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Quarterly Progress Report

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Biological Monitoring Program for East Fork Poplar Creek

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1. Introduction

In May 1985, a National Pollutant Discharge Elimination System (NPDES) permit was issued for the Oak Ridge Y-12 Plant. As a condition of the permit, a Biological Monitoring and Abatement Program (BMAP) was developed to demonstrate that the effluent limitations established for the Y-12 Plant protect the classified uses of the receiving stream (East Fork Poplar Creek; EFPC), in particular, the growth and propagation of aquatic life (Loar et al. 1989). A second objective of the BMAP is to document the ecological effects resulting from the implementation of a water pollution control program designed to eliminate direct discharges of wastewaters to EFPC and to minimize the inadvertent release of pollutants to the environment. Because of the complex nature of the discharges to EFPC and the temporal and spatial variability in the composition of the discharges, a comprehensive, integrated approach to biological monitoring was developed. A new permit was issued to the Y-12 Plant on April 28, 1995 and became effective on July 1, 1995. Biological monitoring continues to be required under the new permit. The BMAP consists of four major tasks that reflect different but complementary approaches to evaluating the effects of the Y-12 Plant discharges on the aquatic integrity of EFPC. These tasks are (1) toxicity monitoring, (2) biological indicator studies, (3) bioaccumulation studies, and (4) ecological surveys of the periphyton, benthic macroinvertebrate, and fish communities.

Monitoring is currently being conducted at five sites, although sites may be excluded and/or others added depending upon the specific objectives of the various tasks. Criteria used in selecting the sites include: (1) location of sampling sites used in other studies, (2) known or suspected sources of downstream impacts, (3) proximity to U.S. Department of Energy (DOE) Oak Ridge Reservation (ORR) boundaries, (4) concentration of mercury in the adjacent floodplain, (5) appropriate habitat distribution, and (6) access. The sampling sites include EFPC at kilometers (EFKs) 24.4 and 23.4 [upstream and downstream of Lake Reality (LR) respectively]; EFK 18.7 (also EFK 18 and 19), located off the ORR and below an area of intensive commercial and limited light industrial development; EFK 13.8 (also EFK 14), located upstream from the Oak Ridge Wastewater Treatment Facility (ORWTF); and EFK 6.3 located approximately 1.4 km below the ORR boundary (Fig. 1.1). Other sampling sites on EFPC are utilized as appropriate for individual tasks. Brushy Fork (BF) at kilometer (BFK) 7.6 is used as a reference stream for most tasks of the BMAP. Additional sites off the ORR are also occasionally used for reference, including Beaver Creek, Bull Run, Hinds Creek, Paint Rock Creek, and the Emory River in Watts Bar Reservoir (Fig. 1.2).

2. Toxicity Monitoring (*L. A. Kszos, D. S. Cicerone, A. J. Stewart and L. F. Wicker*)

2.1. Introduction

The ambient toxicity monitoring task includes three subtasks: toxicity monitoring, toxicity experiments, and supporting studies. Toxicity monitoring uses U.S. Environmental Protection Agency (EPA) approved methods with *Ceriodaphnia dubia* and fathead larvae to provide systematic information that can be used to determine changes in the biological quality of EFPC through time. Toxicity experiments are conducted to test specific hypotheses about stream water quality. The hypotheses are addressed experimentally by the systematic application of ambient toxicity test methods. Supporting studies are used to (1) investigate the relationship between the physicochemical and biological conditions in EFPC, particularly as they relate to processes or rates of ecological recovery and (2) develop better methods for accurately predicting ecological recovery with changes in water quality in EFPC. Toxicity monitoring at the upstream sites from Bear Creek Road [Lake Reality outfall or LR-o (EFK 23.8), LR

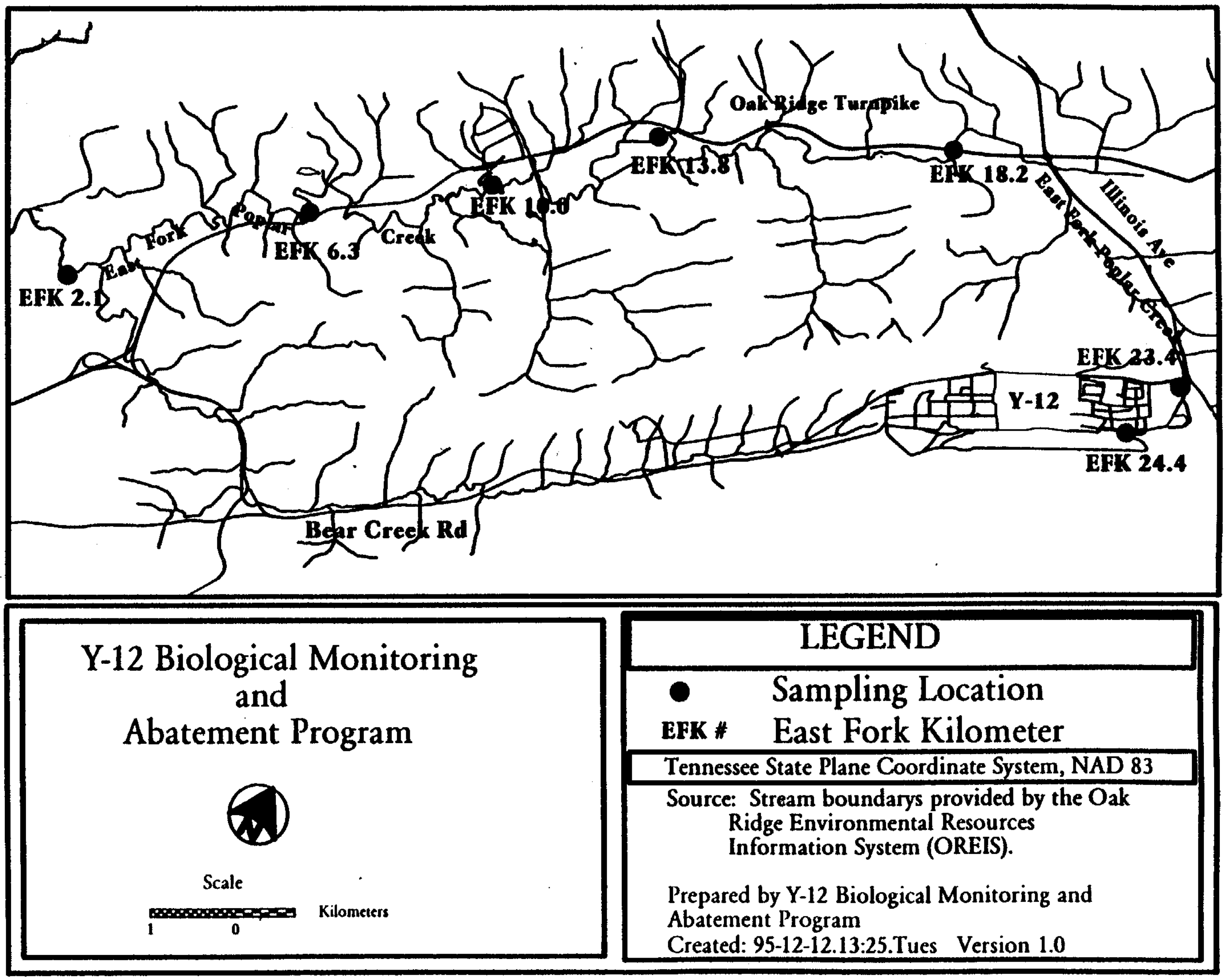

Figure 1.1. Location of biological monitoring sites on East Fork Poplar Creek in relation to the Oak Ridge Y-12 Plant.

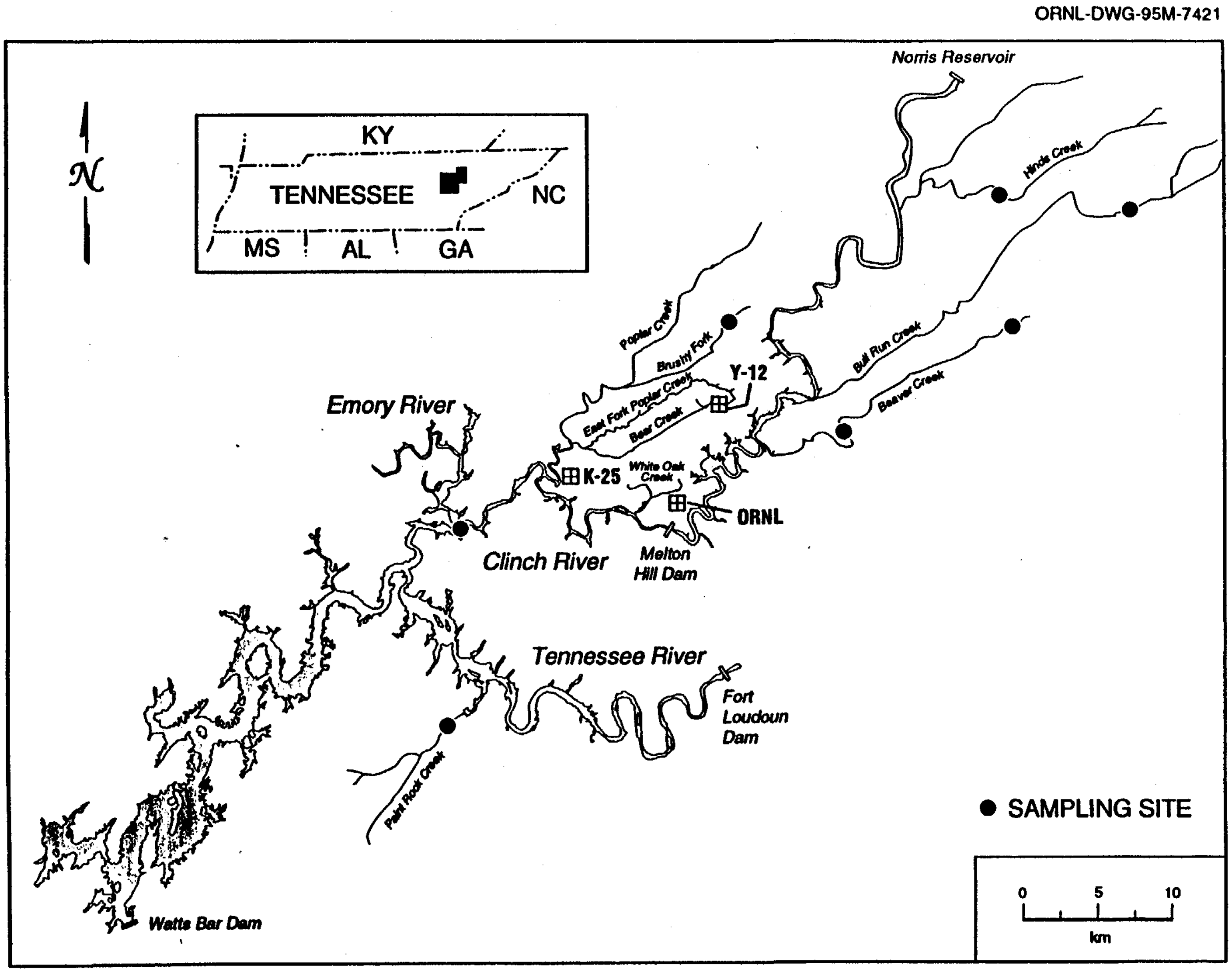

Figure 1.2. Location of reference sites in relation to the Oak Ridge Y-12 Plant.

inlet or LR-i (EFK 24.1) are conducted quarterly. Testing of the ambient sites downstream from Bear Creek Road (EFKs 22.8, 21.9, 20.5, 18.2, 13.8, and 10.9) have been discontinued under the revised BMAP sampling plan (Y-TS-1613).

