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Results from the Biochemical and Morphological Analysis of White Suckers Downstream from the Pine Falls Pulp Mill and Characterization of Effluent Toxicity and the Effluent Induced Mixed-Function Oxygenase Response (1993-1995). Final Report on the Effects of Untreated Effluent to the Department of Indian Affairs and Northern Development, Winnipeg.

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ABSTRACT

White suckers captured downstream from the non-bleaching groundwood/sulphite pulp and paper mill in Pine Falls exhibited an increase in liver somatic index and an induction of the mixed-function oxygenase (MFO) system and decreases in plasma testosterone, fecundity and hepatic stores of vitamins A and E. The MFOs were positively correlated with liver somatic index and negatively correlated with hepatic vitamins, condition factor and most reproductive indices; hepatic vitamins were positively correlated with condition factor and reproductive indices. The majority of the differences between reference and downstream fish appear to be related to the presence of the pulp mill, because effects diminished with increasing distance from the effluent outfall. These effects may have been caused by the current (1993-1994) release of effluent and/or to the habitat degradation of the area.

In a dose-response experiment the MFO enzyme system of rainbow trout was induced by an effluent concentration of 0.23%; less than one tenth of the estimated 96-hour LC50 value of 3.0%. The time-dependence of the MFO response was examined at an effluent concentration of 1% and was significantly induced after 2 days, remained at this induced level for the remaining 6 days of effluent exposure and declined within 2 days after the fish were moved to clean water.

Fish downstream from the Pine Falls pulp mill exhibited responses similar to fish captured downstream from bleaching kraft pulp mills. The MFO inducer(s) in this effluent behaved like polycyclic aromatic hydrocarbons, not highly chlorinated dioxins and/or furans. At the time of this study the effluent released from the mill was untreated; a secondary treatment facility which may alleviate some if not all of these impacts has since been installed.

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INTRODUCTION

Our June 1994 report to the Department of Indian Affairs and Northern Development (DIAND) summarized the results obtained in the first year (1993) of Winnipeg River sampling and analysis. The purpose of the study was to examine the downstream effects of effluent discharge from the non-chlorine bleaching groundwood/sulphite pulp mill in Pine Falls. The report included the results obtained for water chemistry and bacteriology, sediment chemistry, invertebrate taxonomy and fish morphology and biochemistry. From this research it was realized that the sediments and benthic invertebrates required detailed examination and this was conducted in 1994 by Wong et al. (1996). Water sampling was done only in the first year (1993), to determine the approximate location of the effluent plume. This was accomplished using counts of total coliform bacteria since these were elevated in the effluent to a greater degree (relative to background river water) than any other measured effluent parameter, and could thus be traced for the greatest distance downstream (Bezte (nee Friesen) et al., 1994). The purpose of this report is to summarize the results of studies on the effects of the effluent on both wild (feral) and laboratory fish. The report will include results on the biochemistry and morphology of white suckers obtained from the Winnipeg River at three different sampling times (including the data presented in the original report) as well as the results from laboratory experiments designed to examine the toxicological properties of the effluent.

Past studies on the effects of pulp and paper mill effluents have reported alterations in fish including: high larval mortality, reduced abundance of adult fish, increase in liver size, decrease in gonad size (ovary in females or testes in males), increase or decrease in condition factor (a measure of the weight of fish relative to length), reduction in the concentrations of steroid hormones found in blood plasma, (testosterone and estradiol which are important in gonadal development) and an increase in mixed-function oxygenase enzyme activity (Andersson et al., 1988; Rogers et al., 1989, McMaster et al., 1991, Munkittrick et al., 1992, Hodson et al., 1992 and Munkittrick et al., 1994; Sandström, 1994). Mixed-function oxygenase (MFO) enzyme activities can be increased in response to a number of chemical contaminants such as polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons

(PAHs).

The increase in mixed-function oxygenase (MFO) activity has been reported in fish downstream from pulp mill effluents in North America and Europe (Andersson et al., 1988; Larsson et al., 1988; Lindström-Seppä and Oikari, 1990; Boyle et al., 1992; McMaster et al., 1991; Hodson et al., 1992; Munkittrick et al., 1994; Kloepper-Sams and Benton, 1994). Until 1992, research into effects from pulp mill effluents concentrated on chlorine-bleaching kraft mills because the chlorinated compounds in these effluents were assumed to be the most toxic and also to be responsible for most of the effects noted downstream (such as smaller gonads and increases in MFO activity). Pesonen and Andersson (1992) provided the first evidence that effluents from non-chlorine bleaching mills were also capable of inducing MFOs in laboratory cultures of rainbow trout liver cells. Lindström-Seppä et al. (1992) showed an increase in MFO activity in perch captured downstream from a Finnish mill that did not use chlorine. There has been little work on non-chlorine bleaching mills in North America, except for a survey of Ontario mills in 1994 (Munkittrick et al., 1994). Their survey included 2 mills that did not use chlorine bleaching and the fish downstream from these mills had increased MFO activities (only in males), smaller gonads, larger livers and lower levels of estradiol (females), but no reductions in testosterone levels in fish of either sex.

Vitamins A and E, otherwise referred to as retinoids and tocopherol, are fat-soluble vitamins and their depletion has been shown to indicate exposure to a variety of environmental contaminants (Peakall, 1992). Fish obtain these vitamins directly from their diet, or in the case of vitamin A, by conversion of some dietary pro-vitamin carotenoid produced by plants (Halver, 1982). Dietary exposure to chemicals known to induce the MFO enzyme system such as PCBs, polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF) have been shown to cause changes in vitamin A metabolism. Zile (1992) reported severely depleted body stores of vitamin A after chronic exposure to planar halogenated aromatic hydrocarbons (PHAH). Trout deficient in vitamin E have been shown to be more susceptible to contaminant toxicity (Williams et al., 1992) and vitamin E concentrations have been shown to be reduced after exposure to a coplanar PCB (Palace and Brown, 1994; Palace et al., 1996).

Vitamin A has a variety of functions within the body including roles in vision, growth and differentiation of epithelial cells, general growth, reproduction, immunocompetence, hepatic pathology and bone metabolism (Halver, 1982; Taveekijakarn et al., 1994). Tocopherol's primary function is as an antioxidant, where it functions as part of the cellular defence mechanisms against the damaging effects of free radicals (Serbinova et al., 1991, Roberfroid and Calderon, 1995). More recently, vitamin A has also been recognized as having antioxidant activity (Palozza and Krinsky, 1991, Ribera et al., 1991 and Roberfroid and Calderon, 1995).

The individual chemical components of pulp mill effluents responsible for the biochemical and morphological effects in fish are not known. Recent work indicates that the compound(s) responsible for MFO induction in a biotreated bleached kraft mill effluent can be readily cleared from fish. MFO activity was reduced after 4 days in clean water and fish captured downstream from this mill after a 2 week shutdown also had lower MFO activities (Munkittrick et al., 1992). This contradicts the hypothesis that the inducers are highly chlorinated dioxin and/or furan compounds, because these compounds are not readily metabolized (i.e. no reduction in MFO activity would be expected within 4 days). Recent laboratory work with a variety of pulp mill effluents has shown that sulphite/groundwood effluents are capable of inducing the MFO response (Gagne and Blaise, 1993). In their laboratory work Gagne and Blaise (1993) pointed to the need to determine the time-course of effluent exposure, i.e. how long it takes for induction to occur and how long it takes for it to decline after removal of the fish to clean water. For comparative purposes they also pointed out the need to determine the threshold concentration for MFO induction, i.e. the lowest concentration of exposure which results in a significant response. The threshold value will allow comparisons of different effluents for their potency as inducers and time-course information would give some indication as to the stability of inducer(s) in the effluent. Laboratory experiments are also a confirmatory measure, ensuring that at least one of the effects noted in fish captured in the field can be caused in laboratory fish that are exposed only to the effluent.

We hypothesized that discharges from the Pine Falls pulp mill may cause effects in fish similar to those being detected elsewhere. For these reasons the fish from the Winnipeg River were examined for biochemical and morphological factors. Biochemical factors measured were liver MFO activities determined by EROD (7-ethoxyresorufin O-deethylase) and AHH (aryl hydrocarbon hydroxylase), and plasma concentrations of testosterone and 17β-estradiol. Due to the importance of vitamins A and E in normal physiological functions and due to the fact that the MFO enzyme system was induced in fish downstream from the Pine Falls pulp mill, analyses of vitamin A and E levels in the livers of these fish were also undertaken. Liver vitamin concentrations were determined because most vitamin A (90%) is stored in the liver (Brewster, 1984) and vitamin E has been reported to be reduced in liver tissues of fish exposed to PCBs (Palace et al., 1996). To our knowledge, this was the first time that these vitamins have been analyzed in wild fish exposed to a non-chlorinating pulp mill effluent. Other parameters measured included maturity index, fecundity and egg size and morphological parameters such as gonadosomatic index (GSI, the size of the gonad in relation to the body size), liver somatic index (LSI, the size of the liver in relation to body size), and condition factor (CFAC, weight in relation to length). Laboratory experiments were carried out to assess the toxicity of the effluent and its ability to induce MFO activities. The threshold and time-course of the induction were examined to provide indications regarding the strength and stability of the inducer(s). The Pine Falls mill began operation of their secondary treatment facility in late 1995. This study provides background information which may be used to monitor the efficacy of this new treatment facility in eliminating the responses shown by the biological community in the River.

METHODOLOGY

Sampling and Analysis of Feral White Suckers

Sampling of White Suckers

White suckers were sampled from three sites on the Winnipeg River in August of 1993 and 1994 and from two sites in the spring of 1994 (Figure 1). Mature fish were captured using gill nets with mesh sizes ranging from 8.75 to 11.25 cm. A majority of the samples were obtained with the nets being run every hour; in the spring the nets were run after a period of approximately three hours and in 1994 some of the samples were obtained from overnight sets. Once removed from the nets, fish were anaesthetized in buffered tricaine methanesulfonate (MS 222), blood was obtained by caudal puncture with heparinized syringes, and fork length, body weight, liver weight (minus gall bladder) and gonad weight were recorded. Blood was immediately centrifuged and the isolated plasma was frozen on dry ice. Whole livers (minus gall bladders) were also frozen on dry ice. Subsamples of gonad were preserved in Davidson's fixative and 4.0% buffered formalin. All samples were returned to the Freshwater Institute for analysis and the frozen liver and plasma samples were stored at -80°C until analyzed.

Mixed-Function Oxygenase Determinations

In white suckers the MFO enzyme system was monitored in liver microsomes using 7-ethoxyresorufin (EROD assay) and benzo(a)pyrene (AHH assay) as substrates. Field samples were also analyzed for cytochrome P-450 content by running carbon monoxide difference spectra (Omura and Sato, 1964a; Omura and Sato, 1964b). EROD activity in laboratory rainbow trout was determined on post-mitochondrial supernatants since these fish were too small to obtain sufficient liver microsomes (Methods are described in detail in Bezte, 1996 and are the same as those used in previous studies (Lockhart et al., 1989; Hodson et al., 1991; Lockhart and Metner, 1992; Boychuk, 1994).

Steroid Hormone Analysis

Plasma steroid hormone levels (testosterone and 17β-estradiol in females and testosterone in males) were determined in white suckers by means of an enzyme immunoassay technique which has been validated for use in fish; kits were purchased from Cayman Chemical Company (Brown et al., 1993).

Histology of Reproductive Organs

Preserved ovary and testis samples were histologically examined to determine maturity. Ovaries were also examined to measure egg size and weight and fecundity. The maturity index is a number between 1 and 11 in females and 1 and 7 in males, with each number representing a particular stage of sexual development (Appendix, Table A1). The higher the number, the closer the fish is to sexual maturity. Fecundity is an estimate of the number of eggs that a female would be capable of spawning at the next spawning time. Absolute fecundity is the total number of eggs per female fish, while relative fecundity is the number of eggs per gram of fish, thus relative fecundity accounts for fish size differences. Maturity indices, egg diameters, egg weights, absolute and relative fecundities were assessed as described by Brown et al. (1993).

Liver Vitamin Analysis (A and E)

Reverse-phase high performance liquid chromatography was used to determine the concentrations of retinol and retinyl palmitate (forms of vitamin A) and tocopherol (vitamin E) in extracts from white sucker livers (Brown and Vandenbyllaardt, 1996).

Calculations of GSI, LSI and Condition Factor

These morphological parameters were calculated as follows:

Gonadosomatic index (GSI) = (gonad weight / (total body weight - gonad weight)) x 100

Liver somatic index (LSI) = (liver weight / (total body weight - liver weight)) x 100

Condition Factor (CFAC) = (weight (g) / length^3 (cm)) x 100

Liver somatic index and condition factor were not corrected for gonad weight because gonad weights were unavailable for male suckers in August, 1993 and the calculations had to be the same for all fish to facilitate statistical comparisons. Aside from this difference the formulae for the calculations were taken from Hodson et al. (1992).

Fish Age Determinations

Aging was accomplished using dried pectoral fins, by counting annuli in paraffin embedded fin ray cross sections according to Chalanchuk (1984).

Laboratory Experiments

Fish Care

All rainbow trout (*Oncorhynchus mykiss*) used in the laboratory experiments were juveniles (Mount Lassen strain) and were obtained as swim up fry (1 month old, average weight 0.12 g) from the Rockwood Aquaculture Research Centre in the summer of 1993. The fish were held in the laboratory in large tanks with a continuous flow-through supply of 10°C City of Winnipeg dechlorinated tap water; tanks were aerated continuously. The fish were maintained on an a diet of Martin Mills Trout Chow. Fish ages and sizes will be provided in the methods description for each experiment. Mortalities in the test fish prior to experimentation were negligible.

Effluent Collection and Storage

Twenty-four hour composite effluent samples (20 - 80 L) were collected by a chain-and-bucket sampler from the mill sewer prior to release to the river. The effluent was stored in plastic containers (20 - 40 L) and kept in the dark at 10°C.

Experimental Conditions

A series of experiments was run to determine the toxicity of the effluent over time, whether the toxicity was primarily in the dissolved or particulate fraction and whether aeration of effluent and/or exposure tanks altered toxicity. These tests were also run to determine effluent concentrations appropriate for use in experiments characterizing the EROD response.

The preliminary experiments were conducted on unfed (feeding ceased 24 hours prior to experimental exposure) rainbow trout under semi-static conditions (i.e. 50% tank replacement daily) and all treatments were run in duplicate 6-L tanks with five fish per tank. At the end of these experiments there were no concentrations with partial fish kills; either all fish were alive or all fish were dead. Thus LC50 statistics were estimated by averaging the highest concentration in which no mortality occurred with the lowest concentration in which all fish were killed (Parrish, 1985). Following these preliminary experiments one flow-through experiment was conducted over a seven-day period to determine the effluent dose-EROD response relationship and another flow-through experiment was run for 28 days to monitor the time-course of EROD induction and decline. Fish were anaesthetized in tricaine methanesulfonate (MS 222) prior to sampling, and the weight in grams and fork length in mm was recorded for each fish. Tank conditions such as temperature, pH and dissolved oxygen concentrations were recorded daily.

Preliminary Toxicity Experiments

1.) Effect of Effluent Storage on Toxicity. One standard 96-hour LC50 test was run after effluent samples were stored for either 2 , 14 or 330 days. Each of these experiments was run with identical replicate concentrations of 0 (control), 0.5, 1, 5, 10 and 50% effluent to observe if changes in effluent toxicity occurred with storage time. Table 1 lists the average ages, weights and lengths of the fish used in these experiments. The same effluent was used in the 2 day and 14 day exposures, but a different effluent sample was used in the 330 day exposure.

Table 1: Average age, weight and length of rainbow trout used in the 96-hour LC50 experiments with Pine Falls effluent stored for varying amounts of time. (Mean ± S.E.M.)

Effluent Storage Time	n	Fish Age (months)	Fish Weight (g)	Fish Length (mm)
2 Days	59	2.0	0.19±0.006	29.6±0.28
14 Days	60	2.5	0.29±0.009	32.1±0.27
330 Days	57	14.0	3.20±0.156	65.0±1.05

2.) Toxicity of Solid and Liquid Effluent Fractions. The effluent was observed to have a high content of suspended solids. One 96-hour LC50 experiment was conducted to determine if the toxicity was primarily in the liquid or solid fraction of the effluent. The effluent (less than one week old) was centrifuged at 17 000 rpm for 30 minutes in a flow-through centrifuge and was then decanted at a rate of 45 mL per minute. Duplicate controls and liquid effluent concentrations of 1.25, 2.5, 4, 5, and 10% were prepared. Exposure tanks were also prepared by resuspending the isolated fibres at concentrations of 10 and 50%. Because the amount of fibres was limited, the water in these tanks could not be changed during the experiment (i.e. 50% tank replacement daily). Daily aeration for a short period was substituted to maintain oxygen levels. The fish used in this experiment were 2 months old with an average weight and length of 0.57 ± 0.024 g and 37.8 ± 0.43 mm respectively (mean ± S.E.M.).

3.) Effect of Effluent and/or Tank Aeration on Effluent Toxicity. To determine whether the lethal contaminants were highly volatile and whether tank aeration would affect the toxicity of the effluent, a 1-day experiment was set up using 15% effluent. Four litres of effluent were placed in an open glass jar and aerated vigorously for 66 hours prior to the experiment and an identical 4-L glass jar was filled with effluent and capped for the 66 hour period. Four tanks were prepared with either the aerated or non-aerated effluents and two tanks within each treatment were aerated during the experiment. This resulted in four treatments; 1. effluent not aerated and tank not aerated, 2. effluent not aerated and tank aerated, 3. effluent aerated and tank not aerated and 4. effluent and tank aerated. The age of the fish used in this experiment was 14 months with an average weight and length of 5.6 ± 0.35 g and 74 ± 1.5 mm respectively (mean ± S.E.M.).

EROD Laboratory Experiments

Prior to being used in these experiments the effluent was filtered through a 2 to 3 mm plastic mesh to remove the large particulates and clumps of cellulose fibres. This was necessary to avoid clogging of the continuous flow apparatus tubing. The effluent was slowly stirred with a magnetic stirrer during the flow-through experiments to ensure a uniform suspension.

1.) Dose-Response Experiment. Replicate concentrations of 0.0 (controls) 0.25, 0.50, 1.0, 2.0 and 4.0% effluent were used for this effluent dose-response experiment. Five juvenile rainbow trout were exposed to these concentrations via a flow-through apparatus (modified proportional diluter, Mount and Brungs, 1967) in 30-L tanks. The age of the fish was 21 months and their average weight and length was 16.2 ± 0.85 g and 110.2 ± 2.2 mm respectively (mean ± S.E.M.). The average flow rate provided 2.33 L of solution per gram of fish per day (this is well above the recommended maximum loading of 1 g of fish per litre of test solution recommended in standard methods, Priha, 1985). The experiment was run for seven days during which the fish were fed every second day at a rate of 1.2% of body weight. At the end of the experiment, or when the fish were found dead in the tanks, they were immediately sampled for EROD enzyme activity in addition to the regular means of sampling described above. This involved removing the liver, placing it on ice in a pre-chilled 2.5-mL homogenization tube, homogenizing the tissue and isolating the post-mitochondrial supernatant after centrifugation. The post-mitochondrial supernatant was maintained in liquid nitrogen prior to sample analysis. In addition to monitoring temperature, pH and dissolved oxygen, the concentration of the effluent in each tank was monitored fluorometrically. The effluent exhibited a fluorometric emission peak at 398 nm when excited with light at 355 nm and this property was used to estimate the amount of effluent present in the tanks. Samples of effluent, control water and tank solutions were filtered to remove particulates. A range of effluent dilutions in control water was prepared and all standards and tank samples were then read on a Perkin-Elmer fluorometer with excitation and emission wavelengths of 355 and 398 nm respectively, with slit widths of 5 nm. The concentration of effluent in the tanks was determined by using the regression of the standard dilution curve (Figure 2).

2.) <u>EROD Time-Course Experiment</u>. Following the dose-response experiment an effluent concentration of 1% was chosen for the EROD time-course experiment. This was also set up as a flow-through experiment, except the fish were kept in 160-L tanks with 60 fish per tank (at the start) and a different dosing apparatus was used. The 1% effluent concentration was achieved by pumping an appropriate amount of water and effluent into a mixing bucket which was constantly stirred; there was a constant overflow from the bucket to each of the duplicate 1% effluent tanks. Control tanks receiving no effluent were also run in duplicate. The age of the fish used in this experiment was 22 months and their average weight and length was 25.7 ± 0.67 g and 130.9 ± 1.32 mm respectively (mean ± S.E.M.). The initial flow rate during the experiment was 1.45 L per gram of fish per day, which increased as the fish were removed from the tanks. The effluent concentration in the 1% tanks was monitored using fluorometry (as described above) to ensure that the they were receiving the appropriate amount of effluent. Fish were exposed to control or 1% effluent conditions for a period of 8 days and were sampled for EROD activity after 1, 2, 4 and 8 days. On day 8, the fish exposed to 1% effluent were moved to clean tanks with control water (control fish were handled in a similar manner, but were returned to their original tanks) and EROD activity was monitored after 1, 2, 4, 8, and 18 days in the control water. At each sampling time 5 fish were taken from each tank for a total of 20 fish per sampling time (5 from each control tank = 10, and 5 from each treatment tank = 10).

Statistical Analyses

Due to differences in the field data for some of the measured variables between the sexes, data for males and females have been analyzed separately. Homogeneity of variance was assessed using Bartlett's test, and where necessary ($p < 0.01$) data were transformed to obtain more uniform variance by a $\log_{10}$ or Taylor's power law transformation. In instances where the variances could not be made more uniform by transformation, the Kruskal-Wallis nonparametric statistic was used to compare the means. The general linear models program in Systat (Wilkinson et al, 1992) was used for data analysis. Comparisons between sample sites for length and weight were done using ANCOVA with age as a covariate and other parameters were analyzed using ANOVA. Growth was not examined as the range of fish sizes was small and there were too few samples for this type of analysis. Correlations between variables were determined using Pearson's product moment. Statistics for laboratory experiments were calculated using a nested ANOVA with concentration and tank replicate within concentration as independent variables. Weight was used as a covariate when comparing similar concentrations between different trials, because different trials were run with fish of different ages/sizes. EROD data were log transformed and time to death data were not transformed prior to statistical analysis. In the EROD experiments a dose-response relationship was delineated (i.e. EROD activity increased with each increase in effluent dose), however, due to the pattern noted in the residuals a nested ANOVA statistic was used instead of regression (if there is a pattern in the residuals of a regression analysis it indicates that some points are not fit by the line as well as others and the significance of the results are questionable). Pairwise comparisons were conducted by applying Fishers Least Significant Differences (LSD) test. A probability level of <0.05 was considered to be significant. For clarity of presentation, arithmetic means with standard errors have been used in the figures.

RESULTS AND DISCUSSION

The primary focus of the field research was to determine whether there were measurable differences in fish downstream from the Pine Falls pulp mill relative to those caught upstream (i.e. site differences, Figure 1). The most likely reason for differences between upstream and downstream sampling sites would be the presence of the mill, however, the presence of the Powerview dam and proximity to Lake Winnipeg can not be ignored as potential sources of variation among sites.

Differences between sampling times contribute little towards the goal of defining whether the mill impacts the fish downstream and so discussions of temporal differences will be limited, unless warranted by affecting the outcome or enhancing the understanding of site differences. Site differences for all variables will be discussed for each sex. To simplify presentation all figures of field data will show results for female white suckers only, site differences noted for male fish will be described in the text.

Sampling and Analysis of Feral White Suckers

A total of 138 mature white suckers (85 females and 53 males) were obtained from the Winnipeg River during August 1993, May 1994, and August 1994. Table 2 provides a breakdown of samples with respect to time, sex and site and Table 3 indicates the overall weights, lengths and ages of the fish.

Table 2: Summary of white sucker catch data for the Winnipeg River by sampling time, site and sex.

Sampling Time	August, 1993		May, 1994		August, 1994	
Sex	Male	Female	Male	Female	Male	Female
Upstream Site	6	9	3	8	4	15
D1 (Immediately downstream of mill)	9	15	13	9	7	15
D2 (6 to 8 km downstream)	6	7	-	-	5	7

Table 3: Weights, lengths and ages for white sucker caught from the Winnipeg River in 1993 and 1994.

Sex	N	Weight Range (g)	Average Weight (g)	Length Range (cm)	Average Length (cm)	Age Range (years)	Average Age(years)
Male	53	428 - 1719	949	32.0 - 47.8	40.2	3 - 13	6.4
Female	85	449 - 2082	1147	31.6 - 50.2	43.0	3 - 17	6.2

Summary statistics and raw data as categorized by sampling time, site and sex are provided in the Appendix (Table A2 and A3 respectively).

Mixed-Function Oxygenase Activity

The carbon monoxide difference spectra of the hepatic microsome preparations indicated little degradation of samples because peaks at the 420 nm wavelength were always small relative to those at 450 nm (data not shown). The lack of sample degradation indicated that the samples were appropriate for use in the enzyme activity assays.

FEMALES Hepatic EROD (Figure 3) and AHH activities were higher in fish from site D1 than those from upstream, with EROD being induced by 8.6 and 4.1-fold in August, 1993 and 1994, respectively. There were no site differences in May. In August, 1994, fish from site D2 also showed an increase in EROD and AHH activities, with an EROD induction of 2.6-fold.

MALES The trends in EROD and AHH data for males were similar to those of the females, however, an increase in AHH activity observed at site D1 in August, 1993 was the only significant difference.

Numerous field studies have documented similar increases in MFO activities in a variety of fish species captured downstream from a variety of different pulp mill effluent discharges (Andersson et al., 1988; Larsson et al., 1988; Rogers et al., 1989; McMaster et al., 1991; Hodson et al., 1992; Boyle et al., 1992; Kloepper-Sams and Benton, 1994; Munkittrick et al., 1994; Nener et al., 1995). A majority of this research has focussed on pulp mills that use chlorine bleaching, however, Munkittrick et al. (1994) reported a low level of MFO induction in male white suckers downstream from two Canadian non-chlorinating pulp mills.

MFO activity was increased at both August sampling times, but was not increased in either sex when sampled in the spring. It has been documented that the MFO enzyme system of fish may (Boychuk, 1994; van den Heuvel, 1995) or may not (Förlin and Haux, 1990; McMaster et al., 1991; Munkittrick et al., 1991) be readily inducible in fish that are near spawning. Potential reasons for the lack of MFO induction in the spring may include one or more of the following: the nature of the MFO system to respond differently at different times in the reproductive cycle; the movement of the fish into the lake in the winter (as suspected by some individuals at Fort Alexander) this would mean that the fish captured in the spring would be exposed to the effluent for a shorter period of time relative to those caught in the summer; the presence of fish non-native to the Winnipeg River at spawning time; and/or the potential for increased mobility of the fish in the spring relative to the summer. The EROD induction in females at both downstream sites in August, 1994, may be due to the increased effluent concentration in 1994 relative to 1993. In August, 1993, the dilution of the effluent (at the theoretical zone of complete mixing) was 1 in 5302, but was 1 in 3290 in August 1994. These ratios were determined by dividing the average daily discharge of the pulp mill by the average daily discharge of the Winnipeg River. With the effluent concentration being greater in 1994, one would also expect greater impact on fish near the mill in 1994 than in 1993. However at site D1, fish were collected over a larger area in August, 1994 (Figure 1) and may have experienced a greater range of effluent dilutions. This may have countered the effects of the higher effluent concentration at this site in 1994. Another possible reason for a reduced MFO impact at site D1 in August, 1994 was the cessation of log storage on the river near this site in 1994. It is possible that some MFO inducing compounds were released from the logs that were stored on the river near site D1 in August, 1993 (Bezte and Farmer, unpublished data). The effects of the increased effluent concentration (if any) should have been noted at the further downstream site (D2), because a similar sampling area was utilized at this site in both years.

Steroid Hormones

In August, 1994 some samples were obtained using overnight gill-net sets. When testosterone levels were compared between nets cleared hourly and those left overnight, fish obtained in overnight sets were found to have significantly lower levels of testosterone than those obtained with the hourly sets (data not shown). For this reason, all testosterone values for fish captured in overnight sets were not used in the statistical analysis. McMaster et al. (1994) reported similar depressions in testosterone levels with extended time in nets. It is well known that testosterone levels are sensitive to physical stress (Pickering et al., 1987). Other biochemical parameters did not differ between the hourly and overnight sets.

FEMALES Female suckers from site D1 had lower plasma testosterone concentrations than fish from upstream during both August sampling times, with testosterone levels in D1 fish being reduced to 21% of the levels found in the reference fish (Figure 4). Testosterone levels were not significantly reduced in the spring. Estradiol was never significantly reduced at either of the downstream sites, but was lower at site D1 relative to site D2 in August, 1993 (Figure 5).

MALES Plasma testosterone levels in male suckers followed the same trend as those of the female suckers, but were not significantly different between the upstream and downstream sites at any sampling time. Testosterone levels were lower at site D1 relative to site D2 in August, 1993.

White suckers caught immediately downstream of the Pine Falls mill exhibited reductions in plasma steroid hormones similar to those previously reported by others working on different pulp mills (McMaster et al., 1991; Hodson et al., 1992; Munkittrick et al., 1994). Female plasma estradiol was less sensitive to mill effects/effluent exposure than testosterone, as levels of estradiol were not lower at the downstream sites. McMaster et al. (1991) found reduced levels of testosterone and estradiol in female suckers downstream from a bleached kraft mill with primary effluent treatment, and they also had one sampling time when testosterone levels were significantly lower, but estradiol levels were not. Hormone levels at site D2 were similar to those at the upstream site at all sampling times indicating that hormone metabolism was not affected by the effluent/mill at this site. Reductions in steroid hormones noted at site D1 may be due to the inability of animals to produce them or to an increase in their rate of excretion (Kime, 1995). The production of steroid hormones has been shown to be inhibited by exposure to bleached kraft pulp mill effluents (Van Der Kraak et al., 1992; McMaster et al., 1993) and McMaster et al. (1996) showed that the ovaries of fish from site D1 did have a reduced ability to synthesize testosterone (*in vitro*) relative to ovaries from upstream fish in August, 1994.

McMaster et al. (1991) reported a similar if not greater decrease in testosterone levels in BKME exposed prespawning and spawning female white sucker when compared to those caught in the summer from the same sampling location. This differs from the results of our research which show a significant reduction in the summer and no such reduction in the spring. The reason for this discrepancy may be due to the overwintering of the fish in Lake Winnipeg or to the possibility that the population sampled in the spring is non-resident to the area near the pulp mill; being present only in the spring for spawning.

Histology of Reproductive Organs

There were no site differences in maturity indices for either sex at any time. This indicates that all fish examined were at the same stage of sexual maturity, thus validating comparisons of fecundity and egg size.

FEMALES Significant differences were noted in relative fecundity only in May, 1994 when the fecundity of fish from D1 was reduced by 17.4% (Figure 6). The only difference in egg size occurred in August, 1994, when females from site D1 had smaller, lighter eggs relative to those from upstream (Figure 7). Fish from all three sites had lower relative fecundities in August, 1994 than August, 1993, but only fish from the upstream site had larger, heavier eggs in August, 1994 relative to August, 1993. White sucker ovaries contained fewer, larger eggs in May than at either of the August sampling times.

As the ovaries of a fish mature, the size of the eggs increases, but the number of eggs tends to decrease. The number of eggs decreases with ovarian development because a certain percentage of the developing eggs are lost during development (this process is referred to as oocyte atresia) (Scott, 1962). Thus, fish sampled early in egg development should have a large number of small eggs, while those same fish sampled near spawning should have fewer but larger eggs. The white sucker of the Winnipeg River did have fewer, larger eggs in the spring relative to those in the summer. The smaller eggs at site D1 relative to those from upstream or further downstream in August, 1994, suggests that ovarian development at this site was occurring at a slower rate. That a decrease in egg size was noted in 1994 and not 1993 may suggest that the increased effluent concentration in 1994 was having a greater effect on ovarian development. An examination of the site and time differences together revealed that egg sizes at D1 were the same in August, 1993 and August, 1994, but that egg sizes at the upstream site were larger in 1994 than they were in 1993. The larger egg sizes at site U in 1994, accompanied by the decrease in fecundity indicated that the fish at this site were developing faster in 1994 than they had in the previous year. A decrease in fecundity was also noted at sites D1 and D2 in 1994 relative to 1993, but was unaccompanied by an increase in egg size, suggesting that development at the downstream sites was not keeping pace with that at site U.

Testosterone levels were reduced in the summers when gonad maturation would be taking place, however, there was no difference in fecundity estimates. This suggests that the lower testosterone at that time may be insufficient to affect ovarian development. In our previous report, we suggested that although there appeared to be no effects on gonad development at the time, the downstream fish may not be able to maintain this level of gonad development through to spawning. The findings tend to support this hypothesis. When sampled in the spring, female white suckers immediately downstream from the mill with lower hormone levels did not attain a similar level of egg production as those from upstream, with higher hormone levels. Gagnon et al. (1994) report a similar finding in white suckers exposed to bleached kraft mill effluent in the St. Maurice River. GSI was similar at all sites in the summer when hormone levels were reduced, but GSI was lower in the spring. In our research and that of Gagnon et al. (1995) significant effects on fecundity were not detected during gonad development, but were found near gonad maturity, indicating the need to assess reproductive indices at different stages of the reproductive cycle.

There are several pulp mill studies specifically examining fecundity and egg size: 1.) McMaster et al., 1991, reported that fish of the same age exposed to primary treated bleached kraft mill effluent were less fecund than reference fish; 2) Munkittrick et al. (1992) showed that whitefish exposed to this same effluent had higher relative fecundities and lower egg weights than those from a reference site (indicative of a reduced rate of ovarian development); 3) Gagnon et al. (1995) reported alterations in fecundity of white suckers exposed to pulp mill effluent. The results presented in this report concur with the others and suggest that the effects on fecundity and egg size reported to occur downstream from chlorine bleaching kraft mills also occur downstream from the Pine Falls mill.

At spawning time, fish from D1 produced 17.4% fewer eggs than those from upstream. Although this was a significant decrease in fecundity it is important to note that all female fish obtained from the Winnipeg River had very high levels of fecundity. Relative fecundity estimates of approximately 20 eggs/g of fish have been found in white suckers from relatively pristine lakes in the Experimental Lakes Area (R. Evans, personal communication) and Scott and Crossman (1973) report a value of 25 eggs/g of fish. In contrast, the lowest relative fecundity of Winnipeg River white suckers occurred at site D1 in the spring and was greater than 30 eggs/g of fish. This indicates the overall high fecundity of the white suckers in this reach of the Winnipeg River, regardless of the mill inputs. The free movement of the fish, their proximity to the lake, and the possibility that the fish overwinter in the lake, all make it difficult to determine if effects were occurring at the population level.

While maturity and gonadosomatic indices were not different, fecundity estimates and examinations of egg sizes indicated that the fish at site D1 were somewhat less productive and that they developed somewhat slower than the fish upstream. Examinations of fecundity and egg size appear to be more sensitive indicators of potential reproductive effects than maturity or gonadosomatic indices.

Liver Vitamins (A and E)

Hepatic concentrations of retinol, retinyl palmitate and tocopherol (α-tocopherol) could not be determined for every sample, because some liver samples were too small to provide sufficient tissue for all analyses.

FEMALES Hepatic concentrations of retinol, retinyl palmitate and tocopherol were reduced at site D1 during both of the August sampling times, but were unaffected in the spring. In August, 1994, tocopherol levels were also lower at site D2 relative to those at the upstream site. At site D1, hepatic retinol levels were 13 and 26% of those at site U in August, 1993 and August, 1994 respectively (Figure 8); retinyl palmitate levels were 17 and 23% those of upstream fish in 1993 and 1994 respectively (Figure 9); and tocopherol levels were 36 and 45% those at site U in 1993 and 1994, respectively (Figure 10). In August, 1994 females from site D2 had levels of tocopherol that were 63% those in the reference fish. The most notable time differences pertain to the increased retinyl palmitate levels at all sites in August, 1994 compared to those in August, 1993. During this time retinyl palmitate levels at site U increased from 179 to 459 μg/g, levels at site D1 increased from 31 to 107 μg/g and those at site D2 increased from 127 to 477 μg/g.

MALES Hepatic retinol levels were reduced at site D1 in May and at both the D1 and D2 sites in August, 1994, but were not reduced at either of the downstream sites in August, 1993. In May, 1994, retinol levels at site D1 were reduced to 31% of the reference levels and in August, 1994, retinol levels were reduced to 39% and 23% at sites D1 and D2 respectively. Retinyl palmitate and tocopherol levels were significantly reduced at site D1 in August, 1993 and May, 1994, but there were no site differences in August, 1994, and retinyl palmitate and tocopherol levels were never affected at site D2. In August, 1993, retinyl palmitate and tocopherol levels at site D1 were 32% and 26% of the reference levels respectively. Retinyl palmitate levels were greater at sites U and D1 in August, 1994, relative to August, 1993.

The significance of lower hepatic retinol, retinyl palmitate and tocopherol in male suckers from site D1 in the spring should be interpreted cautiously, because the upstream sample size for these parameters was limited (n=3) and was accompanied by a high degree of variability.

Retinyl palmitate is the predominant storage form of vitamin A in white sucker (Branchaud et al., 1995). Therefore, an examination of retinyl palmitate indicates the amount of vitamin A available to the fish and also provides information into the past uptake and dietary availability of this vitamin. Retinol levels indicate the amount of readily usable vitamin A and retinyl palmitate can be readily converted to retinol as required.

Retinol appeared to be somewhat more sensitive than retinyl palmitate, as retinyl palmitate was never significantly reduced at site D2 while retinol was reduced at site D2 in male suckers in August, 1994. Vitamin E (tocopherol) was also lower in female suckers from D1 in the summers and at site D2 in August, 1994. Retinol and tocopherol levels were more affected in August, 1994 as there were significant reductions at site D2 that did not occur in August, 1993. The lack of a significant difference in tocopherol levels of female suckers between U and D2 in August, 1993 however, may have been due to the smaller number of fish captured in August, 1993 relative to 1994. Tocopherol levels were never reduced in males from site D2, and were not significantly reduced at site D1 in August, 1994 indicating that tocopherol levels in males may be less sensitive. The lack of a significant site difference in spring for retinol, retinyl palmitate and tocopherol in female suckers suggests better nutrition of the downstream fish in the spring. As mentioned in the sections on MFOs and hormones, the lack of significant site differences in the spring may be due to the overwintering of the fish in the lake, the potential increased mobility of the fish in the spring or to the presence of non-resident fish at spawning time.

