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The Influence of Potentially Lethal Temperature and Food on the Behavior of Juvenile Chum Salmon (*Oncorhynchus keta*) Under Simulated Marine Conditions

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THE INFLUENCE OF POTENTIALLY LETHAL TEMPERATURE AND FOOD ON THE BEHAVIOR OF JUVENILE CHUM SALMON (*ONCORHYNCHUS KETA*) UNDER SIMULATED MARINE CONDITIONS

by

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PREFACE

This report is one in a series that describe the results of field and laboratory studies on the effect of heated sea water on juvenile chum salmon (*Oncorhynchus keta*). The studies were initiated in response to potential increases in thermal discharges from British Columbia Hydro and Power Authority's (B.C. Hydro) Burrard Thermal Generating Station, into the marine waters of Port Moody Arm, Burrard Inlet, B.C. This gas-fired steam electric station operates under a permit from the provincial government, and utilises a once-through sea water cooling system. The permit allows for the discharge of up to 1.7 million m^3 daily of "cooling waters" (≤ 27 °C), drawn from, and discharged to, Port Moody Arm. An environmental impact study to assess any effects due to the thermal discharge was a requirement of an amendment to the provincial permit. An environmental assessment study plan was submitted by B.C. Hydro to federal and provincial regulatory authorities in 1996, and it was approved in 1997.

The Department of Fisheries and Oceans entered into a co-operative research venture with B.C. Hydro on selected aspects of the environmental assessment. Other studies investigated the effects of the thermal effluent on the growth of juvenile chum salmon, the heat budget of Port Moody Arm and the input from mud flats, an assessment of the potential effects of the effluent on migrating and resident fish, and the potential effects on planktonic organisms drawn into the plant and those entrained in the thermal discharge plume. Reports on these studies were provided to B.C. Hydro in December 1997, and those undertaken by the Department of Fisheries and Oceans are also to be published in the scientific literature.

The Department of Fisheries and Oceans undertook two studies in 1997:

1) The behaviour of chum salmon in response to heated sea water was investigated in the laboratory using a water column simulator that mimicked conditions the fish may encounter in Port Moody Arm. Their behaviour was examined under controlled conditions during a changing thermal regime and under thermally-stratified conditions. The response of the fish to food, their swimming, and school positions were quantified in relation to the experimental conditions.

2) "Preference-avoidance" cages (6.0 m x 0.5 m x 0.5 m) were used in Port Moody Arm to examine the vertical distribution of chum salmon at a reference location and at sites 70 m, 250 m, and 1200 m from the "cooling water" discharge source. The results were related to the ambient aquatic conditions to reveal differences or similarities in the vertical distribution of salmon with proximity to the discharge location, and to identify variables that accounted for these changes.

ABSTRACT

Korstrom, J.S., R.P. Fink, J.A. Tanaka, D.I. Tiessen, B.J. Fink and I.K. Birtwell. 1998. The influence of potentially lethal temperature and food on the behavior of juvenile chum salmon (*Oncorhynchus keta*) under simulated marine conditions. Can. Data Rep. Fish. Aquat. Sci. 1040: 70 p.

Behavioral responses of juvenile chum salmon (*Oncorhynchus keta*) exposed to potentially lethal temperatures in a vertical thermal gradient were determined under controlled laboratory conditions in a 4500 L flow-through Water Column Simulator (WCS). The temperature regime was similar to conditions these fish may encounter when traversing thermal effluent plumes. Changes in measures of fish activity, school location, swim speed, and position in the WCS, with respect to temperature and food, were used as indicators of response.

The activity and shifts in distribution of eight groups of 20 chum salmon were examined under isothermal sea water conditions (10.2 ± 0.5 °C), during the establishment of a thermal gradient, and following stable vertically-stratified conditions (24.1 ± 1.4 °C/10.2 ± 0.4 °C). The presence of food on fish distribution, school location and activity was examined under isothermal and stratified regimes. Food was presented in potentially lethal temperatures, (which were normally avoided), to ascertain whether fish would be motivated to enter these waters and feed successfully.

The distance travelled (cm), swim speed ($cm \cdot s^{-1}$ and $bl \cdot s^{-1}$) and excursion times (s) of individual fish through the thermocline into the top zone of the aquarium, were quantified in relation to the presence of food, under isothermal and vertically stratified conditions. School position was determined through the computer-assisted digital image analysis of time-lapse video recordings.

To assess thermal resistance, eight groups of 20 chum salmon were exposed to heated sea water (25.0 ± 0.3 °C) under air equilibrated (100.6 ± 0.6% air saturation) or supersaturated (109.1 ± 0.8% air saturation) conditions in flow-through bioassay tests. Quantification of the median time to 50% mortality (min), in addition to the corresponding minimum and maximum survival times, allowed for comparison among experimental treatment groups and with controls.

Ancillary studies investigated whether an elevation in total gas pressure (TGP) or the motivation to feed on live prey would modify the response to heated waters when the WCS aquarium was vertically stratified with three distinct temperatures (18 °C, 25 °C and 30 °C) in the surface waters.

Key words: chum salmon, vertical distribution, swimming speed, thermal stratification, temperature, behavioral thermoregulation, thermal resistance

RÉSUMÉ

Korstrom, J.S., R.P. Fink, J.A. Tanaka, D.I. Tiessen, B.J. Fink and I.K. Birtwell. 1998. The influence of potentially lethal temperature and food on the behavior of juvenile chum salmon (*Oncorhynchus keta*) under simulated marine conditions. Can. Data Rep. Fish. Aquat. Sci. 1040: 70 p.

Les réponses comportementales de saumons kétas juvéniles (*Oncorhynchus keta*) exposés à des températures potentiellement létales dans un gradient thermique vertical ont été mesurées en laboratoire, dans des conditions contrôlées, dans un simulateur à colonne d'eau de 4 500 L à circulation continue. Le régime thermique était semblable à celui que les poissons peuvent rencontrer quand ils traversent des panaches d'effluents thermiques. On a utilisé comme indicateurs de réponse les changements dans l'activité des poissons, la localisation des groupes, la vitesse de nage et la position dans le simulateur par rapport à la température et à la nourriture.

L'activité et les changements dans la distribution de huit groupes de 20 saumons kétas ont été examinés dans des conditions de température constante de l'eau de mer (10.2 ± 0.5 °C), au cours de la formation d'un gradient thermique et après stabilisation de la stratification verticale (24.1 ± 1.4 °C/10.2 ± 0.4 °C). Les effets de la présence de nourriture sur la distribution des poissons, la localisation des groupes et l'activité ont été examinés sous le régime isotherme et le régime stratifié. On a administré la nourriture à des températures potentiellement létales (qui sont normalement évitées par les poissons) pour voir s'ils seraient motivés à entrer dans ces eaux pour se nourrir.

La distance parcourue (cm), la vitesse de nage ($cm \cdot s^{-1}$ et $bl \cdot s^{-1}$) et la durée (s) des excursions des individus à travers la thermocline pour atteindre la partie supérieure de l'aquarium ont été quantifiées par rapport à la présence de nourriture dans des conditions d'isothermie et de stratification verticale. La position des groupes a été déterminée par analyse informatique des images numérisées des enregistrements vidéo séquentiels.

Pour évaluer la résistance thermique, on a exposé huit groupes de 20 saumons kétas à de l'eau de mer chauffée (25.0 ± 0.3 °C) dans des conditions équilibrées (100.6 ± 0.6% de saturation en air) ou en sursaturation (109.1 ± 0.8% de saturation en air) lors de bioessais en circulation continue. La quantification du temps médian correspondant à 50 % de mortalité (min) et les temps de survie minimaux et maximaux ont permis de comparer entre eux et avec les témoins les groupes expérimentaux.

Des études complémentaires ont vérifié si une augmentation de la pression totale des gaz ou le désir de se nourrir de proies vivantes modifieraient la réponse aux eaux chauffées quand l'aquarium du simulateur était stratifié verticalement à trois températures différentes (18 °C, 25 °C et 30 °C) dans les eaux de surface.

Mots clés : saumon kéta, distribution verticale, vitesse de nage, stratification thermique, température, thermorégulation comportementale, résistance thermique.

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INTRODUCTION

The ecological success of salmonids in marine environments with reduced water quality and industrial pollutants depends in part on their ability to sense variations in physico-chemical factors and to employ the appropriate compensatory mechanisms in a timely manner. Temperature, among other factors, plays a major role in the distribution of fish in their environment. The body temperature of poikilothermic fish can be regulated only through behavioral responses (Spigarelli 1975) and accordingly, fish tend to select a narrow temperature range when given free choice (Muller and Fry 1976). Often, the preferred temperature is determined in horizontal or vertical gradients in order to explain or predict the distribution of fish in a thermally changing environment (McCauley and Pond 1971). The preferred temperature of a fish is recorded according to its position in the gradient over a certain period of time.

This report presents data on one aspect of a multi-disciplinary study which investigates the behavior of juvenile chum salmon, under simulated estuarine conditions, in relation to potential impacts from thermal discharges. Laboratory studies were utilised to provide controlled conditions in which to determine the distribution of fish in a vertically stratified thermal gradient with and without the motivational element of food. Thermal resistance bioassays were conducted during the behavioral experiments to relate the lethal effects of thermal conditions to the occupation of such waters.

