Sublethal Toxicological Stress in Adult Sockeye Salmon (*Oncorhynchus nerka*) Exposed to a Combination of Sodium Pentachlorophenate and Fresh Water Hypoxia

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SUBLETHAL TOXICOLOGICAL STRESS IN ADULT SOCKEYE SALMON (*ONCORHYNCHUS NERKA*) EXPOSED TO A COMBINATION OF SODIUM PENTACHLOROPHENATE AND FRESH WATER HYPOXIA

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ABSTRACT

Korstrom, J.S., R. Fink, S. Spohn and I.K. Birtwell. 1996. Sublethal toxicological stress in adult sockeye salmon (*Oncorhynchus nerka*) exposed to a combination of sodium pentachlorphenate and fresh water hypoxia. Can. Data Rep. Fish. Aquat. Sci. ???: ?? p.

This study examined the combined sublethal effects of hypoxic fresh water and sodium pentachlorophenate on adult sockeye salmon (*Oncorhynchus nerka*) from Alberni Inlet, British Columbia.

Changes in sustained swimming performance and respiratory frequency were used as indicators of sublethal effects. Assessment of swimming stamina consisted of exposing control and treatment groups of 3 - 8 fish for 30 h to sublethal concentrations of sodium pentachlorophenate (3.9 - 46.0 $\mu g \cdot L^{-1}$) in annular swim chambers, under normoxic (70 - 90% air saturation) or hypoxic (30 - 40% air saturation) conditions, in fresh water (17.5 - 21 °C). Fish were then challenged to swim in 20.0°C fresh water for 6 h against a fixed water velocity of 50 $cm \cdot s^{-1}$ (0.90 body $lengths \cdot s^{-1}$). Following an 18 h recovery period, the fish were challenged again with a 6 h swim test. The temperature, salinity, and dissolved oxygen conditions simulated those which may be encountered by adult sockeye salmon during their spawning migration through Alberni Inlet into the Somass River.

The ventilatatory and cough frequency of the fish were monitored in relation to normoxic and hypoxic conditions under two temperature regimes, and during acclimation in salt water. Quantification of the respiration rate ascertained whether an increased energetic demand was placed on the fish due to the imposition of experimental conditions. Length, weight, and sex were recorded for each fish at the conclusion of each experiment. Scales were collected for age determination plus bile and liver samples to assess the effects of sodium pentachlorphenate on steroid metabolism.

Key words: adult sockeye salmon, swimming performance, respiratory frequency, hypoxic fresh water, sodium pentachlorophenate

RÉSUMÉ

Korstrom, J.S., R. Fink, S. Spohn and I.K. Birtwell. 1996. Sublethal toxicological stress in adult sockeye salmon (*Oncorhynchus nerka*) exposed to a combination of sodium pentachlorphenate and fresh water hypoxia. Can. Data Rep. Fish. Aquat. Sci. ???: ?? p.

Notre étude a porté sur les effets sublétaux combinés de l'eau douce hypoxique et du pentachlorophénate de sodium sur les saumons rouges (*Oncorhynchus nerka*) adultes de l'inlet Alberni (Colombie-Britannique).

Nous avons considéré les changements dans la performance de nage soutenue et la fréquence respiratoire comme indicateurs d'effets sublétaux. Pour mesurer l'endurance à la nage, nous avons exposé des groupes témoins et des groupes d'étude de 3-8 poissons pendant 30 h à des concentrations sublétales de pentachlorophénate de sodium (3,9 - 46,0 $\mu g.L^{-1}$) dans des enceintes annulaires, dans des conditions de normoxie (70-90 % de saturation en air) ou d'hypoxie (30-40 % de saturation en air), en eau douce (17,5-21 C). Les poissons ont ensuite été soumis à un test de nage d'une durée de 6 h en eau douce à 20,0 C contre un courant à vitesse fixe de 50 $cm \cdot s^{-1}$ (0,90 longueurs corporelles$\cdot s^{-1}$). Après une période de récupération de 18 h, les poissons ont subi un deuxième test de nage de 6 h. Les conditions de température, de salinité et de concentration de l'oxygène dissous simulaient alors celles que peuvent rencontrer les saumons rouges adultes pendant leur migration génésique, qui passe par l'inlet Alberni pour les mener à la rivière Somass.

La fréquence de ventilation et de bâillement des poissons a été surveillée par rapport aux conditions de normoxie et d'hypoxie sous deux régimes de température, et pendant l'acclimatement à l'eau salée. La quantification de la fréquence respiratoire a permis de vérifier si l'imposition des conditions expérimentales exerçait une demande énergétique supérieure sur les poissons. À la fin de chaque expérience, on a consigné la longueur, le poids et le sexe de chaque poisson. Des écailles ont été prélevées en vue de la détermination de l'âge, et des échantillons de bile et de foie ont servi à mesurer les effets du pentachlorophénate de sodium sur le métabolisme des stéroïdes.

Mots clés : saumon rouge adulte, performance de nage, fréquence respiratoire, eau douce hypoxique, pentachlorophénate de sodium

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INTRODUCTION

Persistent hypoxic conditions exist in the sub-halocline waters of the Somass River estuary at the head of 45 km long Alberni Inlet, British Columbia. These conditions are related to a naturally slow flushing rate and the biological oxygen demand of organic material in effluent from a pulp and paper mill. Over the last forty years the discharge of effluent into the freshwater lens of the highly stratified estuary, has contributed to a decline in the dissolved oxygen concentrations of these surface waters by an average of $1 mg \cdot L^{-1}$ from pre-discharge conditions. Over the same period the corresponding decline in the deeper sub-halocline waters has been about $4 mg \cdot L^{-1}$, a reduction of almost 60% (Stucchi et al. 1990, unpubl. data). The progressive deterioration in the aquatic habitat of Alberni Inlet, and especially the concern about valuable salmon resources, prompted reviews by federal and provincial government agencies and the forest products industry.

The ecological success of salmonids in estuarine environments with reduced water quality and industrial pollutants depends in part on their ability to sense variations in physio-chemical factors and to employ the appropriate compensatory mechanisms in a timely manner. If migrating salmon encounter suboptimal habitats, e.g., hypoxic waters, toxic effluents, and thermal layers, the accrued compensatory energetic costs may have consequences in terms of both survival and successful reproduction because of their reliance on finite energy reserves. Reduced reproductive potential is possible as a portion of the energy allocated for gamete production and spawning activities may be used during migration (Gilhousen 1980) resulting in the gradual decline of the fish population.

This report presents data on one aspect of a multi-disciplinary study which investigates the physiology and behavior of adult sockeye to simulated aquatic conditions in the laboratory. The few studies which investigate the effects of industrial effluent on sockeye salmon (Davis 1973), provided additional impetus for an examination of the interaction of hypoxic waters and contaminants (such as resin acids and chlorinated phenolics), on their ability to migrate through warm (20.0°C) fresh water.

The focus of this document is on pentachlorphenol and its sodium salt sodium pentachlorophenate (NaPCP) which enter aquatic ecosystems through their extensive use in the agriculture and timber industies as herbicides, bactericides, insecticides and fungicides (Webb and Brett 1973). These chemicals are powerful metabolic poisons which uncouple oxidative phosphorylation (Holmberg and Saunders 1979) in most organisms.

It was recognized that measured indicators of environmental stress may be categorized on different levels of biological integration which range from the biochemical level to the ecosystem level. In this study swimming performance and respiration were examined in relation to conditions which adult sockeye salmon may confront during their migration to natal lakes. Ventilation frequency is a physiological variable and swimming stamina is considered a performance capacity variable (Heath 1990) and both responses segregate along gradients of toxicological and ecological relevance and response time (Adams 1990).

In agreement, Walden (1976) reported that sublethal concentrations of pulp mill effluent affected fish respiration, and fish stamina which is an important sublethal parameter measured most frequently by swimming performance.

Respirometry has been used to assess toxicological stress and the energetic cost of breathing and oxygen uptake, as the difference between resting and active metabolism is easily quantifiable by counting opercular beats per minute (Schreck 1990). An increase in respiration rate is also considered to be the initial response to hypoxia and this elevation in gill ventilation is mediated through increases in ventilatory frequency and ventilatory stroke volume (Tetens and Lykkeboe 1985; Claireaux et al. 1988; Jensen et al. 1993). Accordingly, it reflects the ability of salmonids to compensate for decreased oxygen carrying capacity and oxygen affinity through adjustments of the respiratory system. In sustained long-term hypoxia, increases in ventilation, which require a considerable amount of energy (Marvin and Heath 1968), may lead to a serious depletion of the finite energy stores of the fish which are otherwise reserved for migration and reproductive activities.

Performance tests such as those applied in this study, measure the capacity of fish to carry out essential life processes (Schreck 1990) such as swimming, an ability which is especially important to salmon on a spawning migration (Sprague 1971). If fish suffer from the consequences of toxicological stress, their performance could be impaired (Schreck 1990) and, therefore, measurement of swimming ability is one of the "best" means of evaluating sublethal effects (Cairns 1966). One such performance capacity measure is a fixed velocity swim challenge which tests stamina by encouraging fish to swim against a current for a pre-determined length of time.

MATERIALS AND METHODS

FISH CAPTURE AND MAINTENANCE

Adult sockeye salmon (predominantly aged 4^+ and 5^+ years) were captured by the commercial seiner *Argent 1* in Alberni Inlet and individually transferred into and out of salt water in the ship's hold using a low abrasion dipnet. On July 9, 1996, 62 fish were caught and on July 16, 1996, 54 fish were caught near China Creek (Figure 1) and transported via the seiner within 1 h to the Port Alberni Wharf. Transport to outdoor sea water holding facilities at the West Vancouver Laboratory was accomplished using a truck fitted with an insulated fibreglass tank supplied with compressed oxygen and containing 500 g Ammomex, (Argent Chemical Laboratories, Redmond, WA) a natural clay that rapidly binds to, and eliminates, ammonia. To reduce stress due to handling and thereby facilitate transfer into the outdoor tanks, the fish were mildly anaesthetized during transit with 0.25 $mg \cdot L^{-1}$ metomidate hydrochloride (Syndel Laboratories, Vancouver, BC) in an approximately isosmotic mixture of fresh and sea water (2:1) of 6.4°C - 9.8°C.

The salmon (mean weight 1750 g ± 347 g; fork length 55.5 cm, ± 3.1 cm) were maintained in 3500 L tanks continuously supplied with air-equilibrated salt water (salinity 23 - 30.5 ‰, temperature 10.0 - 12.9 °C, and dissolved oxygen 7.8 - 10.2 $mg \cdot L^{-1}$). Water flow was delivered to the tanks at approximately 46 $L \cdot min^{-1}$ which ensured a 90% replacement within 3 h (Sprague 1969), and fish density was maintained at ≤ 2 $kg \cdot m^{-3}$ (Table 1). The salmon were held under a natural photoperiod and were not fed throughout the 5 - 11 wk acclimation period prior to experiments.

The spawning season is a period of increased susceptibility to disease (Pickering and Christie 1980) and the stress induced from encountering oxygen depleted habitats during their spawning migration may predispose the fish to infection (Jensen et al. 1993). Accordingly, the antibiotic chloramine-T (N-sodium-N-chloro-*para*-toluenesulphonamide) was used for the therapeutic treatment of suspected salt water vibriosis (*Vibrio sp.*) as well as a prophylactic treatment against bacterial gill disease and associated fin rot (*Sporocytophaga sp.*). All experimental fish were exposed for 1 h to 8.5 $mg \cdot L^{-1}$ chloramine-T (Syndel Laboratories, Vancouver, BC) in an aerated static bath, with a second treatment administered 24 h later. Subsequently, the fish were allowed a recovery period of at least 4 wks: no mortality was observed in the 2 wks prior to starting experiments.

HYPOXIC WATER

A vacuum degasser (Point Four Systems, Coquitlam, BC) was used to generate hypoxic sea water. Degassing was accomplished by exposing incoming water to a partial vacuum within a 25 x 350 cm PVC column. The magnitude of the vacuum regulated the degree of degassing that occured. The control of sea water level in the degasser column was maintained through dynamic equilibrium. Sea water supplied through a PVC ball valve (27.5 $L \cdot min^{-1}$) entered the top of, and was dispersed down, the packed (1" Koch flexi-rings) degasser column. Effluent water passed via a 3/4 HP Grundfos single stage impeller pump (Grundfos Pumps Corp., Clovis, CA) through a PVC ball valve to a 40L polyethylene header tank and from there was distributed to two swim chambers. Excess input water was discharged to waste using a stainless steel bypass solenoid valve controlled by a float-activated switch located in the degasser column at the air - water interface.

Measurement and control of dissolved oxygen concentration in the effluent water from the degasser column was achieved through a feedback control loop using a temperature compensated galvanic cell oxygen probe with a multichannel oxygen monitoring unit (Oxyguard Model 1W; Point Four Systems Inc.,Coquitlam, BC, accuracy ± 2.0% saturation). The oxygen controller, in combination with a solenoid valve located on the vacuum line to an aspirator, regulated the absolute pressure within the degassser column. An aspirator was used to evacuate accumulated gas from the column and maintain the desired vacuum. In performance tests conducted on the degasser, a lower operating limit of 14.5% (1.9 $mg \cdot L^{-1}$) dissolved oxygen saturation

level in column effluent was maintained with a water input of 38 $L \cdot min^{-1}$ (salinity 0 ‰, temperature 1 ^{0}C) and a column pressure of 50 mmHg absolute.

SWIM CHAMBERS

The test apparatus (Figure 2) consisted of two 1600 L annular fibreglass raceways (outside length 343 cm, depth 41 cm, width 46 cm) each equipped with a variable output stainless steel boat motor and propellor to provide a controlled flow. Clear plexiglass (10 mm thick) sealed the raceways and was overlain with black polyethylene screens to minimize external disturbances and algal growth. A two-chambered PVC trough (length 122 cm, width 20 cm, depth 30 cm) was arranged within each straight section of a raceway to accomodate two fish side by side. A horizontal grid (1.5 cm spacing of 1 mm stainless steel welding wire) was attached to each end of the trough preventing fish escape. During a swim test the downstream end of each trough was electrified (0 - 9 V pulsed DC current at 0.5 A) to prevent fish from resting.

Light entered the raceways through aluminum cylinders (25cm diameter x 40cm deep) positioned at each end of the test troughs. Water was continuously delivered to the raceways at a rate of 10 $L \cdot min^{-1}$ which corresponded to a 90% replacement time of approxmately 6 h (Sprague 1969). As per Bell and Terhune (1970) straightener vanes located upstream of the test troughs, corrected rotational disturbances introduced by the propellers and smoothed the velocity profile within test sections of the raceways. The correction calculation for flow interference effects such as solid blocking, was ignored, as only 10% of the test trough cross sectional area was occupied by the fish and therefore velocity increases would be minimal (Bell and Terhune 1970). Dissolved oxygen and temperature (Oxyguard PT4 Multichannel Oxygen and Temperature Monitoring System; Point Four Systems Inc. Coquitlam, BC) plus conductivity (Uniloc Model 112 Conductivity Sensor in conjunction with a Uniloc Model 750 Conductivity Analyzer/Transmitter, Rosemount Analytical Instruments Ltd., Uniloc Division, Irvine, CA) in the swim chambers was recorded continuously (Figures 3 - 9, Tables 2 - 8).

TEST CHEMICAL

A stock solution of sodium pentachlorophenate (NaPCP) was made by dissolving 6.659 g of reagent grade pentachlorophenol (MW 266.34) of 99% purity (Aldrich Chemical Company, Milwaukee, WI) in 25 ml of 1 normal sodium hydroxide (Fisher Scientific Ltd., Nepean, ON). The resulting solution was diluted to 1 L with distilled water according to the procedure of Alderdice (1963). The stock solution contained 7209 $mg \cdot L^{-1}$ of sodium pentachlorophenate, was stored in the dark due to rapid photodecomposition of aqueous solutions of NaPCP at pH 7.3 (Wong and Crosby 1981), and was freshly prepared every two weeks using the method of Webb and Brett (1973). Sodium pentachlorophenate of the desired concentration was prepared from this stock solution by withdrawing pre-calculated amounts and diluting with distilled water to 26 L in opaque glass carbouys. The NaPCP or carrier solution (NaOH and

distilled water) was metered from the carbouys to the swim chamber raceways using a positive displacement diaphragm pump (Model 4-MD; Little Giant Pump Co., Okla. City, Okla. or Model G-4a; ProMinent Fluid Controls Ltd., Guelph, ON) and was combined with a continuous flow (10 $L \cdot min^{-1}$) of diluent water upon entering the raceways. The chemical delivery systems were calibrated to provide a drip rate of 9.8 $ml \cdot min^{-1}$ and were adjusted during experimentation as required.

In acidic pH the test chemical is predominantly in the undissociated phenol form and in neutral to alkaline pH in the anionic phenolate form. In test solutions of pH 7.4 the sodium pentachlorophenate is 99% ionized (Alderdice 1963) and therefore a pH level of 6.7 - 7.1 in the chambers recieving toxicant ensured virtually complete ionization of the test solution to the salt (Table 9). Analytical quality assurance was based on water samples collected to confirm concentrations after 24 h of exposure, and quality control was based on the analysis of samples spiked with known concentrations of the surrogate chemical 2,4,6 Tribromophenol as compared to the percent recovery of the surrogate in experimental samples. All sample analysis for sodium pentachlorophenate was performed within 24 h of collection, at the Environment Canada, Pacific Environmental Science Centre, Organic Chemistry Section, North Vancouver B.C. (Chlorinated Phenols Official Method Version 3.1 , 1996, 16p.). The nominal and laboratory determined actual concentrations of NaPCP in the raceways are reported in Table 10. A surrogate recovery of between 80% - 128% was obtained through these analyses and the results presented in this report have not been corrected.

EXPERIMENTAL PROTOCOL

From August 12, to September 27, 1996, 7 consecutive experiments were conducted on a weekly basis (Figure 10). This experimental period coincided with adult sockeye encountering hypoxic conditions in the sub-halocline waters of some coastal inlets (such as Alberni Inlet) of British Columbia during their spawning migration to natal lakes (Spohn et al. 1996). Eight fish per experiment were aneasthetized with 100 $mg \cdot L^{-1}$ MS-222 (tricaine methanesulfonate; Argent Chemical Laboratories, Redmond, WA) and transferred to the swim chamber raceways. Four fish per raceway were acclimated for 24 h in sea water (temperature 9.9 - 14.3 °C; salinity 27.8 - 30.5‰) under continuous flow conditions (17 $cm \cdot s^{-1}$).

Each experiment consisted of a 30 h NaPCP exposure of fish in one raceway, (while the control raceway was supplied with carrier solution), under either normoxic (70 - 100% oxygen saturation) or hypoxic (30 - 40% oxygen saturation) conditions. NaPCP concentrations of 5, 10, 20 and 40 $\mu g \cdot L^{-1}$ were selected on the basis of an anticipated toxicity response curve (Table 11). Concurrent with the initiation of toxicant exposure the salt water was replaced by fresh water (10 $L \cdot min^{-1}$) and the temperature was progressively increased over 6 h to 20.0°C. Following hypoxic exposure, water in the raceways reached a normoxic equilibrium throughout an 18 h recovery period. The fish were then challenged with a 6 h fixed velocity swim test, followed by an 18 h recovery period, and thereafter, a second 6 h fixed velocity swim test. After completing the

second swim test the fish were sacrificed with a lethal dose of anaesthetic (MS-222). The fork length (± 0.5 cm), weight (± 1 g), and sex of all fish were recorded (Table 12). Scales were taken for age determination. Bile and liver samples were also collected from fish in Expt. #5 - #7 to assess of the effects of NaPCP exposure on steroid metabolism (Parks and LeBlanc 1996).