There is little information on vitamins in fish downstream of pulp mill effluents, however, Brown and Vandenbyllaardt (1996) reported a decrease in retinyl palmitate in longnose suckers (*Catostomus catostomus*) downstream of a chlorinating pulp mill effluent in Alberta and Brown and Munkittrick (unpublished data) found a similar decrease in retinoids in white sucker downstream from a bleached kraft mill effluent in Ontario. White sucker sampled from a river contaminated with moderate to high levels of PCBs, PAHs and heavy metals had hepatic vitamin A stores that were only 9.3% (females) and 30% (males) of those of fish from a reference location (Branchaud et al., 1995). The actual amount of retinyl palmitate in the contaminant exposed fish described by Branchaud et al. (1995) was much lower than the lowest levels in fish from site D1, although their retinol levels were similar.

Vitamin levels have been shown to be reduced in organisms exposed to a wide variety of environmental contaminants (Zile, 1992) and contaminants in the mill effluent may be responsible for the reductions in vitamins A and E noted in these fish. Another explanation for these vitamin differences could be the diets of the fish in the area. Because there were few weight differences among the sites (see "Size and Age Comparisons" below), the caloric intake of the fish at the different sites could not have been substantially different. It appears unlikely that the vitamin depletion was due to a lack of food, however, while the food organisms may have been abundant (Wong et al., 1996) they may have been less nutritious, possibly because of the wood fibre contamination (Wong et al., 1996). We have no vitamin data on chironomids, oligochaetes or mayflies, but it seems worth determining whether the depletion of vitamins in the fish could be induced by the change in diet from the benthic community found upstream to that found downstream.

The higher retinyl palmitate levels in 1994 suggest that feeding conditions were better at this time. The reason for the better nutrition in 1994, as indicated by the retinyl palmitate stores is unknown at this time.

Morphological Parameters (GSI, LSI and CFAC)

FEMALES Gonadosomatic indices were never significantly different among the sites.

Condition factor was significantly reduced at site D1 in August, 1993, but there were no site differences found in May or August, 1994 (Figure 11).

Liver somatic indices were significantly higher at site D1 at all sampling times but were never higher at site D2 (Figure 12).

MALES Male gonadosomatic indices could only be calculated for May and August, 1994, as male gonads were not collected in August, 1993. There was no difference in GSI between the sites at either sampling time.

Condition factor was never significantly reduced at either of the downstream sites at any sampling time.

LSI at site D1 were greater in August, 1993, and May, 1994, but were never elevated at site D2.

The lack of significant effects on GSI suggest that the lower fecundity in the spring and the reductions in egg size in August, 1994, were not sufficient to cause a decrease in the overall amount of gonad tissue. Female white suckers captured downstream from seven out of eight pulp mills in Ontario had reduced GSIs regardless of the presence of secondary treatment or absence of chlorine bleaching (Munkittrick et al., 1994). This leaves only one of the eight mills with no impact on gonad size. Similar to our results, Gagnon et al. (1995) reported no significant difference in GSI immediately downstream from a secondary-treated bleached kraft mill effluent in Quebec.

Condition factor generally reflects the nutritional status of the fish and may be higher due to better feeding conditions, (Busacker et al., 1990), but, may also be affected by contaminants. The decrease in condition factor in females at site D1 in August, 1993, indicates that the mill may have had some negative impact. It is uncertain whether the decreased condition factor is attributable to the chemical nature of the pulp mill effluent or to the diet of the fish downstream of the mill since the benthic invertebrate populations were different (Wong et al., 1996). A reduced or similar condition factor downstream from a pulp mill is not new to the pulp mill literature, as increases, no effects and decreases have all been noted downstream of other pulp and paper mills (Munkittrick et al., 1994, Hodson et al., 1992 and Barker et al., 1994). The inconsistencies in the results for condition factor, accompanied by the nearness of the dam, town and lake, do not allow for a definitive conclusion to be drawn.

As with condition factor, liver somatic indices may also be influenced by feeding conditions and/or contaminant exposure. The liver functions in energy storage and tends to increase in size with increasing caloric intake (Busacker et al., 1990), but can also increase in size as a result of contaminant exposure (Kumar and Mukherjee, 1988; Andersson et al., 1988). Contaminant exposure can increase liver size by causing metabolic disturbances which may increase fat storage and/or by increasing the amount of protein produced by the liver (as occurs with the increase in biotransformation enzymes, such as the mixed-function oxygenases; Andersson et al., 1988). Liver somatic indices were higher at the immediate downstream site at all sampling times (Figure 12). This response has frequently been reported in fish downstream from other pulp mill effluent discharges (Kloepper-Sams et al., 1994), including those from other non-chlorinating mills (Larsson et al., 1988; Munkittrick et al., 1994). It could not be determined whether the LSI response was due to differences in feeding conditions between the sites or to contaminant exposure.

Size and Age Comparisons

FEMALES In August 1993, female fish from site D1 were older than those sampled from sites U or D2, but there were no differences in the lengths or weights of these fish at any sampling time. Females from site D1 were older in August 1993, relative to fish caught at this site in August, 1994, but were heavier in August, 1994.

MALES Males from site D2 were longer than those from U and younger than those from D1 in August, 1993. In August 1994, males from both downstream sites were longer and heavier than those from upstream. Male suckers were older at site D1 in August, 1993 when compared to those caught in August, 1994, but there were no weight differences.

It is unknown why fish from site D1 were older than those from the other sites in August, 1993; this difference in age was not noted at the other sampling times. The reason for the increase in fish age at site D1 in 1993 relative to 1994 is also unknown, but the increase in weight of the females in 1994, accompanied by their younger age, indicates that conditions for growth at this site were better in August 1994, than they were in August 1993. Evidence from the males neither contradicts nor supports this hypothesis, as they were younger and of similar weight at site D1 in August, 1994 relative to August, 1993.

White suckers downstream from a primary treated bleached kraft mill in Jackfish Bay were older and shorter than those from a reference site (McMaster et al., 1991), while white suckers below the Pine Falls mill tended to be longer, heavier (males) and of similar age (except at D1 in August, 1993). Gagnon et al. (1995) sampled white suckers from a bleached kraft mill-impacted river below a dam and a reference river below a dam, and found that fish downstream from dams and small towns exhibited an increased rate of growth and were longer than those caught upstream, regardless of their exposure to bleached kraft mill effluent.

Due to the relatively small sample sizes and inconsistencies in the differences for age (only noted in 1993), length and weight (sporadically significant), together with the close proximity of the Powerview Dam, town of Pine Falls and Lake Winnipeg it cannot be concluded that these parameters were affected by discharges from the Pine Falls mill.

Correlations

A summary of correlations obtained from the white suckers caught in August, 1993 and 1994 and May, 1994 is provided in Table 4. Variables which can be considered "autocorrelative" (i.e. length and weight, gonad weight and egg size etc.) have been omitted. Generally, EROD correlated positively with AHH, liver weight, LSI and relative fecundity and negatively with hepatic vitamins, testosterone, egg diameter, egg weight and condition factor. Vitamins were positively correlated with each other and were also positively correlated with condition factor, testosterone, estradiol, egg diameter, egg weight and relative fecundity.

EROD and AHH activities were very highly correlated (R^2 .961, $p < 0.001$) which suggests that only one of these parameters actually requires measurement. The fact that they do correlate so strongly, however, does serve as a check to help assure that the readings are correct.

Retinol and retinyl palmitate negatively correlated with EROD to a greater degree than tocopherol where no significant correlation was noted, a finding previously reported by Palace et al. (1996). Palace et al. (1997) attributed a decrease in retinol to the possibility of direct metabolism of retinol by MFO and phase II conjugating enzymes in lake trout exposed to PCB 126. The decreases in hepatic retinol (reduced by up to 82%) and retinyl palmitate (reduced by up to 77%) in the white suckers in this study were accompanied by EROD induction of less than 10-fold; induction levels produced by Palace et al. (1997) were well over 100-fold. The hypothesis that the vitamin depletion may be entirely due to increased metabolism by MFOs seems unlikely because retinol and tocopherol were reduced in the spring even though there was no increase in MFO activity then, and there was little or no MFO induction at site D2. The negative correlation between liver vitamins (especially retinol and retinyl palmitate) and EROD suggest a number of possibilities: these vitamins may have been utilized as antioxidants (because an increase in EROD results in an increase in oxidative stress which in turn increases the demand for antioxidant molecules such as vitamins A and E, Palace et al., 1996); vitamin metabolism may have been altered by MFOs; MFO induction is correlated with some unknown factor responsible for preventing vitamin absorption and/or increasing vitamin excretion; fish with increased EROD activities live in areas where their food is low in vitamins.

The positive correlation between LSI and vitamin levels supports data presented by Taveekijakarn et al. (1994) who reported an increase in LSI in cherry salmon (*Oncorhynchus masou*) that were depleted in vitamin A. Perhaps a deficiency in vitamin A could account for the increased liver somatic indices. The positive correlations between vitamin stores and reproductive parameters may indicate that poorer nutrition may relate to some of the reproductive effects, although direct chemical effects likely also occur (Van Der Kraak et al., 1992; McMaster et al., 1996). Watanabe and Takashima (1977) found that a tocopherol deficiency in carp affected the pituitary-ovarian system, decreased the production of certain fatty acids, and inhibited ovarian development. Mammals deficient in vitamin A or E have been shown to have reduced levels of testosterone (Kutsky, 1973). There is no work in fish directly linking such vitamin depletions with depletions in hormones, however, there is some evidence that nutrition does affect gonad and offspring development. Woodhead and Plack (1967) noted that vitamin A levels in female tomcod (*Microgadus tomcod*) were correlated with gonad development and Hubbs and Stavenhagen (1958) found that greenthroat darters (*Etheostoma lepidum*) fed a carotenoid and vitamin A deficient diet produced eggs which had a lower survival rate than those on a vitamin A sufficient diet.

The reduced testosterone and fecundity levels noted in these fish may be linked to nutritional status and/or they may result directly from exposure to components in the effluent. Common carp *(Cyprinus carpio)* exposed to phenol or sulfide for one month had smaller gonads than controls (Kumar and Mukherjee, 1988), and exposure to β-sitosterol (a plant sterol found in pulp mill effluent) has been shown to cause a dose-dependent decrease in plasma hormone levels (MacLatchy and Van Der Kraak, 1995). The impacts of β-sitosterol appear to be confined to the gonad, as the pituitary was functioning normally in these fish (although the exposure was run for less than one week). These results indicate that β-sitosterol may be responsible for some of the reproductive effects, but also indicates that there are likely other effluent components or reasons for these effects because there was no impact on gonadotropin production in the β-sitosterol exposed fish and gonadotropin production has been affected in feral white sucker exposed to BKME, (Van Der Kraak et al., 1992). It is possible that both contaminant and dietary factors operate simultaneously to cause reproductive changes. At the present time there are no clear indications of whether these vitamin depletions are due to a decrease in available vitamins or to altered vitamin metabolism.

Laboratory Experiments

Preliminary Toxicity Experiments (original data in Appendix A4)

1.) Effect of Effluent Storage on Toxicity. (Figure 13)

The effluent caused mortality in rainbow trout (within 96 hours) at concentrations of 5% or greater when stored for periods of 2 or 14 days. There was no mortality at concentrations of 10% or less when tests were run with effluent that had been stored for 330 days. Effluent stored for 14 days was slightly more toxic at concentrations of 5 and 10% than effluent stored for only 2 days, however, effluent toxicities at 1 and 50% were similar in both of these trials. Mean time to death was less than 35 hours at 5% and less than 10 hours in 10% effluent in both experiments using samples stored for 2 or 14 days, but there was no mortality at either of these concentrations with effluent stored for 330 days. The effluent stored for 330 days did retain some toxicity since all fish were killed in the 50% dilution within 70 hours.

No partial mortalities occurred at any concentration within the 96 hours. The LC50 was estimated as 3%, regardless of whether the effluent was stored for a period of 2 or 14 days. The LC50 increased to 30% after 330 days of effluent storage.

The results of these experiments revealed that effluent can be stored (in the dark at 10°C) for up to 2 weeks without losing toxicity, that a narrow concentration range needs to be used for an accurate 96-hour LC50 determination, and that the 96-hour LC50 is approximately 3%. This corresponds well with the 3 to 4% reported by the mill in 1993 (T. Youmans, Environmental Protection, personal communication). In comparison with other pulp mill effluents, the effluent from the Pine Falls mill was highly toxic. Gagne and Blaise (1993) tested 13 pulp mill effluent samples from a variety of pulping process and treatment types and they reported a range of LC50s between 4.2-100%. The toxicity of the effluent should be greatly reduced if not completely eliminated by the new secondary treatment facilities. Secondary-treated pulp mill effluents are much less toxic than effluents with only primary treatment, with secondary-treated effluents often resulting in no acute toxicity to fish even at concentrations as high as 100% (Gagne and Blaise, 1993; Priha, 1996; Williams et al., 1996).

2.) <u>Toxicity of Solid and Liquid Effluent Fractions</u>. (Figure 14)

The effluent was a suspension which did not clear readily on standing and the separation of solid and liquid effluent fractions was not complete by the centrifugation procedure. A small amount of liquid was left in the solid fraction and small particulate matter remained in the liquid effluent fraction. There was no significant toxicity in the liquid effluent fraction at concentrations of 4% or less, or in the particulate fraction at 10%. In general, toxicity appeared to be somewhat lower in the liquid fraction than the whole pulp mill effluent, although there was no significant difference between these two at the concentrations tested. The liquid fraction was more toxic than the isolated particulate fraction, as the average time to death for fish in tanks with 10% fibres was 89 hours while that for fish in 10% liquid effluent was 19.4 hours. There was some toxicity in the fibre fraction because all fish in the 50% fibre tanks were dead within 24 hours. This mortality was slower than that of whole effluent where all fish in a 50% concentration were dead within 2 hours, although these times to mortality were not significantly different when fish weight was used as a covariate.

Most effluent toxicity was associated with the liquid/small particulate fraction. The fibre toxicity may have been due to the physical clogging of the gills with particulate matter (particulate was noted in fish gills), to the presence of some effluent liquid (the separation of the liquid and solid fractions was not complete), and/or to the toxicity of particle ingestion or compounds leaching from the particles. Rainbow trout fed food contaminated with the solid fraction of a bleached kraft mill effluent (10%) grew more slowly and had increased hepatic lipid and MFO activity indicating that the solid fraction of other pulp mill effluents also have toxic properties (Lehtinen et al., 1991).

3.) <u>Effect of Effluent and/or Tank Aeration on Effluent Toxicity</u>. (Figure 15)

Effluent aeration did not reduce effluent toxicity, but aeration of the tanks during the toxicity tests did decrease effluent toxicity (comparison of treatments 3 and 4 with treatments 1 and 2 respectively). The fish took longer to die when the tanks were aerated than when they were not, regardless of prior effluent aeration. The cause of death was not due to oxygen depletion as oxygen levels did not drop below 5.9 mg/L in the most oxygen-depleted tanks by the end of the test. The water in the tank with the least oxygen was till more than 50% oxygen saturated and levels of 40% saturation are permissible in static bioassays (Parrish, 1985) Oxygen levels in the tanks averaged 6.4 (effluent and tank not aerated), 7.8 (effluent aerated, tank not aerated), 10.8 (effluent not aerated and tank aerated) and 11.2 (both effluent and tank aerated).

The toxic component(s) in the effluent were not highly volatile, as effluent aeration did not diminish effluent toxicity (treatment 1 versus treatment 2, Fig. 15). Tank aeration during effluent toxicity experiments is not recommended as this would not provide an accurate toxicity assessment (LC50 values would be inflated, making the effluent appear less toxic than it actually is).

Although acute toxicity tests allow for the comparison of effluent toxicities at different times and between different types of effluents, it is important to note that using death as an end point may not be environmentally relevant. For example, Kovacs et al. (1995) conducted acute toxicity, sub-chronic toxicity and life cycle tests with fathead minnows (*Pimephales promelas*) and found that the most sensitive endpoint was fish reproduction, which was significantly affected at an effluent concentration of less than 10 percent. This same effluent was found to be non-toxic to adults and did not affect their growth after 7 days at a concentration of 100%. Effluent exposure also had no effect on egg fertilization, hatching, larval survival or growth of the young when exposed to concentrations ranging from 1.25 to 20%. However, when these exposed fish matured their reproductive capacity was greatly reduced, with effects noted at an effluent concentration as low as 2.5% (no eggs were produced in fish exposed to a concentration of 20% effluent). Effects on *Ceriodaphnia* reproduction as assessed in a 7 day bioassay were also incapable of predicting the effects on minnow reproduction. The results of the short-term tests could not predict the effects of chronic exposure to lower effluent concentrations. Robinson et al. (1994) reported similar findings; that short-term lab toxicity tests using fathead minnow growth or *Ceriodaphnia* survival as end points, were not predictive of the physiological responses noted in wild fish exposed to pulp mill effluents.

EROD Laboratory Experiments

During the course of the EROD induction experiments some of the fish became infected with a disease which caused patches of skin discolouration and loss of equilibrium. The cause of the condition is uncertain but fungal infection is probable. Fish visibly affected by the disease were omitted from analyses, leaving 35 of the 40 living fish from the effluent dose-EROD response experiment and 155 out of 160 living fish from the EROD time-course experiment.

1.) Dose-Response Experiment. (Figure 16, original data in Appendix A5)

Only three of the five effluent concentrations tested were included in this analysis because the fish in the two highest concentrations (2 and 4%) were killed and MFO activity degrades rapidly after death. Enzyme induction occurred at all concentrations, thus defining the threshold for EROD induction as falling at or below 0.23% in laboratory rainbow trout. Average EROD induction was 4.5, 5.3 and 10.9-fold in 0.23, 0.39 and 0.94% effluent respectively. There was high variability in the EROD response of the fish; this has been reported by others working on the EROD-inducing properties of pulp mill effluents with rainbow trout (Martel et al., 1994; Gagne and Blaise, 1993).

The MFO inducing properties of this effluent were quite strong, as induction occurred at only 0.23%. This level is lower than threshold values reported by Williams et al. (1996) in 5 kraft mill effluents which ranged from 0.57 to 9.1% effluent. Martel et al. (1994) tested 31 secondary-treated effluent samples from 8 different mills and found that a majority of samples from thermomechanical and chemi-thermomechanical mills did not cause MFO induction, while most samples from bleaching kraft pulp mills did cause MFO induction. Unfortunately, Martel et al. (1994) only examined one effluent concentration (10%), and since induction may occur at lower effluent concentrations, but be inhibited at higher concentrations (Pesonen and Andersson, 1992; Gagne and Blaise, 1993), the effluent concentration they chose may have been too high for some of the effluents to show induction. Lehtinen (1990) reported up to 6-fold induction in rainbow trout exposed for 7 weeks to 0.25% and greater than 2-fold induction at 0.05% effluent, from a bleaching kraft mill in Sweden with no effluent treatment. Gagne and Blaise (1993) tested three sublethal concentrations of 12 pulp mill effluent samples for MFO inducing properties in rainbow trout, including 9 effluents that were not from the bleached kraft pulping process, and found MFO induction after 4 days in a majority of these effluents, although induction levels were usually low. The highest level of MFO induction noted by Gagne and Blaise (1993) was 9.4-fold, which occurred in 5.6%

sulphite/groundwood effluent with secondary treatment. This level of induction corresponds well with the induction found here, and suggests that the new secondary treatment facility at the Pine Falls mill may not alleviate the MFO response of the fish. Munkittrick et al. (1992) also observed that secondary treatment of a bleaching kraft mill effluent was not sufficient in removing the MFO response in white suckers from Jackfish Bay (Lake Superior) and this is further supported by Martel et al. (1994) who found that secondary treatment at kraft mills did not eliminate the MFO response of fish.

These laboratory data can also serve as background information which may be used to assess the effectiveness of the de-inking and secondary treatment systems which began operation in late 1995. If enzyme induction is not completely reduced, a comparison of this threshold value with a threshold value determined for the treated effluent would provide an estimate of the effectiveness of the treatment in decreasing the enzyme response. Gagne and Blaise (1993) found that MFO induction generally occurred at higher concentrations in secondary-treated effluents than in primary-treated effluents. The toxicity of the Pine Falls pulp mill effluent was approximately 3% and the MFO inducing threshold was below 0.23%; this means that some sub-lethal effects of this effluent occurred at less than 7.7% the LC50 values. The results of this experiment support the contention that it is in fact the effluent responsible for MFO effects in the white suckers from the river.

2.) <u>EROD Time-Course Experiment</u>. (Figure 17, original data in Appendix A6)

EROD activities were greater in fish from the 1% effluent tanks than those from the control tanks after 2 days of exposure. The 1% effluent-exposed fish retained this level of induction (5.8 to 8.5-fold) for the remainder of the exposure period. Upon moving the 1% effluent-exposed fish to clean water (day 8) EROD activities remained significantly elevated for 1 more day, but declined to control levels thereafter. Induction dropped from 8.9-fold after 1 day in clean water to 6.2 and 2.8 fold after 2 and 4 days in clean water respectively, although EROD levels were not significantly higher than controls on days 2 and 4. By day 8, EROD activity was identical to that of the control fish. Induction occurred within 48 hours and was decreased within 48 hours, however, due to the large degree of variability between the tanks on the second day in clean water (day 10), a period of 4 days should be used to indicate the time required to diminish the EROD response. The half-life of induction was approximately 4 days.

The time-course experiment showed that the contaminant responsible for the enzyme induction was readily taken up and apparently eliminated or metabolized by the fish, as induction reached a steady level within 2 days and decreased within this same amount of time after exposure ceased. This indicates that the inducer(s) (as expected due to a lack of chlorine bleaching) was not a highly chlorinated, bioaccumulative and/or non-metabolizable compound. Our findings are similar to those reported by Munkittrick et al. (1992) in white suckers exposed to a bleached kraft mill effluent, indicating that the inducer(s) at this non-chlorine bleaching mill may be similar to that from the bleached kraft mill at Jackfish Bay.

It has been thought that chlorine-containing organic compounds, especially pentachlorodibenzodioxins (PCDD) and pentachlorodibenzofurans (PCDF) were probable causes of the MFO induction noted downstream from bleaching kraft mills, although recent evidence indicates that this is not exclusively the case (Burnison et al., 1996; van den Heuvel et al., 1996; Courtenay et al., 1993; Servos et al., 1994; Bankey et al., 1994; van den Heuvel et al., 1995; Munkittrick et al., 1994). The level and duration of induction caused by such substances tends to be much greater than that noted in this and many other pulp mill effluents. Muir et al. (1990) and Delorme (1995) reported EROD induction from a dietary or intraperitoneal injection of 2,3,4,7,8-PCDF that persisted for more than 180 and 300 days in juvenile and adult rainbow trout respectively. The level of EROD induction was also high, up to 84-fold in juvenile rainbow trout fed PCDF-spiked food for 31 days (Muir et al., 1990) and up to 340-fold in male rainbow trout exposed to an i.p. injection of 3 ng/g 10 months prior (Delorme, 1995). Parrott et al. (1995) exposed fish to varying concentrations of 5 PCDDs and 4 PCDFs with an oral dose at time 0 and monitored induction after 2,4,8 or 16 days. Maximal EROD activity achieved at these sublethal concentrations was up to 250-fold for each contaminant and it was concluded that these compounds would not be rapidly metabolized. The above evidence indicates that if the inducer was one of these PCDDs or

PCDFs then induction would have been greater and its decline to control levels would have taken longer than was observed (Figure 17).

There is also experimental evidence to indicate that the MFO inducers in some bleached kraft mill effluents may be similar to those in the non-bleaching effluent from the Pine Falls mill. Channel catfish (*Ictalurus punctatus*) exposed to 8% bleached kraft mill effluent for 263 days had 13-fold EROD induction which declined to control levels when fish were exposed to clean water for 7 days (Bankey et al., 1994). Van den Heuvel et al. (1996) found that white suckers caged in a bleached kraft mill effluent plume were readily induced within 2 days and remained at this induced level for the remainder of the 8 day exposure, with little or no measurable uptake of PCDDs or PCDFs. Munkittrick et al. (1992) report a 40% decrease in MFO activity in bleached kraft mill effluent exposed white suckers after a 2 week mill shutdown. Munkittrick et al. (1995) later showed a rapid decline in EROD activity in white sucker, but only after the fish had been exposed to the effluent for a period of 14 days. Fish exposed for 4 days then placed in clean water did not show any reduction in EROD activity when sampled up to 8 days later, those exposed for 8 days then placed in clean water did not show any reduction in EROD activity until day 16, while those exposed for 14 days showed a decline in EROD activity beginning after only 2 days in clean water, with a decrease to control values within 8 days. Rainbow trout exposed for 2 or 4 days did not decline to reference levels after 16 or 8 days in clean water respectively (Munkittrick et al., 1995). The discrepancies in Munkittrick et al. (1995) may be due to the length of the exposure period, but may also be due to the presence of different types of inducers.

Further evidence for other types of inducers can be found in Courtenay et al., (1993). Courtenay et al. (1993) report a decrease in CYP1A mRNA induction in Atlantic tomcod (*Microgadus tomcod*); after 14 days of being caged in effluent these fish showed an 11-fold increase in CYP1A mRNA, after 1 day in clean water this increased to 14-fold, after 3 days it increased to 20-fold and after 10 days levels of MFO activity did not differ from controls. Courtenay et al. (1993) concluded that the inducer(s) at this mill, while not behaving like a highly chlorinated compound(s), did also not behave like a readily eliminated/metabolized PAH. Similar results have been found by Muir et al. (1990) with low doses of PCDF. Muir et al. (1990) reported a relatively low level of EROD induction (approximately 4-fold) after 31 days of feeding rainbow trout a low dose (0.82 ng/g) of PCDF and induction was not sustained up to 180 days as it was for the high dose group (9 ng/g). Muir et al. (1990) also found that EROD activity reached a maximal level 2 days after contaminant exposure ceased. Thus, the decrease in induction noted by Courtenay et al. (1993) is very similar to that noted for a low dose of a highly chlorinated compound. While research at many mills would seem to indicate that the inducer(s) are quite readily metabolizable, possibly indicative of PAH compounds (van den Heuvel et al., 1995) research at other mills indicates the presence of a more stable type of inducer (Courtenay et al., 1993; Kloepper-Sams and Benton, 1994). Whitefish (*Prosopium williamsoni*) with elevated EROD activities were found 200 km downstream and 70 km upstream from a secondary-treated bleached kraft mill effluent in northern Alberta and these same fish had elevated muscle TCDD and had not been exposed to the effluent for a number of days (Kloepper-Sams and Benton, 1994). The lack of recent exposure accompanied by EROD induction indicates that the inducer(s) at this Alberta mill is/are not readily metabolized and this was further supported by a caging study with whitefish. Whitefish placed in reference water for 8 days showed no change in their relationship between EROD activity and TCDD concentration. The association between EROD activity and TCDD concentration, together with the lack of recovery when moved to clean water suggests that the inducer(s) in this Alberta mill's effluent may be TCDD or that the inducer was some other compound that was not readily metabolizable.

The above evidence indicates that different mills may produce different types of inducers and individual mills may have more than one inducer, as well as having effluent components which may increase and decrease the EROD response. Different fish species may also show different levels of responsiveness to the same types of inducers (Kloepper-Sams and Benton, 1994). These factors demonstrate the usefulness of characterizing pulp mill effluents in the lab, where effluent characteristics can be examined in the same species, at a similar temperature and at a range of known concentrations and time durations. These types of studies provide information as to the type of inducer present and allow for a more direct comparison of results. Results from field data are influenced by the species used, the time of year (especially in sexually reproducing individuals), and the characteristics of the receiving environment, including: effluent dilution ratio, sediment composition, diet of the fish in the area and background water quality. Furthermore, some potential impacts noted downstream of pulp mill effluents may be due to historical site degradation (Owens, 1991), which means that there may be effects in the fish population downstream that are not attributable to the existing effluent. Laboratory tests which examine similar characteristics to those in the field would also be valuable to separate these types of environmental effects from those caused directly from effluent exposure.

SUMMARY

Feral white suckers captured downstream from the non-bleaching groundwood/sulphite Pine Falls pulp mill exhibited a number of biochemical and morphological differences when compared with reference fish which were isolated from the effluent discharge by the Powerview Dam (Table 5). These differences included an increase in liver MFO activities and liver somatic indices and reductions in plasma testosterone levels and hepatic retinoid and tocopherol stores. Fecundity was also reduced, although this was only detectable in mature gonads from fish captured in the spring.

The decrease in site differences noted in the spring may be due to the spawning migration, which could result in the presence of fish from populations other than those that normally reside in this reach of the Winnipeg River. The possible migration of the downstream fish to the lake in the fall/winter and/or the potential increased mobility of the fish in the spring would also decrease the site differences, because it would mean that the fish would not be exposed to the effluent for as long a period of time prior to being captured compared to those caught in the summer.

Although cause/effect relationships cannot be rigorously proven from the fish taken from the river, there are a number of findings which would indicate that the effluent/mill operations are responsible for these effects. There was a trend towards increasing impacts in August, 1994, relative to August, 1993, because egg weights and diameters were not affected in August, 1993, but were reduced in August, 1994, and hepatic retinol levels (males), hepatic tocopherol levels (females) and EROD activities (females) were not affected at the further downstream site (D2) in August, 1993, but were affected in August, 1994. These increased impacts coincided with an increase in effluent concentration in the Winnipeg River, indicating that the effluent may be responsible for the effects. Most significant differences were noted between the upstream reference site and the site immediately below the effluent outfall and these same differences were not usually displayed between the upstream reference and further downstream sites, further signalling the presence of the mill as the source of the effects. Finally, one of the parameters quantified in the feral fish, the

MFO response, was induced in laboratory fish exposed only to the effluent. Whether the responses in feral fish were due entirely to the (then) currently released effluent discharges or to the historical environmental degradation of the sediments/benthos in the area is uncertain at this time.

The preliminary laboratory experiments revealed that effluent toxicity did not degrade rapidly upon effluent storage, that the toxic components in the effluent were soluble and not highly volatile and that aeration of exposure tanks would not be desired for reliable LC50 estimates.

The MFO experiments confirmed that one of the impacts noted in the feral fish could be caused by effluent exposure alone, indicating that the current pulp mill effluent contains compound(s) with MFO inducing properties. The characteristics of the MFO induction resembled those caused by PAH type compounds and not PCDDs or PCDFs.

Although the species used in the lab experiments were not the same as those from the river, it is worth noting that both species were induced by similar concentrations of effluent. The effluent concentration that fish near the mill would have experienced has been estimated from the complete mixing dilution ratios (given previously) and the counts of coliform bacteria. The bacteriology provided an indication of horizontal mixing across the river at several distances downstream. Using this information a rough estimate of 0.66% effluent was calculated as the highest concentration that the white sucker may have been exposed to during August, 1994. This concentration corresponds to the concentrations used in the laboratory study. The range of induction noted in the field was between 3.4 to 8.6-fold and that in the lab ranged from about 5 to 11-fold. The finding that the laboratory fish were induced after only 2 days of effluent exposure indicates that the fish sampled from the river may also be induced after exposure of a relatively short duration, indicating that they do not have to be resident for an extended period of time prior to the detection of effluent exposure using EROD induction.

CONCLUSIONS

- Aspects of white sucker biochemistry and morphology were altered downstream of the Pine Falls pulp mill prior to the installation of the secondary treatment facility. These differences included increased MFO activities and liver somatic indices and decreased concentrations of testosterone and vitamins A and E and reduced fecundity.

- Although fecundity was reduced, it was still high in comparison with white suckers described in the literature from other locations.

- Many of these effects have also been reported downstream from bleaching and non-bleaching pulp mills at other locations, including some with secondary effluent treatment.

- EROD correlated positively with LSI and negatively with hormones, vitamins and condition factor; vitamins were positively correlated with condition, hormones and other measures of reproductive fitness (egg diameter, egg size and fecundity).

- Vitamin levels may be depleted for a number of reasons, one may be accelerated metabolism (Palace et al., 1997) another may simply be a lack of vitamin availability downstream of the effluent discharge.

- The threshold for EROD induction in laboratory rainbow trout was below 0.23%.

- EROD induction occurred within 2 days of exposure of rainbow trout to a 1% effluent concentration and remained at a similar level over the next 6 days of exposure; induction declined within 2 to 4 days after the fish were removed to clean water, indicating that the contaminant responsible for the induction could be eliminated or was readily metabolized by the fish.

- Fish caught within 1 km of the mill could have been exposed to an effluent concentration up to 0.66% in August, 1994; laboratory fish exposed to concentrations ranging from 0.23 to 1.0% showed similar MFO effects.

- The EROD induction in fish exposed to effluent in the lab offers strong support for the argument that the enzyme induction noted in the field was directly caused by the exposure of fish to the pulp mill effluent, and not by some other variable.

- Maximum EROD induction of white sucker from the Winnipeg River was 8.6-fold in 1993 and 4.1-fold in 1994; a similar induction of 10.9-fold was found in rainbow trout in the lab.

- This research provides background information for monitoring the effectiveness of the secondary treatment system.

PROPOSALS FOR FUTURE WORK

1. To determine if the secondary treatment system is effective in eliminating the effects on fish morphology and biochemistry, samples should be collected in August and May so that direct comparisons for all measured parameters can be made between these collections and the samples collected previously.

2. If EROD induction and other effects are still noted, laboratory experiments on the new effluent could be conducted to monitor whether the treatment has been partially effective in alleviating these responses. If the treatment is at least partially effective then the new threshold for EROD induction should be higher than the old one.

3. If vitamins in the downstream fish are still depleted it would be of benefit to examine how this vitamin depletion might arise. This would involve the sampling of invertebrates at the same time as the fish and analyzing each group (three groups would be examined, chironomids, oligochaetes and mayfly larvae) for biomass and vitamin content, and examining the gut contents of the fish to determine the major components in their diet.

4. Documenting the relevance of the observed vitamin deficiencies to the functioning of the organism is important. This research would involve feeding fish diets low in vitamins to deplete their vitamin stores and assessing at what levels of vitamin deficiency other effects occur.

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Table 4: Correlations between condition factor (CFAC), liver weight (Livwt.), gonadosomatic index (GSI), liver somatic index (LSI), plasma testosterone concentration (Test.), plasma estradiol concentration (Estra.), absolute fecundity (Absfec.), relative fecundity (Relfec.), egg diameter (Eggdiam.), egg weight (Eggwt.), liver retinol concentration (Livret.), liver retinyl palmitate concentration (Livretp.), liver tocopherol concentration (Livtoc.), 7-ethoxyresorufin O-deethylase enzyme activity (EROD) and aryl hydrocarbon hydroxylase enzyme activity (AHH). N is the number of samples used in the correlation, p is the significance level of the correlation and Corr. is the correlation coefficient. Dashes indicate that no significant correlation exists between the variables in question.

Correlation	August 93 + 94 Males			August 93 + 94 Females			May, 1994 Males			May, 1994 Females		
Variables	N	p	Corr.	N	p	Corr.	N	p	Corr.	N	p	Corr.
CFAC. vs. GSI	-	-	-	68	<0.001	0.522	16	0.025	0.577	-	-	-
CFAC. vs. LSI	37	0.001	-0.517	68	<0.001	-0.558	-	-	-	-	-	-
CFAC. vs. Relfec.	-	-	-	68	<0.001	-0.534	-	-	-	-	-	-
CFAC. vs. Livret.	-	-	-	65	0.036	0.260	-	-	-	-	-	-
CFAC. vs. Livretp.	-	-	-	65	<0.001	0.422	-	-	-	-	-	-
CFAC. vs. EROD	-	-	-	68	<0.001	-0.419	-	-	-	-	-	-
CFAC. vs. AHH	-	-	-	68	0.002	-0.361	-	-	-	-	-	-
Livwt. vs. GSI	15	0.039	-0.537	-	-	-	16	0.047	0.503	-	-	-
Livwt. vs. Test.	-	-	-	46	0.012	-0.368	-	-	-	-	-	-
Livwt vs. Absfec.	-	-	-	68	<0.001	0.541	-	-	-	16	0.021	0.569
Livwt. vs. Livret.	-	-	-	65	0.011	-0.315	-	-	-	-	-	-
Livwt. vs. Livretp.	-	-	-	65	0.010	-0.317	-	-	-	-	-	-
Livwt. vs. Livtoc.	-	-	-	-	-	-	16	0.028	-0.549	-	-	-
Livwt. vs. EROD	-	-	-	68	0.002	0.365	-	-	-	-	-	-
Livwt vs. AHH	36	0.001	0.511	68	0.016	0.292	-	-	-	-	-	-
GSI vs. LSI	-	-	-	68	0.003	0.357	-	-	-	-	-	-
LSI vs. Test.	29	0.004	-0.517	46	0.018	-0.348	-	-	-	-	-	-
LSI vs. Relfec.	-	-	-	68	0.013	0.298	-	-	-	-	-	-
LSI vs. Livret.	-	-	-	65	<0.001	-0.508	16	0.007	-0.643	-	-	-
LSI vs. Livretp.	36	0.026	-0.370	65	<0.001	-0.515	16	0.025	-0.556	-	-	-
LSI vs. Livtoc.	-	-	-	65	0.045	-0.249	16	<0.001	-0.836	-	-	-

Correlation Variables	August 93 + 94 Males			August 93 + 94 Females			May, 1994 Males			May, 1994 Females		
	N	p	Corr.	N	p	Corr.	N	p	Corr.	N	p	Corr.
LSI vs. EROD	-	-	-	68	<0.001	0.692	-	-	-	-	-	-
LSI vs. AHH	-	-	-	68	<0.001	0.650	-	-	-	-	-	-
Livret. vs. Test.	28	0.033	0.395	43	<0.001	0.519	-	-	-	-	-	-
Livret. vs. Estra	-	-	-	65	0.009	0.321	-	-	-	14	0.018	0.620
Livret. vs. Livretp.	36	0.009	0.426	65	<0.001	0.749	16	<0.001	0.853	-	-	-
Livret. vs. Livtoc.	-	-	-	65	<0.001	0.455	16	0.002	0.720	16	0.039	0.520
Livret vs. EROD	-	-	-	65	<0.001	-0.469	-	-	-	-	-	-
Livret. vs. AHH	36	0.031	-0.360	65	<0.001	-0.449	-	-	-	-	-	-
Livretp. vs. Test.	28	0.033	0.403	43	0.001	0.492	-	-	-	-	-	-
Livretp. vs. Estra.	-	-	-	65	0.035	0.261	-	-	-	-	-	-
Livretp. vs. Relfec.	-	-	-	65	0.028	0.273	-	-	-	-	-	-
Livretp. vs. Eggdiam.	-	-	-	65	0.018	0.292	-	-	-	-	-	-
Livretp. vs. Eggwt.	-	-	-	65	0.001	0.391	-	-	-	-	-	-
Livretp. vs. Livtoc.	-	-	-	65	0.025	0.278	16	0.005	0.660	-	-	-
Livretp. vs. EROD	-	-	-	65	<0.001	-0.491	-	-	-	-	-	-
Livretp. vs. AHH	36	0.034	-0.354	65	<0.001	-0.501	-	-	-	-	-	-
EROD vs. Test.	-	-	-	46	0.002	-0.454	-	-	-	15	0.027	0.568
EROD vs. Relfec.	-	-	-	68	0.015	0.295	-	-	-	-	-	-
EROD vs. Eggdiam.	-	-	-	68	0.049	-0.239	-	-	-	-	-	-
EROD vs. Eggwt.	-	-	-	68	0.003	-0.355	-	-	-	-	-	-
EROD vs. AHH	36	<0.001	0.838	68	<0.001	0.961	15	0.002	0.730	16	<0.001	0.813
AHH vs. Test.	-	-	-	68	0.001	-0.457	-	-	-	-	-	-
AHH vs. Relfec.	-	-	-	68	0.035	0.256	-	-	-	-	-	-
AHH vs. Eggdiam.	-	-	-	68	0.019	-0.284	-	-	-	-	-	-
AHH vs. Eggwt.	-	-	-	68	0.002	-0.368	-	-	-	-	-	-
Estra. vs. Test.	-	-	-	46	0.002	0.450	-	-	-	-	-	-
Estra vs. Eggdiam.	-	-	-	68	0.048	0.240	-	-	-	14	0.011	0.657
Eggwt. vs. Relfec.	-	-	-	68	<0.001	-0.437	-	-	-	-	-	-

Table 5: Summary of differences noted between the upstream reference and two downstream sites. A dash indicates no significant difference, an up arrow indicates a significant increase above values at the reference site, and a down arrow indicates a significant decrease below values at the reference site. NA indicates that the analysis was not applicable. Differences were considered significant if $p < 0.05$. Units for all variables can be found in the Appendix (Table A2).

