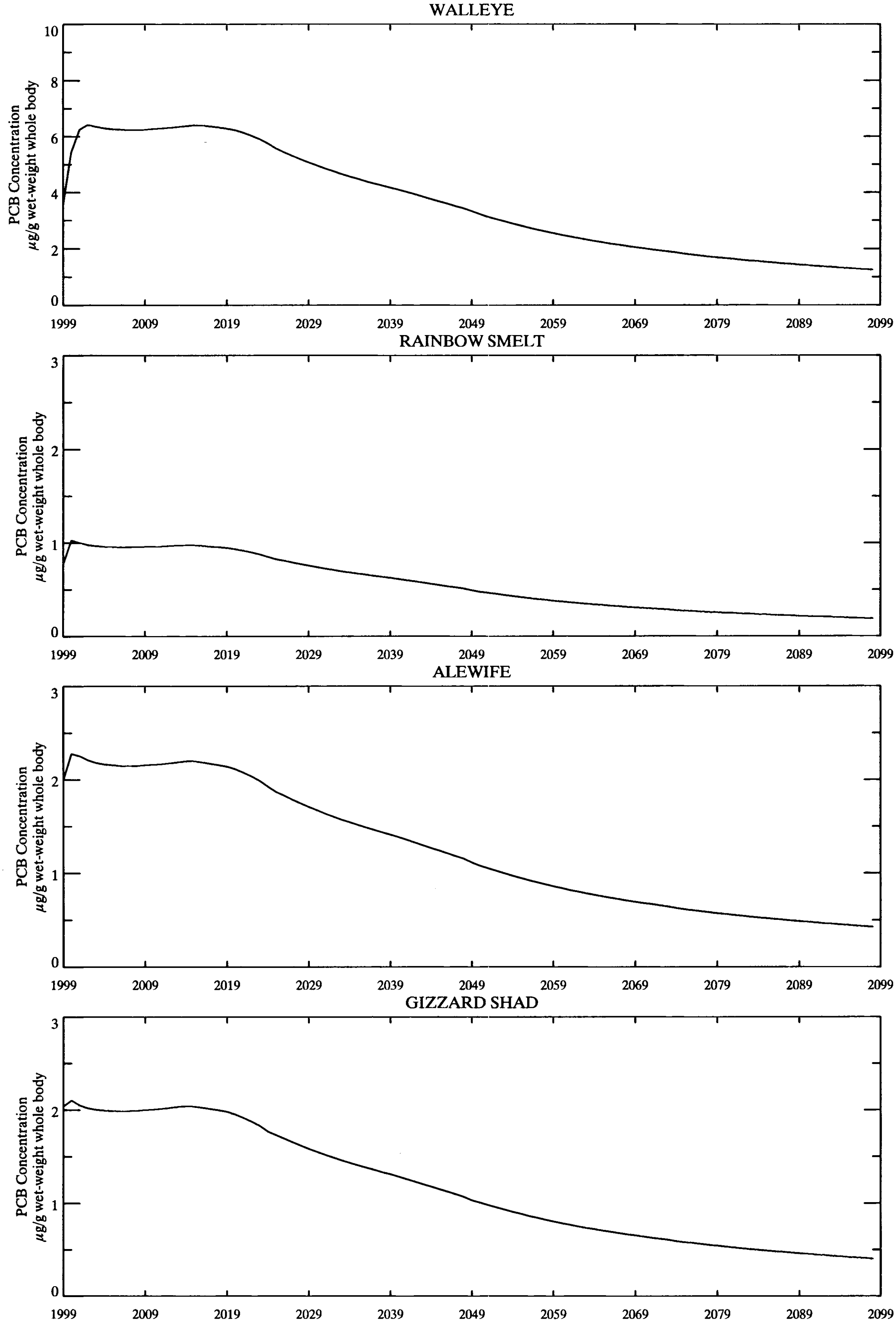

Projection: 1000z1_gbNOAC-fr1000z2_rn34_z12: Annual averages.

Figure 5-44. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: remediate >1000 ppb; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_proj_wet_ann_avg.pro

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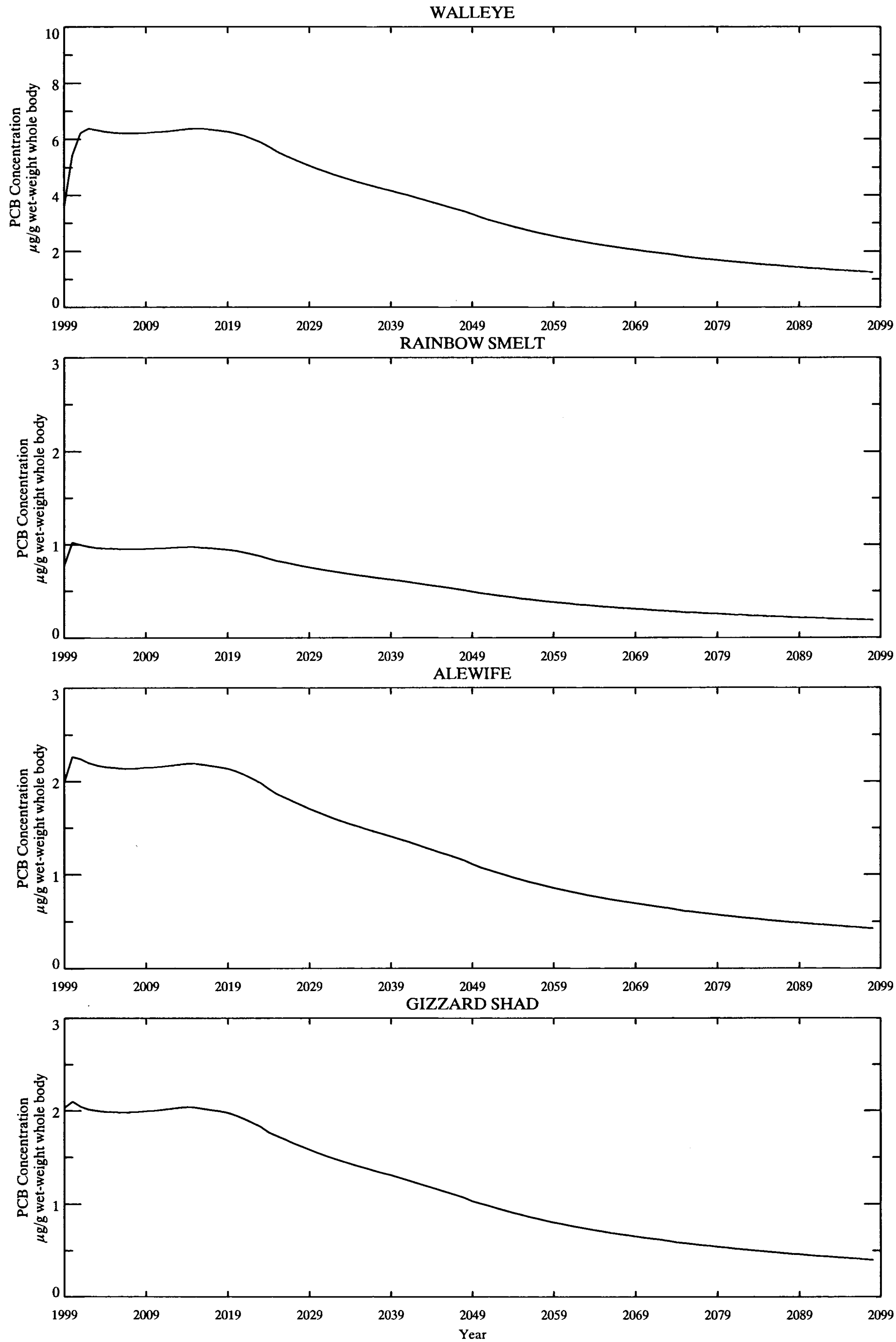

Projection: 0500z1_gbNOAC-fr0500z2_rn34_z12: Annual averages.

Figure 5-45. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: remediate >500 ppb; Green Bay: No Action..

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_proj_wet_ann_avg.pro

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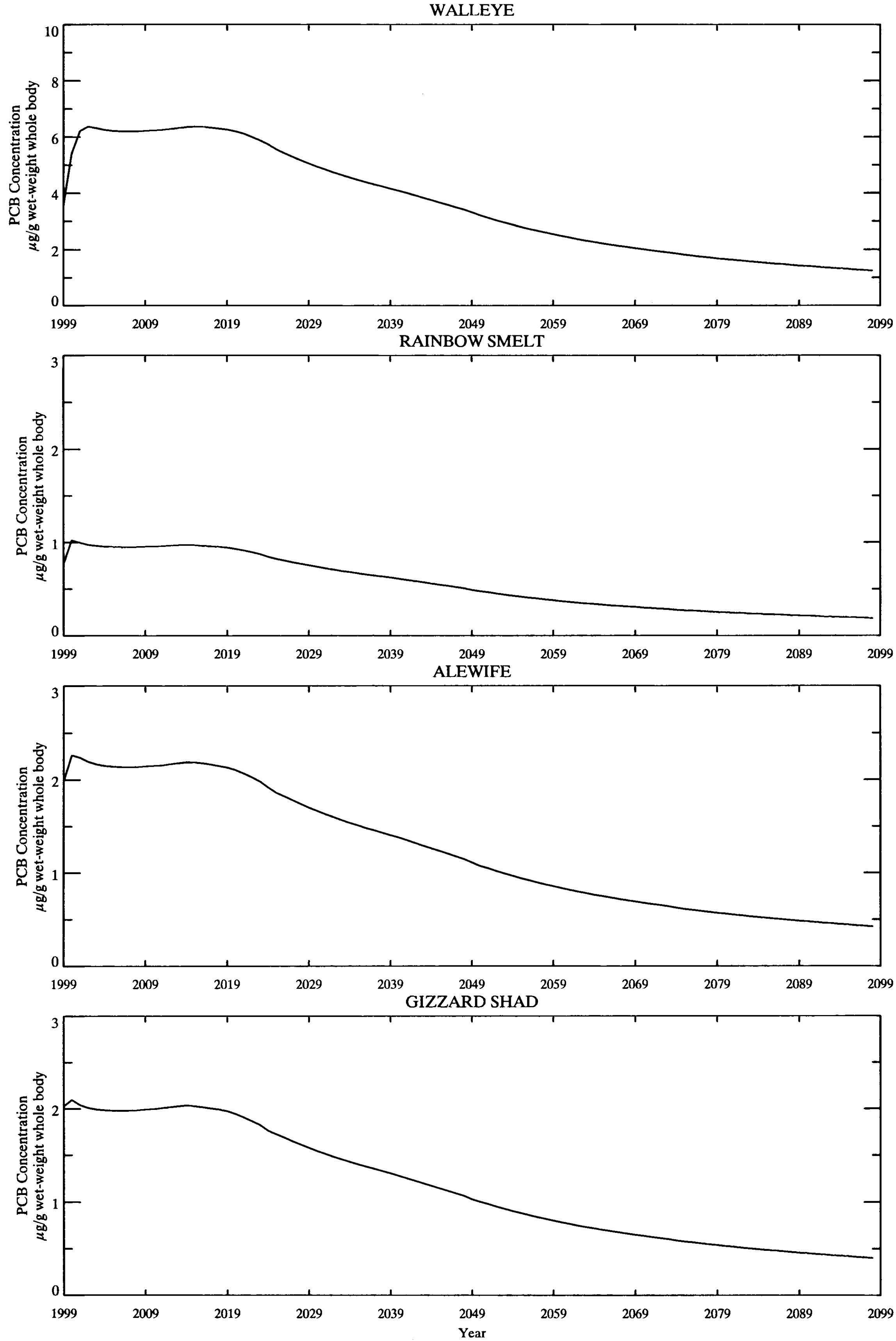

Projection: 0250z1_gbNOAC-fr0250z2_rn34_z12: Annual averages.

Figure 5-46. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: remediate >250 ppb; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_proj_wet_ann_avg.pro

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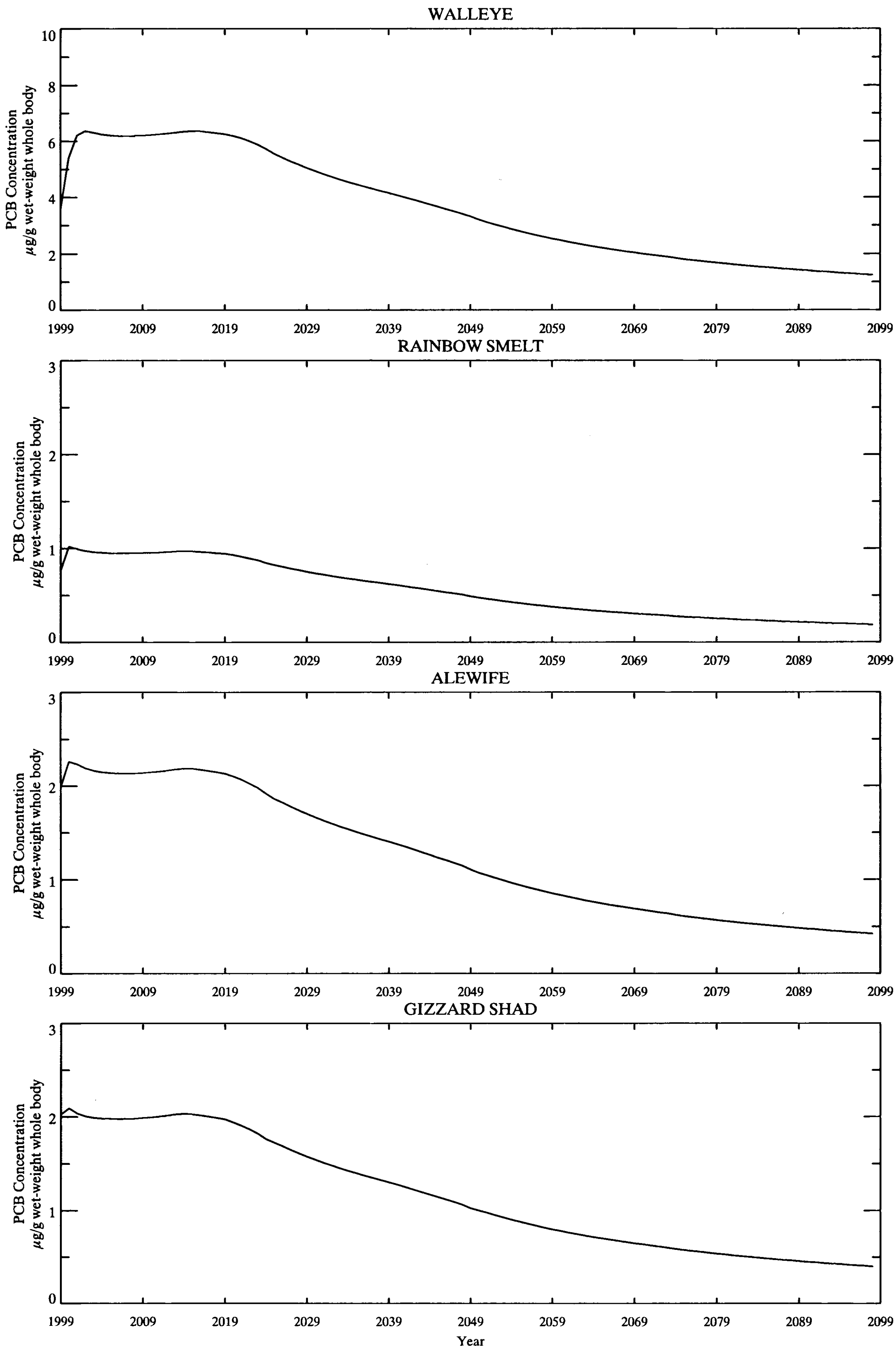
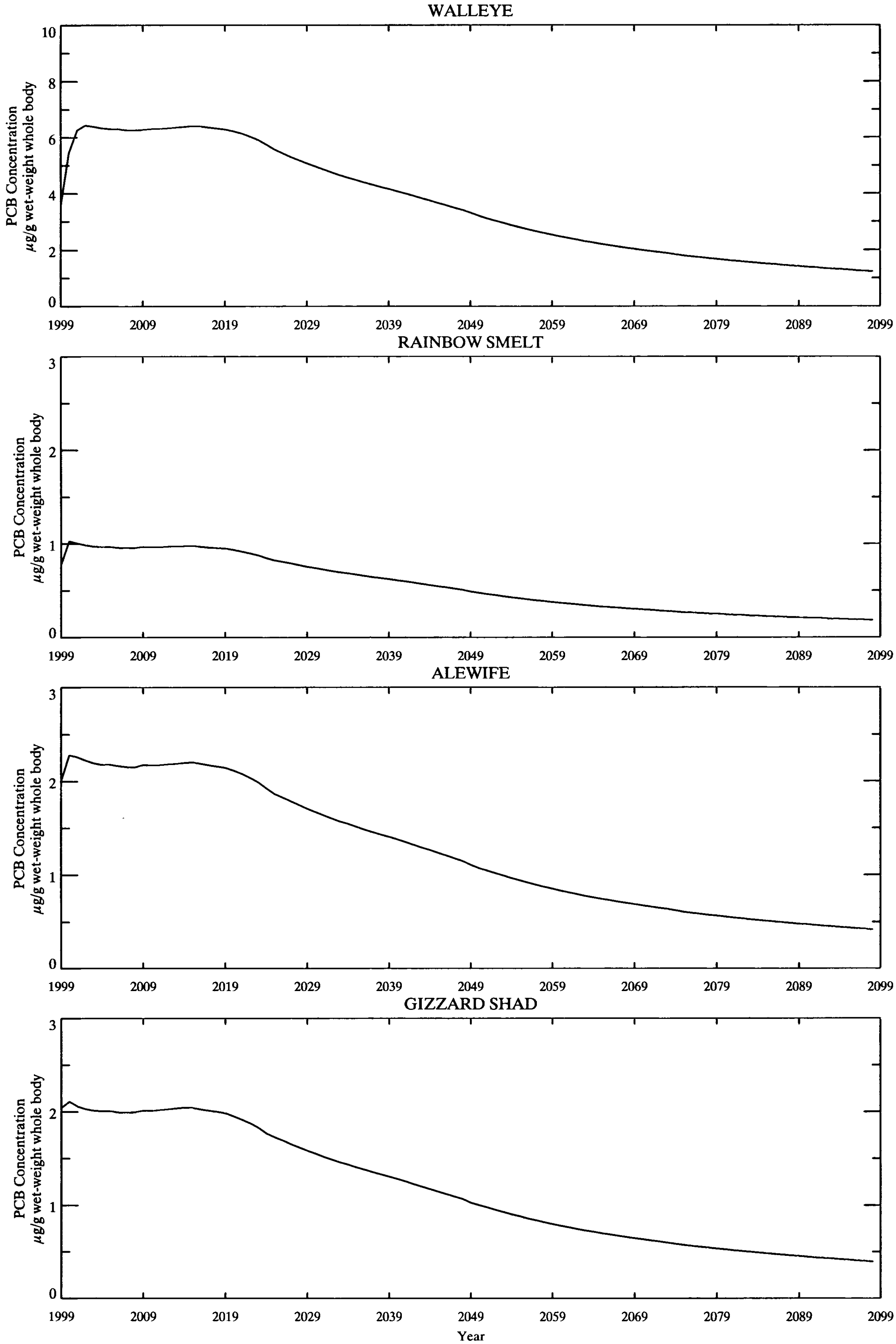


Projection: 0125z1_gbNOAC-fr0125z2_rn34_z12: Annual averages.

Figure 5-47. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: remediate >125 ppb; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_proj_wet_ann_avg.pro

Mon May 14 15:18:25 2001

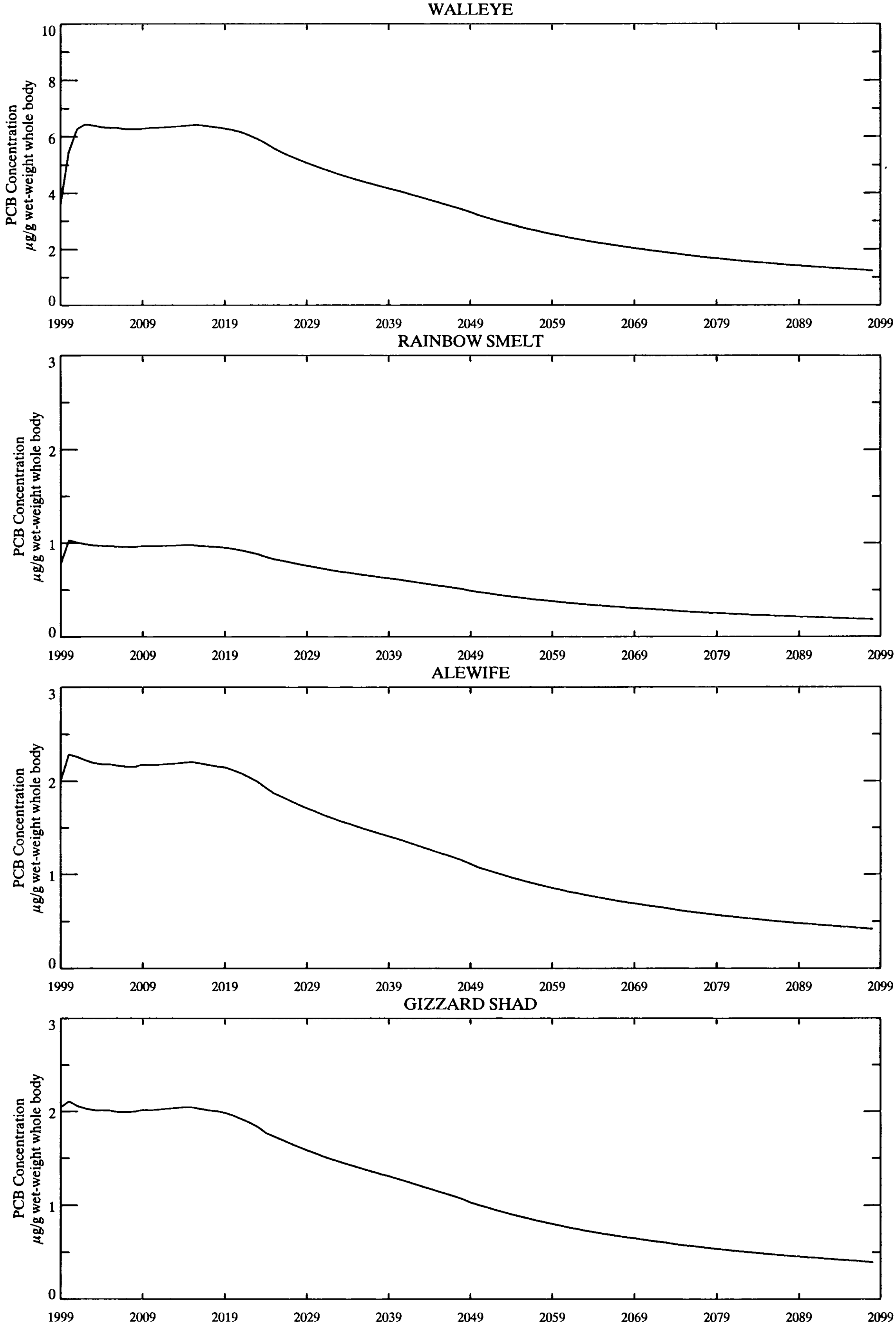


Projection: 000Hz1_gbNOAC-fr000Hz2_rn34_z12: Annual averages.

Figure 5-48. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: Schedule "H"; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_proj_wet_ann_avg.pro

Mon May 14 15:19:41 2001



Projection: 000Iz1_gbNOAC-fr000Iz2_rn34_z12: Annual averages.

Figure 5-49. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: Schedule "I"; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_proj_wet_ann_avg.pro

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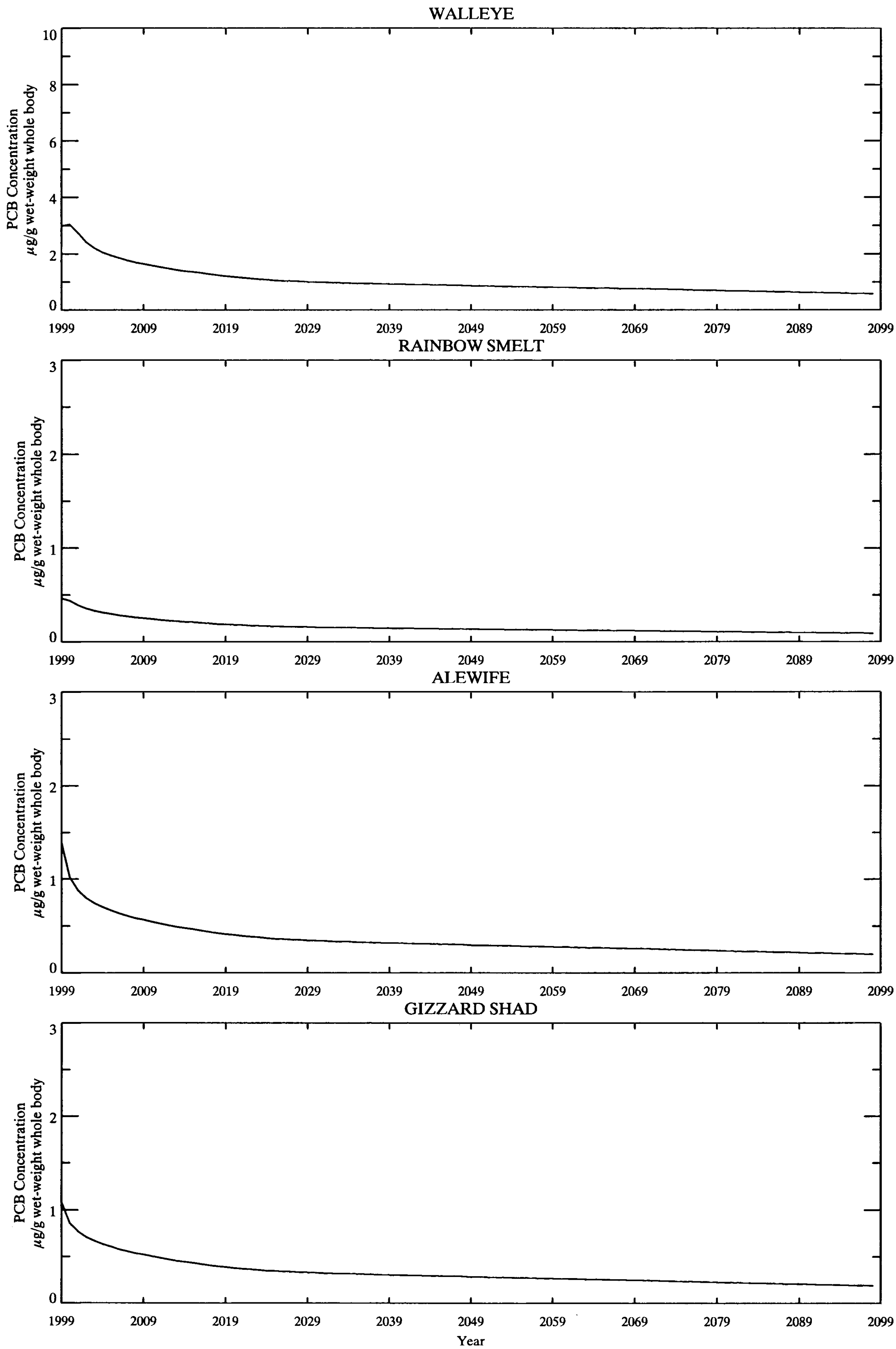

Projection: 1000z1_gb1000-fr1000z2_rn34_z12: Annual averages.