SWIMMING PERFORMANCE TESTS

Fixed velocity swim tests have been developed as a quantitative technique to measure sustained swimming performance in salmonids. Ellis (1967) found that sockeye salmon while on spawning migration through a river where opposing river velocities were a mean of 42 $cm \cdot sec^{-1}$, changed their mode of swimming from nonsustained to sustained steady swimming. In addition, Brett (1965) reported that the optimum efficiency in terms of energy cost per km in relation to swimming speed (for a 2.3 kg sockeye of 61 cm total length) during ocean migration was 50 $cm \cdot s^{-1}$. In this study the initial water velocity in the raceways prior to commencing the performance tests was 17 $cm \cdot s^{-1}$ following which the velocity was increased to 50 $cm \cdot s^{-1}$ (0.90 body $lengths \cdot s^{-1}$) to promote sustained swimming, and maintained for 6 h (Table 13). To encourage swimming during the performance tests, an electrified horizontal grid was situated behind the fish and charged with a 6 - 9 V pulsed DC current at 0.5 A. During the swimming challenge the black polyethylene covers over the raceways were removed from the test trough area to permit unobstructed viewing. Routine observations were recorded at 10 min intervals to determine whether fish were swimming, resting, or in contact with the grid (Tables 14 - 24). Throughout observations special care was exercised to avoid casting shadows on, or otherwise disturbing, the fish.

RESPIRATORY VARIABLES

Observations of breathing frequency (measured as opercular $openings \cdot min^{-1}$) and cough frequency ($number \cdot min^{-1}$) of fish in the swim chambers was recorded daily throughout the acclimation and experimental periods at 07:30 h and again at 14:30 h. Determinations of these respiratory variables were conducted for each fish consecutively, through a series of five sequential 1 min periods, which were averaged for comparative purposes (Tables 25 - 43). In addition, the breathing frequency was monitored hourly for the first 6 h of toxicant exposure with concommitant salinity and thermal regime changes (Table 44).

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Figure 1. Alberni Inlet, British Columbia.

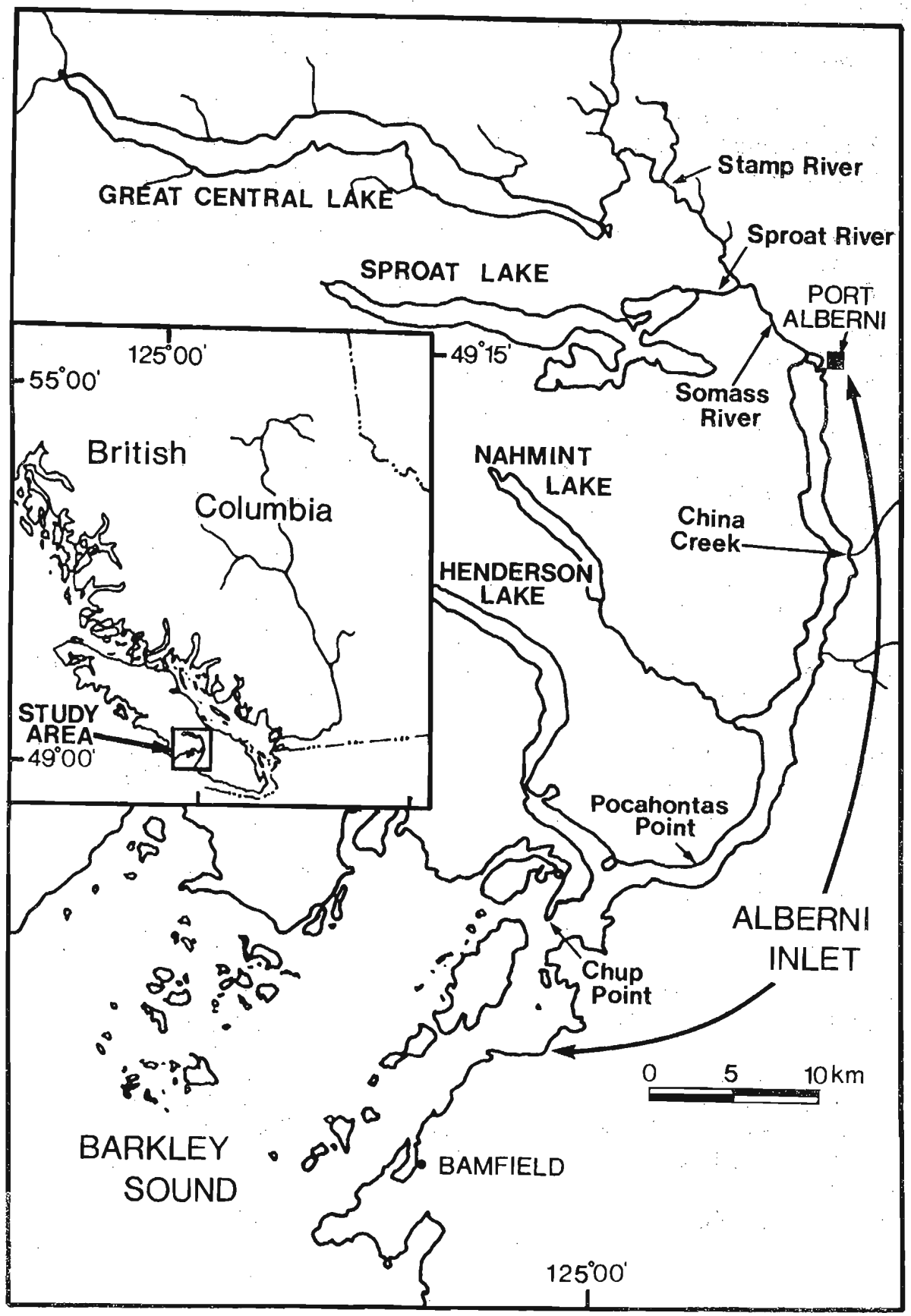
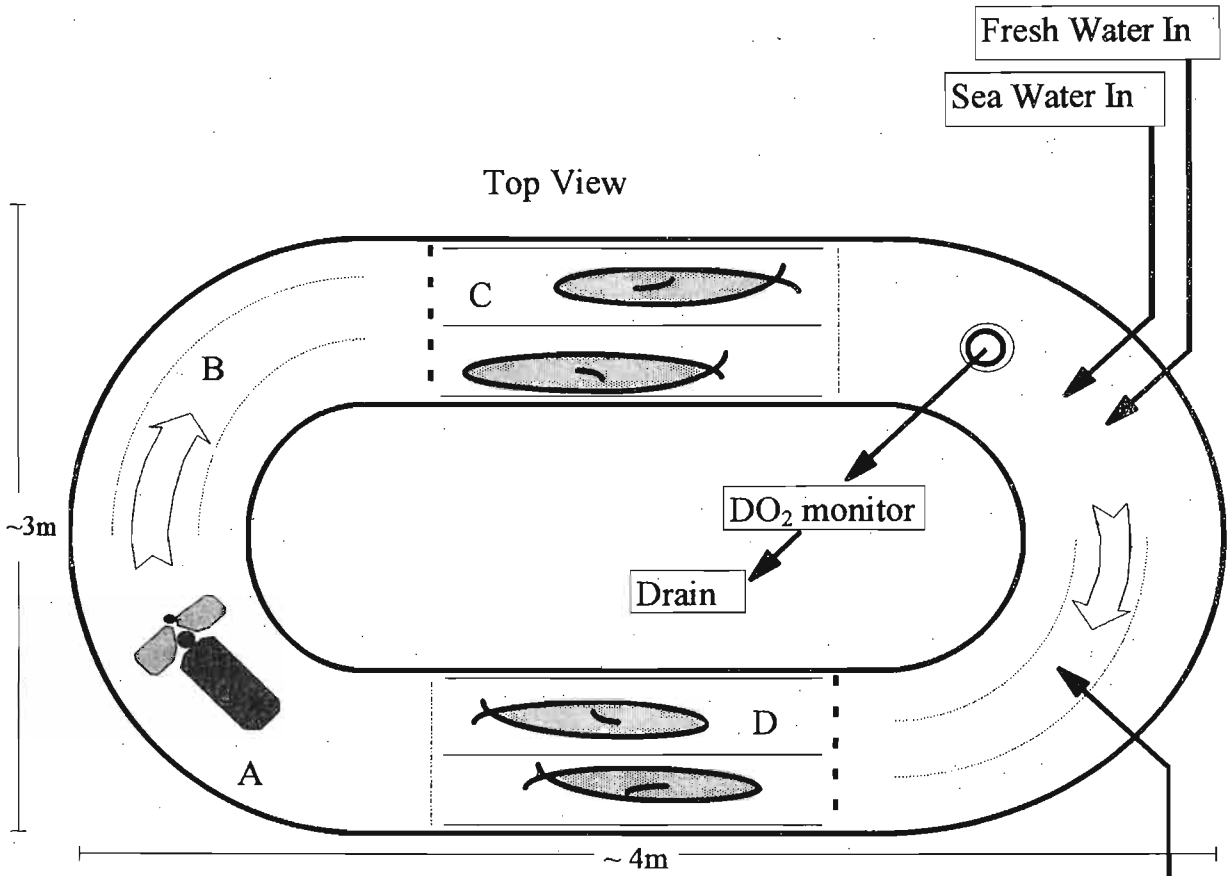


Figure 2. Schematic diagram of swim chamber apparatus



A - 24 Volt stainless motor
B - Flow control vanes
C - Fish trough
D - Fish trough

- - - - - - Fish retaining screen
..... 6-9 Volt electrified grid

<u>Capacity</u>

Flow rate	10 L / minute
Water velocity	0 - 50 cm / second

<u>Water Quality</u>

Sea Water	27.8 - 30.5 PPT	at	10 - 14 ° C
Fresh Water	25 - 75 micro Siemens	at	15 - 20 ° C
Dissolved Oxygen	30 - 100% Saturation	at	10 L/min

Table 1. Adult sockeye salmon stock tank water quality measurements 1996

DATE (1996)	TIME	Dissolved Oxygen (ppm) CORRECTED	Saturation (%)	Salinity (ppt)	Temperature (°C)	Mortality (#)	Comments
Tues, July 9	19:00	9.8	103	27	11.0	0	62 fish arrive from Alberni
Wed, July 10	9:00	(9.1 / 8.7)	(97 / 93)	26	(12.0 / 11.8)	0	
Thurs, July 11	10:30	(8.8 / 8.6)	(96 / 93)	28	(12.5 / 12.3)	0	July 11, 1st Chloramine-T July 12, 2nd Chloramine-T
Mon, July 15	11:15	(8.7 / 7.8)	(96 / 87)	28	(12.9 / 12.8)	7	Suspect Vibrio Infection
Tues, July 16	19:00	9.6	102	28	11.7	6	54 fish arrive from Alberni
Wed, July 17	9:00	8.5	93	23	12.8	4	July 17, 1st Chloramine-T July 18, 2nd Chloramine-T
Wed, July 24	9:45	(8.8 / 8.0)	(95 / 87)	(32/31)	(11.0 / 11.4)	4	
Wed, July 31	8:30	(9.6 / 8.8)	(103 / 94)	27	(11.7 / 11.4)	2	
Wed, Aug 7	10:45	(10.1 / 9.4)	(107 / 100)	27	(11.7 / 11.1)	0	lots of algal growth in tanks
Wed, Aug 14	14:45	(9.8 / 9.3)	(107 / 101)	28	(12.7 / 12.1)	0	lots of algal growth in tanks
Wed, Aug 21	10:00	(10.2 / 9.7)	(109 / 103)	28	(11.1 / 11.0)	0	lots of algal growth in tanks
Thurs, Aug 29	13:15	(9.7 / 9.5)	(108 / 106)	27	12.8	0	
Mon, Sept 9	11:00	(9.3 / 8.9)	(101 / 96)	27.5	11.8	0	
Mon, Sept 16	10:30	9.2	95	29.5	10.0	0	no fish left in stock tanks

* VALUES REPORTED AS DAILY (MAX / MIN) IF POSSIBLE

Table 2. Swim chamber water quality conditions - Expt. #1

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
-19	13.45	14.36	8.38	8.29	96.97	96.71	30.20	28.62
-18	13.32	14.09	7.77	7.86	89.85	91.32	30.54	28.89
-17	12.98	13.65	7.68	7.68	86.69	88.10	28.14	28.31
-16	12.93	13.43	7.47	7.50	84.66	85.89	28.62	28.78
-15	12.97	13.34	7.31	7.50	82.83	85.88	28.47	28.86
-14	12.70	13.04	7.38	7.29	83.08	83.04	28.41	29.12
-13	12.42	12.72	7.36	7.49	82.39	84.84	28.44	29.31
-12	12.16	12.38	7.41	7.82	82.46	88.07	28.33	29.46
-11	11.95	12.09	7.40	7.91	81.91	88.52	28.30	29.48
-10	11.89	11.96	7.31	7.77	80.73	86.61	28.15	29.36
-9	11.79	11.83	7.42	7.65	81.77	85.05	28.07	29.28
-8	11.71	11.70	7.54	7.49	82.90	83.06	28.05	29.28
-7	11.80	11.77	7.67	7.57	84.43	83.88	27.79	29.05
-6	11.96	11.91	7.77	7.63	85.62	84.65	27.50	28.75
-5	11.93	11.88	7.79	7.68	85.83	85.10	27.45	28.71
-4	11.66	11.62	7.80	7.72	85.59	85.28	27.72	28.97
-3	11.50	11.45	7.81	7.82	85.43	86.08	27.86	29.12
-2	11.54	11.47	7.76	7.89	84.94	86.86	27.77	29.03
-1	11.47	11.41	7.77	7.97	84.96	87.71	27.82	29.07
0	11.43	11.39	8.42	8.46	91.87	92.33	27.88	29.15
1	13.05	13.06	8.32	8.73	92.87	93.00	22.77	24.14
2	15.35	15.25	8.55	8.68	92.42	93.25	15.20	16.33
3	17.02	16.84	8.38	8.48	92.13	92.50	10.08	10.92
4	18.19	17.99	8.15	8.33	90.51	91.00	6.70	7.36
5	18.94	18.72	7.91	8.13	86.10	87.75	4.46	4.99
6	19.35	19.21	7.85	8.15	85.10	87.75	2.98	3.40
7	19.58	19.47	7.72	8.05	85.00	88.87	2.02	2.35
8	19.76	19.66	7.64	8.05	84.28	88.76	1.38	1.64
9	19.82	19.75	7.56	8.01	83.29	88.22	0.93	1.14
10	19.84	19.78	7.38	7.87	81.19	86.65	0.65	0.82
11	19.87	19.83	7.19	7.75	79.04	85.27	0.47	0.60
12	19.82	19.80	6.99	7.80	76.73	85.64	0.34	0.46
13	19.75	19.69	6.78	7.85	74.28	85.94	0.25	0.36
14	19.65	19.61	6.55	7.79	71.80	85.21	0.19	0.29
15	19.56	19.52	6.37	7.83	69.51	85.39	0.15	0.24
16	19.49	19.45	6.30	7.83	68.60	85.23	0.12	0.21
17	19.43	19.38	6.25	7.80	68.02	84.79	0.10	0.18
18	19.38	19.32	6.23	7.80	67.68	84.70	0.09	0.16
19	19.33	19.28	6.20	7.80	67.26	84.65	0.07	0.14
20	19.29	19.24	6.21	7.86	67.31	85.15	0.06	0.14
21	19.26	19.20	6.19	7.89	67.09	85.45	0.06	0.13
22	19.24	19.16	6.12	7.90	66.29	85.53	0.05	0.12
23	19.22	19.16	6.12	7.96	66.30	86.14	0.05	0.12
24	19.24	19.19	6.10	8.00	66.12	86.60	0.05	0.11
25	19.32	19.28	6.33	8.10	68.67	87.90	0.05	0.11

Table 2. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
26	19.38	19.37	6.63	8.08	72.07	87.84	0.06	0.11
27	19.55	19.57	6.83	8.09	74.50	88.28	0.05	0.11
28	19.76	19.74	7.04	8.13	77.06	89.02	0.06	0.11
29	19.90	19.87	7.11	8.15	78.06	89.49	0.06	0.11
30	19.95	19.92	7.16	8.10	78.67	88.99	0.05	0.11
31	19.92	19.90	7.11	8.01	78.04	88.04	0.05	0.11
32	19.90	19.87	7.08	8.00	77.73	87.78	0.06	0.11
33	19.90	19.88	7.12	8.02	78.12	88.06	0.06	0.11
34	19.89	19.85	7.14	8.04	78.35	88.28	0.06	0.12
35	19.88	19.87	7.17	7.89	78.70	86.68	0.06	0.12
36	19.81	19.79	7.24	8.06	79.41	88.38	0.05	0.12
37	19.69	19.68	7.33	7.98	80.18	87.19	0.06	0.11
38	19.59	19.56	7.35	7.97	80.18	87.02	0.06	0.11
39	19.51	19.47	7.50	8.06	81.75	87.79	0.06	0.11
40	19.45	19.39	7.64	8.05	83.09	87.52	0.05	0.11
41	19.39	19.35	7.69	8.10	83.56	87.97	0.05	0.11
42	19.34	19.28	7.81	8.11	84.79	87.98	0.06	0.11
43	19.27	19.20	7.93	8.15	85.95	88.32	0.05	0.11
44	19.22	19.15	8.05	8.18	87.24	88.46	0.05	0.11
45	19.18	19.10	8.14	8.18	88.07	88.47	0.05	0.10
46	19.15	19.07	8.18	8.18	88.45	88.39	0.05	0.10
47	19.12	19.05	8.24	8.24	89.10	88.98	0.05	0.11
48	19.14	19.08	8.21	8.25	88.82	89.09	0.05	0.11
49	19.21	19.17	8.12	8.25	87.96	89.27	0.05	0.11
50	19.37	19.34	7.96	7.77	86.51	84.41	0.04	0.10
51	19.66	19.62	8.13	7.36	88.82	80.35	0.04	0.10
52	19.98	19.87	8.35	7.44	91.81	81.67	0.05	0.10
53	20.16	20.04	8.39	7.86	92.59	86.56	0.05	0.10
54	20.22	20.15	8.44	8.05	93.24	88.88	0.04	0.10
55	20.18	20.16	8.46	8.10	93.35	89.45	0.05	0.11
56	20.10	20.06	8.37	8.11	92.31	89.38	0.05	0.11
57	20.02	20.00	8.29	8.17	91.25	89.87	0.05	0.11
58	19.94	19.93	8.36	8.22	91.90	90.36	0.06	0.11
59	19.85	19.84	8.40	8.28	92.18	90.87	0.06	0.11
60	19.76	19.74	8.43	8.40	92.25	91.90	0.05	0.11
61	19.69	19.66	8.50	8.36	92.94	91.43	0.05	0.11
62	19.62	19.60	8.33	8.28	90.90	90.44	0.05	0.11
63	19.56	19.54	8.38	8.33	91.41	90.80	0.05	0.11
64	19.52	19.47	8.40	8.38	91.50	91.21	0.05	0.11
65	19.47	19.44	8.51	8.43	92.60	91.76	0.05	0.11
66	19.42	19.37	8.59	8.36	93.43	90.88	0.05	0.11
67	19.38	19.35	8.67	8.35	94.18	90.72	0.05	0.11
68	19.38	19.34	8.69	8.38	94.41	90.99	0.06	0.11
69	19.37	19.33	8.69	8.39	94.35	91.12	0.04	0.11
70	19.35	19.32	8.68	8.39	94.29	91.08	0.05	0.11

Table 2. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
72	19.35	19.31	8.69	8.38	94.39	90.97	0.05	0.11
73	19.40	19.39	8.45	8.07	91.89	87.72	0.05	0.10
74	19.53	19.50	8.57	7.74	93.36	84.38	0.04	0.10
75	19.78	19.72	8.62	7.67	94.38	83.90	0.04	0.10
76	20.01	19.92	8.60	7.88	94.66	86.54	0.04	0.10
77	20.13	20.06	8.65	7.99	95.40	88.07	0.05	0.10
78	20.17	20.18	8.70	8.15	96.02	90.03	0.04	0.10
79	19.52	20.15	8.70	8.15	96.02	89.97	0.02	0.13