Variable	Females					Males				
	August, 1993		May, 1994	August, 1994		August, 1993		May, 1994	August, 1994	
	D1	D2	D1	D1	D2	D1	D2	D1	D1	D2
Length	–	–	–	–	–	–	↑	–	↑	↑
Weight	–	–	–	–	–	–	–	–	↑	↑
Age	↑	–	–	–	–	↑	–	–	–	–
Condition Factor	↓	–	–	–	–	–	–	–	–	–
Liver Somatic Index	↑	–	↑	↑	–	↑	–	↑	–	–
Gonadosomatic Index	–	–	–	–	–	–	–	–	–	–
Testosterone	↓	–	–	↓	NA	–	–	–	↓	NA
Estradiol	–	–	–	–	–	NA	NA	NA	NA	NA
Relative Fecundity	–	–	↓	–	–	NA	NA	NA	NA	NA
Absolute Fecundity	–	–	↓	–	–	NA	NA	NA	NA	NA
Egg Weight	–	–	–	↓	–	NA	NA	NA	NA	NA
Egg Diameter	–	–	–	↓	–	NA	NA	NA	NA	NA
Liver Retinol	↓	–	–	↓	–	–	–	↓	↓	↓
Liver Retinyl Palmitate	↓	–	–	↓	–	↓	–	↓	–	–
Liver Tocopherol	↓	–	–	↓	↓	↓	–	↓	–	–
EROD	↑	–	–	↑	↑	–	–	–	–	–
AHH	↑	–	–	↑	–	↑	–	–	–	–

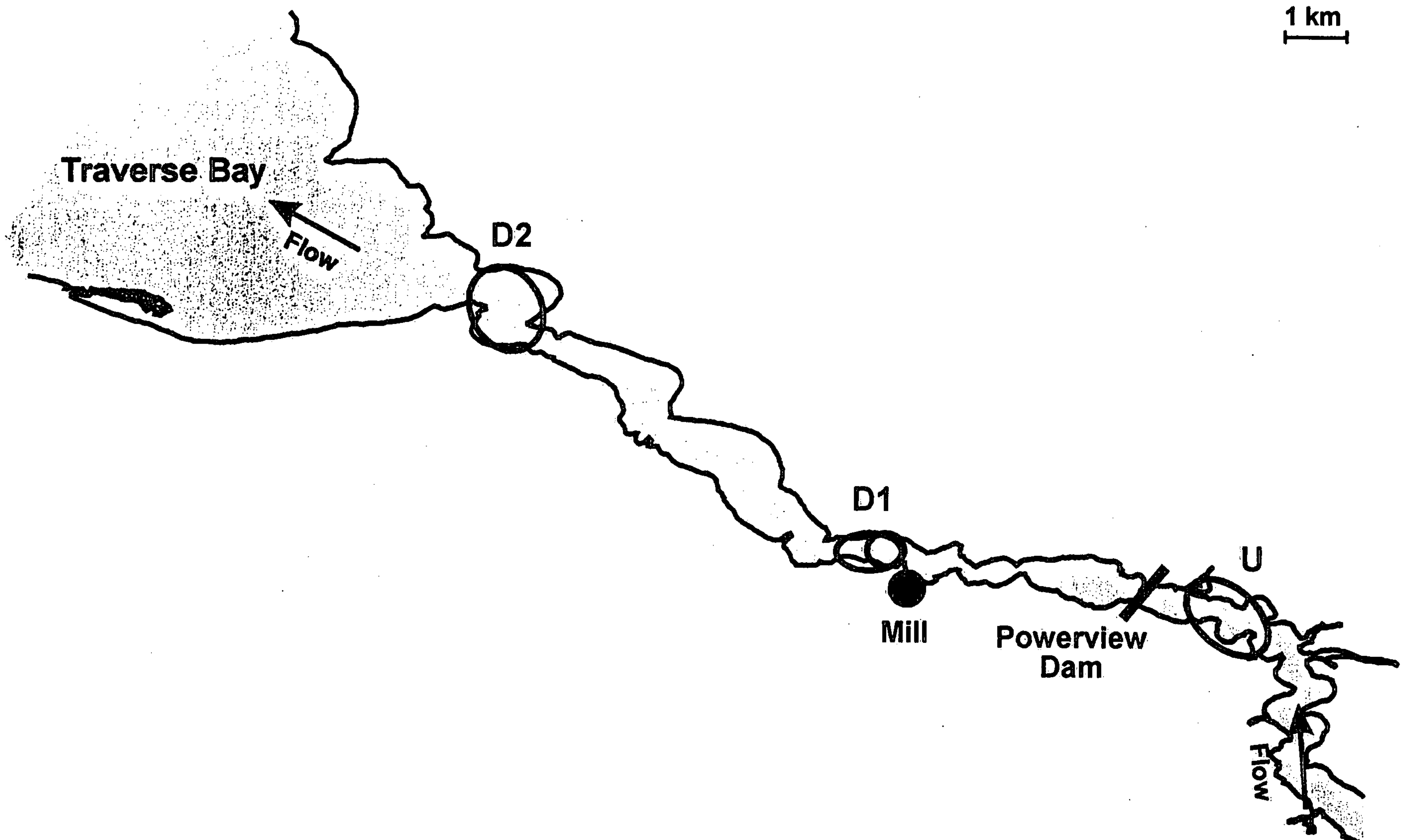


Figure 1: Sampling sites for white sucker along the Winnipeg River in 1993 and 1994. The upstream reference site was located upstream of the Powerview dam and is labelled U on the map. Site D1 was the near downstream site and was located within 1 km of the effluent outfall. The smaller circle at site D1 indicates the sampling area at this site in August, 1993 and May, 1994 and the larger circle indicates the size of the sampling area in August, 1994. Site D2, the far downstream site, was located approximately 6 to 8 km downstream from the effluent discharge.

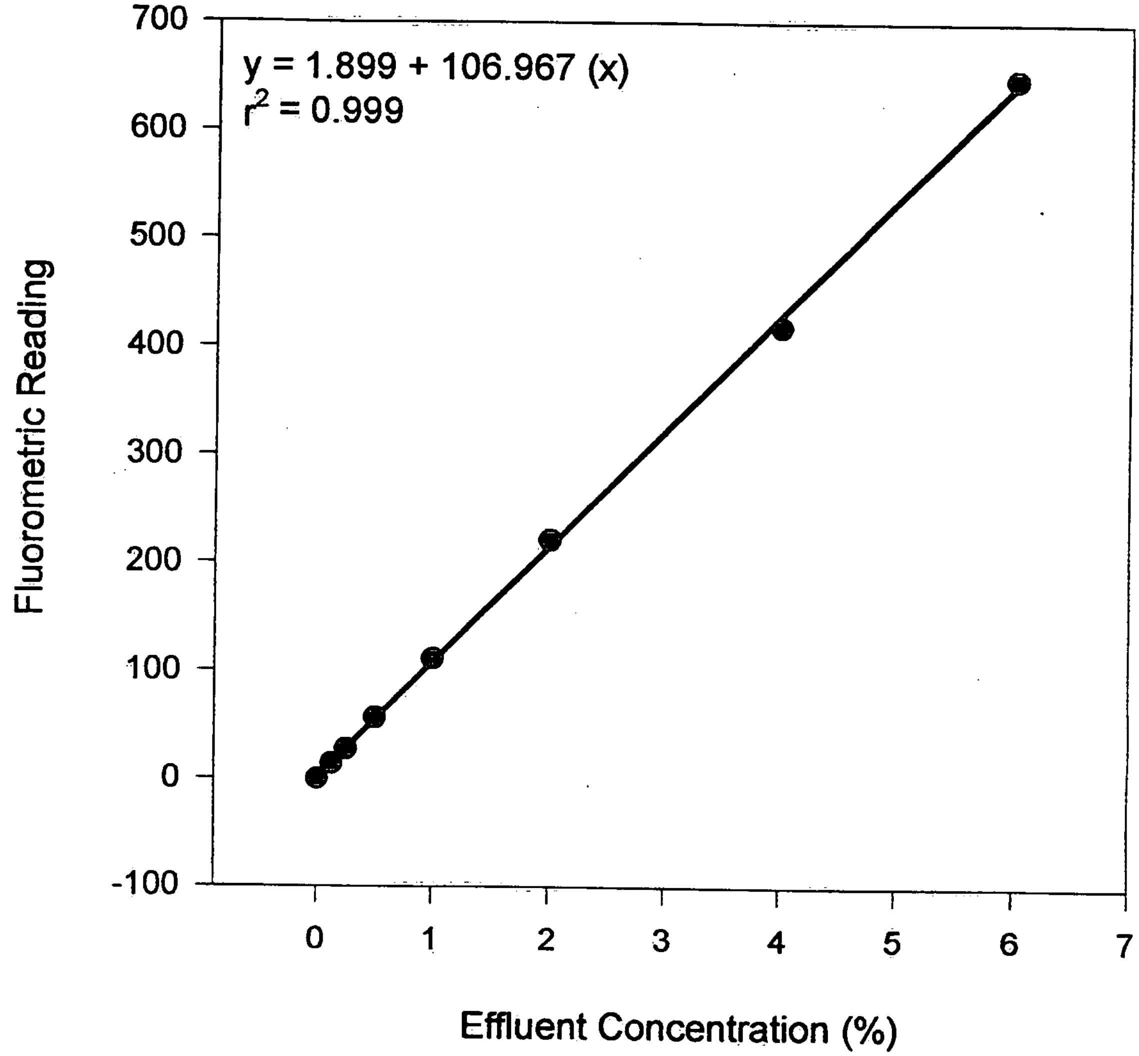


Figure 2: Regression of effluent concentration versus fluorometric readings taken with excitation and emission wavelengths of 355 and 398 nm respectively, with slit widths of 5 nm. This standard dilution curve was prepared on January 24, 1995, and is typical of the standard effluent dilution curves that were obtained when tank effluent concentrations were determined.

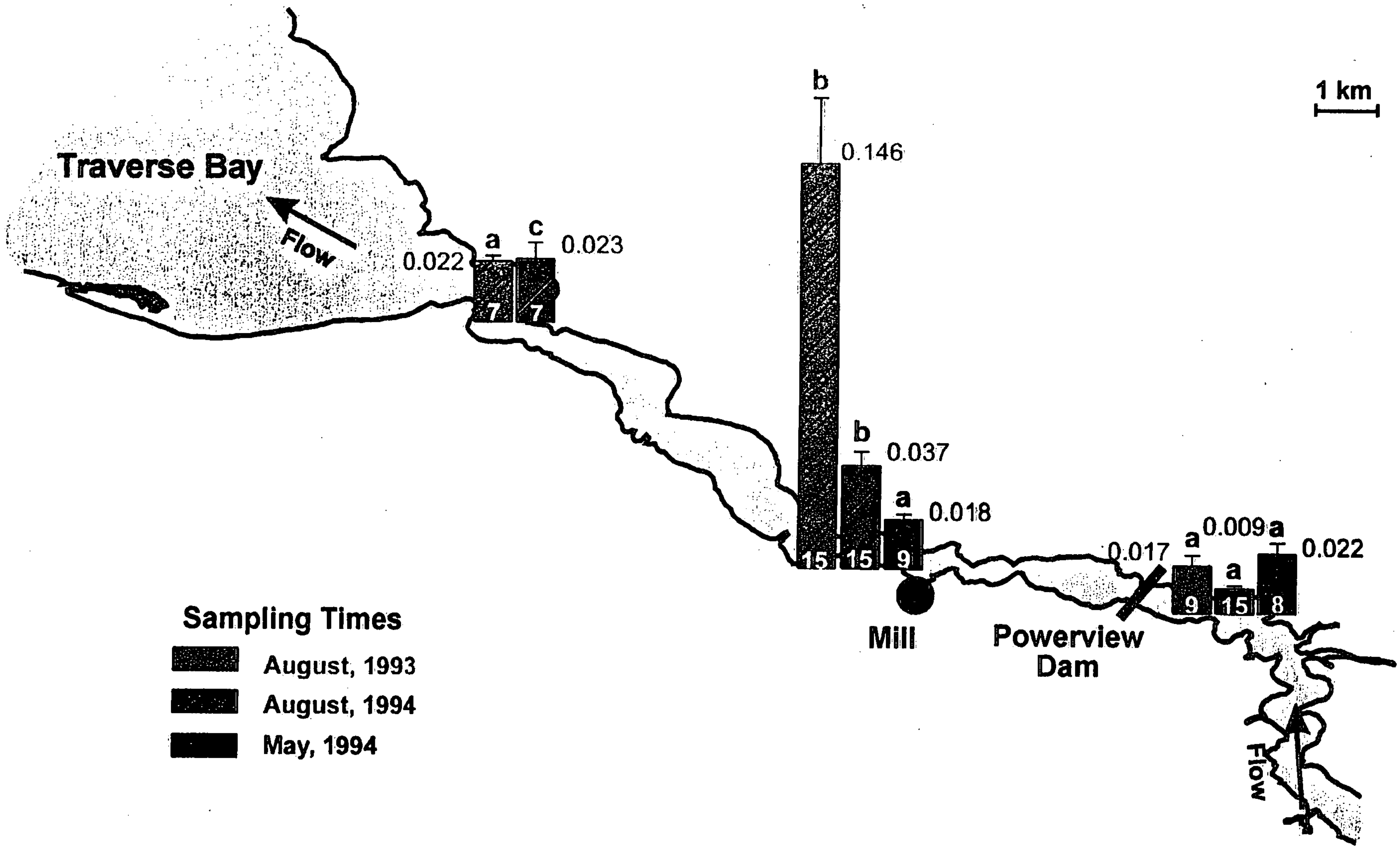


Figure 3: Liver EROD (7-ethoxyresorufin O-deethylase) enzyme activity (nmol/mg protein/minute) in female white suckers taken from the Winnipeg River at three different sampling times. Lines above the bars represent the S.E.M. and bars with the same colour and letter are not significantly different ($p < 0.05$). In August, 1993, EROD enzyme activites were increased at site D1 relative to both U and D2. In August, 1994, EROD activies were higher at both of the downstream sites. There were no site differences in May. The number at the base of each bar indicates the sample size.

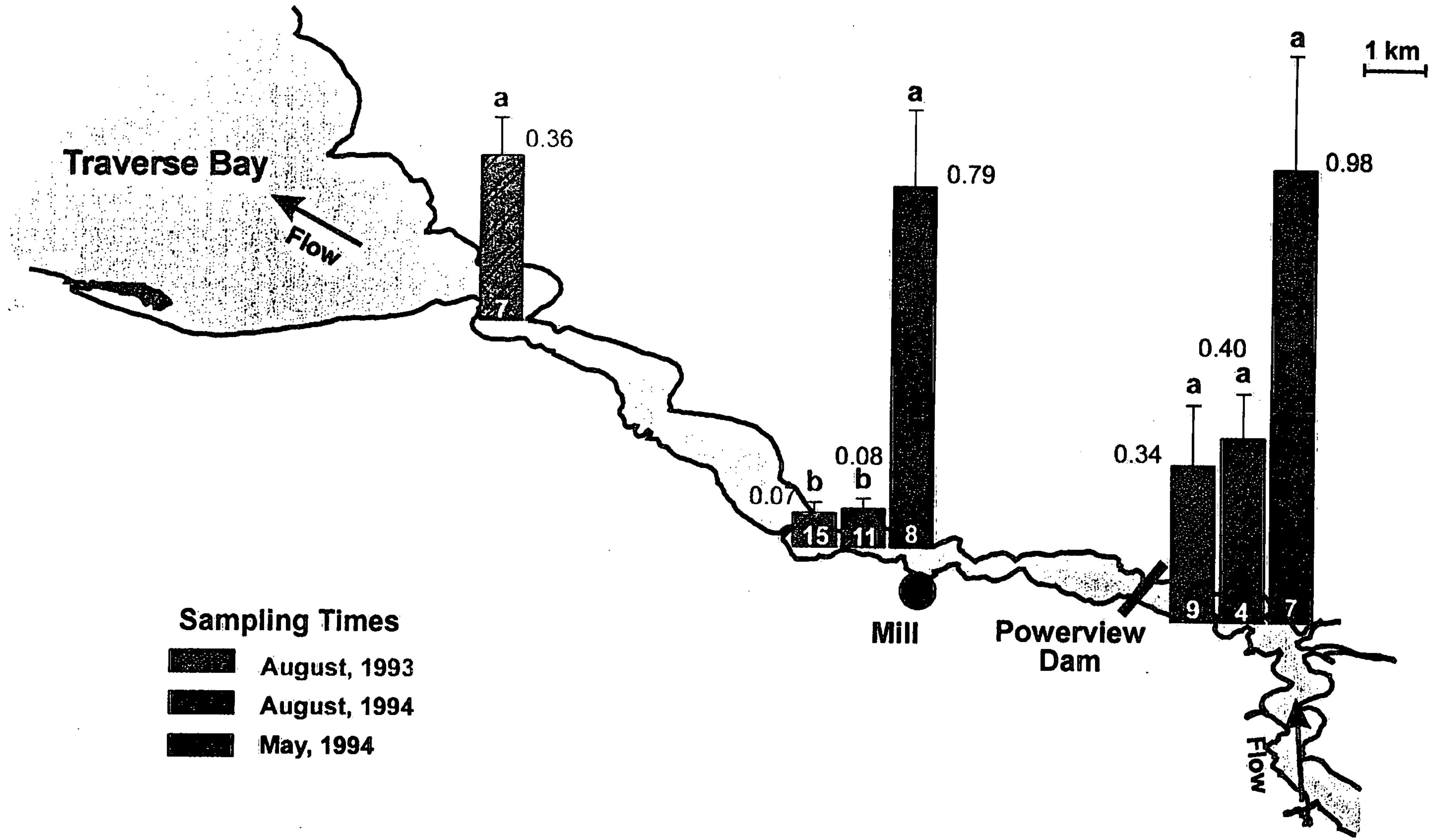


Figure 4: Testosterone concentrations (nmol/L of plasma) of female white suckers taken from the Winnipeg River at three different sampling times. Lines above the bars represent the S.E.M. and bars with the same colour and letter are not significantly different ($p < 0.05$). Testosterone levels were lower at site D1 in August, 1993 and 1994. There were no site differences in May, 1994. Testosterone levels were found to differ in fish caught hourly compared with those captured overnight, as such, all fish caught in overnight sets have been ommitted from this analysis (including some fish from U and D1 and all fish from site D2 in August, 1994). The number at the base of each bar indicates the sample size.

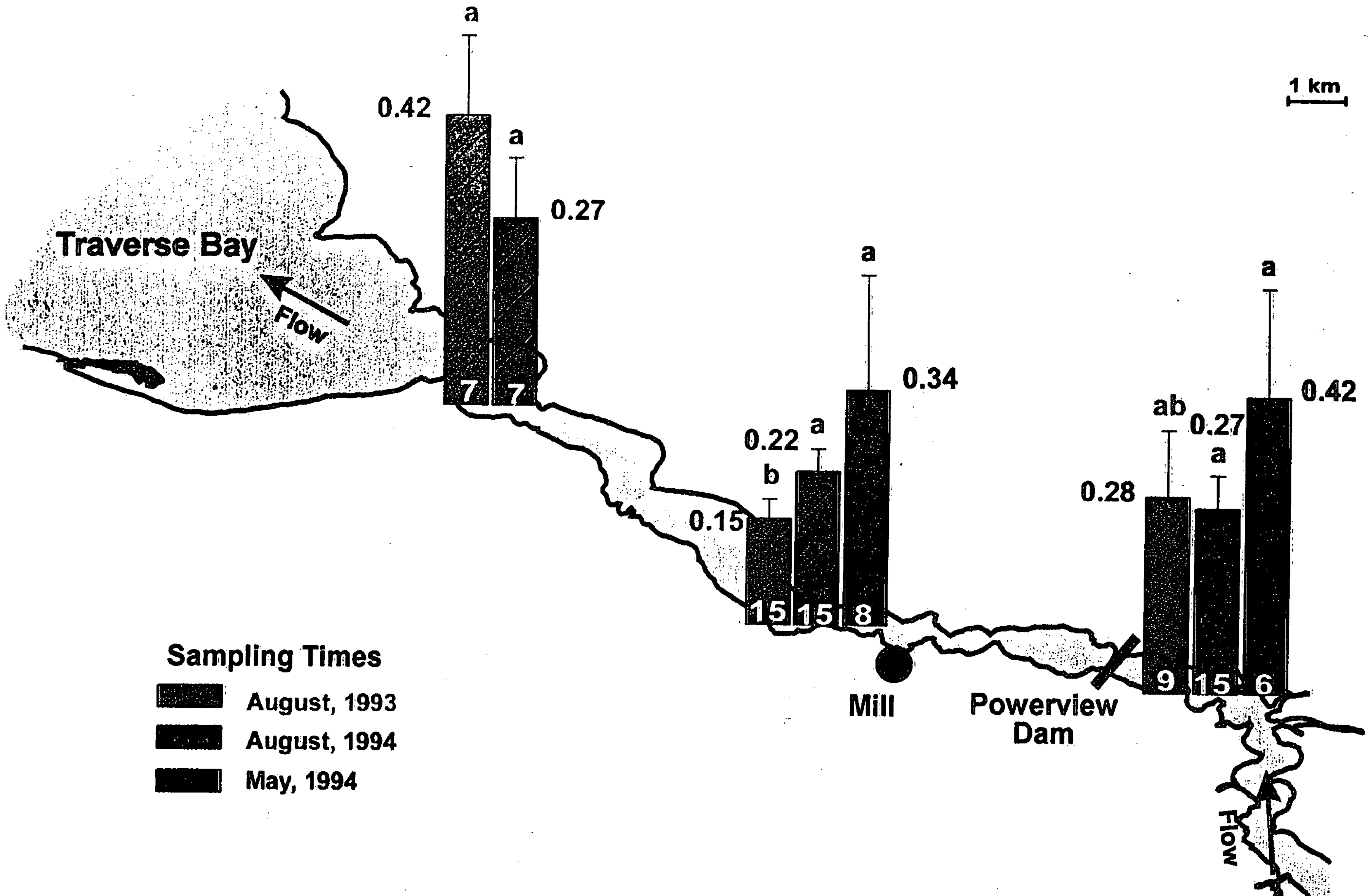


Figure 5: Estradiol concentration (nmol/L of plasma) of female white suckers taken from the Winnipeg River at three different sampling times. Lines above the bars indicate the S.E.M. and bars with the same colour and letter are not significantly different ($p < 0.05$). Estradiol levels were never significantly different downstream relative to upstream, however, in August, 1993, estradiol levels at site D1 were lower than those at site D2. The number at the base of each bar indicates the sample size.

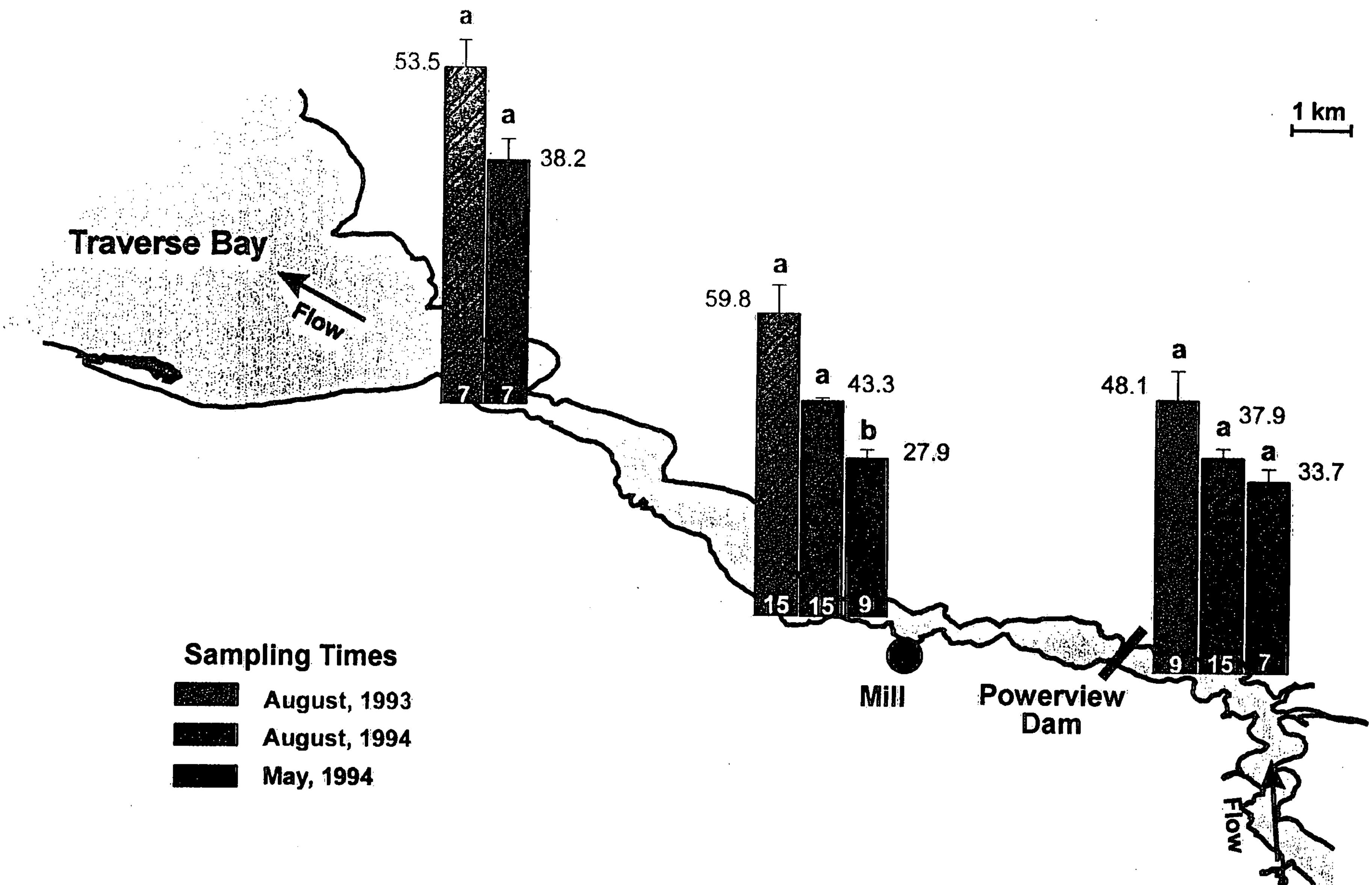


Figure 6: Relative fecundity (# eggs/g of fish weight) of female white suckers taken from the Winnipeg River at three different sampling times. Lines above the bars represent the S.E.M. and bars with the same colour and letter are not significantly different ($p < 0.05$). No site differences were observed in August, 1993 and 1994, but in the spring, females near the mill produced fewer mature eggs than those taken from usptream. The number at the base of each bar indicates the sample size.

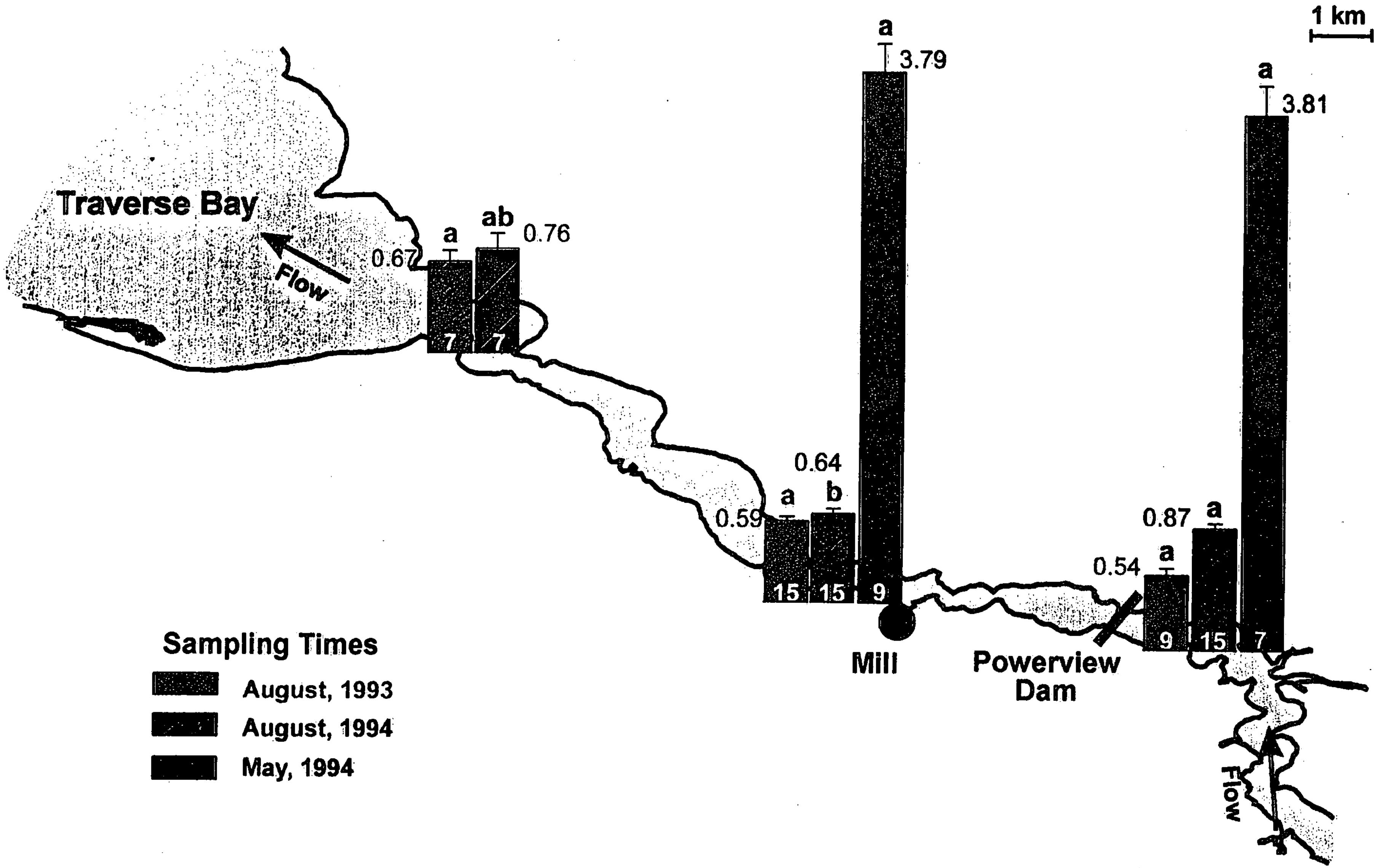


Figure 7: Egg weights (g) of female white suckers taken from the Winnipeg River at three different sampling times. Lines above the bars indicate the S.E.M. and bars with the same colour and letter are not significantly different ($p < 0.05$). In August, 1994, fish from the site nearest the mill had smaller, lighter eggs than those caught upstream. There were no site differences at the other sampling times. Identical results were obtained for egg diameters. The number at the base of each bar indicates the sample size.

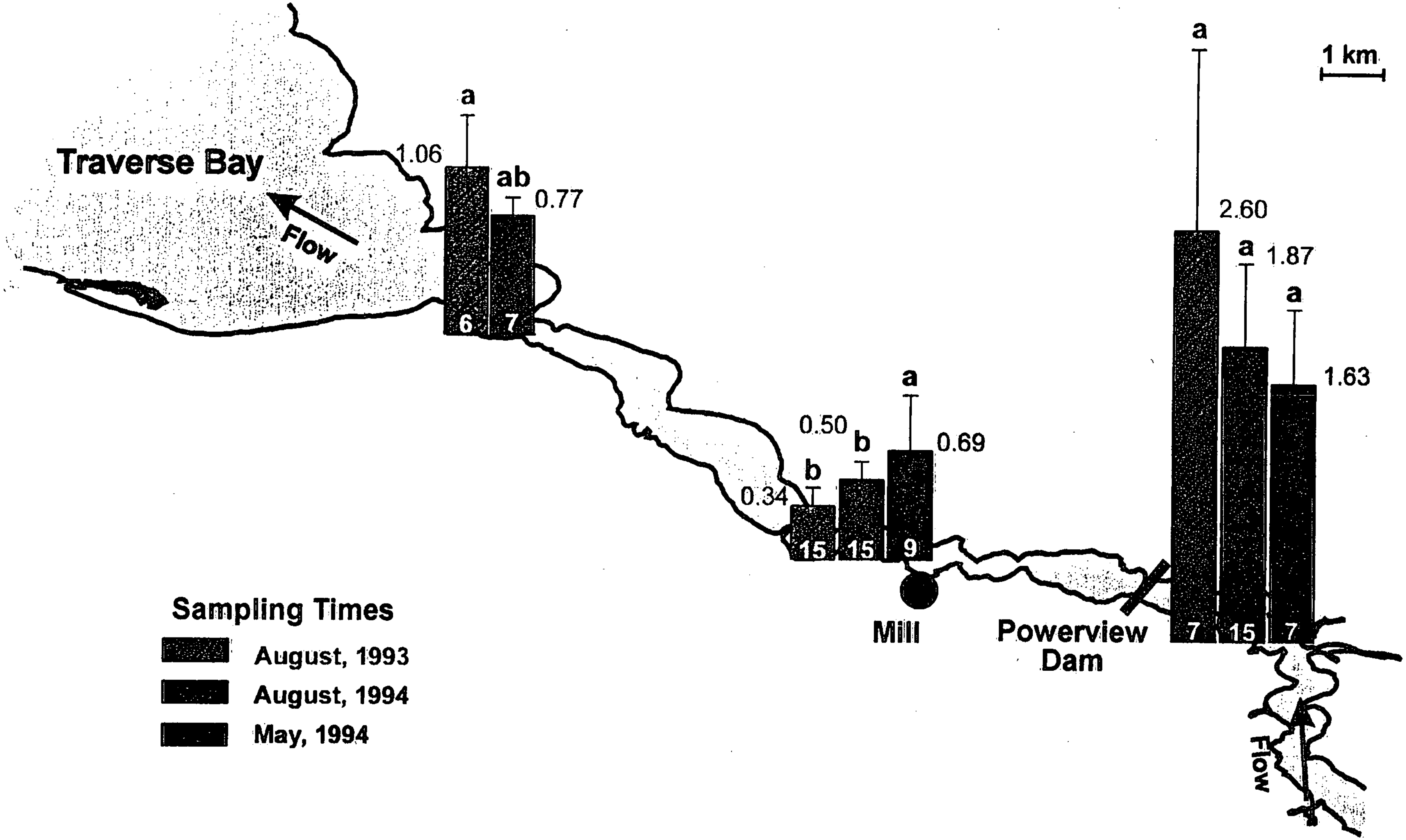


Figure 8: Liver retinol concentrations (μg/g wet tissue weight) of female white suckers from the Winnipeg River at three different sampling times. Lines above the bars represent the S.E.M. and bars with the same colour and letter are not significantly different ($p < 0.05$). Hepatic retinol levels were lower at site D1 at both August sampling times, but were not significantly different in May, 1994. The number at the base of each bar indicates the sample size.