MATERIALS AND METHODS

FISH TRANSPORT AND STOCK TANK MAINTENANCE

On May 9, 1997, 2000 juvenile chum salmon (fork length 38.6 ± 2.1 mm (mean ± SD), weight 0.41 ± 0.09 g), were transported from the Seymour River Hatchery in North Vancouver, BC to sea water holding facilities at the West Vancouver Laboratory (Table 1). The transport of fish from the hatchery occurred when fry would be entering salt water in the wild. Typically, chum salmon fry emerge from the gravel and promptly migrate downstream to estuarine waters at a size of 30-40 mm (Healey 1982; Salo 1991). Transport was accomplished within 2 h using a truck fitted with a 500 L insulated plastic tank supplied with compressed air from a portable compressor unit. A mesh bag containing 500 g Ammonex (Argent Chemical Laboratories, Redmond, WA), a natural clay that rapidly binds to, and eliminates ammonia, (thereby preventing the accumulation of this waste metabolite), was placed in the transport tank. To reduce osmotic stress during the rapid transition to sea water from the fresh water hatchery environment, the transport tank contained an approximately isosmotic saline solution (16 ‰) of 7.5 °C.

At the laboratory, the fish were vaccinated against *Vibrio* sp. via an immersion bath technique with BIOVAX 1300 (Alpharma, Bellevue, WA), a prophylactic health management tool. *Vibrio sp.* are opportunistic bacterial pathogens of fish which are ubiquitous in marine and estuarine environments. BIOVAX 1300 is a water based, whole cell bacterin formulated from killed *Vibrio anguillarum* serotype 1 and *Vibrio ordalii* bacteria. The bacterin suspension was diluted in the transport tank water (1:100) and aerated for 1 h. Following vaccination, the fish were transferred, using a low abrasion dipnet, to a 2500 L outdoor holding tank continuously supplied with air-equilibrated salt water (salinity 27 ± 1.4 ‰, temperature 11.4 ± 0.9 °C, and dissolved oxygen 96.3 ± 5.3 % air saturation). Water flow was delivered to the tanks at approximately 46 $L \cdot min^{-1}$ which ensured a 90% replacement within 3 h (Sprague 1969). Fish density was maintained at ≤ 2 $kg \cdot m^{-3}$, and flow-loading density at ≤ 0.5 $kg \cdot L^{-1} \cdot min^{-1}$.

Stock fish were fed to satiation with a ration of dry pellets (Moore Clarke, Vancouver, BC, Nutra C starter feed, crumble #1,#2, #3 and 1.5 mm pellet) at between 1.2-8.8% mean body weight per day. The ration was calculated assuming the maximum growth rate (5.7%) for chum salmon under experimental conditions (LeBrasseur 1969) with an estimated conversion rate of 75%. Food delivery was via an automatic belt feeder (Zeigler Bros Ltd., Gardner, PA.) set for continuous operation from dawn to dusk to avoid behavioral entrainment on a set feeding schedule, which may have biased subsequent experimental observations. The salmon were held under a natural photoperiod and were acclimated for a period of at least 3 weeks prior to experimentation. Mean mortality rate in the stock tank was negligible at 0.009% per day, well below mortality guidelines established by Sprague (1973) when determining if a stock of fish is to be considered suitable for use in bioassays.

WATER COLUMN SIMULATOR

Birtwell & Kruzynski (1987) have described a Water Column Simulator (WCS) which can mimic the conditions similar to those found in coastal waters of British Columbia and therefore only a brief mention will be made of the significant components. The WCS consists of a 4500 L acrylic aquarium (2.4 x 2.4 x 0.8 m) with three separate water delivery loops, which facilitate the formation of a horizontally flowing, vertically stratified water column. The water column can be divided for physico-chemical monitoring into three equal zones (referred to respectively as Top, Middle, and Bottom), each 0.74 m in depth (Table 2-10). The system permits the controlled manipulation of temperature, salinity, dissolved oxygen and water velocity in each zone.

Continuous monitoring of incoming water parameters such as temperature (Action Instruments Company Inc., San Diego, CA., Visipak VIP501 RTD digital temperature indicator and probes; accuracy ± 0.1 °C, range 0 to 60°C), conductivity (Rosemount Instruments Ltd., Uniloc Division, Model 112-09 sensor and Model 750C-0304 analyzer/transmitter; accuracy ± 2% full scale, range 0 to 50,000 µmhos), and dissolved oxygen (Point 4 Systems, Port Moody, BC, PT4 Oxygen Monitor; accuracy ± 2%, range 0 to 51 $mg \cdot L^{-1}$) was enabled through the use of a computerized data acquisition system (Bentek Systems Ltd., Vancouver, BC; Genesis Control and Monitoring Software, Iconics Inc. 1992). A significant modification to the system described by Birtwell and Kruzynski (1987) was an improvement in the precise control of temperature entering the WCS aquarium. The incorporation of a closed loop heat exchanger refrigeration system which encompasses two chillers, a compressor, condenser, water pump, and an interconnecting refrigerant piping system, modulated the temperature of incoming water. Three-way control valves mounted with self adjusting, motorized, integrated valve actuators (Honeywell Ltd., North York, ON, ML-7984) were used with electronic modulating signal controllers (Honeywell Ltd., North York, ON, T775E Remote Temperature Controller; accuracy ± 1°C at 25 °C) to regulate the chilled water supply to three heat exchangers. Temperature controllers are connected to temperature sensors immersed in the experimental water through an aperture in the pipe 30 cm upstream of the heat exchangers. The temperature set point on the three controllers can be adjusted independently and determines the temperature of water circulating in each zone of the WCS. Temperature was also monitored in the aquarium by twelve data loggers (Onset Stowaway Tidbit waterproof temperature logger, Onset Computer Corporation, Pocasset, MA, USA; accuracy ± 0.2 °C, range -5 to 37 °C) fastened vertically to a Velcro strip spanning the height of the water column (Tables 11-19). The loggers were positioned evenly throughout the top and bottom zones and consecutively along the gradient in the thermocline (Table 20).

Total dissolved gas pressure determinations were made using 3 tensionometers (Model 300C, Alpha Designs Ltd., Victoria, BC; accuracy ± 1 mm Hg, range -200 to 700 mm Hg) and applying calculations provided by Colt (1984). A tensionometer probe was mounted in the center of each zone and oriented vertically on the downstream side of the aquarium. To minimize erroneous readings caused by bubble accumulation on the probe membrane, the bubbles were dislodged by attaching the meter cables to a pulley system, allowing the probes to be manually shaken prior to obtaining readings (Table 21).

Overhead illumination to the WCS was provided by a metal halide light source (daylight spectrum) with seasonal photoperiod control. Photoperiod was adjusted bi-weekly to simulate natural seasonal changes using nautical twilight tables provided by the National Research Council of Canada. Artificial light/dark cycles ranged from 4.5 h dark : 19.5 h light (including two 4.5 h periods of twilight representing dawn and dusk) in June to 6.5 h dark : 17.5 h light in August. The aquarium was illuminated at night with near infra-red lighting, by an alternative light source shone through a red filter (50% transmission at 695 nm and at 722 nm with the peak at 705 nm). Fish behavior and movements were continuously recorded by a high resolution camera (Panasonic WV-1850, 800 lines) with peak sensitivity in the near infra-red, coupled to a closed circuit black and white time-lapse video recorder (Panasonic AG-6750, 400 lines) and high resolution video monitor (Panasonic WV-5470, 850 lines). The aquarium, lighting systems, and camera were enclosed by vinyl curtains to occlude extraneous light and disturbance. The WCS apparatus is housed in a self contained, sound insulated, temperature and humidity controlled building to reduce visual and acoustic interference to the fish.

RESEARCH DESIGN AND EXPERIMENTAL PROTOCOL

To optimize the research design and the eventual choice of 8 replicate experiments, power calculations (PC-SIZE, Version 2.13, Dallal) were applied to estimates of fish distribution in the WCS under isothermal and thermally-stratified conditions, with and without the presence of food. The two main factors of food and temperature effects were being examined with 6 comparisons selected prior to the experiments to determine significance. Paired samples were compared and estimated mean differences were provided. The standard deviation (SD) of the differences was estimated at 20% (based on an estimated SD of 16.6% in our original estimates, and calculated using the formula: variance(x-y) = variance x *2*(1 - corrected(x-y), with an estimated correlation of 0.30, and the test of equality of means was at the 0.008 level of significance. Six comparisons were identified a priori and therefore Bonferroni corrections were made to maintain a family-wise error rate of 0.05. Hence the significance level for any test was at 0.008.

The experimental period was from May 30, 1997 to August 15, 1997 and during this time the test fish grew from 1.39 ± 0.36 g to 15.92 ± 3.80 g (Table 22). Eight groups of twenty fish were tested throughout this period and were observed for 5 consecutive days following 2 days acclimation. Groups, rather than individuals, were used because of the natural schooling tendency of chum salmon and the adverse effect that separation from conspecifics could have on behavioral responses (Davis and Olla 1992; Ryer and Olla 1991). For each test, 20 fish were randomly removed from the stock tank and placed in the WCS aquarium which contained air equilibrated sea water (10.2 ± 0.5 °C, 101.2 ± 1.8% dissolved oxygen, 99.9 ± 1.7% TGP, 27.4 ± 1.3‰ salinity). The fish were left undisturbed but fed to satiation with an automatic feeder for 2 d before observations began.