** Negative experimental time equals the number of hours of acclimation prior to toxicant exposure

Table 3. Swim chamber water quality conditions - Expt. #2

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
-23	11.31	11.36	8.73	8.13	96.07	89.66	29.46	29.59
-22	11.59	11.59	8.26	7.60	91.33	84.11	29.25	29.39
-21	11.83	11.83	7.67	7.13	85.11	79.24	29.15	29.28
-20	12.03	12.04	7.49	6.86	83.51	76.50	29.04	29.19
-19	12.12	12.14	7.55	6.86	84.31	76.71	29.03	29.18
-18	12.30	12.33	7.66	6.90	85.70	77.38	28.81	28.98
-17	12.75	12.74	7.92	6.83	89.17	77.00	28.28	28.52
-16	12.82	12.83	8.08	6.81	91.07	76.94	28.15	28.43
-15	12.46	12.52	8.18	6.78	91.72	76.18	28.60	28.79
-14	12.11	12.20	8.32	6.86	92.87	76.72	28.95	29.10
-13	11.85	11.94	8.40	7.03	93.33	78.30	29.18	29.30
-12	11.63	11.72	8.44	7.07	93.41	78.50	29.36	29.48
-11	11.43	11.51	8.39	6.97	92.63	77.16	29.50	29.62
-10	11.28	11.36	8.41	7.09	92.58	78.27	29.59	29.69
-9	11.26	11.34	8.43	7.30	92.70	80.51	29.58	29.74
-8	11.34	11.38	8.48	7.49	93.44	82.66	29.48	29.64
-7	11.50	11.53	8.54	7.49	94.20	82.75	29.25	29.42
-6	12.09	12.05	8.55	7.54	95.05	83.86	28.49	28.72
-5	12.59	12.52	8.58	7.55	96.14	84.54	27.93	28.23
-4	12.70	12.67	8.56	7.57	96.03	84.95	27.81	28.07
-3	12.73	12.70	8.60	7.43	96.57	83.43	27.82	28.02
-2	12.69	12.69	8.58	7.53	96.23	84.60	27.86	28.09
-1	12.60	12.60	8.66	7.76	97.02	87.05	28.04	28.25
0	13.80	13.90	8.06	7.38	87.98	80.56	23.34	23.44
1	15.79	15.84	6.53	5.78	71.00	63.00	16.16	16.32
2	17.17	17.21	5.53	4.88	61.00	53.25	11.42	11.42
3	18.15	18.20	4.73	4.08	52.50	45.00	8.13	7.98
4	18.86	18.89	4.15	3.80	45.75	41.00	5.80	5.60
5	19.29	19.36	3.55	3.63	39.50	40.25	4.14	3.96
6	19.57	19.62	3.48	3.46	38.78	38.51	2.97	2.82
7	19.73	19.78	3.87	3.44	42.86	38.17	2.13	2.02
8	19.81	19.87	3.92	3.45	43.29	38.20	1.54	1.47
9	19.86	19.92	4.23	3.47	46.71	38.30	1.10	1.05
10	19.82	19.92	4.53	3.46	49.90	38.13	0.81	0.79
11	19.73	19.81	4.75	3.46	52.14	38.03	0.61	0.59
12	19.61	19.68	4.75	3.43	51.96	37.63	0.46	0.46
13	19.49	19.57	4.36	3.46	47.59	37.84	0.35	0.36
14	19.41	19.50	4.10	3.46	44.68	37.69	0.27	0.29
15	19.33	19.41	3.91	3.49	42.45	38.01	0.21	0.24
16	19.26	19.35	3.80	3.56	41.24	38.71	0.17	0.21
17	19.20	19.29	3.72	3.59	40.31	38.96	0.14	0.18
18	19.16	19.24	3.67	3.63	39.70	39.40	0.12	0.16
19	19.10	19.18	3.62	3.69	39.14	40.00	0.10	0.14
20	19.08	19.17	3.57	3.75	38.61	40.58	0.09	0.13
21	19.05	19.13	3.60	3.78	38.86	40.84	0.07	0.13

Table 3. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
22	19.04	19.11	3.74	3.81	40.36	41.18	0.06	0.12
23	19.10	19.20	3.84	3.81	41.53	41.21	0.06	0.12
24	19.22	19.35	3.91	3.83	42.33	41.60	0.06	0.12
25		19.52		3.83		41.71		0.14
26		19.69		3.75		41.07		0.16
27		19.88		3.75		41.12		0.16
28		19.97		3.76		41.33		0.16
29		20.00		3.75		41.32		0.16
30		20.00		4.36		48.00		0.26
31		19.95		5.93		65.28		0.31
32		19.88		6.94		76.25		0.28
33		19.81		7.43		81.54		0.25
34		19.75		7.71		84.50		0.23
35		19.67		7.76		84.88		0.21
36		19.56		7.70		84.08		0.20
37		19.49		7.75		84.51		0.18
38		19.40		7.96		86.60		0.17
39		19.31		8.00		86.90		0.17
40		19.22		8.10		87.84		0.16
41		19.13		8.13		87.91		0.16
42		19.10		8.19		88.49		0.15
43		19.09		8.24		89.09		0.15
44		19.13		8.20		88.71		0.15
45		19.12		7.96		86.08		0.15
46		19.21		8.02		86.94		0.15
47		19.32		8.28		89.87		0.14
48		19.38		8.25		89.68		0.16
49		19.49		8.35		91.03		0.21
50		19.66		8.51		93.07		0.25
51		19.88		8.58		94.28		0.27
52		20.05		8.57		94.51		0.29
53		20.13		8.57		94.63		0.31
54		20.09		8.27		91.28		0.32
55		20.03		8.09		89.17		0.33
56		19.95		8.14		89.59		0.34
57		19.90		8.07		88.71		0.34
58		19.85		8.25		90.65		0.34
59		19.71		8.20		89.83		0.34
60		19.58		8.19		89.53		0.35
61		19.48		8.33		90.90		0.35
62		19.38		8.43		91.73		0.35
63		19.30		8.44		91.71		0.35
64		19.22		8.43		91.46		0.35
65		19.19		8.47		91.82		0.34
66		19.13		8.53		92.44		0.34

Table 3. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
67		19.10		8.59		93.01		0.34
68		19.06		8.64		93.40		0.34
69		19.03		8.44		91.18		0.34
70		19.03		8.45		91.37		0.34
71		19.08		8.56		92.65		0.33
72		19.20		8.69		94.28		0.32
73		19.39		8.67		94.34		0.33
74		19.66		8.61		94.23		0.33
75		19.92		8.50		93.51		0.33
76		20.16		8.45		93.46		0.33
77		20.29		8.48		93.96		0.33

** Negative experimental time equals the number of hours of acclimation prior to toxicant exposure

Table 4. Swim chamber water quality conditions - Expt. #3

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
-20	12.40	12.29	8.22	8.75	92.05	97.84	28.47	28.68
-19	12.26	12.16	7.98	8.45	89.03	94.34	28.41	28.96
-18	12.18	12.09	7.88	8.03	87.78	89.71	28.50	29.19
-17	12.12	12.01	7.84	7.60	87.37	84.80	28.64	29.35
-16	12.08	11.96	7.89	7.52	87.85	83.88	28.69	29.40
-15	11.92	11.82	8.04	7.45	89.23	82.92	28.82	29.55
-14	11.76	11.67	8.23	7.60	91.18	84.40	28.91	29.65
-13	11.58	11.49	8.44	7.96	93.14	88.04	29.00	29.74
-12	11.52	11.42	8.54	8.32	94.13	91.94	28.97	29.69
-11	11.57	11.50	8.64	8.26	95.18	91.32	28.82	29.54
-10	11.59	11.52	8.69	8.23	95.75	90.95	28.71	29.42
-9	11.56	11.47	8.73	8.41	96.06	92.88	28.67	29.40
-8	11.63	11.55	8.79	8.59	96.78	94.86	28.50	29.18
-7	11.70	11.62	8.88	8.68	97.88	95.94	28.37	29.08
-6	11.83	11.78	8.97	8.78	99.01	97.31	28.27	28.98
-5	11.87	11.82	9.01	8.86	99.60	98.26	28.25	28.96
-4	11.82	11.76	9.07	8.73	100.17	96.75	28.34	29.04
-3	11.70	11.63	9.10	8.71	100.33	96.35	28.47	29.16
-2	11.64	11.57	9.00	8.70	99.12	96.08	28.50	29.19
-1	11.59	11.52	8.87	8.71	97.62	96.08	28.53	29.23
0	11.54	11.47	8.42	8.26	92.60	91.09	28.57	29.23
1	12.59	12.62	7.68	7.50	82.75	80.00	25.26	25.61
2	14.66	14.77	6.00	5.50	65.50	60.25	18.41	18.17
3	16.15	16.26	5.15	4.25	56.25	47.25	13.38	12.76
4	17.20	17.32	4.58	3.35	50.00	36.75	9.72	8.88
5	17.99	18.10	4.33	2.93	46.75	31.75	7.06	6.18
6	18.78	18.90	3.68	2.55	39.75	27.75	5.17	4.31
7	19.32	19.46	3.07	2.53	33.59	28.27	3.77	0.66
8	19.72	19.84	3.53	2.76	39.26	30.63	2.80	2.17
9	20.03	20.12	3.75	2.86	41.82	31.79	2.08	1.57
10	20.22	20.29	3.83	2.92	42.65	32.49	1.55	1.14
11	20.33	20.38	3.82	2.97	42.59	33.07	1.17	0.86
12	20.51	20.54	3.79	2.99	42.37	33.39	0.89	0.67
13	20.61	20.64	3.80	3.02	42.52	33.71	0.71	0.54
14	20.69	20.71	3.87	2.91	43.27	32.57	0.58	0.45
15	20.73	20.75	4.24	2.99	47.49	33.40	0.49	0.39
16	20.65	20.63	4.51	3.10	50.35	34.57	0.41	0.35
17	20.66	20.64	4.61	3.16	51.49	35.23	0.36	0.32
18	20.70	20.68	4.65	3.21	51.94	35.83	0.32	0.30
19	20.72	20.70	4.65	3.25	51.99	36.25	0.29	0.28
20	20.72	20.70	4.62	3.28	51.62	36.65	0.27	0.27
21	20.71	20.67	4.56	3.30	50.91	36.79	0.26	0.27
22	20.70	20.64	4.54	3.27	50.71	36.42	0.24	0.27
23	20.70	20.65	4.52	3.26	50.43	36.34	0.23	0.26
24	20.70	20.65	4.22	3.25	47.09	36.30	0.23	0.26

Table 4. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
25	20.72	20.69	3.69	3.27	41.17	36.46	0.22	0.25
26	20.80	20.77	3.33	3.25	37.29	36.30	0.22	0.25
27	20.85	20.79	3.27	3.22	36.60	36.03	0.22	0.25
28	21.03	20.94	3.30	3.17	37.12	35.54	0.22	0.25
29	21.19	21.05	3.34	3.13	37.67	35.24	0.21	0.25
30	21.23	21.10	3.48	3.13	39.22	35.18	0.21	0.25
31		21.13		3.80		42.88		0.40
32		20.97		5.25		59.00		0.40
33		20.90		6.20		69.52		0.39
34		20.80		6.83		76.42		0.38
35		20.71		7.25		81.04		0.37
36		20.60		7.56		84.32		0.36
37		20.54		7.69		85.69		0.36
38		20.46		7.75		86.20		0.36
39		20.35		7.80		86.53		0.36
40		20.31		7.91		87.69		0.35
41		20.26		7.95		88.04		0.35
42		20.24		8.00		88.53		0.35
43		20.23		8.01		88.74		0.35
44		20.19		8.05		89.04		0.34
45		20.31		8.10		89.86		0.34
46		20.24		8.09		89.59		0.34
47		20.15		8.06		89.05		0.34
48		20.20		8.02		88.75		0.34
49		20.25		7.84		86.78		0.33
50		20.39		7.47		82.96		0.30
51		20.60		7.38		82.24		0.27
52		20.87		7.33		82.12		0.25
53		21.11		7.32		82.33		0.22
54		21.23		7.35		82.88		0.21
55		21.12		7.17		80.76		0.22
56		21.03		6.95		78.06		0.23
57		20.96		6.84		76.78		0.25
58		20.89		6.87		76.97		0.26
59		20.81		6.91		77.29		0.27
60		20.72		7.02		78.43		0.27
61		20.67		7.18		80.11		0.27
62		20.59		7.29		81.25		0.27
63		20.63		7.38		82.32		0.27
64		20.54		7.45		82.99		0.27
65		20.57		7.56		84.19		0.27
66		20.60		7.55		84.17		0.27
67		20.48		7.64		84.96		0.27
68		20.50		7.60		84.60		0.27
69		20.54		7.61		84.70		0.27

Table 4. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
70		20.53		7.63		84.90		0.27
71		20.48		7.52		83.67		0.27
72		20.39		7.58		84.11		0.26
73		20.38		7.42		82.32		0.25
74		20.35		7.13		79.05		0.23
75		20.40		6.95		77.20		0.22
76		20.61		6.89		76.80		0.21
77		20.80		7.34		82.09		0.21
78		20.81		7.56		84.55		0.24

** Negative experimental time equals the number of hours of acclimation prior to toxicant exposure

Table 5. Swim chamber water quality conditions - Expt. #4

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
-19	11.37	11.38	8.68	8.02	95.28	88.27	28.86	29.26
-18	11.54	11.54	8.74	8.05	96.21	88.91	28.80	29.24
-17	11.69	11.68	8.75	7.84	96.57	86.79	28.70	29.16
-16	12.05	12.01	8.73	7.55	96.90	83.98	28.37	28.87
-15	12.36	12.30	8.72	7.34	97.31	82.07	28.06	28.58
-14	12.41	12.37	8.69	7.22	96.90	80.72	27.92	28.43
-13	12.04	12.06	8.55	7.12	94.78	79.22	28.18	28.64
-12	11.65	11.70	8.54	6.97	94.04	77.07	28.43	28.86
-11	11.39	11.47	8.46	6.70	92.72	73.83	28.61	29.02
-10	11.24	11.34	8.44	6.32	92.28	69.50	28.72	29.13
-9	11.13	11.21	8.41	5.93	91.82	65.04	28.81	29.22
-8	11.02	11.09	8.43	5.85	91.89	64.00	28.89	29.31
-7	10.89	10.97	8.51	5.97	92.57	65.17	28.99	29.39
-6	10.87	10.92	8.52	6.05	92.61	65.98	28.98	29.41
-5	11.08	11.07	8.45	5.98	92.09	65.36	28.74	29.20
-4	11.39	11.36	8.41	5.98	92.06	65.60	28.36	28.84
-3	11.55	11.50	8.38	5.90	91.95	64.80	28.14	28.62
-2	11.63	11.58	8.40	5.88	92.24	64.73	28.02	28.49
-1	11.63	11.58	8.48	6.14	93.07	67.52	27.98	28.45
0	11.60	11.54	8.74	7.15	95.90	78.58	27.99	28.43
1	12.86	12.96	7.55	6.65	81.75	71.50	23.93	23.71
2	14.97	15.17	5.95	5.18	64.75	56.50	16.94	15.99
3	16.51	16.71	5.20	4.48	56.75	49.00	11.97	10.77
4	17.58	17.74	4.90	3.95	52.75	43.50	8.44	7.27
5	18.29	18.47	4.65	3.60	50.50	39.50	5.97	4.92
6	18.80	18.95	3.95	3.90	42.75	43.00	4.28	3.35
7	19.32	19.42	3.41	3.52	37.18	38.90	3.07	2.29
8	19.73	19.82	3.47	2.79	38.42	30.85	2.20	1.57
9	20.02	20.11	3.74	2.39	41.56	26.50	1.57	1.07
10	20.17	20.25	3.81	2.20	42.34	24.45	1.12	0.76
11	20.22	20.29	3.81	2.12	42.30	23.55	0.82	0.54
12	20.14	20.13	3.72	2.24	41.17	24.72	0.61	0.40
13	20.04	19.98	3.42	3.05	37.79	33.54	0.47	0.31
14	19.92	19.85	3.54	3.11	38.96	34.14	0.36	0.24
15	19.79	19.71	3.63	2.91	39.84	31.89	0.28	0.20
16	19.64	19.55	3.68	2.80	40.27	30.51	0.23	0.17
17	19.47	19.36	3.75	2.70	40.85	29.29	0.19	0.15
18	19.30	19.19	3.76	2.62	40.85	28.33	0.16	0.14
19	19.14	19.01	3.82	2.57	41.31	27.69	0.13	0.13
20	18.98	18.85	3.82	2.57	41.16	27.68	0.11	0.12
21	18.81	18.68	3.89	2.55	41.76	27.37	0.10	0.12
22	18.63	18.51	3.87	2.55	41.38	27.20	0.08	0.11
23	18.40	18.28	4.56	3.38	48.62	35.88	0.07	0.11
24	18.30	18.21	5.17	4.00	55.01	42.44	0.07	0.10
25	18.37	18.32	4.35	3.75	46.33	39.89	0.06	0.11

Table 5. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
26	18.00	17.92	3.42	3.55	36.15	37.41	0.08	0.13
27	17.95	17.86	3.14	3.43	33.13	36.20	0.09	0.13
28	18.31	18.29	2.99	3.36	31.84	35.70	0.08	0.13
29	18.73	18.73	3.08	3.32	33.02	35.64	0.07	0.13
30	19.02	19.01	3.99	3.31	43.01	35.75	0.07	0.12
31	19.13	19.10	4.77	4.06	51.56	43.90	0.13	0.24
32	18.53	18.56	6.63	5.70	70.76	60.92	0.14	0.26
33	16.76	16.92	7.95	7.01	81.87	72.50	0.16	0.25
34	15.93	16.07	8.64	8.01	87.49	81.36	0.18	0.25
35	15.62	15.74	8.96	8.56	90.16	86.36	0.19	0.24
36	15.42	15.47	9.12	8.91	91.34	89.36	0.20	0.25
37	15.26	15.29	9.23	9.05	92.22	90.42	0.21	0.26
38	15.16	15.16	9.29	9.13	92.55	91.04	0.21	0.26
39	15.11	15.09	9.28	9.21	92.39	91.70	0.21	0.26
40	15.09	15.05	9.18	9.23	91.28	91.73	0.21	0.26
41	15.09	15.05	9.18	9.24	91.28	91.84	0.21	0.26
42	15.08	15.02	9.27	9.24	92.18	91.82	0.21	0.26
43	15.07	15.02	9.32	9.27	92.72	92.08	0.22	0.26
44	15.05	14.99	9.34	9.28	92.84	92.12	0.21	0.26
45	15.03	14.97	9.34	9.29	92.84	92.19	0.21	0.26
46	15.02	14.98	9.27	9.28	92.06	92.09	0.21	0.25
47	15.01	14.95	9.28	9.27	92.20	91.95	0.21	0.25
48	15.27	15.20	9.33	9.28	93.23	92.59	0.21	0.25
49	16.08	15.91	9.09	9.08	92.39	91.98	0.21	0.25
50	16.94	16.70	8.33	8.63	86.16	88.90	0.21	0.25
51	17.73	17.42	7.79	8.57	81.93	89.59	0.21	0.25
52	18.36	18.06	7.67	8.48	81.73	89.81	0.20	0.25
53	19.04	18.74	7.76	8.48	83.84	91.06	0.21	0.25
54	19.70	19.40	7.67	8.49	83.98	92.38	0.21	0.25
55	20.18	19.90	7.48	8.53	82.64	93.80	0.21	0.26
56	20.39	20.17	7.85	8.44	87.11	93.32	0.21	0.27
57	20.48	20.30	8.16	8.32	90.74	92.19	0.21	0.27
58	20.51	20.35	8.20	8.27	91.23	91.75	0.21	0.27
59	20.43	20.32	8.32	8.25	92.39	91.50	0.21	0.27
60	20.28	20.16	8.30	8.26	91.89	91.22	0.21	0.26
61	20.05	19.95	8.24	8.29	90.81	91.22	0.21	0.26
62	19.83	19.75	8.36	8.28	91.76	90.73	0.21	0.26
63	19.63	19.55	8.47	8.30	92.56	90.67	0.21	0.26
64	19.47	19.41	8.48	8.35	92.37	90.88	0.21	0.27
65	19.37	19.29	8.42	8.38	91.58	91.00	0.21	0.26
66	19.31	19.22	8.47	8.36	91.96	90.65	0.21	0.26
67	19.30	19.20	8.55	8.37	92.88	90.74	0.21	0.26
68	19.28	19.18	8.53	8.41	92.64	91.08	0.21	0.26
69	19.25	19.14	8.67	8.39	94.10	90.82	0.21	0.26
70	19.21	19.09	8.77	8.38	95.08	90.68	0.21	0.26

Table 5. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
71	19.16	19.06	8.82	8.42	95.55	90.98	0.21	0.26
72	19.14	19.03	8.80	8.40	95.30	90.78	0.20	0.26
73	19.22	19.11	8.17	8.25	88.63	89.29	0.20	0.24
74	19.35	19.23	7.71	8.30	83.81	90.01	0.20	0.25
75	19.47	19.34	7.64	8.43	83.28	91.60	0.21	0.25
76	19.61	19.47	7.70	8.47	84.15	92.34	0.20	0.25
77	19.70	19.54	7.78	8.42	85.21	91.90	0.21	0.25
78	19.77	19.61	7.83	8.44	85.81	92.20	0.21	0.25