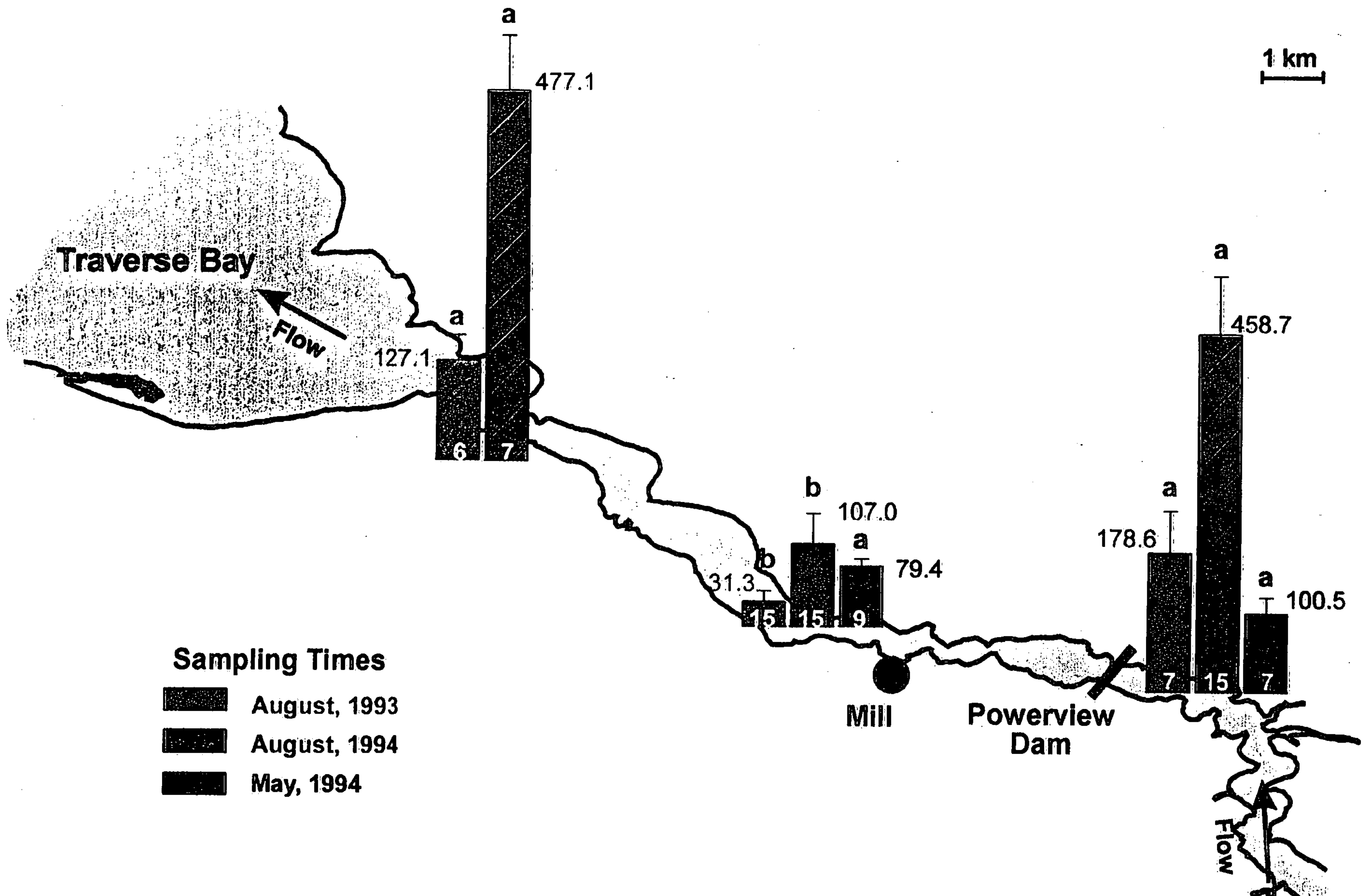


Figure 9: Liver retinyl palmitate concentrations (μg/g wet tissue weight) of female white suckers from the Winnipeg River at three different sampling times. Lines above the bars represent the S.E.M. and bars with the same colour and letter are not significantly different ($p < 0.05$). Hepatic retinyl palmitate levels were lower at site D1 at both August sampling times, but were not significantly reduced in May, 1994. The number at the base of each bar indicates the sample size.

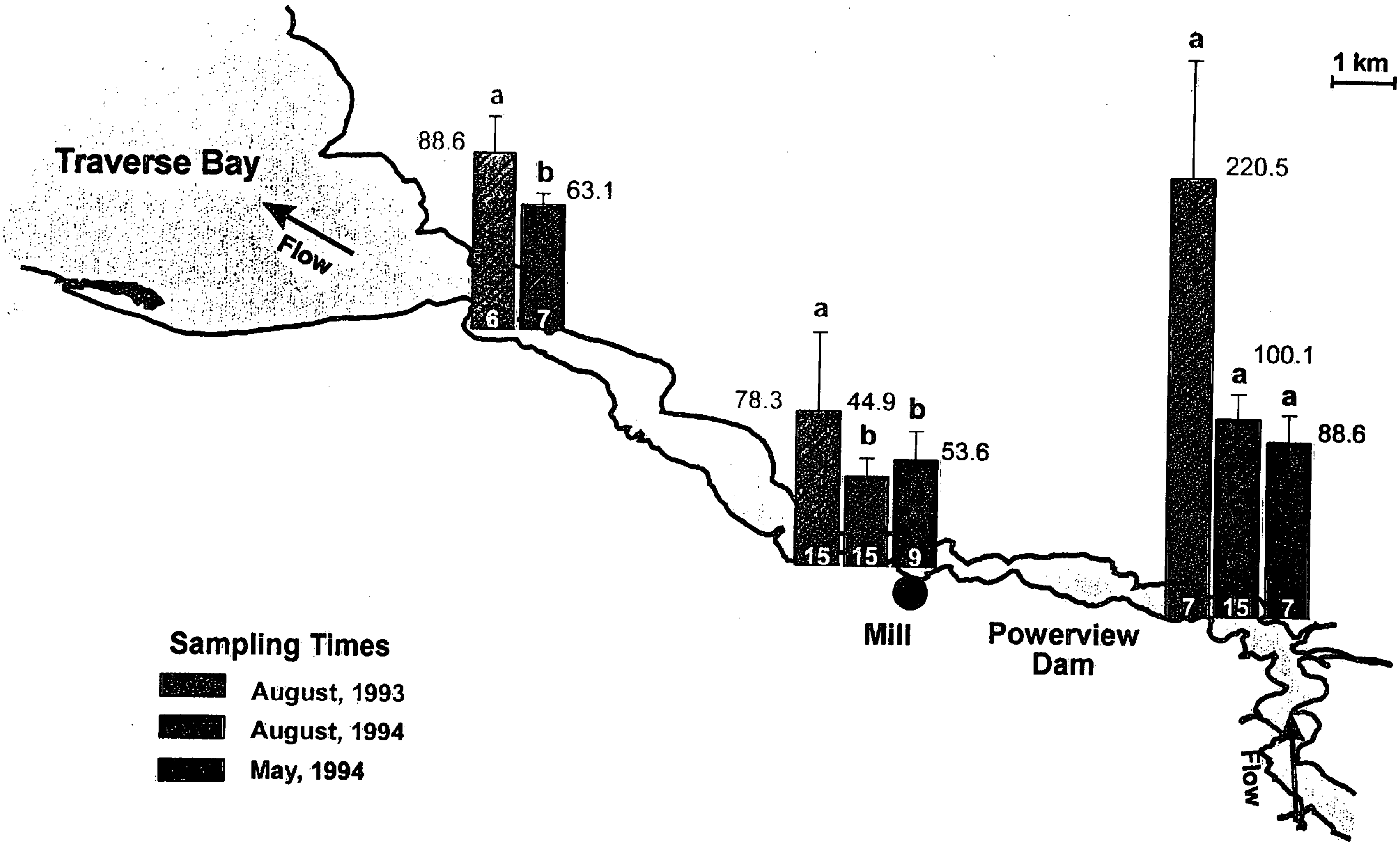


Figure 10: Liver tocopherol concentrations (μg/g wet tissue weight) of female white suckers from the Winnipeg River at three different sampling times. Lines above the bars represent the S.E.M. and bars with the same colour and letter are not significantly different ($p < 0.05$). Hepatic tocopherol levels were lower at site D1 in May and August, 1994, but were not significantly lower at this site in August, 1993. Tocopherol was reduced at both downstream sites in August, 1994. The number at the base of each bar indicates the sample size.

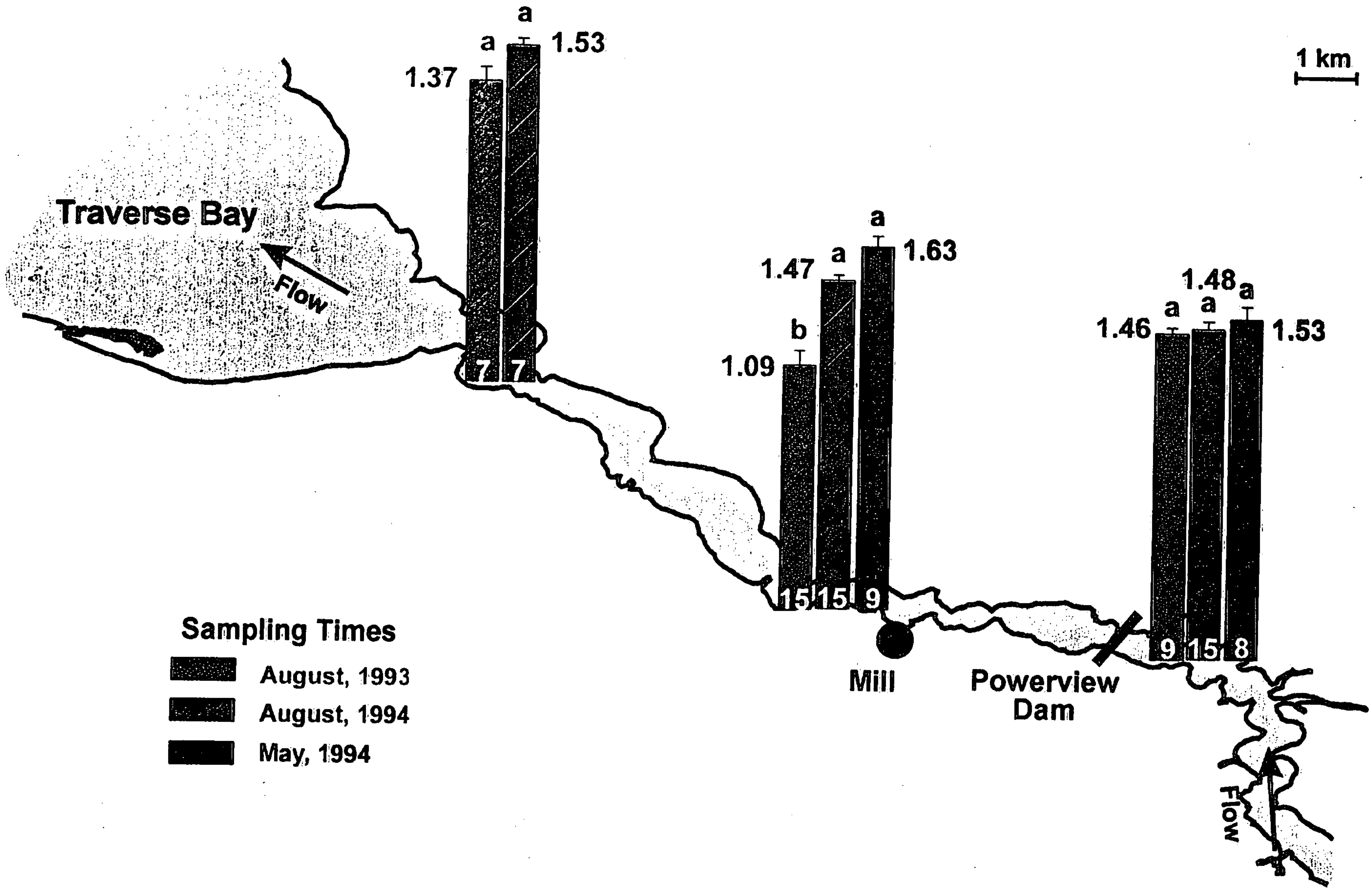


Figure 11: Condition Factor ((body weight / length^3) * 100) of female white suckers taken from the Winnipeg River at three different sampling times. Lines above the bars represent the S.E.M. and bars with the same colour and letter are not significantly different ($p<0.05$). Condition factor was reduced in fish near the mill relative to fish from the upstream or further downstream sites in August, 1993, but not in May or August, 1994. The number at the base of each bar indicates the sample size.

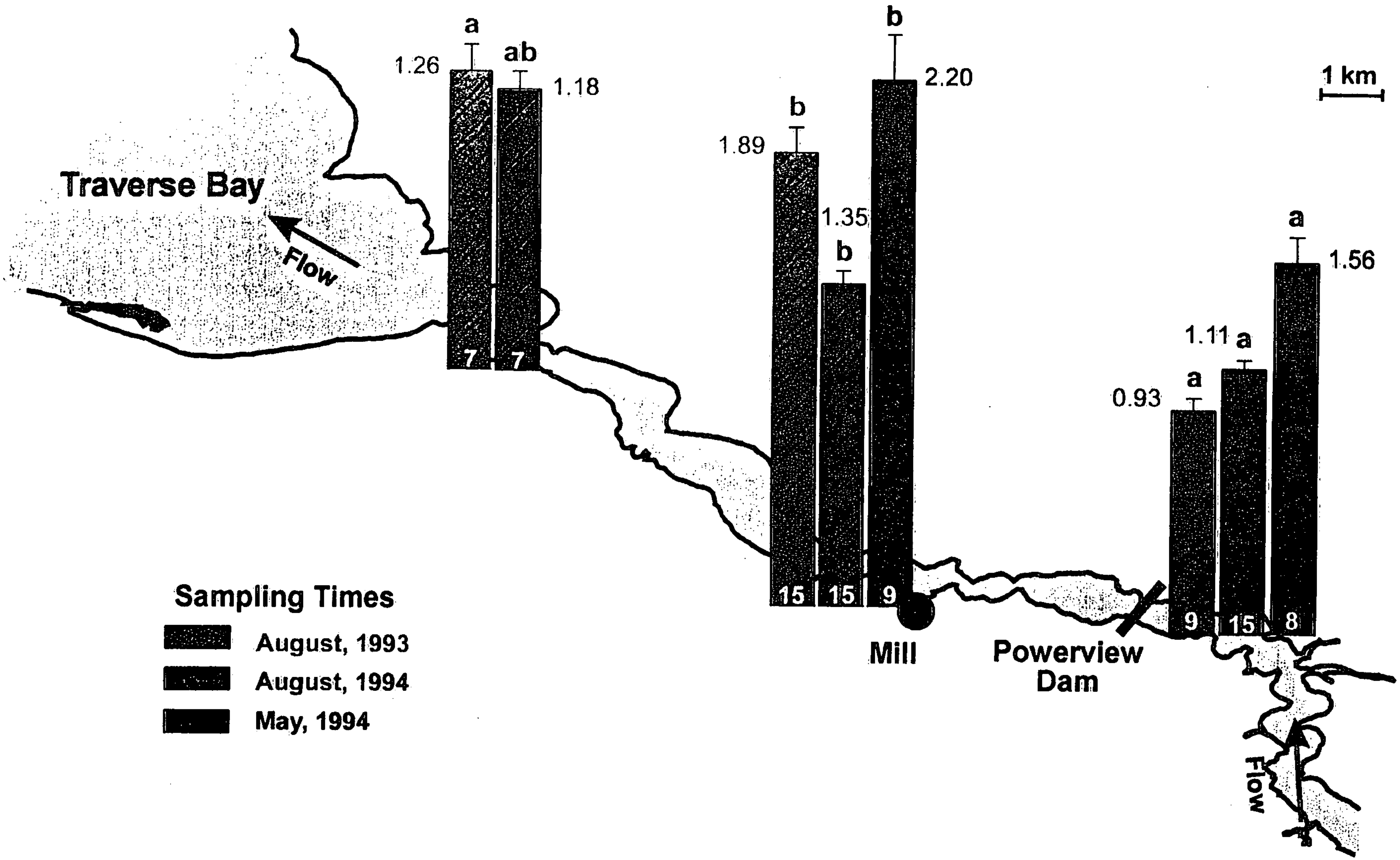


Figure 12: Liver somatic indices (LSI = ((body weight - liver weight) / body weight) * 100) of female white suckers from the Winnipeg River at three different sampling times. Lines above the bars represent the S.E.M and bars with the same colour and letter are not significantly different ($p < 0.05$). LSI was elevated at the site nearest the mill at all sampling times. The number at the base of each bar indicates the sample size.

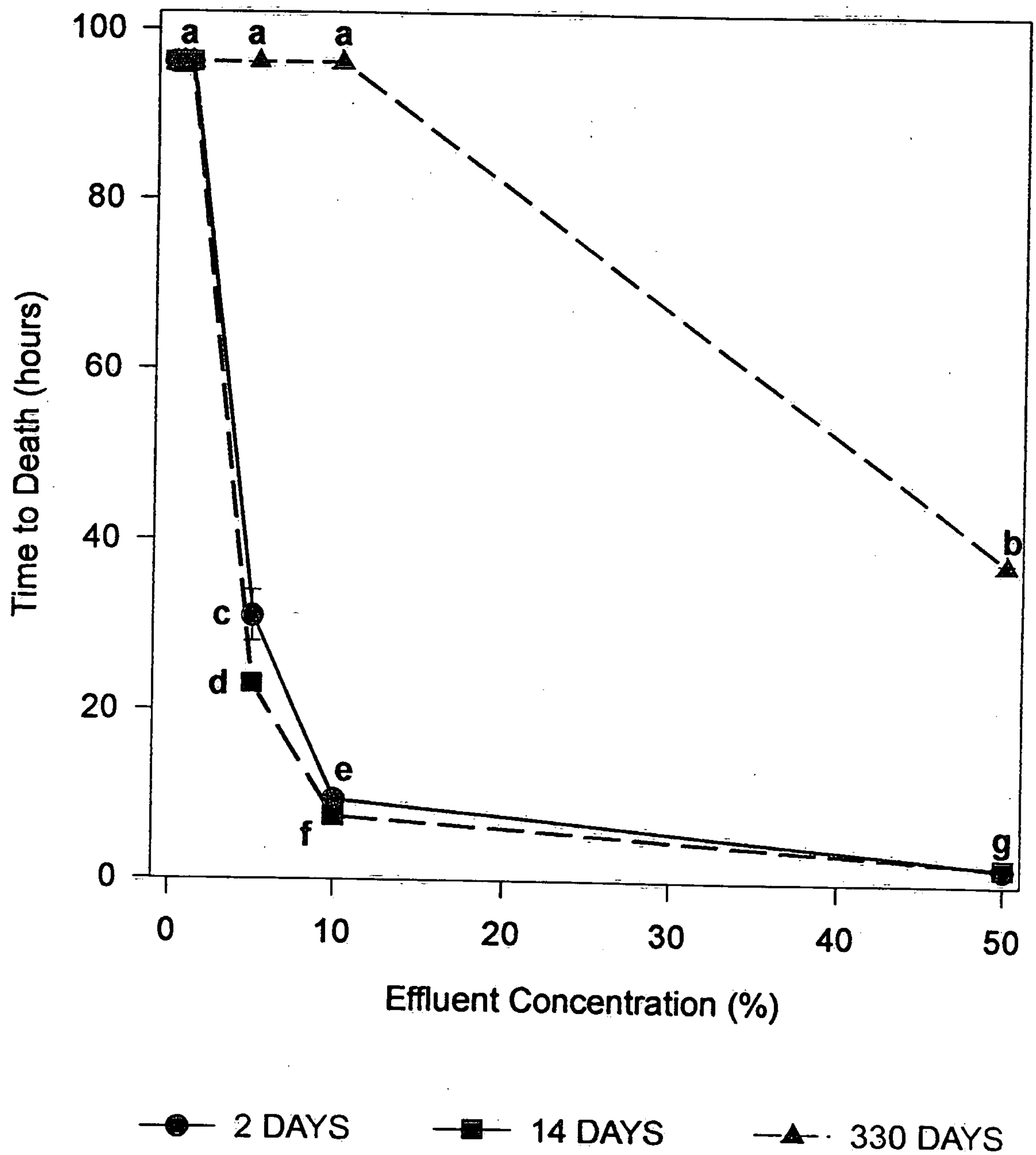


Figure 13: Change in effluent toxicity against juvenile rainbow trout with increasing effluent storage time. Each point represents the arithmetic mean of 2 tanks, with 5 fish per tank. Lines indicate ± S.E.M. A nested ANOVA (fish in tank within concentration) was used to determine significant differences between the different effluent concentrations within the same trial and weight was used as a covariate when comparing the same effluent concentrations of different trials. Points with the same letter are not significantly different ($p < 0.05$). Note: Effluent used in the 330 day trial was not the same sample used in the 2 and 14 day trials.

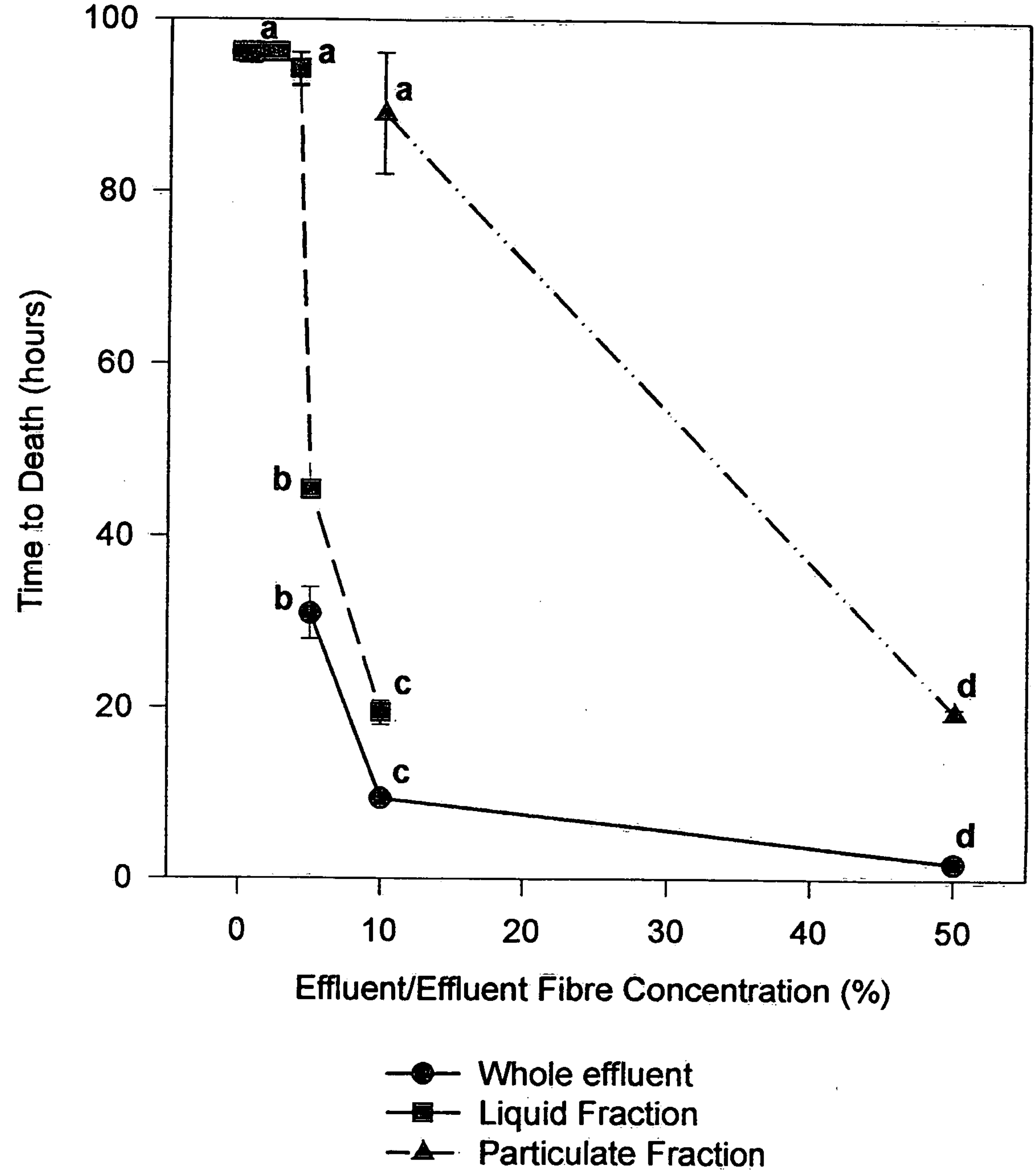
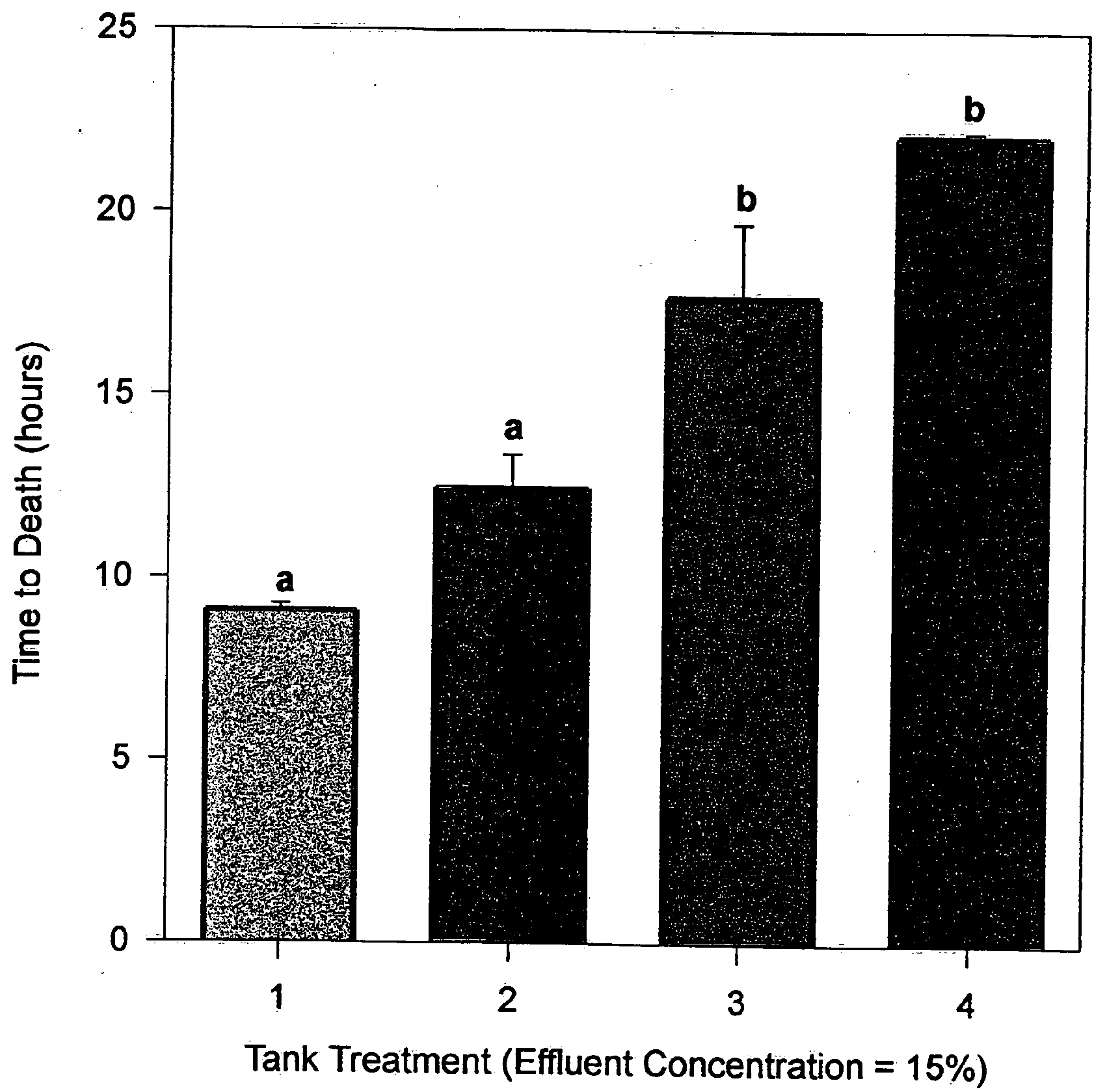


Figure 14: Toxicity of pulp mill effluent fractions to juvenile rainbow trout compared to that of whole pulp mill effluent. Effluent was centrifuged for 30 minutes at 17000 rpm and then decanted at a rate of 45 mL/minute. Each point represents the arithmetic mean of 2 tanks with 5 fish per tank. Lines indicate ± S.E.M.. A nested ANOVA (fish in tank within concentration) was used to determine significant differences ($p < 0.05$) between the different effluent concentrations of the same trial and weight was used as a covariate when comparing the same effluent concentrations of the different trials. Note: the toxicity of the whole effluent was determined in a different trial with a different effluent sample.



Treatment #1 = Effluent not aerated and tank not aerated
Treatment #2 = Effluent aerated and tank not aerated
Treatment #3 = Effluent not aerated and tank aerated
Treatment #4 = Effluent aerated and tank aerated

Figure 15: Effect of effluent and/or tank aeration on effluent toxicity against juvenile rainbow trout. Effluent was vigorously aerated in an open jar for 66 hours prior to the experiment or was not aerated at all; and during the experiment the tanks did or did not receive aeration. Bars represent the arithmetic mean of 2 tanks with 5 fish per tank and the lines above the bars indicate ±S.E.M.. A nested ANOVA (fish in tank within concentration) was used to determine differences between the treatments. Treatments with the same letter are not significantly different ($p < 0.05$).

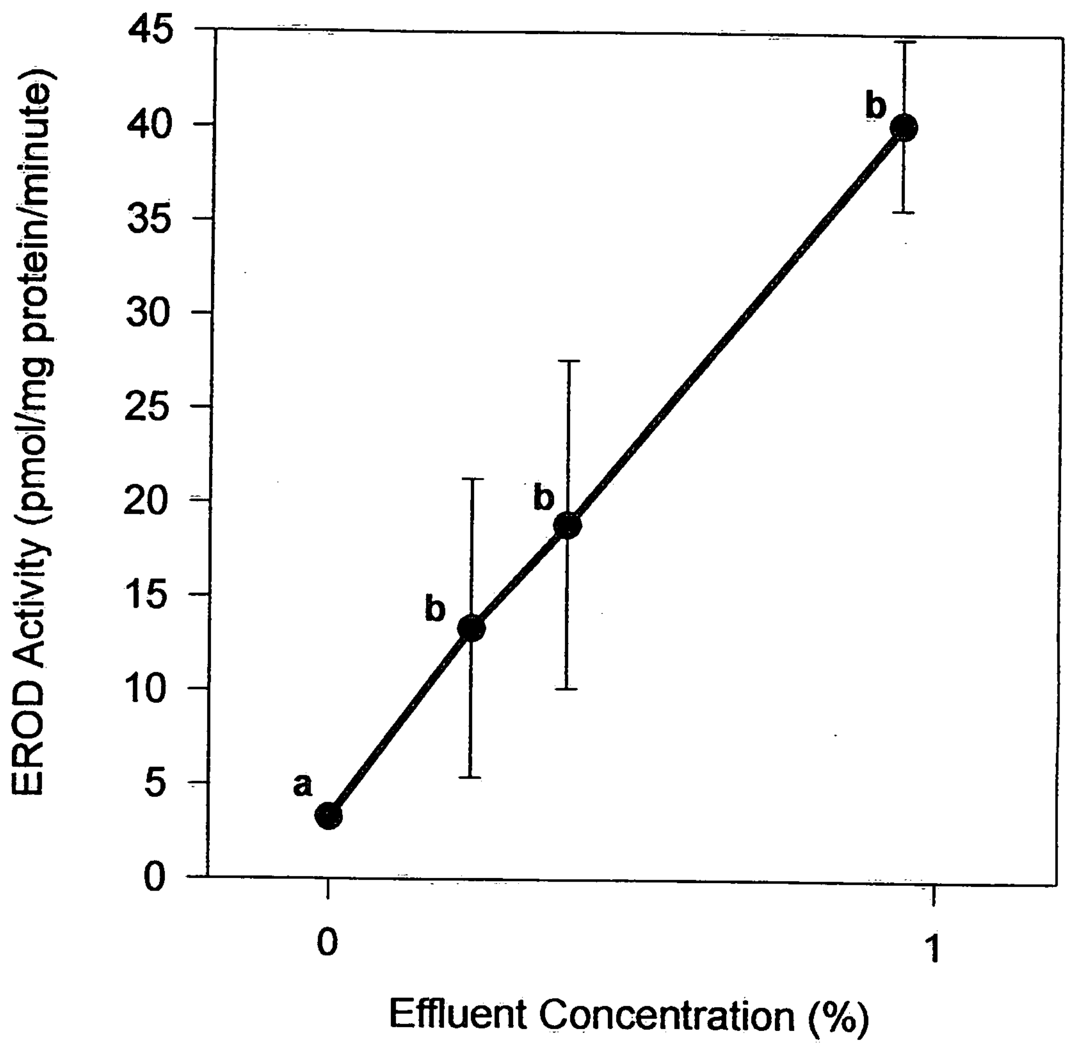


Figure 16: 7-ethoxyresorufin O-deethylase (EROD) enzyme activity in juvenile rainbow trout exposed to concentrations of whole pulp mill effluent under continous flow conditions for 7 days. Each point represents the mean of 2 tanks with 5 fish each and the bars indicate ±S.E.M.. Differences between treatments were determined using a nested ANOVA (fish in tank within concentration). Points with the same letter are not significantly different ($p < 0.05$).

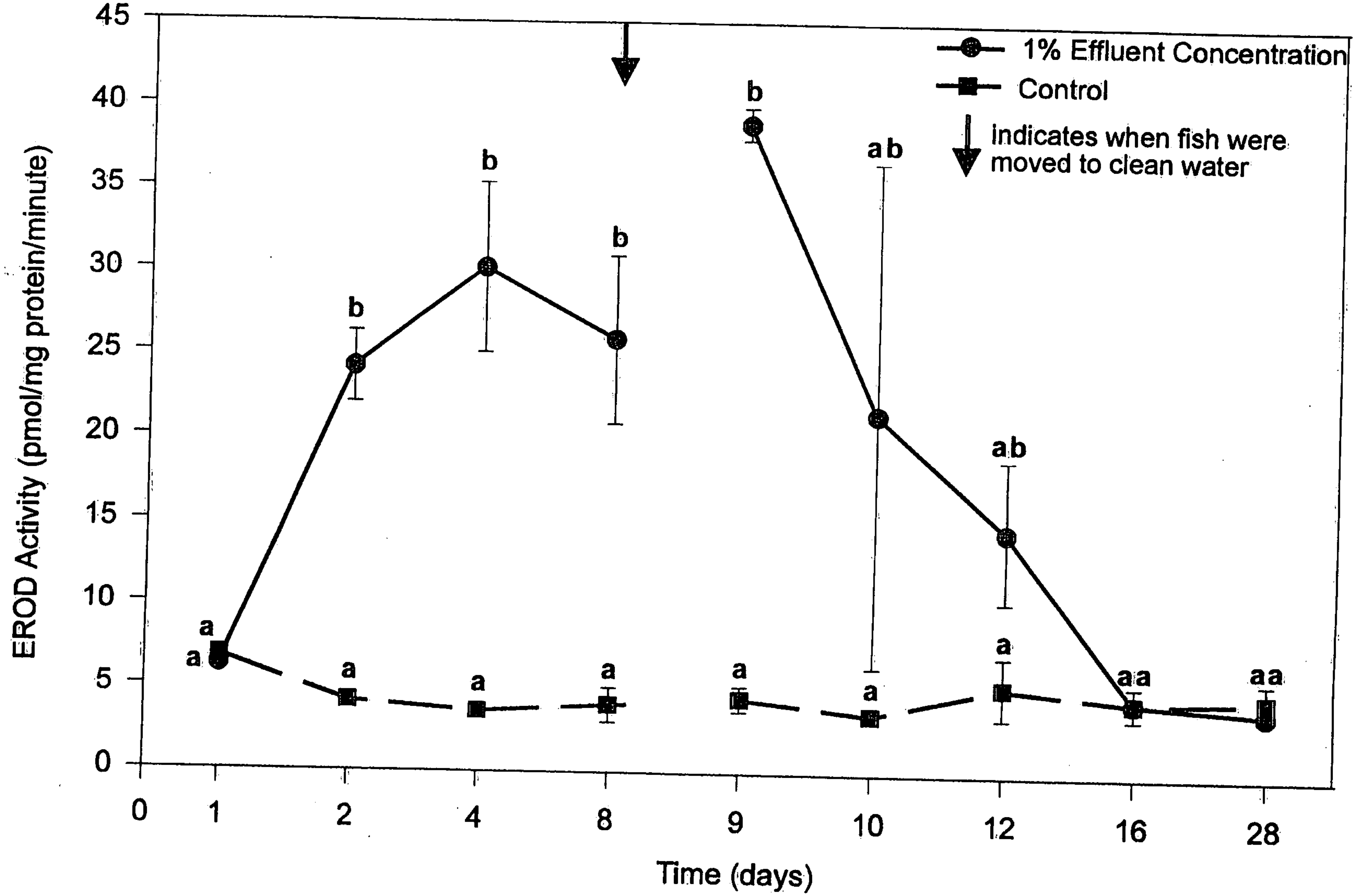


Figure 17: Time dependence of the 7-ethoxyresorufin O-deethylase (EROD) enzyme response of juvenile rainbow trout exposed to a control or 1% effluent concentration. The fish were maintained in tanks under flow-through conditions and were monitored for EROD activity during and following effluent exposure. Each point represents the arithmetic mean of 2 tanks with 5 fish per tank. Lines indicate ± S.E.M.. A nested ANOVA (fish in tank within concentration) was used to determine significant differences between the treatments. Points with the same letter are not significantly different ($p < 0.05$).

APPENDIX

Table A1: Description of maturity index categories for female and male white suckers taken from the Winnipeg River in August, 1993, May, 1994 and August, 1994; including values reported as occurring in the fish at the time of sampling as well as a description of fully mature fish (stage 11 for females and stage 7 for males).

<u>Females</u>

Stage 9: ovarian samples with a distinct vitellogenic clutch of developing oocytes plus a core of pre-vitellogenic resting oocytes

Stage 10: ovarian samples with a distinct vitellogenic clutch of mature oocytes plus a core of pre-vitellogenic resting oocytes.