As required by the Y-12 Plant's National Pollutant Discharge Elimination System (NPDES) permit, quarterly toxicity tests with fathead minnows and *Ceriodaphnia* are also conducted at Outfall 201. Because of the close proximity of Outfall 201 (an instream NPDES location in upper EFPC) to EFK 25.1, toxicity tests at the outfall meet the intent of the BMAP Plan (Adams et al. 1996) to conduct quarterly toxicity tests at EFK 25.1. The results of the Outfall 201 tests are reported elsewhere (in Discharge Monitoring Reports issued by the Y-12 Plant to the Tennessee Department of Environment and Conservation).

2.2 Results/Progress

2.2.1 Toxicity Monitoring

Ambient water samples from EFK 24.1 and EFK 23.8 were evaluated for acute and chronic toxicity to *Ceriodaphnia dubia* during September 3 - 9, 1997. On each sampling day, grab samples were collected by ESD personnel for testing. Results of toxicity tests and chemical analyses are shown in Tables 2.1 and 2.2. During the test period, no toxicity was observed in any of the ambient water samples. *Ceriodaphnia* survival in water from each site equaled 100%. *Ceriodaphnia* reproduction in the water samples was not significantly reduced compared to the controls.

Table 2.1. Results of *Ceriodaphnia dubia* toxicity tests of ambient sites from East Fork Poplar Creek conducted September 3 - 9, 1997.

		Ceriodaphnia dubia	
Sample	**Concentration (%)**	**Survival (%)**	**Mean Reproduction (offspring/surviving female ± SD)**
Control	100	100	29.8 ± 4.9
EFK 24.1	100	100	21.3 ± 8.0
EFK 23.8	100	100	31.5 ± 8.6

Note: EFK = East Fork Poplar Creek kilometer. SD = standard deviation.

2.2.2 Special Studies

During the third quarter, additional laboratory tests were conducted to determine the influence of calcium on the adsorption and desorption of cadmium from calcite particles. These studies were conducted at intermediate levels of pH (8.0 and 8.5) to enhance predictive capabilities about the effect of calcite on cadmium dynamics. A manuscript summarizing the results of these experiments is now in preparation. Zinc, another divalent metal of significance in upper East Fork Poplar Creek, was also

Table 2.2. Summary (mean ± SD) of water chemistry analyses conducted during toxicity tests of ambient samples from East Fork Poplar Creek, September 3 - 9, 1997.

Sample	pH (su)	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)	Conductivity (µS/cm)
Control	8.45 ± 0.10	83.5 ± 2.5	97.3 ± 2.7	209.8 ± 3.8
EFK 24.1	8.19 ± 0.05	113.7 ± 1.2	158.3 ± 7.9	355.2 ± 17.7
EFK 23.8	8.40 ± 0.14	115.2 ± 2.1	158.7 ± 6.2	357.7 ± 16.9

Note: EFK = East Fork Poplar Creek kilometer. SD = standard deviation.

investigated with respect to its ability to reversibly adsorb to calcite. These experiments were performed at pH 7.8, 8.0 and 8.5. The results of these experiments showed that the amount of zinc bound to calcite increases with pH, in a manner anologous to that noted in earlier experiments with cadmium. Future studies are expected to evaluate the influence of dissolved carbon dioxide on the interaction of zinc with calcite.

3. Biological Indicators of Fish Health

3.1 Bioindicators of Fish Health (*S. M. Adams)*

3.1.1 Introduction

This task involves the use and application of bioindicators of fish health, in addition to other investigative approaches, to evaluate the effects of water quality and other environmental variables on fish in EFPC. A suite of diverse bioindicators of fish health has been examined since fall 1985 to evaluate the health of a sentinel species, the redbreast sunfish (*Lepomis auritus*), as a component of the BMAP program.

3.1.2 Results/Progress

In this report, trends since 1990 in three individual bioindicators of fish health in the upper reaches of EFPC below Lake Reality are presented. Two of the indicators, the spleno-somatic index and the level of creatinine in sunfish blood, suggest significant improvement in fish health at this site. A third bioindicator, the fat or lipid index, may also be indicative of improved fish health, although alternative explanations exist for the observed trend in this parameter.

The fat or visceral-somatic index reflects the overall condition of fish relative to their lipid stores or reserves. In general, the higher the fat index, the healthier the fish (Adams and McLean 1985; Goede and Barton 1990). Since 1990 the fat index in male redbreast sunfish collected from EFPC below Lake Reality (EFK 23.4) has remained relatively constant, varying between 3.5 and 4 (Fig. 3.1A). The fat index for female redbreast sunfish has been more variable. The index was lowest in 1995 and 1996 and increased in 1997 to a 8-year high. The low values in 1995 and 1996 may have been

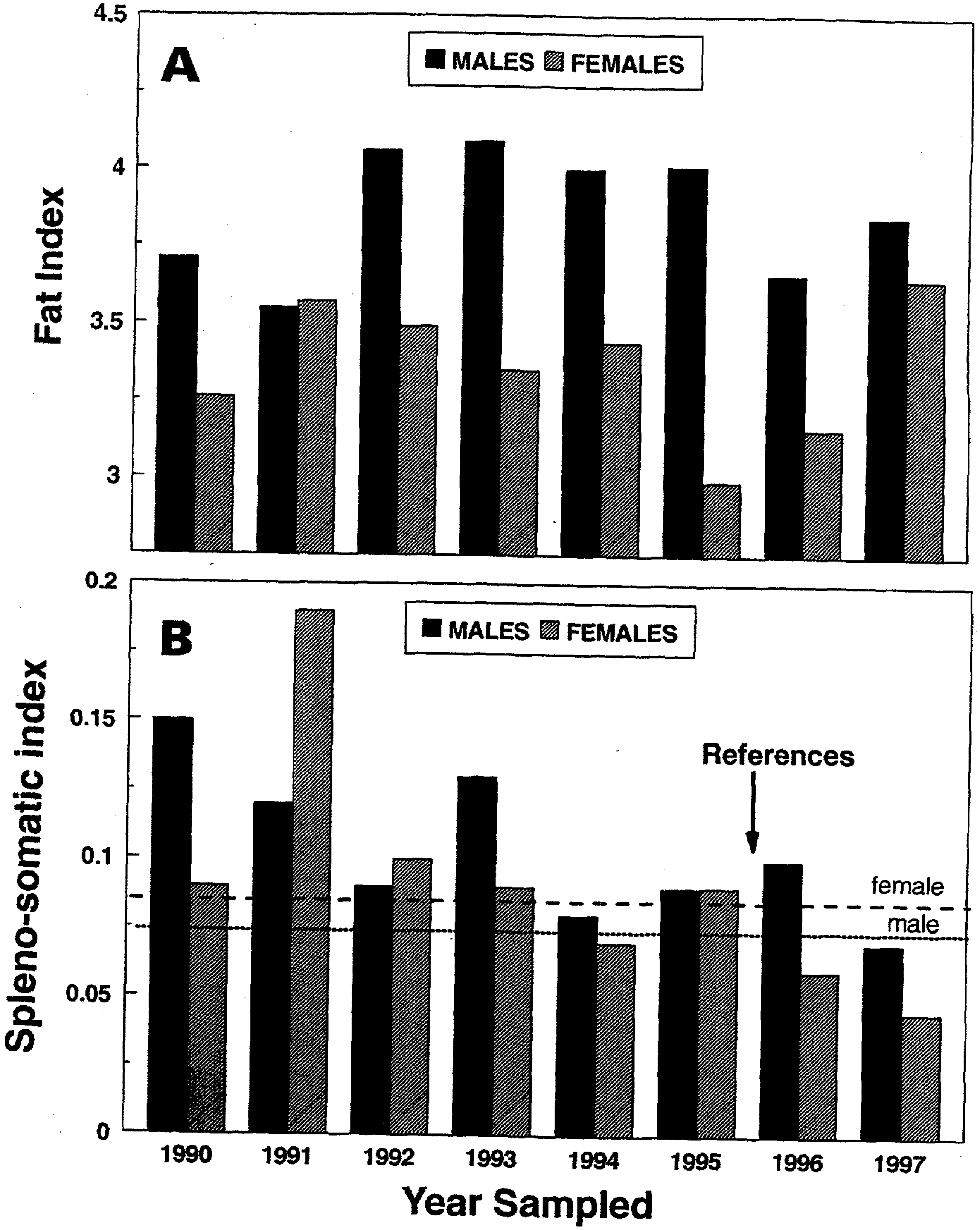

Figure 3.1. Temporal changes in the fat (A) and spleno-somatic indices (B) in male and female redbreast sunfish collected from EFK 23.4.

related to the low water flow regimes in upper EFPC during these two years. During low flow conditions, there is a reduction in the surface area of the stream bed that is submerged which should result in less food (algae and macroinvertebrates) production and availability for consumer species such as the fish community. Low flow conditions would also tend to result in increased crowding and more consumer biomass per unit of water volume in the stream resulting in increased competition for food resources. In addition, low flow regimes typically result in increased stream temperatures which would place increased metabolic demands on fish. This latter situation could result in less physiologically useful energy (consumed energy) being available for growth and fat storage, particularly for female fish who necessarily incur greater metabolic and physiological demands from gonad maturation and spawning. Thus, the increased water flow since fall 1996 could be favoring a decrease in the metabolic demands on fish because of the lower water temperatures, ultimately resulting in an increased fat index.