** Negative experimental time equals the number of hours of acclimation prior to toxicant exposure

Table 6. Swim chamber water quality conditions - Expt. #5

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
-24	11.15	11.14	8.84	9.42	96.38	102.63	28.55	28.50
-23	11.54	11.48	8.26	8.90	90.58	97.36	28.06	28.05
-22	11.88	11.76	7.62	8.50	83.96	93.41	27.82	27.76
-21	12.18	12.05	7.45	8.14	82.65	89.97	27.74	27.66
-20	12.19	12.11	7.63	7.83	81.35	86.83	27.92	27.92
-19	12.00	11.94	7.63	7.57	80.80	83.83	28.38	28.38
-18	11.80	11.73	7.79	7.60	80.81	84.04	28.72	28.72
-17	11.61	11.55	8.06	7.69	81.52	84.80	28.97	28.97
-16	11.42	11.38	8.22	7.86	82.52	86.41	29.16	29.16
-15	11.20	11.18	8.53	8.06	83.75	88.41	29.31	29.31
-14	11.00	11.01	8.72	8.23	84.95	89.93	29.36	29.36
-13	10.95	10.93	8.83	8.21	85.91	89.46	29.28	29.28
-12	10.84	10.82	8.91	8.17	86.33	88.80	29.26	29.26
-11	10.85	10.81	9.13	8.33	88.39	90.52	29.16	29.16
-10	10.81	10.76	9.32	8.45	90.06	91.65	29.09	29.09
-9	10.77	10.72	9.48	8.62	91.41	93.48	29.06	29.06
-8	10.70	10.65	9.56	8.65	91.97	93.58	29.08	29.08
-7	10.60	10.55	9.68	8.74	92.96	94.46	29.14	29.14
-6	10.52	10.46	9.73	8.74	93.74	94.25	29.20	29.20
-5	10.46	10.38	9.87	8.78	93.96	94.55	29.23	29.23
-4	10.42	10.34	9.91	8.90	94.07	95.80	29.26	29.26
-3	10.39	10.32	9.88	8.89	93.66	95.61	29.26	29.26
-2	10.36	10.30	9.58	8.79	93.19	94.48	29.28	29.28
-1	10.45	10.37	9.85	8.77	94.29	94.46	29.23	29.27
0	11.79	11.69	7.95	7.98	83.50	83.75	24.24	24.29
1	13.83	13.72	5.95	6.18	63.25	66.75	16.88	16.74
2	15.44	15.29	5.18	5.45	55.75	58.75	11.70	11.37
3	16.75	16.57	4.88	5.00	52.50	54.75	8.09	7.74
4	17.73	17.57	4.80	4.98	50.75	52.50	5.57	5.30
5	18.39	18.26	4.40	4.73	47.50	49.75	3.86	3.71
6	18.86	18.68	3.71	3.75	40.77	40.30	2.58	2.65
7	19.11	18.93	3.35	3.04	36.57	33.15	1.78	1.93
8	19.25	19.09	3.21	3.08	35.02	33.55	1.32	1.42
9	19.27	19.14	2.95	2.93	32.16	31.82	0.98	1.06
10	19.11	18.98	2.74	2.81	29.78	30.43	0.77	0.83
11	18.77	18.65	2.54	2.64	27.40	28.34	0.60	0.66
12	18.40	18.31	2.77	2.71	29.53	28.92	0.48	0.53
13	18.10	17.99	3.11	3.02	33.02	32.00	0.40	0.46
14	17.88	17.78	2.89	2.93	30.47	30.91	0.34	0.40
15	17.70	17.60	2.71	3.39	28.52	35.57	0.30	0.36
16	17.54	17.46	2.64	3.64	27.69	38.07	0.28	0.33
17	17.44	17.36	2.60	3.78	27.15	39.50	0.25	0.31
18	17.35	17.25	2.87	3.66	29.95	38.19	0.24	0.31
19	17.28	17.19	3.37	3.08	35.15	32.02	0.23	0.29
20	17.23	17.14	3.40	2.45	35.35	25.50	0.22	0.28

Table 6. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
21	17.16	17.05	3.36	2.68	34.96	27.81	0.21	0.28
22	17.08	16.98	3.40	2.89	35.27	29.95	0.21	0.27
23	17.07	16.98	3.45	2.96	35.80	30.66	0.21	0.27
24	17.23	17.13	3.49	3.00	36.32	31.13	0.21	0.27
25	17.56	17.48	3.49	3.02	36.60	31.65	0.21	0.27
26	17.99	17.90	3.48	3.05	36.82	32.24	0.21	0.27
27	18.50	18.43	3.32	3.14	35.46	33.55	0.21	0.27
28	18.91	18.81	3.18	3.22	34.28	34.65	0.21	0.27
29	19.17	19.09	3.85	3.81	41.72	41.21	0.21	0.27
30	19.38	19.31	4.51	4.30	49.03	46.72	0.28	0.34
31	19.74	19.61	6.31	6.00	69.22	65.68	0.32	0.38
32	20.25	20.11	7.17	6.97	79.44	76.99	0.29	0.35
33	20.59	20.43	7.56	7.54	84.26	83.82	0.27	0.32
34	20.81	20.65	7.76	7.90	86.84	88.18	0.24	0.31
35	20.87	20.72	7.72	8.09	86.46	90.42	0.23	0.30
36	20.80	20.67	7.60	8.24	85.00	92.01	0.23	0.29
37	20.70	20.60	7.61	8.38	84.95	93.48	0.22	0.29
38	20.62	20.53	7.69	8.49	85.72	94.52	0.22	0.28
39	20.57	20.48	7.79	8.57	86.77	95.29	0.21	0.28
40	20.54	20.46	7.82	8.64	87.04	96.06	0.21	0.28
41	20.51	20.42	7.95	8.64	88.41	95.98	0.21	0.27
42	20.49	20.39	8.00	8.52	88.94	94.55	0.21	0.28
43	20.50	20.41	8.11	8.50	90.15	94.36	0.21	0.27
44	20.53	20.43	8.15	8.45	90.71	93.91	0.21	0.27
45	20.59	20.50	8.01	8.48	89.25	94.37	0.21	0.27
46	20.64	20.55	7.76	8.26	86.57	92.03	0.20	0.27
47	20.63	20.55	7.51	7.59	83.68	84.51	0.20	0.27
48	20.69	20.61	7.16	7.39	79.87	82.45	0.19	0.27
49	20.78	20.70	7.35	7.41	82.18	82.71	0.20	0.27
50	20.55	20.43	7.52	7.51	83.67	83.44	0.19	0.27
51	20.49	20.34	7.68	7.62	85.41	84.55	0.20	0.27
52	20.42	20.26	7.85	7.73	87.18	85.54	0.20	0.28
53	20.28	20.15	7.87	7.79	87.08	86.09	0.20	0.28
54	20.28	20.14	7.75	7.64	85.84	84.37	0.21	0.28
55	20.64	20.49	7.53	7.48	83.98	83.19	0.21	0.28
56	20.91	20.77	7.45	7.37	83.52	82.45	0.21	0.28
57	21.01	20.87	7.48	7.22	83.99	80.96	0.21	0.28
58	21.00	20.86	7.48	6.99	83.96	78.29	0.21	0.28
59	20.91	20.81	7.46	6.81	83.58	76.17	0.21	0.28
60	20.81	20.72	7.52	6.76	84.17	75.58	0.21	0.28
61	20.74	20.66	7.64	6.80	85.38	75.93	0.21	0.28
62	20.67	20.61	7.73	6.87	86.27	76.54	0.21	0.28
63	20.61	20.52	7.74	6.96	86.28	77.46	0.21	0.28
64	20.51	20.43	7.82	7.02	86.96	77.99	0.21	0.28
65	20.41	20.31	7.82	7.02	86.79	77.85	0.21	0.28

Table 6. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
66	20.33	20.24	7.80	7.06	86.45	78.15	0.21	0.28
67	20.26	20.16	7.81	7.14	86.50	78.94	0.21	0.28
68	20.22	20.11	7.81	7.20	86.35	79.54	0.21	0.28
69	20.17	20.05	7.65	7.16	84.51	78.98	0.20	0.28
70	20.11	20.00	7.64	7.23	84.26	79.68	0.20	0.27
71	20.08	19.98	7.73	7.31	85.21	80.52	0.19	0.28
72	20.18	20.08	7.86	7.39	86.86	81.56	0.18	0.27
73	20.28	20.20	8.02	7.56	88.84	83.64	0.18	0.27
74	20.33	20.20	8.04	7.77	89.12	85.90	0.18	0.27
75	20.36	20.14	8.08	7.80	89.58	86.20	0.18	0.27
76	20.42	20.21	8.07	7.81	89.62	86.36	0.18	0.27
77	20.51	20.32	7.98	7.85	88.73	87.07	0.18	0.27

** Negative experimental time equals the number of hours of acclimation prior to toxicant exposure

Table 7. Swim chamber water quality conditions - Expt. #6

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
-23	10.58	10.61	8.37	8.69	90.74	94.30	29.68	29.68
-22	10.71	10.69	8.14	8.38	88.53	91.11	29.75	29.73
-21	10.99	10.92	8.06	8.13	88.16	88.79	29.55	29.61
-20	11.15	11.11	7.98	8.07	87.43	88.49	29.41	29.50
-19	11.53	11.46	8.03	8.01	88.50	88.23	28.96	29.14
-18	11.95	11.84	8.02	7.92	88.92	87.75	28.46	28.70
-17	12.07	11.99	8.14	7.88	90.34	87.51	28.29	28.54
-16	12.02	11.98	8.17	7.93	90.65	87.99	28.26	28.51
-15	11.80	11.78	8.23	7.96	90.95	88.09	28.56	28.78
-14	11.44	11.49	8.28	8.06	91.09	88.81	28.91	29.12
-13	11.10	11.16	8.26	8.25	90.28	90.47	29.23	29.42
-12	10.80	10.86	8.24	8.46	89.63	92.36	29.45	29.65
-11	10.57	10.61	8.20	8.57	88.81	93.09	29.60	29.83
-10	10.41	10.42	8.14	8.64	87.96	93.59	29.70	29.94
-9	10.35	10.36	8.18	8.60	88.23	92.96	29.63	29.91
-8	10.42	10.38	8.19	8.31	88.37	89.77	29.39	29.72
-7	10.63	10.55	8.20	8.15	88.48	88.12	28.77	29.18
-6	10.82	10.71	8.33	8.11	89.99	87.64	28.27	28.71
-5	10.91	10.79	8.44	8.15	91.25	88.05	28.00	28.45
-4	10.93	10.80	8.55	8.08	92.45	87.26	27.93	28.34
-3	10.86	10.75	8.68	8.16	93.73	88.14	28.07	28.44
-2	10.61	10.54	8.63	8.16	93.03	87.97	28.58	28.87
-1	10.46	10.40	8.63	8.30	92.98	89.40	28.96	29.20
0	12.16	11.86	8.67	8.07	92.00	87.00	24.16	25.10
1	15.73	15.06	8.47	8.27	93.00	89.00	14.35	16.11
2	18.00	17.24	8.27	8.13	92.33	88.67	8.58	10.38
3	19.81	19.05	7.90	7.90	89.00	87.00	5.18	6.75
4	20.91	20.22	7.50	7.47	85.00	82.67	3.46	4.76
5	20.97	20.50	7.47	7.30	84.33	80.67	2.38	3.41
6	20.81	20.47	7.68	7.13	86.29	79.53	1.63	2.44
7	20.66	20.42	7.89	7.33	88.49	82.16	1.12	1.75
8	20.49	20.31	7.91	7.44	88.19	82.90	0.80	1.27
9	20.15	20.02	8.00	7.62	88.53	84.26	0.59	0.93
10	19.67	19.60	7.92	7.76	86.78	85.07	0.45	0.73
11	19.20	19.16	7.64	7.70	82.90	83.56	0.37	0.58
12	18.78	18.74	7.68	7.83	82.53	84.17	0.31	0.48
13	18.40	18.38	7.83	7.93	83.56	84.61	0.27	0.41
14	18.14	18.11	8.13	8.04	86.21	85.29	0.25	0.37
15	17.98	17.92	8.34	8.18	88.23	86.48	0.23	0.34
16	17.87	17.81	8.46	8.33	89.23	87.81	0.22	0.32
17	17.79	17.72	8.58	8.42	90.34	88.55	0.22	0.30
18	17.72	17.66	8.58	8.61	90.24	90.49	0.22	0.29
19	17.67	17.60	8.55	8.58	89.79	90.03	0.21	0.29
20	17.64	17.56	8.80	8.64	92.34	90.57	0.21	0.28
21	17.62	17.55	8.81	8.72	92.43	91.39	0.21	0.28

Table 7. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
22	17.62	17.54	8.50	8.62	89.22	90.34	0.21	0.28
23	17.65	17.55	8.67	8.68	91.04	90.99	0.21	0.28
24	17.76	17.66	8.84	8.54	93.08	89.74	0.21	0.28
25	17.93	17.80	8.80	8.47	92.94	89.20	0.21	0.28
26	18.11	18.00	8.74	8.37	92.66	88.55	0.21	0.28
27	18.34	18.24	8.76	8.29	93.26	88.12	0.21	0.28
28	18.57	18.46	8.78	8.22	93.94	87.77	0.21	0.28
29	18.80	18.68	8.66	8.13	93.08	87.24	0.22	0.28
30	18.95	18.85	8.69	8.23	93.74	88.62	0.22	0.29
31	19.01	18.91	8.55	8.35	92.29	90.02	0.22	0.28
32	18.91	18.79	8.66	8.51	93.31	91.50	0.21	0.28
33	18.65	18.47	8.62	8.57	92.40	91.55	0.22	0.27
34	18.40	18.28	8.50	8.63	90.63	91.88	0.21	0.28
35	18.23	18.11	8.47	8.56	89.98	90.78	0.22	0.28
36	18.12	18.02	8.54	8.54	90.59	90.40	0.21	0.28
37	18.06	17.96	8.65	8.60	91.63	90.93	0.21	0.28
38	18.05	17.94	8.72	8.61	92.30	90.95	0.21	0.28
39	18.04	17.93	8.73	8.62	92.41	91.10	0.22	0.28
40	18.00	17.91	8.72	8.65	92.27	91.36	0.22	0.28
41	18.00	17.89	8.80	8.68	93.05	91.66	0.22	0.28
42	18.00	17.89	8.90	8.69	94.17	91.69	0.22	0.29
43	18.01	17.89	8.95	8.66	94.72	91.44	0.22	0.29
44	17.94	17.82	9.01	8.74	95.22	92.22	0.21	0.28
45	17.76	17.66	9.03	8.79	95.04	92.34	0.21	0.28
46	17.57	17.49	8.89	8.77	93.21	91.84	0.21	0.27
47	17.48	17.38	8.95	8.85	93.68	92.41	0.21	0.28
48	17.61	17.52	8.31	8.41	87.14	88.10	0.19	0.27
49	17.86	17.77	8.02	8.14	84.59	85.73	0.20	0.27
50	18.12	18.01	7.97	8.16	84.50	86.39	0.20	0.28
51	18.64	18.41	7.91	8.08	84.79	86.14	0.20	0.28
52	19.14	18.83	7.99	8.11	86.52	87.22	0.20	0.28
53	19.46	19.20	8.16	8.08	88.84	87.63	0.20	0.28
54	19.70	19.44	8.19	8.10	89.65	88.23	0.22	0.29
55	19.83	19.62	8.26	8.07	90.61	88.21	0.22	0.29
56	19.85	19.66	8.37	8.08	91.86	88.37	0.22	0.29
57	19.75	19.61	8.45	8.17	92.61	89.26	0.22	0.29
58	19.50	19.41	8.49	8.26	92.62	89.96	0.22	0.28
59	19.15	19.06	8.27	8.28	89.60	89.47	0.22	0.28
60	18.77	18.69	8.33	8.33	89.51	89.36	0.22	0.28
61	18.41	18.36	8.51	8.43	90.76	89.88	0.21	0.28
62	18.12	18.06	8.66	8.53	91.82	90.38	0.21	0.28
63	17.92	17.85	8.72	8.63	92.09	91.05	0.22	0.28
64	17.77	17.70	8.78	8.66	92.39	91.05	0.21	0.28
65	17.69	17.62	8.81	8.68	92.60	91.13	0.21	0.28
66	17.65	17.58	8.76	8.69	91.95	91.14	0.21	0.28

Table 7. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
67	17.63	17.55	8.82	8.74	92.60	91.67	0.21	0.28
68	17.62	17.53	8.81	8.74	92.51	91.60	0.21	0.28
69	17.62	17.54	8.79	8.69	92.22	91.07	0.21	0.27
70	17.62	17.54	8.76	8.64	91.98	90.59	0.21	0.28
71	17.65	17.55	8.78	8.63	92.19	90.51	0.21	0.28
72	17.75	17.62	8.30	8.39	87.26	88.13	0.20	0.27
73	17.87	17.78	8.19	8.40	86.35	88.50	0.20	0.28
74	18.06	17.94	8.27	8.46	87.60	89.38	0.21	0.28
75	18.22	18.11	8.26	8.44	87.71	89.48	0.20	0.28
76	18.40	18.29	8.25	8.43	87.99	89.77	0.20	0.28
77	18.61	18.55	8.28	8.37	88.68	89.53	0.20	0.28

** Negative experimental time equals the number of hours of acclimation prior to toxicant exposure

Table 8. Swim chamber water quality conditions - Expt. #7

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
-23	10.19	10.09	8.65	8.46	92.48	90.39	28.68	29.07
-22	10.45	10.29	8.41	8.16	90.28	87.62	28.57	29.02
-21	10.66	10.50	8.23	7.83	88.90	84.53	28.76	29.22
-20	10.76	10.61	8.21	7.62	89.01	82.65	29.03	29.54
-19	10.76	10.67	8.12	7.58	88.20	82.48	29.24	29.79
-18	10.74	10.62	8.15	7.61	88.59	82.82	29.41	30.02
-17	10.68	10.57	8.29	7.67	90.00	83.38	29.51	30.15
-16	10.58	10.50	8.33	7.94	90.27	86.30	29.52	30.24
-15	10.43	10.36	8.42	8.17	90.91	88.56	29.44	30.29
-14	10.25	10.19	8.52	8.32	91.56	89.84	29.43	30.33
-13	10.10	10.04	8.49	8.16	90.88	87.84	29.34	30.31
-12	10.14	10.08	8.31	8.26	88.90	88.83	29.01	30.01
-11	10.26	10.19	8.27	8.25	88.40	88.69	28.57	29.60
-10	10.32	10.24	8.26	8.35	88.20	89.76	28.09	29.37
-9	10.21	10.14	8.27	8.44	88.16	90.55	28.16	29.49
-8	10.14	10.06	8.32	8.50	88.43	91.09	28.04	29.58
-7	10.06	9.97	8.38	8.51	88.87	91.09	27.86	29.71
-6	10.01	9.94	8.49	8.57	89.63	91.69	27.38	29.77
-5	10.03	9.95	8.65	8.62	91.26	92.22	27.26	29.72
-4	10.04	9.95	8.68	8.65	92.05	92.51	27.91	29.67
-3	10.01	9.93	8.81	8.65	93.00	92.50	27.38	29.68
-2	9.99	9.91	8.81	8.62	92.56	92.19	26.66	29.66
-1	10.01	9.93	8.88	8.64	93.05	92.39	26.23	29.61
0	11.57	11.54	8.53	8.88	90.25	91.75	21.75	24.33
1	13.89	13.92	8.68	8.80	91.00	93.00	15.38	16.59
2	15.69	15.68	8.45	8.75	90.00	93.00	10.82	11.04
3	17.12	17.09	8.35	8.73	89.50	93.25	7.57	7.31
4	18.20	18.16	7.98	8.50	85.25	91.50	5.29	4.93
5	18.97	18.95	7.90	8.20	84.00	89.50	3.70	3.37
6	19.51	19.48	7.74	7.59	84.76	83.54	2.61	2.34
7	19.87	19.83	7.64	7.37	84.77	81.54	1.86	1.66
8	20.05	19.99	7.67	7.46	85.07	82.57	1.34	1.19
9	20.04	19.98	7.64	7.51	84.62	82.96	0.97	0.88
10	19.78	19.73	7.47	7.54	82.11	82.80	0.74	0.68
11	19.35	19.30	7.47	7.29	81.39	79.33	0.58	0.55
12	18.94	18.86	7.63	7.24	82.39	78.07	0.47	0.45
13	18.59	18.52	7.71	7.29	82.64	78.06	0.40	0.39
14	18.34	18.27	7.77	7.36	82.80	78.33	0.34	0.35
15	18.13	18.07	7.86	7.48	83.43	79.26	0.31	0.32
16	17.98	17.91	7.88	7.59	83.35	80.20	0.29	0.31
17	17.85	17.79	7.86	7.53	82.86	79.36	0.27	0.29
18	17.76	17.69	7.91	7.51	83.29	78.99	0.25	0.29
19	17.75	17.71	7.94	7.51	83.59	78.95	0.24	0.28
20	17.77	17.72	8.00	7.59	84.25	79.89	0.24	0.27
21	17.79	17.73	8.06	7.59	84.90	79.91	0.23	0.27