Figure 5-50. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: remediate >1000 ppb; Green Bay: remediate >1000 ppb.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_proj_wet_ann_avg.pro

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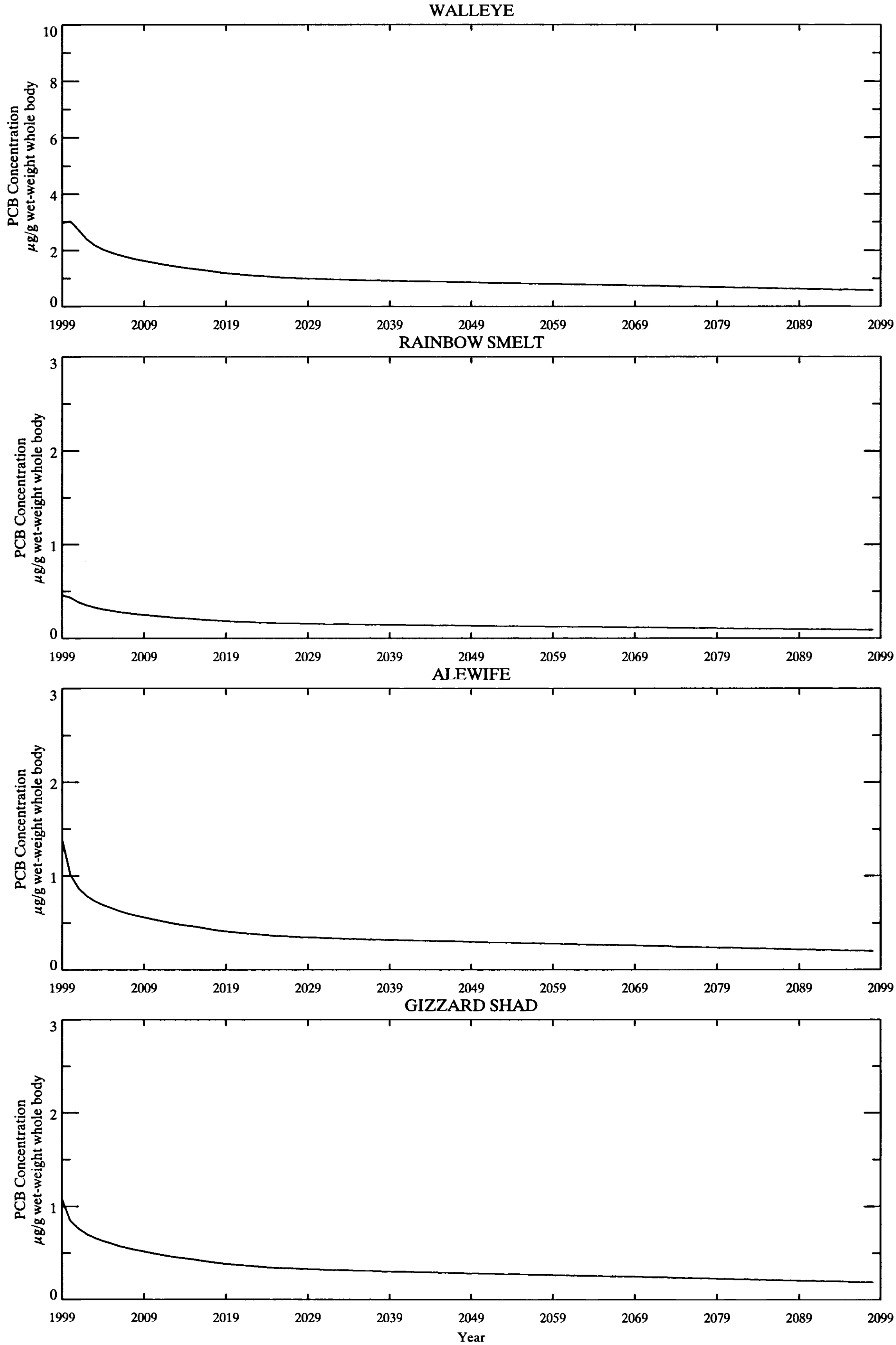

Projection: 0500z1_gb1000-fr0500z2_rn34_z12: Annual averages.

Figure 5-51. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: remediate >500 ppb; Green Bay: remediate >1000 ppb.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_proj_wet_ann_avg.pro

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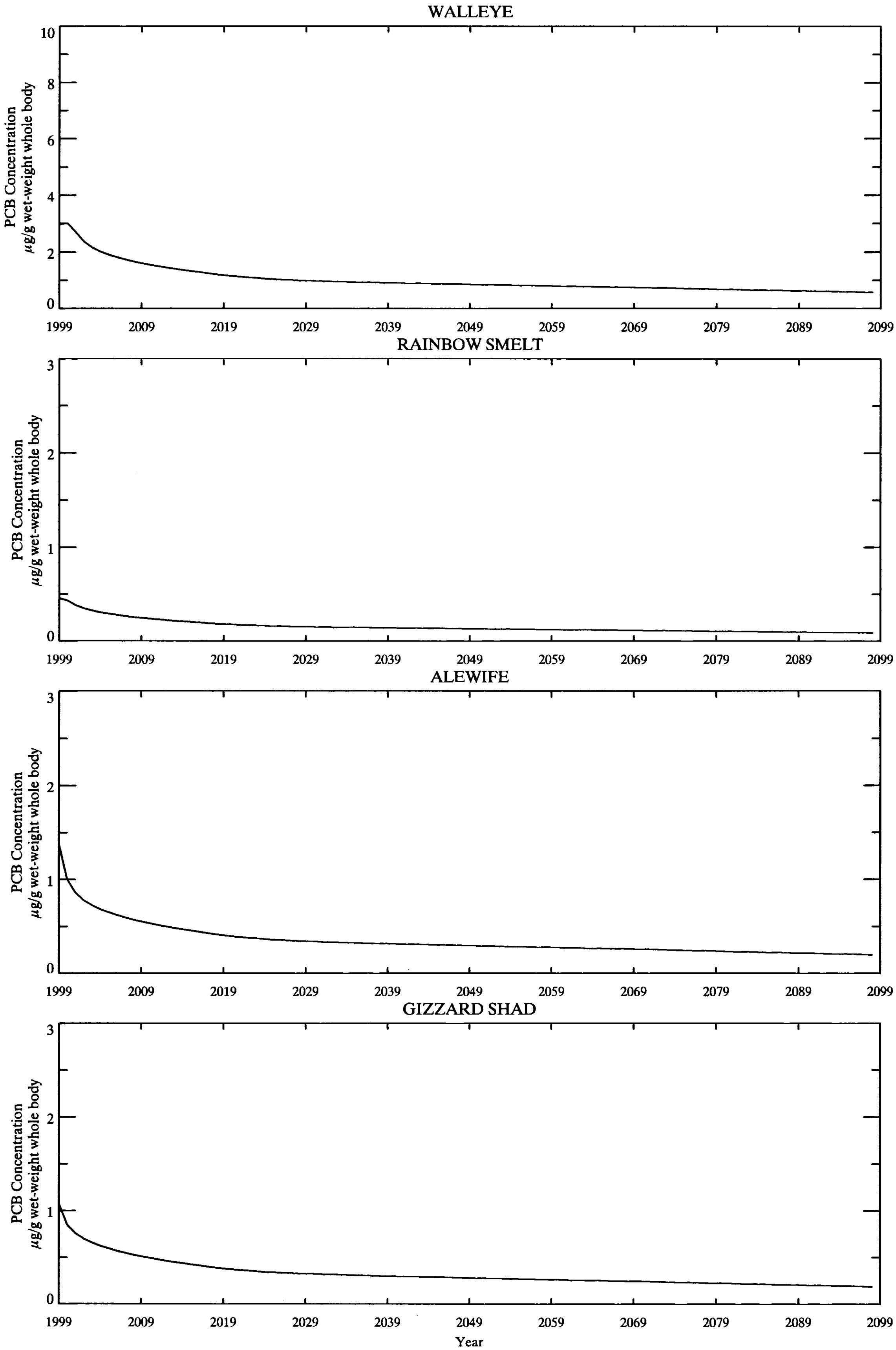
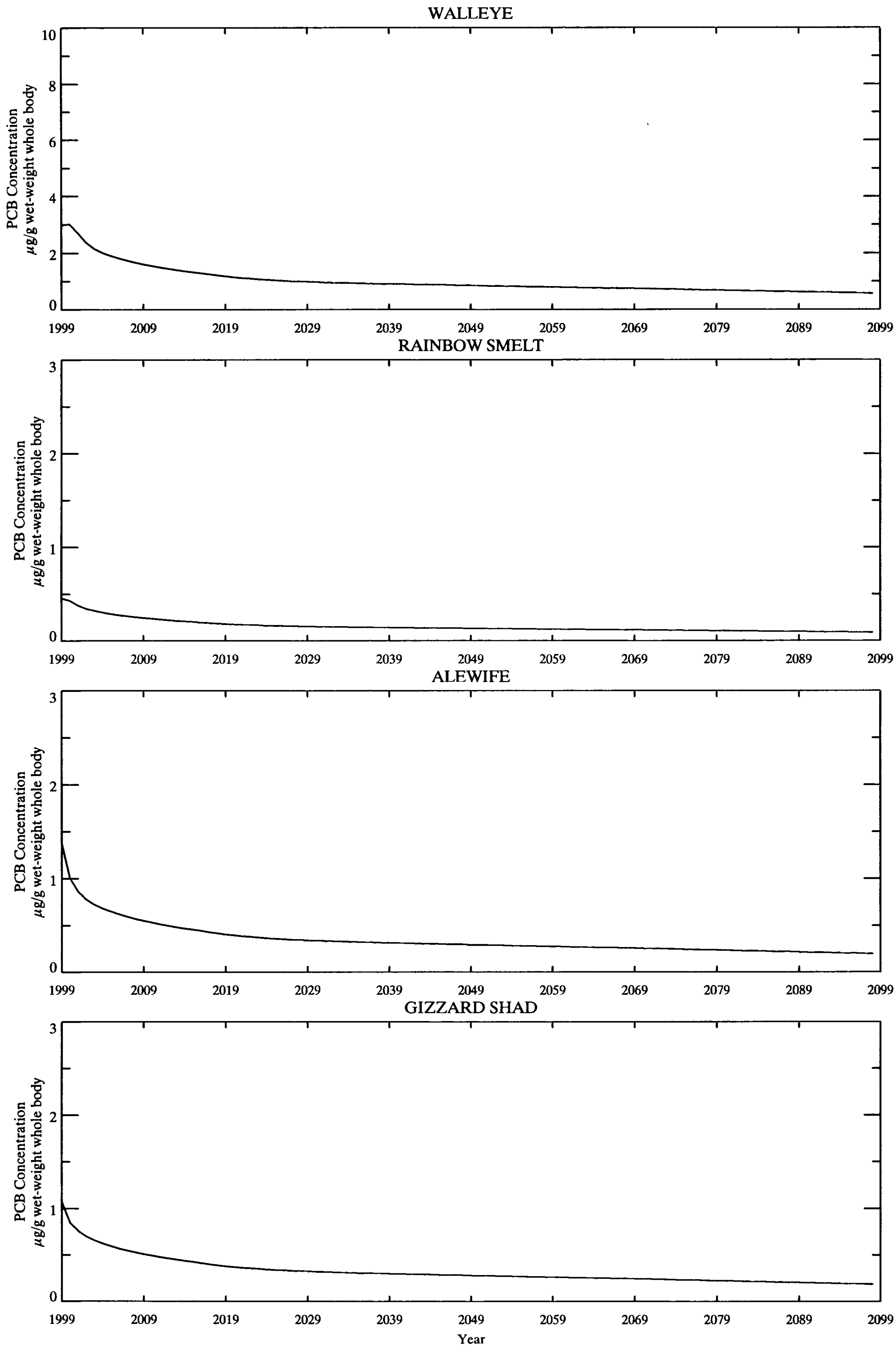


Projection: 0250z1_gb1000-fr0250z2_rn34_z12: Annual averages.

Figure 5-52. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: remediate >250 ppb; Green Bay: remediate >1000 ppb.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_proj_wet_ann_avg.pro

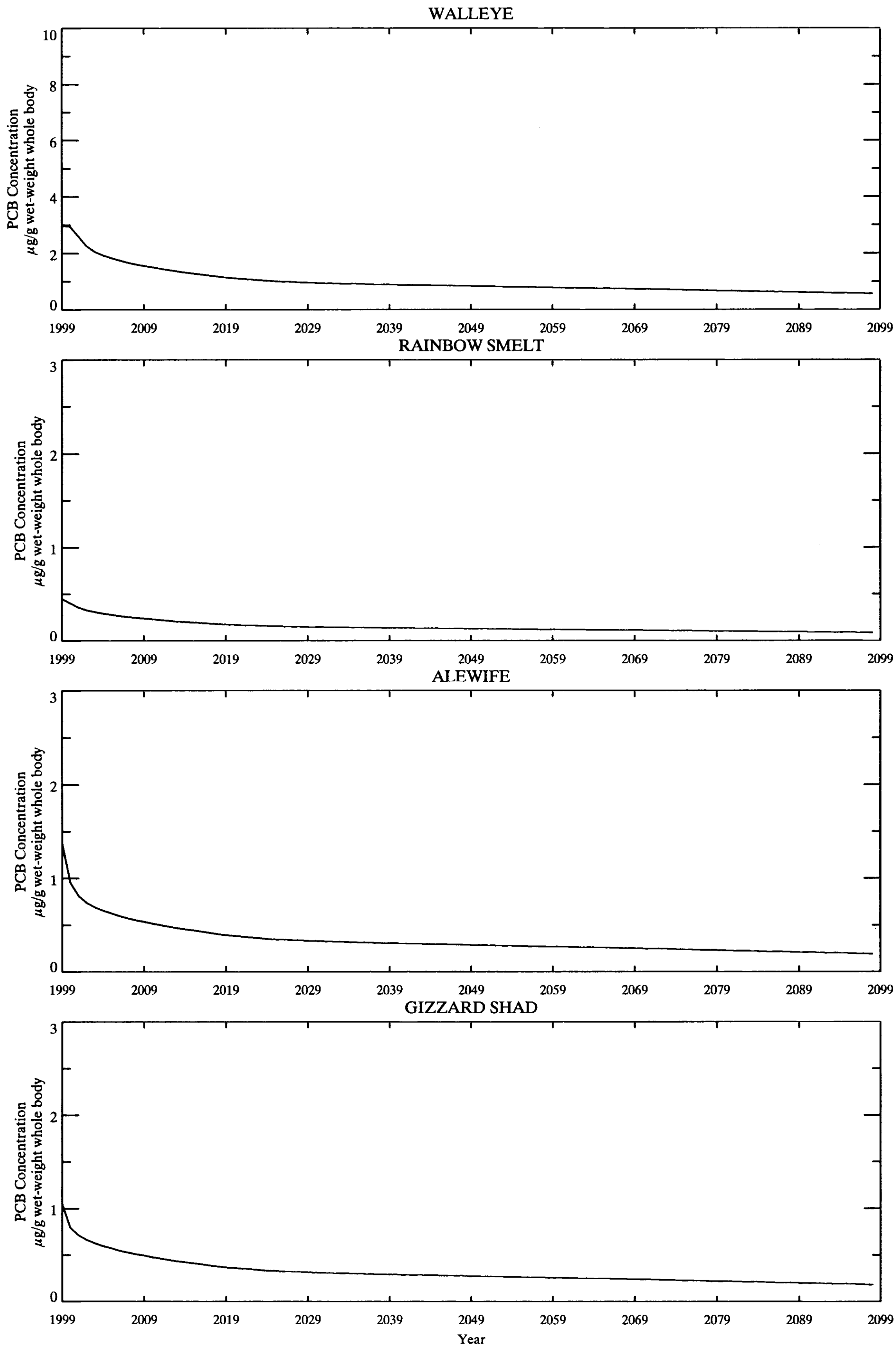
Mon May 14 15:26:04 2001



Projection: 0125z1_gb1000-fr0125z2_rn34_z12: Annual averages.

Figure 5-53. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: remediate >125 ppb; Green Bay: remediate >1000 ppb.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_proj_wet_ann_avg.pro
Mon May 14 15:27:43 2001

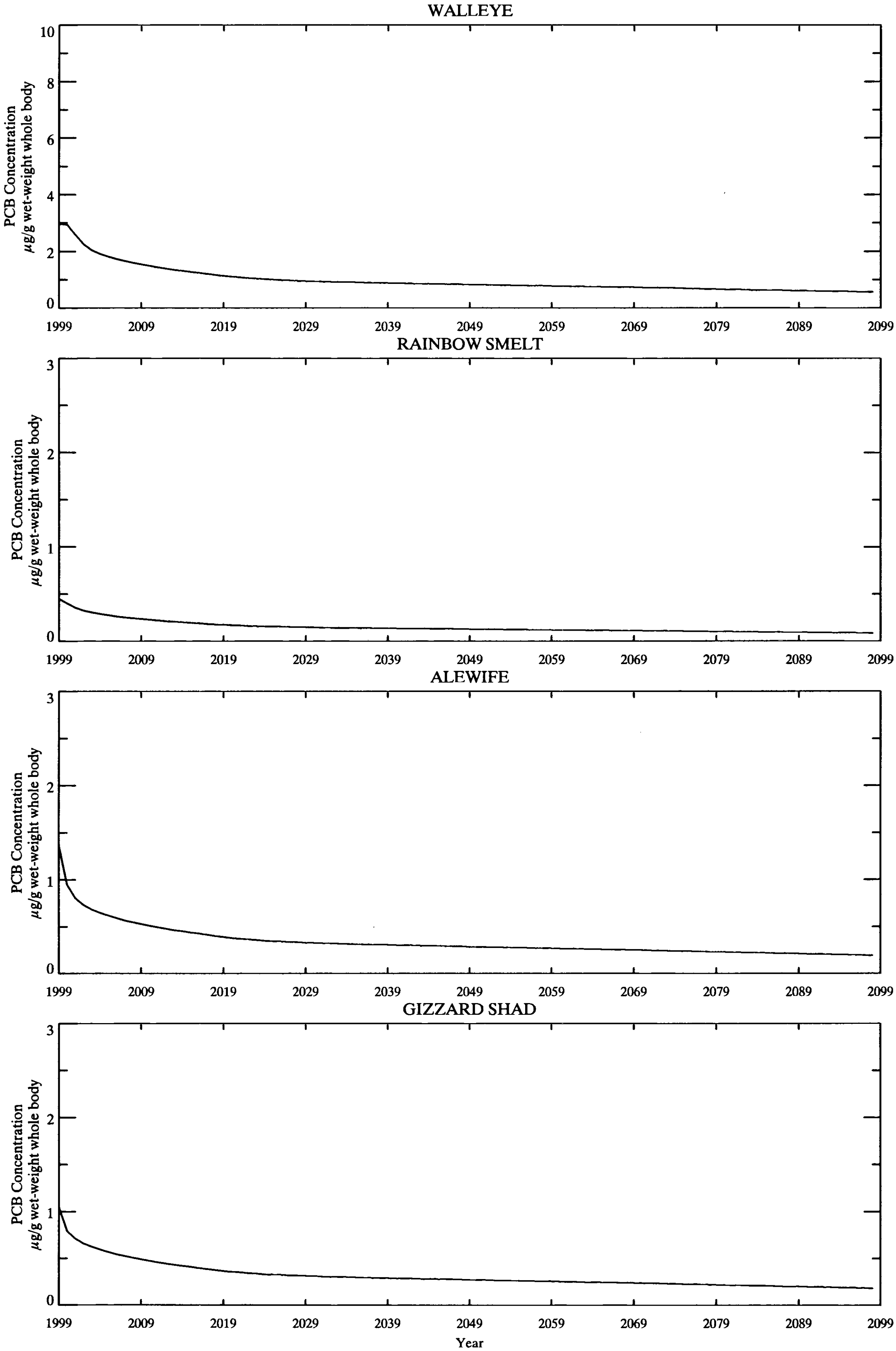


Projection: 0500z1_gb0500-fr0500z2_rn34_z12: Annual averages.

Figure 5-54. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: remediate >500 ppb; Green Bay: remediate >500 ppb.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_proj_wet_ann_avg.pro

Mon May 14 15:29:17 2001



Projection: 0250z1_gb0500-fr0250z2_rn34_z12: Annual averages.

Figure 5-55. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: remediate >250 ppb; Green Bay: remediate >500 ppb

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_proj_wet_ann_avg.pro
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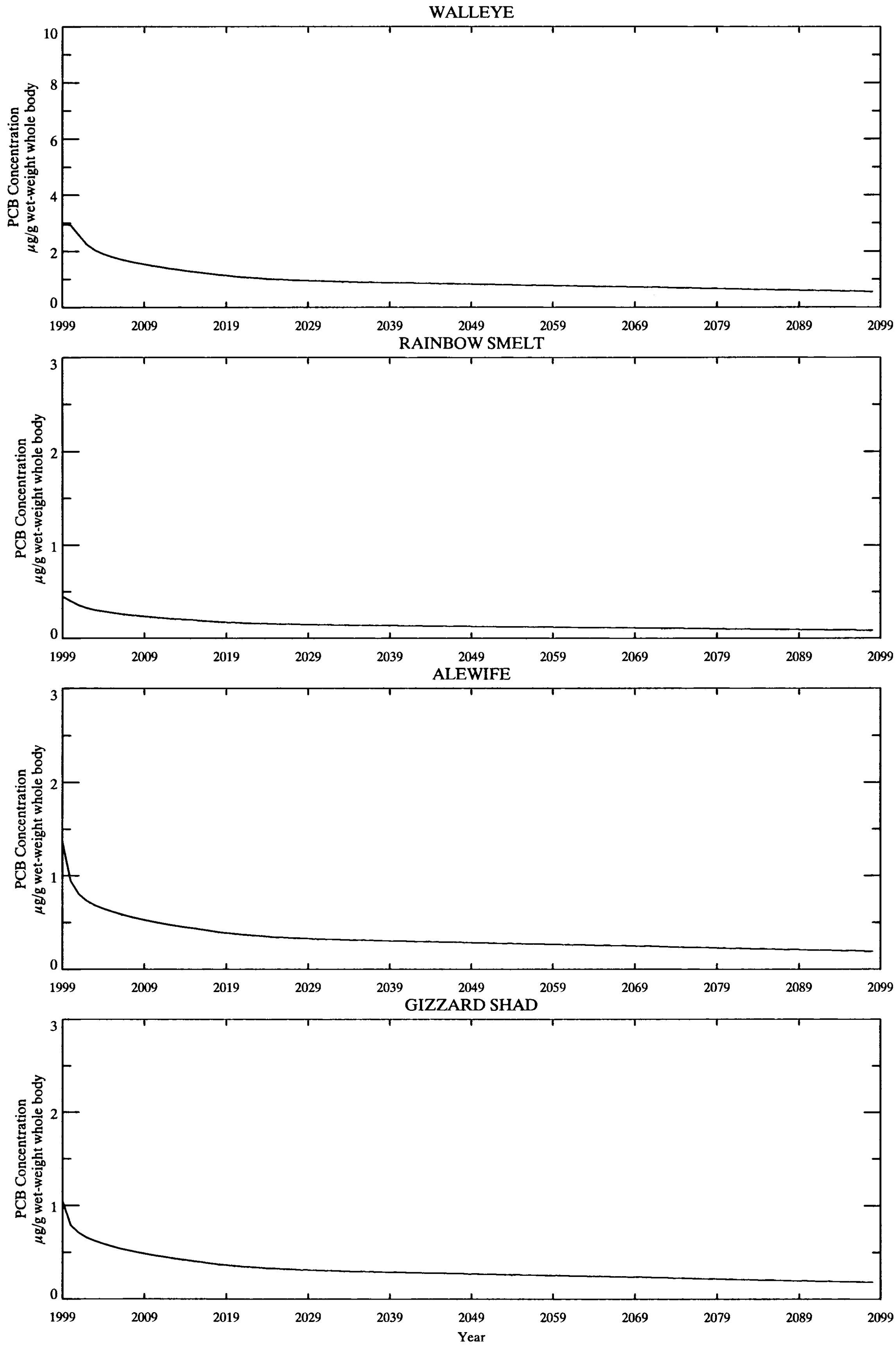

Projection: 0125z1_gb0500-fr0125z2_rn34_z12: Annual averages.