Fish were observed through slits in the light occlusion curtains which provided a view of the plexiglass front of the aquarium. This permitted visual observation of the fish without disturbance. The nature of the present experimental protocol required that the pre-established boundaries between the top (0.74 m), thermocline (0.09 m), and bottom (1.48 m) sections of the thermally stratified tank be visually drawn, by lines of taut string on the front viewing glass. Time-lapse video recordings commenced 10 min prior to the first observation period and continued to the completion of each experiment.

Specific observation periods were chosen to assist in the characterization of the behavior of chum salmon under different experimental conditions. Each observation period consisted of 100 determinations of fish distribution in either the top (0.74 m), thermocline (0.09 m) or bottom zone (1.48 m) of the aquarium. Positions of fish were recorded visually in real time during a schedule of 9 observation periods during the 5 day sequence of experimental events which alternated between morning and afternoon determinations, under isothermal or thermally stratified conditions, with food present or absent (Table 23). Each group of fish were observed under baseline and experimental conditions, thereby constituting their own controls. Vertical distribution of fish was recorded by observers noting the number of fish present in the two least-occupied zones of the WCS, at 30 s intervals, during a 50 min observation period. Fish not counted by observers were assigned a position in the remaining zone, for a sum of twenty fish per reading. Using these numbers the average percentage of fish in each zone was calculated for comparative purposes between observation periods (Tables 24-26).

FEEDING IN A THERMAL GRADIENT

On day 2 (isothermal) and day 4 (thermally stratified) of the experimental period (afternoon observation periods), small amounts of dry pelleted feed (Moore Clarke, Vancouver, BC, Nutra C starter feed #1) were made available to the fish, from the water surface, in the top zone of the aquarium. Feed was replenished on the water surface in 10 min intervals throughout the 50 min observation period with precautions taken to avoid startling the fish.

SWIM SPEED

The distance travelled and swim speeds of 20 randomly-chosen fish were determined during each of the 9 observation periods (Table 27-30). The trajectories of fish within the WCS aquarium were traced for 30 s periods on transparent mylar sheets superimposed on the video monitor screen. The actual distance each fish travelled in cm was calculated from correction factors based upon the dimensions of the WCS and the image reduction on the monitor. Swim speed over a 30 s period was calculated from the known distance travelled, and was expressed in both absolute ($cm \cdot s^{-1}$) terms and relative to bodylength ($bl \cdot s^{-1}$).

EXCURSION TIMES

During afternoon observation periods, under different experimental conditions, excursions by randomly selected fish into the top zone of the WCS were timed with a stopwatch and recorded in s (Table 31). The excursion time was arbitrarily terminated at 120 s and noted to that effect in the data log.

TRANSITION TO THERMAL STRATIFICATION

On day 3, between the morning and afternoon observation periods, a thermal gradient was established between the top and bottom zones of the tank and a narrow well defined thermocline layer developed. A vertical thermal stratification was created by progressively raising the temperature in the top zone through the continuous replacement of the 10 °C water with gas equilibrated 30 °C water (approximate 90% replacement time of 2.5 h at 20 $L \cdot min^{-1}$). The rate of change of temperature varied, becoming progressively slower over time but the average rate of heating over the 4 h period was 0.06 °C min^{-1}. Tables 32-33 show the mean temperatures derived from data loggers which recorded temperature every 15 min during this transition period and through to when a stable thermal structure had developed. After 4 h, temperature ranges for the 3 zones were: top, 23.3 - 23.8 °C, thermocline, 13.7 - 22.8 °C, and bottom, were 9.9 - 11.4 °C. Water in the middle and bottom zones of the WCS resisted downward heat transfer from the top zone due to constant chilling by continuous recirculation through the closed loop refrigeration system. This protocol produced constantly changing, but controlled and reproducible variation in temperature, in the WCS aquarium, and provided a stable thermocline with the maintenance of two discrete horizontally flowing water masses under continuous flow conditions.

During establishment of thermally stratified conditions, vertical distribution of the fish was regularly recorded by observers noting the number of fish present in the two least occupied zones of the WCS at 30 s intervals over the 4 h period. Again, fish not counted by observers were assigned a position in the remaining zone for a sum of twenty fish per reading. Using these numbers, the average percentage of fish in each zone during the transition of the temperature in the top zone from 10.2 ± 0.5 °C to 24.1 ± 1.4 °C could be examined.

DIGITAL IMAGE ANALYSIS

The precise location of individual and groups of fish was quantified from an analysis of video tapes, using a computerized image analysis system. The analog video images were captured by a video processor (PIP 640B Video Digitizer Board, Matrox Electronic Systems Ltd., Dorval, Que.) which is a "plug in" card that allows an IBM PC microcomputer to perform frame grabbing operations on a video signal from an external source. The computer software program "Snap" (Sci Tech Consultants Inc., Vancouver, BC) digitized the image of the fish on the video frame by transforming the x,y coordinates of each fish into graphic images that depict the school distribution. Subsequently, the program calculated statistical parameters for each image which included the center or mean of the distribution, the median value which gives some indication of the normality of the distribution and standard deviational ellipse values which give a statistical indication of the shape of the fish school.

Seven randomly chosen frames of video tape from each of the 9 observation periods in Experiment #5, were superimposed onto one composite graphical image and digitized to represent fish distribution under each stable isothermal or stratified condition. During the transition period, when the thermal gradient was being established in the aquarium, a composite image of 7 randomly chosen frames of video tape were digitized for each degree increase in temperature occurring in the top zone. For the purpose of image clarity, when overlaying multiple video frames onto a single composite image, only 7 frames were combined to illustrate the distribution during the selected time periods.

THERMAL RESISTANCE BIOASSAY APPARATUS

The flow-through bioassay apparatus consisted of six cylindrical insulated polyethylene tanks measuring 33.5 cm in diameter with water depth maintained at 34 cm by a central stand-pipe drain, providing a total water volume of 29.6 L. The tanks were covered with sheets of styrene-foam insulation in order to reduce heat loss, to provide cover for fish, and to reduce disturbance. Treatment water was supplied to 1L reservoirs mounted in the tank covers. To facilitate mixing, water in the reservoirs was discharged through polyethylene tubing to the tank bottom while displaced water exited via the standpipe at the water surface.

Heated sea water was maintained in a 2500 L insulated constant head reservoir. The water in this reservoir was cycled through a thermostatically controlled, counter current titanium heat-exchanger unit connected to a two stage boiler system, which provided a continuous flow of water at a constant temperature. Heating of water in a closed system results in dissolved gas supersaturation or an elevation in total gas pressure (TGP) over atmospheric conditions. The supersaturated (109.1 ± 0.8% TGP), heated sea water (25.0 ± 0.3 °C) was delivered, as required, directly to the bioassay apparatus from the reservoir or was re-equilibrated to air saturation levels by diversion through an insulated, packed (2.5 cm Koch flexi-rings) aeration column (Birtwell and Kruzynski 1987), which fractured and dispersed incoming water. The air-equilibrated (100.6 ± 0.6% TGP), heated sea water (24.9 ± 0.3 °C) exiting the column flowed into a 140 L constant head polyethylene tank and was subsequently distributed to the bioassay test tanks. During acclimation conditions, the bioassay test tanks were supplied with sand filtered, ambient temperature (10.8 ± 0.3 °C) air-equilibrated (98.9 ± 0.6% TGP) sea water pumped from an intake structure situated approximately 100 m offshore from the laboratory, at a depth of 15 m below the low tide level. Temperature in the bioassay test tanks was recorded every 10 min by data loggers (Onset Stowaway Tidbit waterproof temperature logger, Onset Computer Corporation, Pocasset, MA, USA, ± 0.2 °C accuracy, -5 to 37 °C range).

THERMAL RESISTANCE BIOASSAY PROTOCOL

Eight thermal resistance bioassays were conducted between June 30, 1997 and August 15, 1997. During the experimental period the juvenile chum grew and accordingly different sizes of fish were used (weight 4.0 ± 1.4 to 19.1 ± 4.2 g; length 76.4 ± 9.4 to 123.6 ± 8.4 mm). Ten fish were randomly removed from the stock tank and transferred to each of the 6 bioassay test tanks containing air equilibrated 10 °C sea water. The fish were not fed and were left undisturbed to allow recovery from handling stress for 18 h prior to experimentation. All fish holding criteria were within standards established by Sprague (1973). Water flow during acclimation was delivered to the tanks at 2.5 $L \cdot min^{-1}$, which ensured a 90% replacement of the tank water volume within 1 h and provided a flow-loading of 0.08 $kg \cdot L^{-1} \cdot min^{-1}$. Fish density was maintained at $\leq$ 6.4 $kg \cdot m^{-3}$.

Following acclimation, duplicates of two treatments and controls were randomly assigned to the test tanks. Treatments comprised exposure to either supersaturated heated sea water (109.1 ± 0.8% TGP; 25.0 ± 0.3 °C) or air-equilibrated heated sea water (100.6 ± 0.6% TGP; 24.9 ± 0.3 °C). Control fish were supplied with air equilibrated ambient temperature sea water (98.9 ± 0.6% TGP; 10.8 ± 0.3 °C). Water flow was increased to 5 $L{\cdot}min^{-1}$ (99% replacement in 36 min) which facilitated a rapid transition to treatment water temperatures (0.4 $°C{\cdot}min^{-1}$) and ensured minimal heat loss from the test tanks (Table 34).