Table 8. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
22	17.80	17.74	7.95	7.53	83.73	79.26	0.22	0.27
23	17.84	17.78	8.06	7.53	85.01	79.34	0.23	0.27
24	17.94	17.89	8.17	7.59	86.34	80.14	0.23	0.27
25	18.15	18.09	8.18	7.59	86.74	80.44	0.22	0.27
26	18.60	18.49	8.05	7.45	86.16	79.58	0.23	0.27
27	19.17	19.02	8.04	7.35	87.14	79.41	0.23	0.27
28	19.61	19.50	8.05	7.23	88.00	78.89	0.23	0.27
29	19.97	19.88	8.00	7.09	87.99	77.94	0.23	0.27
30	20.23	20.15	7.66	6.97	84.73	77.03	0.23	0.27
31	20.38	20.31	7.66	6.75	84.99	74.79	0.23	0.27
32	20.44	20.38	7.72	6.63	85.79	73.54	0.23	0.27
33	20.36	20.30	7.75	6.61	86.02	73.20	0.23	0.27
34	20.12	20.03	7.76	6.56	85.69	72.31	0.23	0.27
35	19.75	19.67	7.67	6.61	84.02	72.33	0.23	0.27
36	19.37	19.29	7.76	6.78	84.40	73.66	0.23	0.27
37	19.05	18.97	7.78	6.92	84.06	74.65	0.23	0.27
38	18.80	18.70	7.87	7.07	84.57	75.83	0.23	0.27
39	18.57	18.49	8.02	7.18	85.81	76.75	0.22	0.27
40	18.40	18.33	8.13	7.29	86.75	77.60	0.23	0.27
41	18.24	18.17	8.18	7.38	86.91	78.40	0.23	0.27
42	18.13	18.06	8.22	7.41	87.21	78.45	0.22	0.27
43	18.06	17.96	8.25	7.48	87.39	79.07	0.22	0.27
44	17.98	17.88	8.28	7.54	87.51	79.61	0.22	0.27
45	17.89	17.80	8.29	7.60	87.47	80.11	0.22	0.26
46	17.81	17.73	8.39	7.72	88.41	81.19	0.22	0.26
47	17.76	17.71	8.81	8.02	92.71	84.31	0.22	0.26
48	17.89	17.82	8.30	7.78	87.63	81.99	0.20	0.27
49	18.13	18.09	7.95	7.77	84.27	82.33	0.19	0.27
50	18.65	18.51	7.71	7.79	82.61	83.33	0.20	0.27
51	19.30	19.06	7.76	7.87	84.21	85.10	0.20	0.27
52	19.78	19.50	8.10	7.77	88.74	84.76	0.19	0.28
53	20.08	19.85	8.36	7.85	92.19	86.23	0.21	0.28
54	20.24	20.04	8.36	7.81	92.47	86.06	0.24	0.27
55	20.31	20.15	8.39	7.75	92.95	85.63	0.24	0.28
56	20.26	20.14	8.39	7.76	92.94	85.78	0.24	0.28
57	20.12	20.01	8.46	7.78	93.42	85.74	0.24	0.28
58	19.81	19.72	8.44	7.85	92.56	86.04	0.24	0.28
59	19.38	19.31	8.41	7.93	91.52	86.16	0.24	0.28
60	19.01	18.93	8.52	8.07	91.95	87.04	0.24	0.28
61	18.68	18.62	8.63	8.17	92.61	87.53	0.24	0.28
62	18.44	18.38	8.63	8.25	92.16	88.00	0.24	0.28
63	18.26	18.20	8.72	8.29	92.69	88.06	0.24	0.27
64	18.13	18.06	8.80	8.34	93.30	88.32	0.24	0.28
65	18.03	17.96	8.84	8.40	93.58	88.78	0.24	0.28
66	17.95	17.89	8.83	8.44	93.32	89.12	0.24	0.28

Table 8. (cont.)

Exp. Time (Hrs)	Mean Hourly Temperature (°C)		Mean Hourly Dissolved O_2 $mg \cdot L^{-1}$		Mean Hourly Percent O_2 Saturation		Mean Hourly Salinity (ppt)	
	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2	Ch 1	Ch 2
67	17.88	17.83	8.86	8.48	93.47	89.36	0.24	0.28
68	17.82	17.76	8.90	8.48	93.83	89.26	0.23	0.27
69	17.75	17.69	8.93	8.52	94.00	89.61	0.23	0.27
70	17.67	17.62	8.92	8.53	93.73	89.52	0.23	0.27
71	17.67	17.61	8.74	8.51	91.82	89.28	0.22	0.27
72	17.80	17.76	8.34	8.42	87.85	88.70	0.22	0.28
73	18.08	18.05	8.26	8.53	87.54	90.38	0.22	0.28
74	18.63	18.48	8.19	8.47	87.79	90.46	0.23	0.28
75	19.35	19.11	8.24	8.32	89.56	89.99	0.23	0.28
76	19.91	19.66	8.20	8.36	90.12	91.48	0.23	0.28
77	20.19	19.94	8.15	8.38	90.06	92.22	0.24	0.29