Alternatively, the increased female sunfish fat index in 1997 may simply be related to the relatively under-developed reproductive stage of the female fish utilized for the 1997 fish health assessment (see Section 3.2, Table 3.1: EFK 23.4 samples collected on May 27, 1997). Decreased water temperatures, caused both by flow management and an unusually cool spring, significantly delayed the 1997 seasonal reproductive cycle of sunfish in EFPC and other streams in the area. Lipid utilization by oocytes, which is particularly pronounced in the later stages of development, was undoubtably also delayed in these particular female fish samples. Thus the increased fat index of the female's somatic tissues in 1997 might just be a reflection of a decreased utilization of lipid reserves by the female gametes. This example illustrates the importance of examining a diverse suite of physiological and reproductive bioindicators when interpreting patterns in any single indicator.

The remaining two bioindicators provide clear support for improved fish health at EFK 23.4. The spleno-somatic index (spleen weight/total body weight) is applied in the field as a general indicator of infection or disease in fish (Goede and Barton 1990). Because the spleen serves a hemopoietic function in vertebrates, an enlarged spleen often results from bacterial or parasitic infections. Conversely, low values for this index suggest relatively low infection or disease rates. In both male and female sunfish from the upper reaches of EFPC, this index remained higher than reference conditions until 1994 (Fig. 3.1B). By 1994 and 1995, the indices for both sexes were similar to reference values, with the index for females actually dropping below the reference in 1996 and 1997. The continuing decline in the spleno-somatic index in 1997 could have been assisted by the water flow management initiated in the fall of 1996. Both cooler water temperatures and increased water flow would tend to reduce disease rates in a fish population: reduced temperatures decrease the rate of pathogen proliferation and increased water flow volume reduces the crowding of fish (less fish per unit water volume). Also, fish which are in a higher state of nutritional condition, as possibly reflected by the increased fat index in 1997 (Fig. 3.1A), are less inclined to incur disease and infection. Low energy reserves weaken fish and renders them more susceptible to disease from numerous causes (Shul'man 1974).

Elevated creatinine levels in the blood are typically used as an indicator of kidney damage or malfunction in vertebrates (Tietz 1986). Levels of creatinine in redbreast sunfish collected from upper EFPC were much higher than reference values until 1993-1994 (Fig. 3.2). After this period, levels in the blood remained similar to reference concentrations indicating an improvement in kidney condition. This improvement may be related to the temporal declines in mercury observed in upper EFPC over this same period. Mercury concentrations in the water from upper EFPC have declined steadily over the 1989-1997 time period, and levels have been generally less than 1ug/L since 1994 (DOE 1996; Southworth et al. in press). Heavy metals, and particularly mercury, are known to cause chronic poisoning and renal

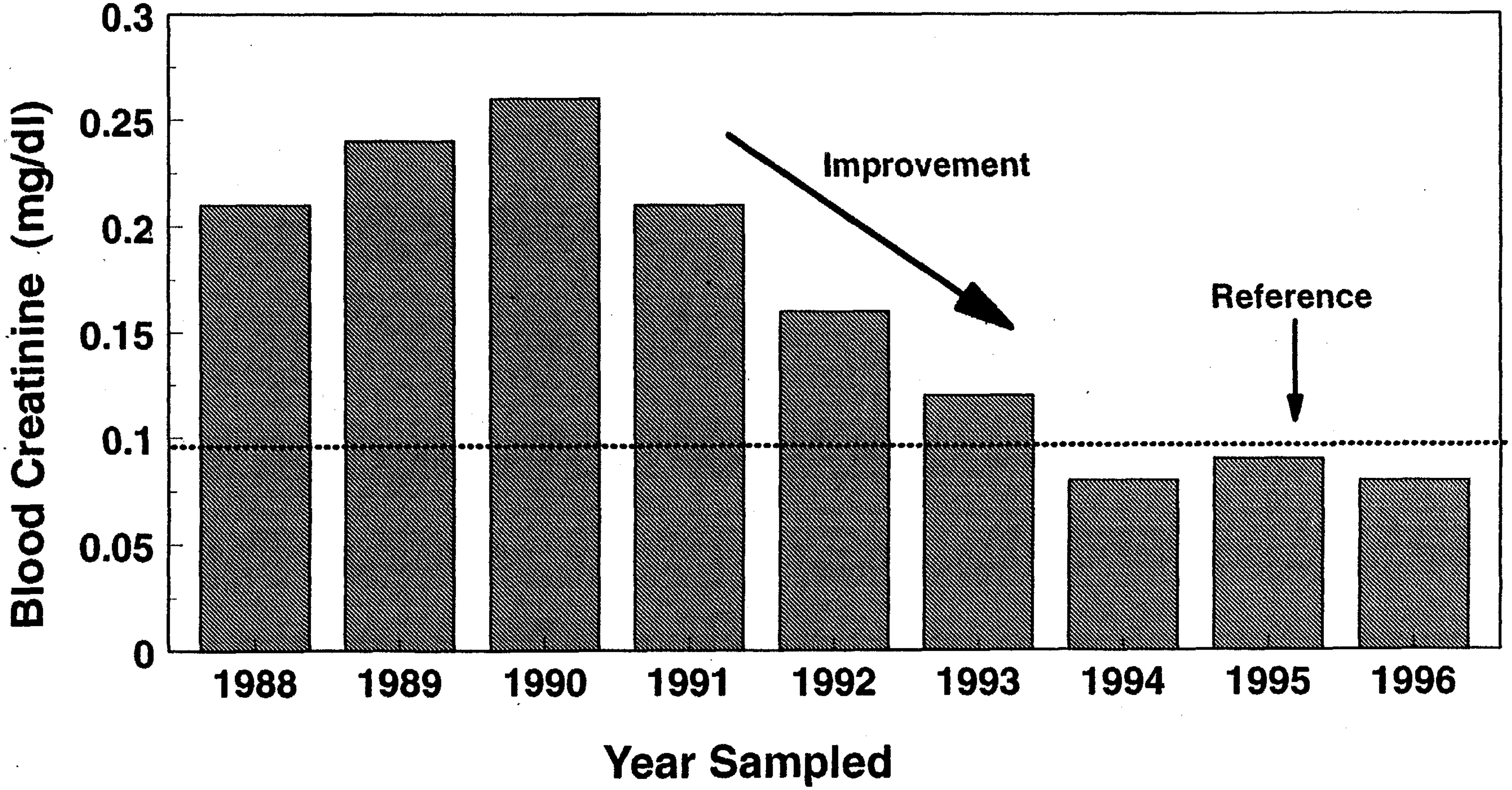

Figure 3.2. Temporal Changes in creatinine levels in the blood of redbreast sunfish collected from EFK 23.4. Decreases in this bioindicator since 1990 indicate improvement in kidney function of redbreast sunfish in the upper reaches of EFPC.

toxicity in vertebrates (Hultman and Enestrom 1992), hyperplasia and necrosis of kidney tubules in guppies (Wester and Canton 1992), and pathological alterations in the trunck kidney of the freshwater teleost C. punctatus (Banerjee and Bhattacharya 1994). Thus, remedial activities at the Y-12 facility, which reduced loading of mercury into upper EFPC, could be responsible for the observed improvement of kidney condition and function in individuals within the redbreast sunfish population of upper EFPC.

3.2 Bioindicators of Reproductive Competence (*M. S. Greeley, Jr.)*

3.2.1 Introduction

Successful reproduction of fish populations requires that adult fish be capable of producing and spawning viable gametes. To address the reproductive competence of adult fish in EFPC, various reproductive indicators, representing several different levels of reproductive organization related to gamete production, have been routinely examined in redbreast sunfish sampled from EFPC and reference streams at the beginning of each annual breeding season since 1988. Establishment and maintenance of stable fish populations also requires that offspring be able to develop normally into subsequent reproductive cohorts. Beginning in 1990, water samples from several sites in EFPC and other streams on and about the ORR have been tested for their effects on fish developmental processes utilizing a medaka (*Oryzias latipes*) embryo-larval test.

3.2.2 Results/Progress

During May and June, 1997, redbreast sunfish were sampled from 4 sites in EFPC (EFKs 24.6, 23.4, 18.2 and 13.8) and 2 sites in reference streams (Brushy Fork and Hinds Creek), in order to assess relative reproductive condition at the beginning of the breeding season. Because water temperatures were much cooler than in previous years, several sites had to be sampled up to three times in the spring of 1997 before suitable pre-spawning samples were obtained. Blood samples were drawn from each fish and frozen for later analysis of reproductive hormones. Fish body weights and lengths were measured and recorded. Reproductive organs were weighed, then preserved in fixative for later analysis. Testes from male fish were subsequently prepared for histopathological examination, while ovaries from female fish were directly analyzed for the occurrence of ovarian parasites, the abundance of atretic (dead or dying) oocytes, and fecundity. Partial results of these analyses are presented in table 3.1. The remaining results will be reported as additional analyses are completed.

Redbreast sunfish typically spawn when water temperatures reach approximately 20°C. In previous years, such water temperatures could generally be found in lower EFPC by the third or fourth week of May. However, in 1997 (Table 3.1), this threshold temperature was not observed until mid-June due apparently to a combination of an unusually cool spring and the addition of cool water to the upper reaches of EFPC during flow management. The differing effects of this delay on the reproduction of redbreast sunfish at different sites in EFPC are evidenced by the reproductive parameters presented in table 3.1, with the effects being most pronounced at EFK 23.4.