Fish in the treatment test tanks were observed continuously, and the time to death of each fish was recorded. The bioassays were terminated when the last fish, exposed to either treatment, died. The standard behavioral criteria for stress at lethal temperatures described by Baroudy and Elliot (1994) included loss of equilibrium, sudden bursts of activity with frequent collisions with the tank sides, followed by rolling and pitching with rapid ventilatory movements. However, for the purposes of this study, fish were considered dead when there was cessation of opercular movement. The control groups were simultaneously observed to assess any incidental mortality due to handling stress or exposure to laboratory conditions. Absolute mortality times were calculated from data logger temperature readings (Tables 35-37). Time zero was determined to be when the test tank reached the target temperature of 24.5 °C, which was approximately 36 min after admission of treatment water.

The fork length (mm) and weight (g) of the 20 control fish from each bioassay were recorded. Dissolved oxygen concentration (Handy MKIII, Point 4 Systems, Port Moody, BC), salinity (YSI portable salinity meter, Yellow Springs Instruments Ltd., Yellow Springs, Ohio) and TGP (Model 300C Tensionometer, Alpha Designs Ltd., Victoria, BC; accuracy ± 1 mm Hg, range -200 to 700 mm Hg) values were measured at the conclusion of each test to eliminate interference. Salinity ranged from 25-28 ‰ and dissolved oxygen concentration was 81.2 ± 4.7% and 96.5 ± 2.4% in the control and heated water treatment tanks respectively.

SUPPLEMENTARY EXPERIMENTS

In addition to the primary study, a brief preliminary and supplemental investigation also employed the WCS apparatus. On September 22, 1997, 20 juvenile chum salmon (weight 36.88 ± 8.54 g; length 154.60 ± 12.01 mm) were transferred to the WCS aquarium from the stock tank. Following 24 h of acclimation in air-equilibrated salt water, live brine shrimp (*Artemia* sp.) were introduced to the top zone of the isothermal (10 °C) aquarium in an attempt to determine if the hatchery reared, pellet fed fish would adapt to feeding on live prey. Aliquots of aerated sea water (Elite 800 air pump, Rolf C. Hagen Inc., Montreal, Que.) containing brine shrimp were metered through a valve and connecting tube from a 25 L polyethylene carbuoy fitted with a progammable timer device (Cat. No. N1507, Noma Ltd., Scarborough, ON).

On September 24 and 25, 1997 the WCS aquarium was vertically stratified with three distinct temperature regimes (18 °C, 25 °C and 30 °C) in the top zone overlying 10 °C in the lower zones, separated by a thermocline. Concomitantly, an elevation in total gas pressure (109.0 - 113.5%) was manipulated by injecting a steady stream of air (approximately 2 $L \cdot min^{-1}$) from a compressed air cylinder into flowing water in the PVC pipe upstream of the centrifugal pump which supplied water to the top zone of the aquarium. Entrainment of this air in the closed system supersaturated the recirculating water in the apparatus. During the trial, dissolved oxygen, salinity, temperature and TGP were monitored (Table 38). Feed (*Artemia* sp.) was presented to the fish in the top zone under each temperature regime. Vertical distribution of fish was recorded by observers noting the number of fish present in the two least occupied zones of the WCS at 15 or 30 s intervals during a 4, 6, 8, or 13 min observation period. Fish not counted by observers were assigned a position in the remaining zone for a sum of twenty fish per reading. Using these numbers, the average percentage of fish in each zone was calculated for comparative purposes between the temperature regimes.

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REFERENCES

Baroudy, E., and J. M. Elliot. 1994. The critical thermal limits for juvenile Arctic charr (*Salvelinus alpinus*). J. Fish. Biol. 45: 1041-1053.

Birtwell, I. K. and G. M. Kruzynski. 1987. Laboratory apparatus for studying the behavior of organisms in vertically stratified waters. Can. J. Fish. Aquat. Sci. 44: 1343-1350.

Colt, J. 1984. Computation of dissolved gas concentrations in water as functions of temperature, salinity, and pressure. Spec. Publ. No. 14. American Fisheries Society, Washington, DC. 154 p.

Davis, M. W. and B. L. Olla. 1992. The role of visual cues in the facilitation of growth in a schooling fish. Environ. Biol. Fish 34: 421-424.

Healey, M. C. 1982. Timing and relative intensity of size-selective mortality of juvenile chum salmon (*Oncorhynchus keta*) during early sea life. Can. J. Fish. Aquat. Sci. 39: 952-957.

LeBrasseur, R. J. 1969. Growth of juvenile chum salmon (*Oncorhynchus keta*) under different feeding regimes. J. Fish. Res. Board Can. 26: 1631-1645.

McCauley, R. W., and W. L. Pond. 1971. Temperature selection of rainbow trout (Salmo gairdneri) fingerlings in vertical and horizontal gradients. J. Fish Res. Board Can. 28: 1801-1804.

Muller, R., and F. E. J. Fry. 1976. Preferred temperature of fish: a new method. J. Fish. Res. Board Can. 33: 1815-1817.

Ryer, C. H. and B. L. Olla. 1991. Information transfer and the facilitation and inhibition of feeding in a schooling fish. Environ. Biol. Fish. 30: 317-323.

Salo, E. O. 1991. Life history of chum salmon (*Oncorhynchus keta*). p. 231-309. In: Pacific Salmon Life Histories. C. Groot and L. Margolis (eds.) UBC Press, Vancouver. 564 p.

Spigarelli, S. A. 1975. Behavioral responses of Lake Michigan fishes to a nuclear power plant discharge. p.479-498. In: Environmental Effects of Cooling Systems at Nuclear Power Plants. IAEA-SM-187/18, Vienna, Austria.

Sprague, J. B. 1973. The ABC's of Pollutant Bioassay Using Fish. Biological Methods for the Assessment of Water Quality, ASTM STP 528, American Society for Testing and Materials: 6-30.

Sprague, J. B. 1969. Review paper: measurement of pollutant toxicity to fish: 1. Bioassay methods for acute toxicity. Water Res. 3: 793-821.

Systat Inc. 1992. SYSTAT for Windows, Version 5.0. Evanston, IL. 750 p.

Table 1. 1997 Hatchery releases of salmon into Indian Arm and Port Moody Arm of Burrard Inlet, British Columbia.

Project	Area of Release	Species	Number Released
Noon's Creek Hatchery	Port Moody Arm	chum	65 000
Port Moody Ecological Society		coho	9 300
Reed Point Marina / Ioco Seapens	Port Moody Arm	chinook	52 100
Burnaby Fish and Game Rearing Society		coho	9 050
Mossom Creek Hatchery	Port Moody Arm	chum	106 600
Centennial High School		coho	13 201
Hutchinson Creek Incubation	Indian Arm	coho	5 000
Seymour River Hatchery	Indian Arm	chum	279 000
Seymour Salmonid Society		coho	55 000
Transmountain Seapens	Port Moody Arm	chinook	52 000
Burnaby Fish and Game Rearing Society		coho	8 750
Buntzen Bay Hatchery	Indian Arm	chinook	42 000
		coho	300
Bedwell Bay Seapens	Indian Arm	chinook	38 000
Windermere Creek Enhancement		coho	7 500
Total Chinook Salmon Released			184 100
Total Chum Salmon Released			450 600
Total Coho Salmon Released			108 101
Total Salmon Released into Indian Arm and Port Moody Arm			**742 801**

Table 2. Temperature of water entering the WCS aquarium - isothermal conditions (100 h) prior to thermal stratification.

Tank Zone		Temperature (°C) Experiment Number 1	2	3	4	5	6	8	Period Mean (°C)
Top	MEAN	10.7	10.5	9.9	9.9	10.1	10	10.1	10.2
	SD	1.0	0.3	0.1	0.1	0.2	0.2	0.2	0.5
	MIN	9.6	9.7	9.5	9.5	9.7	9.7	9.7	9.5
	MAX	12.3	10.9	11.4	10.4	12.2	12.7	11.6	12.7
	N=	455	459	465	459	460	460	464	3237
Middle	MEAN	10.9	10.5	9.9	10.1	10.2	10.2	10.3	10.3
	SD	1.1	0.2	0.1	0.1	0.2	0.2	0.1	0.5
	MIN	9.7	9.8	9.4	9.8	9.8	9.8	9.9	9.4
	MAX	12.7	10.8	11.2	10.3	11.8	12.5	11.3	12.7
	N=	455	459	465	459	460	460	464	3237
Bottom	MEAN	10.7	9.9	9.9	9.9	9.9	9.9	9.9	10
	SD	1	0.1	0.1	0.1	0.1	0.2	0.1	0.5
	MIN	9.2	9.3	9.4	9.5	9.5	9.4	9.5	9.2
	MAX	12.3	10.1	11.4	10.1	11.8	12.7	11.2	12.7
	N=	455	459	465	459	460	460	464	3237

Data for Experiment #7 was unavailable

Table 3. Temperature of water entering the WCS aquarium - thermal stratification (24 h).