** Negative experimental time equals the number of hours of acclimation prior to toxicant exposure

Figure 3. Water quality conditions - Experiment #1

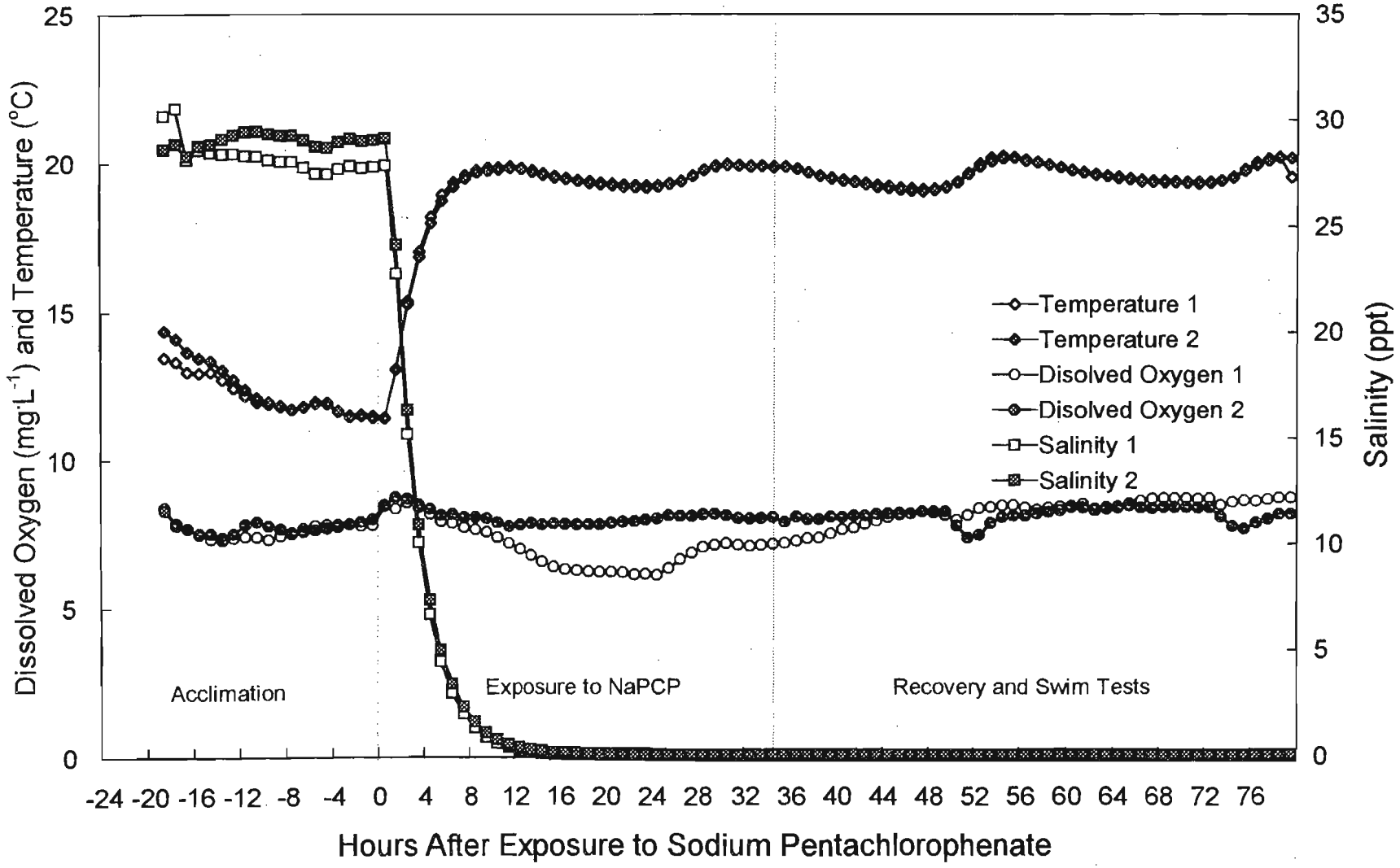


Figure 4. Water quality conditions - Experiment #2

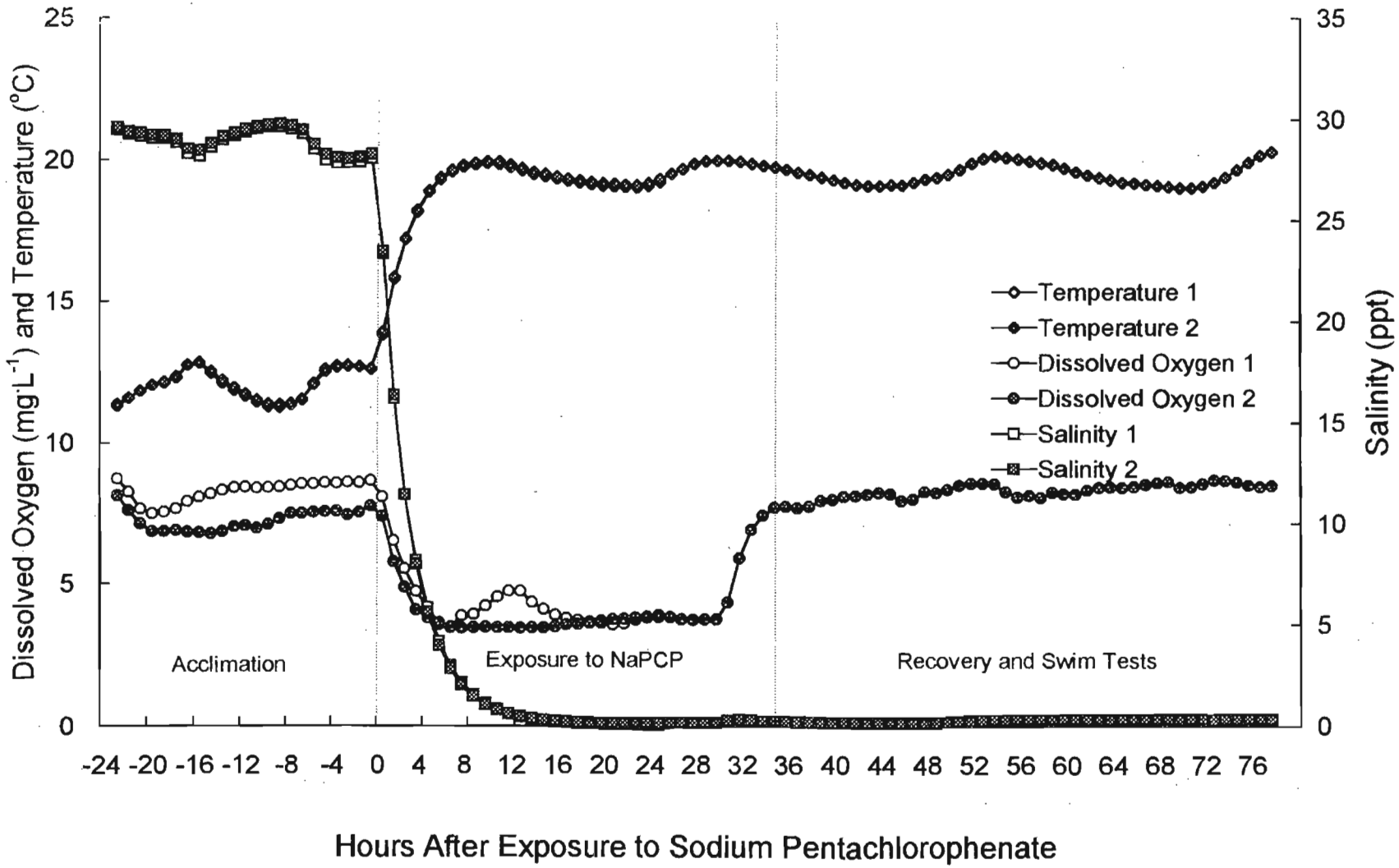


Figure 5. Water quality conditions - Experiment #3

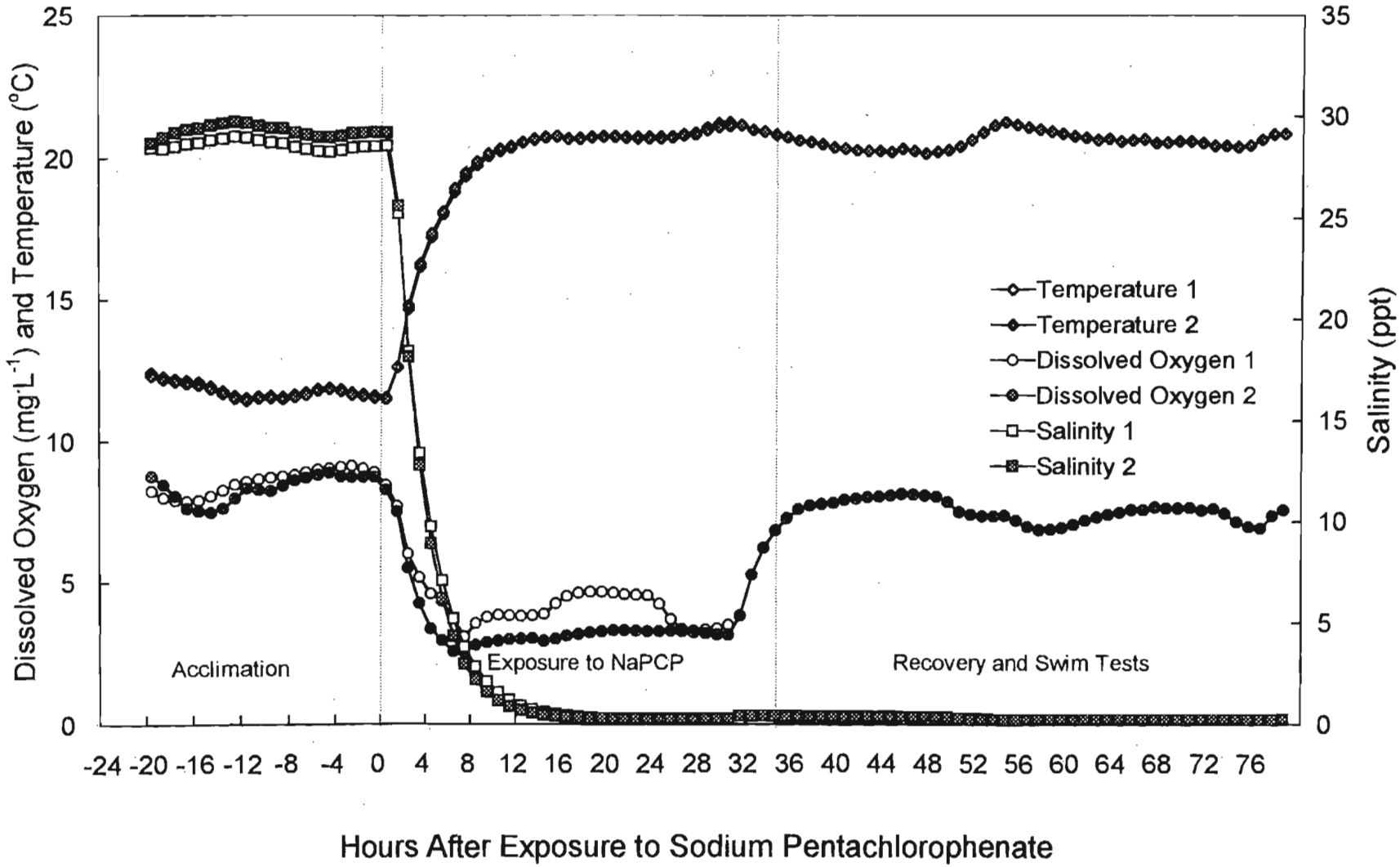


Figure 6. Water quality conditions - Experiment #4

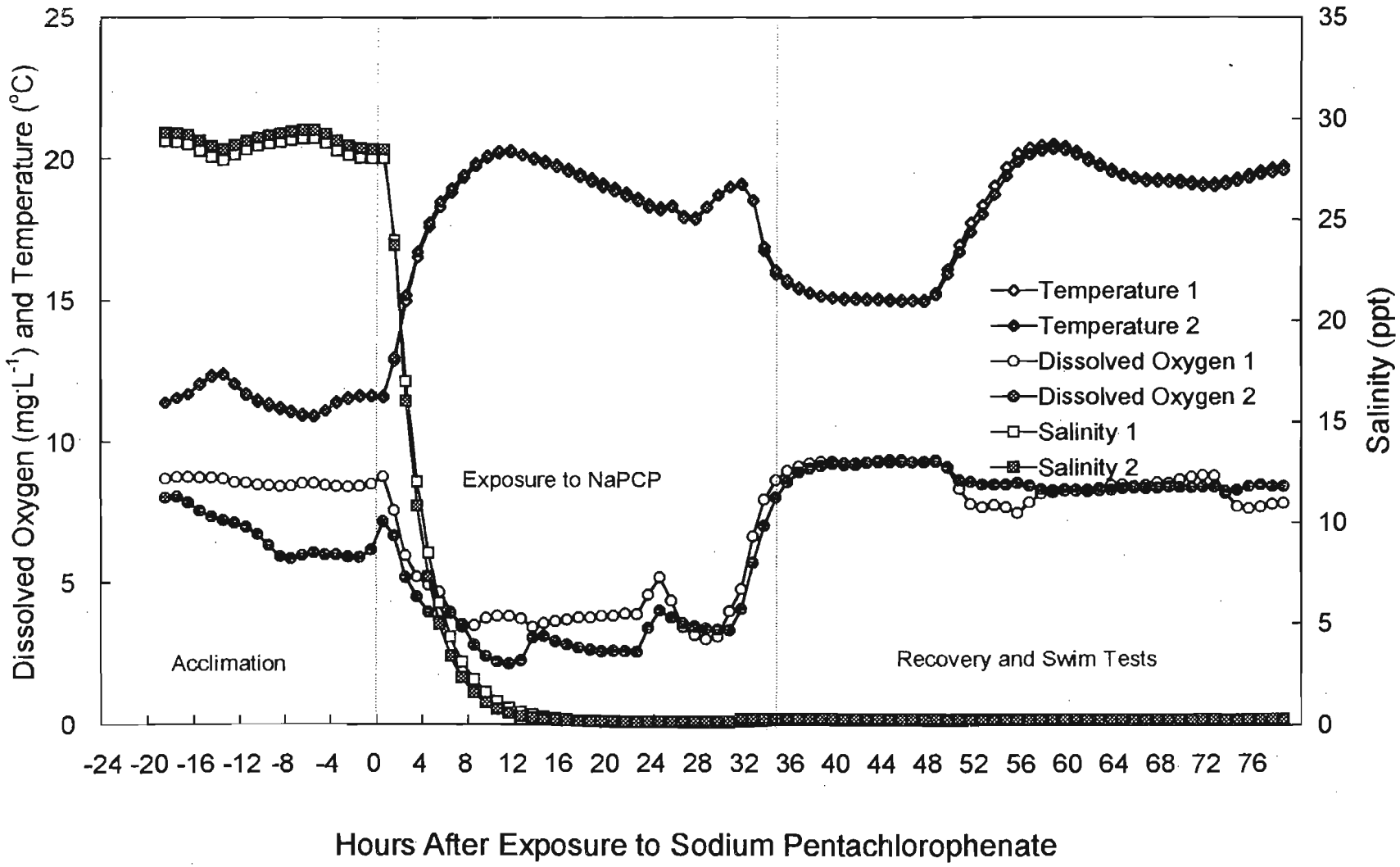


Figure 7. Water quality conditions - Experiment #5

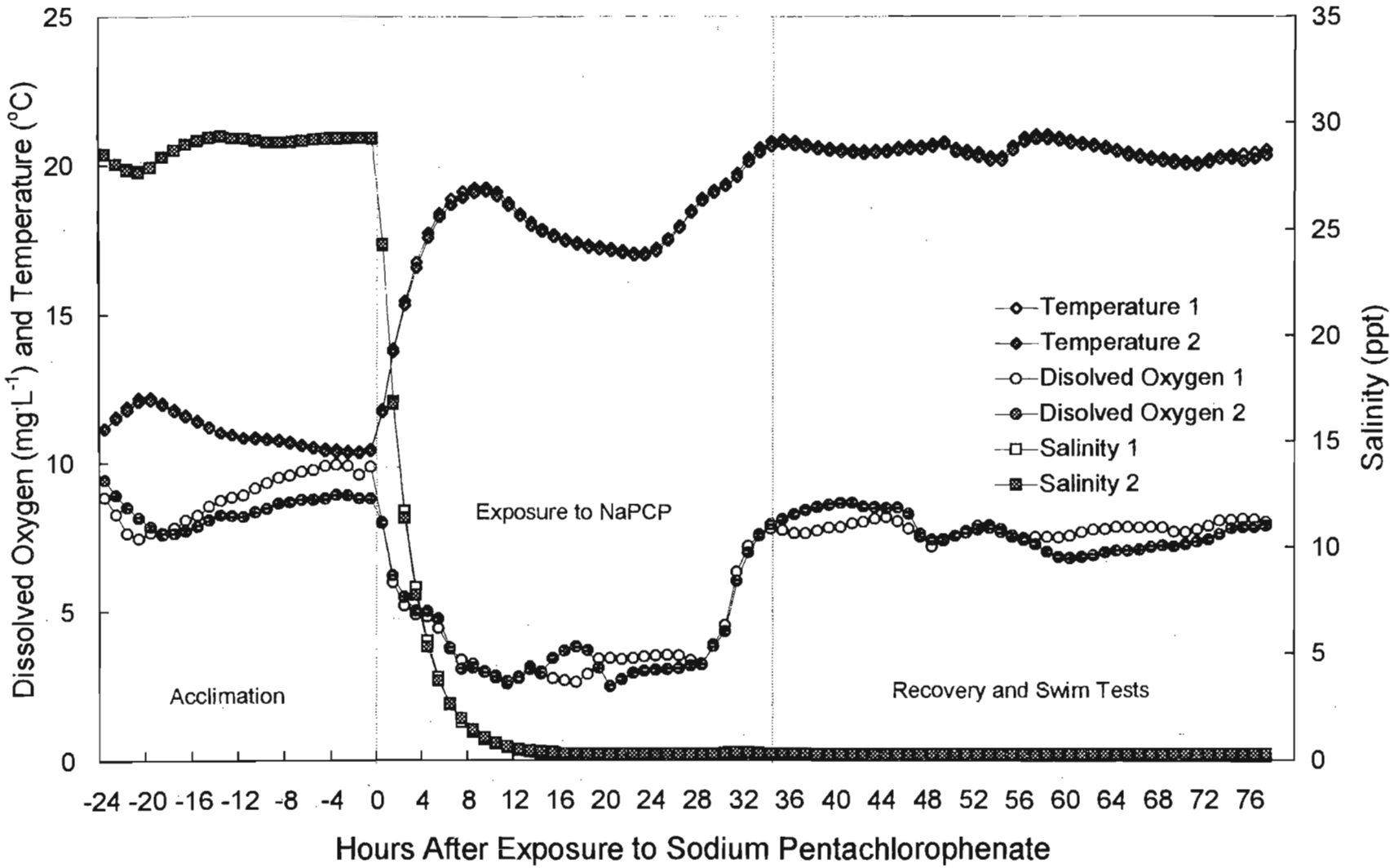


Figure 8. Water quality conditions - Experiment #6

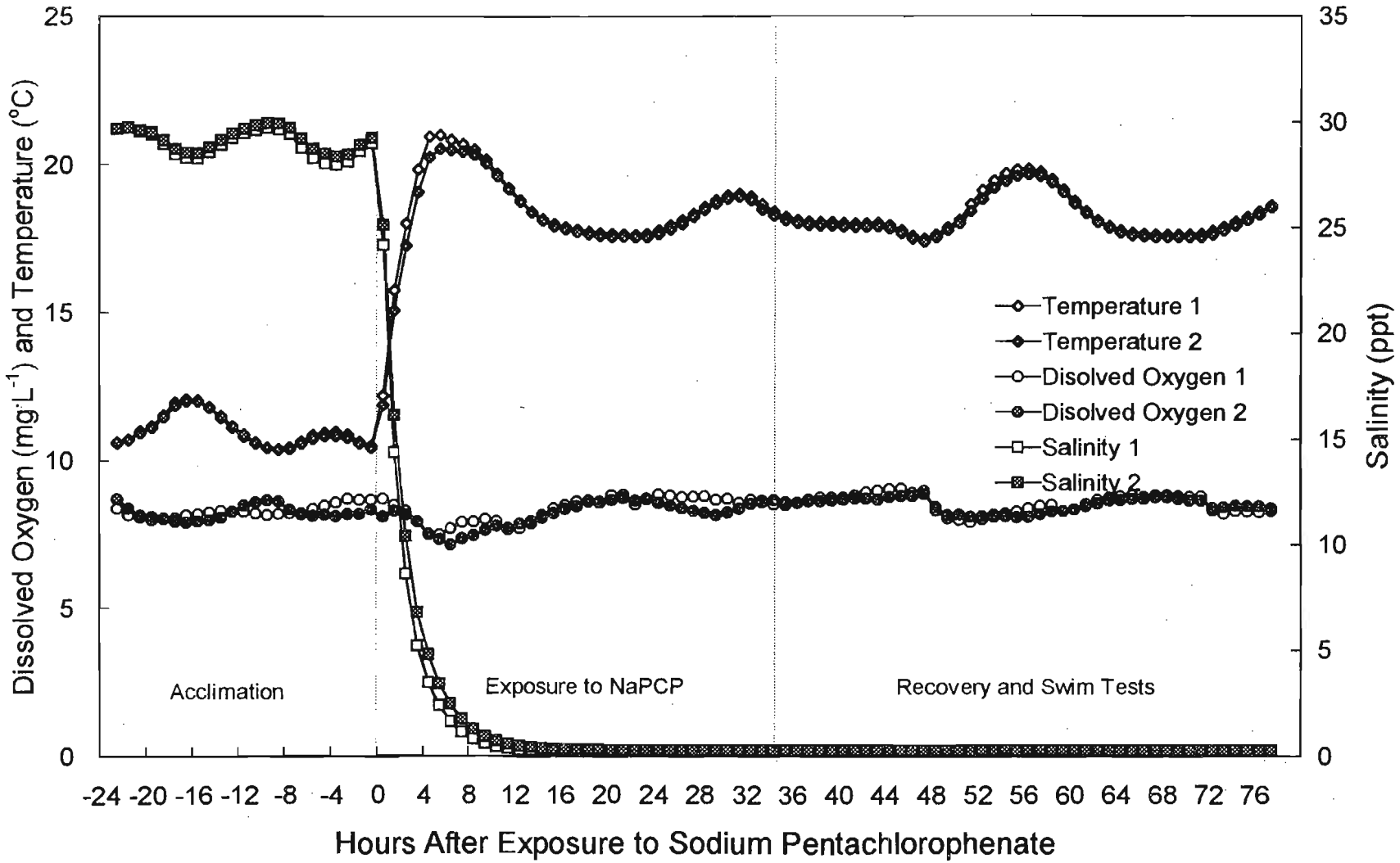


Figure 9. Water quality conditions - Experiment #7

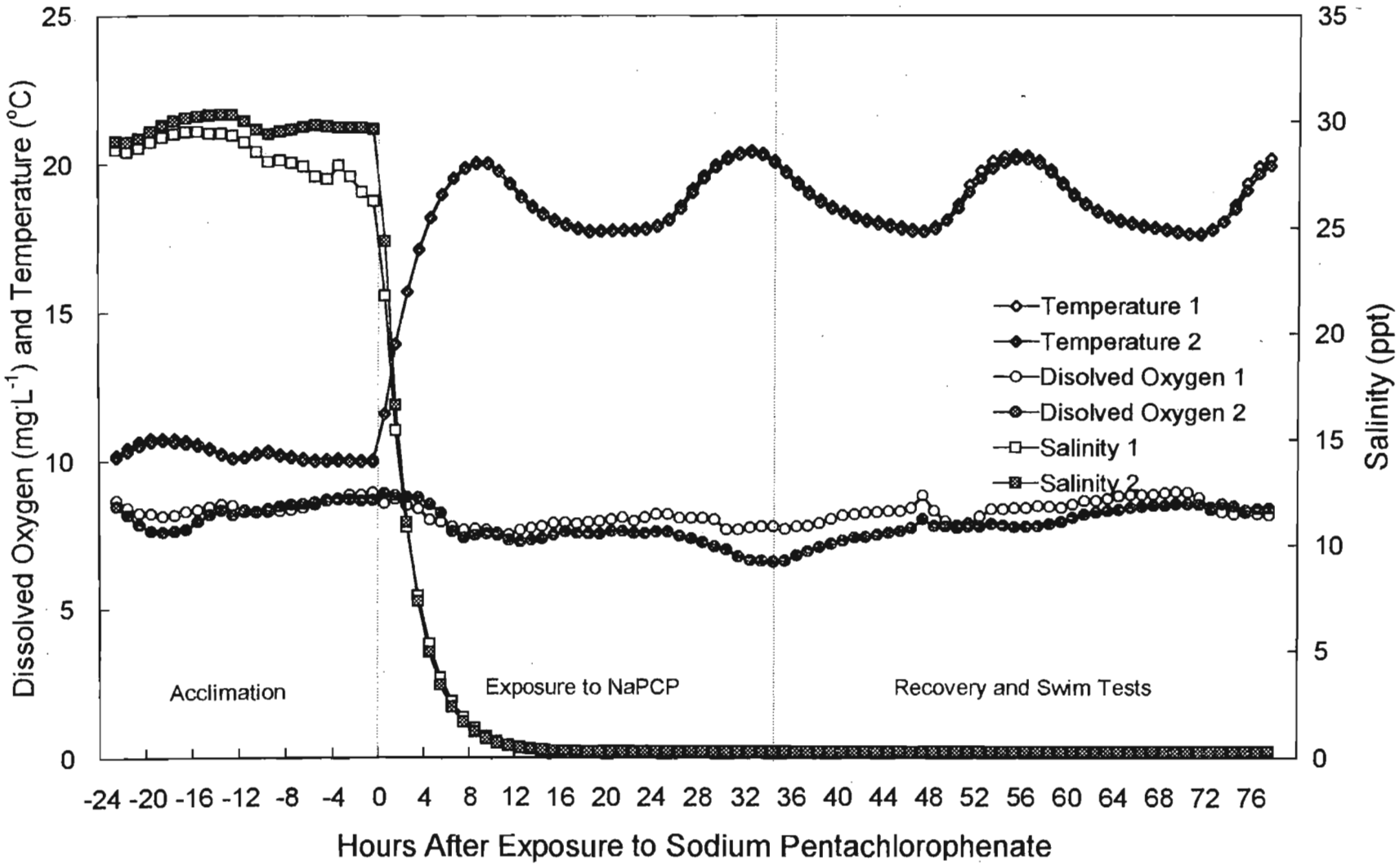


Table 9. Summary of experimental pH values.

Expt.#	Date	Sample Location	pH
1	August 14, 1996	Chamber 1 (NaPCP 50 ppb)	6.7
		Chamber 2 (Carrier)	7.3
		Cyprus Creek water	7.2
2	August 21, 1996	Chamber 1 (NaPCP 50 ppb)	7.0
		Chamber 2 (Carrier)	6.9
		Cyprus Creek water	7.3
3	August 28, 1996	Chamber 1 (NaPCP 20 ppb)	7.1
		Chamber 2 (Carrier)	7.2
		Well Water	7.3
		Chamber 1 Stock Solution	6.8
4	September 4, 1996	Chamber 1 (NaPCP 5 ppb)	6.8
		Chamber 2 (NaPCP 10 ppb)	6.9
		Chamber 1 Stock Solution	6.7
		Chamber 2 Stock Solution	7.0
5	September 11, 1996	Chamber 1 (NaPCP 5 ppb)	7.0
		Chamber 2 (NaPCP 5 ppb)	7.0
		Chamber 1 Stock Solution	7.3
		Chamber 2 Stock Solution	7.4
		Well Water	7.0
6	September 18, 1996	Chamber 1 (NaPCP 5 ppb)	7.1
		Chamber 2 (NaPCP 5 ppb)	7.1
		Chamber 1 Stock Solution	7.0
		Chamber 2 Stock Solution	6.8
		Well Water	7.0
7	September 25, 1996	Chamber 1 (Carrier)	7.1
		Chamber 2 (NaPCP 20ppb)	7.1
		Chamber 2 Stock Solution	7.0
		Carrier Stock Solution	10.0
		Well Water	7.0

Figure 10. Experimental protocol for 1996 sockeye salmon experiments

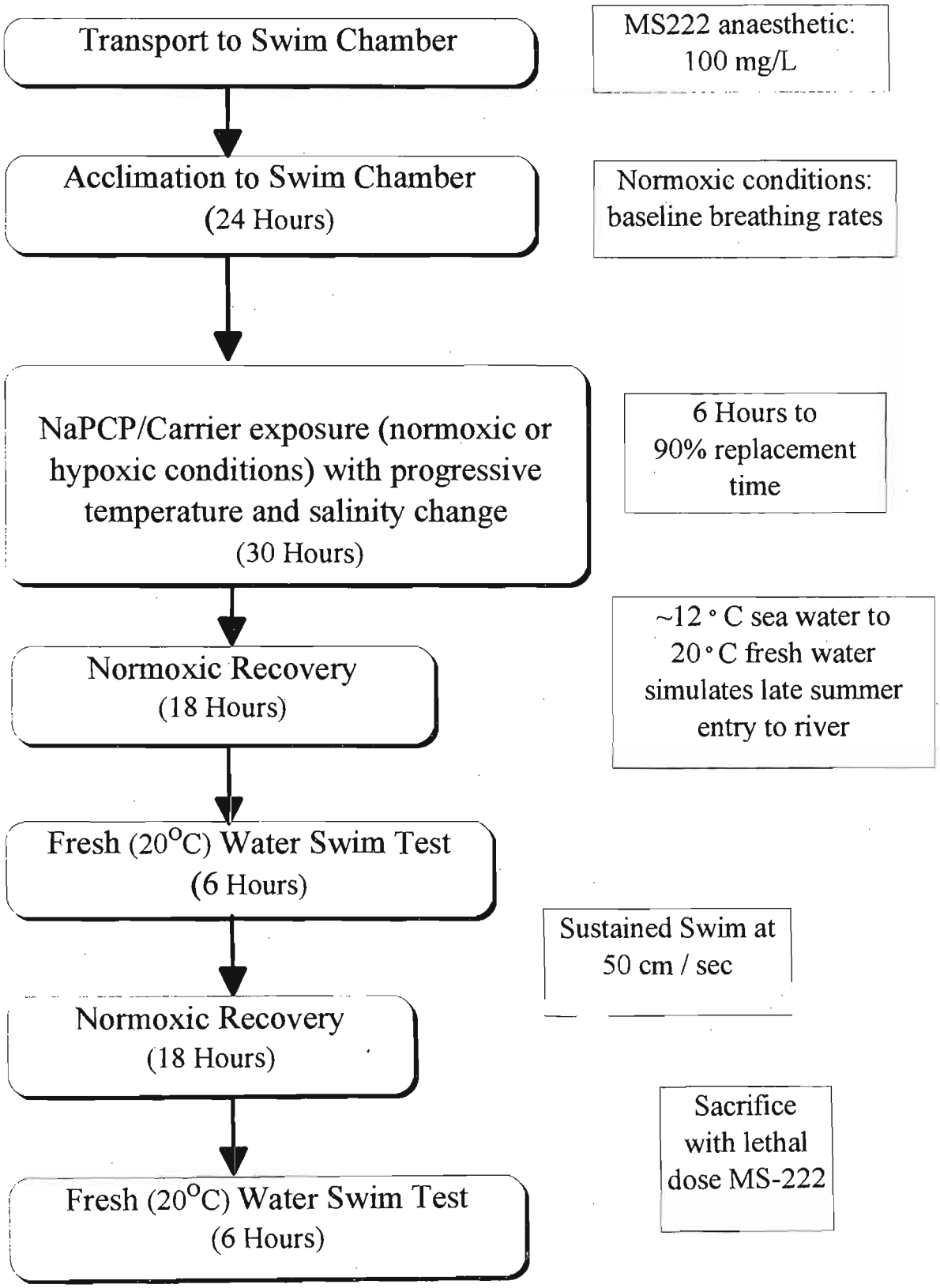


Table 10. Concentrations of NaPCP administered in swim chambers 1996

QUALITY ASSURANCE / QUALITY CONTROL ANALYSIS BY:
ENVIRONMENT CANADA - LABORATORIES, PACIFIC ENVIRONMENTAL SCIENCE CENTRE
2645 DOLLARTON HWY, NORTH VANCOUVER B.C. V7H 1V2 (604) 924-2500
AUTHORIZED BY: PAUL KLUCKNER (MANAGER) TECHNICIAN: VESNA FORTULA

EXPT #	CHAMBER #	TREATMENT	NOMINAL CONCENTRATION	ACTUAL CONCENTRATION	MEAN ACTUAL CONCENTRATION	SURROGATE RECOVERY
1	1	NORMOXIC	40 ppb	39.3/40.4 ppb	39.9 ppb	109% / 102%
1	2	NORMOXIC	CONTROL	0 ppb	0 ppb	85% / 92%
2	1	HYPOXIC	40 ppb	47.5/44.6 ppb	46.0 ppb	105% / 95%
2	2	HYPOXIC	CONTROL	0 ppb	0 ppb	-
3	1	HYPOXIC	20 ppb	19.2/15.7 ppb	17.5 ppb	99% / 94%
3	2	HYPOXIC	CONTROL	0 ppb	0 ppb	-
4	2	HYPOXIC	10 ppb	9.67 ppb	9.7 ppb	86%
4	1	HYPOXIC	5 ppb	4.02 ppb	4.0 ppb	87%
5	1	HYPOXIC	5 ppb	4.13 ppb	4.1 ppb	80%
5	2	HYPOXIC	5 ppb	3.86 ppb	3.9 ppb	82%
6	1	NORMOXIC	5 ppb	3.94 ppb	3.9 ppb	98%
6	2	NORMOXIC	5 ppb	5.08 ppb	5.1 ppb	128%
7	1	NORMOXIC	CONTROL	0 ppb	0 ppb	-
7	2	NORMOXIC	20 ppb	13.1/12.8 ppb	13.0 ppb	100% / 100%