Figure 5-56. GBFood projection results. Average computed total PCB concentrations in fish resident in Zone 2 based on Fox River: remediate >125 ppb; Green Bay: remediate >500 ppb.

beth - D:\THEfox\model\Biota\Projections\Zones12\plots\Z2_proj_wet_ann_avg.pro

Mon May 14 15:32:28 2001

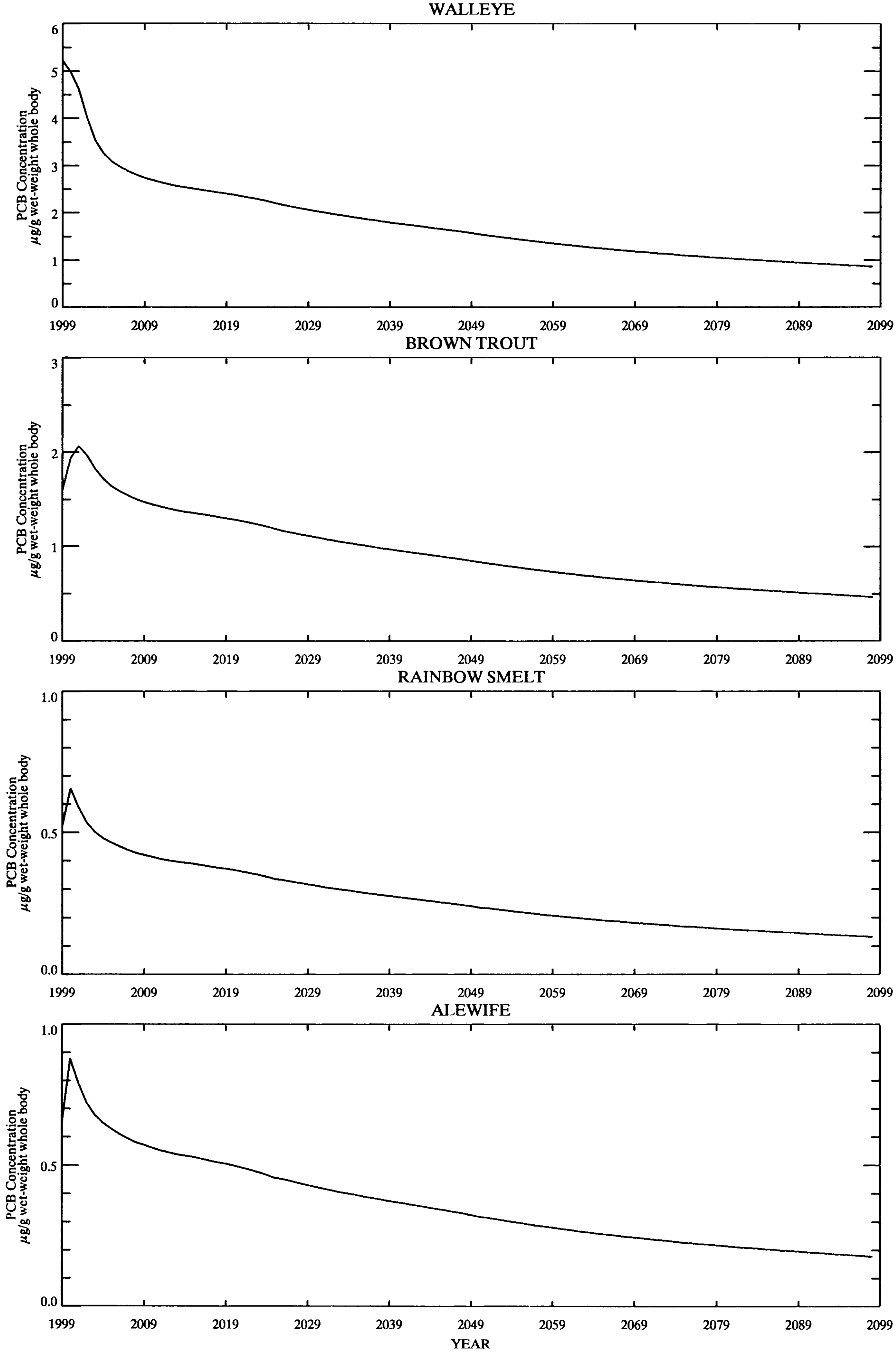

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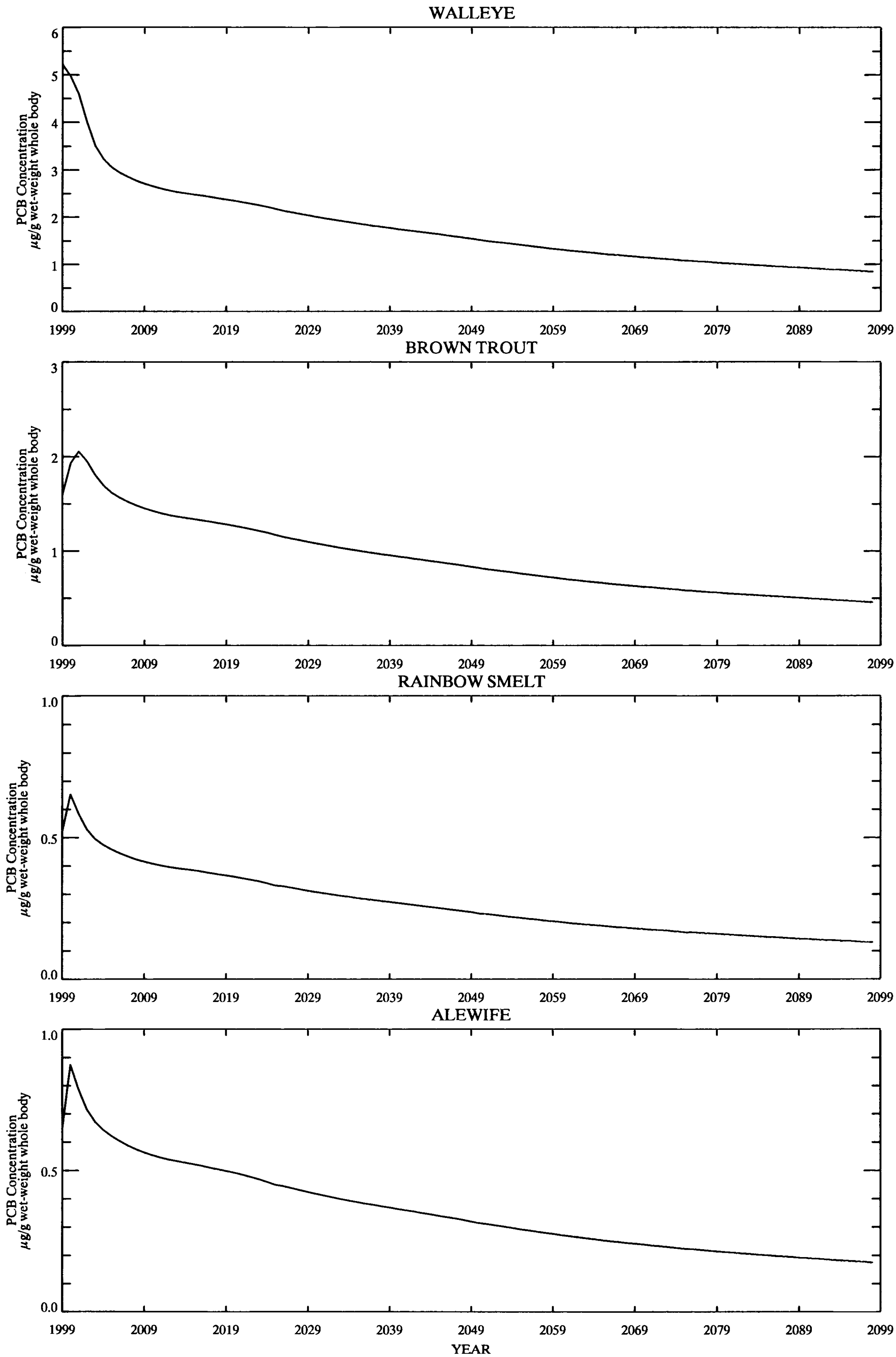
Figure 5-57. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: >5000 ppb; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro

Mon May 14 14:41:50 2001

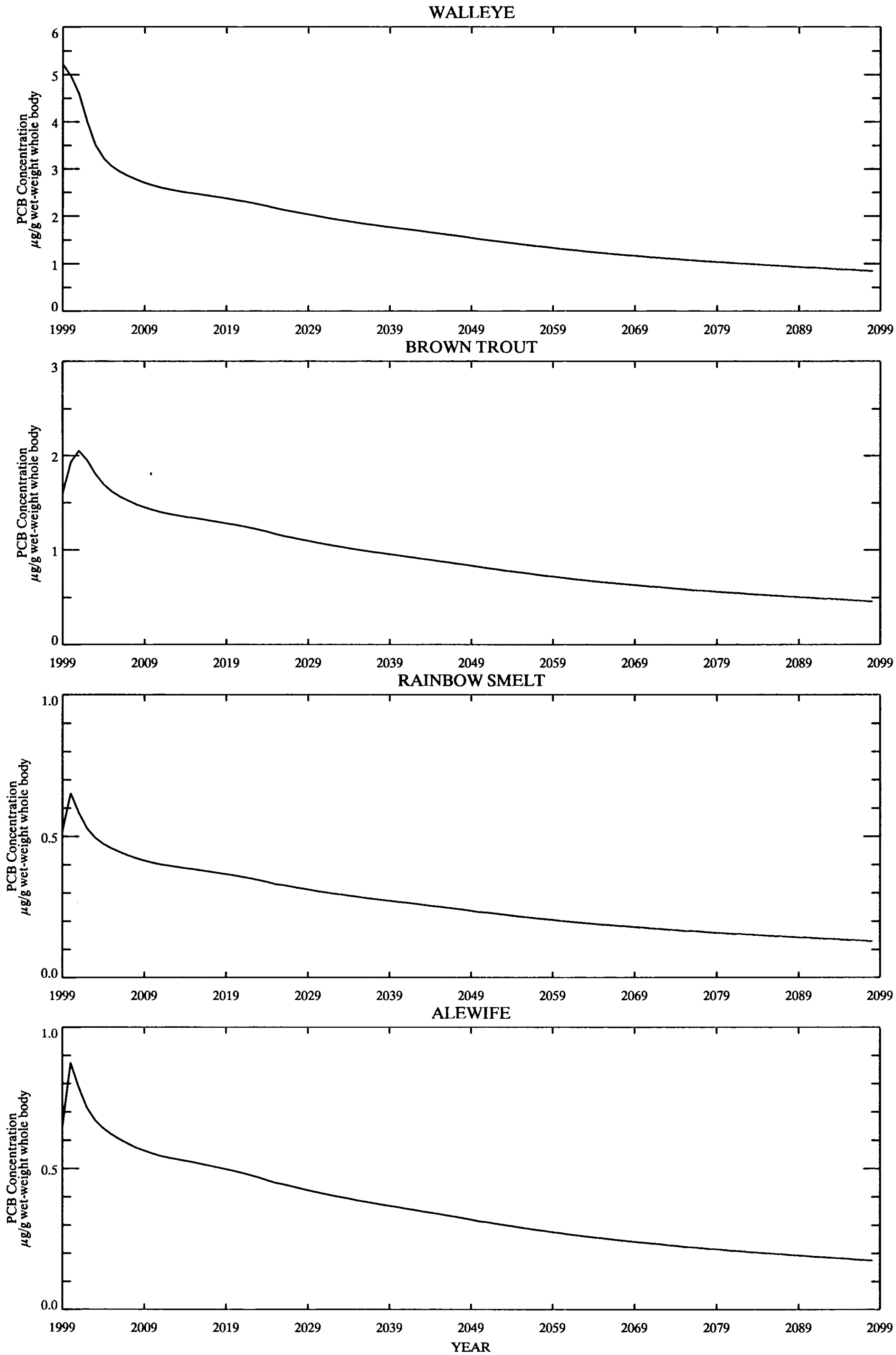


Projection: gbNOAC-fr1000_0-5_0-10_rn29_z3a: Annual averages.

Figure 5-58. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: >1000 ppb; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro

Mon May 14 14:47:44 2001

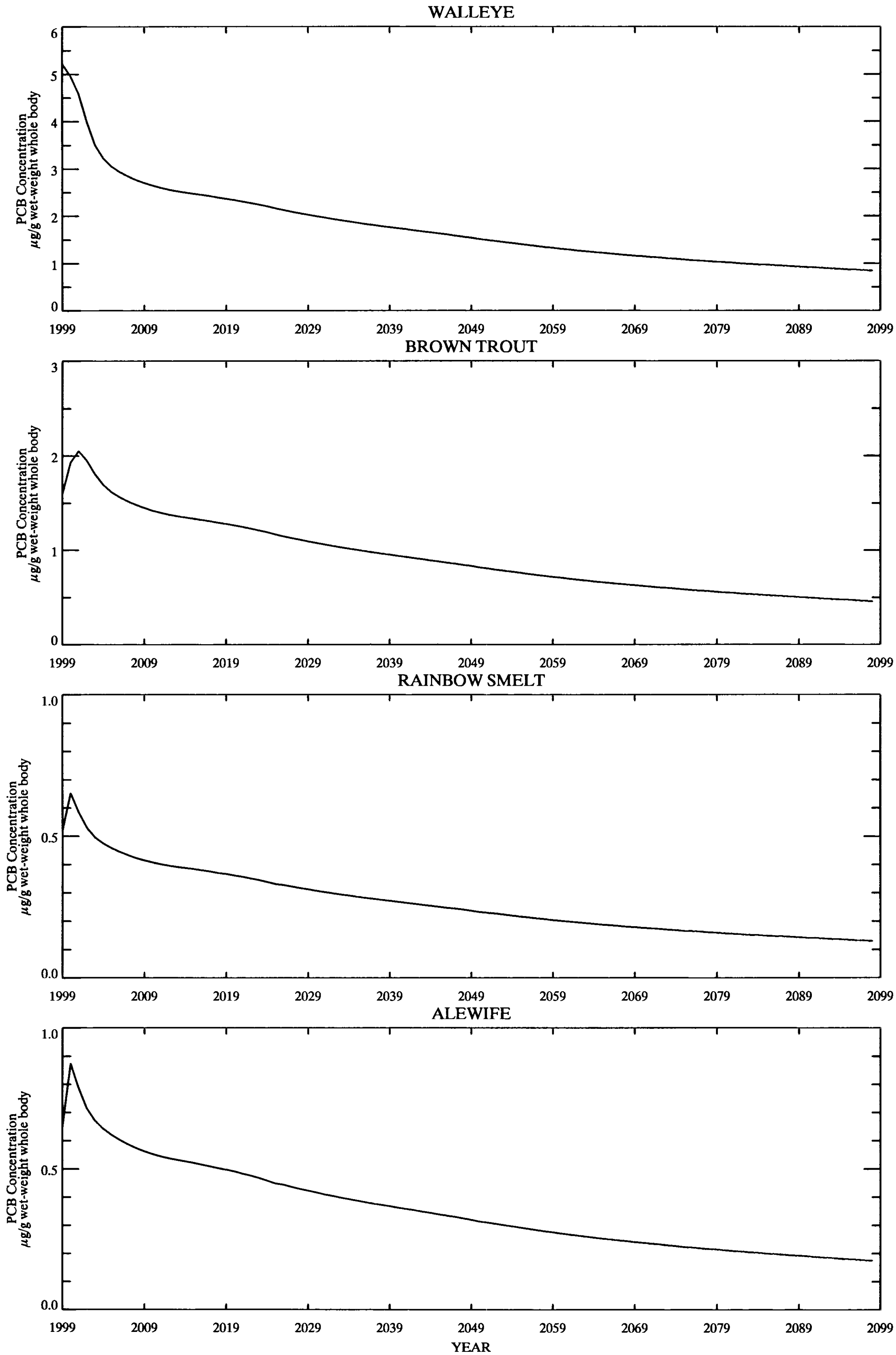


Projection: gbNOAC-fr0500_0-5_0-10_rn29_z3a: Annual averages.

Figure 5-59. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: >500; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro

Mon May 14 14:49:08 2001

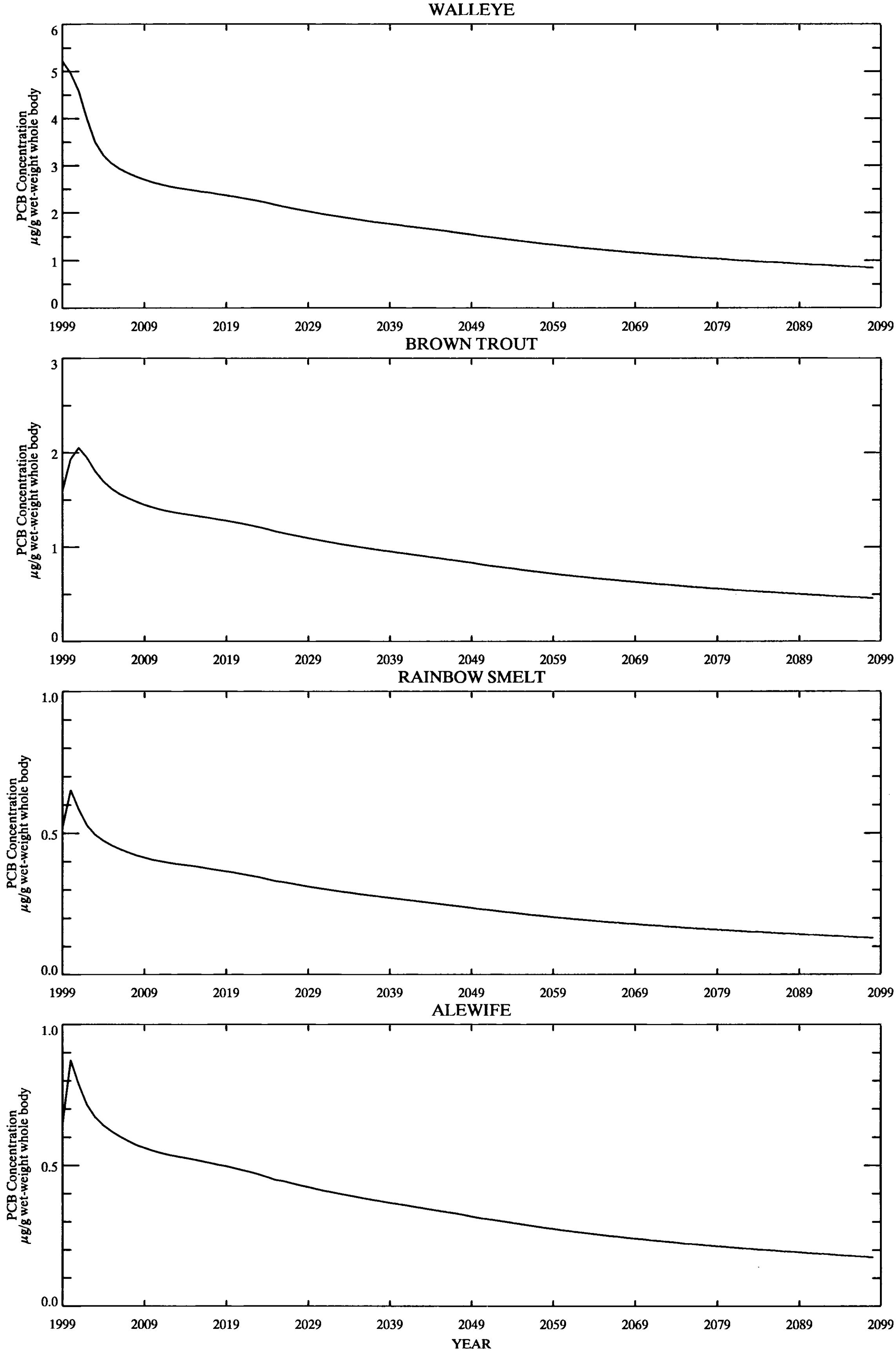


Projection: gbNOAC-fr0250_0-5_0-10_rn29_z3a: Annual averages.

Figure 5-60. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: >250 ppb; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro

Mon May 14 14:50:34 2001

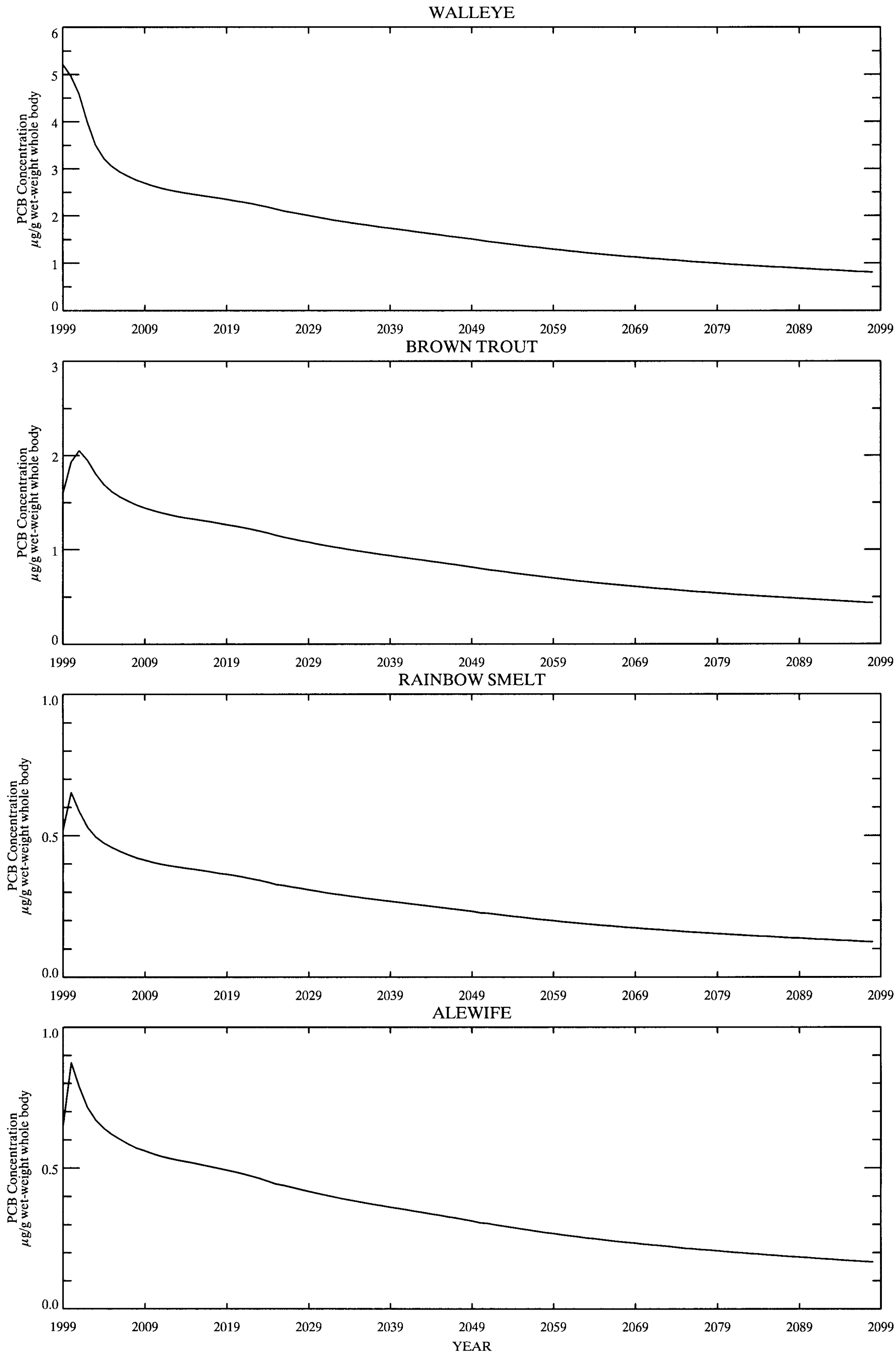


Projection: gbNOAC-fr0125_0-5_0-10_rn29_z3a: Annual averages.

Figure 5-61. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: >125 ppb; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro

Mon May 14 14:51:59 2001

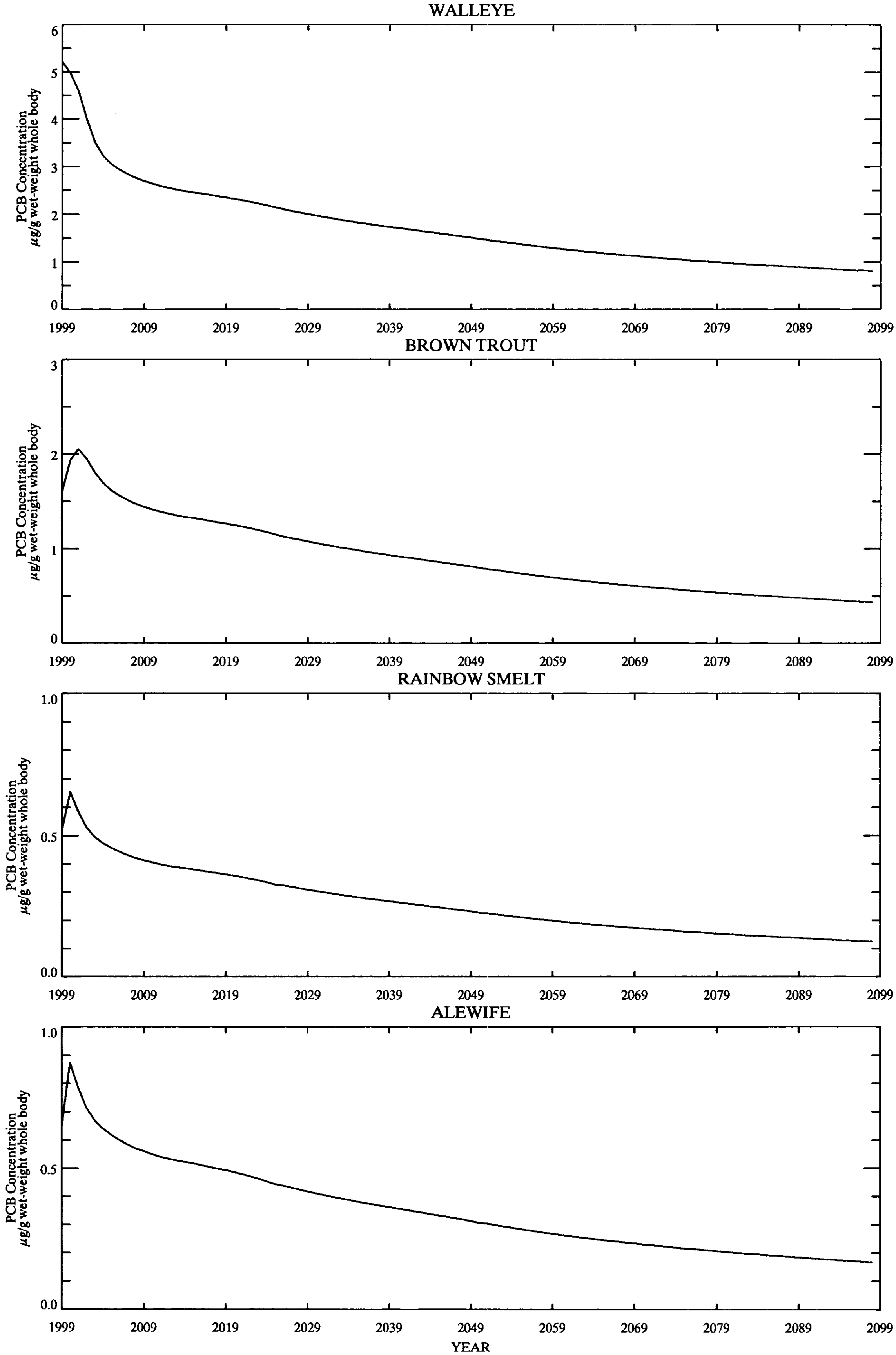


Projection: gbNOAC-fr000H_0-5_0-10_rn29_z3a: Annual averages.