In previous years, redbreast sunfish at EFK 23.4 typically began spawning in the interval between May 20 and May 27 when water temperatures passed the spawning threshold. In the spring of 1997, spot checks of water temperatures and noninvasive examinations of female fish in mid-May predicted a significantly later initiation of spawning this year in lower EFPC . Three subsequent fish collections at EFK 23.4 conducted over a period from May 27 through June 26, 1997, failed to identify fish with either mature ovulated eggs (indicative of an imminent spawn) or shed follicles (the covering of the immature

Table 3.1. Means and standard errors for condition factors and reproductive indices measured in female redbreast sunfish sampled from EFPC and reference sites in late May or June immediately prior to the 1997 breeding season.

Site	Date	Temperature (°C.)	Condition Factor	GSI	Ovulated eggs (#/g body wt)	Median oocyte size in largest clutch (mm)	Atretic oocytes (#/g body wt)	Fecundity (oocytes/g body wt)	Ovary parasites (#/g body wt)
EFK 24.6	6/4/97	17.9	1.55±0.04	13.08±1.61	0	1.6	3.02±1.03	55.29±4.91	0
EFK 23.4	5/27/97	19.0	1.69±0.04	7.62±1.32	0	1.3	3.03±0.96	55.66±14.47	0.22±0.16
	6/19/97	18.8	1.71±0.02	8.73±0.92	0	1.6	20.21±7.50	41.13±6.16	0.43±0.28
	6/26/97	21.0	1.76±0.05	9.59±1.06	0	1.5	18.38±5.48	45.95±5.82	0.36±0.16
EFK 18.2	6/2/97	18.0	1.86±0.02	9.91±0.76	0	1.7	2.04±0.09	41.28±3.05	0.10±0.07
	6/19/97	19.0	1.84±0.06	10.35±0.99	0	1.7	5.15±1.98	36.06±2.08	0
	6/26/97	20.5	1.73±0.03	8.41±2.06	9.07±4.91	1.7	2.93±0.80	46.72±2.72	0.3±0.3
EFK 13.8	6/3/97	17.0	1.94±0.03	12.80±0.48	0	1.7	1.54±0.48	42.61±3.16	0.05±0.05
	6/20/97	19.0	1.79±0.04	17.55±1.84	2.16±2.16	1.8	7.51±3.13	41.67±4.223	0.11±0.11
	6/27/97	20.5	1.79±0.03	6.38±0.69	0	1.4	2.87±0.95	37.83±4.17	0
Hinds Creek	6/12/97	16.5	1.89±0.04	10.64±0.60	0	1.5	3.53±1.16	52.00±2.97	0
Brushy Fork	6/11/97	Not obtained	1.79±0.04	10.10±0.83	0	1.6	6.79±2.09	42.72±4.36	0.04±0.04

Note: EFK = East Fork kilometer; Hinds Creek and Brushy Fork are reference sites. Condition factor = [(body wt - gonad wt)/(body lgth)^3] x 100 ; GSI = gonadal somatic index *or* (gonad wt/body wt) x 100. Shaded areas delineate prespawning samples for comparisons between sites and years.

egg or oocyte which is left behind in the ovary when the mature egg is spawned: indicative of a recent spawn), even after the 20°C threshold for spawning was reached at this site. Instead, massive amounts of atresia (death and reabsorption) of the larger oocytes were noted, indicating a total failure of the initial redbreast sunfish spawn during the 1997 breeding season at EFK 23.4. There were also no obvious signs of an imminent spawn. However, females still possessed numerous small oocytes in loosely organized clutches (on which the estimated fecundity in table 3.1 is based), so spawns later in the summer were still possible. Sampling for redbreast sunfish young-of-the-year will be conducted this fall to examine the ultimate effect of the cooler waters on redbreast sunfish recruitment at this site.

In contrast, late but apparently successful redbreast sunfish pawns were documented at sites further downstream in EFPC (EFK 18.2, 13.8), although these initial spawns were delayed by nearly a month and some atresia of the largest oocytes was noted (Table 3.1). Fish were collected during spawning at EFK 18.2, as evidenced by the presence of numerous ovulated eggs and freshly-shed follicles in female fish on June 26, 1997. Fish were collected both during and just after a major spawn at EFK 13.8, as evidenced by large decreases in the GSI and in the sizes of the largest ovarian oocytes in consecutive collections on June 20 and 27, 1997.

Although fish health is undoubtably improving in the upper reaches of lower EFPC below Lake Reality (see preceding section), certain bioindicators continue to suggest that fish here and in upper EFPC above Lake Reality are still experiencing significant physiological stress from either bioenergetic and/or pollution-related factors. The condition factor, an indicator of the relative "plumpness" of a fish, continues to be lower in female sunfish collected upstream (EFK 24.6) and downstream (EFK 23.4) of Lake Reality in comparison with fish from the other study sites (Table 3.1), consistent with trends established in previous years. Lower condition factors suggest that sunfish in the upper reaches of EFPC have less energy resources to devote to reproduction than fish from reference sites or sites farther downstream in EFPC. However, fecundities measured in fish from these sites are actually relatively high (despite the loss of the initial clutch of developing oocytes in 1997), suggesting instead that these fish devote a disproportionally higher percentage of their limited resources to reproduction rather than to somatic growth. Similar observations have been noted previously in sunfish sampled from the same EFPC sites (Greeley et al. 1996; previous Y-12 BMAP quarterly reports), from White Oak Creek downstream of ORNL (Adams et al. 1994) and from Mitchell Branch downstream of the K-25 Site (Greeley 1994), and may constitute a response of sunfish to the stressful environmental conditions at these sites.

Another continuing concern with the sunfish populations in the upper reaches of EFPC (EFK 24.6 and 23.4) is the abnormally high incidence of oocyte atresia in female fish. Incidences of oocyte atresia were unusually high at all sites sampled in the spring of 1997 (Table 3.1), apparently due to the cooler than-normal water temperatures as noted in the preceding discussion. However, atresia at EFK 23.4 continues a trend established over many years of much higher incidences of atresia at this site as compared with fish from reference sites (Fig 3.3) or other EFPC sites. Nearly all of the atresia in fish from reference sites in 1997 was due to the reabsorption of larger oocytes that failed to mature when spawning was delayed by the cool spring. In contrast, the oocyte atresia observed at EFK 24.6 on June 24 and at EFK 23.4 on May 27 in particular involved oocytes of all sizes and stages of development, was similar in scope and type to atresia observed previously at these sites, and apparently reflected the basal levels of stress experienced by fish at these upstream EFPC sites.

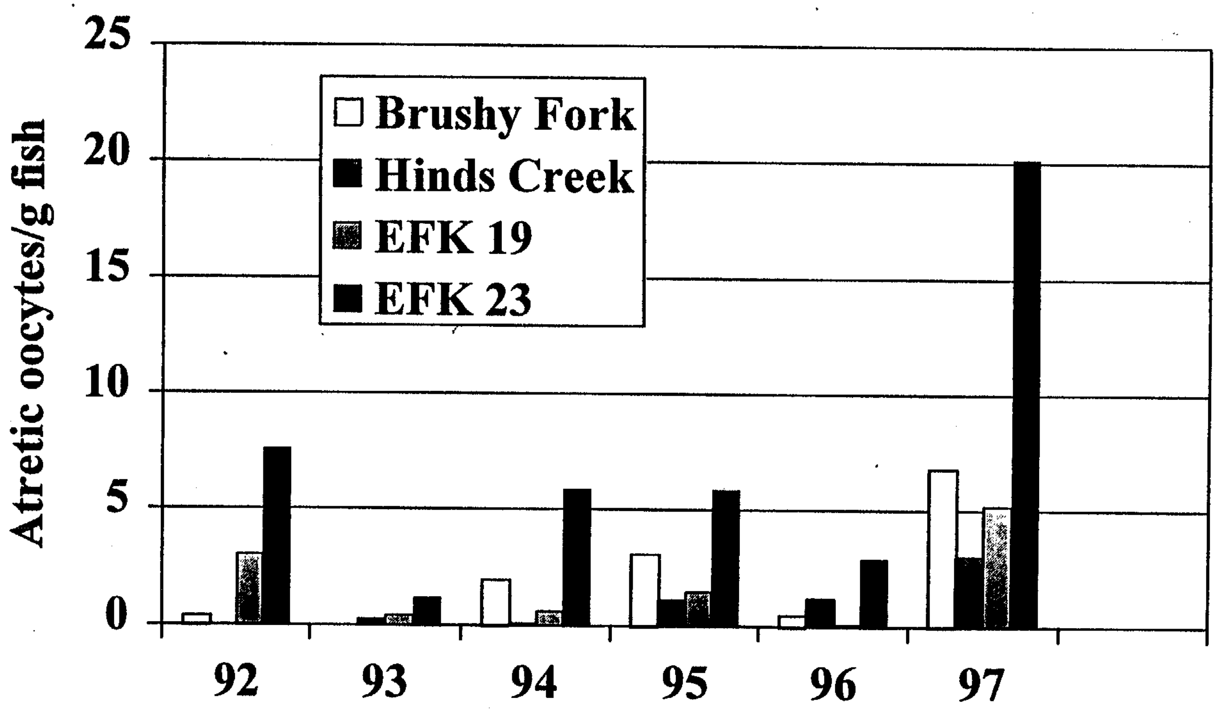

Fig. 3.3. Temporal changes in the incidences of atretic oocytes in female redbreast sunfish in EFPC and references sites. EFK 23 = EFK 23.4; EFK 19 = EFK 18.2.

4. Bioaccumulation Monitoring

4.1 Routine bioaccumulation monitoring (*M. J. Peterson and G. R. Southworth*)

4.1.1 Introduction

Bioaccumulation monitoring conducted since 1985 as part of the EFPC BMAP has identified mercury and polychlorinated biphenyls (PCBs) as substances that accumulate to concentrations in fish that may pose health concerns to human consumers. Redbreast sunfish are collected twice annually from six sites along the length of EFPC to evaluate spatial and temporal trends in mercury and PCB contamination. Largemouth bass, a species that achieves a large size, is at the top of the food chain, and contains relatively high levels of intramuscular lipids, are sampled once annually in upper EFPC to evaluate the maximum mercury and PCB concentrations likely in the EFPC system. Presented in this report are the mercury and PCB results for sunfish and largemouth bass *(Micropterus salmoides)* collected in the fall/winter 1996 (prior to full operation of the Lake Reality bypass experiment) and spring/summer 1997 (approximately 6 months after the bypass start-up).