Table 11. Time to death in NaPCP exposed adult sockeye salmon

TREATMENT	N	PERCENT MORTALITY DURING 30 H EXPOSURE PERIOD			
		6H TOXICANT & NORM/HYP 20°C FW	10-12H TOXICANT & NORM/HYP 20°C FW	24H TOXICANT & NORM/HYP 20°C FW	30H TOXICANT & NORM/HYP 20°C FW
N CONTROL	8	0	0	0	0
N PCP (5ppb)	8	0	0	0	0
N PCP (20ppb)	3	0	0	0	0
N PCP (50ppb)	4	0	0	0	25%
H CONTROL	8	0	0	12.5%	12.5%
H PCP (5ppb)	8	0	0	0	0
H PCP (5ppb ##)	4	0	0	0	0
H PCP (10ppb ##)	4	0	75%	75%	75%
H PCP (20ppb)	4	25%	25%	75%	100%
H PCP (50ppb)	4	0	75%	100%	100%

= 15°C RECOVERY AFTER TOXICANT EXPOSURE INSTEAD OF 17.5°C - 20°C PLUS DEGASSER MALFUNCTION

N = NORMOXIC CONDITIONS PREVAILED THROUGHOUT THE TOXICANT EXPOSURE PERIOD

H = HYPOXIC CONDITIONS PREVAILED THROUGHOUT THE TOXICANT EXPOSURE PERIOD (30 - 40% SATURATION)

Table 12. Summary of physical parameters of adult sockeye salmon 1996

TREATMENT	SEX	(cm) LENGTH	(g) WEIGHT	SEX	(cm) LENGTH	(g) WEIGHT
NORMOXIC PCP (50ppb)	M	56.5	2094	F	53.0	1522
	M	52.5	1470			
	M	58.0	2308			
HYPOXIC PCP (50ppb)	M	56.3	1914	F	48.8	1388
				F	53.0	1470
				F	48.8	1300
NORMOXIC PCP (20ppb)	M	60.0	2072			
	M	54.0	1482			
	M	61.5	2424			
HYPOXIC PCP (20ppb)	M	58.5	2114			
	M	58.5	2184			
	M	58.6	2224			
	M	57.5	2126			
HYPOXIC PCP (10ppb)	M	55.7	1958	F	56.2	2012
	M	58.5	1950			
	M	58	2232			
NORMOXIC PCP (5ppb)	M	55.5	1624	F	52.5	1436
	M	56.0	1306	F	51.0	1130
	M	57.5	1808	F	60.0	2122
	M	53.0	1374	F	56.5	1950
HYPOXIC PCP (5ppb) (Extra Group)				F	54.8	1376
				F	52.5	1292
				F	54.8	1450
				F	57.4	1712
HYPOXIC PCP (5ppb)	M	52.0	1458	F	58.5	2064
	M	55.0	1606	F	51.5	1278
	M	59.0	2188	F	55.0	1584
	M	50.5	1324			
	M	52.0	1310			
NORMOXIC CONTROL	M	59.0	2022	F	49.5	1282
	M	56.5	1984	F	54.5	1616
	M	58.0	1978	F	58.0	1898
	M	52.0	1382	F	55.0	1580
HYPOXIC CONTROL	M	60.4	2380	F	53.7	1784
	M	55.2	1678	F	54.9	1616
	M	55.2	1730	F	55.0	1610
	M	59.0	2268	F	57.0	1810
MEAN	31 MALE	56.4	1870	24 FEMALE	54.2	1595
SD		2.8	353		3.0	275

Table 13. Summary of swim chamber water velocity tests.

DATE: WED AUGUST 7, 1996

MOTOR POSITION = 10/11 BARS

** VALUES EQUAL TIME IN SECONDS FOR DYE SHOT TO TRAVEL 115 cm **

SIDE A		SIDE B	
INSIDE	OUTSIDE	INSIDE	OUTSIDE
5.98	4.68	5.22	4.82
6.12	4.92	5.8	4.75
5.52	4.85	6.35	4.94
5.42	4.82	5.6	5.07
4.72	6.02	6.25	5.04
5.07	5.2	5.64	4.86
	5.61	5.6	
	5.19	5.14	
		5.39	

AVERAGE TIME (sec)

5.47	5.16	5.67	4.91

AVERAGE VELOCITY (cm/sec)

21.0	22.3	20.3	23.4

GRAND AVERAGE = 21.8 cm/sec

MOTOR POSITION = 13/14 BARS

SIDE A		SIDE B	
INSIDE	OUTSIDE	INSIDE	OUTSIDE
2.66	2.54	2.38	2.57
2.55	2.52	2.42	2.23
2.44	2.15	2.11	2.26
2.21	2.46	2.42	2.45
2.32	2.31		
2.39	2.37		
	2.14		
	2.1		
	2.16		
	2.51		
	2.18		

AVERAGE TIME (sec)

2.43	2.31	2.33	2.38

AVERAGE VELOCITY (cm/sec)

47.4	49.7	49.3	48.4

GRAND AVERAGE = 48.7 cm/sec

Table 14. Summary of performance in 2 consecutive 6 h swim tests

TREATMENT	TOTAL (N)	(cm) LENGTH	(g) WEIGHT	(bl/s) SPEED	SWIM TEST (N)	DUPLICATE 6H SWIM TEST OBSERVATIONS #1 GRID	#1 SWIM	#1 % GRID	#1 % SWIM	#2 GRID	#2 SWIM	#2 % GRID	#2 % SWIM
N CONTROL	8	54.9	1619	0.91	8	22	266	7.6	92.4	12	276	4.2	95.8
N PCP (5ppb)	8	56.3	1753	0.89	8	13	275	4.5	95.5	12	276	4.2	95.8
N PCP (20ppb)	3	58.5	1993	0.86	3	3	105	2.8	97.2	3	105	2.8	97.2
N PCP (50ppb)	4	55.0	1849	0.91	3	6	102	5.6	94.4	5	103	4.6	95.4
H CONTROL	8	56.5	1855	0.89	7	13	239	5.2	94.8	10	242	4.0	96.0
H PCP (5ppb)	8	52.3	1374	0.96	8	12	276	4.2	95.8	10	278	3.5	96.5
H PCP (5ppb)**	4	54.9	1458	0.91	4	8	136	5.6	94.4	7	137	4.9	95.1
H PCP (10ppb*)	4	57.1	2038	0.88	1	2	34	5.6	94.4	1	35	2.8	97.2
H PCP (20ppb)	4	58.3	2162	0.86	0	-	-	-	-	-	-	-	-
H PCP (50ppb)	4	51.7	1518	0.97	0	-	-	-	-	-	-	-	-

**** = 15°C RECOVERY AFTER TOXICANT EXPOSURE INSTEAD OF 17.5°C - 20°C PLUS DEGASSER MALFUNCTION**

*** = 15°C RECOVERY AFTER TOXICANT EXPOSURE INSTEAD OF 17.5°C - 20°C**

N = NORMOXIC CONDITIONS PREVAILED THROUGHOUT THE TOXICANT EXPOSURE PERIOD

H = HYPOXIC CONDITIONS PREVAILED THROUGHOUT THE TOXICANT EXPOSURE PERIOD (30% - 40% SATURATION)

Table 15. Swim performance test results - Normoxic Control Group

						DUPLICATE 6H SWIM TEST OBSERVATIONS							
FISH	SEX	(cm) LENGTH	(g) WEIGHT	SCALE SAMPLE	(bl/s) SPEED	#1 GRID	#1 SWIM	#1 % GRID	#1 % SWIM	#2 GRID	#2 SWIM	#2 % GRID	#2 % SWIM
1	M	59.0	2022	Yes	0.85	0	36	0.0	100.0	0	36	0.0	100.0
2	M	56.5	1984	Yes	0.88	3	33	8.3	91.7	4	32	11.1	88.9
3	M	58.0	1978	Yes	0.86	1	35	2.8	97.2	1	35	2.8	97.2
4	F	49.5	1282	Yes	1.01	7	29	19.4	80.6	2	34	5.6	94.4
5	F	54.5	1616	Yes	0.92	0	36	0.0	100.0	1	35	2.8	97.2
6	F	58.0	1898	Yes	0.86	0	36	0.0	100.0	1	35	2.8	97.2
7	F	55.0	1580	Yes	0.91	2	34	5.6	94.4	0	36	0.0	100.0
8	M	52.0	1382	Yes	0.96	9	27	25.0	75.0	3	33	8.3	91.7
MEAN		54.9	1619		0.91	2.8	33.3			1.3	34.8		
SD		3.3	291.7		0.1	3.5	3.5			1.4	1.4		
TOTAL						22	266	7.6	92.4	12	276	4.2	95.8

COMMENTS:

LIVER AND BILE SAMPLES WERE COLLECTED FROM FISH #5 - #8 FOR ANALYSIS AT IOS
FISH #6 DID NOT HAVE ENOUGH BILE TO COLLECT

Table 16. Swim performance test results - Normoxic NaPCP (5 ppb) Group

						DUPLICATE 6H SWIM TEST OBSERVATIONS							
FISH	SEX	(cm) LENGTH	(g) WEIGHT	SCALE SAMPLE	(bl/s) SPEED	#1 GRID	#1 SWIM	#1 % GRID	#1 % SWIM	#2 GRID	#2 SWIM	#2 % GRID	#2 % SWIM
1	M	55.5	1624	No	0.9	2	34	5.6	94.4	1	35	2.8	97.2
2	M	56.0	1306	Yes	0.89	0	36	0.0	100.0	1	35	2.8	97.2
3	F	52.5	1436	No	0.95	1	35	2.8	97.2	0	36	0.0	100.0
4	M	53.0	1374	Yes	0.94	2	34	5.6	94.4	3	33	8.3	91.7
5	F	51.0	1130	Yes	0.98	3	33	8.3	91.7	4	32	11.1	88.9
6	F	60.0	2122	Yes	0.83	2	34	5.6	94.4	0	36	0.0	100.0
7	M	57.5	1808	No	0.87	2	34	5.6	94.4	2	34	5.6	94.4
8	F	56.5	1950	Yes	0.89	1	35	2.8	97.2	1	35	2.8	97.2
MEAN		56.3	1753		0.89	2	34			1.8	34.3		
SD		2.9	343.1		0.0	0.9	0.9			1.4	1.4		
TOTAL						13	275	4.5	95.5	12	276	4.2	95.8

COMMENTS:

SCALES FROM FISH #1, #3, & #7 WERE RESORBED
LIVER AND BILE SAMPLES WERE COLLECTED FOR ANALYSIS AT IOS.

Table 17. Swim performance test results - Normoxic NaPCP (20 ppb) Group

						DUPLICATE 6H SWIM TEST OBSERVATIONS							
FISH	SEX	(cm) LENGTH	(g) WEIGHT	SCALE SAMPLE	(bl/s) SPEED	#1 GRID	#1 SWIM	#1 % GRID	#1 % SWIM	#2 GRID	#2 SWIM	#2 % GRID	#2 % SWIM
1	M	60.0	2072	No	0.83	0	36	0	100	0	36	0	100
2	M	54.0	1482	No	0.93	2	34	5.6	94.4	2	34	5.6	94.4
3	M	61.5	2424	No	0.81	1	35	2.8	97.2	1	35	2.8	97.2
MEAN		58.5	1993		0.86	1	35			1	35		
SD		4.0	476.0		0.1	1.0	1.0			1.0	1.0		
TOTAL						3	105	2.8	97.2	3	105	2.8	97.2

COMMENTS:

SCALES FROM FISH #1, #2, & #3 WERE RESORBED

LIVER AND BILE SAMPLES WERE COLLECTED FOR ANALYSIS AT IOS.

Table 18. Swim performance test results - Normoxic NaPCP (50 ppb) Group

						DUPLICATE 6H SWIM TEST OBSERVATIONS							
FISH	SEX	(cm) LENGTH	(g) WEIGHT	SCALE SAMPLE	(bl/s) SPEED	#1 GRID	#1 SWIM	#1 % GRID	#1 % SWIM	#2 GRID	#2 SWIM	#2 % GRID	#2 % SWIM
1	M	56.5	2094	Yes	0.88	-	-	-	-	-	-	-	-
2	M	52.5	1470	Yes	0.95	3	33	8.3	91.7	1	35	2.8	97.2
3	F	53.0	1522	Yes	0.94	2	34	5.6	94.4	2	34	5.6	94.4
4	M	58.0	2308	Yes	0.86	1	35	2.8	97.2	2	34	5.6	94.4
MEAN		55.0	1849		0.91	2	34			1.7	34.3		
SD		2.7	416.8		0.0	1.0	1.0			0.6	0.6		
TOTAL						6	102	5.6	94.4	5	103	4.6	95.4

Table 19. Swim performance test results - Hypoxic Control Group

						DUPLICATE 6H SWIM TEST OBSERVATIONS							
FISH	SEX	(cm) LENGTH	(g) WEIGHT	SCALE SAMPLE	(bl/s) SPEED	#1 GRID	#1 SWIM	#1 % GRID	#1 % SWIM	#2 GRID	#2 SWIM	#2 % GRID	#2 % SWIM
1	F	53.7	1784	Yes	0.93	0	36	0.0	100.0	0	36	0.0	100.0
2	M	60.4	2380	Yes	0.83	0	36	0.0	100.0	0	36	0.0	100.0
3	M	55.2	1678	Yes	0.91	8	28	22.2	77.8	6	30	16.7	83.3
4	F	54.9	1616	Yes	0.91	3	33	8.3	91.7	2	34	5.6	94.4
5	F	55.0	1610	Yes	0.91	2	34	5.6	94.4	0	36	0.0	100.0
6	F	57.0	1810	Yes	0.88	0	36	0.0	100.0	1	35	2.8	97.2
7	M	55.2	1730	Yes	0.91	0	36	0.0	100.0	1	35	2.8	97.2
8	M	59.0	2268	Yes	0.85	-	-	-	-	-	-	-	-
MEAN		56.6	1855		0.89	0.67	35.3			0.7	35.3		
SD		2.3	296.9		0.0	3.0	3.0			2.1	2.1		
TOTAL						13	239	5.2	94.8	10	242	4.0	96.0

Table 20. Swim performance test results - Hypoxic NaPCP (5 ppb) Group

						DUPLICATE 6H SWIM TEST OBSERVATIONS							
FISH	SEX	(cm) LENGTH	(g) WEIGHT	SCALE SAMPLE	(bl/s) SPEED	#1 GRID	#1 SWIM	#1 % GRID	#1 % SWIM	#2 GRID	#2 SWIM	#2 % GRID	#2 % SWIM
1	F	58.5	2064	Yes	0.85	3	33	8.3	91.7	3	33	8.3	91.7
2	M	52.0	1458	No	0.96	0	36	0.0	100.0	0	36	0.0	100.0
3	M	55.0	1606	Yes	0.91	1	35	2.8	97.2	1	35	2.8	97.2
4	M	59.0	2188	Yes	0.85	2	34	5.6	94.4	3	33	8.3	91.7
5	F	51.5	1278	Yes	0.97	0	36	0.0	100.0	0	36	0.0	100.0
6	M	50.5	1324	Yes	0.99	3	33	8.3	91.7	2	34	5.6	94.4
7	M	52.0	1310	No	0.96	1	35	2.8	97.2	0	36	0.0	100.0
8	F	55.0	1584	Yes	0.91	2	34	5.6	94.4	1	35	2.8	97.2
MEAN		52.3	1374		0.96	1.5	34.5			0.8	35.3		
SD		3.2	347.5		0.1	1.2	1.2			1.3	1.3		
TOTAL						12	276	4.2	95.8	10	278	3.5	96.5

COMMENTS:

SCALES FROM FISH #2 & #7 WERE RESORBED.
LIVER AND BILE SAMPLES WERE COLLECTED FOR ANALYSIS AT IOS.
FISH #2 & #6 DID NOT HAVE ENOUGH BILE TO COLLECT

Table 21. Swim performance test results - Hypoxic NaPCP (5 ppb - extra) Group

						DUPLICATE 6H SWIM TEST OBSERVATIONS							
FISH	SEX	(cm) LENGTH	(g) WEIGHT	SCALE SAMPLE	(bl/s) SPEED	#1 GRID	#1 SWIM	#1 % GRID	#1 % SWIM	#2 GRID	#2 SWIM	#2 % GRID	#2 % SWIM
1	F	54.8	1376	Yes	0.91	4	32	11.1	88.9	3	33	8.3	91.7
2	F	52.5	1292	Yes	0.95	1	35	2.8	97.2	1	35	2.8	97.2
3	F	54.8	1450	Yes	0.91	3	33	8.3	91.7	2	34	5.6	94.4
4	F	57.4	1712	Yes	0.87	0	36	0.0	100.0	1	35	2.8	97.2
MEAN		54.9	1458		0.91	2	34			1.8	34.3		
SD		2.0	181.5		0.0	1.8	1.8			1.0	1.0		
TOTAL						8	136	5.6	94.4	7	137	4.9	95.1

COMMENTS:

15°C OVERNIGHT RECOVERY TEMPERATURE AFTER TOXICANT EXPOSURE PERIOD INSTEAD OF 17.5°C - 20°C.
17.5°C - 20°C TEMPERATURES RESUMED DURING MORNING OF 1ST SWIM TEST AND CONTINUED FOR DURATION OF EXPERIMENT.
DEGASSER MALFUNCTIONED AFTER APPROX. 21 HRS OF TOXICANT EXPOSURE AND THEREFORE WAS DELIVERING WATER OF HIGHER SATURATION THAN INTENDED TO THE CHAMBER FOR A TWO HR PERIOD (06:00 - 08:00).

Table 22. Swim performance test results - Hypoxic NaPCP (10 ppb) Group

						DUPLICATE 6H SWIM TEST OBSERVATIONS							
FISH	SEX	(cm) LENGTH	(g) WEIGHT	SCALE SAMPLE	(bl/s) SPEED	#1 GRID	#1 SWIM	#1 % GRID	#1 % SWIM	#2 GRID	#2 SWIM	#2 % GRID	#2 % SWIM
1	F	56.2	2012	Yes	0.89	-	-	-	-	-	-	-	-
2	M	55.7	1958	Yes	0.9	-	-	-	-	-	-	-	-
3	M	58.5	1950	Yes	0.85	2	34	5.6	94.4	1	35	2.8	97.2
4	M	58	2232	Yes	0.86	-	-	-	-	-	-	-	-
MEAN		57.1	2038		0.88	2	34			1	35		
SD		1.4	132.2		0.0								
TOTAL						2	34	5.6	94.4	1	35	2.8	97.2

COMMENTS:

15°C OVERNIGHT RECOVERY TEMPERATURE AFTER TOXICANT EXPOSURE PERIOD INSTEAD OF 17.5°C - 20°C.

17.5°C - 20°C TEMPERATURES RESUMED DURING MORNING OF 1ST SWIM TEST AND CONTINUED FOR DURATION OF EXPERIMENT.

Table 23. Swim performance test results - Hypoxic NaPCP (20 ppb) Group

						DUPLICATE 6H SWIM TEST OBSERVATIONS							
FISH	SEX	(cm) LENGTH	(g) WEIGHT	SCALE SAMPLE	(bl/s) SPEED	#1 GRID	#1 SWIM	#1 % GRID	#1 % SWIM	#2 GRID	#2 SWIM	#2 % GRID	#2 % SWIM
1	M	58.5	2114	Yes	0.85	-	-	-	-	-	-	-	-
2	M	58.5	2184	Yes	0.85	-	-	-	-	-	-	-	-
3	M	58.6	2224	Yes	0.85	-	-	-	-	-	-	-	-
4	M	57.5	2126	No	0.87	-	-	-	-	-	-	-	-
MEAN		58.3	2162		0.86								
SD		0.5	51.4		0.0								
TOTAL													

COMMENTS:

SCALES FROM FISH #4 WERE RESORBED

Table 24. Swim performance test results - Hypoxic NaPCP (50 ppb) Group

						DUPLICATE 6H SWIM TEST OBSERVATIONS							
FISH	SEX	(cm) LENGTH	(g) WEIGHT	SCALE SAMPLE	(bl/s) SPEED	#1 GRID	#1 SWIM	#1 % GRID	#1 % SWIM	#2 GRID	#2 SWIM	#2 % GRID	#2 % SWIM
1	F	48.8	1388	No	1.02	-	-	-	-	-	-	-	-
2	F	53.0	1470	No	0.94	-	-	-	-	-	-	-	-
3	M	56.3	1914	No	0.88	-	-	-	-	-	-	-	-
4	F	48.8	1300	No	1.02	-	-	-	-	-	-	-	-
MEAN		51.7	1518		0.97								
SD		3.6	273.0		0.1								
TOTAL													

COMMENTS:

SCALES WERE NOT COLLECTED AS NEW SCALE BOOKS HAD NOT YET ARRIVED FROM THE AGING LAB.