Figure 5-62. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: Schedule "H"; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro

Mon May 14 14:53:23 2001

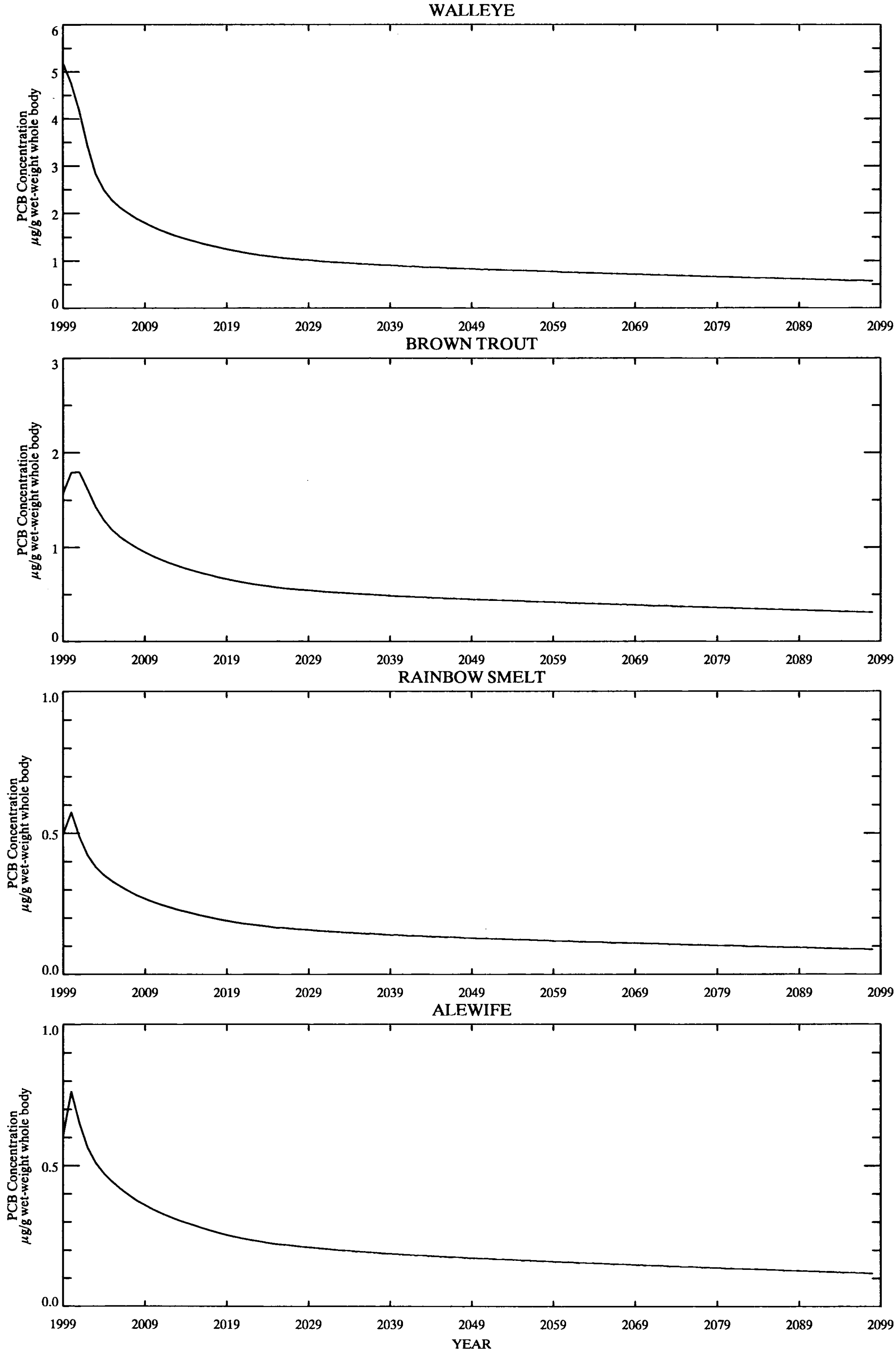


Projection: gbNOAC-fr000I_0-5_0-10_rn29_z3a: Annual averages.

Figure 5-63. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: Schedule "I"; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro

Mon May 14 15:11:55 2001

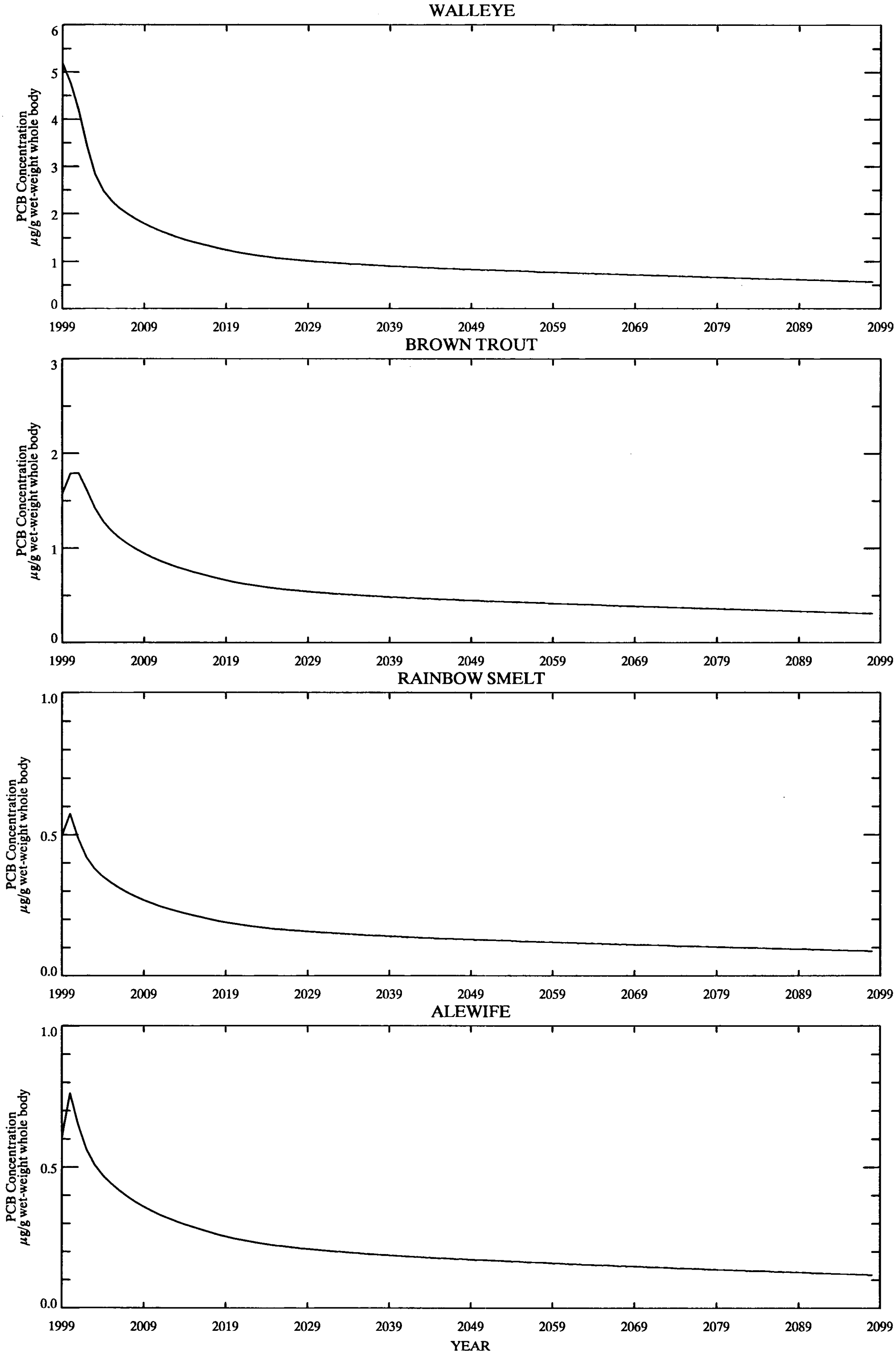


Projection: gb1000-fr1000_0-5_0-10_rn29_z3a: Annual averages.

Figure 5-64. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: >1000 ppb; Green Bay: >1000 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro

Mon May 14 14:56:18 2001

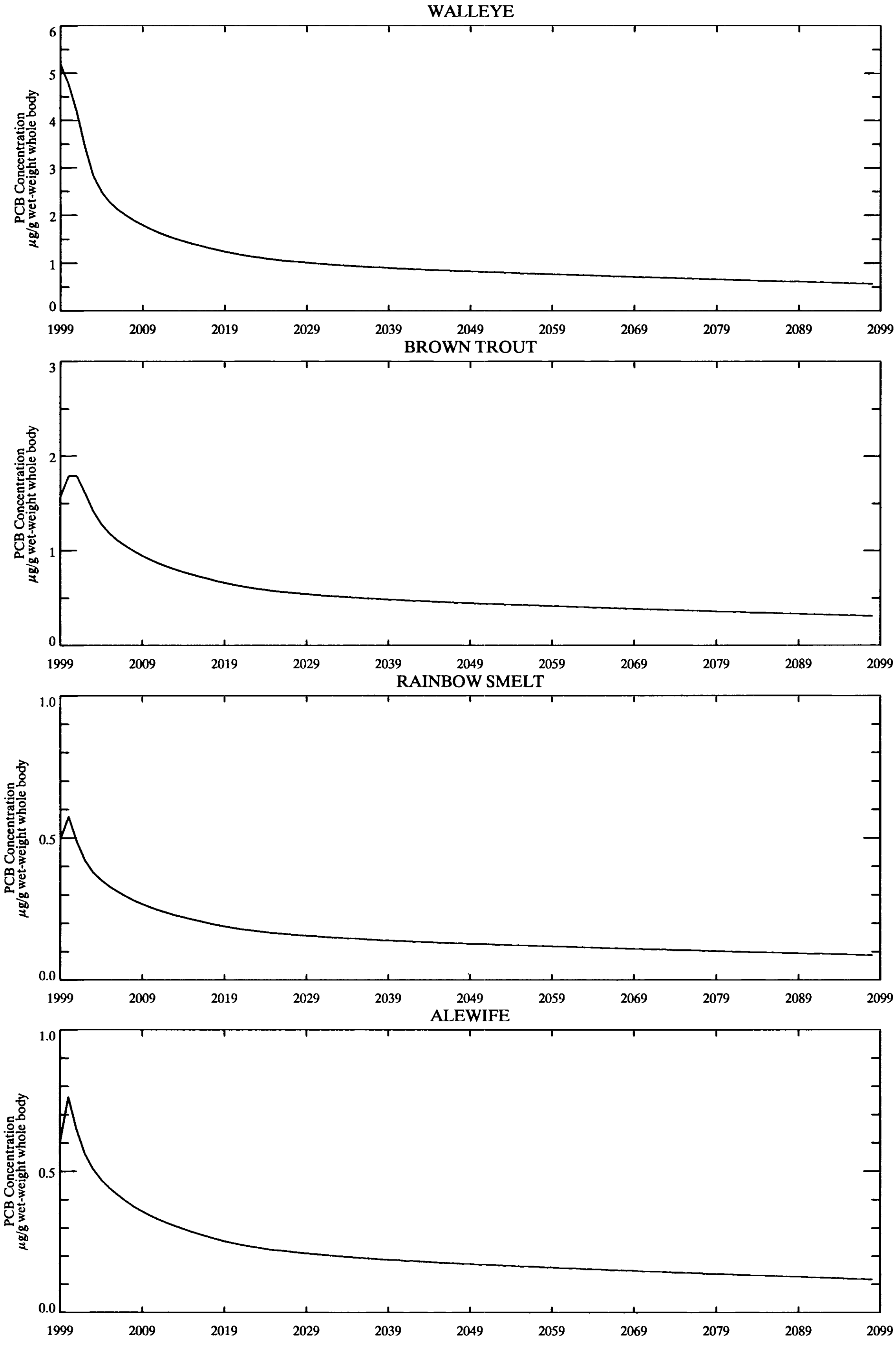


Projection: gb1000-fr0500_0-5_0-10_rn29_z3a: Annual averages.

Figure 5-65. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: >500 ppb; Green Bay: >1000 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro

Mon May 14 14:57:43 2001

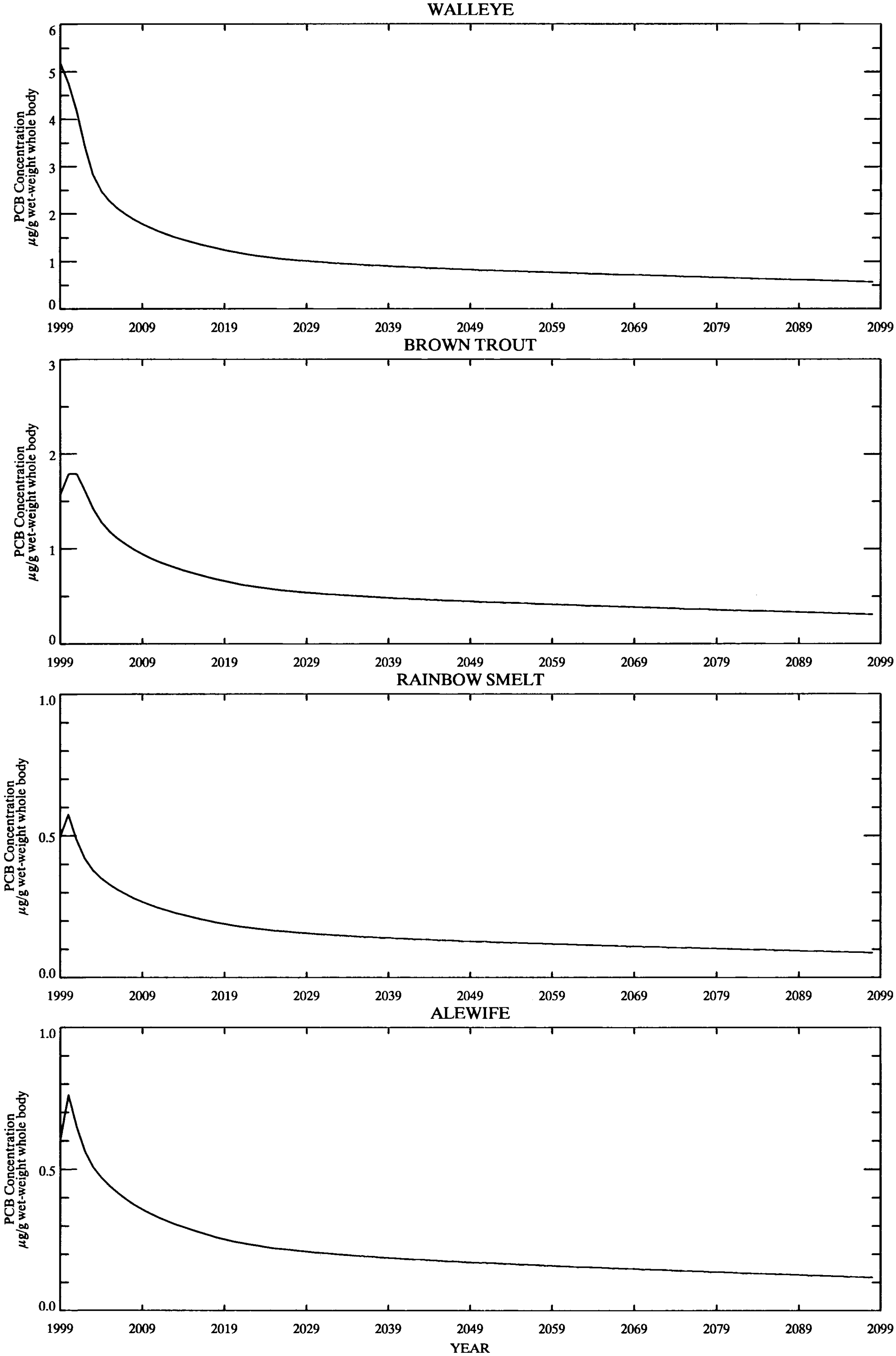


Projection: gb1000-fr0250_0-5_0-10_rn29_z3a: Annual averages.

Figure 5-66. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: >250 ppb; Green Bay: >1000 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro

Mon May 14 14:59:08 2001

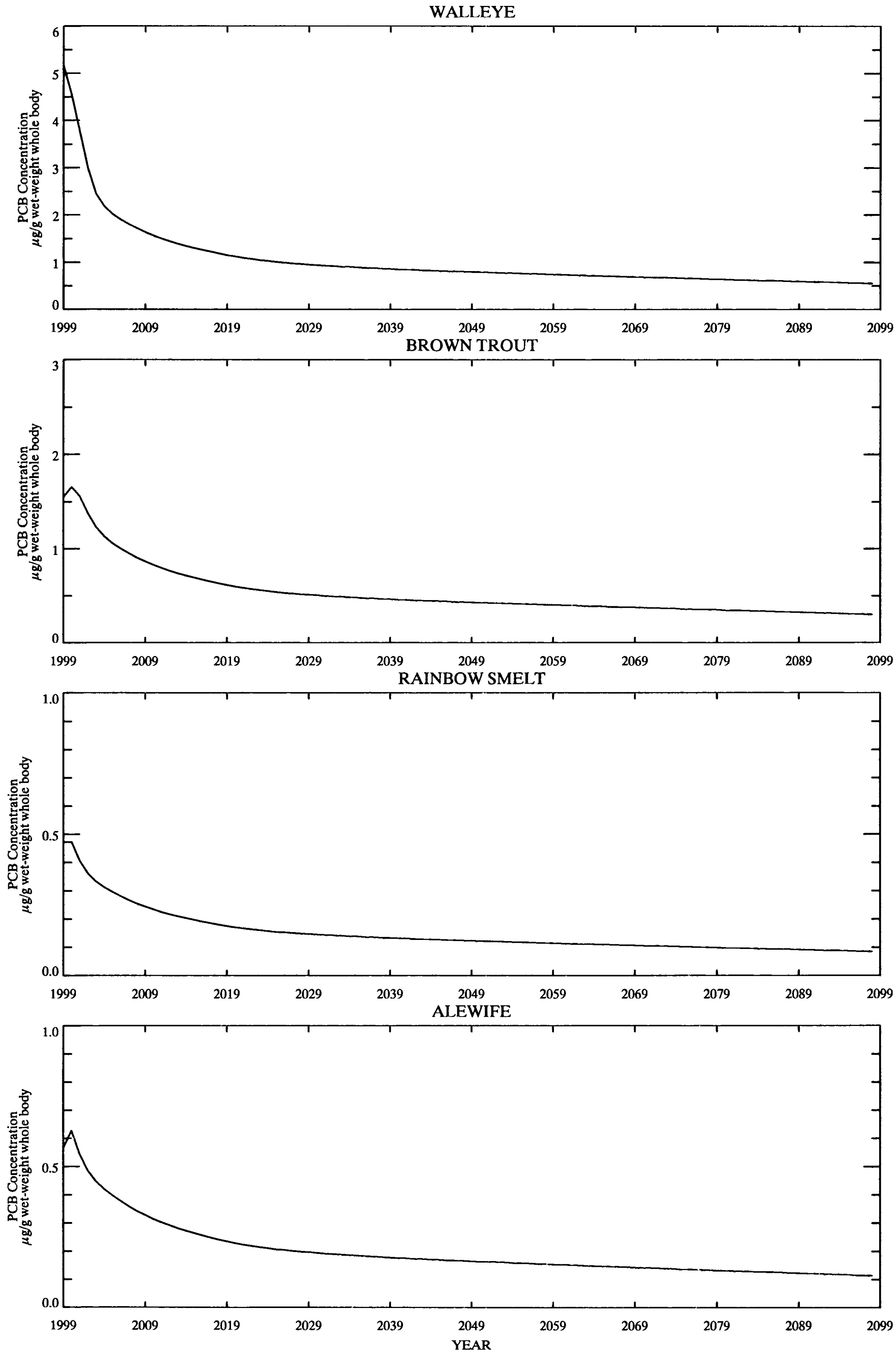


Projection: gb1000-fr0125_0-5_0-10_rn29_z3a: Annual averages.

Figure 5-67. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: >125 ppb; Green Bay: >1000 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro

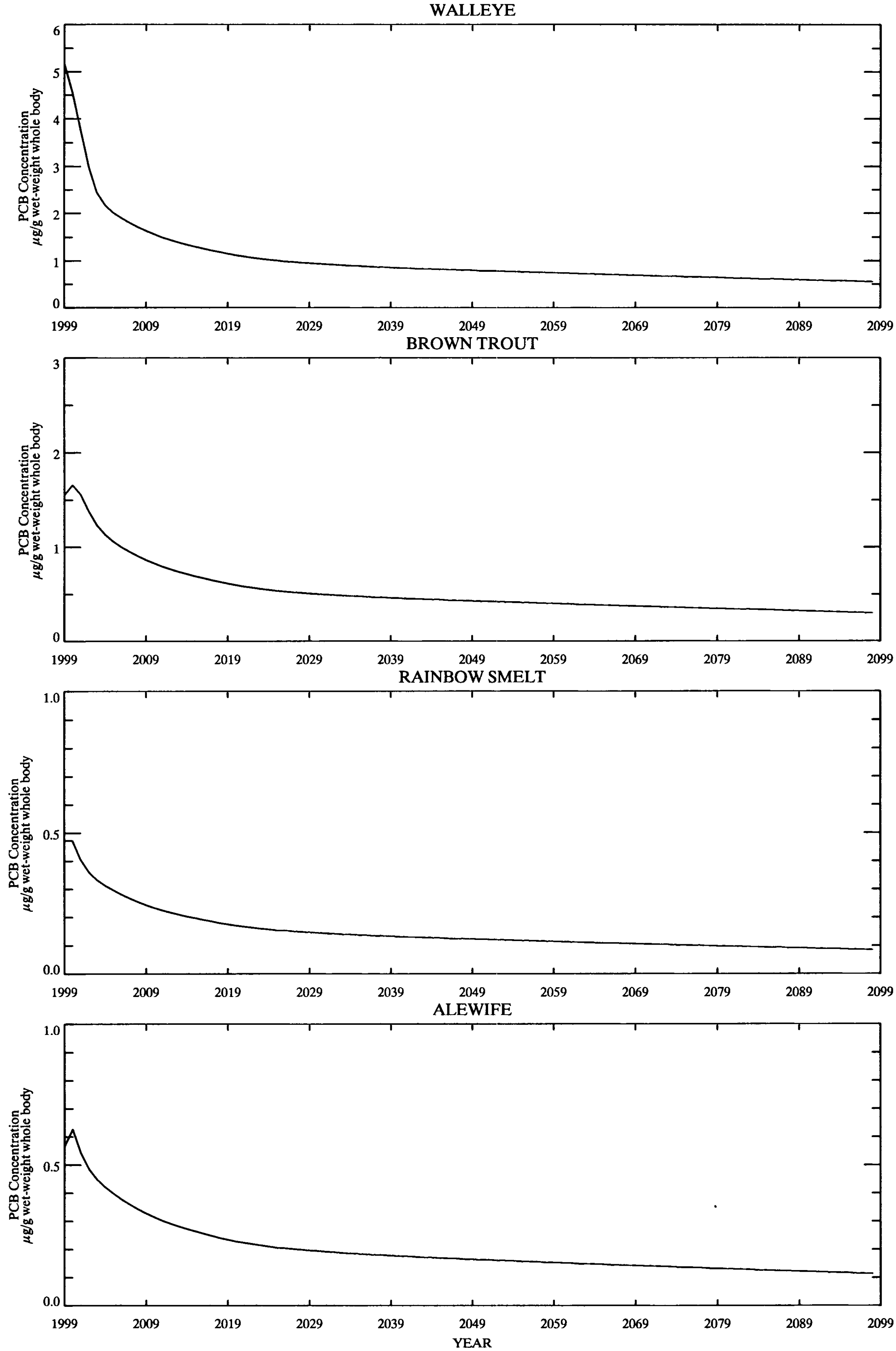
Mon May 14 15:00:35 2001



Projection: gb0500-fr0500_0-5_0-10_rn29_z3a: Annual averages.

Figure 5-68. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: >500 ppb; Green Bay: >500 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro
Mon May 14 15:02:00 2001

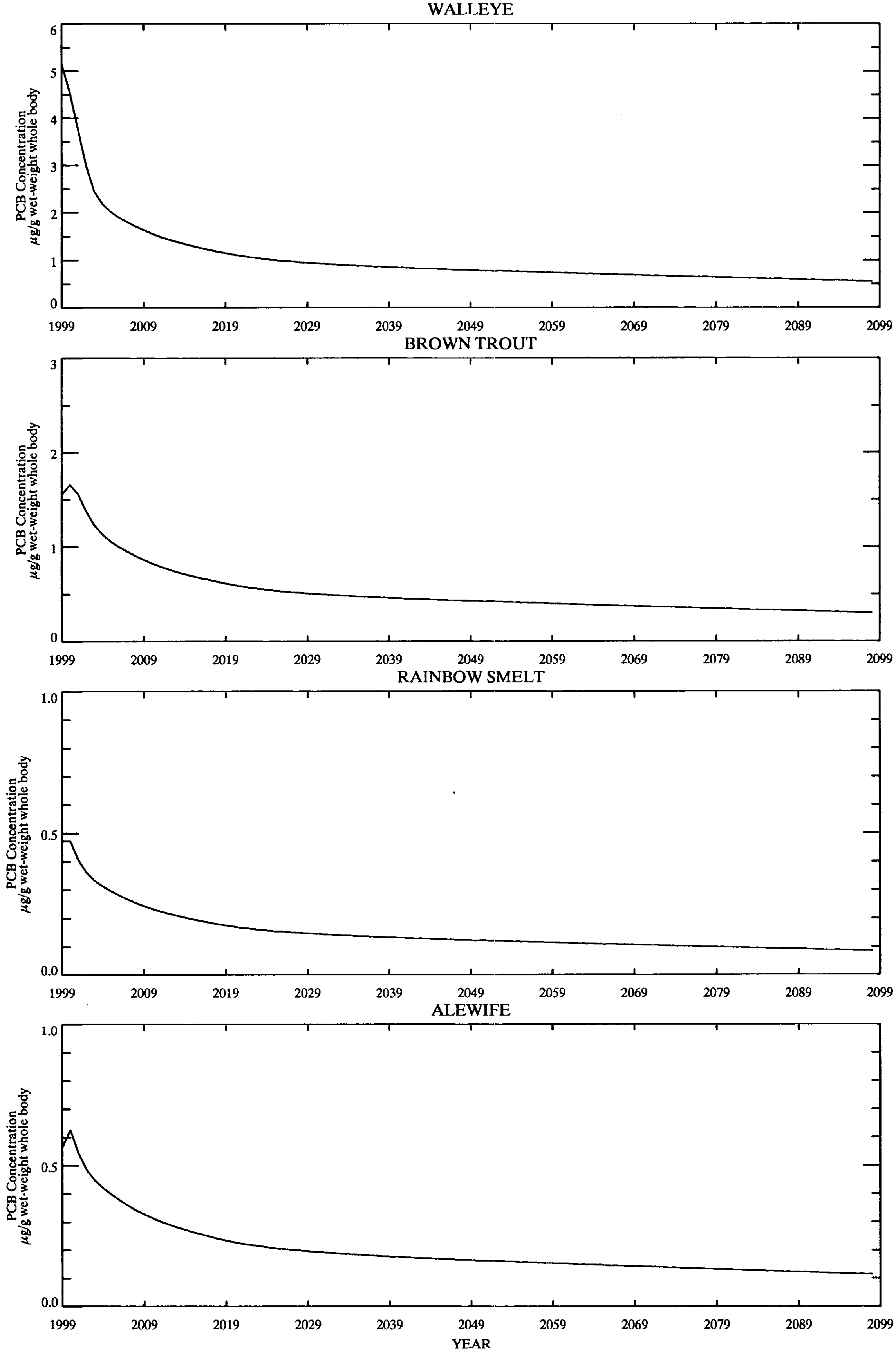


Projection: gb0500-fr0250_0-5_0-10_rn29_z3a: Annual averages.