4.1.2 Results/Progress

Sunfish monitoring

Mean mercury concentrations in redbreast sunfish collected from EFPC in fall 1996 and spring 1997 are presented in table 4.1. In fall 1996, the highest level of contamination was again found in EFPC above Lake Reality (EFK 24.8), where five of six fish exceeded 1 ppm total mercury. Mean mercury concentrations were consistent across the next four sites downstream, averaging 0.76 - 1.01 µg/g. The average mercury concentration in sunfish at EFK 23.4 (0.95 µg/g) was atypically high in comparison to the average at this site over the last 5 years (~ 0.7 µg/g). The lowest average mercury concentration (0.45 µg/g) was in fish from EFK 6.3, the most downstream site in EFPC. Mercury concentrations in sunfish from Hinds Creek, an uncontaminated reference site, averaged approximately 0.1 µg/g (Table 4.1).

In spring 1997, mercury concentrations in redbreast sunfish decreased from fall 1996 values at all sites except EFK 6.3. The greatest differences were at the two sites most impacted by the bypass experiment, Lake Reality and EFK 23.4 (the site immediately downstream of the Lake Reality discharge). The decrease at EFK 23.4 followed an atypically high average mercury concentration in fall 1996, nevertheless the spring 1997 value of 0.52 µg/g was the lowest average reported for this site since monitoring started in 1985. The average mercury concentration in redbreast from Lake Reality decreased from 0.76 µg/g in fall 1996 to 0.45 µg/g in spring 1997. Mercury in sunfish from the stream reach above Lake Reality (EFK 24.8) also exhibited a decrease over the 6-month period, but proportionately smaller than downstream sites (Table 4.1).

Although the mercury concentrations in many East Fork Poplar Creek fish exceeded the Environmental Protection Agency's screening value of 0.6 µg/g, for the first time since monitoring began in 1985 no sunfish downstream of EFK 24.8 exceeded the 1 µg/g Food and Drug Administration threshold limit. Five of six sunfish exceeded 1µg/g at EFK 24.8.

Table 4.1. Average (± SE) concentrations of mercury (µg/g, wet wt.) in muscle tissue of redbreast sunfish collected from East Fork Poplar Creek and reference streams in fall 1996 and spring 1997.

Site	Fall 1996	Spring 1997
EFK 24.8	1.45 0.15	1.22 ± 0.10
Lake Reality	0.76 ± 0.04	0.45 ± 0.03
EFK 23.4	0.95 ± 0.26	0.52 ± 0.09
EFK 18.2	0.82 ± 0.06	0.72 ± 0.06
EFK 13.8	1.01 ± 0.17	0.68 ± 0.04
EFK 6.3	0.41 ± 0.03	0.76 ± 0.05
Hinds Creek	0.12 ± 0.03	0.09 ± 0.02

Note: EFK = East Fork kilometer. Hinds Creek is an uncontaminated reference stream. N = 6 fish/site.

Mean PCB concentrations in redbreast sunfish collected from EFPC in fall 1996 and spring 1997 are presented in Table 4.2. In general, the mean PCB concentrations were highest in fish from sites nearest the Y-12 plant and decreased with distance downstream in both sampling seasons. In fall 1996, average PCB concentrations ranged from 1.68 - 1.95 µg/g at the three most upstream EFPC sites, but concentrations were substantially lower at sites downstream of Bear Creek road (EFKs 18.2, 13.8, 6.3). Mean PCB concentrations at the three lowermost sites in EFPC were approximately 25% of the averages observed near the Y-12 Plant, averaging 0.21 - 0.48 µg/g. The average PCB concentration in sunfish from Hinds Creek, an uncontaminated reference stream, was less than 0.01 µg/g PCBs.

In spring 1997, PCB concentrations in sunfish were similar to those observed in fall 1996 at Lake Reality and the three most downstream sites. However, at EFK 23.4, the site most impacted by the Lake Reality bypass, the average PCB concentration in sunfish decreased to less than half of the average observed in fall 1996. A less dramatic decrease was also observed in sunfish from EFK 24.8. The mean PCB concentration in sunfish at EFK 24.8 decreased from near 2 µg/g in fall 1996 to approximately 1.4 µg/g in spring 1997.

The experimental Lake Reality bypass achieved its goals of reducing baseflow mercury concentrations and loading in EFPC at station 17, and of reducing waterborne methylmercury export to the creek downstream (Southworth et al. 1997). None of the hypothesized adverse effects of the bypass, including potential increases in mercury and PCB concentrations in fish, proved to be a concern. With the exception of PCB concentrations in redbreast sunfish from Lake Reality (which exhibited no change), average mercury and PCB concentrations decreased at the three most upstream sites on EFPC. Although the results to date show no adverse effects of the bypass on bioaccumulation of mercury or PCBs, the

Table 4.2. Average (± SE) concentrations (µg/g, wet wt.) of total PCBs (Arochlor 1254 + 1260) in muscle tissue of redbreast sunfish collected from East Fork Poplar Creek and reference streams in fall 1996 and spring 1997.

Site	Fall 1996	Spring 1997
EFK 24.8	1.95 ± 0.08	1.39 ± 0.17
Lake Reality	1.68 ± 0.41	1.63 ± 0.47
EFK 23.4	1.93 ± 0.45	0.86 ± 0.18
EFK 18.2	0.48 ± 0.05	0.45 ± 0.07
EFK 13.8	0.21 ± 0.07	0.42 ± 0.08
EFK 6.3	0.41 ± 0.04	0.44 ± 0.05
Reference stream	< 0.01	< 0.01

Note: EFK = East Fork kilometer. The reference stream was Hinds Creek. N=6 fish/site except in spring 1997 at EFK 24.8 and Hinds Creek (N=4 each site) and EFK 23.4 (N=5).

possibility that such effects will become evident in the future remains. Only long term observation will determine conclusively if the successes of the short term study (six month bypass) continue in the future.

Largemouth bass monitoring

Average mercury and PCB concentrations in bass collected in November 1996 to January 1997 are reported in table 4.3. The mean mercury concentration in bass from Lake Reality exceeded 1 µg/g. Bass from EFK 23.4 were substantially lower in mercury (0.72 µg/g), and surprisingly averaged less than the mean mercury concentration in sunfish from the same site. Differences in food web structure is a probable reason for the relatively low mercury concentrations in bass from the stream proper. Largemouth bass from EFK 23.4 most likely feed on abundant stoneroller minnows that contain relatively low methyl mercury concentrations, whereas fish from Lake Reality may feed on sunfish or shiners that contain higher methyl mercury body burdens.

The mean PCB concentrations in bass from Lake Reality and EFK 23.4 were 7.3 and 4.4 µg/g respectively. All bass from upper EFPC contained total PCB concentrations that exceeded the 2 ppm FDA threshold limit, with individual fish ranging from 3.1 to 11.1 µg/g total PCBs. The higher PCB concentrations in fish from Lake Reality may be due in part to fish eating gizzard shad, which contain very high levels of intramuscular lipids. Although shad are rare at EFK 23.4, PCB levels are also high in stream bass because stonerollers, assumed to be a major food item in stream bass, are also relatively high in PCBs compared to other fish species.

Table 4.3. Average (± SE) concentrations (µg/g, wet wt.) of total mercury and PCBs (Arochlor 1254 + 1260) in muscle tissue of largemouth bass collected from East Fork Poplar Creek (November 1996 - January 1997).

Site	Total mercury	Total PCBs
Lake Reality	1.16 ± 0.13	7.32 ± 1.34
EFK 23.4	0.72 ± 0.11	4.35 ± 1.26

Note: EFK = East Fork kilometer. N = 4 fish/site.

4.2 Special Mercury Studies *(G. R. Southworth)*

Streams where mercury concentrations in fish exceed background levels were sampled and analyzed for mercury, methylmercury, halides, and other anions in July and August , 1997. These data are being evaluated along with measurements of mercury concentrations in fish to further understand the relationship between mercury in water and its bioaccumulation in fish. The 1997 data verify the striking difference in bioavailability between mercury in upper EFPC and other mercury contaminated sites that was noted in 1996. Mercury bioavailability appeared to be inversely related to fluoride concentration. No chemical interaction between fluoride and mercury is expected, but fluoride may act as an indicator of the presence of another unspecified substance present in process water at Y-12 and ORNL that reduces the bioavailability of mercury.

Data on mercury collected in the Y-12 BMAP program are being compiled for inclusion in the 1997 Mercury Abatement Report.

4.3 PCB Source Identification *(J. F. McCarthy)*

In an effort to identify sources and sinks of PCBs in upper EFPC, passive monitors (semi-permeable membrane devices; SPMDs) were deployed in 24 monitoring locations in storm drains, outfalls and within upper EFPC in June-July 1997. Results were analyzed in terms of both the aqueous concentration of PCBs[1] at the different monitoring locations, and the time-integrated flux of PCBs. The

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[1] *The time-averaged aqueous concentrations of PCB's were estimated, based on the following assumptions:*

(1) The total mass of PCB's were calculated from a standard curve based on a mixture of Arochlors. Differences in congener profiles between the samples and the Arochlor standards could affect this calibration, but the error should be relatively minor.

(2) A mass transfer coefficient for PCB's entering the SPMD (referred to as a sampling rate) was estimated based on data from a Finnish researcher who measured this coefficient for a few congeners. This estimate should be good within a factor of 3 to 5-fold. Controlled laboratory exposure experiments to directly measure the sampling rate of PCBs are required to improve estimates of the aqueous concentration based on SPMD data. Nevertheless, the estimate provide a reasonable estimate of the aqueous concentration, although the uncertainty associated with these estimates must be understood.

outfall NPDES-135 had the highest PCB concentration, followed closely by NPDES-125, and the SWHISS Houses 9422-12 and 9422-16 (all estimated to be >30 ng/L). The lowest concentrations were seen in Outfall-17 and Clinch River Flow management water (<1.0 ng/L).

The flux of PCBs (mg PCB/day; calculated as the product of the time-integrated concentration and the average volumetric flow at the monitoring location) was calculated to:

1. identify the relative importance of the different outfalls and storm sewer tributaries that were monitored to the total flux of PCBs from the Plant, and
2. more importantly, identify the magnitude and location of additional PCB sources, such as nonpoint sources or unmonitored outfalls, as well as PCB sinks (possibly as depositional areas). The flux of PCBs at a given location in upper EFPC was compared to the flux at the next downstream monitoring location (after correcting for differences in volumetric flow rate). An increase in the flux indicated the presence of a PCB source between the two locations, while a decrease in flux indicated a sink for PCBs.