Tank Zone		Temperature (°C) Experiment Number 1	2	3	4	5	6	7	8	Period Mean (°C)
Top	MEAN	24.5	23.1	23.7	22.6	24.7	24.4	25.5	24.5	24.1
	SD	0.3	1.2	1.2	1.4	0.7	0.5	1.2	1.3	1.4
	MIN	23.9	20.4	21.7	19.7	23.1	23.1	21.6	21.4	19.7
	MAX	25.0	24.4	25.6	25.0	25.9	25.3	26.5	26.0	26.5
	N=	77	95	96	96	103	98	102	109	790
Middle	MEAN	10.4	10.6	10.4	11.2	10.7	11.7	11	11.3	10.9
	SD	0.1	0.3	0.3	0.3	0.2	0.5	0.2	0.5	0.5
	MIN	10.2	10.1	10.1	10.8	10.3	11.1	10.7	10.5	10.1
	MAX	10.8	11.3	11.5	12.0	11.2	13.3	11.5	12.5	13.3
	N=	77	95	96	96	103	98	102	109	790
Bottom	MEAN	9.8	9.8	9.8	9.8	9.8	10.1	9.8	10	9.9
	SD	0.1	0.1	0.1	0.2	0.1	0.5	0.1	0.3	0.3
	MIN	9.7	9.6	9.6	9.5	9.5	9.6	9.5	9.5	9.5
	MAX	10.0	10.0	10.1	10.6	10.0	11.6	10.1	10.8	11.6
	N=	77	95	96	96	103	98	102	109	790

Table 4. Temperature of water entering the WCS aquarium - isothermal conditions (16h) following thermal stratification.

Tank Zone		Temperature (°C) Experiment Number 1	2	3	4	5	6	7	8	Period Mean (°C)
Top	MEAN	10.5	9.9	9.9	9.9	9.9	10	10	10.1	10
	SD	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
	MIN	10.3	9.6	9.8	9.8	9.7	9.7	9.6	9.8	9.6
	MAX	10.7	10.1	10.4	10.1	10.2	10.5	10.5	10.6	10.7
	N=	64	67	67	63	61	65	62	58	521
Middle	MEAN	10.1	9.8	9.5	10.1	10.2	10.2	10.2	10.3	10
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3
	MIN	9.6	9.6	9.3	10.0	10.0	9.7	10.0	10.0	9.3
	MAX	10.2	10.0	9.7	10.2	10.4	10.6	10.7	10.6	10.6
	N=	64	67	67	63	61	65	62	58	521
Bottom	MEAN	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.8	9.9
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	MIN	9.7	9.5	9.7	9.8	9.7	9.5	9.6	9.7	9.5
	MAX	10.1	10.1	10.1	10.1	10.0	10.2	10.1	10.1	10.2
	N=	64	67	67	63	61	65	62	58	521

Table 5. Dissolved oxygen of water entering the WCS aquarium - isothermal conditions (100 h) prior to thermal stratification.

Tank Zone		Dissolved Oxygen (% Saturation) Experiment Number 1	2	3	4	5	6	8	Period Mean (% Sat)
Top	MEAN	102.9	101.2	101.4	102.4	100.4	100.9	99.5	101.2
	SD	2.6	1.4	0.7	1.0	1.2	0.9	1.2	1.8
	MIN	96.0	97.2	99.9	100.2	97.2	99.2	96.4	96.0
	MAX	118.6	104.4	105.1	104.4	104.4	107.5	102.6	118.6
	N=	455	459	465	459	460	460	464	3237
Middle	MEAN	107.9	102.8	100.2	101.0	98.4	97.7	98.5	100.9
	SD	1.6	1.1	0.7	0.9	1.2	1.1	1.0	3.5
	MIN	98.2	99.5	98.0	98.7	95.7	95.1	96.0	95.1
	MAX	113.3	104.6	105.2	102.7	103.9	105.3	101.0	113.3
	N=	455	459	465	459	460	460	464	3237
Bottom	MEAN	106.6	101.6	97.6	99.0	96.5	96.7	98.0	99.4
	SD	1.5	1.1	1.0	0.9	1.7	1.0	1.1	3.5
	MIN	97.9	98.7	94.8	96.4	92.7	93.8	95.8	92.7
	MAX	112.2	102.8	102.9	100.4	104.0	104.0	100.9	112.2
	N=	455	459	465	459	460	460	464	3237

Data for Experiment #7 was unavailable

Table 6. Dissolved oxygen of water entering the WCS aquarium - thermal stratification (24 h).

Tank Zone		Dissolved Oxygen (% Saturation) Experiment Number 1	2	3	4	5	6	7	8	Period Mean (% Sat)
Top	MEAN	98.1	97.2	101.2	97.4	97.6	97.7	95.2	95.5	97.4
	SD	0.6	1.2	1.0	1.1	1.0	0.5	1.2	4.3	2.6
	MIN	97.0	96.1	98.9	95.1	95.1	97.2	92.0	58.4	58.4
	MAX	99.2	99.3	103.0	100.2	100.2	98.3	98.3	103.7	103.7
	N=	77	95	96	96	103	98	102	109	790
Middle	MEAN	102.8	97.4	96.5	95.7	94.8	92.8	93.9	94.2	95.7
	SD	0.6	0.9	0.7	0.6	0.7	0.4	0.7	0.6	2.8
	MIN	102.2	95.5	94.9	94.6	93.6	92.0	92.4	92.8	92.0
	MAX	104.3	98.5	98.0	96.7	95.7	93.1	94.6	94.9	104.3
	N=	77	95	96	96	103	98	102	109	790
Bottom	MEAN	101.5	96.5	93.6	92.9	92.6	91.6	93.8	93.6	94.2
	SD	0.7	1.1	0.7	0.6	0.7	0.4	0.6	0.7	2.8
	MIN	99.9	93.6	91.8	92.3	90.7	90.8	92.7	92.7	90.7
	MAX	103.0	97.8	94.9	94.3	93.8	91.8	94.8	94.8	103.0
	N=	77	95	96	96	103	98	102	109	790

Table 7. Dissolved oxygen of water entering the WCS aquarium - isothermal conditions (16 h) following thermal stratification.

Tank Zone		Dissolved Oxygen (% Saturation) Experiment Number								Period Mean (% Sat)
		1	2	3	4	5	6	7	8	
Top	MEAN	105.6	100.6	107.0	102.1	102.0	103.2	100.5	105.4	103.3
	SD	0.8	1.0	1.0	0.5	0.6	0.6	0.9	0.8	2.4
	MIN	102.2	97.2	104.0	100.3	100.2	101.3	98.2	103.7	97.2
	MAX	106.3	102.3	110.2	102.3	103.3	104.4	101.4	106.8	110.2
	N=	64	67	67	63	61	65	62	58	521
Middle	MEAN	109.9	101.7	101.9	100.9	99.3	97.3	97.9	97.8	100.9
	SD	1.0	2.3	2.0	0.7	0.6	0.8	0.9	0.7	4.0
	MIN	105.4	85.2	87.7	98.7	97.7	94.0	95.7	96.0	85.2
	MAX	110.4	102.6	104.1	101.8	100.7	98.2	98.7	99.0	110.4
	N=	64	67	67	63	61	65	62	58	521
Bottom	MEAN	107.5	100.4	98.8	98.3	96.8	96.8	97.7	97.1	99.2
	SD	1.1	1.3	1.3	0.7	0.8	0.9	1.1	1.0	3.5
	MIN	102.9	95.6	91.8	96.4	94.8	92.9	95.8	95.7	91.8
	MAX	108.1	101.8	100.9	99.4	98.0	98.0	98.9	98.9	108.1
	N=	64	67	67	63	61	65	62	58	521

Table 8. Salinity of water entering the WCS aquarium - isothermal conditions (100 h) prior to thermal stratification.

Tank Zone		Salinity (‰) Experiment Number 1	2	3	4	5	6	8	Period Mean (‰)
Top	MEAN	28.8	27.0	26.7	28.2	26.5	27.3	27.3	27.4
	SD	1.0	1.6	1.3	0.6	0.8	0.7	0.7	1.3
	MIN	21.6	20.4	22.6	26.2	24.3	25.1	25.6	20.4
	MAX	29.5	29.2	29.1	28.9	28.2	28.5	28.7	29.5
	N=	455	459	465	459	460	460	464	3237
Middle	MEAN	30.0	27.9	29.2	28.4	26.5	27.6	27.4	28.2
	SD	1.9	1.1	0.7	0.6	0.8	0.7	0.6	1.5
	MIN	26.5	25.3	27.0	26.3	24.3	25.4	25.9	24.3
	MAX	32.8	29.7	30.2	29.0	28.2	28.8	28.7	32.8
	N=	455	459	465	459	460	460	464	3237
Bottom	MEAN	29.2	28.6	28.0	28.3	26.8	28.0	27.7	28.1
	SD	0.5	0.9	0.7	0.6	0.9	0.7	0.6	1.0
	MIN	27.5	26.5	25.7	26.2	24.6	25.3	26.2	24.6
	MAX	29.7	29.5	28.8	28.9	28.4	29.1	28.8	29.7
	N=	455	459	465	459	460	460	464	3237

Data for Experiment #7 was unavailable

Table 9. Salinity of water entering the WCS aquarium - thermal stratification (24 h).