Figure 5-69. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: >250 ppb; Green Bay: >500 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro

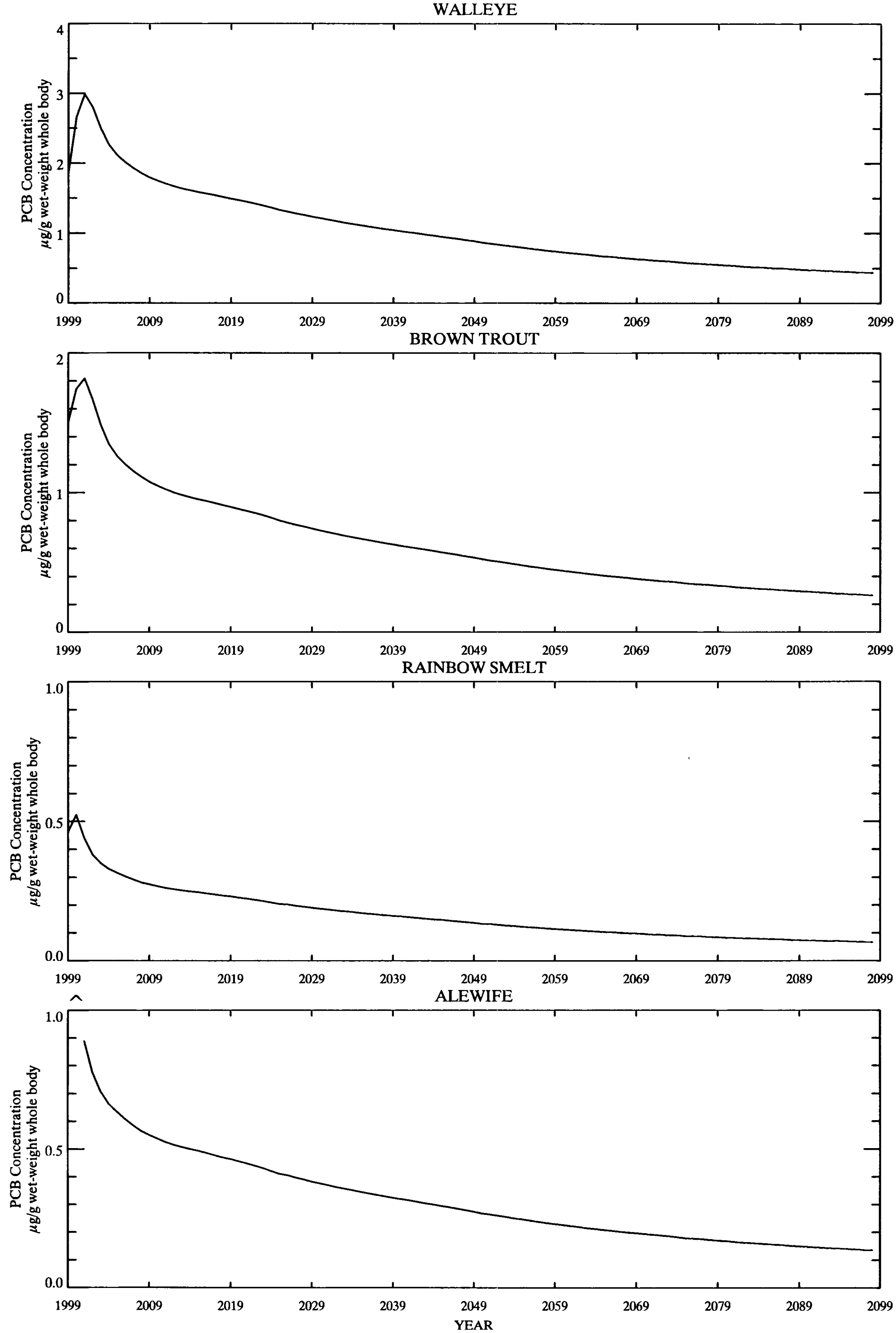
Mon May 14 15:03:27 2001



Projection: gb0500-fr0125_0-5_0-10_rn29_z3a: Annual averages.

Figure 5-70. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3A based on Fox River: >125 ppb; Green Bay: >500 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone3a\plots\z3a_proj_wet_ann_avg.pro
Mon May 14 15:04:54 2001

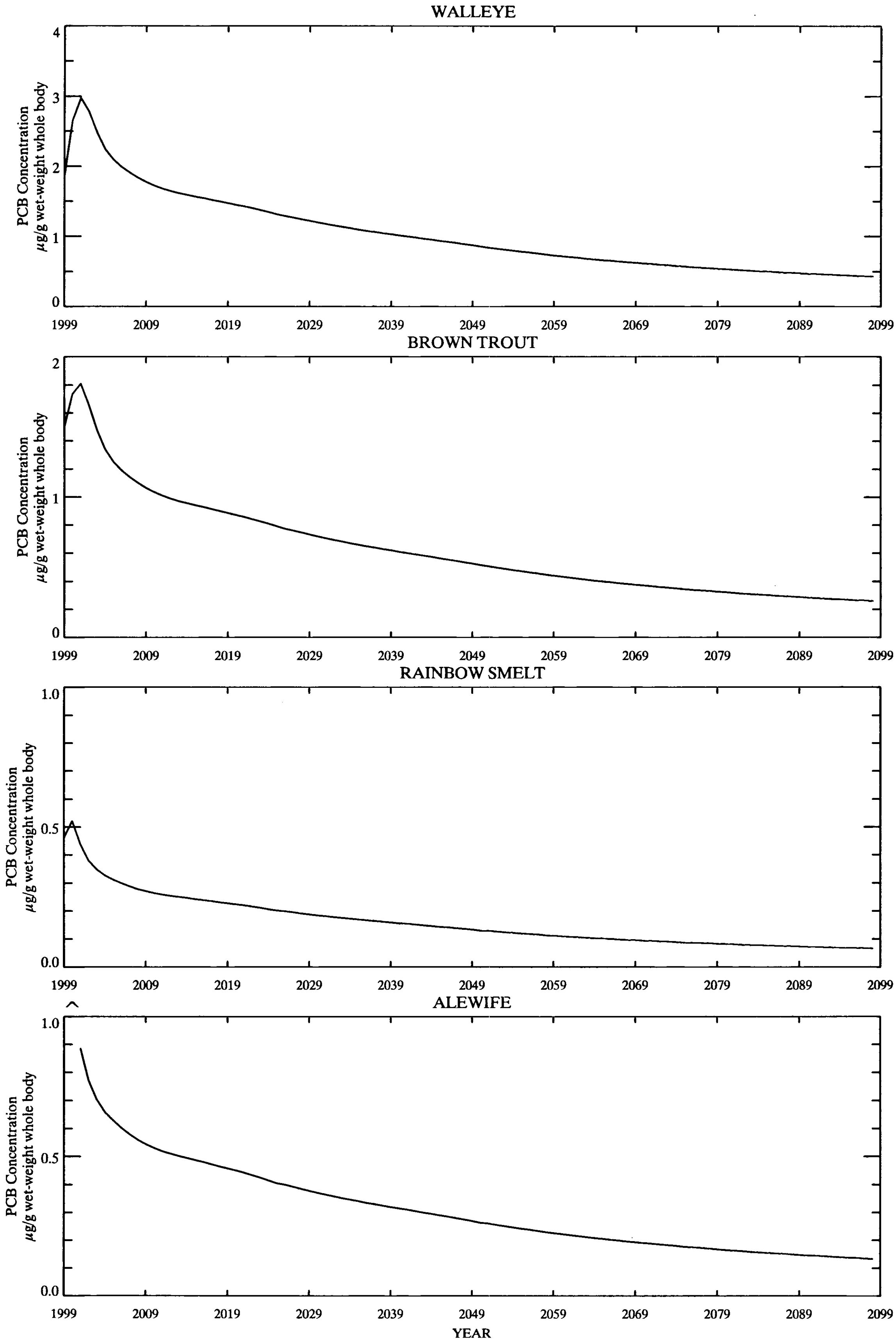


Projection: gbNOAC-fr5000_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-71. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: >5000 ppb; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 15:45:40 2001

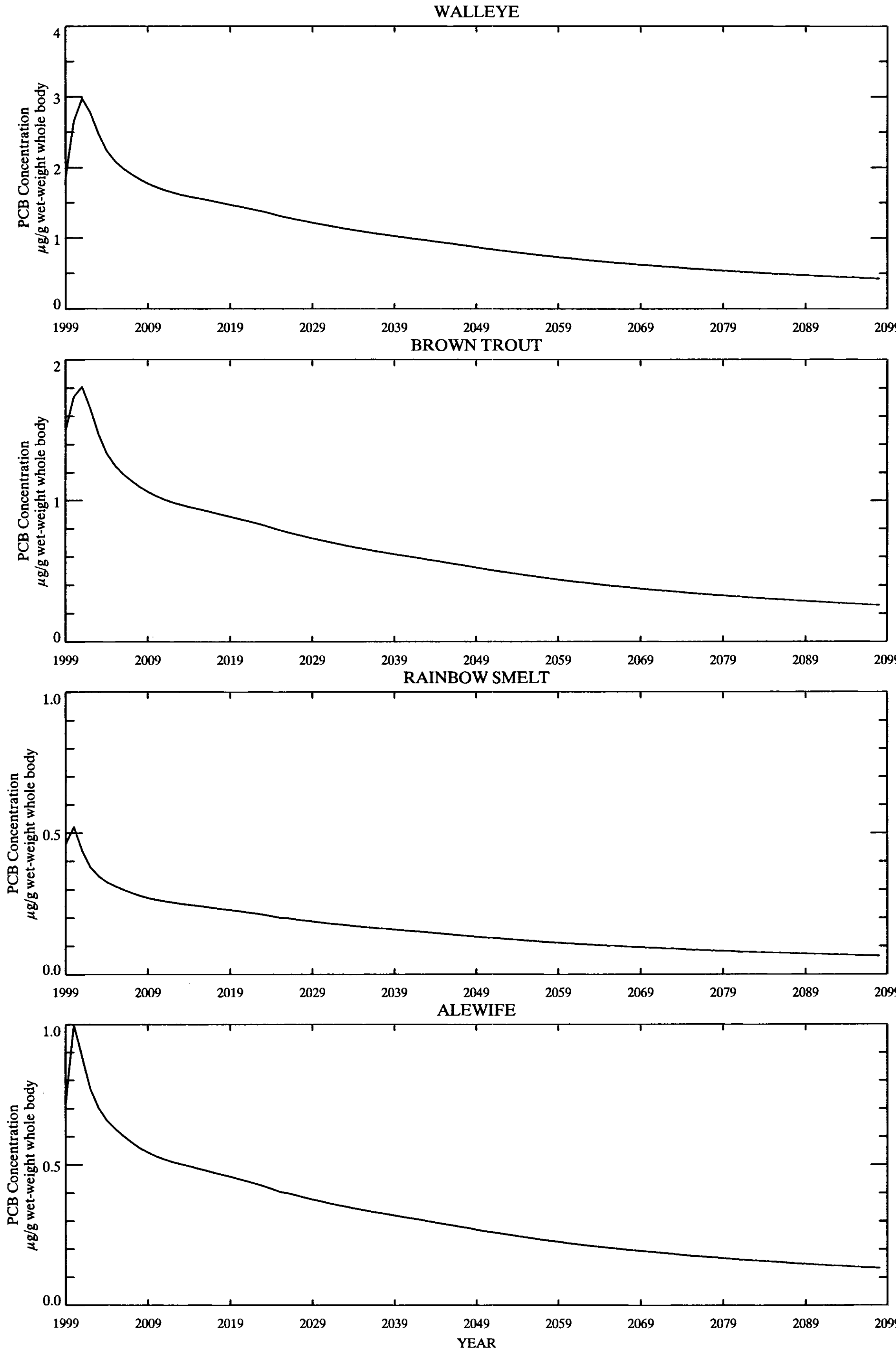


Projection: gbNOAC-fr1000_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-72. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: >1000 ppb; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 15:49:47 2001

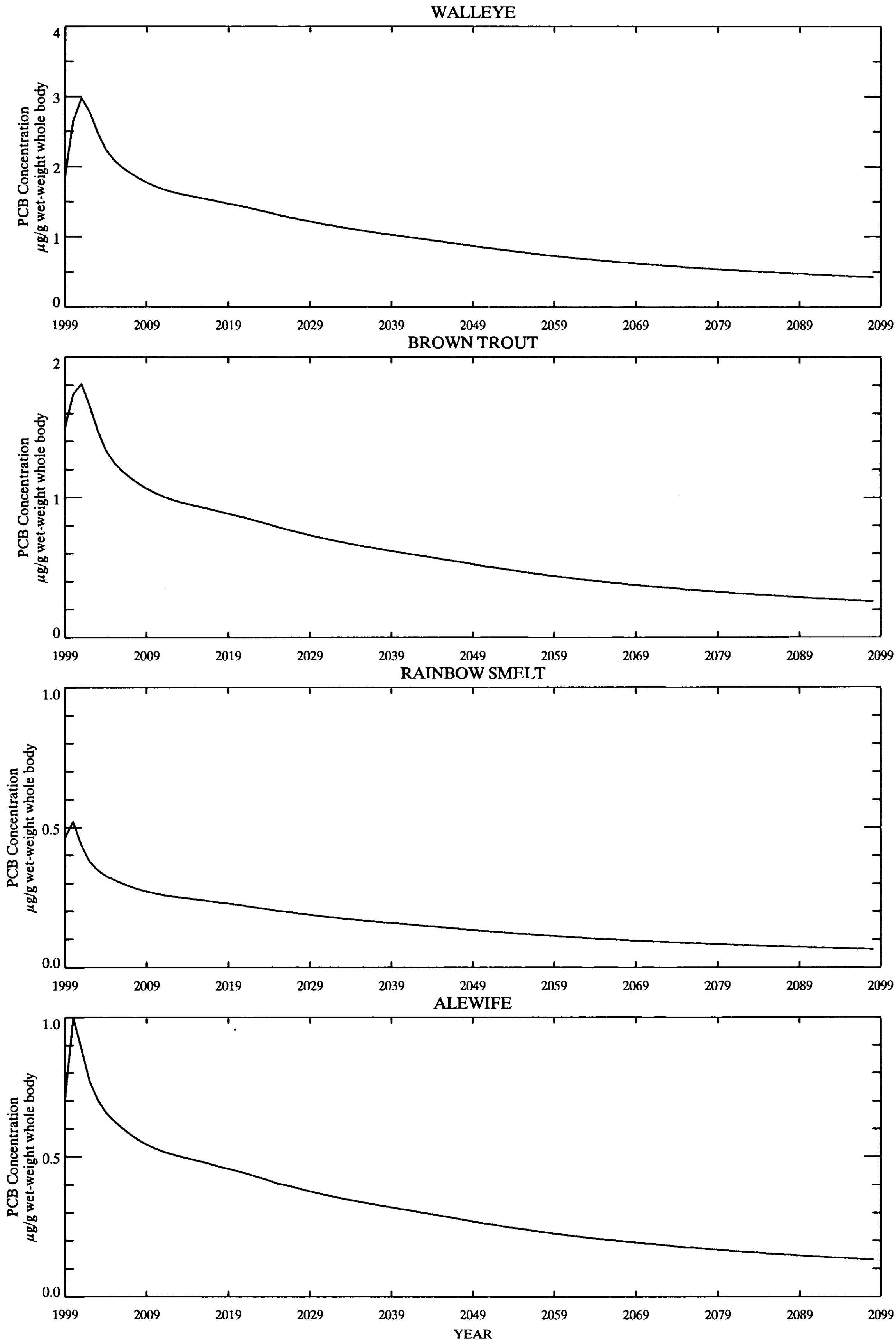


Projection: gbNOAC-fr0500_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-73. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: >500; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 15:50:59 2001

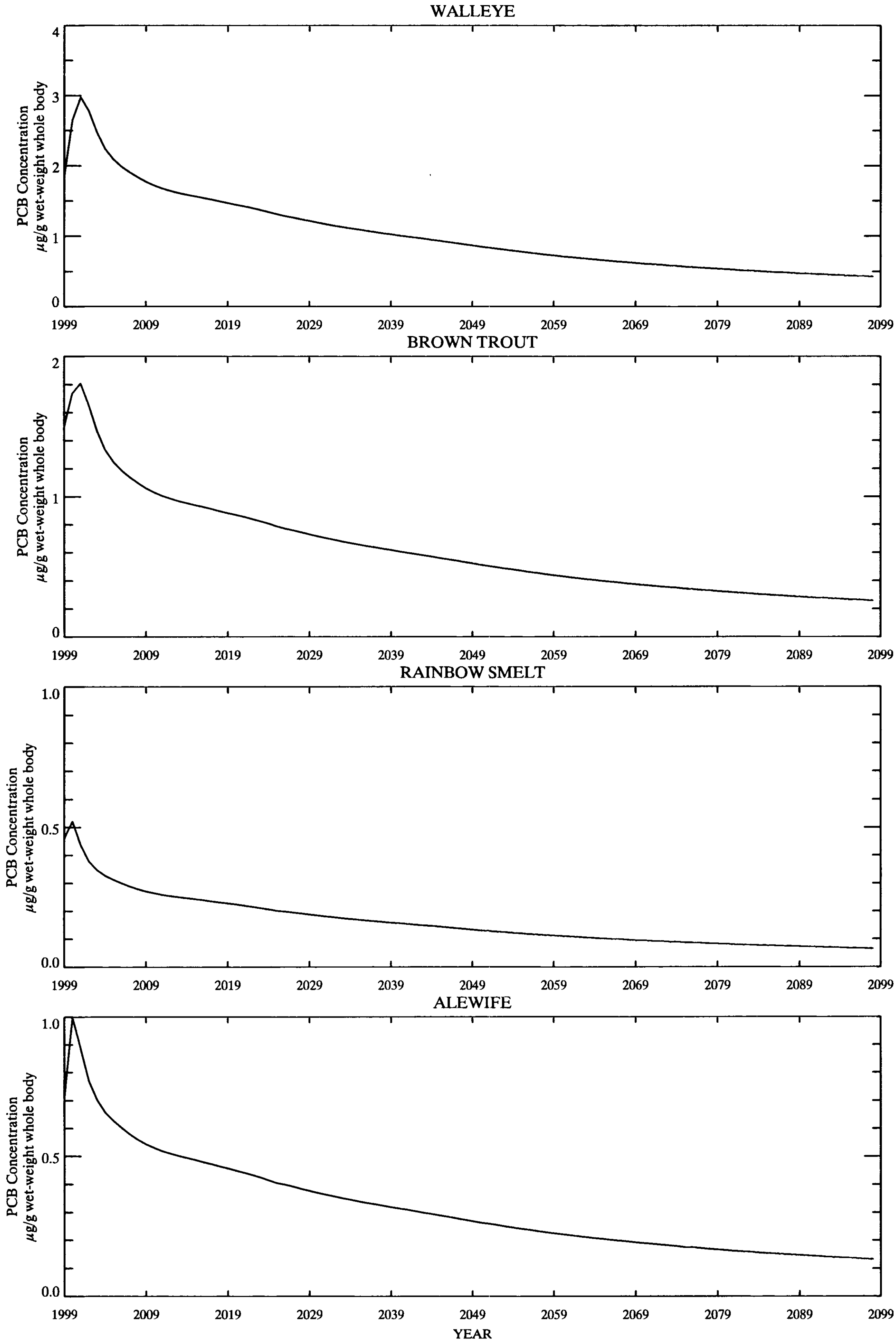


Projection: gbNOAC-fr0250_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-74. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: >250 ppb; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 15:52:13 2001

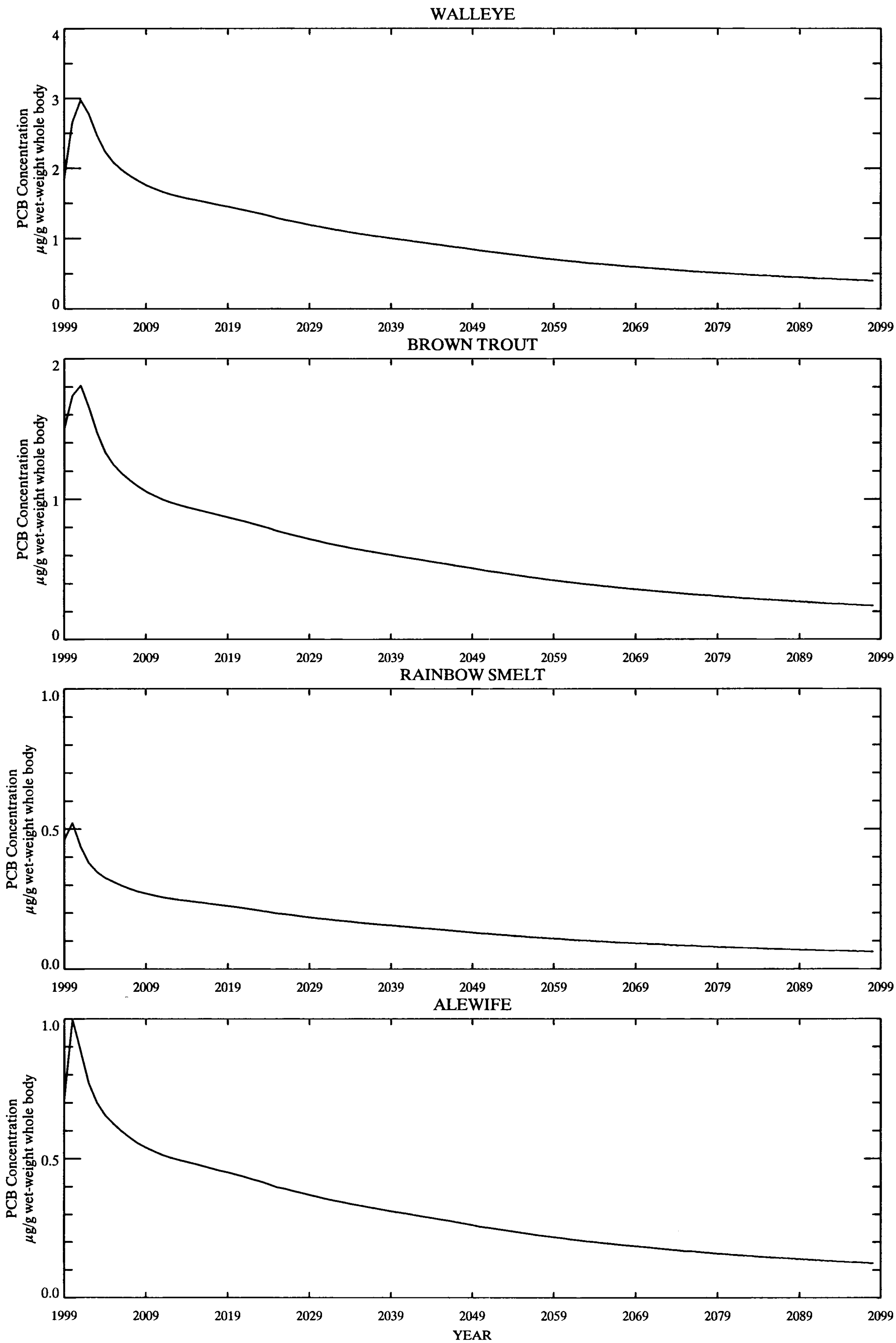


Projection: gbNOAC-fr0125_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-75. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: >125 ppb; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 15:53:31 2001

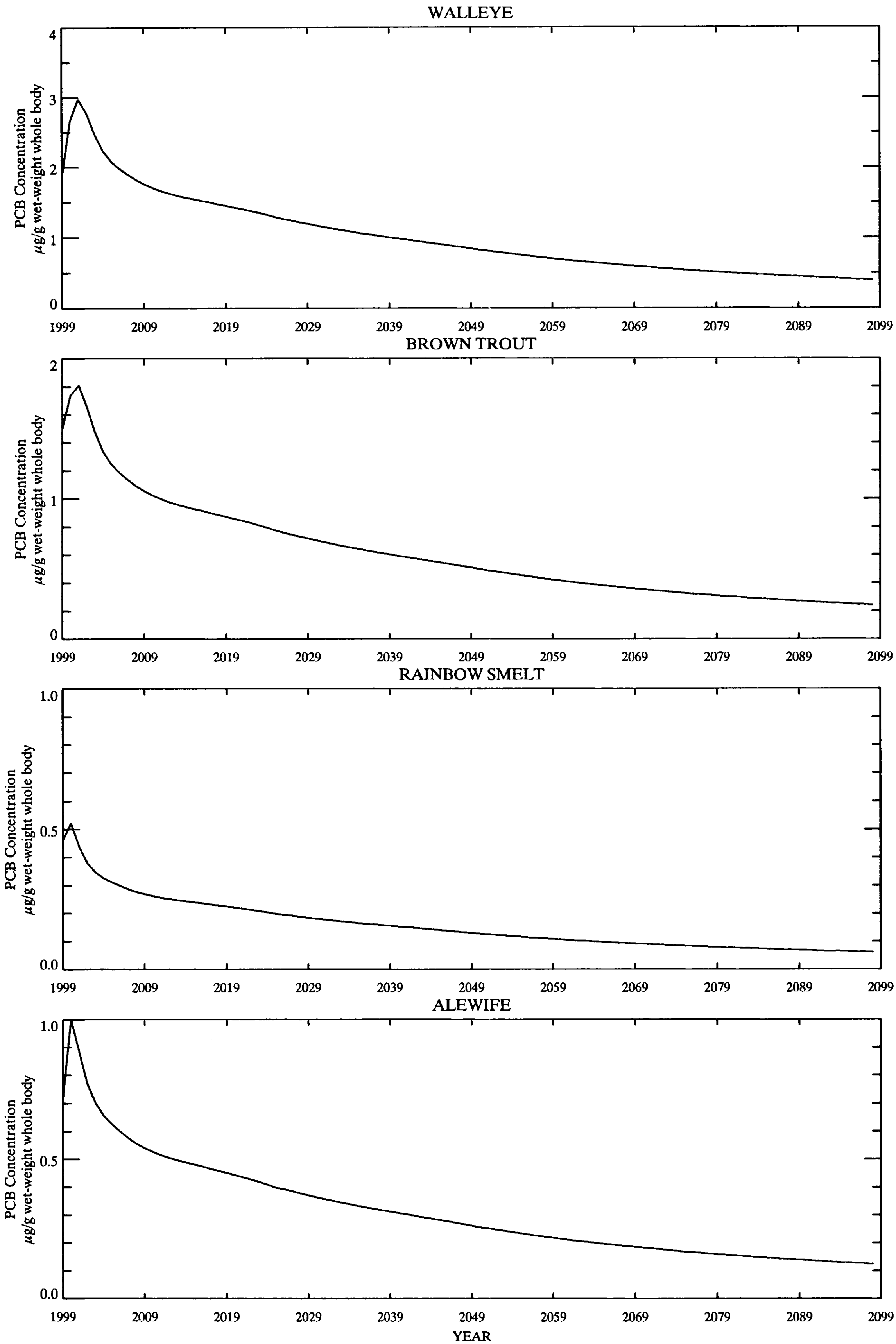


Projection: gbNOAC-fr000H_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-76. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: Schedule "H"; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 15:54:42 2001