Two principal sources of PCBs (mg/d) to upper EFPC were identified, and neither was associated with the outfalls included in this monitoring effort. The first source was located along a reach of stream between the North/South Pipe and the NPDES-109 Bridge. The second was located in the stream reach between the Station-8 Bridge and the East Patrol Road Bridge. Conversely, the reaches between the 109 Bridge and the Station 8 Bridge, and between the East Patrol Road Bridge and the inlet to Lake Reality, were sinks for PCBs (i.e., the flux of PCBs decreased between these locations). The magnitude of the two unidentified PCB sources greatly exceeds that from any of the monitored outfalls. For example, the increase in PCB flux between North/South Pipe and the NPDES-109 Bridge was several-fold greater than the combined flux contributed by outfalls NPDES-135, NPDES-125 and the North/South Pipe.

Although significant PCB fluxes were associated with several point sources, the results suggest that the principal sources of PCBs in upper EFPC are from historic releases, not current discharges. The releases may originate through diffusion of in-place contaminants from the sediment or by advection of shallow groundwater sources beneath or adjacent to the stream. It should be noted that the SPMDs only measure the dissolved PCBs, not those associated with suspended particles. The increases in the flux of PCBs thus reflect inputs of dissolved, rather than particle-associated PCBs. The rapid decline in PCB flux over relatively short reaches of the stream suggests that the dissolved PCBs rapidly become associated with natural organic matter, suspended particles or sediment.

Flow management has not appeared to have an effect on PCB flux. The flux of PCBs from Y-12 in June-July 1997 are very similar to those measured in an SPMD deployment at the 3rd Street Bridge and Station 17 during a similar time period in 1996, prior to flow management. The increased volumetric flow rate appears to have resulted in a decrease in PCB concentrations, but the mass of PCBs exiting the Plant has not changed.

It is worth noting that the North/South Pipe-to-Outfall 109 reach has also been identified as a major source of unidentified mercury inputs to EFPC. The SPMD data suggest that mercury and PCB inputs to EFPC in this reach may have similar origins.

5. Community Studies

5.1 Periphyton (*W. R. Hill*)

5.1.1 Introduction

Periphyton monitoring in EFPC occurs four times a year (as close to a quarterly sampling regime as environmental conditions will allow). Rocks and their associated periphyton are collected from three sites on EFPC (EFKs 24.4, 23.4, 6.3) and one site on Brushy Fork (BFK 7.6). Four rocks from each site are used in determining algal biomass (chlorophyll *a*) and rate of photosynthesis (^{14}C incorporation).

5.1.2 Results/Progress

Periphyton biomass and photosynthesis was measured on July 9,1997. The results of the periphyton analysis appear in table 5.1. Biomass and photosynthesis for all sites were well within the range of historical means and were quite similar to data obtained in July, 1996. The similarity of this year's data to previous years suggests that flow management has not had a significant effect on biomass and photosynthesis, even at EFK 24.4, where the largest changes in current and temperature are anticipated. Biomass and photosynthesis in upper EFPC appear to be principally constrained by grazers, nutrients, and light, none of which have changed dramatically before this sampling episode. However, the catastrophic flood and consequent dechlorination mishap of July 24 caused significant reductions in the populations of stoneroller minnows, which are the primary grazers in upper EFPC. Some parts of upper EFPC have become colonized by filamentous algae after the fish kill, consistent with the hypothesis that stonerollers limit the development of periphyton at our sampling sites. If there is an increase in periphyton resulting from the fish kill, it should be quantified in the September sampling.

Table 5.1. Means and standard errors for biomass, photosynthesis, and chlorophyll-specific photosynthesis rates of periphyton collected from EFPC and Brushy Fork, July 9, 1997.

Site	Algal biomass (μg chla/cm^2)	Photosynthesis (μgC/cm^2/h)	Chlorophyll-specific photosynthesis (μgC/μgchla/cm^2/h)
EFK 24.4	50.4 ± 5.0	9.16 ± 1.69	0.19 ± 0.04
EFK 23.4	31.9 ± 3.9	10.9 ± 1.73	0.34 ± 0.02
EFK 6.3	25.7 ± 2.6	8.90 ± 1.50	0.34 ± 0.04
BFK 7.6	4.47 ± 1.29	1.51 ± 0.27	0.36 ± 0.03

Note: EFK = East Fork kilometer, BFK = Brushy Fork kilometer

Metal concentrations in periphyton collected on three dates from April 1996 to April 1997 were analyzed in August. The analyses showed that concentrations of most metals decreased substantially between April 1996 and September 1996 at EFK 24.4 (Figure 5.1). Changes in metal concentrations can result from many factors, but a disproportionately large decrease at EFK 24.4 suggests that flow management at the North-South pipes could have been responsible for the decrease. Flow management with uncontaminated river water should have diluted the concentration of most metals in the upper reaches of EFPC, and the effect would have been greatest at the sites closest the North-South pipes (e.g., EFK 24.4). Periphyton was again sampled in September, 1997, for metals analysis.

5.2 Benthic Macroinvertebrate Community Monitoring (*J. G. Smith*)

5.2.1 Introduction

Benthic macroinvertebrates are those organisms lacking spinal columns that are large enough to be seen without the aid of magnification and that live on or among the substrate particles of flowing and non-flowing bodies of water. The limited mobility and relatively long life spans (a few months to more than a year) of most taxa make them ideal for use in following long-term ecological trends associated with natural or unnatural changes in the environment. Thus, the composition and structure of the benthic macroinvertebrate community reflects the relatively recent past and can be considerably more informative than methods that rely solely on water quality analyses.

The objectives of the benthic macroinvertebrate task are to monitor the benthic macroinvertebrate community in EFPC in order to provide information on the ecological condition of the stream, and to evaluate the response of macroinvertebrates to operational changes, abatement activities, or remedial actions at the Y-12 Plant as a measure of the effectiveness of these actions. To meet these objectives, routine quantitative benthic macroinvertebrate samples have been collected at least twice annually (April and October) since June 1985 from four sites in EFPC (EFK 24.4, EFK 23.4, EFK 13.8, and EFK 6.3). Since 1986, up to two reference sites unimpacted by industrial discharges have also been monitored: one site each on BF at kilometer 7.6 (BFK 7.6) and Hinds Creek at kilometer 20.6 (HCK 20.6) (Figs. 1.1 and 1.2). This report includes a summary of the results for the April sampling periods from 1986 through 1997 for EFK 24.4, EFK 23.4, EFK 13.8, and BFK 7.6.

5.2.2 Results/Progress

Average values for total taxonomic richness (number of taxa/sample) and richness of the Ephemeroptera, Plecoptera, and Trichoptera (number of EPT taxa/sample) for samples collected during the April sampling periods from 1986 through 1997 are presented in Fig. 5.?. These two metrics have consistently helped determine the condition of stream sites, as well as, help detect potentially important temporal changes within sites. EPT richness is particularly useful because the three major insect orders it includes are generally intolerant of poor water quality.

Total and EPT richness values were clearly low at EFK 24.4 and EFK 23.4 compared with BFK 7.6 from 1986 through 1997. However, values for both metrics have generally increased through time at these two sites while values for BFK 7.6 have shown no consistent trend of change. Since April 1986, total richness has almost tripled at EFK 24.4 and EFK 23.4, and since April 1994, EPT richness has increased from consistently almost no EPT taxa at EFK 24.4 to approximately 2 EPT taxa/sample. From 1989 through 1997, values for total richness at EFK 13.8 have consistently changed within the range exhibited by BFK 7.6. This has generally be true of EPT richness, although values at EFK 13.8 have been slightly less than

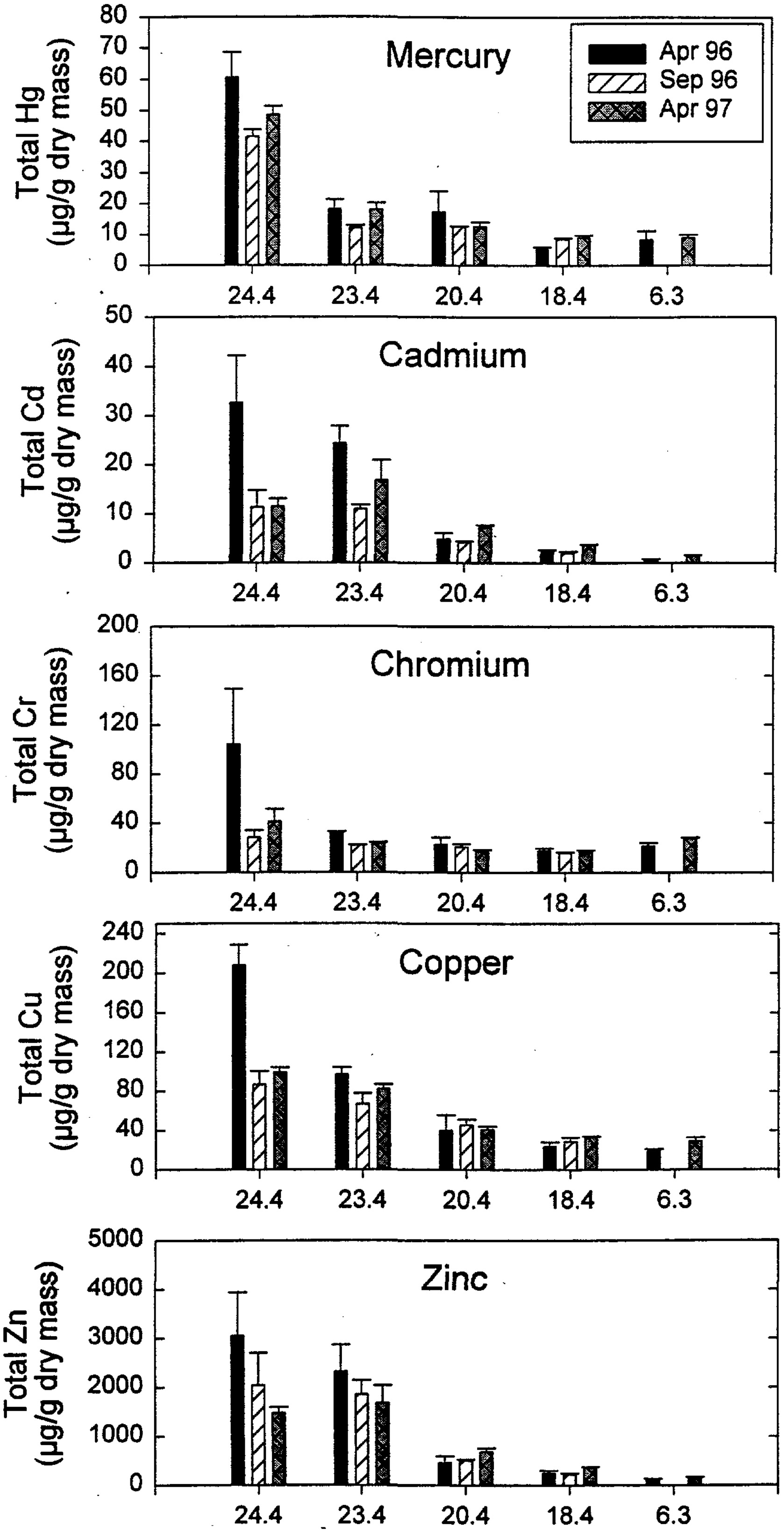

Fig. 5.1. Changes in periphyton metal concentrations in EFPC between April 1996 and April 1997. X-axis labels refer to EFPC kilometer.