Table 25. Summary of breathing rates of adult sockeye salmon 1996

TREATMENT	N	BASELINE 12°C SW	6H TOX/CAR & NORM/HYP 20°C FW	24H TOX/CAR & NORM/HYP 20°C FW	30H TOX/CAR & NORM/HYP 20°C FW	18H RECOVERY FROM HYP/TOX 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
		BREATHING RATE (OPERCULAR OPENINGS / MIN)					
N CONTROL	8	45 ± 3.3	74 ± 9.2 #	66 ± 8.6	74 ± 16.9	67 ± 6.3	68 ± 8.1
N PCP (5ppb)	8	49 ± 3.8	77 ± 5.0	71 ± 5.6	75 ± 11.4	64 ± 4.9	65 ± 5.0
N PCP (20ppb)	3	43 ± 3.5	95 ± 33.5	90 ± 2.6	101 ± 10.1	81 ± 3.5	72 ± 1.7
N PCP (50ppb)	4	45 ± 3.3	-	156 ± 13.8	168 ± 15.0 **	104 ± 4.9 **	70 ± 4.4 **
H CONTROL	8	49 ± 4.5	137 ± 11.1	132 ± 25.5 *	135 ± 17.2 *	69 ± 10.0 *	72 ± 6.8 *
H PCP (5ppb)	8	46 ± 3.0	130 ± 19.8	129 ± 22.1	147 ± 15.8	76 ± 7.5	71 ± 7.8
H PCP (5ppb ##)	4	45 ± 4.6	113 ± 23.8	70 ± 8.3	102 ± 14.3	52 ± 8.5	60 ± 8.7
H PCP (10ppb ##)	4	50 ± 7.9	133 ± 14.9	161 ***	163 ***	68 ***	80 ***
H PCP (20ppb)	4	49 ± 4.8	142 ± 15.1 **	143 ***	****	****	****
H PCP (50ppb)	4	48 ± 5.9	147 ± 7.7	****	****	****	****

* = 12.5% MORTALITY
** = 25% MORTALITY
*** = 75% MORTALITY
**** = 100% MORTALITY

= MEAN OF 4 FISH NOT 8
= 15°C RECOVERY AFTER TOXICANT EXPOSURE INSTEAD OF 17.5°C - 20°C
N = NORMOXIC CONDITIONS PREVAILED THROUGHOUT THE TOXICANT EXPOSURE PERIOD
H = HYPOXIC CONDITIONS PREVAILED THROUGHOUT THE TOXICANT EXPOSURE PERIOD

Table 26. Breathing rates - Normoxic Control Group Summary

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H CARRIER & NORMOXIA 20°C FW	24H CARRIER & NORMOXIA 20°C FW	30H CARRIER & NORMOXIA 20°C FW	18H RECOVERY FROM CARRIER 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	M	46	-	58	63	60	66
2	M	48	-	54	60	65	57
3	M	45	-	67	64	60	70
4	F	47	-	79	69	70	77
5	F	39	80	62	71	68	58
6	F	45	61	RAM	RAM	RAM	RAM
7	F	40	73	72	107	78	75
8	M	47	81	69	87	69	74
MEAN		45	74	66	74	67	68
SD		3.3	9.2	8.6	16.9	6.3	8.1

Table 27. Breathing rates - Normoxic Control Group #1

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H CARRIER & NORMOXIA 20°C FW	24H CARRIER & NORMOXIA 20°C FW	30H CARRIER & NORMOXIA 20°C FW	18H RECOVERY FROM CARRIER 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	M	46	-	58	63	60	66
2	M	48	-	54	60	65	57
3	M	45	-	67	64	60	70
4	F	47	-	79	69	70	77
MEAN		47		65	64	64	68
SD		1.3		11.1	3.7	4.8	8.3
TEMP (°C)		11.4	-	19.1	19.9	19.1	19.3
SAL (ppt)		29.0	-	0	0	0	0
SAT (%)		93.0	-	86.0	88.7	89.1	90.9

Table 28. Breathing rates - Normoxic Control Group #2

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H CARRIER & NORMOXIA 20°C FW	24H CARRIER & NORMOXIA 20°C FW	30H CARRIER & NORMOXIA 20°C FW	18H RECOVERY FROM CARRIER 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
5	F	39	80	62	71	68	58
6	F	45	61	RAM	RAM	RAM	RAM
7	F	40	73	72	107	78	75
8	M	47	81	69	87	69	74
MEAN		43	74	68	88	72	69
SD		3.9	9.2	5.1	18.0	5.5	9.5
TEMP (°C)		10.1	19.2	17.8	20.1	17.8	17.7
SAL (ppt)		29.1	2.7	0	0	0	0
SAT (%)		90.0	84.0	88.0	88.0	92.0	94.0

Table 29. Breathing rates - Normoxic PCP (5ppb) Group Summary

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H TOXICANT & NORMOXIA 20°C FW	24H TOXICANT & NORMOXIA 20°C FW	30H TOXICANT & NORMOXIA 20°C FW	18H RECOVERY FROM TOXICANT 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	M	51	69	68	62	60	60
2	M	47	80	70	60	67	61
3	F	57	72	80	96	61	61
4	M	46	72	60	72	60	61
5	F	49	79	71	78	60	70
6	F	45	78	72	73	63	72
7	M	47	82	71	80	66	69
8	F	49	82	73	80	74	69
MEAN		49	77	71	75	64	65
SD		3.8	5.0	5.6	11.4	4.9	5.0

Table 30. Breathing rates - Normoxic PCP (5ppb) Group #1

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H TOXICANT & NORMOXIA 20°C FW	24H TOXICANT & NORMOXIA 20°C FW	30H TOXICANT & NORMOXIA 20°C FW	18H RECOVERY FROM TOXICANT 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	M	51	69	68	62	60	60
2	M	47	80	70	60	67	61
3	F	57	72	80	96	61	61
4	M	46	72	60	72	60	61
MEAN		50	73	70	73	62	61
SD		5.0	4.7	8.2	16.5	3.4	0.5
TEMP (°C)		10.3	20.6	17.7	18.8	17.6	17.6
SAL (ppt)		29.3	2.0	0	0	0	0
SAT (%)		91.0	86.0	87.0	93.0	93.0	95.0

Table 31. Breathing rates - Normoxic PCP (5ppb) Group #2

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H TOXICANT & NORMOXIA 20°C FW	24H TOXICANT & NORMOXIA 20°C FW	30H TOXICANT & NORMOXIA 20°C FW	18H RECOVERY FROM TOXICANT 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
5	F	49	79	71	78	60	70
6	F	45	78	72	73	63	72
7	M	47	82	71	80	66	69
8	F	49	82	73	80	74	69
MEAN		48	80	72	78	66	70
SD		1.9	2.1	1.0	3.3	6.0	1.4
TEMP (°C)		10.3	20.5	17.6	18.7	17.6	17.6
SAL (ppt)		29.3	2.0	0	0	0	0
SAT (%)		86.0	81.0	89.0	87.0	92.0	92.0

Table 32. Breathing rates - Normoxic PCP (20ppb) Group

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H TOXICANT & NORMOXIA 20°C FW	24H TOXICANT & NORMOXIA 20°C FW	30H TOXICANT & NORMOXIA 20°C FW	18H RECOVERY FROM TOXICANT 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	M	45	76	87	90	85	71
2	M	45	76	91	110	81	74
3	M	39	134	92	103	78	71
MEAN		43	95	90	101	81	72
SD		3.5	33.5	2.6	10.1	3.5	1.7
TEMP (°C)		10.1	19.2	17.8	20.0	17.8	17.7
SAL (ppt)		29.1	2.7	0	0	0	0
SAT (%)		91.0	86.0	80.0	78.0	83.0	88.0

Table 33. Breathing rates - Normoxic PCP (50ppb) Group

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H TOXICANT & NORMOXIA 20°C FW	24H TOXICANT & NORMOXIA 20°C FW	30H TOXICANT & NORMOXIA 20°C FW	18H RECOVERY FROM TOXICANT 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	M	41	-	148	DEAD	DEAD	DEAD
2	M	48	-	146	185	101	73
3	F	43	-	176	160	110	65
4	M	47	-	154	158	102	72
MEAN		45		156	168	104	70
SD		3.3		13.8	15.0	4.9	4.4
TEMP (°C)		11.4	-	19.1	19.9	19.1	19.3
SAL (ppt)		29.0	-	0	0	0	0
SAT (%)		93.0	-	66.0	78.4	89.5	94.5

Table 34. Breathing rates - Hypoxic Control Group Summary

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H CARRIER & HYPOXIA 20°C FW	24H CARRIER & HYPOXIA 20°C FW	30H CARRIER & HYPOXIA 20°C FW	18H RECOVERY FROM HYPOXIA 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	F	56	134	127	140	76	66
2	M	51	127	135	129	85	82
3	M	53	144	100	101	60	70
4	F	47	118	103	100	60	66
5	F	52	154	166	165	75	80
6	F	45	143	161	167	71	75
7	M	45	142	131	144	59	67
8	M	44	136	DEAD	DEAD	DEAD	DEAD
MEAN		49	137	132	135	69	72
SD		4.5	11.1	25.5	27.2	10.0	6.8

Table 35. Breathing rates - Hypoxic Control Group #1

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H CARRIER & HYPOXIA 20°C FW	24H CARRIER & HYPOXIA 20°C FW	30H CARRIER & HYPOXIA 20°C FW	18H RECOVERY FROM HYPOXIA 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	F	56	134	127	140	76	66
2	M	51	127	135	129	85	82
3	M	53	144	100	101	60	70
4	F	47	118	103	100	60	66
MEAN		52	131	116	118	70	71
SD		3.8	11.0	17.4	20.1	12.4	7.6
TEMP (°C)		12.7	19.4	19.1	19.8	19.1	19.1
SAL (ppt)		27.9	3.6	0	0	0	0
SAT (%)		85.0	36.0	40.0	41.0	87.0	88.0

Table 36. Breathing rates - Hypoxic Control Group #2

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H CARRIER & HYPOXIA 20°C FW	24H CARRIER & HYPOXIA 20°C FW	30H CARRIER & HYPOXIA 20°C FW	18H RECOVERY FROM HYPOXIA 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
5	F	52	154	166	165	75	80
6	F	45	143	161	167	71	75
7	M	45	142	131	144	59	67
8	M	44	136	DEAD	DEAD	DEAD	DEAD
MEAN		47	144	153	159	68	74
SD		3.7	7.5	18.9	12.7	8.3	6.6
TEMP (°C)		11.5	19.0	20.6	21.2	20.4	20.5
SAL (ppt)		29.2	3.9	0	0	0	0
SAT (%)		88.0	27.0	37.0	36.0	89.0	87.0

Table 37. Breathing rates - Hypoxic PCP (5ppb) Group Summary

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H TOXICANT & HYPOXIA 20°C FW	24H TOXICANT & HYPOXIA 20°C FW	30H TOXICANT & HYPOXIA 20°C FW	18H RECOVERY FROM HYP/TOX 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	F	48	101	115	139	69	62
2	M	44	108	105	130	74	74
3	M	49	113	99	121	74	60
4	M	45	151	118	149	78	69
5	F	41	151	142	153	73	81
6	M	-	138	150	168	69	71
7	M	44	133	154	161	91	81
8	F	49	143	149	153	83	67
MEAN		46	130	129	147	76	71
SD		3.0	19.8	22.1	15.8	7.5	7.8

Table 38. Breathing rates - Hypoxic PCP (5ppb) Group #1

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H TOXICANT & HYPOXIA 20°C FW	24H TOXICANT & HYPOXIA 20°C FW	30H TOXICANT & HYPOXIA 20°C FW	18H RECOVERY FROM HYP/TOX 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	F	48	101	115	139	69	62
2	M	44	108	105	130	74	74
3	M	49	113	99	121	74	60
4	M	45	151	118	149	78	69
MEAN		47	118	109.25	135	74	66
SD		2.4	22.4	8.8	12.0	3.7	6.4
TEMP (°C)		10.3	18.7	17.1	19.2	20.6	20.1
SAL (ppt)		29.5	2.7	0	0	0	0
SAT (%)		95.0	39.0	39.0	42.0	83.0	83.0

Table 39. Breathing rates - Hypoxic PCP (5ppb) Group #2

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H TOXICANT & HYPOXIA 20°C FW	24H TOXICANT & HYPOXIA 20°C FW	30H TOXICANT & HYPOXIA 20°C FW	18H RECOVERY FROM HYP/TOX 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
5	F	41	151	142	153	73	81
6	M	-	138	150	168	69	71
7	M	44	133	154	161	91	81
8	F	49	143	149	153	83	67
MEAN		45	141	148.75	159	79	75
SD		4.0	7.7	5.0	7.2	9.9	7.1
TEMP (°C)		10.3	18.7	17.0	19.2	20.6	20.0
SAL (ppt)		29.7	2.7	0	0	0	0
SAT (%)		95.0	39.0	34.0	42.0	83.0	81.0

Table 40. Breathing rates - Hypoxic PCP (5ppb - extra) Group

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H TOXICANT & HYPOXIA 20°C FW	24H TOXICANT & HYPOXIA 20°C FW	30H TOXICANT & HYPOXIA 20°C FW	18H RECOVERY FROM HYP/TOX **20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	F	42	98	60	88	40	51
2	F	41	101	67	92	52	56
3	F	51	148	78	110	55	63
4	F	47	103	76	118	60	71
MEAN		45	113	70	102	52	60
SD		4.6	23.8	8.3	14.3	8.5	8.7
TEMP (°C)		11.6	18.9	18.4	19.1	15.1**	19.1
SAL (ppt)		28.7	3.5	0	0	0	0
SAT (%)		90.0	39.0	57.0**	41.0	95.0	95.0

**15°C OVERNIGHT RECOVERY (18 H) TEMPERATURE AFTER TOXICANT EXPOSURE PERIOD INSTEAD OF 17.5°C - 20°C. 17.5°C - 20°C TEMPERATURES RESUMED DURING MORNING OF 1ST SWIM TEST AND CONTINUED FOR DURATION OF EXPERIMENT.

** DEGASSER MALFUNCTIONED AFTER APPROX. 21 HRS OF TOXICANT EXPOSURE AND THEREFORE WAS DELIVERING WATER OF HIGHER SATURATION (4.7ppm / approx 57% sat) THAN INTENDED TO THE CHAMBER FOR A TWO HR PERIOD LASTING FROM (06:00 - 08:00). THIS EXPLAINS THE LOWER BREATHING RATES OBSERVED AFTER 24H OF TOXICANT EXPOSURE.

Table 41. Breathing rates - Hypoxic PCP (10ppb) Group

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H TOXICANT & HYPOXIA 20°C FW	24H TOXICANT & HYPOXIA 20°C FW	30H TOXICANT & HYPOXIA 20°C FW	18H RECOVERY FROM HYP/TOX 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	F	40	114	DEAD	DEAD	DEAD	DEAD
2	M	51	149	DEAD	DEAD	DEAD	DEAD
3	M	59	139	161	163	68	80
4	M	48	129	DEAD	DEAD	DEAD	DEAD
MEAN		50	133	161	163	68	80
SD		7.9	14.9				
TEMP (°C)		11.6	18.9	18.1	18.9	15**	19.1
SAL (ppt)		28.6	3.5	0	0	0	0
SAT (%)		61.0	42.0	39.0	35.0	98.0	91.0

**15°C OVERNIGHT (18H) RECOVERY TEMPERATURE AFTER TOXICANT EXPOSURE PERIOD INSTEAD OF 17.5°C - 20°C.
17.5°C - 20°C TEMPERATURES RESUMED DURING MORNING OF 1ST SWIM TEST AND CONTINUED FOR DURATION OF EXPERIMENT.
DEGASSER MALFUNCTIONED AFTER APPROX. 21 H OF TOXICANT EXPOSURE HOWEVER OXYGEN SATURATION VALUES REMAINED LOW IN THIS CHAMBER FOR THAT 2 H PERIOD (ie. 3.6 ppm / 38% saturation)

Table 42. Breathing rates - Hypoxic PCP (20ppb) Group

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H TOXICANT & HYPOXIA 20°C FW	24H TOXICANT & HYPOXIA 20°C FW	30H TOXICANT & HYPOXIA 20°C FW	18H RECOVERY FROM HYP/TOX 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	M	51	DEAD	DEAD	DEAD	DEAD	DEAD
2	M	42	153	DEAD	DEAD	DEAD	DEAD
3	M	49	125	143	DEAD	DEAD	DEAD
4	M	53	149	DEAD	DEAD	DEAD	DEAD
MEAN		49	142	143			
SD		4.8	15.1				
TEMP (°C)		11.4	19.0	20.6	-	-	-
SAL (ppt)		28.9	3.9	0	-	-	-
SAT (%)		90.0	34.0	53.0	-	-	-

Table 43. Breathing rates - Hypoxic PCP (50ppb) Group

BREATHING RATE (OPERCULAR OPENINGS / MIN)

FISH #	SEX	BASELINE 12°C SW	6H TOXICANT & HYPOXIA 20°C FW	24H TOXICANT & HYPOXIA 20°C FW	30H TOXICANT & HYPOXIA 20°C FW	18H RECOVERY FROM HYP/TOX 20°C FW	18H RECOVERY FROM SWIM #1 20°C FW
1	F	56	140	DEAD	DEAD	DEAD	DEAD
2	F	49	151	DEAD	DEAD	DEAD	DEAD
3	M	44	140	DEAD	DEAD	DEAD	DEAD
4	F	43	155	DEAD	DEAD	DEAD	DEAD
MEAN		48	147				
SD		5.9	7.7				
TEMP (°C)		12.7	19.4	-	-	-	-
SAL (ppt)		27.9	3.6	-	-	-	-
SAT (%)		94.0	36.0	-	-	-	-

Table 44. Summary of breathing rates during initial 6 h of NaPCP exposure

		BREATHING RATE (OPERCULAR OPENINGS / MIN)						
TREATMENT	**N**	**BASE**	**1 h**	**2 h**	**3 h**	**4 h**	**5 h**	**6 h**
N CONTROL	2	43 ± 4.9	58 ± 0.7	61 ± 1.4	66 ± 2.8	83 ± 21.2	75 ± 8.5	77 ± 5.7
N PCP (5ppb)	4	49 ± 5.4	54 ± 4.5	59 ± 2.4	79 ± 23.0	79 ± 11.4	78 ± 4.8	76 ± 4.3
N PCP (20ppb)	2	46 ± 0.7	50 ± 3.5	52 ± 2.1	59 ± 2.1	70 ± 0.0	76 ± 1.4	77 ± 0.7
H CONTROL	2	52 ± 4.9	N/A	N/A	116 ± 27.6	118 ± 8.5	132 ± 5.7	131 ± 4.9
H PCP (5ppb)	6	46 ± 3.7	58 ± 9.9	70 ± 6.9	79 ± 5.8	88 ± 10.7	108 ± 19.1	134 ± 20.9
H PCP (10ppb)	2	46 ± 7.8	55 ± 7.1	61 ± 4.2	83 ± 2.1	123 ± 27.6	112 ± 24.0	131 ± 22.6
H PCP (50ppb)	2	43 ± 1.4	59 ± 9.2	68 ± 1.4	90 ± 3.5	102 ± 14.1	136 ± 0.7	147 ± 11.3
TEMPERATURE	(^{o}C)	10.1 - 12.7	12.6 - 14.9	14.5 - 17.2	15.9 - 19.0	17.0 - 20.6	17.9 - 21.0	18.7 - 20.5
SALINITY	(ppt)	27.9 - 29.7	17.8 - 20.3	10.6 - 14.1	6.3 - 9.8	4.0 - 6.9	2.7 - 4.9	2.0 - 3.5
DO_2 SATURATION	(%)	80 - 95	68 - 91	51 - 93	45 - 93	40 - 92	40 - 90	36 - 86

N = Normoxic conditions prevailed throughout the 30 h toxicant exposure period (60 - 95% saturation).
H = Hypoxic conditions prevailed throughout the 30 h toxicant exposure period (30 - 40% saturation).