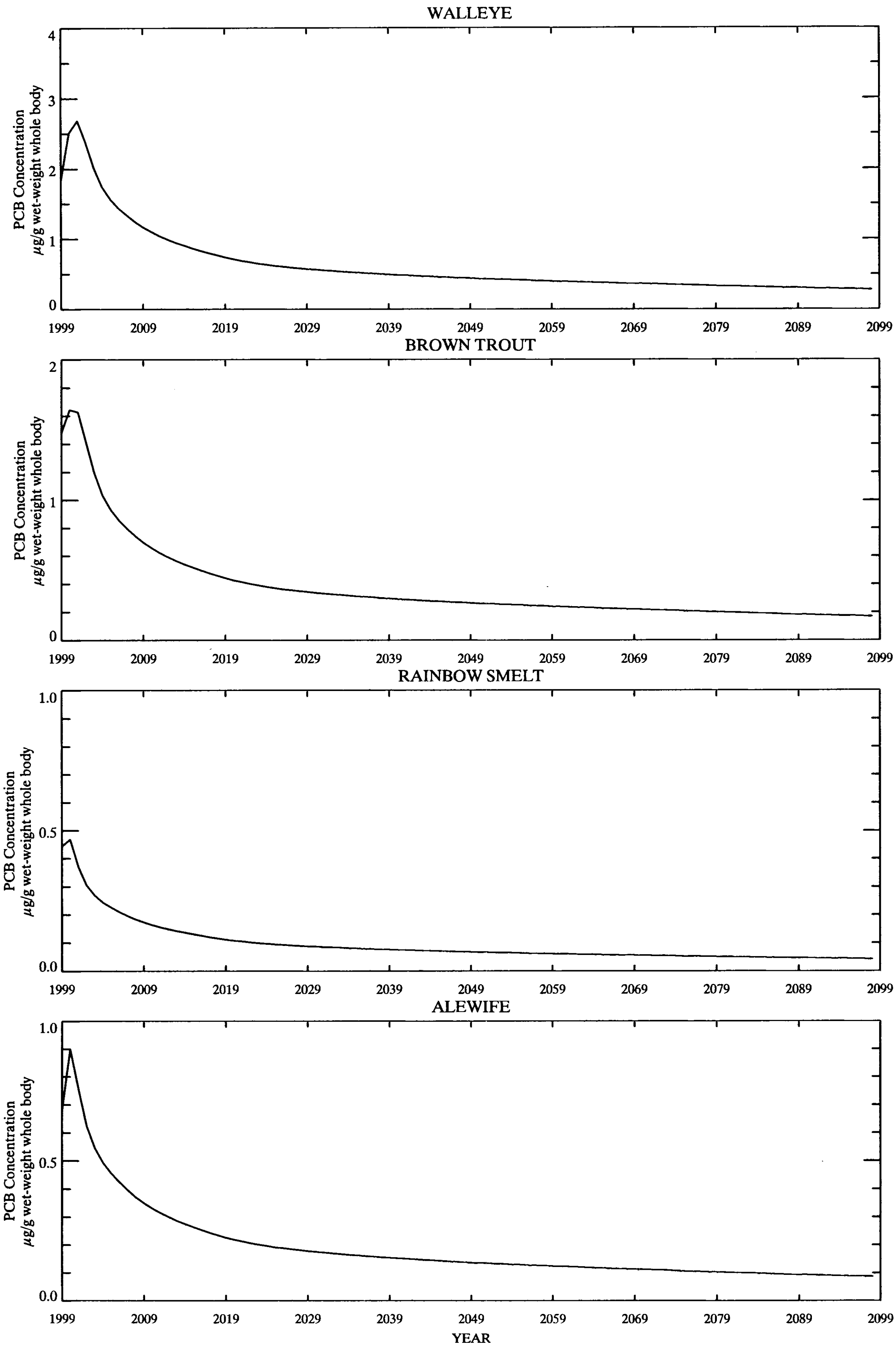


Projection: gbNOAC-fr000I_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-77. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: Schedule "I"; Green Bay: No Action.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 16:07:02 2001

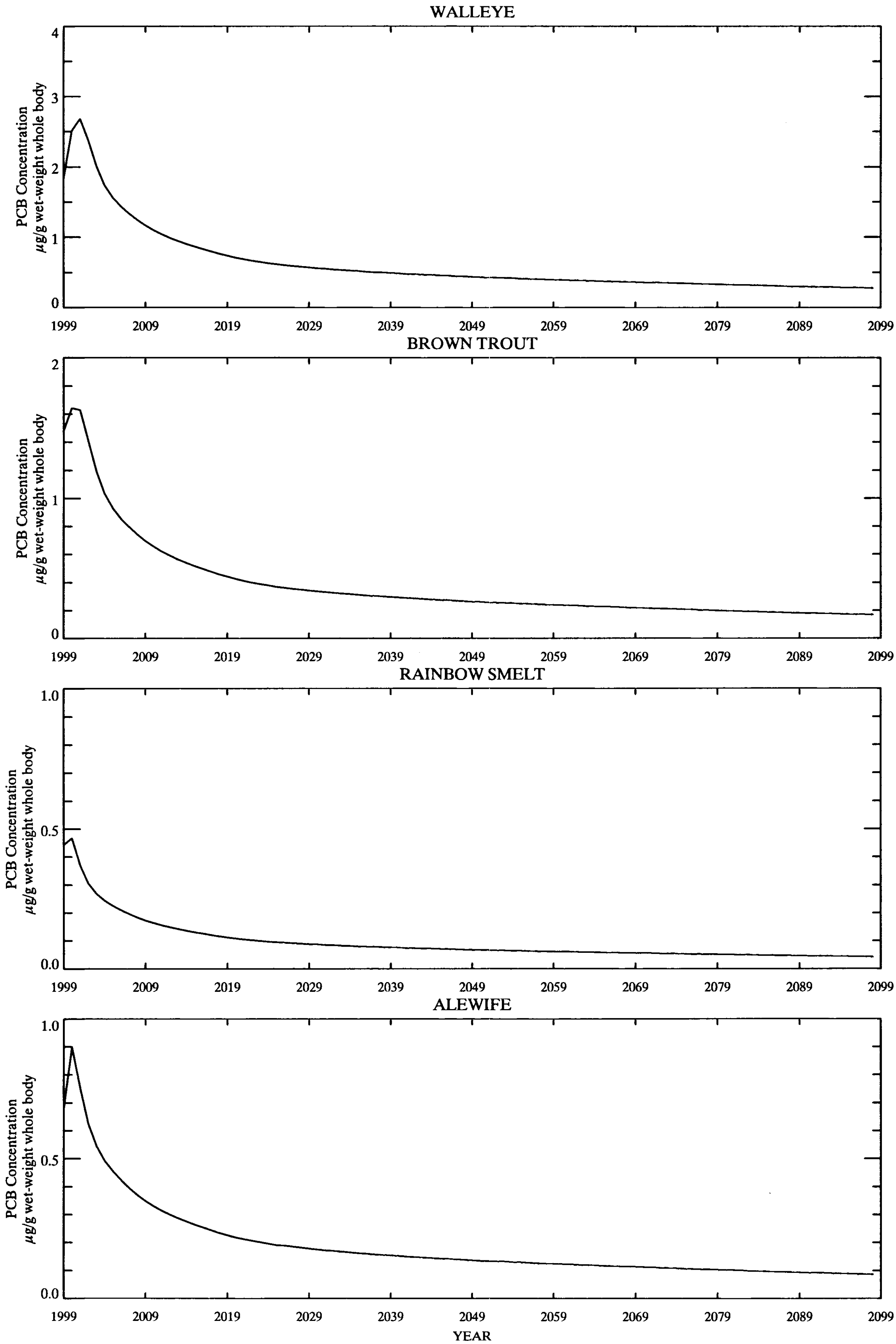


Projection: gb1000-fr1000_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-78. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: >1000 ppb; Green Bay: >1000 ppb.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 15:57:04 2001

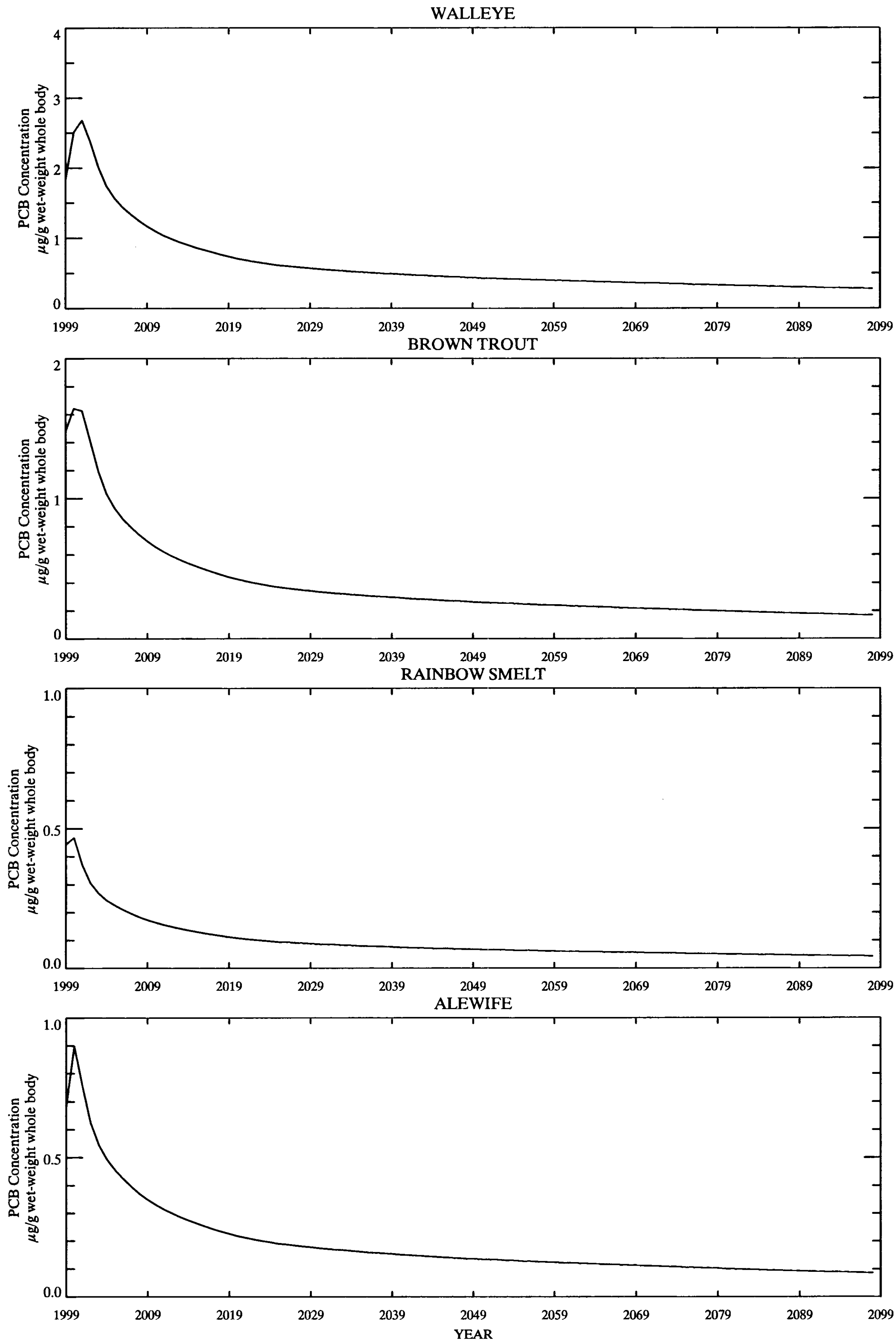


Projection: gb1000-fr0500_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-79. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: >500 ppb; Green Bay: >1000 ppb.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 15:58:19 2001

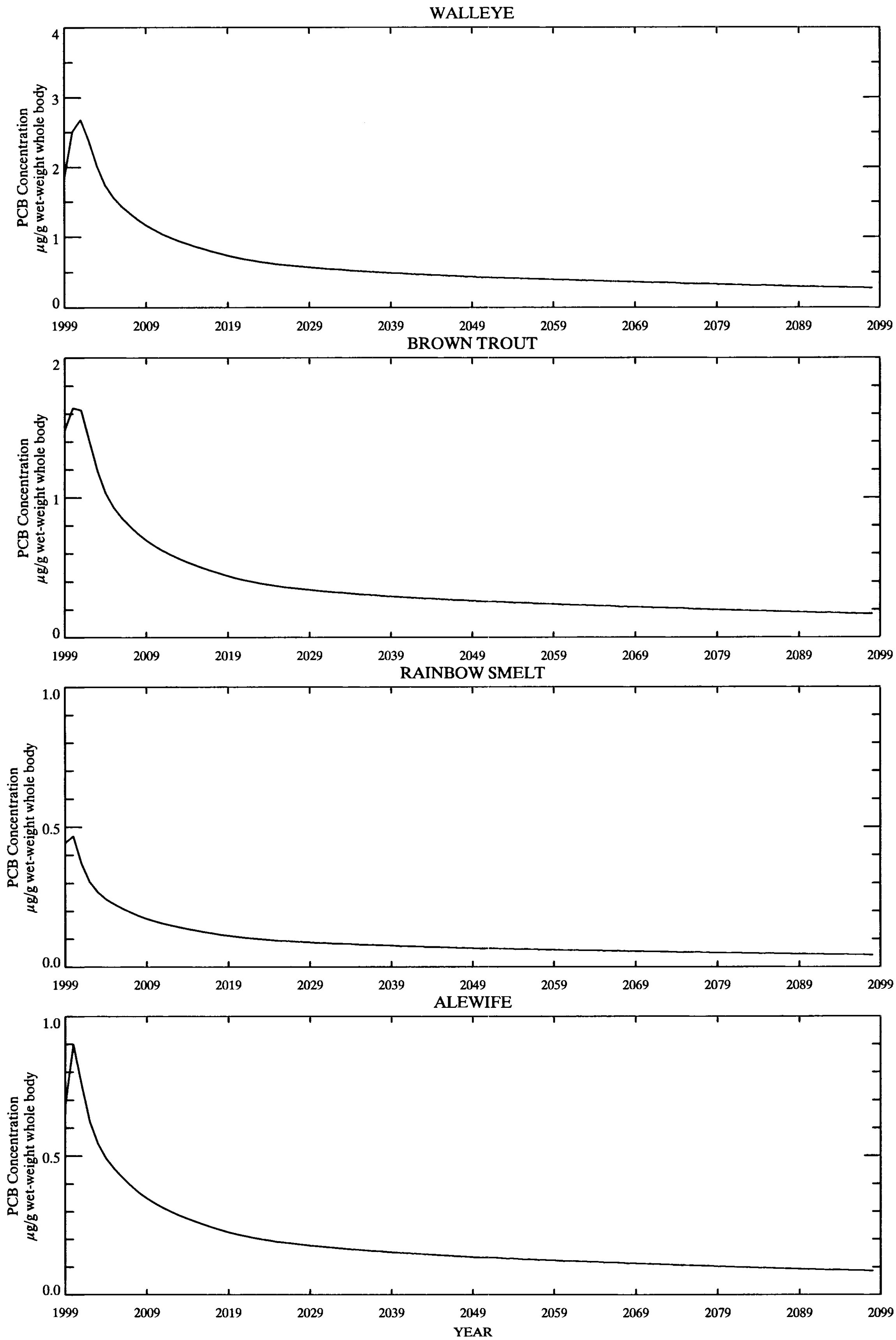


Projection: gb1000-fr0250_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-80. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: >250 ppb; Green Bay: >1000 ppb.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 15:59:32 2001

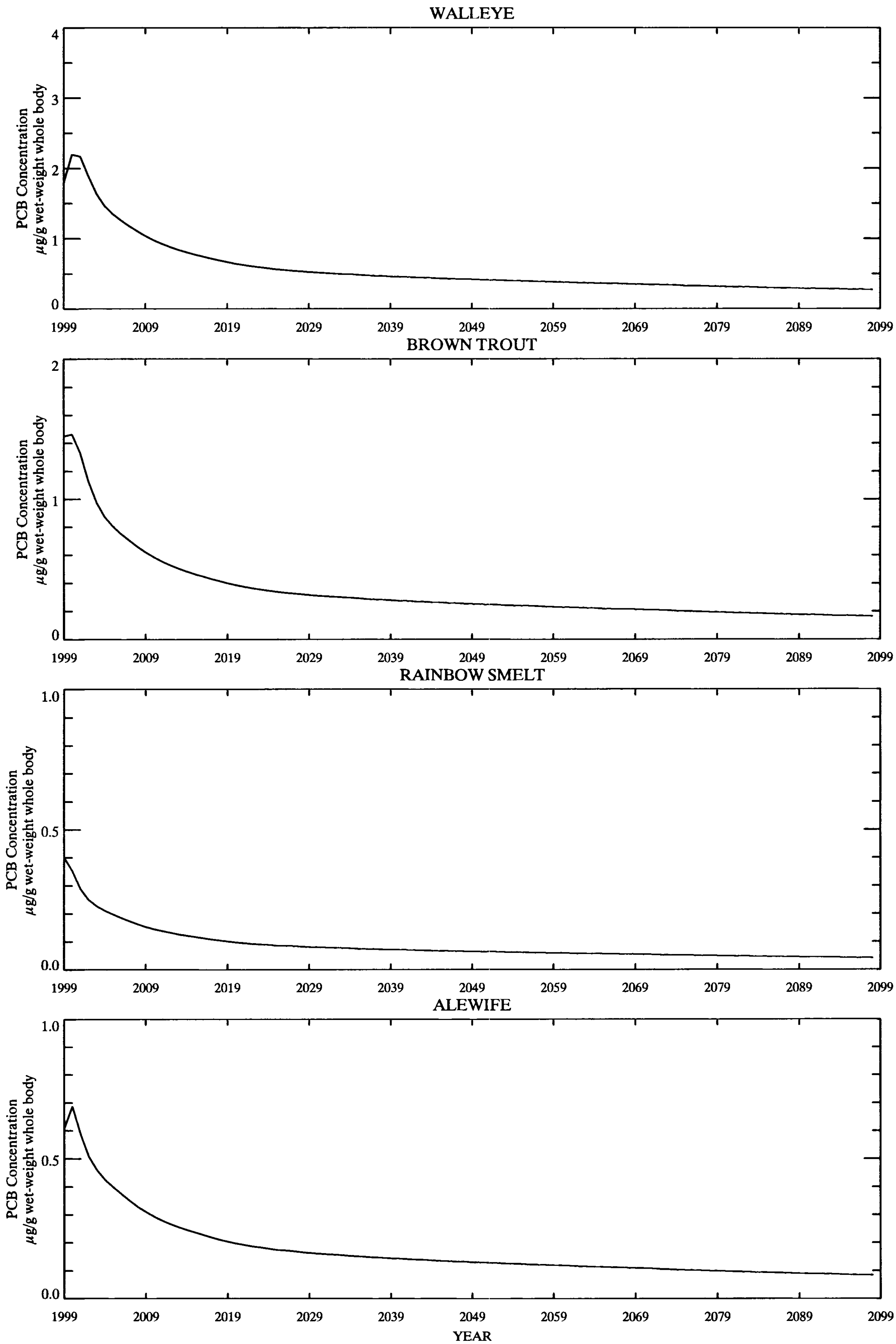


Projection: gb1000-fr0125_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-81. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: >125 ppb; Green Bay: >1000 ppb.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 16:00:45 2001

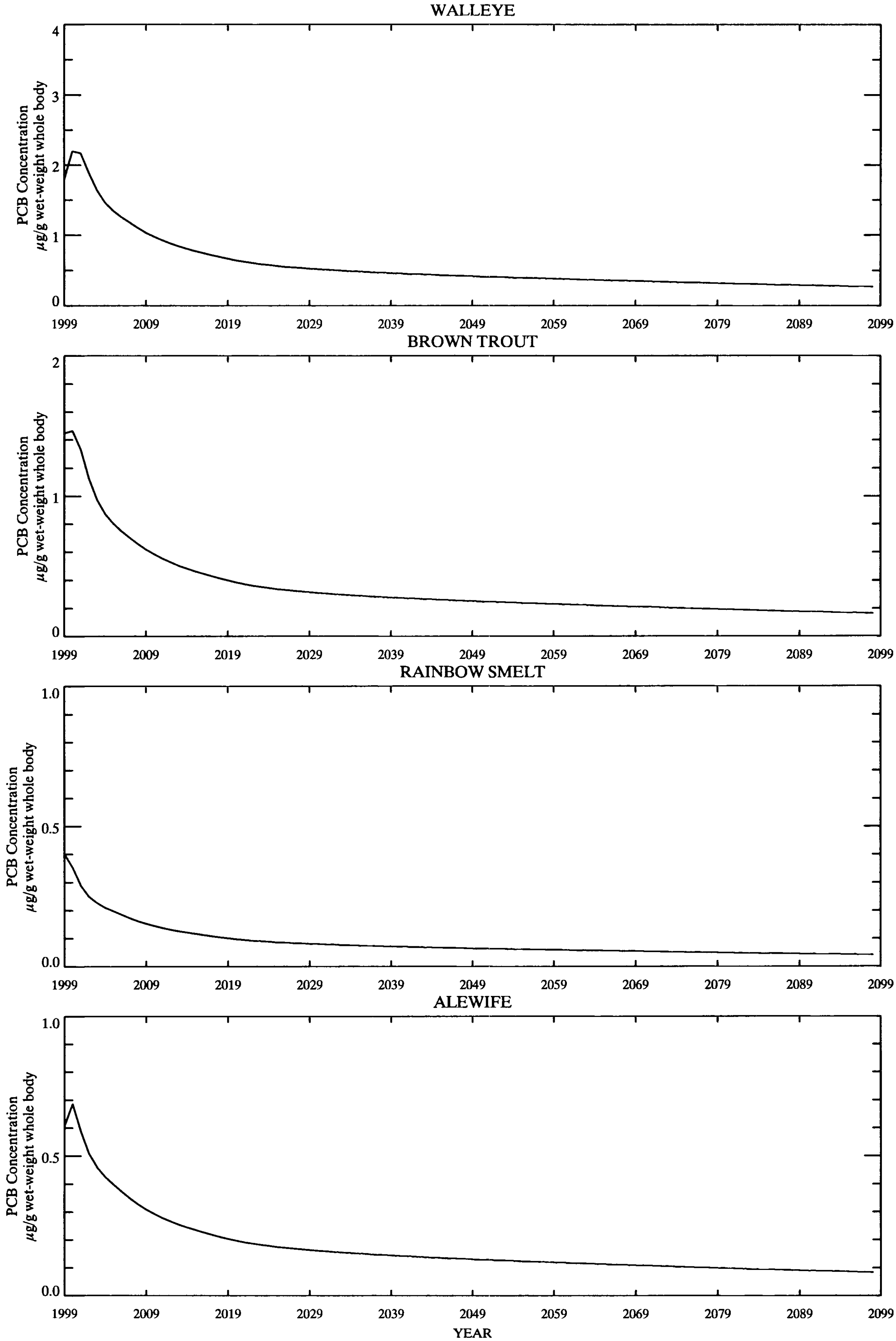


Projection: gb0500-fr0500_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-82. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: >500 ppb; Green Bay: >500 ppb.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 16:01:58 2001

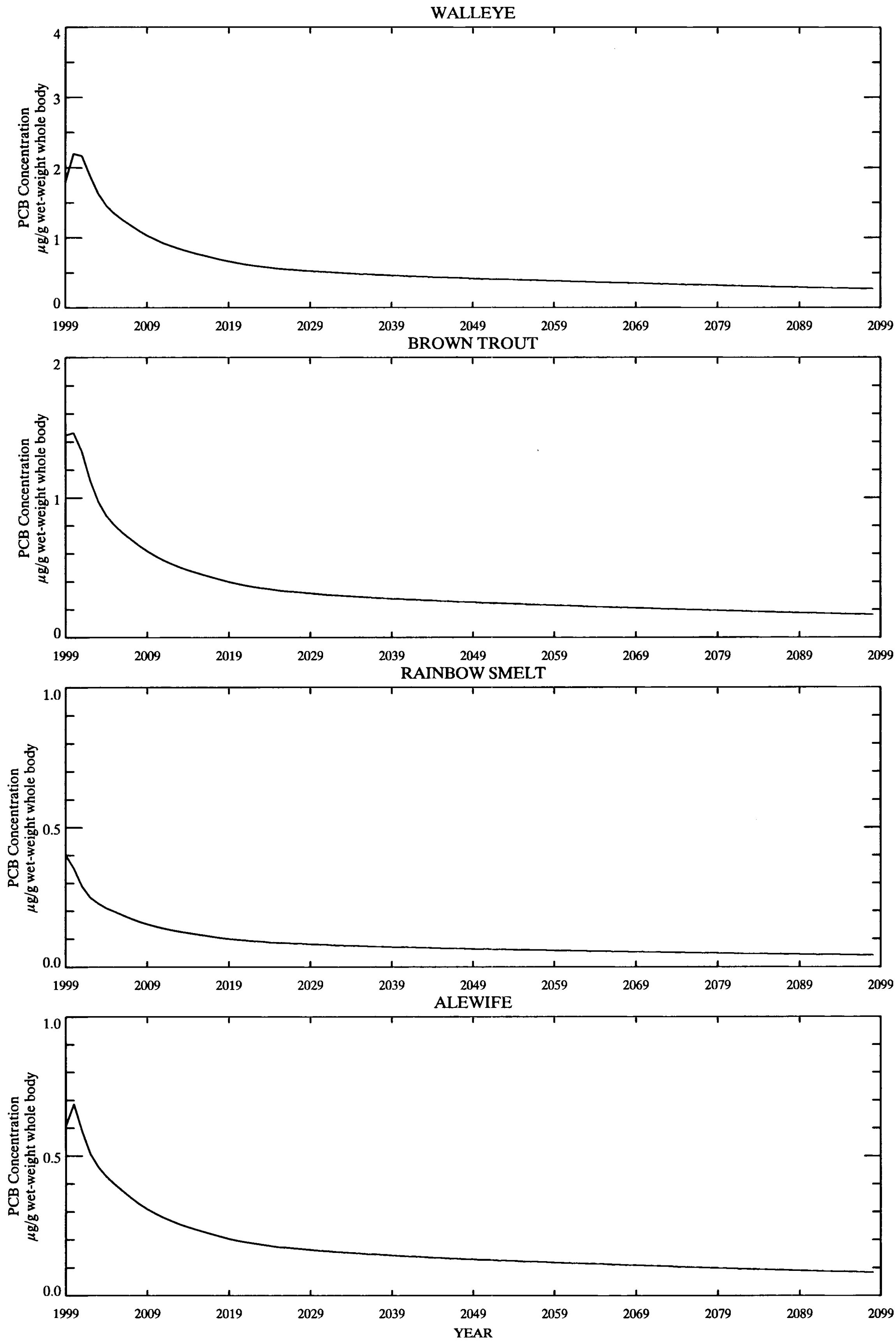


Projection: gb0500-fr0250_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-83. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: >250 ppb; Green Bay: >500 ppb.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 16:03:09 2001

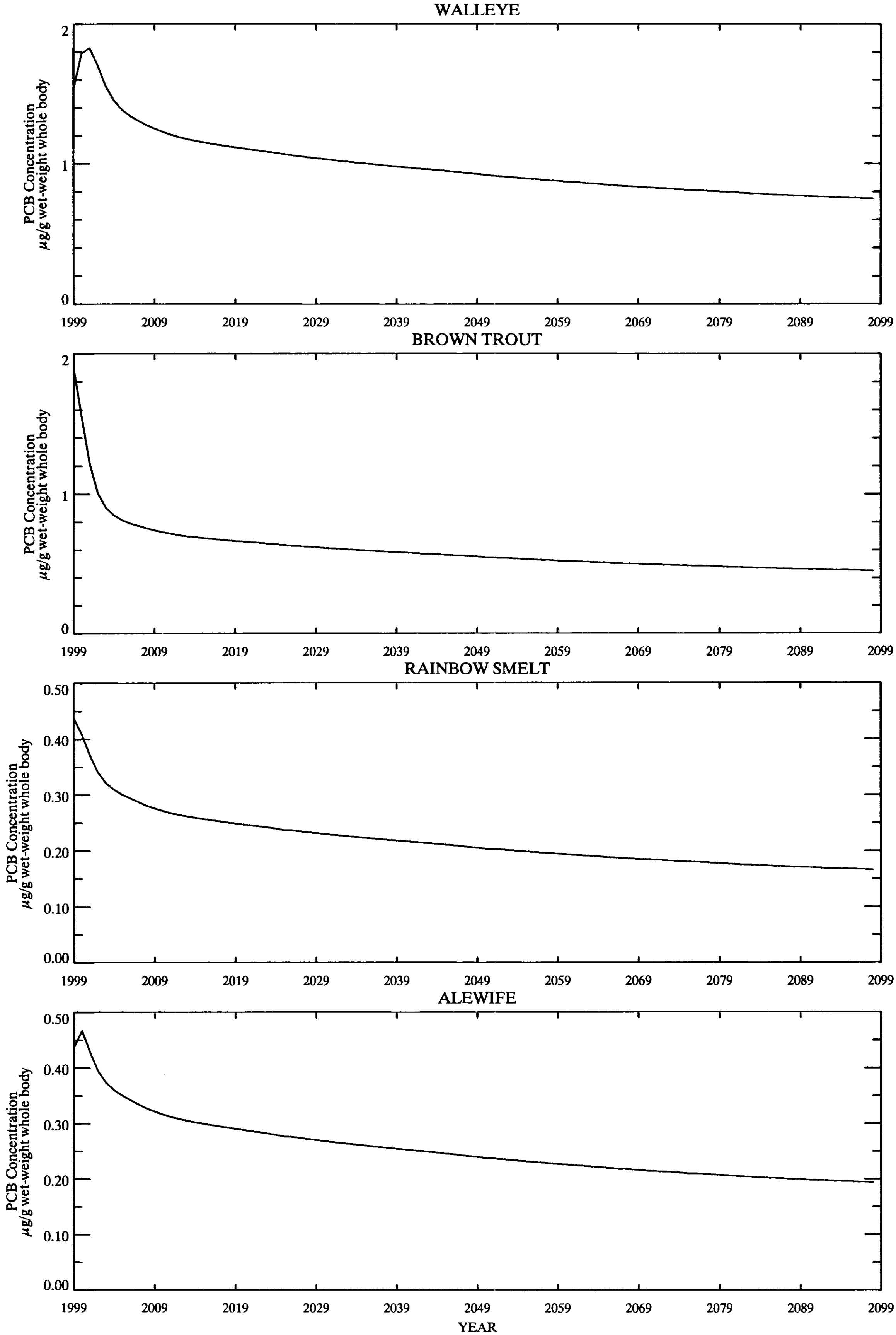


Projection: gb0500-fr0125_0-5_0-10_rn19_z3b: Annual averages.