Stage 11: fish have ovulated, ovarian samples comprised almost entirely of loose clutch oocytes, cannot be used for fecundity estimates as eggs may have been discharged from the body cavity

<u>Males</u>

Stage 3: the tunica is clearly defined; lobule formation is complete; many cysts containing spermatocytes; spermatids and spermatozoa are present; lobules are wider than in stage 2

Stage 4: within sperm cysts spermatocytes are mostly replaced by spermatids and spermatozoa

Stage 5: lobules are tightly packed with spermatozoa; no cysts, spermatocytes or spermatids present

Stage 6: testes are "ripe and running"; there is an absence of sperm from some lobules; lobule walls are thickened

Stage 7: fibrous connective tissue is thickened by contraction; tunica is thick and folded; lobules are distorted and collapsed; relic sperm and cell debris can be found in the lobules

Variable	Time	Sex	Site	N	Min.	Max.	Mean	Variance	Standard Deviation	Standard Error
Livwt. (g)	93AUG	F	D1	15	14.0	28.9	18.97	12.708	3.565	0.920
Livwt. (g)	93AUG	F	D2	7	6.1	16.0	11.97	14.859	3.855	1.457
Livwt. (g)	93AUG	F	U	9	5.0	15.8	10.66	13.248	3.640	1.213
Livwt. (g)	93AUG	M	D1	9	13.0	22.5	17.11	14.531	3.812	1.271
Livwt. (g)	93AUG	M	D2	6	6.6	15.3	10.12	10.614	3.528	1.330
Livwt. (g)	93AUG	M	U	6	3.4	17.8	10.38	28.442	5.333	2.177
Livwt. (g)	94AUG	F	D1	15	9.7	26.5	17.27	23.591	4.857	1.254
Livwt. (g)	94AUG	F	D2	7	6.9	17.9	13.19	16.875	4.108	1.553
Livwt. (g)	94AUG	F	U	15	7.5	22.0	14.37	22.071	4.698	1.213
Livwt. (g)	94AUG	M	D1	7	5.3	18.7	12.60	27.457	5.240	1.981
Livwt. (g)	94AUG	M	D2	5	8.3	10.8	9.62	1.397	1.182	0.529
Livwt. (g)	94AUG	M	U	4	7.2	11.0	9.58	2.909	1.706	0.853
Livwt. (g)	94MAY	F	D1	9	14.1	28.8	20.10	33.990	5.830	1.943
Livwt. (g)	94MAY	F	U	8	9.5	28.2	15.91	44.833	6.696	2.367
Livwt. (g)	94MAY	M	D1	13	10.2	20.3	14.81	9.616	3.101	0.860
Livwt. (g)	94MAY	M	U	3	5.8	18.2	10.00	50.440	7.102	4.100
Gowt. (g)	93AUG	F	D1	15	23.6	55.1	40.90	82.203	9.067	2.341
Gowt. (g)	93AUG	F	D2	7	10.5	76.6	39.54	442.793	21.043	7.953
Gowt. (g)	93AUG	F	U	9	7.4	51.1	35.08	172.269	13.125	4.375
Gowt. (g)	93AUG	M	D1	0	-	-	-	-	-	-
Gowt. (g)	93AUG	M	D2	0	-	-	-	-	-	-
Gowt. (g)	93AUG	M	U	0	-	-	-	-	-	-
Gowt. (g)	94AUG	F	D1	15	20.1	52.9	37.57	115.039	10.726	2.769
Gowt. (g)	94AUG	F	D2	7	6.2	56.7	36.47	262.239	16.194	6.121
Gowt. (g)	94AUG	F	U	15	17.3	75.8	45.28	280.242	16.740	4.322
Gowt. (g)	94AUG	M	D1	6	22.9	56.4	43.95	204.175	14.289	5.833
Gowt. (g)	94AUG	M	D2	5	31.8	64.4	50.38	149.912	12.244	5.476
Gowt. (g)	94AUG	M	U	4	24.3	71.6	56.88	490.296	22.143	11.071
Gowt. (g)	94MAY	F	D1	9	60.5	123.3	88.57	376.855	19.413	6.471
Gowt. (g)	94MAY	F	U	8	15.6	232.0	107.99	5238.827	72.380	25.590
Gowt. (g)	94MAY	M	D1	13	22.4	58.0	38.80	104.580	10.226	2.836
Gowt. (g)	94MAY	M	U	3	19.4	73.6	38.57	923.223	30.385	17.543
GSI	93AUG	F	D1	15	2.65	6.87	4.18	1.393	1.180	0.305
GSI	93AUG	F	D2	7	1.98	6.18	4.03	2.035	1.427	0.539
GSI	93AUG	F	U	9	1.66	6.10	3.11	1.563	1.250	0.417
GSI	93AUG	M	D1	0	-	-	-	-	-	-
GSI	93AUG	M	D2	0	-	-	-	-	-	-
GSI	93AUG	M	U	0	-	-	-	-	-	-
GSI	94AUG	F	D1	15	1.93	3.61	2.98	0.283	0.532	0.137
GSI	94AUG	F	D2	7	0.87	4.03	3.21	1.149	1.072	0.405
GSI	94AUG	F	U	15	2.57	4.87	3.56	0.649	0.806	0.208
GSI	94AUG	M	D1	6	2.23	8.37	5.37	7.421	2.724	1.112
GSI	94AUG	M	D2	5	3.22	6.39	5.42	1.740	1.319	0.590
GSI	94AUG	M	U	4	2.94	7.91	5.91	5.249	2.291	1.145
GSI	94MAY	F	D1	9	7.87	12.35	10.38	2.058	1.435	0.478
GSI	94MAY	F	U	8	1.26	19.69	11.45	25.983	5.097	1.802
GSI	94MAY	M	D1	13	3.39	7.08	5.31	1.127	1.061	0.294
GSI	94MAY	M	U	3	2.31	7.16	4.47	6.097	2.469	1.426
LSI	93AUG	F	D1	15	1.15	2.61	1.89	0.165	0.406	0.105
LSI	93AUG	F	D2	7	1.04	1.93	1.26	0.092	0.303	0.115
LSI	93AUG	F	U	9	0.66	1.13	0.93	0.025	0.158	0.053
LSI	93AUG	M	D1	9	0.88	3.24	1.82	0.443	0.665	0.222
LSI	93AUG	M	D2	6	0.76	1.40	0.97	0.055	0.234	0.096
LSI	93AUG	M	U	6	0.48	1.28	1.04	0.083	0.288	0.117
LSI	94AUG	F	D1	15	1.00	1.78	1.35	0.045	0.213	0.055
LSI	94AUG	F	D2	7	0.97	1.45	1.18	0.042	0.205	0.077
LSI	94AUG	F	U	15	0.88	1.42	1.11	0.022	0.149	0.038
LSI	94AUG	M	D1	7	0.87	1.68	1.25	0.092	0.304	0.115
LSI	94AUG	M	D2	5	0.89	1.06	0.98	0.004	0.062	0.028
LSI	94AUG	M	U	4	0.85	1.12	0.95	0.014	0.118	0.059
LSI	94MAY	F	D1	9	1.34	2.99	2.20	0.334	0.578	0.193
LSI	94MAY	F	U	8	1.10	1.91	1.56	0.093	0.304	0.108
LSI	94MAY	M	D1	13	1.36	2.87	1.98	0.153	0.392	0.109
LSI	94MAY	M	U	3	0.68	1.68	1.12	0.260	0.510	0.294
Test. (nmol/L of plasma)	93AUG	F	D1	15	0.003	0.319	0.072	0.008	0.088	0.023
Test. (nmol/L of plasma)	93AUG	F	D2	7	0.128	0.662	0.360	0.048	0.220	0.083
Test. (nmol/L of plasma)	93AUG	F	U	9	0.049	1.331	0.335	0.156	0.395	0.132
Test. (nmol/L of plasma)	93AUG	M	D1	9	0.021	0.215	0.100	0.005	0.069	0.023

Variable	Time	Sex	Site	N	Min.	Max.	Mean	Variance	Standard Deviation	Standard Error
Test. (nmol/L of plasma)	93AUG	M	D2	6	0.257	1.182	0.667	0.116	0.341	0.139
Test. (nmol/L of plasma)	93AUG	M	U	6	0.003	0.430	0.337	0.028	0.166	0.068
Test. (nmol/L of plasma)	94AUG	F	D1	11	0.003	0.218	0.084	0.005	0.072	0.022
Test. (nmol/L of plasma)	94AUG	F	D2	0	-	-	-	-	-	-
Test. (nmol/L of plasma)	94AUG	F	U	4	0.111	0.551	0.398	0.039	0.197	0.098
Test. (nmol/L of plasma)	94AUG	M	D1	5	0.045	0.454	0.157	0.029	0.170	0.076
Test. (nmol/L of plasma)	94AUG	M	D2	0	-	-	-	-	-	-
Test. (nmol/L of plasma)	94AUG	M	U	3	0.260	0.981	0.506	0.169	0.411	0.238
Test. (nmol/L of plasma)	94MAY	F	D1	8	0.191	1.540	0.787	0.222	0.472	0.167
Test. (nmol/L of plasma)	94MAY	F	U	7	0.156	1.793	0.983	0.438	0.661	0.250
Test. (nmol/L of plasma)	94MAY	M	D1	13	0.170	0.992	0.360	0.051	0.227	0.063
Test. (nmol/L of plasma)	94MAY	M	U	3	0.347	0.641	0.495	0.022	0.147	0.085
Estra. (nmol/L of plasma)	93AUG	F	D1	15	0.040	0.470	0.153	0.011	0.107	0.028
Estra. (nmol/L of plasma)	93AUG	F	D2	7	0.158	0.951	0.418	0.090	0.301	0.114
Estra. (nmol/L of plasma)	93AUG	F	U	9	0.040	0.988	0.282	0.079	0.282	0.094
Estra. (nmol/L of plasma)	94AUG	F	D1	15	0.004	0.400	0.221	0.015	0.121	0.031
Estra. (nmol/L of plasma)	94AUG	F	D2	7	0.059	0.749	0.271	0.053	0.231	0.087
Estra. (nmol/L of plasma)	94AUG	F	U	15	0.018	0.723	0.266	0.033	0.180	0.047
Estra. (nmol/L of plasma)	94MAY	F	D1	8	0.037	1.435	0.335	0.221	0.470	0.166
Estra. (nmol/L of plasma)	94MAY	F	U	6	0.022	1.112	0.423	0.145	0.381	0.155
Absfec. (eggs/fish)	93AUG	F	D1	15	42772	95034	60301	236648000	15383	3972
Absfec. (eggs/fish)	93AUG	F	D2	7	24917	87639	52468	479519000	21898	8277
Absfec. (eggs/fish)	93AUG	F	U	9	18992	73577	55238	303661000	17426	5809
Absfec. (eggs/fish)	94AUG	F	D1	15	35443	80431	52951	201926000	14210	3669
Absfec. (eggs/fish)	94AUG	F	D2	7	28182	66549	41754	155607000	12474	4715
Absfec. (eggs/fish)	94AUG	F	U	15	21257	79455	47800	254308000	15947	4118
Absfec. (eggs/fish)	94MAY	F	D1	9	18114	30856	23639	268929000	5186	1729
Absfec. (eggs/fish)	94MAY	F	U	8	16968	54104	30942	226285000	15043	5686
Relfec. (eggs/g of fish)	93AUG	F	D1	15	32.9	93.1	59.75	353.421	18.800	4.854
Relfec. (eggs/g of fish)	93AUG	F	D2	7	35.2	75.5	53.51	183.491	13.546	5.120
Relfec. (eggs/g of fish)	93AUG	F	U	9	33.6	74.3	48.10	160.855	12.683	5.228
Relfec. (eggs/g of fish)	94AUG	F	D1	15	28.2	91.3	43.30	212.784	14.587	3.766
Relfec. (eggs/g of fish)	94AUG	F	D2	7	35.7	39.6	38.19	1.791	1.338	0.506
Relfec. (eggs/g of fish)	94AUG	F	U	15	27.2	51.1	37.87	40.848	6.391	1.650
Relfec. (eggs/g of fish)	94MAY	F	D1	9	18.9	33.8	27.86	20.970	4.579	1.526
Relfec. (eggs/g of fish)	94MAY	F	U	7	29.1	45.9	33.74	32.896	5.736	2.168
Eggdiam. (mm)	93AUG	F	D1	15	0.844	1.035	0.921	0.003	0.056	0.014
Eggdiam. (mm)	93AUG	F	D2	7	0.813	1.094	0.971	0.011	0.104	0.039
Eggdiam. (mm)	93AUG	F	U	9	0.784	0.932	0.887	0.003	0.052	0.017
Eggdiam. (mm)	94AUG	F	D1	15	0.760	1.004	0.884	0.004	0.066	0.017
Eggdiam. (mm)	94AUG	F	D2	7	0.588	1.045	0.949	0.026	0.161	0.061
Eggdiam. (mm)	94AUG	F	U	15	0.891	1.089	0.990	0.004	0.066	0.017
Eggdiam. (mm)	94MAY	F	D1	9	1.807	2.116	1.931	0.009	0.096	0.032
Eggdiam. (mm)	94MAY	F	U	7	1.671	2.013	1.904	0.015	0.122	0.046
Eggwt. (mg)	93AUG	F	D1	15	0.412	0.757	0.588	0.013	0.113	0.029
Eggwt. (mg)	93AUG	F	D2	7	0.395	0.907	0.667	0.043	0.207	0.078
Eggwt. (mg)	93AUG	F	U	9	0.294	0.688	0.539	0.020	0.143	0.048
Eggwt. (mg)	94AUG	F	D1	15	0.311	0.891	0.637	0.022	0.148	0.038
Eggwt. (mg)	94AUG	F	D2	7	0.142	0.990	0.762	0.083	0.288	0.109
Eggwt. (mg)	94AUG	F	U	15	0.539	1.144	0.865	0.018	0.135	0.035
Eggwt. (mg)	94MAY	F	D1	9	2.685	4.822	3.788	0.361	0.601	0.200
Eggwt. (mg)	94MAY	F	U	7	3.047	4.510	3.812	0.313	0.559	0.211
Maturity Index	93AUG	F	D1	15	9	9	9.00	0.000	0.000	0.000
Maturity Index	93AUG	F	D2	7	9	9	9.00	0.000	0.000	0.000
Maturity Index	93AUG	F	U	9	9	9	9.00	0.000	0.000	0.000
Maturity Index	93AUG	M	D1	0	-	-	-	-	-	-
Maturity Index	93AUG	M	D2	0	-	-	-	-	-	-
Maturity Index	93AUG	M	U	0	-	-	-	-	-	-
Maturity Index	94AUG	F	D1	15	9	9	9.00	0.000	0.000	0.000
Maturity Index	94AUG	F	D2	7	9	9	9.00	0.000	0.000	0.000
Maturity Index	94AUG	F	U	15	9	9	9.00	0.000	0.000	0.000
Maturity Index	94AUG	M	D1	7	3	4	3.67	0.267	0.516	0.211
Maturity Index	94AUG	M	D2	5	4	4	4.00	0.000	0.000	0.000
Maturity Index	94AUG	M	U	4	4	4	4.00	0.000	0.000	0.000
Maturity Index	94MAY	F	D1	9	10	10	10.00	0.000	0.000	0.000
Maturity Index	94MAY	F	U	7	10	10	10.00	0.000	0.000	0.000

Variable	Time	Sex	Site	N	Min.	Max.	Mean	Variance	Standard Deviation	Standard Error
Maturity Index	94MAY	M	D1	13	5	5	5.00	0.000	0.000	0.000
Maturity Index	94MAY	M	U	3	5	5	5.00	0.000	0.000	0.000
Livret. (μg/g wet tissue)	93AUG	F	D1	15	0.020	1.528	0.338	0.195	0.441	0.114
Livret. (μg/g wet tissue)	93AUG	F	D2	6	0.518	2.584	1.064	0.639	0.799	0.326
Livret. (μg/g wet tissue)	93AUG	F	U	7	0.138	7.677	2.600	9.264	3.044	1.150
Livret. (μg/g wet tissue)	93AUG	M	D1	9	0.020	1.750	0.674	0.292	0.540	0.180
Livret. (μg/g wet tissue)	93AUG	M	D2	6	0.752	2.009	1.272	0.301	0.548	0.224
Livret. (μg/g wet tissue)	93AUG	M	U	5	0.384	2.163	1.270	0.557	0.746	0.334
Livret. (μg/g wet tissue)	94AUG	F	D1	15	0.020	1.402	0.502	0.190	0.436	0.113
Livret. (μg/g wet tissue)	94AUG	F	D2	7	0.418	1.228	0.767	0.087	0.295	0.112
Livret. (μg/g wet tissue)	94AUG	F	U	15	0.279	8.022	1.869	4.149	2.037	0.526
Livret. (μg/g wet tissue)	94AUG	M	D1	7	0.306	1.880	0.760	0.386	0.621	0.235
Livret. (μg/g wet tissue)	94AUG	M	D2	5	0.020	0.843	0.446	0.109	0.331	0.148
Livret. (μg/g wet tissue)	94AUG	M	U	4	1.024	3.728	1.926	1.529	1.237	0.618
Livret. (μg/g wet tissue)	94MAY	F	D1	9	0.129	3.359	0.688	1.094	1.046	0.349
Livret. (μg/g wet tissue)	94MAY	F	U	7	0.074	3.336	1.632	1.579	1.257	0.475
Livret. (μg/g wet tissue)	94MAY	M	D1	13	0.146	0.747	0.375	0.033	0.183	0.051
Livret. (μg/g wet tissue)	94MAY	M	U	3	0.497	2.270	1.226	0.860	0.927	0.535
Livretp. (μg/g wet tissue)	93AUG	F	D1	15	0.120	177.530	31.254	2961	54.41	14.05
Livretp. (μg/g wet tissue)	93AUG	F	D2	6	51.300	269.430	127.105	6896	83.04	33.90
Livretp. (μg/g wet tissue)	93AUG	F	U	7	0.300	413.900	178.610	19779	140.64	53.16
Livretp. (μg/g wet tissue)	93AUG	M	D1	9	0.120	119.870	60.574	2379	48.78	16.26
Livretp. (μg/g wet tissue)	93AUG	M	D2	6	98.620	410.630	238.963	16455	128.28	52.37
Livretp. (μg/g wet tissue)	93AUG	M	U	5	54.260	320.470	189.464	11689	108.12	48.35
Livretp. (μg/g wet tissue)	94AUG	F	D1	15	0.120	554.470	107.026	22459	149.86	38.70
Livretp. (μg/g wet tissue)	94AUG	F	D2	7	239.100	744.260	477.083	35314	187.92	71.03
Livretp. (μg/g wet tissue)	94AUG	F	U	15	12.550	1072.320	458.657	85372	292.19	75.44
Livretp. (μg/g wet tissue)	94AUG	M	D1	7	70.340	684.800	315.861	51242	226.37	85.56
Livretp. (μg/g wet tissue)	94AUG	M	D2	5	0.120	438.100	251.910	33497	183.02	81.85
Livretp. (μg/g wet tissue)	94AUG	M	U	4	349.000	522.600	441.030	8189	90.50	45.25
Livretp. (μg/g wet tissue)	94MAY	F	D1	9	17.960	112.350	79.429	746	27.32	9.11
Livretp. (μg/g wet tissue)	94MAY	F	U	7	48.690	212.360	100.493	2817	53.08	20.06
Livretp. (μg/g wet tissue)	94MAY	M	D1	13	40.590	182.300	100.428	1634	40.43	11.21
Livretp. (μg/g wet tissue)	94MAY	M	U	3	53.520	738.050	358.627	121288	348.26	201.07
Livtoc. (μg/g wet tissue)	93AUG	F	D1	15	9.42	623.79	78.32	23281	152.58	39.40
Livtoc. (μg/g wet tissue)	93AUG	F	D2	6	47.49	168.91	88.62	2012	44.85	18.31
Livtoc. (μg/g wet tissue)	93AUG	F	U	7	35.01	467.99	220.53	24997	158.10	59.76
Livtoc. (μg/g wet tissue)	93AUG	M	D1	9	10.80	193.02	52.92	3233	56.86	18.95
Livtoc. (μg/g wet tissue)	93AUG	M	D2	6	62.64	307.93	153.27	7521	86.72	35.40
Livtoc. (μg/g wet tissue)	93AUG	M	U	5	127.14	272.22	203.83	4218	64.94	29.04
Livtoc. (μg/g wet tissue)	94AUG	F	D1	15	9.55	130.58	44.90	1230	35.07	9.06
Livtoc. (μg/g wet tissue)	94AUG	F	D2	7	39.73	78.20	63.05	215	14.65	5.54
Livtoc. (μg/g wet tissue)	94AUG	F	U	15	38.73	227.35	100.10	2346	48.43	12.51
Livtoc. (μg/g wet tissue)	94AUG	M	D1	7	14.23	131.45	46.64	1594	39.92	15.09
Livtoc. (μg/g wet tissue)	94AUG	M	D2	5	26.77	124.69	75.21	1682	41.02	18.34
Livtoc. (μg/g wet tissue)	94AUG	M	U	4	46.69	193.34	101.18	4117	64.16	32.08
Livtoc. (μg/g wet tissue)	94MAY	F	D1	9	14.68	159.50	53.62	1869	43.23	14.41
Livtoc. (μg/g wet tissue)	94MAY	F	U	7	48.72	145.01	88.65	1298	36.03	13.62
Livtoc. (μg/g wet tissue)	94MAY	M	D1	13	53.62	252.30	123.72	3438	58.64	16.26
Livtoc. (μg/g wet tissue)	94MAY	M	U	3	373.83	1057.42	656.95	127151	356.58	205.87
EROD (nmol/mg protein/minute)	93AUG	F	D1	15	0.011	0.375	0.146	0.009	0.095	0.024
EROD (nmol/mg protein/minute)	93AUG	F	D2	7	0.010	0.030	0.022	0.000	0.006	0.002
EROD (nmol/mg protein/minute)	93AUG	F	U	9	0.003	0.048	0.017	0.000	0.013	0.004
EROD (nmol/mg protein/minute)	93AUG	M	D1	9	0.003	0.300	0.153	0.010	0.098	0.033
EROD (nmol/mg protein/minute)	93AUG	M	D2	6	0.017	0.105	0.057	0.001	0.035	0.014
EROD (nmol/mg protein/minute)	93AUG	M	U	6	0.003	0.061	0.034	0.001	0.023	0.010
EROD (nmol/mg protein/minute)	94AUG	F	D1	15	0.010	0.073	0.037	0.000	0.020	0.005
EROD (nmol/mg protein/minute)	94AUG	F	D2	7	0.005	0.052	0.023	0.000	0.017	0.006
EROD (nmol/mg protein/minute)	94AUG	F	U	15	0.003	0.016	0.009	0.000	0.004	0.001
EROD (nmol/mg protein/minute)	94AUG	M	D1	7	0.031	0.216	0.091	0.005	0.068	0.026
EROD (nmol/mg protein/minute)	94AUG	M	D2	5	0.002	0.079	0.041	0.001	0.034	0.015
EROD (nmol/mg protein/minute)	94AUG	M	U	4	0.011	0.040	0.027	0.000	0.016	0.008
EROD (nmol/mg protein/minute)	94MAY	F	D1	9	0.006	0.026	0.018	0.000	0.006	0.002
EROD (nmol/mg protein/minute)	94MAY	F	U	8	0.008	0.041	0.022	0.000	0.011	0.004
EROD (nmol/mg protein/minute)	94MAY	M	D1	13	0.042	0.173	0.084	0.001	0.031	0.009
EROD (nmol/mg protein/minute)	94MAY	M	U	3	0.061	0.094	0.073	0.000	0.019	0.011

Variable	Time	Sex	Site	N	Min.	Max.	Mean	Variance	Standard Deviation	Standard Error
AHH (nmol/mg protein/minute)	93AUG	F	D1	15	0.052	0.450	0.249	0.011	0.105	0.027
AHH (nmol/mg protein/minute)	93AUG	F	D2	7	0.032	0.151	0.077	0.001	0.036	0.014
AHH (nmol/mg protein/minute)	93AUG	F	U	9	0.017	0.100	0.056	0.001	0.026	0.009
AHH (nmol/mg protein/minute)	93AUG	M	D1	9	0.036	0.438	0.265	0.018	0.134	0.045
AHH (nmol/mg protein/minute)	93AUG	M	D2	6	0.065	0.217	0.120	0.003	0.059	0.024
AHH (nmol/mg protein/minute)	93AUG	M	U	6	0.018	0.142	0.093	0.003	0.051	0.023
AHH (nmol/mg protein/minute)	94AUG	F	D1	15	0.035	0.234	0.112	0.004	0.061	0.016
AHH (nmol/mg protein/minute)	94AUG	F	D2	7	0.017	0.163	0.071	0.002	0.047	0.018
AHH (nmol/mg protein/minute)	94AUG	F	U	15	0.020	0.064	0.041	0.000	0.016	0.004
AHH (nmol/mg protein/minute)	94AUG	M	D1	7	0.114	0.403	0.191	0.011	0.106	0.040
AHH (nmol/mg protein/minute)	94AUG	M	D2	5	0.018	0.200	0.111	0.005	0.072	0.032
AHH (nmol/mg protein/minute)	94AUG	M	U	4	0.059	0.103	0.085	0.000	0.022	0.011
AHH (nmol/mg protein/minute)	94MAY	F	D1	8	0.010	0.058	0.036	0.000	0.017	0.006
AHH (nmol/mg protein/minute)	94MAY	F	U	8	0.017	0.128	0.060	0.001	0.035	0.012
AHH (nmol/mg protein/minute)	94MAY	M	D1	12	0.071	0.235	0.132	0.002	0.043	0.012
AHH (nmol/mg protein/minute)	94MAY	M	U	3	0.107	0.169	0.137	0.001	0.031	0.018

Table A3: Raw data for white suckers collected from the Winnipeg River in 1993 and 1994. The data set includes year, number, month, time sex, season, site, set, length, weight (Wt.), condition factor (CFAC), liver weight (Livwt.), gonad weight (Gowt.), gonadosomatic index (GSI), liver-somatic index (LSI), age, estradiol (Estra.), testosterone (Test.), liver retinol (Livret.), liver retinyl palmitate (Livretp.), liver tocopherol (Livtoc.), egg diameter (Eggdiam.), egg weight (Eggwt.), absolute fecundity (Absfec.), relative fecundity (Relfec.), maturity index (MI), 7-ethoxyresorufin O-deethylase enzyme activity (EROD) and aryl hydrocarbon hydroxylase enzyme activity (AHH). Units for all variables may be found in Table A2.

Year	Number	Month	Time	Sex	Season	Site	Set	Length	Wt.	CFAC	Livwt.	Gowt.	GSI	LSI	AGE	Estra.	Test.	Livret.	Livretp.	Livtoc.
93	9300019	AUG	93AUG	F	SUM	D1	HR	48.7	1530.5	1.33	28.9	50.6	3.42	1.92	12	0.136	0.042	1.085	139.72	623.79
93	9300022	AUG	93AUG	F	SUM	D1	HR	44.8	1076.0	1.20	17.0	46.9	4.56	1.61	8	0.198	0.031	1.528	177.53	103.97
93	9300024	AUG	93AUG	F	SUM	D1	HR	49.2	1104.0	0.93	19.7	46.1	4.36	1.82	17	0.283	0.066	0.568	9.36	37.52
93	9300027	AUG	93AUG	F	SUM	D1	HR	43.6	1284.0	1.55	18.3	33.2	2.65	1.44	6	0.187	0.017	0.020	0.12	35.67
93	9300028	AUG	93AUG	F	SUM	D1	HR	45.3	1003.5	1.08	17.3	48.2	5.04	1.75	7	0.040	0.232	0.174	29.02	52.68
93	9300029	AUG	93AUG	F	SUM	D1	HR	46.2	1133.0	1.15	19.7	37.9	3.46	1.77	9	0.147	0.052	0.020	0.12	9.42
93	9300030	AUG	93AUG	F	SUM	D1	HR	49.0	1432.0	1.22	16.3	46.6	3.37	1.15	12	0.084	0.069	0.117	1.88	16.91
93	9300032	AUG	93AUG	F	SUM	D1	HR	41.8	685.5	0.94	14.0	23.6	3.57	2.09	5	0.070	0.042	0.068	2.25	49.99
93	9300033	AUG	93AUG	F	SUM	D1	HR	48.4	1021.0	0.90	23.3	55.1	5.71	2.33	8	0.147	0.017	0.020	0.30	24.62
93	9300034	AUG	93AUG	F	SUM	D1	HR	46.2	1217.0	1.23	21.8	38.5	3.27	1.83	8	0.088	0.007	0.489	18.29	35.87
93	9300035	AUG	93AUG	F	SUM	D1	HR	46.1	737.0	0.75	16.8	47.4	6.87	2.33	7	0.470	0.319	0.196	8.33	42.21
93	9300036	AUG	93AUG	F	SUM	D1	HR	45.6	895.0	0.94	16.8	26.0	2.99	1.91	6	0.121	0.052	0.083	3.02	23.31
93	9300038	AUG	93AUG	F	SUM	D1	HR	46.7	804.0	0.79	19.0	35.9	4.67	2.42	7	0.154	0.094	0.477	57.58	29.85
93	9300039	AUG	93AUG	F	SUM	D1	HR	43.5	678.5	0.82	17.3	34.6	5.38	2.61	8	0.084	0.035	0.207	19.88	62.20
93	9300041	AUG	93AUG	F	SUM	D1	HR	44.0	1308.0	1.54	18.4	42.9	3.39	1.43	9	0.081	0.003	0.022	1.41	26.77
93	9300020	AUG	93AUG	M	SUM	D1	HR	45.7	1252.5	1.31	22.0	-	-	1.79	13	-	0.163	0.466	61.33	193.02
93	9300021	AUG	93AUG	M	SUM	D1	HR	46.0	1719.0	1.77	15.0	-	-	0.88	10	-	0.166	0.786	37.97	34.87
93	9300023	AUG	93AUG	M	SUM	D1	HR	47.8	964.0	0.88	21.1	-	-	2.24	11	-	0.215	1.257	119.87	39.13
93	9300025	AUG	93AUG	M	SUM	D1	HR	45.7	754.0	0.79	13.6	-	-	1.84	11	-	0.045	1.750	96.15	78.24
93	9300026	AUG	93AUG	M	SUM	D1	HR	40.0	763.0	1.19	13.0	-	-	1.74	4	-	0.021	0.477	12.18	10.80
93	9300037	AUG	93AUG	M	SUM	D1	HR	45.9	878.0	0.91	16.3	-	-	1.89	10	-	0.097	0.613	110.49	31.24
93	9300040	AUG	93AUG	M	SUM	D1	HR	43.4	428.0	0.52	13.5	-	-	3.24	11	-	0.021	0.020	0.12	16.63
93	9300042	AUG	93AUG	M	SUM	D1	HR	44.3	1455.5	1.67	17.0	-	-	1.18	10	-	0.094	0.577	104.26	58.07
93	9300043	AUG	93AUG	M	SUM	D1	HR	47.2	1419.5	1.35	22.5	-	-	1.61	11	-	0.076	0.124	2.76	14.31
93	9300045	AUG	93AUG	F	SUM	D2	HR	47.2	1485.0	1.41	15.3	47.2	3.28	1.04	6	0.720	0.662	1.306	53.21	50.98
93	9300046	AUG	93AUG	F	SUM	D2	HR	33.3	540.5	1.46	6.1	10.5	1.98	1.14	3	0.158	0.163	0.578	51.30	72.35
93	9300047	AUG	93AUG	F	SUM	D2	HR	35.7	663.5	1.46	7.7	22.5	3.52	1.18	3	0.951	0.378	-	-	-
93	9300052	AUG	93AUG	F	SUM	D2	HR	47.5	1317.0	1.23	16.0	76.6	6.18	1.23	5	0.231	0.139	0.591	162.31	47.49
93	9300053	AUG	93AUG	F	SUM	D2	HR	40.1	943.0	1.46	11.0	33.0	3.63	1.18	4	0.224	0.128	0.518	86.85	104.03
93	9300054	AUG	93AUG	F	SUM	D2	HR	41.7	767.0	1.06	14.6	40.6	5.58	1.93	4	0.257	0.555	0.806	139.53	168.91
93	9300059	AUG	93AUG	F	SUM	D2	HR	43.0	1201.5	1.51	13.1	46.4	4.02	1.10	4	0.382	0.496	2.584	269.43	87.95
93	9300044	AUG	93AUG	M	SUM	D2	HR	40.1	879.0	1.36	6.6	-	-	0.76	4	-	1.182	0.752	164.41	187.37
93	9300051	AUG	93AUG	M	SUM	D2	HR	39.4	1162.0	1.90	11.3	-	-	0.98	5	-	0.492	0.899	410.63	307.93
93	9300055	AUG	93AUG	M	SUM	D2	HR	38.1	925.0	1.67	7.3	-	-	0.79	4	-	0.503	1.024	98.62	93.91
93	9300056	AUG	93AUG	M	SUM	D2	HR	46.9	1510.0	1.46	15.3	-	-	1.02	9	-	0.257	1.926	254.36	137.80
93	9300057	AUG	93AUG	M	SUM	D2	HR	44.5	991.0	1.12	8.6	-	-	0.87	-	-	0.607	2.009	368.91	129.94
93	9300058	AUG	93AUG	M	SUM	D2	HR	42.5	846.0	1.10	11.6	-	-	1.40	6	-	0.960	1.023	136.85	62.64
93	9300003	AUG	93AUG	F	SUM	U	HR	45.3	1468.0	1.58	12.8	38.3	2.68	0.88	6	0.195	0.423	0.726	210.76	156.64
93	9300004	AUG	93AUG	F	SUM	U	HR	44.6	1258.0	1.42	8.3	41.8	3.44	0.66	6	0.158	0.302	0.682	167.00	349.55
93	9300006	AUG	93AUG	F	SUM	U	HR	39.6	851.5	1.37	7.0	48.9	6.10	0.83	6	0.239	0.156	-	-	-
93	9300008	AUG	93AUG	F	SUM	U	HR	31.6	449.0	1.42	5.0	7.4	1.66	1.13	3	0.040	0.107	-	-	-
93	9300010	AUG	93AUG	F	SUM	U	HR	46.5	1582.5	1.57	15.8	51.1	3.34	1.01	7	0.213	0.114	1.237	21.73	35.01

Year	Number	Month	Time	Sex	Eggdiam.	Eggwt.	Absfec.	Relfec.	MI	EROD	BAP
93	9300019	AUG	93AUG	F	0.852	0.520	77073	50.4	9	0.074	0.188
93	9300022	AUG	93AUG	F	0.964	0.635	60193	55.9	9	0.111	0.168
93	9300024	AUG	93AUG	F	0.919	0.703	56357	51.0	9	0.025	0.100
93	9300027	AUG	93AUG	F	0.930	0.576	50922	39.7	9	0.126	0.279
93	9300028	AUG	93AUG	F	0.879	0.490	80805	80.5	9	0.215	0.301
93	9300029	AUG	93AUG	F	0.948	0.695	48839	43.1	9	0.099	0.193
93	9300030	AUG	93AUG	F	0.884	0.511	71394	49.9	9	0.011	0.052
93	9300032	AUG	93AUG	F	0.844	0.471	42772	62.4	9	0.207	0.377
93	9300033	AUG	93AUG	F	0.894	0.536	95034	93.1	9	0.205	0.298
93	9300034	AUG	93AUG	F	0.931	0.695	45628	37.5	9	0.375	0.450
93	9300035	AUG	93AUG	F	1.025	0.749	59126	80.2	9	0.269	0.369
93	9300036	AUG	93AUG	F	0.876	0.412	55991	62.6	9	0.098	0.232
93	9300038	AUG	93AUG	F	0.904	0.451	68697	85.4	9	0.128	0.235
93	9300039	AUG	93AUG	F	0.923	0.614	48638	71.7	9	0.133	0.221
93	9300041	AUG	93AUG	F	1.035	0.757	43039	32.9	9	0.115	0.266
93	9300020	AUG	93AUG	M	-	-	-	-	-	0.083	0.229
93	9300021	AUG	93AUG	M	-	-	-	-	-	0.171	0.347
93	9300023	AUG	93AUG	M	-	-	-	-	-	0.107	0.210
93	9300025	AUG	93AUG	M	-	-	-	-	-	0.054	0.119
93	9300026	AUG	93AUG	M	-	-	-	-	-	0.215	0.259
93	9300037	AUG	93AUG	M	-	-	-	-	-	0.194	0.322
93	9300040	AUG	93AUG	M	-	-	-	-	-	0.003	0.036
93	9300042	AUG	93AUG	M	-	-	-	-	-	0.253	0.425
93	9300043	AUG	93AUG	M	-	-	-	-	-	0.300	0.438
93	9300045	AUG	93AUG	F	0.924	0.489	87639	59.0	9	0.022	0.079
93	9300046	AUG	93AUG	F	0.813	0.395	24917	46.1	9	0.030	0.151
93	9300047	AUG	93AUG	F	0.925	0.509	41282	62.2	9	0.025	0.073
93	9300052	AUG	93AUG	F	1.054	0.873	71256	54.1	9	0.010	0.032
93	9300053	AUG	93AUG	F	1.071	0.907	33209	35.2	9	0.022	0.061
93	9300054	AUG	93AUG	F	0.915	0.666	57943	75.5	-	0.020	0.064
93	9300059	AUG	93AUG	F	1.094	0.828	51033	42.5	9	0.022	0.076
93	9300044	AUG	93AUG	M	-	-	-	-	-	0.090	0.085
93	9300051	AUG	93AUG	M	-	-	-	-	-	0.060	0.166
93	9300055	AUG	93AUG	M	-	-	-	-	-	0.105	0.217
93	9300056	AUG	93AUG	M	-	-	-	-	-	0.017	0.065
93	9300057	AUG	93AUG	M	-	-	-	-	-	0.035	0.084
93	9300058	AUG	93AUG	M	-	-	-	-	-	0.034	0.100
93	9300003	AUG	93AUG	F	0.842	0.415	73577	50.1	9	0.018	0.080
93	9300004	AUG	93AUG	F	0.925	0.594	61424	48.8	9	0.003	0.017
93	9300006	AUG	93AUG	F	0.917	0.688	63286	74.3	9	0.023	0.073
93	9300008	AUG	93AUG	F	0.784	0.294	18992	42.3	9	0.007	0.037
93	9300010	AUG	93AUG	F	0.924	0.673	66536	42.0	9	0.014	0.066