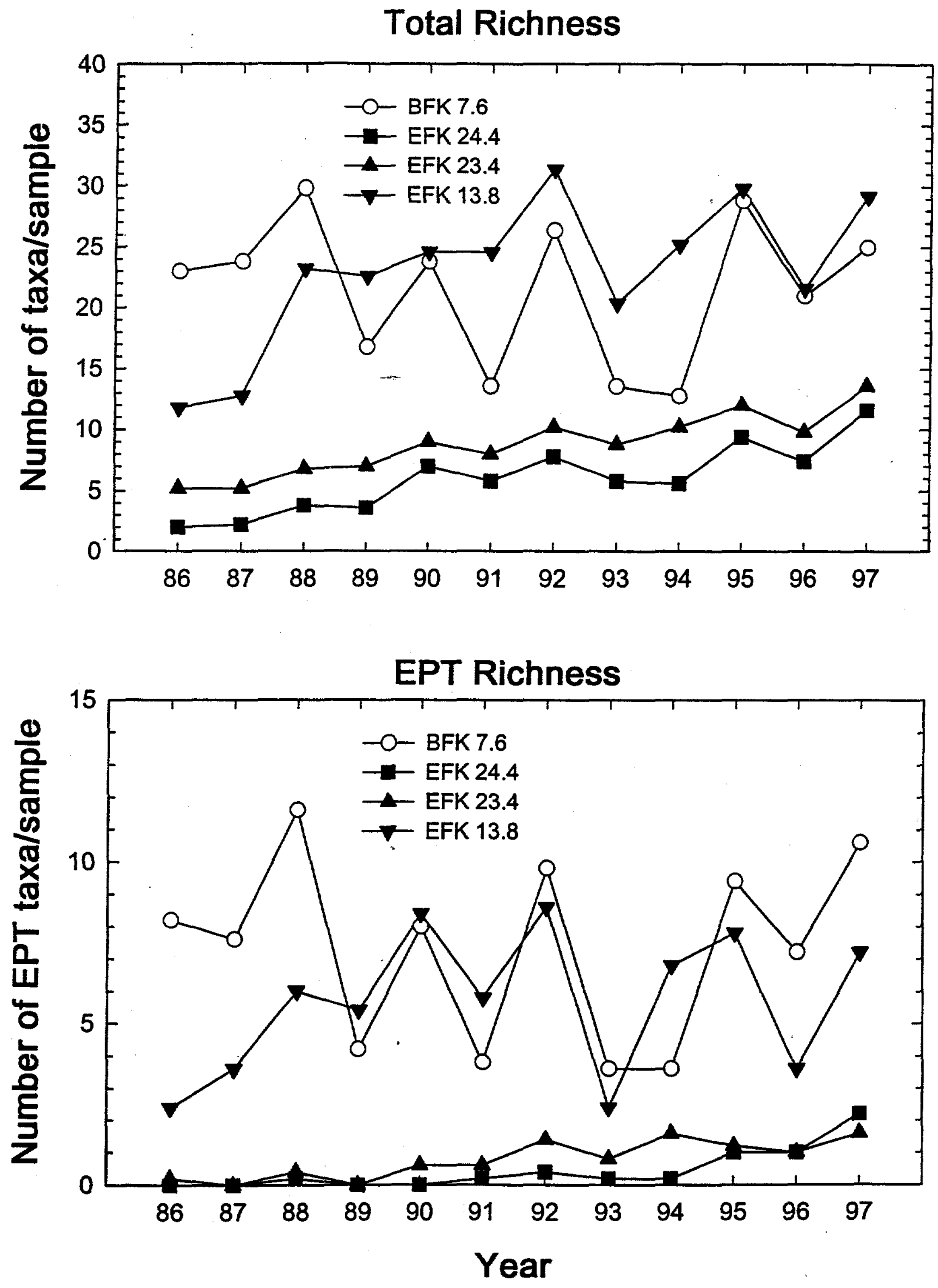

Fig. 5.2. Mean values for total taxonomic richness and richness of the Ephemeroptera, Plecoptera, and Trichoptera (EPT) of the benthic macroinvertebrate communities in EFPC and reference site in Brushy Fork. Values are based on samples collected during the April sampling periods from 1986 through 1997.

at BFK 7.6 since 1995.

These results indicate that the macroinvertebrate community at EFK 23.4 and EFK 24.4 remained significantly degraded through 1997. However, subtle but persistent increases in total richness and richness of pollution intolerant taxa at these sites indicate improvements have occurred in upper EFPC since 1986. Within approximately 10 km downstream of EFK 23.4 (i.e., EFK 13.8), the macroinvertebrate community, as judged from total and EPT richness only, exhibits characteristics that indicate minimal or no impact relative to reference conditions.

5.3 Fish community monitoring (*M. G. Ryon*)

5.3.1 Introduction

Fish population and community studies can be used to assess the ecological effects of water quality and/or habitat degradation. Fish communities, for example, include several trophic levels, and species that are at or near the end of food chains. Consequently, they integrate the direct effects of water quality and habitat degradation on primary producers (periphyton) and consumers (benthic invertebrates) that are utilized for food. Because of these trophic interrelationships, the well-being of fish populations has often been used as an index of water quality. Moreover, statements about the condition of the fish community are easily understood by the general public.

The two primary activities conducted by the Fish Community Studies task in EFPC are: (1) biannual, quantitative estimates of the fish community at six EFPC sites and two reference stream sites; and (2) investigative procedures in response to fish kills near the Y-12 Plant. The quantitative sampling of the fish populations at sites is conducted by electrofishing in March–April and September–October. The resulting data are used to estimate population size (numbers and biomass per unit area), determine length frequency, estimate production, and calculate Index of Biotic Integrity values. Fish kill investigations are conducted in response to chemical spills, unplanned water releases, or when dead fish are observed in EFPC. The basic tool used for fish kill investigations is a survey of upper EFPC (above Bear Creek Road to the N/S Pipes) in which numbers and locations of dead, dying, and stressed fish are recorded. This baseline is supplemented by special toxicity tests, histopathological examinations, and water quality measurements in an effort to determine the cause of observed mortality.

5.3.2 Results/Progress

The quantitative fish community data from the spring 1997 sampling of the EFPC sites are given in table 5.2. Based on density data for sensitive species, conditions in EFPC continue to improve. Densities have increased for most sensitive species such as the northern hog sucker (*Hypentelium nigricans*), snubnose darter (*Etheostoma simoterum*), greenside darter (*E. blennioides*), and rock bass (*Ambloplites rupestris*). Such sensitive species have expanded their distributions within EFPC as well (Figure 5.3), indicating continued improvement. In general, densities continue to be highest at the upstream sites and generally higher than reference values. Biomass is highest as well at the upstream sites and continues to reach extraordinary levels for the stream size.

During the past quarter, two events occurred in EFPC that had tremendous impacts on the fish communities both in the vicinity of the Y-12 Plant and further downstream. In late July, a record rainfall occurred in the Y-12 Valley with tremendous flows in upper EFPC and down through the watershed. This rain occurred in a few hours and resulted in a pulsed flow that blasted through the system. In upper EFPC,

Table 5. 2. Fish density (number of fish/m^2) and biomass (g/m^2, in parentheses) for March-May 1997 in East Fork Poplar Creek (EFK) and the reference sites, Brushy Fork (BFK) and Hinds Creek (HCK).

Species	EFK 25.1[a]	EFK 24.4	EFK 23.4	EFK 18.7	EFK 13.8	EFK 6.3	HCK 20.6	BFK 7.6
American brook lamprey								0.01 (0.07)
Gizzard shad					<0.01 (0.23)	0.01 (1.19)		
Central stoneroller	2.86 (37.00)	2.03 (35.48)	1.67 (13.98)	0.15 (1.66)	0.23 (4.51)	0.01 (0.17)	0.66 (5.46)	0.01 (0.22)
Central stoneroller X striped shiner hybrid[b]	<0.01 (0.01)							
Spotfin shiner						0.01 (0.02)		<0.01 (<0.01)
Striped shiner	3.92 (21.80)	0.74 (5.48)	2.34 (9.44)	0.18 (2.04)	0.11 (3.41)	0.07 (0.29)	0.09 (0.90)	0.04 (0.51)
Rosefin shiner				<0.01 (<0.01)	0.01 (0.01)	<0.01 (<0.01)		<0.01 (<0.01)
Bigeye chub							0.01 (0.03)	
Bluntnose minnow					<0.01 (0.02)	0.01 (0.01)	0.05 (0.12)	
Blacknose dace	2.45 (6.24)	1.68 (3.03)	0.41 (0.54)	0.10 (0.34)	0.06 (0.16)	<0.01 (<0.01)	0.09 (0.19)	0.01 (0.01)
Creek chub					<0.01 (0.01)	<0.01 (0.01)	0.02 (0.12)	<0.01 (<0.01)