Figure 5-84. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 3B based on Fox River: >125 ppb; Green Bay: >500 ppb.

beth - D:\THEfox\model\Biota\Projections\Zone3b\plots\z3b_proj_wet_ann_avg.pro

Mon May 14 16:04:32 2001

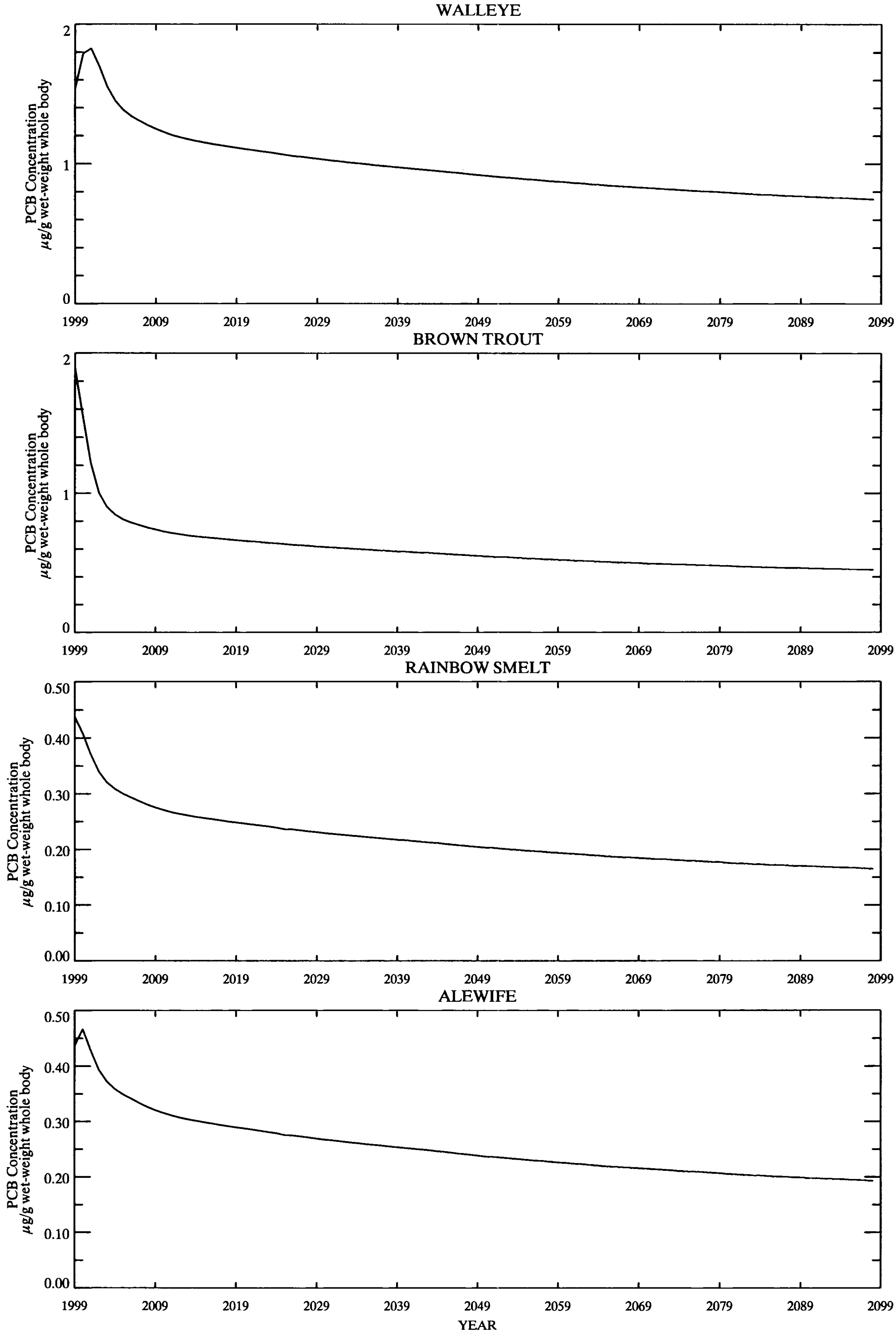


Projection: gbNOAC-fr5000_0-5_0-10_rn20_z4: Annual averages.

Figure 5-85. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: >5000 ppb; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro

Mon May 14 15:21:47 2001

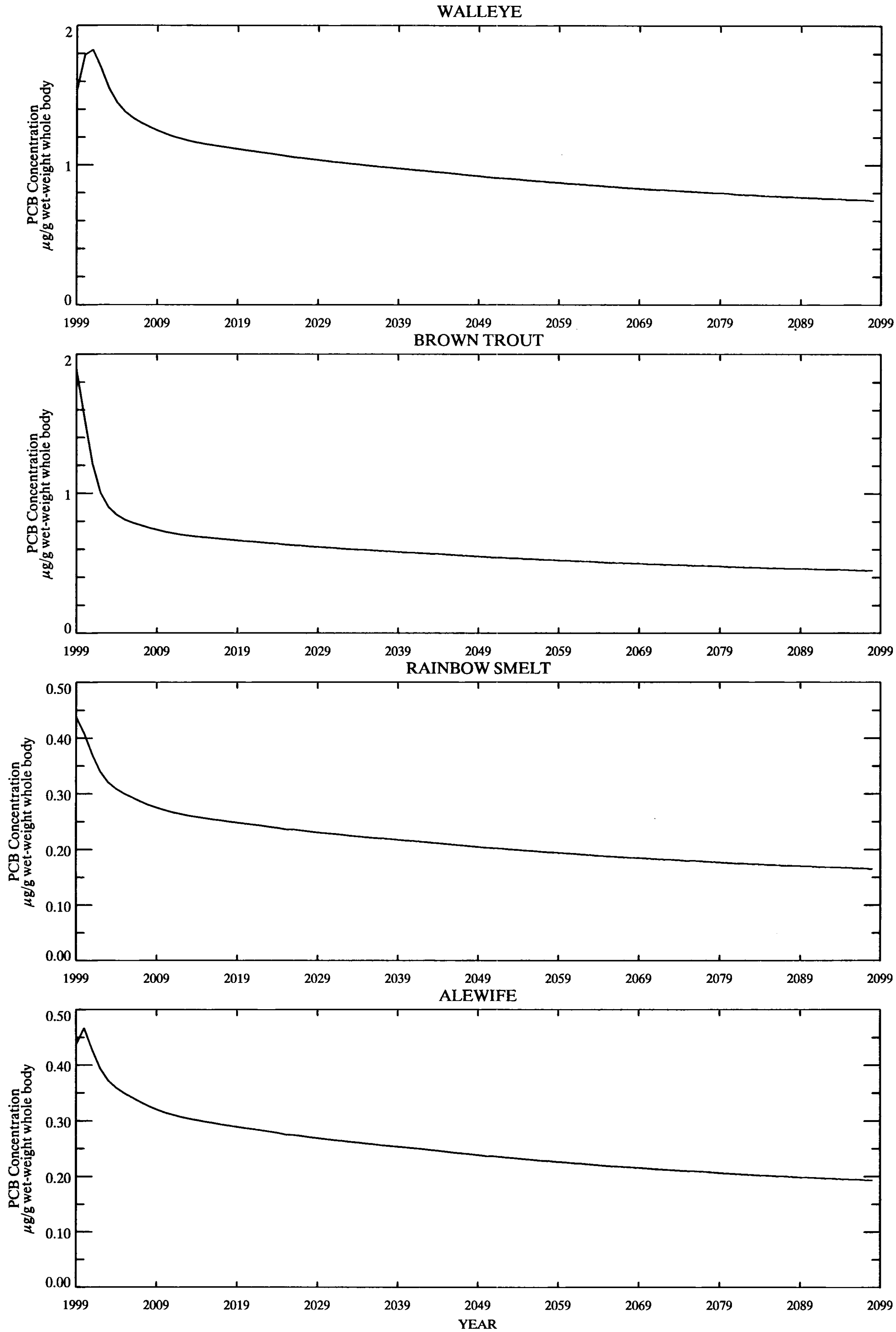


Projection: gbNOAC-fr1000_0-5_0-10_rn20_z4: Annual averages.

Figure 5-86. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: >1000 ppb; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro

Mon May 14 15:25:17 2001

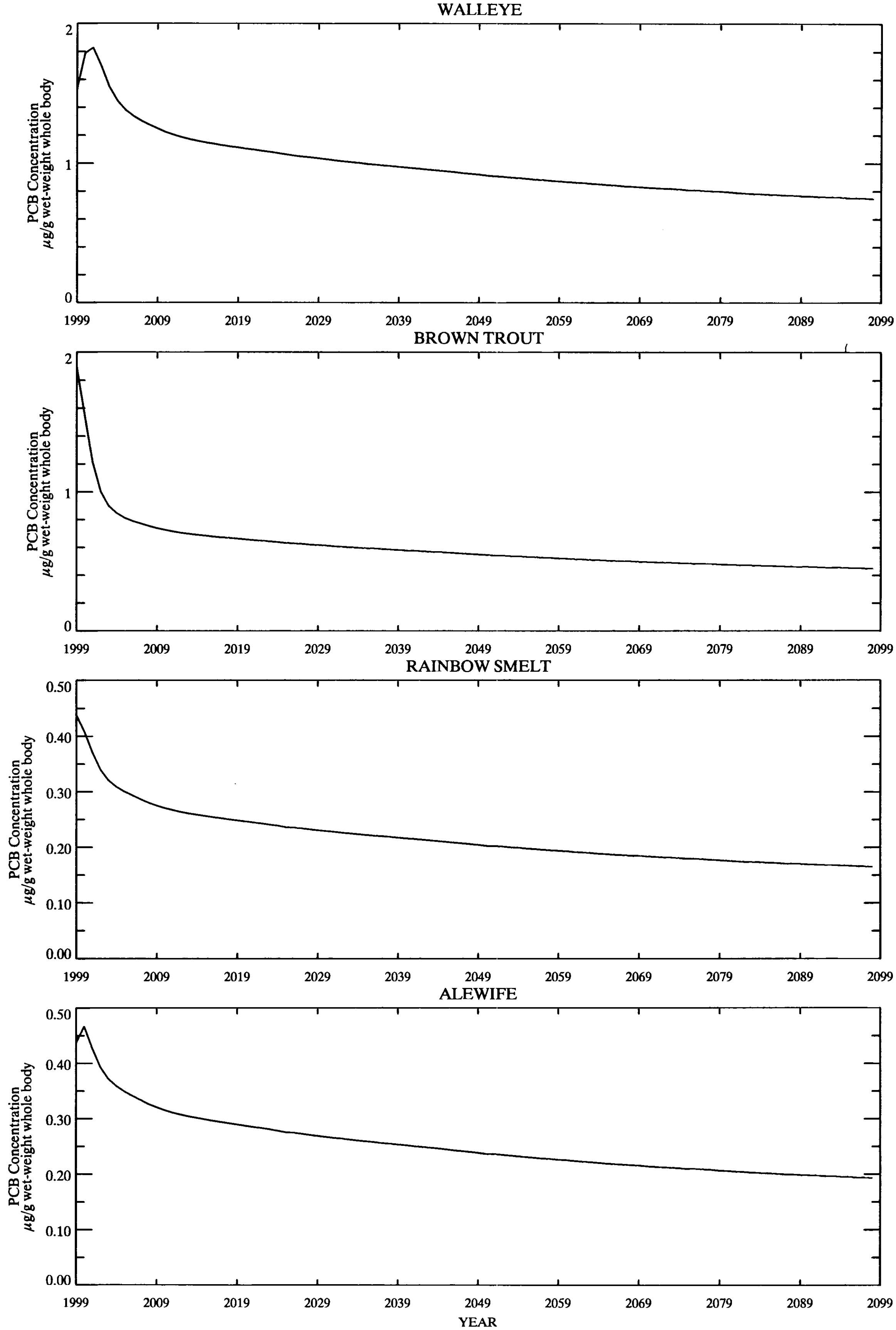


Projection: gbNOAC-fr0500_0-5_0-10_rn20_z4: Annual averages.

Figure 5-87. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: >500; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro

Mon May 14 15:26:47 2001

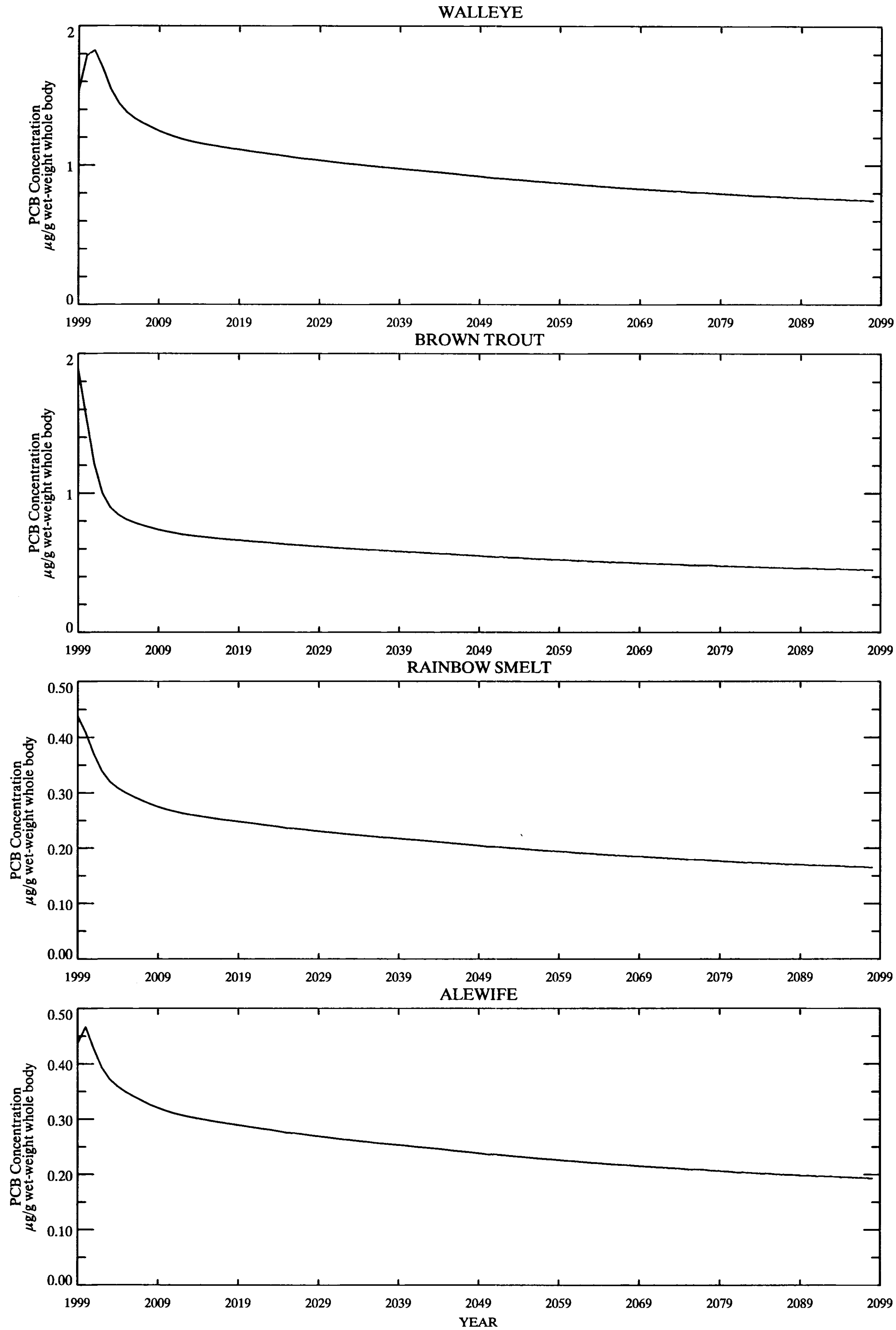


Projection: gbNOAC-fr0250_0-5_0-10_rn20_z4: Annual averages.

Figure 5-88. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: >250 ppb; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro

Mon May 14 15:28:17 2001

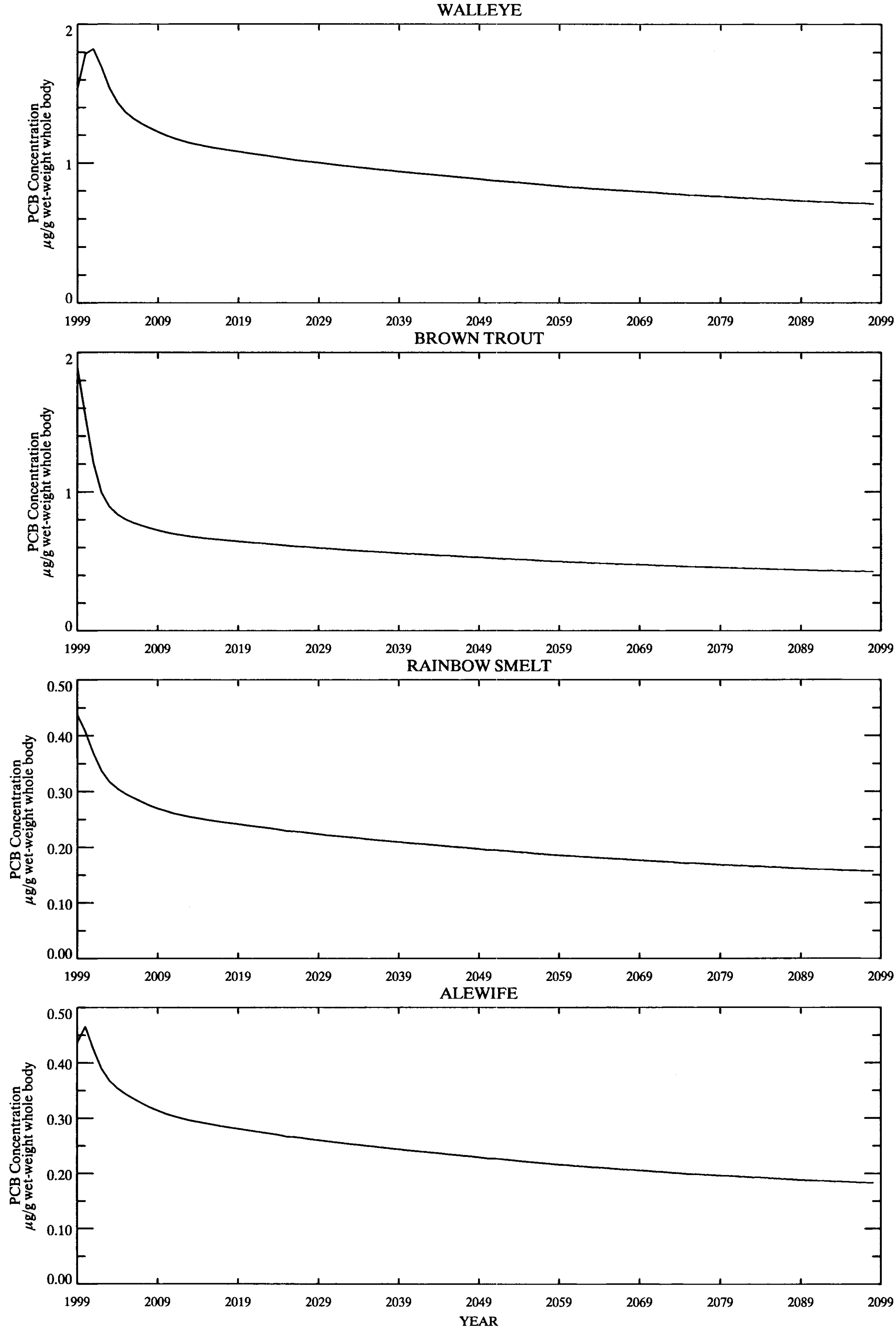


Projection: gbNOAC-fr0125_0-5_0-10_rn20_z4: Annual averages.

Figure 5-89. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: >125 ppb; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro

Mon May 14 15:29:54 2001

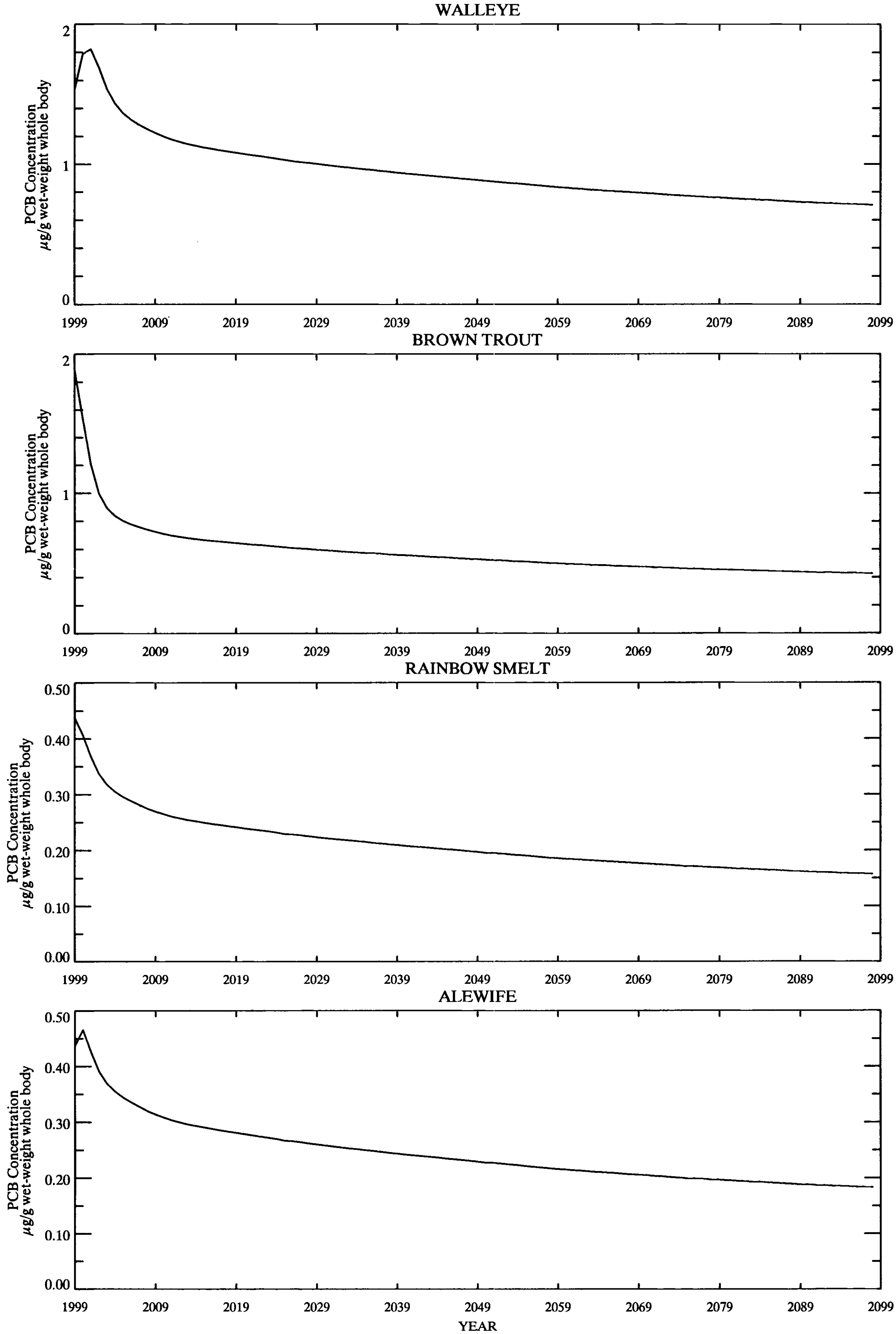


Projection: gbNOAC-fr000H_0-5_0-10_rn20_z4: Annual averages.