Year	Number	Month	Time	Sex	Season	Site	Set	Length	Wt.	CFAC	Livwt.	Gowt.	GSI	LSI	AGE	Estra.	Test.	Livret.	Livretp.	Livtoc.
93	9300012	AUG	93AUG	F	SUM	U	HR	42.3	1156.0	1.53	8.6	29.1	2.58	0.75	6	0.228	0.163	7.677	254.26	467.99
93	9300013	AUG	93AUG	F	SUM	U	HR	43.4	1195.5	1.46	11.8	26.7	2.28	0.99	7	0.385	0.368	1.475	182.32	127.02
93	9300014	AUG	93AUG	F	SUM	U	HR	46.6	1373.5	1.36	14.8	36.6	2.73	1.09	14	0.095	0.049	0.138	0.30	93.55
93	9300015	AUG	93AUG	F	SUM	U	HR	43.3	1171.5	1.44	11.8	35.8	3.15	1.01	7	0.988	1.331	6.265	413.90	313.97
93	9300001	AUG	93AUG	M	SUM	U	HR	37.0	727.5	1.44	3.4	-	-	0.48	6	-	0.430	-	-	-
93	9300005	AUG	93AUG	M	SUM	U	HR	41.7	1133.5	1.56	12.1	-	-	1.08	9	-	0.416	1.866	270.91	272.22
93	9300007	AUG	93AUG	M	SUM	U	HR	32.0	451.0	1.38	5.0	-	-	1.13	4	-	0.409	0.384	54.26	267.51
93	9300009	AUG	93AUG	M	SUM	U	HR	41.1	1007.5	1.45	12.8	-	-	1.28	6	-	0.003	0.735	121.71	157.13
93	9300011	AUG	93AUG	M	SUM	U	HR	41.8	1103.0	1.51	11.2	-	-	1.02	8	-	0.347	1.201	320.47	195.13
93	9300016	AUG	93AUG	M	SUM	U	HR	45.8	1477.5	1.54	17.8	-	-	1.22	12	-	0.416	2.163	179.97	127.14
94	9400011	APR	94MAY	F	SPRING	D1	HR	42.5	1122.0	1.46	14.8	123.3	12.35	1.34	5	0.459	1.540	1.111	106.76	28.25
94	9400009	FEB	94MAY	F	SPRING	D1	HR	34.0	765.0	1.95	14.1	70.1	10.09	1.88	4	-	-	0.232	81.12	48.48
94	9400018	MAY	94MAY	F	SPRING	D1	HR	38.1	833.0	1.51	19.7	87.7	11.77	2.42	4	0.037	0.270	0.129	17.96	14.68
94	9400020	MAY	94MAY	F	SPRING	D1	HR	38.7	984.0	1.70	28.6	100.2	11.34	2.99	4	0.341	0.978	0.168	64.91	23.95
94	9400021	MAY	94MAY	F	SPRING	D1	HR	41.1	1052.0	1.52	15.3	88.0	9.13	1.47	7	1.435	0.943	0.467	76.18	159.50
94	9400022	MAY	94MAY	F	SPRING	D1	HR	40.1	1019.0	1.58	28.8	90.0	9.69	2.91	5	0.070	1.026	0.276	89.64	68.63
94	9400024	MAY	94MAY	F	SPRING	D1	HR	37.1	829.0	1.62	17.3	60.5	7.87	2.13	4	0.073	0.340	0.224	84.85	55.33
94	9400028	MAY	94MAY	F	SPRING	D1	HR	41.5	1176.0	1.65	24.8	105.1	9.81	2.15	5	0.055	1.009	0.226	112.35	32.74
94	9400029	MAY	94MAY	F	SPRING	D1	HR	34.8	707.0	1.68	17.5	72.2	11.37	2.54	4	0.206	0.191	3.359	81.09	51.03
94	9400010	APR	94MAY	M	SPRING	D1	HR	35.9	692.0	1.50	12.5	34.3	5.22	1.84	4	-	0.236	0.459	100.92	81.28
94	9400012	APR	94MAY	M	SPRING	D1	HR	37.1	820.0	1.61	17.2	37.9	4.85	2.14	4	-	0.267	0.414	139.39	154.35
94	9400008	FEB	94MAY	M	SPRING	D1	HR	36.5	684.0	1.41	13.5	22.4	3.39	2.01	4	-	0.264	0.146	81.83	181.87
94	9400013	MAY	94MAY	M	SPRING	D1	HR	33.9	611.0	1.57	10.2	40.4	7.08	1.70	4	-	0.205	0.206	72.86	105.65
94	9400014	MAY	94MAY	M	SPRING	D1	HR	35.2	637.0	1.46	17.8	31.7	5.24	2.87	4	-	0.257	0.246	54.64	53.26
94	9400015	MAY	94MAY	M	SPRING	D1	HR	35.0	700.0	1.63	15.1	34.0	5.11	2.20	4	-	0.361	0.462	143.06	115.11
94	9400016	MAY	94MAY	M	SPRING	D1	HR	38.5	912.0	1.60	13.2	58.0	6.79	1.47	5	-	0.669	0.452	125.29	199.48
94	9400017	MAY	94MAY	M	SPRING	D1	HR	35.7	738.0	1.62	14.3	35.2	5.01	1.98	4	-	0.402	0.747	113.25	119.77
94	9400019	MAY	94MAY	M	SPRING	D1	HR	34.9	671.0	1.58	13.1	26.1	4.05	1.99	4	-	0.309	0.187	56.77	57.16
94	9400023	MAY	94MAY	M	SPRING	D1	HR	39.6	1016.0	1.64	13.6	41.5	4.26	1.36	9	-	0.277	0.656	182.30	252.30
94	9400025	MAY	94MAY	M	SPRING	D1	HR	35.8	703.0	1.53	11.8	39.3	5.92	1.71	4	-	0.992	0.368	90.88	96.54
94	9400026	MAY	94MAY	M	SPRING	D1	HR	38.0	905.0	1.65	20.3	52.3	6.13	2.29	5	-	0.170	0.217	40.59	115.27
94	9400027	MAY	94MAY	M	SPRING	D1	HR	38.2	912.0	1.64	19.9	51.3	5.96	2.23	5	-	0.277	0.313	103.79	76.36
94	9400034	MAY	94MAY	F	SPRING	U	HR	49.7	1846.0	1.50	28.2	187.6	11.31	1.55	-	0.474	0.270	1.883	94.77	145.01
94	9400035	MAY	94MAY	F	SPRING	U	HR	33.8	529.0	1.37	9.5	51.7	10.83	1.83	4	0.022	0.510	1.161	109.74	48.72
94	9400036	MAY	94MAY	F	SPRING	U	HR	44.2	1410.0	1.63	24.0	232.0	19.69	1.73	7	1.112	1.200	3.258	71.25	88.23
94	9400037	MAY	94MAY	F	SPRING	U	HR	38.8	846.0	1.45	10.2	85.7	11.27	1.22	5	-	0.156	0.803	91.74	72.42
94	9400039	MAY	94MAY	F	SPRING	U	HR	44.5	1266.0	1.44	13.6	15.6	1.26	1.10	7	-	-	-	-	-
94	9400040	MAY	94MAY	F	SPRING	U	HR	39.8	1075.0	1.71	14.2	133.8	14.22	1.34	5	0.426	1.578	0.074	48.69	53.14
94	9400041	MAY	94MAY	F	SPRING	U	HR	37.2	685.0	1.33	12.0	65.0	10.48	1.78	5	0.136	1.793	0.906	212.36	85.81
94	9400042	MAY	94MAY	F	SPRING	U	HR	36.0	832.0	1.78	15.6	92.5	12.51	1.91	5	0.367	1.373	3.336	74.90	127.21
94	9400032	MAY	94MAY	M	SPRING	U	HR	39.5	858.0	1.39	5.8	19.4	2.31	0.68	7	-	0.496	2.270	738.05	1057.42
94	9400033	MAY	94MAY	M	SPRING	U	HR	40.8	1101.0	1.62	18.2	73.6	7.16	1.68	7	-	0.641	0.912	284.31	373.83
94	9400038	MAY	94MAY	M	SPRING	U	HR	33.7	601.0	1.57	6.0	22.7	3.93	1.01	4	-	0.347	0.497	53.52	539.61
94	9400062	AUG	94AUG	F	SUM	D1	HR	44.0	1368.0	1.61	16.2	39.1	2.94	1.20	5	0.275	0.218	0.251	28.47	36.91
94	9400063	AUG	94AUG	F	SUM	D1	HR	48.6	1690.0	1.47	22.1	51.0	3.11	1.33	7	0.191	0.049	0.565	61.07	19.52
94	9400064	AUG	94AUG	F	SUM	D1	HR	45.9	1336.0	1.38	16.6	44.5	3.45	1.26	6	0.338	0.173	0.904	252.39	92.09
94	9400066	AUG	94AUG	F	SUM	D1	HR	41.9	1139.0	1.55	18.3	37.7	3.42	1.63	6	0.360	0.073	0.084	3.16	9.55
94	9400067	AUG	94AUG	F	SUM	D1	HR	48.6	1526.0	1.33	21.6	52.9	3.59	1.44	8	0.360	0.052	0.234	32.22	50.81

Year	Number	Month	Time	Sex	Eggdiam.	Eggwt.	Absfec.	Relfec.	MI	EROD	BAP
93	9300012	AUG	93AUG	F	0.839	0.371	71324	61.7	9	0.012	0.057
93	9300013	AUG	93AUG	F	0.918	0.587	40166	33.6	9	0.048	0.100
93	9300014	AUG	93AUG	F	0.904	0.572	54471	39.7	9	0.013	0.034
93	9300015	AUG	93AUG	F	0.932	0.654	47364	40.4	9	0.016	0.042
93	9300001	AUG	93AUG	M	-	-	-	-	-	0.001	0.001
93	9300005	AUG	93AUG	M	-	-	-	-	-	0.030	0.084
93	9300007	AUG	93AUG	M	-	-	-	-	-	0.052	0.140
93	9300009	AUG	93AUG	M	-	-	-	-	-	0.003	0.018
93	9300011	AUG	93AUG	M	-	-	-	-	-	0.061	0.142
93	9300016	AUG	93AUG	M	-	-	-	-	-	0.025	0.080
94	9400011	APR	94MAY	F	1.942	3.996	30856	30.9	10	0.025	0.010
94	9400009	FEB	94MAY	F	1.885	3.870	18114	26.1	10	0.022	0.058
94	9400018	MAY	94MAY	F	2.009	4.078	21506	28.9	10	0.021	0.046
94	9400020	MAY	94MAY	F	1.900	3.355	29866	33.8	10	0.011	0.021
94	9400021	MAY	94MAY	F	2.116	4.822	18250	18.9	10	0.006	0.021
94	9400022	MAY	94MAY	F	1.999	4.188	21490	23.1	10	0.026	0.047
94	9400024	MAY	94MAY	F	1.807	2.685	22533	29.3	10	0.016	0.041
94	9400028	MAY	94MAY	F	1.844	3.494	30080	28.1	10	0.018	0.047
94	9400029	MAY	94MAY	F	1.880	3.600	20056	31.6	10	0.018	-
94	9400010	APR	94MAY	M	-	-	-	-	5	0.078	0.122
94	9400012	APR	94MAY	M	-	-	-	-	5	0.066	0.123
94	9400008	FEB	94MAY	M	-	-	-	-	5	0.092	0.175
94	9400013	MAY	94MAY	M	-	-	-	-	5	0.081	0.146
94	9400014	MAY	94MAY	M	-	-	-	-	5	0.073	0.115
94	9400015	MAY	94MAY	M	-	-	-	-	5	0.102	0.071
94	9400016	MAY	94MAY	M	-	-	-	-	5	0.069	0.143
94	9400017	MAY	94MAY	M	-	-	-	-	5	0.173	0.235
94	9400019	MAY	94MAY	M	-	-	-	-	5	0.078	0.117
94	9400023	MAY	94MAY	M	-	-	-	-	5	0.042	0.078
94	9400025	MAY	94MAY	M	-	-	-	-	5	0.103	-
94	9400026	MAY	94MAY	M	-	-	-	-	5	0.076	0.145
94	9400027	MAY	94MAY	M	-	-	-	-	5	0.064	0.114
94	9400034	MAY	94MAY	F	1.922	3.748	50053	30.2	10	0.008	0.017
94	9400035	MAY	94MAY	F	1.671	3.047	16968	35.5	10	0.023	0.071
94	9400036	MAY	94MAY	F	2.013	4.288	54104	45.9	10	0.012	0.030
94	9400037	MAY	94MAY	F	1.909	3.440	24913	32.8	10	0.013	0.043
94	9400039	MAY	94MAY	F	-	-	-	-	-	0.026	0.058
94	9400040	MAY	94MAY	F	2.000	4.610	29667	31.5	10	0.041	0.128
94	9400041	MAY	94MAY	F	1.824	3.360	19345	31.2	10	0.032	0.084
94	9400042	MAY	94MAY	F	1.992	4.293	21547	29.1	10	0.024	0.046
94	9400032	MAY	94MAY	M	-	-	-	-	5	0.063	0.107
94	9400033	MAY	94MAY	M	-	-	-	-	5	0.094	0.169
94	9400038	MAY	94MAY	M	-	-	-	-	5	0.061	0.134
94	9400062	AUG	94AUG	F	0.891	0.720	45946	34.6	9	0.019	0.057
94	9400063	AUG	94AUG	F	0.932	0.713	63830	38.9	9	0.040	0.121
94	9400064	AUG	94AUG	F	0.872	0.553	63937	49.5	9	0.039	0.099
94	9400066	AUG	94AUG	F	0.840	0.612	53857	48.9	9	0.037	0.076
94	9400067	AUG	94AUG	F	0.916	0.723	62678	42.5	9	0.054	0.177

Year	Number	Month	Time	Sex	Season	Site	Set	Length	Wt.	CFAC	Livwt.	Gowt.	GSI	LSI	AGE	Estra.	Test.	Livret.	Livrelp.	Livtoo.
94	9400073	AUG	94AUG	F	SUM	D1	HR	50.2	1847.0	1.46	26.5	52.2	2.91	1.46	8	0.081	0.024	0.020	0.12	31.79
94	9400075	AUG	94AUG	F	SUM	D1	HR	38.8	913.0	1.56	11.2	20.1	2.25	1.24	4	0.073	0.003	0.601	172.69	43.11
94	9400078	AUG	94AUG	F	SUM	D1	HR	48.7	1616.0	1.40	19.7	30.6	1.93	1.23	7	0.132	0.007	0.692	37.01	25.54
94	9400081	AUG	94AUG	F	SUM	D1	HR	41.3	1039.0	1.47	12.1	28.0	2.77	1.18	7	0.147	0.069	0.020	0.12	12.54
94	9400082	AUG	94AUG	F	SUM	D1	HR	44.1	1288.0	1.50	15.1	40.0	3.21	1.19	5	0.264	0.087	0.228	30.80	68.05
94	9400084	AUG	94AUG	F	SUM	D1	HR	43.8	1290.0	1.54	22.5	29.6	2.35	1.78	6	0.004	0.173	0.261	24.18	17.12
94	9400110	AUG	94AUG	F	SUM	D1	ON	38.6	866.0	1.51	11.7	26.3	3.13	1.37	4	0.275	0.007	1.402	216.74	130.58
94	9400111	AUG	94AUG	F	SUM	D1	ON	47.1	1320.0	1.26	15.7	45.3	3.55	1.20	8	0.143	0.007	0.777	171.47	37.57
94	9400114	AUG	94AUG	F	SUM	D1	ON	39.9	978.0	1.54	9.7	23.4	2.45	1.00	4	0.400	0.014	1.264	554.47	85.65
94	9400115	AUG	94AUG	F	SUM	D1	ON	43.4	1232.0	1.51	20.1	42.9	3.61	1.66	7	0.275	0.003	0.222	20.48	12.65
94	9400065	AUG	94AUG	M	SUM	D1	HR	41.2	1015.0	1.45	12.1	22.9	2.31	1.21	7	-	0.118	0.306	539.79	131.45
94	9400076	AUG	94AUG	M	SUM	D1	HR	43.3	1134.0	1.40	18.7	-	-	1.68	7	-	0.125	0.659	147.91	29.85
94	9400080	AUG	94AUG	M	SUM	D1	HR	42.0	1056.0	1.43	16.5	52.2	5.20	1.59	5	-	0.045	0.436	137.51	34.38
94	9400083	AUG	94AUG	M	SUM	D1	HR	41.4	1036.0	1.46	10.7	56.4	5.76	1.04	6	-	0.045	0.357	336.45	49.14
94	9400086	AUG	94AUG	M	SUM	D1	HR	45.7	1345.0	1.41	17.7	29.4	2.23	1.33	8	-	0.454	1.880	684.80	14.23
94	9400113	AUG	94AUG	M	SUM	D1	ON	35.3	721.0	1.64	7.2	55.4	8.32	1.01	4	-	0.905	1.372	294.23	50.23
94	9400117	AUG	94AUG	M	SUM	D1	ON	33.8	614.0	1.59	5.3	47.4	8.37	0.87	3	-	0.160	0.310	70.34	17.17
94	9400119	AUG	94AUG	F	SUM	D2	ON	35.5	721.0	1.61	6.9	6.2	0.87	0.97	3	0.169	0.173	0.418	306.57	39.73
94	9400127	AUG	94AUG	F	SUM	D2	ON	42.3	1137.0	1.50	16.3	44.0	4.03	1.45	5	0.191	0.128	0.449	411.26	65.84
94	9400120	AUG	94AUG	F	SUM	D2	ON	39.6	864.0	1.39	10.9	27.1	3.24	1.28	5	0.059	0.062	1.025	694.36	70.11
94	9400128	AUG	94AUG	F	SUM	D2	ON	49.6	1773.0	1.45	17.9	56.7	3.30	1.02	7	0.110	0.125	1.228	744.26	78.20
94	9400121	AUG	94AUG	F	SUM	D2	ON	42.6	1216.0	1.57	17.2	45.6	3.90	1.43	5	0.749	0.173	0.818	512.01	45.54
94	9400131	AUG	94AUG	F	SUM	D2	ON	40.5	1038.0	1.56	10.3	35.0	3.49	1.00	4	0.319	0.024	0.797	432.02	67.44
94	9400124	AUG	94AUG	F	SUM	D2	ON	41.5	1159.0	1.62	12.8	40.7	3.64	1.12	5	0.297	0.069	0.634	239.10	74.52
94	9400122	AUG	94AUG	M	SUM	D2	ON	43.3	1103.0	1.36	10.8	64.4	6.20	0.99	5	-	0.628	0.843	425.40	124.69
94	9400126	AUG	94AUG	M	SUM	D2	ON	41.5	979.0	1.37	9.8	48.0	5.16	1.01	5	-	0.128	0.382	438.10	86.99
94	9400123	AUG	94AUG	M	SUM	D2	ON	38.0	959.0	1.75	8.5	57.6	6.39	0.89	5	-	0.479	0.020	0.12	98.06
94	9400129	AUG	94AUG	M	SUM	D2	ON	38.5	868.0	1.52	8.3	50.1	6.13	0.97	4	-	0.430	0.704	199.12	26.77
94	9400125	AUG	94AUG	M	SUM	D2	ON	39.7	1018.0	1.63	10.7	31.8	3.22	1.06	5	-	0.243	0.281	196.81	39.52
94	9400089	AUG	94AUG	F	SUM	U	HR	43.3	1077.0	1.33	13.0	48.5	4.72	1.22	6	0.723	0.551	2.094	380.46	116.08
94	9400133	AUG	94AUG	F	SUM	U	ON	47.7	1631.0	1.50	16.0	75.8	4.87	0.99	6	0.477	0.475	1.207	704.53	71.29
94	9400090	AUG	94AUG	F	SUM	U	HR	49.8	1914.0	1.55	20.0	67.6	3.66	1.06	6	0.297	0.437	2.737	805.25	78.33
94	9400136	AUG	94AUG	F	SUM	U	ON	47.4	1683.0	1.58	16.1	48.4	2.96	0.97	9	0.077	0.003	1.041	1072.32	68.76
94	9400091	AUG	94AUG	F	SUM	U	HR	45.3	1439.0	1.55	20.2	36.1	2.57	1.42	8	0.283	0.492	0.279	69.32	72.84
94	9400137	AUG	94AUG	F	SUM	U	ON	39.1	954.0	1.60	9.4	42.6	4.67	1.00	4	0.147	0.045	0.938	415.10	64.27
94	9400096	AUG	94AUG	F	SUM	U	HR	36.8	650.0	1.30	7.5	17.3	2.73	1.17	4	0.206	0.111	1.072	620.35	104.92
94	9400140	AUG	94AUG	F	SUM	U	ON	43.5	1344.0	1.63	17.8	41.7	3.20	1.34	6	0.246	0.101	1.081	287.72	101.80
94	9400097	AUG	94AUG	F	SUM	U	ON	37.9	788.0	1.45	9.8	20.8	2.71	1.26	4	0.349	0.350	0.783	261.78	95.23
94	9400141	AUG	94AUG	F	SUM	U	ON	45.0	1132.0	1.24	9.9	48.6	4.49	0.88	6	0.132	0.035	1.217	326.11	38.73
94	9400098	AUG	94AUG	F	SUM	U	ON	39.2	829.0	1.38	9.0	27.1	3.38	1.10	4	0.246	0.014	0.945	191.94	167.15
94	9400101	AUG	94AUG	F	SUM	U	ON	50.2	2082.0	1.65	22.0	53.7	2.65	1.07	8	0.066	0.017	4.871	767.36	135.21
94	9400102	AUG	94AUG	F	SUM	U	ON	44.7	1166.0	1.31	11.6	40.0	3.55	1.00	6	0.018	0.003	0.561	12.55	50.57
94	9400104	AUG	94AUG	F	SUM	U	ON	50.2	1829.0	1.45	18.4	68.5	3.89	1.02	7	0.396	0.014	8.022	491.76	108.95
94	9400106	AUG	94AUG	F	SUM	U	ON	43.2	1329.0	1.65	14.9	42.5	3.30	1.13	7	0.327	0.042	1.187	473.31	227.35
94	9400087	AUG	94AUG	M	SUM	U	HR	43.9	1231.0	1.46	11.0	61.7	5.28	0.90	8	-	0.277	1.724	522.60	193.34
94	9400094	AUG	94AUG	M	SUM	U	HR	38.8	852.0	1.46	7.2	24.3	2.94	0.85	6	-	0.260	3.728	377.63	72.91
94	9400095	AUG	94AUG	M	SUM	U	HR	38.3	954.0	1.70	10.6	69.9	7.91	1.12	6	-	0.981	1.229	514.80	91.77
94	9400105	AUG	94AUG	M	SUM	U	ON	40.3	1026.0	1.57	9.5	71.6	7.50	0.93	8	-	0.097	1.024	349.09	46.69

Year	Number	Month	Time	Sex	Eggdiam.	Eggwt.	Absfec.	Relfec.	MI	EROD	BAP
94	9400073	AUG	94AUG	F	0.890	0.574	80431	44.8	9	0.017	0.035
94	9400075	AUG	94AUG	F	0.772	0.527	36413	40.8	9	0.049	0.167
94	9400078	AUG	94AUG	F	0.864	0.559	44672	28.2	9	0.020	0.057
94	9400081	AUG	94AUG	F	0.939	0.723	35443	35.1	9	0.015	0.085
94	9400082	AUG	94AUG	F	1.004	0.891	42248	33.9	9	0.049	0.130
94	9400084	AUG	94AUG	F	0.824	0.552	50685	40.2	9	0.043	0.164
94	9400110	AUG	94AUG	F	0.760	0.311	76676	91.3	9	0.010	0.037
94	9400111	AUG	94AUG	F	0.942	0.684	57470	45.1	9	0.072	0.234
94	9400114	AUG	94AUG	F	0.877	0.530	40625	42.6	9	0.073	0.177
94	9400115	AUG	94AUG	F	0.941	0.877	39358	33.1	9	0.016	0.065
94	9400065	AUG	94AUG	M	-	-	-	-	3	0.061	0.150
94	9400076	AUG	94AUG	M	-	-	-	-	-	0.216	0.403
94	9400080	AUG	94AUG	M	-	-	-	-	4	0.106	0.158
94	9400083	AUG	94AUG	M	-	-	-	-	4	0.140	0.263
94	9400086	AUG	94AUG	M	-	-	-	-	3	0.044	0.128
94	9400113	AUG	94AUG	M	-	-	-	-	4	0.039	0.119
94	9400117	AUG	94AUG	M	-	-	-	-	4	0.031	0.114
94	9400119	AUG	94AUG	F	0.588	0.142	28182	39.4	9	0.052	0.163
94	9400127	AUG	94AUG	F	1.011	0.990	43265	39.6	9	0.014	0.059
94	9400120	AUG	94AUG	F	0.984	0.763	32224	38.5	9	0.010	0.041
94	9400128	AUG	94AUG	F	0.998	0.746	66549	38.8	9	0.005	0.017
94	9400121	AUG	94AUG	F	0.986	0.945	44272	37.8	9	0.035	0.089
94	9400131	AUG	94AUG	F	1.031	0.891	35824	35.7	9	0.032	0.075
94	9400124	AUG	94AUG	F	1.045	0.860	41959	37.5	9	0.012	0.056
94	9400122	AUG	94AUG	M	-	-	-	-	4	0.027	0.107
94	9400126	AUG	94AUG	M	-	-	-	-	4	0.074	0.160
94	9400123	AUG	94AUG	M	-	-	-	-	4	0.079	0.200
94	9400129	AUG	94AUG	M	-	-	-	-	4	0.024	0.068
94	9400125	AUG	94AUG	M	-	-	-	-	4	0.002	0.018
94	9400089	AUG	94AUG	F	1.000	0.960	45285	44.0	9	0.012	0.057
94	9400133	AUG	94AUG	F	1.067	0.902	79455	51.1	9	0.010	0.033
94	9400090	AUG	94AUG	F	0.982	0.863	75028	40.6	9	0.007	0.020
94	9400136	AUG	94AUG	F	1.030	0.861	53128	32.5	9	0.009	0.028
94	9400091	AUG	94AUG	F	0.891	0.539	56495	40.3	9	0.016	0.056
94	9400137	AUG	94AUG	F	1.079	0.990	39813	43.7	9	0.004	0.028
94	9400096	AUG	94AUG	F	0.942	0.776	21257	33.6	9	0.011	0.061
94	9400140	AUG	94AUG	F	1.002	0.812	43438	33.4	9	0.010	0.061
94	9400097	AUG	94AUG	F	0.901	0.749	26329	34.3	9	0.010	0.038
94	9400141	AUG	94AUG	F	1.068	0.947	48503	44.8	9	0.009	0.040
94	9400098	AUG	94AUG	F	0.914	0.776	33374	41.6	9	0.005	0.027
94	9400101	AUG	94AUG	F	0.929	0.836	55190	27.2	9	0.013	0.064
94	9400102	AUG	94AUG	F	0.976	0.881	39293	34.9	9	0.003	0.020
94	9400104	AUG	94AUG	F	1.089	1.144	57660	32.8	9	0.006	0.028
94	9400106	AUG	94AUG	F	0.978	0.946	42757	33.2	9	0.011	0.054
94	9400087	AUG	94AUG	M	-	-	-	-	4	0.015	0.059
94	9400094	AUG	94AUG	M	-	-	-	-	4	0.011	0.075
94	9400095	AUG	94AUG	M	-	-	-	-	4	0.040	0.103
94	9400105	AUG	94AUG	M	-	-	-	-	4	0.040	0.102

Table A4: Raw data for the preliminary toxicity experiments with pulp mill effluent against rainbow trout in the laboratory. Data include experiment start date, experiment number (in order done), tank replicate, fish number, effluent concentration, time to death, weight (Wt.), fork length (Length), and temperature (temp.), dissolved oxygen (D.O.) and pH of the tanks at the beginning of the experiment (0), and on each successive day (i.e. after 24, 48, 72 and 96 hours).