Tank Zone		Salinity (‰) Experiment Number 1	2	3	4	5	6	7	8	Period Mean (‰)
Top	MEAN	27.4	26.8	26.9	27.1	26.7	26.4	26.8	26.8	26.8
	SD	0.8	0.9	1.6	0.6	0.4	0.8	0.4	0.4	0.9
	MIN	25.8	23.4	17.8	25.9	25.7	24.6	25.6	25.8	17.8
	MAX	28.1	27.7	28.7	27.7	27.4	27.2	27.3	27.4	28.7
	N=	77	95	96	96	103	98	102	109	790
Middle	MEAN	28.7	28.3	29.2	28.1	27.2	27.2	27.8	27.3	27.9
	SD	0.9	0.6	0.8	0.6	0.4	0.9	0.4	0.4	1.0
	MIN	27.0	26.6	27.2	26.5	26.3	25.2	26.9	26.1	25.2
	MAX	29.6	29.1	30.0	28.7	28.1	28.0	28.4	28.0	30.0
	N=	77	95	96	96	103	98	102	109	790
Bottom	MEAN	28.8	28.1	27.9	28.0	27.6	28.0	28.2	27.6	28.0
	SD	1.0	0.6	0.8	0.6	0.4	0.9	0.4	0.4	0.7
	MIN	27.1	26.4	26.0	26.3	26.7	25.8	27.2	26.4	25.8
	MAX	29.6	28.9	28.6	28.5	28.5	28.8	28.7	28.3	29.6
	N=	77	95	96	96	103	98	102	109	790

Table 10. Salinity of water entering the WCS aquarium - isothermal conditions (16 h) following thermal stratification.

Tank Zone		Salinity (‰) Experiment Number 1	2	3	4	5	6	7	8	Period Mean (‰)
Top	MEAN	27.6	27.5	28.5	27.8	27.5	27.5	27.4	27.4	27.7
	SD	0.7	0.8	0.9	0.6	0.7	0.4	0.8	0.4	0.8
	MIN	25.8	23.1	23.9	26.3	26.2	26.0	25.8	26.0	23.1
	MAX	28.7	28.3	29.4	28.5	28.4	28.0	28.3	27.9	29.4
	N=	64	67	67	63	61	65	62	58	521
Middle	MEAN	28.0	27.7	29.6	28.7	27.5	27.8	27.7	27.4	28.1
	SD	1.1	0.6	0.6	0.2	0.7	0.4	0.8	0.4	1.0
	MIN	25.8	27.0	28.4	28.1	26.2	26.3	26.0	26.1	25.8
	MAX	29.4	28.7	30.4	28.8	28.4	28.3	28.4	27.9	30.4
	N=	64	67	67	63	61	65	62	58	521
Bottom	MEAN	29.0	28.0	28.5	28.5	28.0	28.7	28.0	27.6	28.3
	SD	0.5	0.6	0.3	0.2	0.7	0.4	0.8	0.4	0.7
	MIN	27.8	26.9	27.8	28.0	26.6	27.1	26.3	26.3	26.3
	MAX	29.5	28.8	28.9	28.7	28.8	29.2	28.8	28.1	29.5
	N=	64	67	67	63	61	65	62	58	521

Table 11. Temperature recordings by dataloggers under isothermal conditions (observation period #1-AM)

Expt #	(N = 5)	Temperature (°C)											
		Datalogger Number											
		Top				Thermocline				Bottom			
		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
1	Mean	10.1	10.1	10.1	10.1	10.2	10.1	10.2	10.1	10.2	10.1	10.2	n/a
	SD	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	n/a
	Min	10.0	10.1	10.1	10.0	10.1	10.0	10.1	10.0	10.2	10.0	10.1	n/a
	Max	10.1	10.1	10.1	10.1	10.3	10.1	10.2	10.2	10.3	10.1	10.3	n/a
2	Mean	10.6	10.6	10.6	10.5	10.5	10.4	10.4	10.3	10.4	10.3	10.0	n/a
	SD	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	n/a
	Min	10.6	10.6	10.6	10.5	10.5	10.3	10.4	10.3	10.3	10.3	9.9	n/a
	Max	10.6	10.6	10.6	10.5	10.6	10.4	10.5	10.3	10.5	10.5	10.1	n/a
3	Mean	10.1	10.2	10.2	10.2	10.3	10.2	10.3	10.2	10.4	10.2	10.1	9.9
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
	Min	10.1	10.1	10.1	10.1	10.3	10.1	10.2	10.2	10.3	10.1	10.1	9.9
	Max	10.3	10.3	10.3	10.3	10.5	10.3	10.4	10.3	10.5	10.3	10.1	9.9
4	Mean	9.9	10.0	9.9	10.0	10.0	10.1	10.0	10.1	10.0	10.1	9.8	9.8
	SD	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.1
	Min	9.7	9.9	9.8	10.0	9.9	10.1	10.0	10.1	10.0	10.1	9.8	9.8
	Max	9.9	10.1	10.0	10.0	10.0	10.1	10.1	10.1	10.1	10.1	10.0	10.0
5	Mean	10.0	10.0	10.0	10.0	10.1	10.1	10.2	10.0	10.2	10.1	10.0	9.9
	SD	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0
	Min	10.0	10.0	10.0	10.0	10.1	10.0	10.1	10.0	10.2	10.1	9.9	9.9
	Max	10.0	10.0	10.0	10.0	10.1	10.1	10.2	10.0	10.2	10.1	10.1	9.9

Table 11. (cont.)

Expt #	(N = 5)	Temperature (°C) Datalogger Number: Top #1	Top #2	Top #3	Top #4	Thermocline #5	Thermocline #6	Thermocline #7	Thermocline #8	Bottom #9	Bottom #10	Bottom #11	Bottom #12
6	Mean	10.3	10.3	10.4	10.4	10.5	10.4	10.5	10.4	10.4	10.4	10.1	9.9
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
	Min	10.1	10.3	10.3	10.3	10.3	10.3	10.4	10.3	10.3	10.3	10.1	9.9
	Max	10.4	10.4	10.4	10.5	10.6	10.4	10.5	10.5	10.5	10.5	10.1	9.9
7	Mean	10.0	10.1	10.1	10.0	10.2	10.1	10.2	10.2	10.3	10.1	10.0	9.9
	SD	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.1
	Min	10.0	10.0	10.1	10.0	10.1	10.1	10.2	10.2	10.2	10.1	9.9	9.7
	Max	10.1	10.1	10.1	10.1	10.3	10.1	10.2	10.2	10.3	10.1	10.1	9.9
8	Mean	10.3	10.3	10.4	10.3	10.5	10.4	10.5	n/a	10.4	10.4	10.1	9.9
	SD	0.0	0.1	0.1	0.0	0.0	0.1	0.1	n/a	0.1	0.1	0.1	0.1
	Min	10.3	10.3	10.3	10.3	10.5	10.3	10.4	n/a	10.3	10.3	10.1	9.9
	Max	10.3	10.4	10.4	10.3	10.5	10.4	10.5	n/a	10.5	10.5	10.3	10.1
Period Mean (N=40)	Mean	10.1	10.2	10.2	10.2	10.3	10.2	10.3	10.2	10.3	10.2	10.0	9.9
	SD	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.1
	Min	9.7	9.9	9.8	10.0	9.9	10.0	10.0	10.0	10.0	10.0	9.8	9.7
	Max	10.6	10.6	10.6	10.5	10.6	10.4	10.5	10.5	10.5	10.5	10.3	10.1

n/a = datalogger malfunction

Table 12. Temperature recordings by dataloggers under isothermal conditions (observation period #2-PM)

Expt #	(N = 5)	Temperature (°C)											
		Datalogger Number											
		Top				Thermocline				Bottom			
		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
1	Mean	10.0	10.0	10.1	10.0	10.1	10.0	10.1	10.0	10.1	10.0	10.1	n/a
	SD	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	n/a
	Min	10.0	10.0	10.0	10.0	10.1	10.0	10.1	9.9	10.0	10.0	10.1	n/a
	Max	10.0	10.1	10.1	10.0	10.1	10.0	10.1	10.0	10.2	10.1	10.3	n/a
2	Mean	10.8	10.8	10.8	10.6	10.5	10.4	10.5	10.3	10.4	10.3	9.9	n/a
	SD	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.0	n/a
	Min	10.7	10.7	10.8	10.6	10.5	10.3	10.4	10.3	10.3	10.3	9.9	n/a
	Max	10.9	10.9	10.9	10.6	10.6	10.4	10.5	10.3	10.5	10.3	9.9	n/a
3	Mean	9.8	9.8	9.9	9.8	10.0	10.0	10.1	10.0	10.0	10.0	9.9	9.7
	SD	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0
	Min	9.8	9.8	9.8	9.8	10.0	10.0	10.1	9.9	10.0	10.0	9.9	9.7
	Max	9.8	9.8	10.0	9.8	10.1	10.0	10.1	10.0	10.2	10.0	9.9	9.7
4	Mean	9.7	9.9	9.8	9.9	9.9	10.0	10.0	10.1	10.0	10.1	10.0	9.9
	SD	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
	Min	9.7	9.9	9.8	9.8	9.9	9.9	10.0	10.0	10.0	10.0	10.0	9.8
	Max	9.7	9.9	9.8	10.0	9.9	10.1	10.0	10.1	10.0	10.1	10.0	10.0
5	Mean	10.3	10.3	10.3	10.3	10.5	10.3	10.4	10.3	10.5	10.3	9.9	9.7
	SD	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1
	Min	10.3	10.3	10.3	10.3	10.5	10.3	10.4	10.3	10.5	10.3	9.8	9.6
	Max	10.3	10.3	10.3	10.3	10.5	10.4	10.4	10.3	10.5	10.3	9.9	9.7

Table 12. (cont.)