Figure 5-90. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: Schedule "H"; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro

Mon May 14 15:31:22 2001

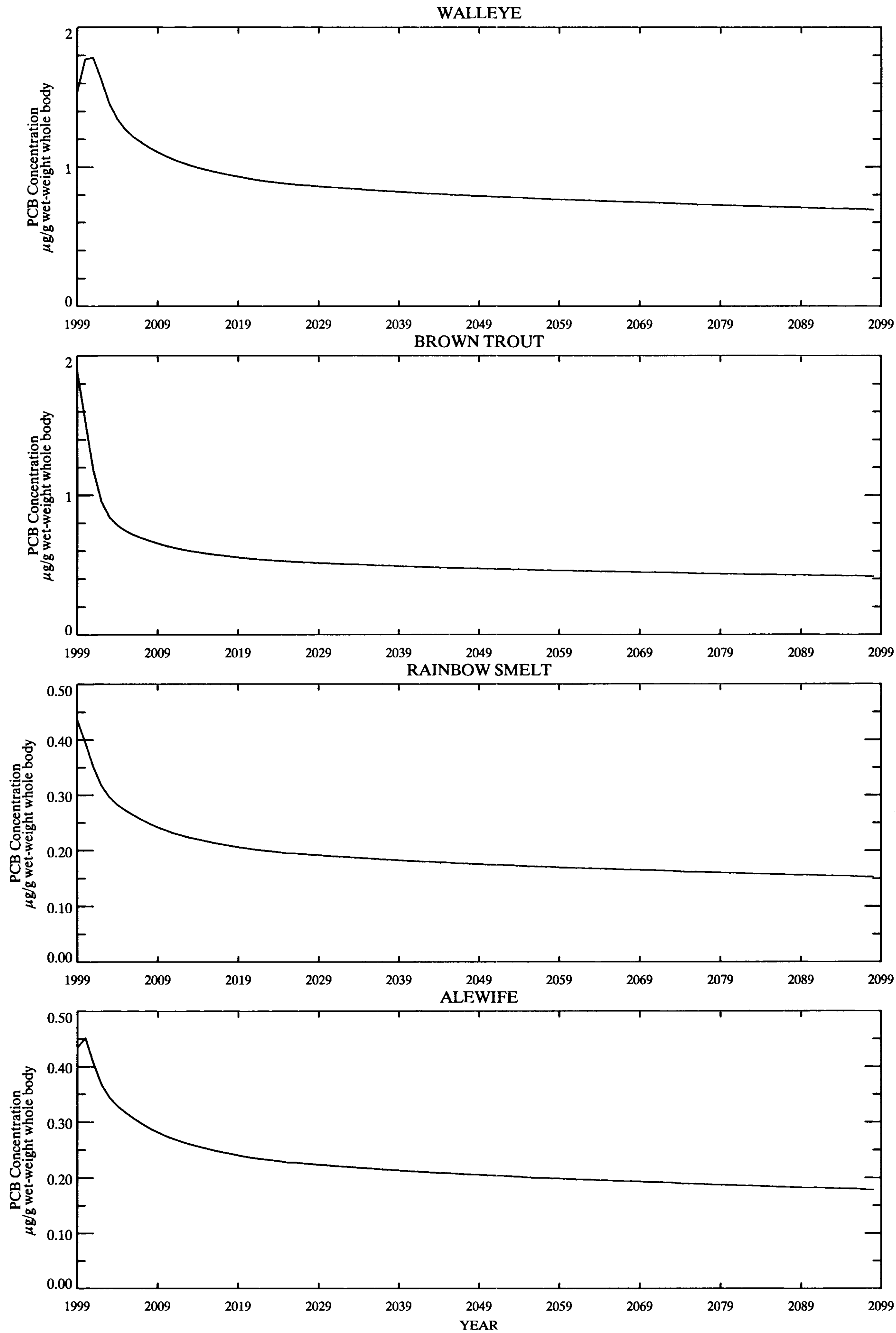


Projection: gbNOAC-fr000I_0-5_0-10_rn20_z4: Annual averages.

Figure 5-91. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: Schedule "I"; Green Bay: No Action.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro

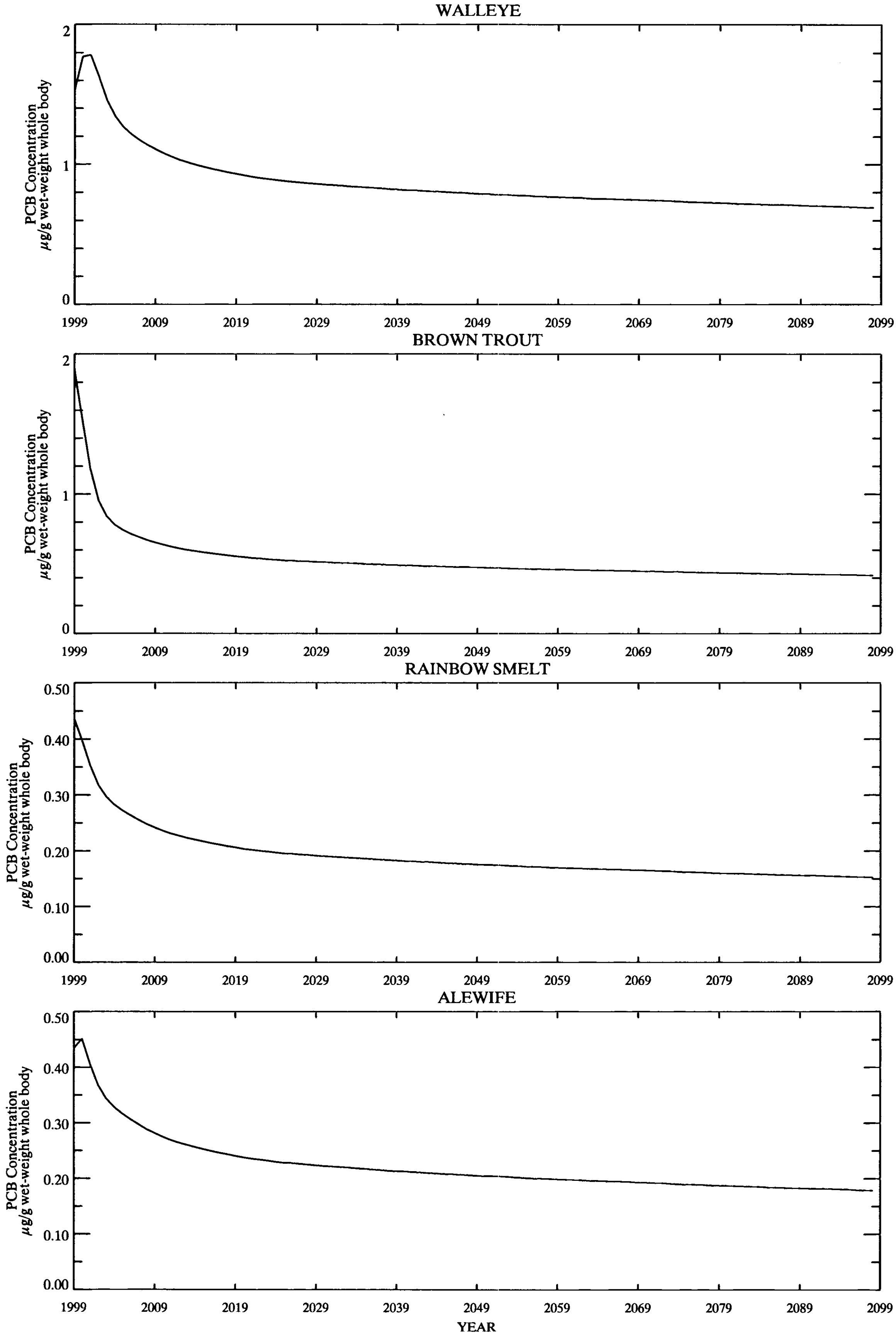
Mon May 14 15:32:52 2001



Projection: gb1000-fr1000_0-5_0-10_rn20_z4: Annual averages.

Figure 5-92. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: >1000 ppb; Green Bay: >1000 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro
Mon May 14 15:34:24 2001

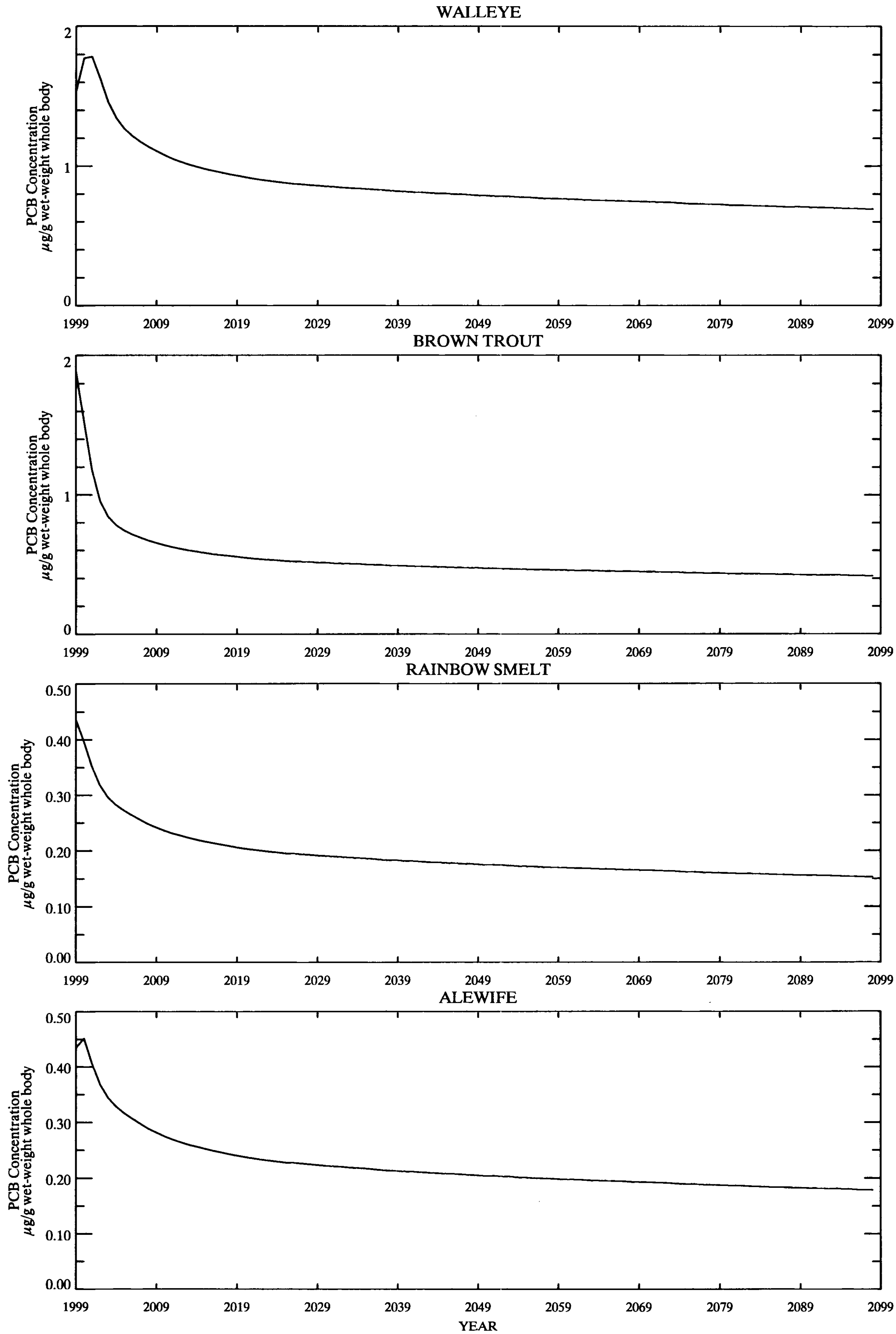


Projection: gb1000-fr0500_0-5_0-10_rn20_z4: Annual averages.

Figure 5-93. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: >500 ppb; Green Bay: >1000 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro

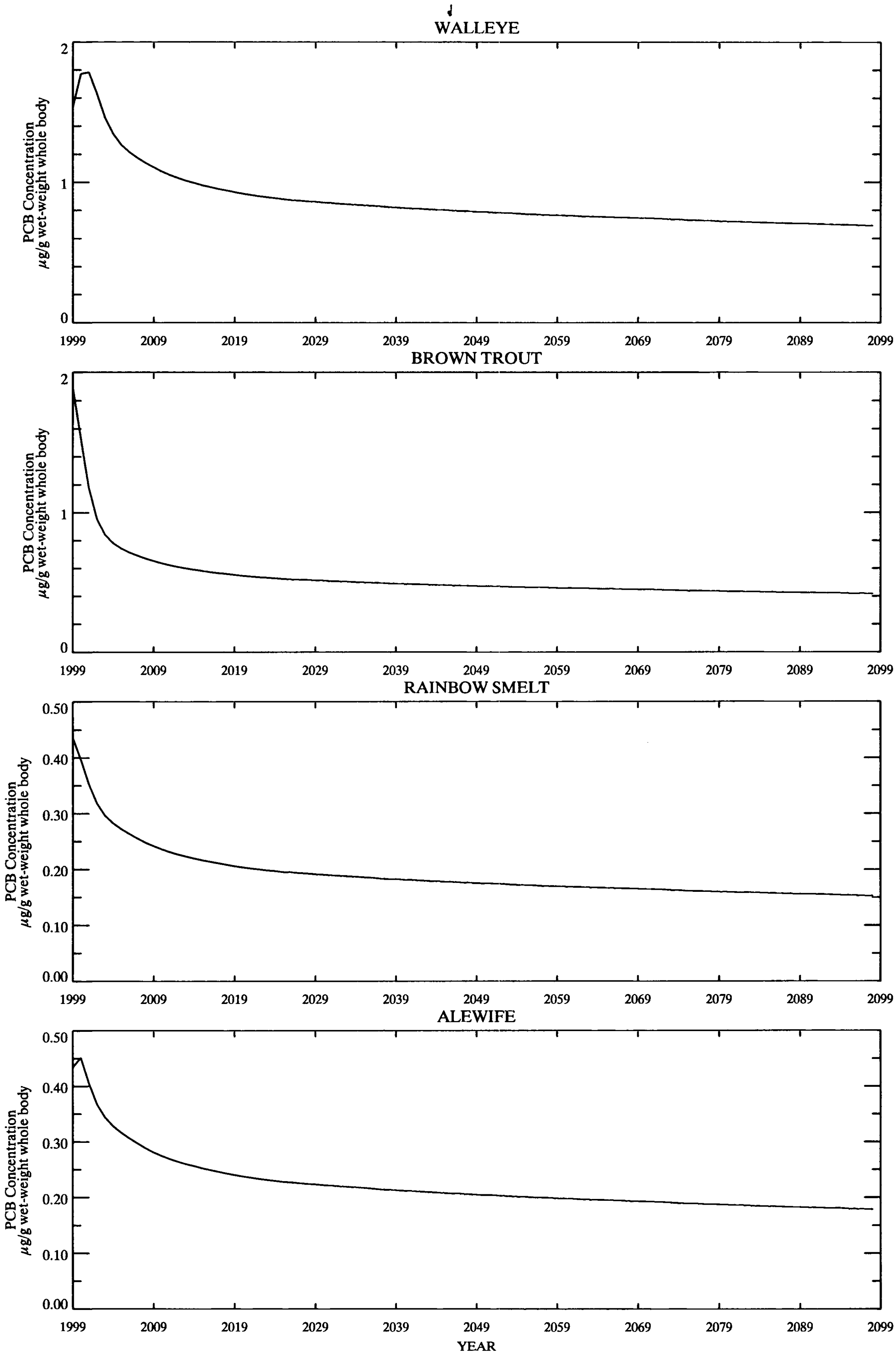
Mon May 14 15:35:54 2001



Projection: gb1000-fr0250_0-5_0-10_rn20_z4: Annual averages.

Figure 5-94. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: >250 ppb; Green Bay: >1000 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro
Mon May 14 15:37:25 2001

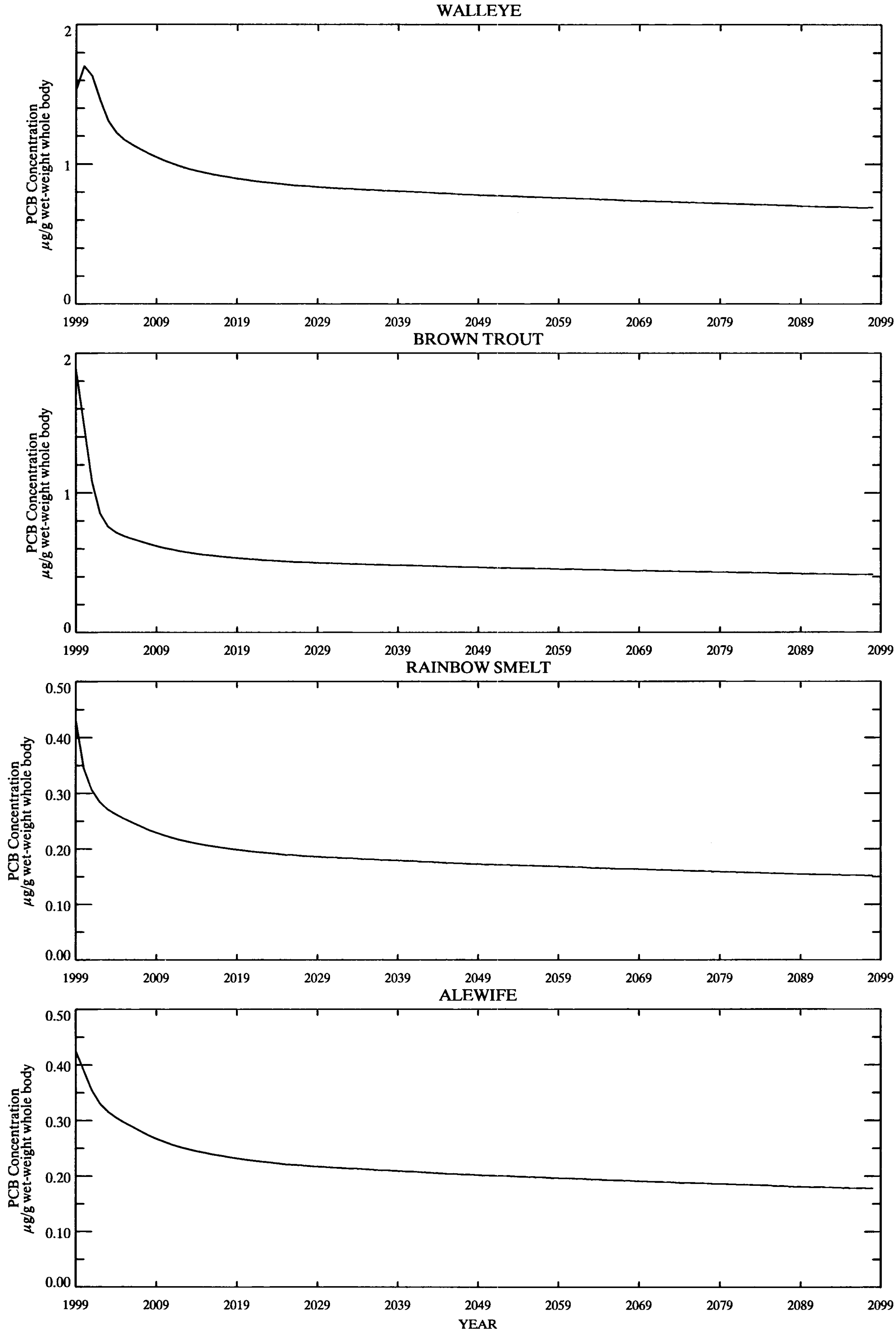


Projection: gb1000-fr0125_0-5_0-10_rn20_z4: Annual averages.

Figure 5-95. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: >125 ppb; Green Bay: >1000 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro

Mon May 14 15:38:53 2001

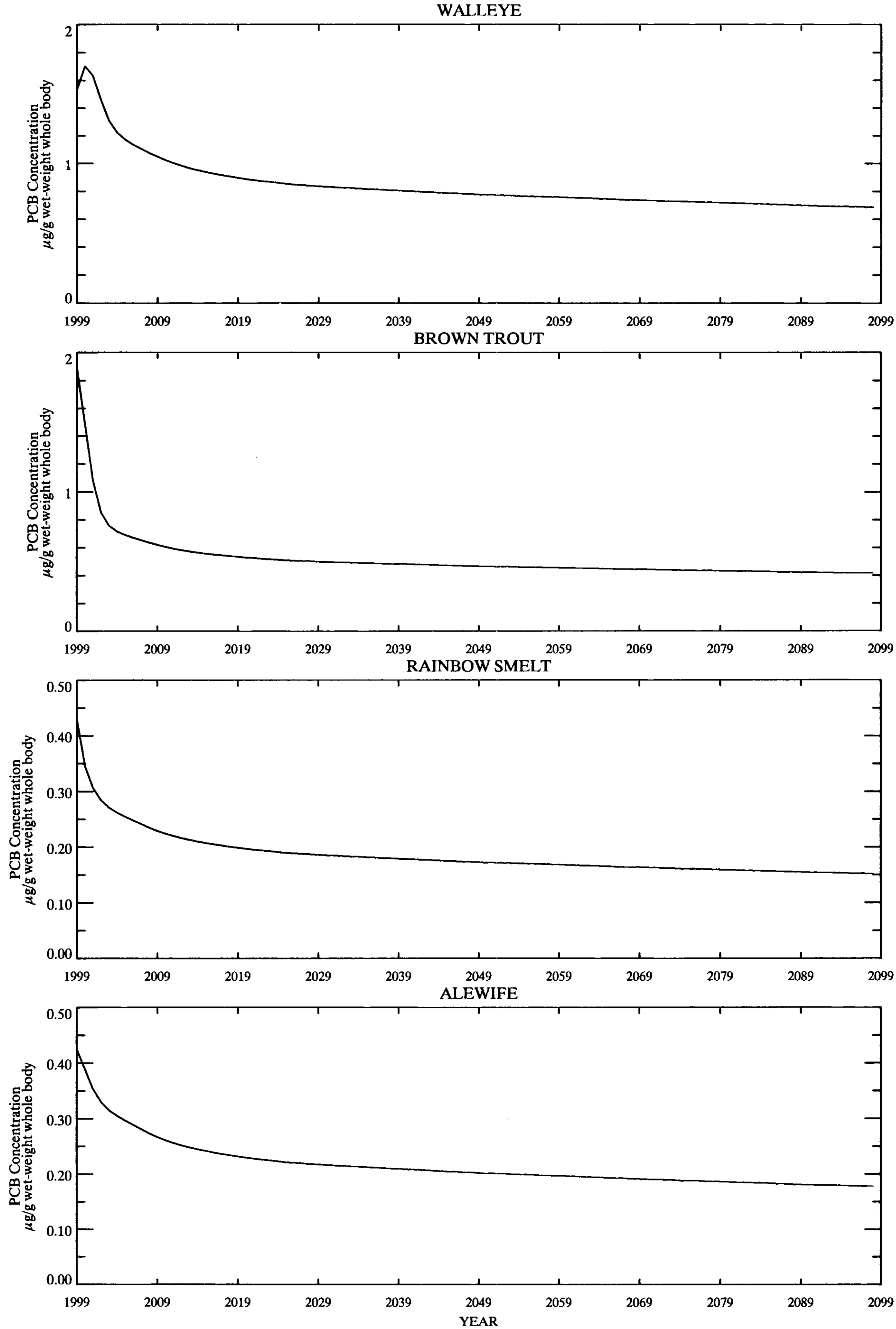


Projection: gb0500-fr0500_0-5_0-10_rn20_z4: Annual averages.

Figure 5-96. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: >500 ppb; Green Bay: >500 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro

Mon May 14 15:40:22 2001

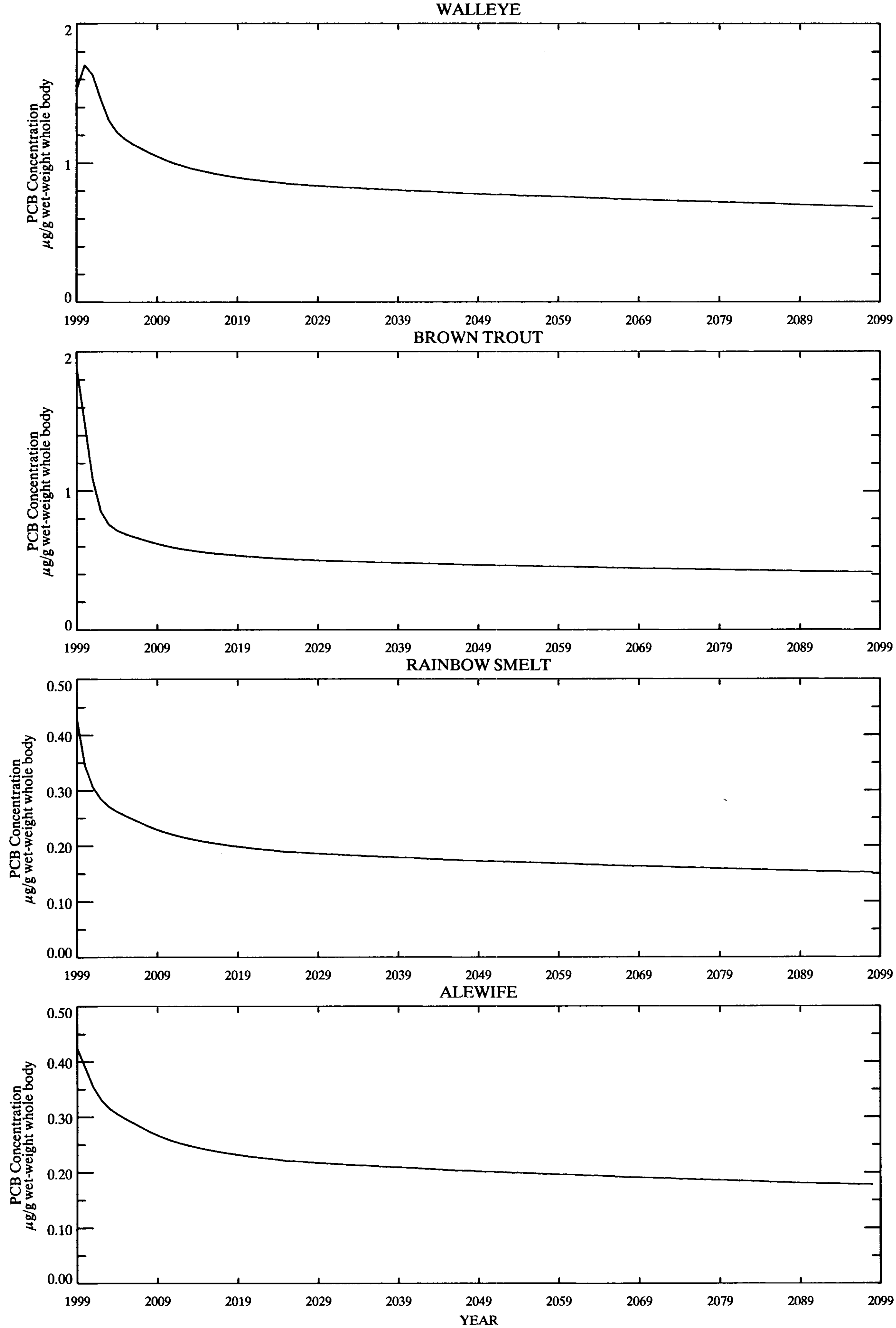


Projection: gb0500-fr0250_0-5_0-10_rn20_z4: Annual averages.

Figure 5-97. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: >250 ppb; Green Bay: >500 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro

Mon May 14 15:41:50 2001



Projection: gb0500-fr0125_0-5_0-10_rn20_z4: Annual averages.

Figure 5-98. GBFood projection results. Average computed total PCB concentrations in fish from in Zone 4 based on Fox River: >125 ppb; Green Bay: >500 ppb.

beth - \\Beth\D_Drive\THEfox\model\Biota\Projections\Zone4\plots\Z4_proj_wet_ann_avg.pro

Mon May 14 15:43:20 2001