Date	Experiment Number	Tank Replicate	Fish Number	Effluent Conc.	Time to Death (h)	Wt. (g)	Length (mm)	0 Temp (°C)	0 D.O. (mg/L)	0 pH	24 temp (°C)	24 D.O. (mg/L)	24 pH	48 temp. (°C)	48 D.O. (mg/L)	48 pH	72 temp. (°C)	72 D.O. (mg/L)	72 pH	96 temp. (°C)	96 D.O. (mg/L)	96 pH
June 9/93	1	A	1	0	96.1	0.197	32	10.3	10.2	7.75	10.0	10.4	7.77	12.0	9.8	7.74	13.5	9.4	7.68	14.1	9.2	7.67
June 9/93	1	A	2	0	96.1	0.158	31	10.3	10.2	7.75	10.0	10.4	7.77	12.0	9.8	7.74	13.5	9.4	7.68	14.1	9.2	7.67
June 9/93	1	A	3	0	96.1	0.191	32	10.3	10.2	7.75	10.0	10.4	7.77	12.0	9.8	7.74	13.5	9.4	7.68	14.1	9.2	7.67
June 9/93	1	A	4	0	96.1	0.176	29	10.3	10.2	7.75	10.0	10.4	7.77	12.0	9.8	7.74	13.5	9.4	7.68	14.1	9.2	7.67
June 9/93	1	A	5	0	96.1	0.188	24	10.3	10.2	7.75	10.0	10.4	7.77	12.0	9.8	7.74	13.5	9.4	7.68	14.1	9.2	7.67
June 9/93	1	B	1	0	96.1	0.117	26	10.2	10.2	7.85	10.0	10.6	7.80	11.9	9.8	7.74	13.4	9.5	7.69	14.2	9.2	7.69
June 9/93	1	B	2	0	96.1	0.160	29	10.2	10.2	7.85	10.0	10.6	7.80	11.9	9.8	7.74	13.4	9.5	7.69	14.2	9.2	7.69
June 9/93	1	B	3	0	96.1	0.140	28	10.2	10.2	7.85	10.0	10.6	7.80	11.9	9.8	7.74	13.4	9.5	7.69	14.2	9.2	7.69
June 9/93	1	B	4	0	96.1	0.159	29	10.2	10.2	7.85	10.0	10.6	7.80	11.9	9.8	7.74	13.4	9.5	7.69	14.2	9.2	7.69
June 9/93	1	B	5	0	96.1	0.243	32	10.2	10.2	7.85	10.0	10.6	7.80	11.9	9.8	7.74	13.4	9.5	7.69	14.2	9.2	7.69
June 9/93	1	A	1	0.5	96.1	0.201	31	10.2	10.2	7.81	10.0	10.6	7.77	11.9	10.0	7.67	13.5	9.5	7.68	14.2	9.1	7.62
June 9/93	1	A	2	0.5	96.1	0.128	27	10.2	10.2	7.81	10.0	10.6	7.77	11.9	10.0	7.67	13.5	9.5	7.68	14.2	9.1	7.62
June 9/93	1	A	3	0.5	96.1	0.195	31	10.2	10.2	7.81	10.0	10.6	7.77	11.9	10.0	7.67	13.5	9.5	7.68	14.2	9.1	7.62
June 9/93	1	A	4	0.5	96.1	0.143	28	10.2	10.2	7.81	10.0	10.6	7.77	11.9	10.0	7.67	13.5	9.5	7.68	14.2	9.1	7.62
June 9/93	1	A	5	0.5	96.1	0.181	29	10.2	10.2	7.81	10.0	10.6	7.77	11.9	10.0	7.67	13.5	9.5	7.68	14.2	9.1	7.62
June 9/93	1	B	1	0.5	96.1	0.174	29	10.3	10.2	7.82	9.9	10.6	7.82	11.9	10.0	7.74	13.5	9.5	7.70	14.2	9.0	7.65
June 9/93	1	B	2	0.5	96.1	0.189	30	10.3	10.2	7.82	9.9	10.6	7.82	11.9	10.0	7.74	13.5	9.5	7.70	14.2	9.0	7.65
June 9/93	1	B	3	0.5	96.1	0.176	30	10.3	10.2	7.82	9.9	10.6	7.82	11.9	10.0	7.74	13.5	9.5	7.70	14.2	9.0	7.65
June 9/93	1	B	4	0.5	96.1	0.105	27	10.3	10.2	7.82	9.9	10.6	7.82	11.9	10.0	7.74	13.5	9.5	7.70	14.2	9.0	7.65
June 9/93	1	B	5	0.5	96.1	0.188	30	10.3	10.2	7.82	9.9	10.6	7.82	11.9	10.0	7.74	13.5	9.5	7.70	14.2	9.0	7.65
June 9/93	1	A	1	1	96.1	0.184	31	10.3	10.3	7.65	10.0	10.5	7.70	11.7	9.9	7.68	13.2	9.4	7.65	14.1	8.9	7.55
June 9/93	1	A	2	1	96.1	0.219	32	10.3	10.3	7.65	10.0	10.5	7.70	11.7	9.9	7.68	13.2	9.4	7.65	14.1	8.9	7.55
June 9/93	1	A	3	1	96.1	0.183	30	10.3	10.3	7.65	10.0	10.5	7.70	11.7	9.9	7.68	13.2	9.4	7.65	14.1	8.9	7.55
June 9/93	1	A	4	1	96.1	0.166	29	10.3	10.3	7.65	10.0	10.5	7.70	11.7	9.9	7.68	13.2	9.4	7.65	14.1	8.9	7.55
June 9/93	1	A	5	1	96.1	0.145	28	10.3	10.3	7.65	10.0	10.5	7.70	11.7	9.9	7.68	13.2	9.4	7.65	14.1	8.9	7.55
June 9/93	1	B	1	1	96.1	0.129	27	10.5	10.2	7.75	9.8	10.4	7.73	11.7	9.8	7.68	13.5	9.3	7.61	14.1	8.8	7.54
June 9/93	1	B	2	1	96.1	0.153	28	10.5	10.2	7.75	9.8	10.4	7.73	11.7	9.8	7.68	13.5	9.3	7.61	14.1	8.8	7.54
June 9/93	1	B	3	1	96.1	0.218	32	10.5	10.2	7.75	9.8	10.4	7.73	11.7	9.8	7.68	13.5	9.3	7.61	14.1	8.8	7.54
June 9/93	1	B	4	1	96.1	0.219	31	10.5	10.2	7.75	9.8	10.4	7.73	11.7	9.8	7.68	13.5	9.3	7.61	14.1	8.8	7.54
June 9/93	1	B	5	1	96.1	-	-	10.5	10.2	7.75	9.8	10.4	7.73	11.7	9.8	7.68	13.5	9.3	7.61	14.1	8.8	7.54
June 9/93	1	A	1	5	29	0.198	29	10.3	10.2	7.42	9.7	10.2	7.48	11.5	10.0	7.48	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	2	5	29	0.279	32	10.3	10.2	7.42	9.7	10.2	7.48	11.5	10.0	7.48	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	3	5	32	0.158	28	10.3	10.2	7.42	9.7	10.2	7.48	11.5	10.0	7.48	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	4	5	32	0.220	29	10.3	10.2	7.42	9.7	10.2	7.48	11.5	10.0	7.48	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	5	5	48	0.169	29	10.3	10.2	7.42	9.7	10.2	7.48	11.5	10.0	7.48	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	1	5	24	0.263	33	10.2	10.2	7.39	9.6	10.2	7.46	11.2	10.1	7.53	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	2	5	29	0.164	22	10.2	10.2	7.39	9.6	10.2	7.46	11.2	10.1	7.53	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	3	5	29	0.178	29	10.2	10.2	7.39	9.6	10.2	7.46	11.2	10.1	7.53	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	4	5	29	0.192	30	10.2	10.2	7.39	9.6	10.2	7.46	11.2	10.1	7.53	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	5	5	29	0.236	32	10.2	10.2	7.39	9.6	10.2	7.46	11.2	10.1	7.53	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	1	10	8	0.174	31	10.1	10.0	7.18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	2	10	8	0.177	29	10.1	10.0	7.18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	3	10	8	0.253	31	10.1	10.0	7.18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	4	10	10	0.205	31	10.1	10.0	7.18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	5	10	10	0.198	31	10.1	10.0	7.18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	1	10	10	0.220	31	10.1	9.9	7.19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	2	10	10	0.166	31	10.1	9.9	7.19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	3	10	10	0.140	28	10.1	9.9	7.19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	4	10	10	0.143	29	10.1	9.9	7.19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Date	Experiment Number	Tank Replicate	Fish Number	Effluent Conc.	Time to Death (h)	Wt. (g)	Length (mm)	0 Temp (°C)	0 D.O. (mg/L)	0 pH	24 temp (°C)	24 D.O. (mg/L)	24 pH	48 temp. (°C)	48 D.O. (mg/L)	48 pH	72 temp. (°C)	72 D.O. (mg/L)	72 pH	96 temp. (°C)	96 D.O. (mg/L)	96 pH
June 9/93	1	B	5	10	10	0.218	30	10.1	9.9	7.19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	1	50	1.5	0.275	31	10.7	8.1	6.45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	2	50	2	0.189	32	10.7	8.1	6.45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	3	50	2	0.168	29	10.7	8.1	6.45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	4	50	2	0.215	29	10.7	8.1	6.45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	A	5	50	2	0.113	26	10.7	8.1	6.45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	1	50	1.5	0.259	32	10.7	8.1	6.45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	2	50	1.5	0.335	33	10.7	8.1	6.45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	3	50	2	0.233	30	10.7	8.1	6.45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	4	50	2	0.146	29	10.7	8.1	6.45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 9/93	1	B	5	50	2	0.141	26	10.7	8.1	6.45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	1	0	96.1	0.187	29	12.9	10.6	7.49	14.8	9.0	7.57	7.9	10.2	7.52	7.8	10.2	7.52	10.9	10.0	7.61
June 21/93	2	A	2	0	96.1	0.295	33	12.9	10.6	7.49	14.8	9.0	7.57	7.9	10.2	7.52	7.8	10.2	7.52	10.9	10.0	7.61
June 21/93	2	A	3	0	96.1	0.315	34	12.9	10.6	7.49	14.8	9.0	7.57	7.9	10.2	7.52	7.8	10.2	7.52	10.9	10.0	7.61
June 21/93	2	A	4	0	96.1	0.297	34	12.9	10.6	7.49	14.8	9.0	7.57	7.9	10.2	7.52	7.8	10.2	7.52	10.9	10.0	7.61
June 21/93	2	A	5	0	96.1	0.282	34	12.9	10.6	7.49	14.8	9.0	7.57	7.9	10.2	7.52	7.8	10.2	7.52	10.9	10.0	7.61
June 21/93	2	B	1	0	96.1	0.278	33	11.3	10.8	7.50	14.5	9.2	7.61	8.0	10.2	7.62	7.7	10.4	7.55	10.9	10.0	7.63
June 21/93	2	B	2	0	96.1	0.294	34	11.3	10.8	7.50	14.5	9.2	7.61	8.0	10.2	7.62	7.7	10.4	7.55	10.9	10.0	7.63
June 21/93	2	B	3	0	96.1	0.269	33	11.3	10.8	7.50	14.5	9.2	7.61	8.0	10.2	7.62	7.7	10.4	7.55	10.9	10.0	7.63
June 21/93	2	B	4	0	96.1	0.278	33	11.3	10.8	7.50	14.5	9.2	7.61	8.0	10.2	7.62	7.7	10.4	7.55	10.9	10.0	7.63
June 21/93	2	B	5	0	96.1	0.290	34	11.3	10.8	7.50	14.5	9.2	7.61	8.0	10.2	7.62	7.7	10.4	7.55	10.9	10.0	7.63
June 21/93	2	A	1	0.5	96.1	0.290	31	11.0	10.8	7.48	14.7	9.2	7.56	8.0	10.4	7.60	7.6	10.4	7.54	10.9	9.9	7.55
June 21/93	2	A	2	0.5	96.1	0.268	33	11.0	10.8	7.48	14.7	9.2	7.56	8.0	10.4	7.60	7.6	10.4	7.54	10.9	9.9	7.55
June 21/93	2	A	3	0.5	96.1	0.219	31	11.0	10.8	7.48	14.7	9.2	7.56	8.0	10.4	7.60	7.6	10.4	7.54	10.9	9.9	7.55
June 21/93	2	A	4	0.5	96.1	0.214	31	11.0	10.8	7.48	14.7	9.2	7.56	8.0	10.4	7.60	7.6	10.4	7.54	10.9	9.9	7.55
June 21/93	2	A	5	0.5	96.1	0.322	34	11.0	10.8	7.48	14.7	9.2	7.56	8.0	10.4	7.60	7.6	10.4	7.54	10.9	9.9	7.55
June 21/93	2	B	1	0.5	96.1	0.305	33	10.8	10.8	7.46	14.9	9.2	7.55	7.8	10.4	7.58	7.6	10.4	7.52	10.9	9.9	7.59
June 21/93	2	B	2	0.5	96.1	0.231	31	10.8	10.8	7.46	14.9	9.2	7.55	7.8	10.4	7.58	7.6	10.4	7.52	10.9	9.9	7.59
June 21/93	2	B	3	0.5	96.1	0.219	30	10.8	10.8	7.46	14.9	9.2	7.55	7.8	10.4	7.58	7.6	10.4	7.52	10.9	9.9	7.59
June 21/93	2	B	4	0.5	96.1	0.213	30	10.8	10.8	7.46	14.9	9.2	7.55	7.8	10.4	7.58	7.6	10.4	7.52	10.9	9.9	7.59
June 21/93	2	B	5	0.5	96.1	0.213	31	10.8	10.8	7.46	14.9	9.2	7.55	7.8	10.4	7.58	7.6	10.4	7.52	10.9	9.9	7.59
June 21/93	2	A	1	1	96.1	0.243	30	10.5	10.8	7.42	14.8	9.0	7.53	7.8	10.4	7.58	7.6	10.4	7.54	11.0	9.8	7.50
June 21/93	2	A	2	1	96.1	0.289	34	10.5	10.8	7.42	14.8	9.0	7.53	7.8	10.4	7.58	7.6	10.4	7.54	11.0	9.8	7.50
June 21/93	2	A	3	1	96.1	0.355	34	10.5	10.8	7.42	14.8	9.0	7.53	7.8	10.4	7.58	7.6	10.4	7.54	11.0	9.8	7.50
June 21/93	2	A	4	1	96.1	0.273	32	10.5	10.8	7.42	14.8	9.0	7.53	7.8	10.4	7.58	7.6	10.4	7.54	11.0	9.8	7.50
June 21/93	2	A	5	1	96.1	0.177	30	10.5	10.8	7.42	14.8	9.0	7.53	7.8	10.4	7.58	7.6	10.4	7.54	11.0	9.8	7.50
June 21/93	2	B	1	1	96.1	0.178	28	10.5	10.8	7.40	14.8	9.0	7.49	7.8	10.4	7.58	7.5	10.2	7.49	11.0	9.6	7.48
June 21/93	2	B	2	1	96.1	0.238	30	10.5	10.8	7.40	14.8	9.0	7.49	7.7	10.4	7.51	7.5	10.2	7.49	11.0	9.6	7.48
June 21/93	2	B	3	1	96.1	0.311	33	10.5	10.8	7.40	14.8	9.0	7.49	7.7	10.4	7.51	7.5	10.2	7.49	11.0	9.6	7.48
June 21/93	2	B	4	1	96.1	0.350	34	10.5	10.8	7.40	14.8	9.0	7.49	7.7	10.4	7.51	7.5	10.2	7.49	11.0	9.6	7.48
June 21/93	2	B	5	1	96.1	0.386	36	10.5	10.8	7.40	14.8	9.0	7.49	7.7	10.4	7.51	7.5	10.2	7.49	11.0	9.6	7.48
June 21/93	2	A	1	5	23	0.356	32	10.4	10.5	7.22	14.8	9.2	7.38	7.7	10.4	7.51	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	2	5	23	0.210	30	10.4	10.5	7.22	14.8	9.2	7.38	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	3	5	23	0.309	31	10.4	10.5	7.22	14.8	9.2	7.38	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	4	5	23	0.472	34	10.4	10.5	7.22	14.8	9.2	7.38	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	5	5	23	0.258	29	10.4	10.5	7.22	14.8	9.2	7.38	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	1	5	23	0.339	31	10.4	10.4	7.22	14.8	9.2	7.32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	2	5	23	0.230	28	10.4	10.4	7.22	14.8	9.2	7.32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	3	5	23	0.413	34	10.4	10.4	7.22	14.8	9.2	7.32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	4	5	23	0.272	29	10.4	10.4	7.22	14.8	9.2	7.32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	5	5	23	0.412	33	10.4	10.4	7.22	14.8	9.2	7.32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	1	10	7	0.211	27	10.4	10.1	7.05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	2	10	7	0.319	33	10.4	10.1	7.05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Date	Experiment Number	Tank Replicate	Fish Number	Effluent Conc.	Time to Death (h)	Wt. (g)	Length (mm)	0 Temp (°C)	0 D.O. (mg/L)	0 pH	24 temp (°C)	24 D.O. (mg/L)	24 pH	48 temp. (°C)	48 D.O. (mg/L)	48 pH	72 temp. (°C)	72 D.O. (mg/L)	72 pH	96 temp. (°C)	96 D.O. (mg/L)	96 pH
June 21/93	2	A	3	10	7	0.369	34	10.4	10.1	7.05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	4	10	8	0.345	33	10.4	10.1	7.05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	5	10	9	0.338	34	10.4	10.1	7.05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	1	10	5	0.191	29	10.4	10.0	7.04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	2	10	7	0.292	32	10.4	10.0	7.04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	3	10	8	0.163	28	10.4	10.0	7.04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	4	10	8	0.313	32	10.4	10.0	7.04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	5	10	8	0.397	34	10.4	10.0	7.04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	1	50	2	0.265	32	10.4	7.2	6.26	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	2	50	2	0.355	34	10.4	7.2	6.26	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	3	50	2	0.418	35	10.4	7.2	6.26	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	4	50	2	0.238	32	10.4	7.2	6.26	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	A	5	50	2	0.296	33	10.4	7.2	6.26	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	1	50	2	0.321	34	10.5	7.3	6.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	2	50	2	0.329	34	10.5	7.3	6.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	3	50	2	0.310	32	10.5	7.3	6.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	4	50	2	0.436	36	10.5	7.3	6.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 21/93	2	B	5	50	2	0.193	31	10.5	7.3	6.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	A	1	0	96.1	0.277	33	10.8	10.9	7.57	10.2	10.4	7.51	10.5	9.2	7.58	10.3	9.5	7.61	10.5	9.3	7.59
July 5/93	3	A	2	0	96.1	0.259	32	10.8	10.9	7.57	10.2	10.4	7.51	10.5	9.2	7.58	10.3	9.5	7.61	10.5	9.3	7.59
July 5/93	3	A	3	0	96.1	0.570	40	10.8	10.9	7.57	10.2	10.4	7.51	10.5	9.2	7.58	10.3	9.5	7.61	10.5	9.3	7.59
July 5/93	3	A	4	0	96.1	0.659	41	10.8	10.9	7.57	10.2	10.4	7.51	10.5	9.2	7.58	10.3	9.5	7.61	10.5	9.3	7.59
July 5/93	3	A	5	0	96.1	0.652	40	10.8	10.9	7.57	10.2	10.4	7.51	10.5	9.2	7.58	10.3	9.5	7.61	10.5	9.3	7.59
July 5/93	3	B	1	0	96.1	0.496	39	11.2	10.8	7.51	10.1	10.4	7.50	10.5	9.2	7.57	10.3	9.6	7.64	10.5	9.4	7.59
July 5/93	3	B	2	0	96.1	0.435	38	11.2	10.8	7.51	10.1	10.4	7.50	10.5	9.2	7.57	10.3	9.6	7.64	10.5	9.4	7.59
July 5/93	3	B	3	0	96.1	0.314	34	11.2	10.8	7.51	10.1	10.4	7.50	10.5	9.2	7.57	10.3	9.6	7.64	10.5	9.4	7.59
July 5/93	3	B	4	0	96.1	0.539	39	11.2	10.8	7.51	10.1	10.4	7.50	10.5	9.2	7.57	10.3	9.6	7.64	10.5	9.4	7.59
July 5/93	3	B	5	0	96.1	0.543	39	11.2	10.8	7.51	10.1	10.4	7.50	10.5	9.2	7.57	10.3	9.6	7.64	10.5	9.4	7.59
July 5/93	3	A	1	1.25	96.1	0.332	35	10.4	11.0	7.30	9.8	10.6	7.42	10.5	9.4	7.51	10.3	9.5	7.48	10.5	9.2	7.49
July 5/93	3	A	2	1.25	96.1	0.595	40	10.4	11.0	7.30	9.8	10.6	7.42	10.5	9.4	7.51	10.3	9.5	7.48	10.5	9.2	7.49
July 5/93	3	A	3	1.25	96.1	0.481	36	10.4	11.0	7.30	9.8	10.6	7.42	10.5	9.4	7.51	10.3	9.5	7.48	10.5	9.2	7.49
July 5/93	3	A	4	1.25	96.1	0.225	30	10.4	11.0	7.30	9.8	10.6	7.42	10.5	9.4	7.51	10.3	9.5	7.48	10.5	9.2	7.49
July 5/93	3	A	5	1.25	96.1	0.437	38	10.4	11.0	7.30	9.8	10.6	7.42	10.5	9.4	7.51	10.3	9.5	7.48	10.5	9.2	7.49
July 5/93	3	B	1	1.25	96.1	0.534	39	10.3	11.0	7.30	9.8	10.3	7.40	10.3	8.8	7.43	10.2	8.9	7.40	10.4	8.6	7.40
July 5/93	3	B	2	1.25	96.1	0.609	38	10.3	11.0	7.30	9.8	10.3	7.40	10.3	8.8	7.43	10.2	8.9	7.40	10.4	8.6	7.40
July 5/93	3	B	3	1.25	96.1	0.757	42	10.3	11.0	7.30	9.8	10.3	7.40	10.3	8.8	7.43	10.2	8.9	7.40	10.4	8.6	7.40
July 5/93	3	B	4	1.25	96.1	0.633	39	10.3	11.0	7.30	9.8	10.3	7.40	10.3	8.8	7.43	10.2	8.9	7.40	10.4	8.6	7.40
July 5/93	3	B	5	1.25	96.1	0.425	36	10.3	11.0	7.30	9.8	10.3	7.40	10.3	8.8	7.43	10.2	8.9	7.40	10.4	8.6	7.40
July 5/93	3	A	1	2.5	96.1	0.459	32	10.3	11.0	7.17	10.0	10.4	7.39	10.3	9.0	7.45	10.2	9.2	7.40	10.5	8.3	7.38
July 5/93	3	A	2	2.5	96.1	0.402	35	10.3	11.0	7.17	10.0	10.4	7.39	10.3	9.0	7.45	10.2	9.2	7.40	10.5	8.3	7.38
July 5/93	3	A	3	2.5	96.1	0.362	35	10.3	11.0	7.17	10.0	10.4	7.39	10.3	9.0	7.45	10.2	9.2	7.40	10.5	8.3	7.38
July 5/93	3	A	4	2.5	96.1	0.310	32	10.3	11.0	7.17	10.0	10.4	7.39	10.3	9.0	7.45	10.2	9.2	7.40	10.5	8.3	7.38
July 5/93	3	A	5	2.5	96.1	0.934	47	10.3	11.0	7.17	10.0	10.4	7.39	10.3	9.0	7.45	10.2	9.2	7.40	10.5	8.3	7.38
July 5/93	3	B	1	2.5	96.1	0.420	33	10.3	11.0	7.15	10.0	10.6	7.33	10.3	8.9	7.40	10.2	9.0	7.32	10.5	7.8	7.28
July 5/93	3	B	2	2.5	96.1	0.407	35	10.3	11.0	7.15	10.0	10.6	7.33	10.3	8.9	7.40	10.2	9.0	7.32	10.5	7.8	7.28
July 5/93	3	B	3	2.5	96.1	0.527	38	10.3	11.0	7.15	10.0	10.6	7.33	10.3	8.9	7.40	10.2	9.0	7.32	10.5	7.8	7.28
July 5/93	3	B	4	2.5	96.1	0.407	35	10.3	11.0	7.15	10.0	10.6	7.33	10.3	8.9	7.40	10.2	9.0	7.32	10.5	7.8	7.28
July 5/93	3	B	5	2.5	96.1	0.455	36	10.3	11.0	7.15	10.0	10.6	7.33	10.3	8.9	7.40	10.2	9.0	7.32	10.5	7.8	7.28
July 5/93	3	A	1	4	77.5	0.656	41	10.2	11.0	7.05	10.0	10.2	7.21	10.5	8.3	7.28	10.2	8.2	7.20	10.5	7.0	7.19
July 5/93	3	A	2	4	96	0.814	43	10.2	11.0	7.05	10.0	10.2	7.21	10.5	8.3	7.28	10.2	8.2	7.20	10.5	7.0	7.19
July 5/93	3	A	3	4	96	0.646	39	10.2	11.0	7.05	10.0	10.2	7.21	10.5	8.3	7.28	10.2	8.2	7.20	10.5	7.0	7.19
July 5/93	3	A	4	4	96.1	0.417	37	10.2	11.0	7.05	10.0	10.2	7.21	10.5	8.3	7.28	10.2	8.2	7.20	10.5	7.0	7.19
July 5/93	3	A	5	4	96.1	0.325	33	10.2	11.0	7.05	10.0	10.2	7.21	10.5	8.3	7.28	10.2	8.2	7.20	10.5	7.0	7.19

Date	Experiment Number	Tank Replicate	Fish Number	Effluent Conc.	Time to Death (h)	Wt. (g)	Length (mm)	0 Temp (°C)	0 D.O. (mg/L)	0 pH	24 temp (°C)	24 D.O. (mg/L)	24 pH	48 temp. (°C)	48 D.O. (mg/L)	48 pH	72 temp. (°C)	72 D.O. (mg/L)	72 pH	96 temp. (°C)	96 D.O. (mg/L)	96 pH
July 5/93	3	B	1	4	96	0.660	38	10.2	11.0	7.03	10.0	10.2	7.28	10.4	8.6	7.34	10.2	9.2	7.35	10.5	8.0	7.33
July 5/93	3	B	2	4	96.1	0.706	43	10.2	11.0	7.03	10.0	10.2	7.28	10.4	8.6	7.34	10.2	9.2	7.35	10.5	8.0	7.33
July 5/93	3	B	3	4	96.1	0.448	36	10.2	11.0	7.03	10.0	10.2	7.28	10.4	8.6	7.34	10.2	9.2	7.35	10.5	8.0	7.33
July 5/93	3	B	4	4	96.1	0.552	38	10.2	11.0	7.03	10.0	10.2	7.28	10.4	8.6	7.34	10.2	9.2	7.35	10.5	8.0	7.33
July 5/93	3	B	5	4	96.1	0.703	40	10.2	11.0	7.03	10.0	10.2	7.28	10.4	8.6	7.34	10.2	9.2	7.35	10.5	8.0	7.33
July 5/93	3	A	1	5	27.5	0.183	28	10.2	11.0	6.95	10.0	10.4	7.22	10.5	9.0	7.33	10.2	9.8	7.25	N/A	N/A	N/A
July 5/93	3	A	2	5	31	0.840	41	10.2	11.0	6.95	10.0	10.4	7.22	10.5	9.0	7.33	10.2	9.8	7.25	N/A	N/A	N/A
July 5/93	3	A	3	5	48	0.699	38	10.2	11.0	6.95	10.0	10.4	7.22	10.5	9.0	7.33	10.2	9.8	7.25	N/A	N/A	N/A
July 5/93	3	A	4	5	50	0.286	33	10.2	11.0	6.95	10.0	10.4	7.22	10.5	9.0	7.33	10.2	9.8	7.25	N/A	N/A	N/A
July 5/93	3	A	5	5	72	1.020	43	10.2	11.0	6.95	10.0	10.4	7.22	10.5	9.0	7.33	10.2	9.8	7.25	N/A	N/A	N/A
July 5/93	3	B	1	5	24	0.276	32	10.3	11.0	6.92	10.0	10.6	7.17	10.4	9.2	7.28	10.2	10.2	7.20	N/A	N/A	N/A
July 5/93	3	B	2	5	48	0.463	34	10.3	11.0	6.92	10.0	10.6	7.17	10.4	9.2	7.28	10.2	10.2	7.20	N/A	N/A	N/A
July 5/93	3	B	3	5	48	0.428	36	10.3	11.0	6.92	10.0	10.6	7.17	10.4	9.2	7.28	10.2	10.2	7.20	N/A	N/A	N/A
July 5/93	3	B	4	5	48	0.293	33	10.3	11.0	6.92	10.0	10.6	7.17	10.4	9.2	7.28	10.2	10.2	7.20	N/A	N/A	N/A
July 5/93	3	B	5	5	56	0.729	40	10.3	11.0	6.92	10.0	10.6	7.17	10.4	9.2	7.28	10.2	10.2	7.20	N/A	N/A	N/A
July 5/93	3	A	1	10	7	0.520	37	10.3	10.9	6.69	10.0	10.6	6.92	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	A	2	10	11	0.757	38	10.3	10.9	6.69	10.0	10.6	6.92	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	A	3	10	24	1.031	42	10.3	10.9	6.69	10.0	10.6	6.92	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	A	4	10	24	0.358	33	10.3	10.9	6.69	10.0	10.6	6.92	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	A	5	10	24	0.809	41	10.3	10.9	6.69	10.0	10.6	6.92	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	B	1	10	8	0.650	37	10.3	10.9	6.70	10.0	10.5	6.90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	B	2	10	24	0.675	40	10.3	10.9	6.70	10.0	10.5	6.90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	B	3	10	24	0.649	39	10.3	10.9	6.70	10.0	10.5	6.90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	B	4	10	24	0.740	42	10.3	10.9	6.70	10.0	10.5	6.90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	B	5	10	24	0.668	39	10.3	10.9	6.70	10.0	10.5	6.90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	A	1	10F	48	0.441	35	10.6	11.0	7.50	10.1	10.5	7.48	10.6	8.9	7.49	10.2	9.2	7.55	10.5	8.6	7.51
July 5/93	3	A	2	10F	74	0.445	36	10.6	11.0	7.50	10.1	10.5	7.48	10.6	8.9	7.49	10.2	9.2	7.55	10.5	8.6	7.51
July 5/93	3	A	3	10F	96.1	0.465	37	10.6	11.0	7.50	10.1	10.5	7.48	10.6	8.9	7.49	10.2	9.2	7.55	10.5	8.6	7.51
July 5/93	3	A	4	10F	96.1	0.500	38	10.6	11.0	7.50	10.1	10.5	7.48	10.6	8.9	7.49	10.2	9.2	7.55	10.5	8.6	7.51
July 5/93	3	A	5	10F	96.1	0.402	36	10.6	11.0	7.50	10.1	10.5	7.48	10.6	8.9	7.49	10.2	9.2	7.55	10.5	8.6	7.51
July 5/93	3	B	1	10F	96.1	0.395	31	10.7	11.0	7.50	10.2	10.3	7.48	10.6	8.7	7.48	10.2	8.8	7.50	10.6	8.3	7.44
July 5/93	3	B	2	10F	96.1	0.462	32	10.7	11.0	7.50	10.2	10.3	7.48	10.6	8.7	7.48	10.2	8.8	7.50	10.6	8.3	7.44
July 5/93	3	B	3	10F	96.1	0.618	42	10.7	11.0	7.50	10.2	10.3	7.48	10.6	8.7	7.48	10.2	8.8	7.50	10.6	8.3	7.44
July 5/93	3	B	4	10F	96.1	0.498	39	10.7	11.0	7.50	10.2	10.3	7.48	10.6	8.7	7.48	10.2	8.8	7.50	10.6	8.3	7.44
July 5/93	3	B	5	10F	96.1	1.012	48	10.7	11.0	7.50	10.2	10.3	7.48	10.6	8.7	7.48	10.2	8.8	7.50	10.6	8.3	7.44
July 5/93	3	A	1	50 F	4	0.380	34	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	A	2	50 F	24	0.768	41	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	A	3	50 F	24	0.811	42	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	A	4	50 F	24	1.119	42	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	A	5	50 F	24	0.607	39	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	B	1	50 F	11	0.923	41	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	B	2	50 F	12	0.845	44	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	B	3	50 F	24	0.930	40	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	B	4	50 F	24	0.860	41	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
July 5/93	3	B	5	50 F	24	0.764	43	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
May 30/94	4	A	1	0	96.1	4.237	73	10.3	11.0	7.49	10.4	6.5	7.18	10.9	10.4	7.86	10.5	10.7	7.89	N/A	N/A	N/A
May 30/94	4	A	2	0	96.1	2.695	64	10.3	11.0	7.49	10.4	6.5	7.18	10.9	10.4	7.86	10.5	10.7	7.89	N/A	N/A	N/A
May 30/94	4	A	3	0	96.1	3.579	72	10.3	11.0	7.49	10.4	6.5	7.18	10.9	10.4	7.86	10.5	10.7	7.89	N/A	N/A	N/A
May 30/94	4	A	4	0	96.1	3.688	71	10.3	11.0	7.49	10.4	6.5	7.18	10.9	10.4	7.86	10.5	10.7	7.89	N/A	N/A	N/A
May 30/94	4	A	5	0	96.1	2.300	56	10.3	11.0	7.49	10.4	6.5	7.18	10.9	10.4	7.86	10.5	10.7	7.89	N/A	N/A	N/A
May 30/94	4	B	1	0	96.1	2.058	56	10.3	11.0	7.54	10.5	6.4	7.32	10.8	10.7	7.94	10.6	10.9	7.96	N/A	N/A	N/A
May 30/94	4	B	2	0	96.1	2.868	63	10.3	11.0	7.54	10.5	6.4	7.32	10.8	10.7	7.94	10.6	10.9	7.96	N/A	N/A	N/A
May 30/94	4	B	3	0	96.1	3.661	70	10.3	11.0	7.54	10.5	6.4	7.32	10.8	10.7	7.94	10.6	10.9	7.96	N/A	N/A	N/A

Date	Experiment Number	Tank Replicate	Fish Number	Effluent Conc.	Time to Death (h)	Wt. (g)	Length (mm)	0 Temp (°C)	0 D.O. (mg/L)	0 pH	24 temp (°C)	24 D.O. (mg/L)	24 pH	48 temp. (°C)	48 D.O. (mg/L)	48 pH	72 temp. (°C)	72 D.O. (mg/L)	72 pH	96 temp. (°C)	96 D.O. (mg/L)	96 pH
May 30/94	4	B	4	0	96.1	4.563	78	10.3	11.0	7.54	10.5	6.4	7.32	10.8	10.7	7.94	10.6	10.9	7.96	N/A	N/A	N/A
May 30/94	4	B	5	0	96.1	1.633	55	10.3	11.0	7.54	10.5	6.4	7.32	10.8	10.7	7.94	10.6	10.9	7.96	N/A	N/A	N/A
May 30/94	4	A	1	0.5	96.1	-	-	10.2	10.9	7.51	10.4	6.6	7.38	10.8	10.7	8.00	10.7	11.0	8.00	N/A	N/A	N/A
May 30/94	4	A	2	0.5	96.1	-	-	10.2	10.9	7.51	10.4	6.6	7.38	10.8	10.7	8.00	10.7	11.0	8.00	N/A	N/A	N/A
May 30/94	4	A	3	0.5	96.1	-	-	10.2	10.9	7.51	10.4	6.6	7.38	10.8	10.7	8.00	10.7	11.0	8.00	N/A	N/A	N/A
May 30/94	4	A	4	0.5	96.1	3.358	62	10.2	10.9	7.51	10.4	6.6	7.38	10.8	10.7	8.00	10.7	11.0	8.00	N/A	N/A	N/A
May 30/94	4	A	5	0.5	96.1	2.677	61	10.2	10.9	7.51	10.4	6.6	7.38	10.8	10.7	8.00	10.7	11.0	8.00	N/A	N/A	N/A
May 30/94	4	B	1	0.5	96.1	5.410	78	10.2	11.0	7.50	10.5	6.4	8.30	10.8	10.4	7.86	10.8	10.6	7.86	N/A	N/A	N/A
May 30/94	4	B	2	0.5	96.1	4.421	73	10.2	11.0	7.50	10.5	6.4	8.30	10.8	10.4	7.86	10.8	10.6	7.86	N/A	N/A	N/A
May 30/94	4	B	3	0.5	96.1	2.880	63	10.2	11.0	7.50	10.5	6.4	8.30	10.8	10.4	7.86	10.8	10.6	7.86	N/A	N/A	N/A
May 30/94	4	B	4	0.5	96.1	1.701	55	10.2	11.0	7.50	10.5	6.4	8.30	10.8	10.4	7.86	10.8	10.6	7.86	N/A	N/A	N/A
May 30/94	4	B	5	0.5	96.1	2.959	64	10.2	11.0	7.50	10.5	6.4	8.30	10.8	10.4	7.86	10.8	10.6	7.86	N/A	N/A	N/A
May 30/94	4	A	1	1	96.1	2.702	64	10.2	10.9	7.45	10.4	6.4	7.32	10.8	10.5	7.98	10.8	10.7	7.99	N/A	N/A	N/A
May 30/94	4	A	2	1	96.1	3.948	73	10.2	10.9	7.45	10.4	6.4	7.32	10.8	10.5	7.98	10.8	10.7	7.99	N/A	N/A	N/A
May 30/94	4	A	3	1	96.1	3.873	69	10.2	10.9	7.45	10.4	6.4	7.32	10.8	10.5	7.98	10.8	10.7	7.99	N/A	N/A	N/A
May 30/94	4	A	4	1	96.1	2.374	61	10.2	10.9	7.45	10.4	6.4	7.32	10.8	10.5	7.98	10.8	10.7	7.99	N/A	N/A	N/A
May 30/94	4	A	5	1	96.1	2.145	57	10.2	10.9	7.45	10.4	6.4	7.32	10.8	10.5	7.98	10.8	10.7	7.99	N/A	N/A	N/A
May 30/94	4	B	1	1	96.1	4.439	72	10.3	10.8	7.50	10.5	6.6	7.30	11.1	10.4	7.89	10.6	10.6	7.81	N/A	N/A	N/A
May 30/94	4	B	2	1	96.1	1.951	57	10.3	10.8	7.50	10.5	6.6	7.30	11.1	10.4	7.89	10.6	10.6	7.81	N/A	N/A	N/A
May 30/94	4	B	3	1	96.1	3.073	62	10.3	10.8	7.50	10.5	6.6	7.30	11.1	10.4	7.89	10.6	10.6	7.81	N/A	N/A	N/A
May 30/94	4	B	4	1	96.1	1.970	57	10.3	10.8	7.50	10.5	6.6	7.30	11.1	10.4	7.89	10.6	10.6	7.81	N/A	N/A	N/A
May 30/94	4	B	5	1	96.1	2.624	63	10.3	10.8	7.50	10.5	6.6	7.30	11.1	10.4	7.89	10.6	10.6	7.81	N/A	N/A	N/A
May 30/94	4	A	1	5	96.1	1.997	58	10.4	10.9	7.33	10.6	6.8	7.34	11.0	10.4	7.9	10.6	10.5	7.90	N/A	N/A	N/A
May 30/94	4	A	2	5	96.1	1.949	58	10.4	10.9	7.33	10.6	6.8	7.34	11.0	10.4	7.9	10.6	10.5	7.90	N/A	N/A	N/A
May 30/94	4	A	3	5	96.1	2.758	63	10.4	10.9	7.33	10.6	6.8	7.34	11.0	10.4	7.9	10.6	10.5	7.90	N/A	N/A	N/A
May 30/94	4	A	4	5	96.1	2.737	64	10.4	10.9	7.33	10.6	6.8	7.34	11.0	10.4	7.9	10.6	10.5	7.90	N/A	N/A	N/A
May 30/94	4	A	5	5	96.1	3.419	63	10.4	10.9	7.33	10.6	6.8	7.34	11.0	10.4	7.9	10.6	10.5	7.90	N/A	N/A	N/A
May 30/94	4	B	1	5	96.1	5.831	79	10.2	10.8	7.28	10.6	6.2	7.23	10.8	10.0	7.8	10.6	10.2	7.74	N/A	N/A	N/A
May 30/94	4	B	2	5	96.1	5.928	82	10.2	10.8	7.28	10.6	6.2	7.23	10.8	10.0	7.8	10.6	10.2	7.74	N/A	N/A	N/A
May 30/94	4	B	3	5	96.1	1.132	45	10.2	10.8	7.28	10.6	6.2	7.23	10.8	10.0	7.8	10.6	10.2	7.74	N/A	N/A	N/A
May 30/94	4	B	4	5	96.1	2.299	60	10.2	10.8	7.28	10.6	6.2	7.23	10.8	10.0	7.8	10.6	10.2	7.74	N/A	N/A	N/A
May 30/94	4	B	5	5	96.1	2.965	66	10.2	10.8	7.28	10.6	6.2	7.23	10.8	10.0	7.8	10.6	10.2	7.74	N/A	N/A	N/A
May 30/94	4	A	1	10	96.1	4.625	78	10.2	11.0	7.13	10.6	6.1	7.15	10.8	9.7	7.63	11.0	9.7	7.71	N/A	N/A	N/A
May 30/94	4	A	2	10	96.1	3.701	73	10.2	11.0	7.13	10.6	6.1	7.15	10.8	9.7	7.63	11.0	9.7	7.71	N/A	N/A	N/A
May 30/94	4	A	3	10	96.1	2.813	62	10.2	11.0	7.13	10.6	6.1	7.15	10.8	9.7	7.63	11.0	9.7	7.71	N/A	N/A	N/A
May 30/94	4	A	4	10	96.1	4.481	74	10.2	11.0	7.13	10.6	6.1	7.15	10.8	9.7	7.63	11.0	9.7	7.71	N/A	N/A	N/A
May 30/94	4	A	5	10	96.1	2.247	59	10.2	11.0	7.13	10.6	6.1	7.15	10.8	9.7	7.63	11.0	9.7	7.71	N/A	N/A	N/A
May 30/94	4	B	1	10	96.1	1.295	50	10.3	11.0	7.14	10.7	6.9	7.24	10.9	10.2	7.83	11.0	9.9	7.57	N/A	N/A	N/A
May 30/94	4	B	2	10	96.1	4.067	72	10.3	11.0	7.14	10.7	6.9	7.24	10.9	10.2	7.83	11.0	9.9	7.57	N/A	N/A	N/A
May 30/94	4	B	3	10	96.1	1.994	59	10.3	11.0	7.14	10.7	6.9	7.24	10.9	10.2	7.83	11.0	9.9	7.57	N/A	N/A	N/A
May 30/94	4	B	4	10	96.1	2.235	58	10.3	11.0	7.14	10.7	6.9	7.24	10.9	10.2	7.83	11.0	9.9	7.57	N/A	N/A	N/A
May 30/94	4	B	5	10	96.1	1.916	57	10.3	11.0	7.14	10.7	6.9	7.24	10.9	10.2	7.83	11.0	9.9	7.57	N/A	N/A	N/A
May 30/94	4	A	1	50	22	3.177	67	10.1	11.0	5.94	10.6	5.3	6.12	11.0	10.0	6.90	N/A	N/A	N/A	N/A	N/A	N/A
May 30/94	4	A	2	50	26	2.164	57	10.1	11.0	5.94	10.6	5.3	6.12	11.0	10.0	6.90	N/A	N/A	N/A	N/A	N/A	N/A
May 30/94	4	A	3	50	26	3.472	66	10.1	11.0	5.94	10.6	5.3	6.12	11.0	10.0	6.90	N/A	N/A	N/A	N/A	N/A	N/A
May 30/94	4	A	4	50	46	4.761	73	10.1	11.0	5.94	10.6	5.3	6.12	11.0	10.0	6.90	N/A	N/A	N/A	N/A	N/A	N/A
May 30/94	4	A	5	50	70	6.299	80	10.1	11.0	5.94	10.6	5.3	6.12	11.0	10.0	6.90	N/A	N/A	N/A	N/A	N/A	N/A
May 30/94	4	B	1	50	23	3.020	64	10.1	10.9	5.93	10.6	5.4	6.16	10.9	10.3	7.00	N/A	N/A	N/A	N/A	N/A	N/A
May 30/94	4	B	2	50	27	3.840	67	10.1	10.9	5.93	10.6	5.4	6.16	10.9	10.3	7.00	N/A	N/A	N/A	N/A	N/A	N/A
May 30/94	4	B	3	50	46	3.648	66	10.1	10.9	5.93	10.6	5.4	6.16	10.9	10.3	7.00	N/A	N/A	N/A	N/A	N/A	N/A
May 30/94	4	B	4	50	46	4.531	72	10.1	10.9	5.93	10.6	5.4	6.16	10.9	10.3	7.00	N/A	N/A	N/A	N/A	N/A	N/A
May 30/94	4	B	5	50	46	3.246	64	10.1	10.9	5.93	10.6	5.4	6.16	10.9	10.3	7.00	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	1A	1	15	10.5	7.380	80	10.8	11	7.24	10.0	5.9	6.85	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Date	Experiment Number	Tank Replicate	Fish Number	Effluent Conc.	Time to Death (h)	Wt. (g)	Length (mm)	0 Temp (°C)	0 D.O. (mg/L)	0 pH	24 temp (°C)	24 D.O. (mg/L)	24 pH	48 temp. (°C)	48 D.O. (mg/L)	48 pH	72 temp. (°C)	72 D.O. (mg/L)	72 pH	96 temp. (°C)	96 D.O. (mg/L)	96 pH
June 20/94	5	1A	2	15	11.5	5.500	78	10.8	11	7.24	10.0	5.9	6.85	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	1A	3	15	11.5	6.904	82	10.8	11	7.24	10.0	5.9	6.85	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	1A	4	15	11.5	6.608	79	10.8	11	7.24	10.0	5.9	6.85	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	1A	5	15	13	6.229	79	10.8	11	7.24	10.0	5.9	6.85	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	1B	1	15	9.5	3.603	65	10.9	11	7.21	10.1	6.8	6.88	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	1B	2	15	9.5	3.819	70	10.9	11	7.21	10.1	6.8	6.88	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	1B	3	15	13	5.951	73	10.9	11	7.21	10.1	6.8	6.88	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	1B	4	15	13	5.633	78	10.9	11	7.21	10.1	6.8	6.88	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	1B	5	15	22	6.047	75	10.9	11	7.21	10.1	6.8	6.88	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	2A	1	15	7.5	3.847	66	10.6	10.8	7.07	10.2	8.2	6.91	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	2A	2	15	8.5	3.030	65	10.6	10.8	7.07	10.2	8.2	6.91	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	2A	3	15	9.5	3.479	66	10.6	10.8	7.07	10.2	8.2	6.91	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	2A	4	15	10.5	4.799	68	10.6	10.8	7.07	10.2	8.2	6.91	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	2A	5	15	10.5	7.475	83	10.6	10.8	7.07	10.2	8.2	6.91	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	2B	1	15	7.5	4.113	71	10.4	10.9	7.05	10.3	7.3	7.87	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	2B	2	15	7.5	9.871	91	10.4	10.9	7.05	10.3	7.3	7.87	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	2B	3	15	8.5	6.212	75	10.4	10.9	7.05	10.3	7.3	7.87	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	2B	4	15	10.5	8.013	84	10.4	10.9	7.05	10.3	7.3	7.87	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	2B	5	15	10.5	5.434	72	10.4	10.9	7.05	10.3	7.3	7.87	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	3A	1	15	13	2.489	60	10.6	11.2	7.24	10.0	10.8	7.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	3A	2	15	22	4.934	72	10.6	11.2	7.24	10.0	10.8	7.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	3A	3	15	22	4.593	66	10.6	11.2	7.24	10.0	10.8	7.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	3A	4	15	24	9.256	87	10.6	11.2	7.24	10.0	10.8	7.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	3A	5	15	30	10.102	88	10.6	11.2	7.24	10.0	10.8	7.70	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	3B	1	15	22	5.551	74	10.7	11.1	7.21	10.0	10.8	7.54	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	3B	2	15	22	7.717	78	10.7	11.1	7.21	10.0	10.8	7.54	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	3B	3	15	22	4.935	70	10.7	11.1	7.21	10.0	10.8	7.54	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	3B	4	15	22	5.792	77	10.7	11.1	7.21	10.0	10.8	7.54	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	3B	5	15	22	4.707	75	10.7	11.1	7.21	10.0	10.8	7.54	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	4A	1	15	10.5	3.941	69	10.7	10.8	7.10	10.2	11.3	7.36	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	4A	2	15	22	8.379	86	10.7	10.8	7.10	10.2	11.3	7.36	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	4A	3	15	22	6.692	84	10.7	10.8	7.10	10.2	11.3	7.36	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	4A	4	15	22	5.735	74	10.7	10.8	7.10	10.2	11.3	7.36	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	4A	5	15	22	3.878	67	10.7	10.8	7.10	10.2	11.3	7.36	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	4B	1	15	10.5	2.776	61	10.7	10.7	7.07	10.1	11.0	7.66	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	4B	2	15	11	1.895	54	10.7	10.7	7.07	10.1	11.0	7.66	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	4B	3	15	13	2.005	55	10.7	10.7	7.07	10.1	11.0	7.66	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	4B	4	15	22	11.018	94	10.7	10.7	7.07	10.1	11.0	7.66	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
June 20/94	5	4B	5	15	22	4.100	68	10.7	10.7	7.07	10.1	11.0	7.66	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A 5: Raw data obtained during the flow-through effluent dose-EROD response experiment. Data include tank number, tank replicate (2 per concentration), effluent concentration (as determined by fluorometry), nominal effluent concentration, fish number (5 per tank), analytical number, value modifier, time to death, weight, fork length, liver weight, 7-ethoxyresorufin O-deethylase activity (EROD), condition information (those with fungus were omitted from the statistical analysis), whether the fish ate when fed, and temperature (Temp.), dissolved oxygen (DO) and pH of the tanks on various days of the experiment.