		Temperature (°C)											
		Datalogger Number											
		Top				Thermocline				Bottom			
Expt #	(N = 5)	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
6	Mean	10.1	10.2	10.2	10.2	10.3	10.2	10.3	10.2	10.3	10.2	9.9	9.7
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1
	Min	10.1	10.1	10.1	10.1	10.3	10.1	10.2	10.2	10.3	10.1	9.8	9.6
	Max	10.3	10.3	10.3	10.3	10.5	10.3	10.4	10.3	10.3	10.3	10.1	9.9
7	Mean	10.3	10.3	10.4	10.3	10.4	10.3	10.4	10.3	10.4	10.4	9.9	9.7
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Min	10.1	10.3	10.3	10.1	10.3	10.1	10.2	10.2	10.3	10.1	9.8	9.6
	Max	10.4	10.4	10.4	10.3	10.5	10.4	10.5	10.3	10.5	10.5	9.9	9.7
8	Mean	10.4	10.5	10.5	10.4	10.6	10.4	10.5	n/a	10.5	10.5	10.1	9.9
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	n/a	0.1	0.1	0.1	0.1
	Min	10.3	10.4	10.4	10.3	10.5	10.3	10.4	n/a	10.5	10.3	9.9	9.7
	Max	10.4	10.6	10.6	10.5	10.6	10.6	10.5	n/a	10.6	10.6	10.3	10.1
Period Mean (N=40)	Mean	10.2	10.2	10.2	10.2	10.3	10.2	10.3	10.2	10.3	10.2	10.0	9.8
	SD	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
	Min	9.7	9.8	9.8	9.8	9.9	9.9	10.0	9.9	10.0	10.0	9.8	9.6
	Max	10.9	10.9	10.9	10.6	10.6	10.6	10.5	10.3	10.6	10.6	10.3	10.1

n/a = datalogger malfunction

Table 13. Temperature recordings by dataloggers under isothermal conditions (observation period #3-AM)

Expt		Temperature (°C)											
		Datalogger Number											
		Top				Thermocline				Bottom			
#	(N = 5)	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
1	Mean	10.0	10.1	10.2	10.0	10.2	10.0	10.1	10.1	10.2	10.1	10.2	n/a
	SD	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	n/a
	Min	10.0	10.1	10.1	10.0	10.1	10.0	10.1	10.0	10.2	10.0	10.1	n/a
	Max	10.1	10.1	10.3	10.1	10.3	10.1	10.2	10.2	10.2	10.1	10.3	n/a
2	Mean	10.6	10.6	10.6	10.5	10.5	10.4	10.4	10.3	10.4	10.3	9.9	n/a
	SD	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	n/a
	Min	10.6	10.6	10.6	10.5	10.5	10.4	10.4	10.3	10.3	10.3	9.9	n/a
	Max	10.6	10.6	10.6	10.5	10.5	10.4	10.5	10.3	10.5	10.3	9.9	n/a
3	Mean	10.2	10.2	10.3	10.2	10.4	10.3	10.4	10.3	10.4	10.3	10.1	9.9
	SD	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0
	Min	10.1	10.1	10.1	10.1	10.3	10.3	10.4	10.2	10.3	10.3	10.1	9.9
	Max	10.3	10.3	10.3	10.3	10.5	10.3	10.4	10.3	10.5	10.3	10.1	9.9
4	Mean	10.0	10.1	10.0	10.2	10.2	10.2	10.2	10.3	10.2	10.2	10.0	9.9
	SD	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.1
	Min	9.9	10.1	10.0	10.2	10.0	10.2	10.1	10.3	10.1	10.1	10.0	9.8
	Max	10.1	10.3	10.1	10.2	10.2	10.2	10.3	10.3	10.3	10.3	10.1	10.0
5	Mean	9.9	10.0	10.0	10.0	10.1	10.1	10.1	10.0	10.2	10.1	9.9	9.7
	SD	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0
	Min	9.8	10.0	10.0	10.0	10.1	10.0	10.1	10.0	10.2	10.0	9.9	9.7
	Max	10.0	10.0	10.0	10.0	10.1	10.1	10.2	10.0	10.2	10.1	9.9	9.7

Table 13. (cont.)

Expt #	(N = 5)	Temperature (°C) Datalogger Number: Top #1	Top #2	Top #3	Top #4	Thermocline #5	Thermocline #6	Thermocline #7	Thermocline #8	Bottom #9	Bottom #10	Bottom #11	Bottom #12
6	Mean	10.3	10.3	10.4	10.3	10.5	10.4	10.5	10.4	10.5	10.4	10.0	9.8
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1
	Min	10.3	10.3	10.3	10.3	10.5	10.3	10.4	10.3	10.5	10.3	9.9	9.7
	Max	10.4	10.4	10.4	10.5	10.6	10.4	10.5	10.5	10.5	10.5	10.1	9.9
7	Mean	10.0	10.1	10.2	10.1	10.2	10.2	10.3	10.2	10.3	10.2	9.9	9.7
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Min	10.0	10.1	10.1	10.0	10.1	10.1	10.2	10.0	10.2	10.1	9.8	9.6
	Max	10.1	10.3	10.3	10.3	10.5	10.3	10.4	10.3	10.5	10.3	10.1	9.9
8	Mean	10.4	10.4	10.5	10.5	10.6	10.4	10.5	n/a	10.5	10.5	10.0	9.8
	SD	0.0	0.0	0.1	0.0	0.0	0.0	0.0	n/a	0.0	0.0	0.1	0.1
	Min	10.4	10.4	10.4	10.5	10.6	10.4	10.5	n/a	10.5	10.5	9.9	9.7
	Max	10.4	10.4	10.6	10.5	10.6	10.4	10.5	n/a	10.5	10.5	10.1	9.9
Period Mean (N=40)	Mean	10.2	10.2	10.3	10.2	10.3	10.2	10.3	10.2	10.3	10.2	10.0	9.8
	SD	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
	Min	9.8	10.0	10.0	10.0	10.0	10.0	10.1	10.0	10.1	10.0	9.8	9.6
	Max	10.6	10.6	10.6	10.5	10.6	10.4	10.5	10.5	10.5	10.5	10.3	10.0

n/a = datalogger malfunction

Table 14. Temperature recordings by dataloggers under isothermal conditions (observation period #4-PM)

Expt #	(N = 5)	Top #1	Top #2	Top #3	Top #4	Thermocline #5	Thermocline #6	Thermocline #7	Thermocline #8	Bottom #9	Bottom #10	Bottom #11	Bottom #12
1	Mean	10.0	10.0	10.0	10.0	10.1	10.0	10.1	10.0	10.2	10.0	10.2	n/a
	SD	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	n/a
	Min	10.0	10.0	10.0	10.0	10.1	10.0	10.1	10.0	10.2	10.0	10.1	n/a
	Max	10.0	10.0	10.1	10.0	10.1	10.0	10.1	10.0	10.2	10.1	10.3	n/a
2	Mean	10.9	10.9	10.9	10.6	10.6	10.4	10.5	10.3	10.4	10.3	10.0	n/a
	SD	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	n/a
	Min	10.7	10.7	10.8	10.6	10.5	10.3	10.4	10.2	10.3	10.1	9.9	n/a
	Max	10.9	10.9	10.9	10.6	10.6	10.4	10.5	10.5	10.5	10.5	10.1	n/a
3	Mean	10.1	10.1	10.1	10.1	10.2	10.1	10.2	10.2	10.3	10.1	10.1	9.9
	SD	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0
	Min	10.0	10.0	10.0	10.0	10.1	10.1	10.2	10.2	10.2	10.1	10.1	9.9
	Max	10.1	10.1	10.1	10.1	10.3	10.1	10.2	10.2	10.3	10.1	10.1	9.9
4	Mean	9.7	9.9	9.7	9.8	9.9	9.9	9.8	10.0	10.0	10.0	10.0	9.8
	SD	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
	Min	9.6	9.8	9.7	9.8	9.9	9.9	9.8	10.0	10.0	10.0	10.0	9.8
	Max	9.7	9.9	9.8	9.8	9.9	9.9	10.0	10.0	10.0	10.0	10.0	10.0
5	Mean	10.4	10.4	10.4	10.5	10.6	10.4	10.5	10.5	10.5	10.3	9.9	9.8
	SD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	Min	10.4	10.4	10.4	10.5	10.6	10.4	10.5	10.5	10.5	10.3	9.9	9.7
	Max	10.4	10.4	10.4	10.5	10.6	10.4	10.5	10.5	10.5	10.3	9.9	9.9

Temperature (°C), by Datalogger Number.

Table 14. (cont.)