Species	EFK 25.1[a]	EFK 24.4	EFK 23.4	EFK 18.7	EFK 13.8	EFK 6.3	HCK 20.6	BFK 7.6
White sucker			0.02 (2.45)	0.01 (2.27)	<0.01 (0.03)	<0.01 (0.02)	0.01 (1.60)	<0.01 (0.54)
Northern hog sucker			0.02 (0.77)	0.04 (2.48)	0.03 (2.84)	0.02 (0.73)	0.02 (1.15)	<0.01 (0.21)
Spotted sucker					<0.01 (0.55)	<0.01 (3.04)		
Black redhorse						<0.01 (0.26)	0.01 (0.35)	<0.01 (0.07)
Golden redhorse						0.01 (1.19)		
Yellow bullhead			<0.01 (0.14)		<0.01 (0.52)	<0.01 (0.11)	<0.01 (0.15)	
Blackspotted topminnow								<0.01 (<0.01)
Western mosquitofish				<0.01 (<0.01)		<0.01 (<0.01)		
Banded sculpin				<0.01 (0.02)	0.02 (0.18)	0.05 (0.29)	0.64 (3.83)	0.12 (0.87)
Rock bass				<0.01 (0.03)	<0.01 (0.37)	<0.01 (0.09)	0.01 (0.54)	0.02 (1.88)
Redbreast sunfish	<0.01 (0.04)	0.03 (0.85)	0.17 (1.29)	0.06 (1.18)	0.06 (2.83)	0.01 (0.55)	0.01 (0.19)	0.01 (0.24)
Green sunfish			<0.01 (0.04)	<0.01 (0.01)	0.01 (0.15)	0.03 (0.18)		
Warmouth						<0.01 (0.16)		
Bluegill			0.08 (0.66)	0.02 (0.15)	0.02 (0.63)	0.01 (0.22)	0.03 (0.27)	0.02 (0.19)

Species	EFK 25.1[a]	EFK 24.4	EFK 23.4	EFK 18.7	EFK 13.8	EFK 6.3	HCK 20.6	BFK 7.6
Hybrid sunfish			<0.01 (0.04)	<0.01 (0.06)	<0.01 (0.09)	0.01 (0.09)		
Spotted bass						<0.01 (0.33)		
Largemouth bass			0.02 (5.43)			<0.01 (0.77)	<0.01 (0.01)	
Greenside darter			0.01 (0.03)	<0.01 (0.01)	<0.01 (0.01)		0.01 (0.03)	<0.01 (<0.01)
Blueside darter							0.01 (0.01)	0.01 (0.02)
Stripetail darter							0.02 (0.02)	
Redline darter					<0.01 (<0.01)	<0.01 (<0.01)	0.06 (0.09)	
Snubnose darter			0.04 (0.11)	0.07 (0.12)	0.06 (0.08)	0.05 (0.06)	0.16 (0.23)	0.02 (0.02)
Logperch					<0.01 (0.03)	0.01 (0.09)		
Freshwater drum						<0.01 (0.17)		
Species richness	4	4	12	14	20	27	20	18
Density	9.23	4.48	4.78	0.64	0.63	0.33	1.91	0.28
Biomass	65.09	44.84	34.92	10.37	16.66	10.04	15.29	4.85

[a] Site designated by stream kilometer.

[b] Identification verified by D. A. Etnier, Department of Zoology, University of Tennessee, Knoxville.

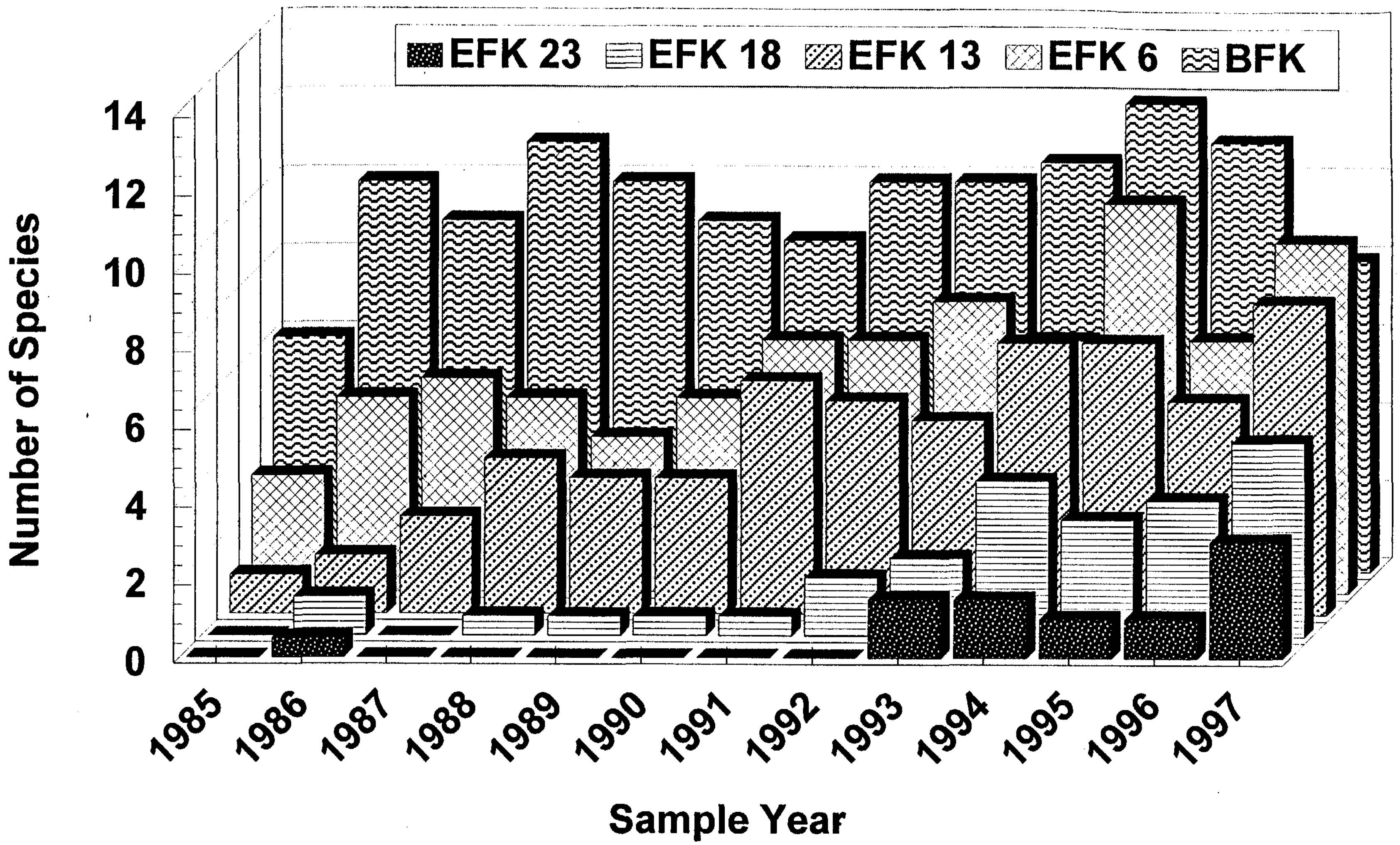

Figure 5.3. Colonization of EFPC by sensitive fish species. EFK = East Fork kilometer; BFK = Brushy Fork (reference site).

particularly inside the plant, fish were displaced, stranded, and killed by this pulse. Even in lower EFPC, the pulse could be significant because of the timing of the impact. Usually in July most of the fish have spawned and small young of the year (YOY) individuals are widespread in the shallow and backwater areas of the system. Because the pulse of water was so large, many of these YOY fishes may have been killed or displaced out of EFPC, even as far down as EFK 6.3. Effects on future community assessments may be evident from these impacts, including lower species richness and density during the next few sampling seasons.

In addition to the record rainfall and partly as a result of the alterations to the flow management operations that were necessitated by the rain, an extremely large fish kill occurred in upper EFPC on July 24, 1997. The kill was a very acute kill, based on zero or low dissolved oxygen conditions augmented by sodium bisulfide toxicity that affected the stream from just below the north-south pipes down to Lake Reality. The result was a fish kill with an estimated total of greater than 24,000 fish. This was almost five times larger than any previous kill in upper EFPC. The kill included all species and all size classes within that section of stream. Unlike most previous fish kills in this stream section, all of the mortality occurred within a few hours if not minutes on July 24. Conditions within the stream returned to normal and acceptable shortly after full flow was restored to the stream. The impact on the fish communities in upper EFPC should be substantial for the short term, with only about 40% of the fish left in the stream. This lowered fish density should be evident in fall 1997 and likely in spring 1998 samples at sites within this area. However, because the reproductive capacity of the fish species that occur in this section are fairly robust, the long-term impact should not be significant. Within one or two spawning seasons, the total fish community size should approach pre-kill levels. The only uncertainty may lie with the impact of the flow management on the fish community and whether the densities of fish in this section may have declined as a consequence of this management strategy even in the absence of a large fish kill. The conditions prior to flow management may have represented optimum conditions for exploitation by the few tolerant species that have colonized upper EFPC. By altering those conditions, these species may have faced increased competition from other species and therefore suffered a decline from the exceeding high densities recorded in upper EFPC. Thus, recovery from the fish kill may not necessarily mean that the extremely high density and biomass found prior to the kill will return.

6. Data Management (*S. W. Christensen, C. C. Brandt, and T. W. Beaty*)

6.1. Introduction

Environmental Compliance projects are required by provisions of the Oak Ridge Reservation Federal Facilities Agreement (FFA) and the State of Tennessee Oversight Agreement (TOA) to transmit their data to the Oak Ridge Environmental Information System (OREIS). BMAP data managers receive data packages from the PIs of the other tasks, transform the data into appropriate OREIS formats, and facilitate the data transfer to OREIS. This task also administers the BMAP workstation.

6.2. Results/Progress

During the last quarter, data managers sent to the Oak Ridge Environmental Information System (OREIS) data from toxicity testing, benthic macroinvertebrate community studies, and fish community studies tasks. These transmittals contained data spanning the period from the beginning of sampling (historical data as early as 1985) through the most recent data available. In addition, disk storage and tape backup hardware was acquired for the BMAP workstation, the SAS data manipulation software was upgraded, and major upgrades were accomplished on the workstation's operating system and on the Oracle database software.

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