Tank Number	Tank Replicate	Effluent Conc. (%)	Nominal Conc. (%)	Fish Number	Analytical Number	Value Modifier	Time to Death (h)	Weight (g)	Fork Length (mm)	Liver Wt. (g)	EROD Activity pmol/mg/min.
4	A	0.000	0.000	1	9505015	>	168	24.5	131	0.21	3.034
4	A	0.000	0.000	2	9505016	>	168	23.3	126	0.21	4.419
4	A	0.000	0.000	3	9505017	>	168	24	135	0.19	2.58
4	A	0.000	0.000	4	9505018	>	168	17.3	112	0.1	4.197
4	A	0.000	0.000	5	9505019	>	168	13.6	107	0.15	1.732
12	B	0.000	0.000	1	9505055	>	142	13.9	110	0.18	0.224
12	B	0.000	0.000	2	9505056	>	168	11	97	0.12	2.838
12	B	0.000	0.000	3	9505057	>	168	17.4	118	0.22	2.448
12	B	0.000	0.000	4	9505058	>	168	19.1	119	0.15	5.27
12	B	0.000	0.000	5	9505059	>	168	9.1	95	0.09	6.207
6	A	0.234	0.250	1	9505025	<	70.5	5.2	68	0.05	1.571
6	A	0.234	0.250	2	9505026	>	142	19.7	116	0.14	0.382
6	A	0.234	0.250	3	9505027	>	142	13.1	109	0.11	1.48
6	A	0.234	0.250	4	9505028	>	168	14.9	113	0.13	14
6	A	0.234	0.250	5	9505029	>	168	21.1	126	0.16	9.609
11	B	0.234	0.250	1	9505050	>	168	7.2	83	0.08	16.45
11	B	0.234	0.250	2	9505051	>	168	18.1	117	0.15	29.31
11	B	0.234	0.250	3	9505052	>	168	7.5	89	0.07	24.58
11	B	0.234	0.250	4	9505053	>	168	14.4	111	0.08	25.67
11	B	0.234	0.250	5	9505054	>	168	7.5	88	0.08	10.49
1	A	0.391	0.500	1	9505000	>	168	7.2	84	0.06	12.69
1	A	0.391	0.500	2	9505001	>	168	20.5	123	0.17	16.64
1	A	0.391	0.500	3	9505002	>	168	18.2	120	0.17	38.71
1	A	0.391	0.500	4	9505003	>	168	26.1	132	0.24	41.91
1	A	0.391	0.500	5	9505004	>	168	26.2	135	0.17	28.05
10	B	0.391	0.500	1	9505045	>	142	7.7	81	0.06	3.865
10	B	0.391	0.500	2	9505046	>	168	6.9	85	0.08	3.967
10	B	0.391	0.500	3	9505047	>	168	8.8	93	0.1	10.68
10	B	0.391	0.500	4	9505048	>	168	10	98	0.11	14.38
10	B	0.391	0.500	5	9505049	>	168	21.9	129	0.18	17.9
2	A	0.940	1.000	1	9505005	>	168	15.8	115	0.18	55.8
2	A	0.940	1.000	2	9505006	>	168	18	112	0.21	65.84
2	A	0.940	1.000	3	9505007	>	168	26.6	117	0.25	78.52
2	A	0.940	1.000	4	9505008	>	168	6.8	84	0.08	11.69
2	A	0.940	1.000	5	9505009	>	168	7.4	89	0.1	11.69
8	B	0.940	1.000	1	9505035	>	168	16.4	116	0.14	45.37
8	B	0.940	1.000	2	9505036	>	168	18.9	116	0.15	19.28
8	B	0.940	1.000	3	9505037	>	168	15.7	111	0.14	35.7
8	B	0.940	1.000	4	9505038	>	168	23.1	132	0.26	56.14
8	B	0.940	1.000	5	9505039	>	168	13.7	112	0.15	21.93
5	A	2.001	2.000	1	9505020	<	70.5	26.2	127	0.4	7.559
5	A	2.001	2.000	2	9505021	<	120	20.7	119	0.13	2.974
5	A	2.001	2.000	3	9505022	<	142	7	77	0.06	2.973
5	A	2.001	2.000	4	9505023	>	142	14.9	115	0.14	2.235
5	A	2.001	2.000	5	9505024	>	168	6.6	83	0.07	3.956
9	B	2.001	2.000	1	9505040	<	73.5	16.3	112	0.11	23.81
9	B	2.001	2.000	2	9505041	<	120	21.7	126	0.16	6.843
9	B	2.001	2.000	3	9505042	<	120	10.1	92	0.02	2.972
9	B	2.001	2.000	4	9505043	<	142	21	119	0.2	3.79
9	B	2.001	2.000	5	9505044	<	167	15.7	110	0.21	2.405
3	A	3.915	4.000	1	9505010	<	50	9.5	89	0.07	10.56
3	A	3.915	4.000	2	9505011	<	50	17.9	107	0.18	2.451
3	A	3.915	4.000	3	9505012	<	50	21.7	122	0.16	1.292
3	A	3.915	4.000	4	9505013	<	50	14.7	113	0.11	2.054
3	A	3.915	4.000	5	9505014	<	50	25.2	131	0.14	5.698
7	B	3.915	4.000	1	9505030	<	50	31.5	136	0.23	1.575
7	B	3.915	4.000	2	9505031	<	50	25	130	0.22	5.732
7	B	3.915	4.000	3	9505032	<	50	13.3	104	0.06	1.354
7	B	3.915	4.000	4	9505033	<	50	20.4	119	0.13	3.751
7	B	3.915	4.000	5	9505034	<	50	22.2	125	0.15	5.511

Tank Number	Tank Replicate	Effluent Conc. (%)	Condition Information	Do fish eat when fed?	Temp day 1 (oC)	DO day 1 (mg/L)	Temp day 4 (oC)	DO day 4 (mg/L)	pH day 4	Temp day 7 (oC)	DO day 7 (mg/L)
4	A	0.000	GOOD	EAT	10.2	10.3	10.3	10.2	7.74	10.7	10.5
4	A	0.000	GOOD	EAT	10.2	10.3	10.3	10.2	7.74	10.7	10.5
4	A	0.000	GOOD	EAT	10.2	10.3	10.3	10.2	7.74	10.7	10.5
4	A	0.000	GOOD	EAT	10.2	10.3	10.3	10.2	7.74	10.7	10.5
4	A	0.000	GOOD	EAT	10.2	10.3	10.3	10.2	7.74	10.7	10.5
12	B	0.000	FUNGUS	EAT	10.5	10.4	10.6	10.6	7.81	10.9	10.9
12	B	0.000	GOOD	EAT	10.5	10.4	10.6	10.6	7.81	10.9	10.9
12	B	0.000	GOOD	EAT	10.5	10.4	10.6	10.6	7.81	10.9	10.9
12	B	0.000	GOOD	EAT	10.5	10.4	10.6	10.6	7.81	10.9	10.9
12	B	0.000	GOOD	EAT	10.5	10.4	10.6	10.6	7.81	10.9	10.9
6	A	0.234	GOOD	EAT	10.4	10.4	10.5	10.1	7.72	10.7	11.0
6	A	0.234	FUNGUS	EAT	10.4	10.4	10.5	10.1	7.72	10.7	11.0
6	A	0.234	FUNGUS	EAT	10.4	10.4	10.5	10.1	7.72	10.7	11.0
6	A	0.234	GOOD	EAT	10.4	10.4	10.5	10.1	7.72	10.7	11.0
6	A	0.234	GOOD	EAT	10.4	10.4	10.5	10.1	7.72	10.7	11.0
11	B	0.234	GOOD	EAT	10.4	10.5	10.5	10.4	7.75	10.8	10.8
11	B	0.234	GOOD	EAT	10.4	10.5	10.5	10.4	7.75	10.8	10.8
11	B	0.234	GOOD	EAT	10.4	10.5	10.5	10.4	7.75	10.8	10.8
11	B	0.234	GOOD	EAT	10.4	10.5	10.5	10.4	7.75	10.8	10.8
11	B	0.234	GOOD	EAT	10.4	10.5	10.5	10.4	7.75	10.8	10.8
1	A	0.391	GOOD	EAT	10.4	10.1	10.6	10.3	7.71	10.7	10.4
1	A	0.391	GOOD	EAT	10.4	10.1	10.6	10.3	7.71	10.7	10.4
1	A	0.391	GOOD	EAT	10.4	10.1	10.6	10.3	7.71	10.7	10.4
1	A	0.391	GOOD	EAT	10.4	10.1	10.6	10.3	7.71	10.7	10.4
1	A	0.391	GOOD	EAT	10.4	10.1	10.6	10.3	7.71	10.7	10.4
10	B	0.391	FUNGUS	EAT	10.4	10.6	10.6	10.3	7.71	10.8	10.8
10	B	0.391	GOOD	EAT	10.4	10.6	10.6	10.3	7.71	10.8	10.8
10	B	0.391	GOOD	EAT	10.4	10.6	10.6	10.3	7.71	10.8	10.8
10	B	0.391	GOOD	EAT	10.4	10.6	10.6	10.3	7.71	10.8	10.8
10	B	0.391	GOOD	EAT	10.4	10.6	10.6	10.3	7.71	10.8	10.8
2	A	0.940	GOOD	EAT	10.4	10.2	10.7	10.2	7.64	10.8	10.4
2	A	0.940	GOOD	EAT	10.4	10.2	10.7	10.2	7.64	10.8	10.4
2	A	0.940	GOOD	EAT	10.4	10.2	10.7	10.2	7.64	10.8	10.4
2	A	0.940	GOOD	EAT	10.4	10.2	10.7	10.2	7.64	10.8	10.4
2	A	0.940	GOOD	EAT	10.4	10.2	10.7	10.2	7.64	10.8	10.4
8	B	0.940	GOOD	EAT	10.3	10.5	10.3	10.6	7.68	10.8	10.7
8	B	0.940	GOOD	EAT	10.3	10.5	10.3	10.6	7.68	10.8	10.7
8	B	0.940	GOOD	EAT	10.3	10.5	10.3	10.6	7.68	10.8	10.7
8	B	0.940	GOOD	EAT	10.3	10.5	10.3	10.6	7.68	10.8	10.7
8	B	0.940	GOOD	EAT	10.3	10.5	10.3	10.6	7.68	10.8	10.7
5	A	2.001	GOOD	NOEAT	10.3	10.6	10.3	11.1	7.60	10.7	11.4
5	A	2.001	GOOD	NOEAT	10.3	10.6	10.3	11.1	7.60	10.7	11.4
5	A	2.001	GOOD	NOEAT	10.3	10.6	10.3	11.1	7.60	10.7	11.4
5	A	2.001	FUNGUS	NOEAT	10.3	10.6	10.3	11.1	7.60	10.7	11.4
5	A	2.001	GOOD	NOEAT	10.3	10.6	10.3	11.1	7.60	10.7	11.4
9	B	2.001	GOOD	NOEAT	10.5	10.6	10.6	10.8	7.60	10.9	11.3
9	B	2.001	GOOD	NOEAT	10.5	10.6	10.6	10.8	7.60	10.9	11.3
9	B	2.001	GOOD	NOEAT	10.5	10.6	10.6	10.8	7.60	10.9	11.3
9	B	2.001	GOOD	NOEAT	10.5	10.6	10.6	10.8	7.60	10.9	11.3
9	B	2.001	GOOD	NOEAT	10.5	10.6	10.6	10.8	7.60	10.9	11.3
3	A	3.915	GOOD	NOEAT	10.2	10.8	10.5	11.4	7.51	10.5	11.4
3	A	3.915	GOOD	NOEAT	10.2	10.8	10.5	11.4	7.51	10.5	11.4
3	A	3.915	GOOD	NOEAT	10.2	10.8	10.5	11.4	7.51	10.5	11.4
3	A	3.915	GOOD	NOEAT	10.2	10.8	10.5	11.4	7.51	10.5	11.4
3	A	3.915	GOOD	NOEAT	10.2	10.8	10.5	11.4	7.51	10.5	11.4
7	B	3.915	GOOD	NOEAT	10.5	10.2	10.6	11.6	7.52	10.8	11.4
7	B	3.915	GOOD	NOEAT	10.5	10.2	10.6	11.6	7.52	10.8	11.4
7	B	3.915	GOOD	NOEAT	10.5	10.2	10.6	11.6	7.52	10.8	11.4
7	B	3.915	GOOD	NOEAT	10.5	10.2	10.6	11.6	7.52	10.8	11.4
7	B	3.915	GOOD	NOEAT	10.5	10.2	10.6	11.6	7.52	10.8	11.4

Table A6: Raw data obtained during the flow-through EROD time-course experiment. Data include, phase (uptake or depuration and the day in each phase), day, tank number, tank replicate (2 per concentration), effluent concentration, fish number (5 per tank), analytical number, weight, fork length, 7-ethoxyresorufin O-deethylase activity (EROD), fish condition (only fish in good condition were used in the statistical analysis), and temperature (TEMP), dissolved oxygen (DO) and pH of the tanks on various days of the experiment.

Up/Dep Phase	Day	Tank Number	Tank Replicate	Effluent Conc. (%)	Fish Number	Analytical Number	Weight (g)	Fork Length (mm)	EROD Activity (pmol/mg/min.)	Fish Condition	TEMP 1 (oC)	DO 1 (mg/L)	TEMP2 (oC)	DO2 (mg/L)	pH2
UP1	1	1	A	1	1	9505080	18.5	121	3.19	GOOD	10.6	9.6	10.2	11.7	7.92
UP1	1	1	A	1	2	9505081	18.3	112	7.21	GOOD	10.6	9.6	10.2	11.7	7.92
UP1	1	1	A	1	3	9505082	35.1	142	8.09	GOOD	10.6	9.6	10.2	11.7	7.92
UP1	1	1	A	1	4	9505083	25.2	133	1.17	GOOD	10.6	9.6	10.2	11.7	7.92
UP1	1	1	A	1	5	9505084	26.8	130	12.42	GOOD	10.6	9.6	10.2	11.7	7.92
UP1	1	2	A	0	1	9505085	31.4	143	2.42	GOOD	10.1	9.7	9.5	11.8	8.02
UP1	1	2	A	0	2	9505086	39.2	154	8.37	GOOD	10.1	9.7	9.5	11.8	8.02
UP1	1	2	A	0	3	9505087	18.1	115	9.34	GOOD	10.1	9.7	9.5	11.8	8.02
UP1	1	2	A	0	4	9505088	27.7	129	6.69	GOOD	10.1	9.7	9.5	11.8	8.02
UP1	1	2	A	0	5	9505089	28.9	133	6.04	GOOD	10.1	9.7	9.5	11.8	8.02
UP1	1	3	B	1	1	9505090	29.8	135	11.39	GOOD	10.5	9.4	10.2	11.8	7.91
UP1	1	3	B	1	2	9505091	30.2	136	2.89	GOOD	10.5	9.4	10.2	11.8	7.91
UP1	1	3	B	1	3	9505092	34.4	141	1.69	GOOD	10.5	9.4	10.2	11.8	7.91
UP1	1	3	B	1	4	9505093	22.1	122	8.33	GOOD	10.5	9.4	10.2	11.8	7.91
UP1	1	3	B	1	5	9505094	18.8	119	6.51	GOOD	10.5	9.4	10.2	11.8	7.91
UP1	1	4	B	0	1	9505095	30.1	135	6.47	GOOD	10.2	9.9	9.8	11.8	8.09
UP1	1	4	B	0	2	9505096	31.3	137	5.04	GOOD	10.2	9.9	9.8	11.8	8.09
UP1	1	4	B	0	3	9505097	24.3	130	9.33	GOOD	10.2	9.9	9.8	11.8	8.09
UP1	1	4	B	0	4	9505098	25.4	136	9.27	GOOD	10.2	9.9	9.8	11.8	8.09
UP1	1	4	B	0	5	9505099	35.2	145	5.49	GOOD	10.2	9.9	9.8	11.8	8.09
UP2	2	1	A	1	1	9505100	23.9	124	22.71	GOOD	10.6	9.5	10.2	11.7	7.92
UP2	2	1	A	1	2	9505101	32.4	139	46.75	GOOD	10.6	9.5	10.2	11.7	7.92
UP2	2	1	A	1	3	9505102	37.9	154	12.02	GOOD	10.6	9.5	10.2	11.7	7.92
UP2	2	1	A	1	4	9505103	25.3	134	16.91	GOOD	10.6	9.5	10.2	11.7	7.92
UP2	2	1	A	1	5	9505104	36.3	139	11.82	GOOD	10.6	9.5	10.2	11.7	7.92
UP2	2	2	A	0	1	9505105	10.6	93	5.69	GOOD	10.1	9.7	9.5	11.8	8.02
UP2	2	2	A	0	2	9505106	24.4	133	4.25	GOOD	10.1	9.7	9.5	11.8	8.02
UP2	2	2	A	0	3	9505107	22.1	120	3.59	GOOD	10.1	9.7	9.5	11.8	8.02
UP2	2	2	A	0	4	9505108	33.4	145	2.90	GOOD	10.1	9.7	9.5	11.8	8.02
UP2	2	2	A	0	5	9505109	35.8	139	3.56	GOOD	10.1	9.7	9.5	11.8	8.02
UP2	2	3	B	1	1	9505110	18.2	117	10.41	GOOD	10.6	9.2	10.2	11.8	7.91
UP2	2	3	B	1	2	9505111	35.7	146	53.27	GOOD	10.6	9.2	10.2	11.8	7.91
UP2	2	3	B	1	3	9505112	38.4	148	33.29	GOOD	10.6	9.2	10.2	11.8	7.91
UP2	2	3	B	1	4	9505113	20.0	118	8.91	GOOD	10.6	9.2	10.2	11.8	7.91
UP2	2	3	B	1	5	9505114	29.7	140	25.68	GOOD	10.6	9.2	10.2	11.8	7.91
UP2	2	4	B	0	1	9505115	22.6	127	4.30	GOOD	10.4	10.0	9.8	11.8	8.09
UP2	2	4	B	0	2	9505116	16.5	115	4.94	GOOD	10.4	10.0	9.8	11.8	8.09
UP2	2	4	B	0	3	9505117	24.8	128	4.12	GOOD	10.4	10.0	9.8	11.8	8.09
UP2	2	4	B	0	4	9505118	45.9	158	3.22	GOOD	10.4	10.0	9.8	11.8	8.09
UP2	2	4	B	0	5	9505119	43.1	160	4.81	GOOD	10.4	10.0	9.8	11.8	8.09
UP4	4	1	A	1	1	9505120	47.8	162	6.37	GOOD	10.2	10.3	10.2	11.7	7.92
UP4	4	1	A	1	2	9505121	33.6	147	60.68	GOOD	10.2	10.3	10.2	11.7	7.92
UP4	4	1	A	1	3	9505122	28.7	142	33.45	GOOD	10.2	10.3	10.2	11.7	7.92
UP4	4	1	A	1	4	9505123	26.8	132	7.74	GOOD	10.2	10.3	10.2	11.7	7.92
UP4	4	1	A	1	5	9505124	24.3	127	16.99	GOOD	10.2	10.3	10.2	11.7	7.92
UP4	4	2	A	0	1	9505125	38.4	155	1.98	GOOD	9.7	10.4	9.5	11.8	8.02
UP4	4	2	A	0	2	9505126	27.9	135	2.69	GOOD	9.7	10.4	9.5	11.8	8.02
UP4	4	2	A	0	3	9505127	34.6	147	8.59	GOOD	9.7	10.4	9.5	11.8	8.02
UP4	4	2	A	0	4	9505128	40.5	152	1.58	GOOD	9.7	10.4	9.5	11.8	8.02
UP4	4	2	A	0	5	9505129	9.4	95	2.88	GOOD	9.7	10.4	9.5	11.8	8.02
UP4	4	3	B	1	1	9505130	20.1	121	31.50	GOOD	10.3	10.2	10.2	11.8	7.91
UP4	4	3	B	1	2	9505131	32.1	140	23.57	GOOD	10.3	10.2	10.2	11.8	7.91
UP4	4	3	B	1	3	9505132	28.5	133	13.75	GOOD	10.3	10.2	10.2	11.8	7.91
UP4	4	3	B	1	4	9505133	33.5	144	72.85	GOOD	10.3	10.2	10.2	11.8	7.91
UP4	4	3	B	1	5	9505134	26.7	138	34.90	GOOD	10.3	10.2	10.2	11.8	7.91
UP4	4	4	B	0	1	9505135	24.9	130	2.76	GOOD	9.9	10.4	9.8	11.8	8.09
UP4	4	4	B	0	2	9505136	14.9	115	2.75	GOOD	9.9	10.4	9.8	11.8	8.09
UP4	4	4	B	0	3	9505137	37.7	146	3.67	GOOD	9.9	10.4	9.8	11.8	8.09
UP4	4	4	B	0	4	9505138	29.9	140	5.03	GOOD	9.9	10.4	9.8	11.8	8.09
UP4	4	4	B	0	5	9505139	11.5	111	3.55	GOOD	9.9	10.4	9.8	11.8	8.09
UP8	8	1	A	1	1	9505140	25.8	128	3.05	SICK	11.2	10.0	10.2	11.7	7.92
UP8	8	1	A	1	2	9505141	28.6	140	43.24	GOOD	11.2	10.0	10.2	11.7	7.92
UP8	8	1	A	1	3	9505142	19.1	110	12.32	GOOD	11.2	10.0	10.2	11.7	7.92
UP8	8	1	A	1	4	9505143	25.1	133	21.00	GOOD	11.2	10.0	10.2	11.7	7.92
UP8	8	1	A	1	5	9505144	12.2	97	24.54	GOOD	11.2	10.0	10.2	11.7	7.92
UP8	8	2	A	0	1	9505145	36.7	150	10.07	GOOD	10.6	10.0	9.5	11.8	8.02
UP8	8	2	A	0	2	9505146	30.6	138	2.66	GOOD	10.6	10.0	9.5	11.8	8.02
UP8	8	2	A	0	3	9505147	25.3	133	1.79	GOOD	10.6	10.0	9.5	11.8	8.02
UP8	8	2	A	0	4	9505148	12.3	109	6.63	GOOD	10.6	10.0	9.5	11.8	8.02
UP8	8	2	A	0	5	9505149	25.8	138	4.03	GOOD	10.6	10.0	9.5	11.8	8.02
UP8	8	3	B	1	1	9505150	20.4	119	25.41	GOOD	11.2	10.0	10.2	11.8	7.91
UP8	8	3	B	1	2	9505151	28.5	139	9.83	SICK	11.2	10.0	10.2	11.8	7.91
UP8	8	3	B	1	3	9505152	22.8	133	30.56	GOOD	11.2	10.0	10.2	11.8	7.91
UP8	8	3	B	1	4	9505153	31.4	148	37.82	GOOD	11.2	10.0	10.2	11.8	7.91
UP8	8	3	B	1	5	9505154	8.6	89	51.18	GOOD	11.2	10.0	10.2	11.8	7.91
UP8	8	4	B	0	1	9505155	24.2	130	2.23	GOOD	10.8	10.9	9.8	11.8	8.09
UP8	8	4	B	0	2	9505156	24.6	134	2.62	GOOD	10.8	10.9	9.8	11.8	8.09
UP8	8	4	B	0	3	9505157	6.6	80	1.79	GOOD	10.8	10.9	9.8	11.8	8.09
UP8	8	4	B	0	4	9505158	38.9	156	3.97	GOOD	10.8	10.9	9.8	11.8	8.09
UP8	8	4	B	0	5	9505159	26.3	137	4.13	GOOD	10.8	10.9	9.8	11.8	8.09

Up/Dep Phase	Day	Tank Number	Tank Replicate	Effluent Conc. (%)	Fish Number	Analytical Number	Weight (g)	Fork Length (mm)	EROD Activity (pmol/mg/min.)	Fish Condition	TEMP 1 (oC)	DO 1 (mg/L)	TEMP2 (oC)	DO2 (mg/L)	pH2
DEP1	9	1	A	1	1	9505160	13.0	92	14.80	GOOD	9.6	10.8	10.2	11.7	7.92
DEP1	9	1	A	1	2	9505161	23.8	129	35.19	GOOD	9.6	10.8	10.2	11.7	7.92
DEP1	9	1	A	1	3	9505162	30.6	140	36.72	GOOD	9.6	10.8	10.2	11.7	7.92
DEP1	9	1	A	1	4	9505163	17.1	118	55.87	GOOD	9.6	10.8	10.2	11.7	7.92
DEP1	9	1	A	1	5	9505164	22.3	128	56.91	GOOD	9.6	10.8	10.2	11.7	7.92
DEP1	9	2	A	0	1	9505165	7.7	88	9.38	GOOD	9.8	10.4	9.5	11.8	8.02
DEP1	9	2	A	0	2	9505166	30.8	141	4.32	GOOD	9.8	10.4	9.5	11.8	8.02
DEP1	9	2	A	0	3	9505167	33.2	148	4.13	GOOD	9.8	10.4	9.5	11.8	8.02
DEP1	9	2	A	0	4	9505168	36.3	157	4.12	GOOD	9.8	10.4	9.5	11.8	8.02
DEP1	9	2	A	0	5	9505169	11.3	99	3.80	GOOD	9.8	10.4	9.5	11.8	8.02
DEP1	9	3	B	1	1	9505170	21.5	126	38.55	GOOD	10.4	10.6	10.2	11.8	7.91
DEP1	9	3	B	1	2	9505171	19.1	124	4.99	GOOD	10.4	10.6	10.2	11.8	7.91
DEP1	9	3	B	1	3	9505172	27.1	140	90.49	GOOD	10.4	10.6	10.2	11.8	7.91
DEP1	9	3	B	1	4	9505173	26.2	136	42.37	GOOD	10.4	10.6	10.2	11.8	7.91
DEP1	9	3	B	1	5	9505174	12.6	112	13.54	GOOD	10.4	10.6	10.2	11.8	7.91
DEP1	9	4	B	0	1	9505175	14.0	118	2.89	GOOD	10.0	10.9	9.8	11.8	8.09
DEP1	9	4	B	0	2	9505176	16.1	116	4.41	GOOD	10.0	10.9	9.8	11.8	8.09
DEP1	9	4	B	0	3	9505177	33.2	142	4.95	GOOD	10.0	10.9	9.8	11.8	8.09
DEP1	9	4	B	0	4	9505178	30.6	140	2.54	GOOD	10.0	10.9	9.8	11.8	8.09
DEP1	9	4	B	0	5	9505179	33.2	152	3.40	GOOD	10.0	10.9	9.8	11.8	8.09
DEP2	10	1	A	1	1	9505180	24.1	124	50.22	GOOD	10.3	10.8	10.2	11.7	7.92
DEP2	10	1	A	1	2	9505181	34.8	146	65.13	GOOD	10.3	10.8	10.2	11.7	7.92
DEP2	10	1	A	1	3	9505182	23.1	127	14.69	GOOD	10.3	10.8	10.2	11.7	7.92
DEP2	10	1	A	1	4	9505183	30.9	143	31.42	GOOD	10.3	10.8	10.2	11.7	7.92
DEP2	10	1	A	1	5	9505184	20.3	128	21.78	GOOD	10.3	10.8	10.2	11.7	7.92
DEP2	10	2	A	0	1	9505185	23.2	129	3.92	GOOD	10.2	10.7	9.5	11.8	8.02
DEP2	10	2	A	0	2	9505186	25.8	130	2.42	GOOD	10.2	10.7	9.5	11.8	8.02
DEP2	10	2	A	0	3	9505187	21.0	130	3.33	GOOD	10.2	10.7	9.5	11.8	8.02
DEP2	10	2	A	0	4	9505188	16.8	112	3.01	GOOD	10.2	10.7	9.5	11.8	8.02
DEP2	10	2	A	0	5	9505189	8.0	91	4.12	GOOD	10.2	10.7	9.5	11.8	8.02
DEP2	10	3	B	1	1	9505190	28.2	143	2.15	GOOD	11.0	10.6	10.2	11.8	7.91
DEP2	10	3	B	1	2	9505191	22.2	124	14.54	GOOD	11.0	10.6	10.2	11.8	7.91
DEP2	10	3	B	1	3	9505192	34.3	146	5.56	SICK	11.0	10.6	10.2	11.8	7.91
DEP2	10	3	B	1	4	9505193	19.6	124	3.18	GOOD	11.0	10.6	10.2	11.8	7.91
DEP2	10	3	B	1	5	9505194	9.0	95	6.27	GOOD	11.0	10.6	10.2	11.8	7.91
DEP2	10	4	B	0	1	9505195	26.2	133	2.75	GOOD	10.4	10.6	9.8	11.8	8.09
DEP2	10	4	B	0	2	9505196	27.6	133	3.53	GOOD	10.4	10.6	9.8	11.8	8.09
DEP2	10	4	B	0	3	9505197	25.5	134	5.02	GOOD	10.4	10.6	9.8	11.8	8.09
DEP2	10	4	B	0	4	9505198	30.4	148	2.71	GOOD	10.4	10.6	9.8	11.8	8.09
DEP2	10	4	B	0	5	9505199	16.4	111	3.88	GOOD	10.4	10.6	9.8	11.8	8.09
DEP4	12	1	A	1	1	9505200	40.3	158	25.34	GOOD	10.2	11.2	10.2	11.7	7.92
DEP4	12	1	A	1	2	9505201	6.9	86	20.97	GOOD	10.2	11.2	10.2	11.7	7.92
DEP4	12	1	A	1	3	9505202	34.3	151	16.10	GOOD	10.2	11.2	10.2	11.7	7.92
DEP4	12	1	A	1	4	9505203	28.9	142	13.38	GOOD	10.2	11.2	10.2	11.7	7.92
DEP4	12	1	A	1	5	9505204	23.7	125	18.57	GOOD	10.2	11.2	10.2	11.7	7.92
DEP4	12	2	A	0	1	9505205	24.3	131	4.63	GOOD	10.0	11.0	9.5	11.8	8.02
DEP4	12	2	A	0	2	9505206	24.1	131	3.44	GOOD	10.0	11.0	9.5	11.8	8.02
DEP4	12	2	A	0	3	9505207	39.6	156	5.18	GOOD	10.0	11.0	9.5	11.8	8.02
DEP4	12	2	A	0	4	9505208	25.5	135	15.49	GOOD	10.0	11.0	9.5	11.8	8.02
DEP4	12	2	A	0	5	9505209	21.6	126	6.67	GOOD	10.0	11.0	9.5	11.8	8.02
DEP4	12	3	B	1	1	9505210	21.9	131	4.43	GOOD	10.6	10.8	10.2	11.8	7.91
DEP4	12	3	B	1	2	9505211	24.0	135	28.68	GOOD	10.6	10.8	10.2	11.8	7.91
DEP4	12	3	B	1	3	9505212	13.2	116	12.75	GOOD	10.6	10.8	10.2	11.8	7.91
DEP4	12	3	B	1	4	9505213	20.9	121	3.11	GOOD	10.6	10.8	10.2	11.8	7.91
DEP4	12	3	B	1	5	9505214	24.7	134	2.90	GOOD	10.6	10.8	10.2	11.8	7.91
DEP4	12	4	B	0	1	9505215	28.2	138	5.42	GOOD	10.4	11.1	9.8	11.8	8.09
DEP4	12	4	B	0	2	9505216	34.5	147	3.13	GOOD	10.4	11.1	9.8	11.8	8.09
DEP4	12	4	B	0	3	9505217	22.3	130	3.12	GOOD	10.4	11.1	9.8	11.8	8.09
DEP4	12	4	B	0	4	9505218	31.3	142	2.69	GOOD	10.4	11.1	9.8	11.8	8.09
DEP4	12	4	B	0	5	9505219	25.8	126	2.34	GOOD	10.4	11.1	9.8	11.8	8.09
DEP8	16	1	A	1	1	9505220	12.9	104	5.98	GOOD	10.1	11.2	10.2	11.7	7.92
DEP8	16	1	A	1	2	9505221	24.8	133	7.07	GOOD	10.1	11.2	10.2	11.7	7.92
DEP8	16	1	A	1	3	9505222	16.5	115	7.25	GOOD	10.1	11.2	10.2	11.7	7.92
DEP8	16	1	A	1	4	9505223	28.1	140	4.57	GOOD	10.1	11.2	10.2	11.7	7.92
DEP8	16	1	A	1	5	9505224	35.8	156	2.13	GOOD	10.1	11.2	10.2	11.7	7.92
DEP8	16	2	A	0	1	9505225	23.3	131	6.92	GOOD	10.2	11.2	9.5	11.8	8.02
DEP8	16	2	A	0	2	9505226	39.6	158	5.16	GOOD	10.2	11.2	9.5	11.8	8.02
DEP8	16	2	A	0	3	9505227	49.6	171	2.04	GOOD	10.2	11.2	9.5	11.8	8.02
DEP8	16	2	A	0	4	9505228	8.3	90	4.97	GOOD	10.2	11.2	9.5	11.8	8.02
DEP8	16	2	A	0	5	9505229	33.2	148	3.37	GOOD	10.2	11.2	9.5	11.8	8.02
DEP8	16	3	B	1	1	9505230	20.3	119	4.13	GOOD	11.0	11.1	10.2	11.8	7.91
DEP8	16	3	B	1	2	9505231	15.4	109	4.41	GOOD	11.0	11.1	10.2	11.8	7.91
DEP8	16	3	B	1	3	9505232	27.6	135	2.59	GOOD	11.0	11.1	10.2	11.8	7.91
DEP8	16	3	B	1	4	9505233	27.9	143	3.29	GOOD	11.0	11.1	10.2	11.8	7.91
DEP8	16	3	B	1	5	9505234	24.5	133	2.68	SICK	11.0	11.1	10.2	11.8	7.91
DEP8	16	4	B	0	1	9505235	22.6	126	1.68	SICK	10.8	11.2	9.8	11.8	8.09
DEP8	16	4	B	0	2	9505236	10.1	95	3.59	GOOD	10.8	11.2	9.8	11.8	8.09
DEP8	16	4	B	0	3	9505237	39.4	150	7.15	GOOD	10.8	11.2	9.8	11.8	8.09
DEP8	16	4	B	0	4	9505238	30.1	141	4.19	GOOD	10.8	11.2	9.8	11.8	8.09
DEP8	16	4	B	0	5	9505239	12.3	113	2.24	GOOD	10.8	11.2	9.8	11.8	8.09
DEP18	26	1	A	1	1	9505240	14.1	111	3.92	GOOD	-	-	10.2	11.7	7.92
DEP18	26	1	A	1	2	9505241	45.3	164	5.29	GOOD	-	-	10.2	11.7	7.92
DEP18	26	1	A	1	3	9505242	38.7	157	3.49	GOOD	-	-	10.2	11.7	7.92
DEP18	26	1	A	1	4	9505243	9.2	95	4.60	GOOD	-	-	10.2	11.7	7.92

Up/Dep Phase	Day	Tank Number	Tank Replicate	Effluent Conc. (%)	Fish Number	Analytical Number	Weight (g)	Fork Length (mm)	EROD Activity (pmol/mg/min.)	Fish Condition	TEMP 1 (oC)	DO 1 (mg/L)	TEMP2 (oC)	DO2 (mg/L)	pH2
DEP18	26	1	A	1	5	9505244	12.5	107	1.59	GOOD	-	-	10.2	11.7	7.92
DEP18	26	2	A	0	1	9505245	11.1	98	2.62	GOOD	-	-	9.5	11.8	8.02
DEP18	26	2	A	0	2	9505246	36.0	156	7.20	GOOD	-	-	9.5	11.8	8.02
DEP18	26	2	A	0	3	9505247	24.4	130	5.02	GOOD	-	-	9.5	11.8	8.02
DEP18	26	2	A	0	4	9505248	43.7	160	4.34	GOOD	-	-	9.5	11.8	8.02
DEP18	26	2	A	0	5	9505249	22.2	127	9.29	GOOD	-	-	9.5	11.8	8.02
DEP18	26	3	B	1	1	9505250	26.5	135	4.82	GOOD	-	-	10.2	11.8	7.91
DEP18	26	3	B	1	2	9505251	26.3	130	3.00	GOOD	-	-	10.2	11.8	7.91
DEP18	26	3	B	1	3	9505252	28.6	140	5.42	GOOD	-	-	10.2	11.8	7.91
DEP18	26	3	B	1	4	9505253	19.7	122	1.94	GOOD	-	-	10.2	11.8	7.91
DEP18	26	3	B	1	5	9505254	35.2	146	4.08	GOOD	-	-	10.2	11.8	7.91
DEP18	26	4	B	0	1	9505255	31.2	140	3.27	GOOD	-	-	9.8	11.8	8.09
DEP18	26	4	B	0	2	9505256	37.9	157	1.19	GOOD	-	-	9.8	11.8	8.09
DEP18	26	4	B	0	3	9505257	22.7	127	2.10	GOOD	-	-	9.8	11.8	8.09
DEP18	26	4	B	0	4	9505258	11.6	103	7.73	GOOD	-	-	9.8	11.8	8.09
DEP18	26	4	B	0	5	9505259	15.5	113	3.38	GOOD	-	-	9.8	11.8	8.09