Expt #	(N = 5)	Temperature (°C) Datalogger Number: Top #1	Top #2	Top #3	Top #4	Thermocline #5	Thermocline #6	Thermocline #7	Thermocline #8	Bottom #9	Bottom #10	Bottom #11	Bottom #12
6	Mean	10.1	10.1	10.2	10.2	10.3	10.2	10.3	10.2	10.3	10.3	10.0	9.8
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1
	Min	10.0	10.1	10.1	10.1	10.3	10.1	10.2	10.2	10.3	10.1	9.9	9.7
	Max	10.1	10.3	10.3	10.3	10.5	10.3	10.4	10.3	10.3	10.3	10.1	9.9
7	Mean	10.3	10.3	10.4	10.3	10.3	10.2	10.3	10.2	10.3	10.2	9.9	9.7
	SD	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0
	Min	10.3	10.3	10.3	10.1	10.3	10.1	10.2	10.2	10.3	10.1	9.9	9.7
	Max	10.3	10.4	10.4	10.3	10.5	10.3	10.4	10.2	10.3	10.3	9.9	9.7
8	Mean	10.3	10.3	10.4	10.3	10.4	10.3	10.4	n/a	10.4	10.3	10.0	9.8
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	n/a	0.1	0.1	0.1	0.1
	Min	10.3	10.3	10.3	10.1	10.3	10.3	10.2	n/a	10.3	10.3	9.9	9.7
	Max	10.4	10.4	10.4	10.5	10.5	10.4	10.5	n/a	10.5	10.5	10.1	9.9
Period Mean (N=40)	Mean	10.2	10.2	10.3	10.2	10.3	10.2	10.3	10.2	10.3	10.2	10.0	9.8
	SD	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
	Min	9.6	9.8	9.7	9.8	9.9	9.9	9.8	10.0	10.0	10.0	9.9	9.7
	Max	10.9	10.9	10.9	10.6	10.6	10.4	10.5	10.5	10.5	10.5	10.3	10.0

n/a = datalogger malfunction

Table 15. Temperature recordings by dataloggers under isothermal conditions (observation period #5-AM)

Expt #	(N = 5)	Temperature (°C) – Datalogger Number – Top #1	Top #2	Top #3	Top #4	Thermocline #5	Thermocline #6	Thermocline #7	Thermocline #8	Bottom #9	Bottom #10	Bottom #11	Bottom #12
1	Mean	10.0	10.1	10.1	10.0	10.1	10.0	10.1	10.0	10.2	10.0	10.1	n/a
	SD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	n/a
	Min	10.0	10.1	10.1	10.0	10.1	10.0	10.1	10.0	10.2	10.0	10.1	n/a
	Max	10.0	10.1	10.1	10.0	10.1	10.0	10.1	10.0	10.2	10.0	10.1	n/a
2	Mean	10.0	10.1	10.1	10.0	10.1	10.1	10.1	10.0	10.2	10.1	10.1	n/a
	SD	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	n/a
	Min	10.0	10.0	10.0	10.0	10.1	10.0	10.1	10.0	10.2	10.1	10.1	n/a
	Max	10.0	10.1	10.1	10.0	10.1	10.1	10.2	10.0	10.2	10.1	10.1	n/a
3	Mean	10.1	10.1	10.2	10.1	10.3	10.2	10.3	10.2	10.3	10.2	10.0	9.8
	SD	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1
	Min	10.0	10.0	10.1	10.0	10.1	10.1	10.2	10.0	10.2	10.1	9.9	9.7
	Max	10.3	10.3	10.3	10.3	10.5	10.3	10.4	10.3	10.5	10.3	10.1	9.9
4	Mean	10.0	10.2	10.1	10.2	10.2	10.3	10.2	10.3	10.2	10.2	10.1	10.0
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
	Min	9.9	10.1	10.0	10.2	10.0	10.2	10.1	10.1	10.1	10.1	10.0	10.0
	Max	10.1	10.3	10.1	10.3	10.2	10.4	10.3	10.3	10.3	10.3	10.1	10.0
5	Mean	10.0	10.0	10.0	10.0	10.1	10.1	10.2	10.1	10.3	10.1	10.0	9.8
	SD	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.1
	Min	10.0	10.0	10.0	10.0	10.1	10.0	10.1	10.0	10.2	10.1	9.9	9.7
	Max	10.0	10.0	10.1	10.0	10.1	10.1	10.2	10.2	10.3	10.1	10.1	9.9

Table 15. (cont.)

Expt #	(N = 5)	Temperature (°C)											
		Datalogger Number											
		Top				Thermocline				Bottom			
		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
6	Mean	10.3	10.3	10.3	10.3	10.5	10.3	10.4	10.3	10.4	10.3	10.0	9.8
	SD	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2
	Min	10.1	10.1	10.1	10.1	10.3	10.1	10.2	10.2	10.2	10.1	9.8	9.6
	Max	10.6	10.6	10.6	10.6	10.8	10.6	10.7	10.7	10.6	10.5	10.3	10.1
7	Mean	10.1	10.1	10.2	10.1	10.3	10.2	10.3	10.2	10.3	10.3	10.0	9.8
	SD	0.1	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.1
	Min	10.0	10.1	10.1	10.1	10.3	10.1	10.2	10.2	10.3	10.1	9.9	9.7
	Max	10.1	10.1	10.3	10.1	10.3	10.3	10.4	10.2	10.3	10.3	10.1	9.9
8	Mean	10.3	10.4	10.4	10.3	10.4	10.3	10.4	n/a	10.4	10.3	10.0	9.8
	SD	0.1	0.1	0.1	0.2	0.1	0.1	0.2	n/a	0.1	0.1	0.1	0.1
	Min	10.3	10.3	10.3	10.1	10.3	10.1	10.2	n/a	10.3	10.1	9.9	9.7
	Max	10.4	10.4	10.4	10.5	10.5	10.4	10.5	n/a	10.5	10.5	10.1	9.9
Period Mean (N=40)	Mean	10.1	10.2	10.2	10.1	10.3	10.2	10.2	10.2	10.3	10.2	10.0	9.8
	SD	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
	Min	9.9	10.0	10.0	10.0	10.0	10.0	10.1	10.0	10.1	10.0	9.8	9.6
	Max	10.6	10.6	10.6	10.6	10.8	10.6	10.7	10.7	10.6	10.5	10.3	10.1

n/a = datalogger malfunction

Table 16. Temperature recordings by dataloggers under thermally stratified conditions (observation period #6-PM).

Expt #	(N = 5)	Temperature (°C)											
		Datalogger Number											
		Top				Thermocline				Bottom			
		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
1	Mean	23.7	23.7	23.7	23.3	22.9	22.4	21.3	14.9	10.8	10.6	10.1	n/a
	SD	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.1	0.1	0.0	n/a
	Min	23.3	23.2	23.2	22.7	22.4	21.8	20.8	14.5	10.6	10.5	10.1	n/a
	Max	24.1	24.2	24.1	23.8	23.2	22.8	21.6	15.1	10.8	10.6	10.1	n/a
2	Mean	23.9	24.0	23.9	23.4	22.9	21.8	16.7	12.9	10.8	10.6	9.9	n/a
	SD	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	n/a
	Min	23.8	23.9	23.7	23.3	22.6	21.5	16.6	12.8	10.8	10.6	9.8	n/a
	Max	23.9	24.0	24.1	23.6	23.1	22.0	16.8	13.0	10.9	10.8	10.1	n/a
3	Mean	24.4	24.4	24.3	23.9	23.3	22.2	15.2	12.6	11.0	10.8	9.9	9.7
	SD	0.4	0.3	0.4	0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.0	0.0
	Min	23.9	24.0	23.9	23.4	22.9	21.8	15.0	12.3	10.9	10.8	9.9	9.7
	Max	24.8	24.9	24.8	24.3	23.7	22.7	15.2	12.7	11.1	10.9	9.9	9.7
4	Mean	23.5	23.6	23.4	23.1	22.3	20.9	16.9	13.8	11.4	11.3	10.0	9.8
	SD	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1
	Min	23.1	23.2	23.2	22.8	21.9	20.6	16.6	13.7	11.2	11.2	9.8	9.6
	Max	23.8	23.9	23.7	23.4	22.6	21.1	17.1	14.0	11.5	11.5	10.1	10.0
5	Mean	24.5	24.5	24.5	24.0	23.7	22.1	16.5	12.8	11.2	11.0	10.2	10.0
	SD	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
	Min	24.3	24.2	24.2	23.8	23.4	21.8	16.5	12.7	11.1	10.9	10.1	9.9
	Max	24.6	24.7	24.8	24.3	23.9	22.3	16.6	12.8	11.2	11.1	10.3	10.1

Table 16. (cont.)

Expt #	(N = 5)	Temperature (°C)											
		Datalogger Number											
		Top				Thermocline				Bottom			
		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
6	Mean	24.4	24.4	24.2	23.6	23.2	22.2	17.3	13.9	11.9	11.7	10.1	9.9
	SD	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	Min	24.1	24.2	23.9	23.4	23.1	22.0	17.2	13.9	11.9	11.7	10.1	9.9
	Max	24.6	24.6	24.4	23.8	23.4	22.3	17.6	13.9	11.9	11.7	10.1	9.9
7	Mean	24.5	24.5	24.6	24.1	23.5	21.4	17.0	13.7	11.7	11.5	10.2	10.0
	SD	0.4	0.3	0.3	0.3	0.4	0.5	0.4	0.2	0.1	0.1	0.1	0.1
	Min	24.1	24.0	24.1	23.8	22.9	20.8	16.5	13.4	11.6	11.4	10.1	9.9
	Max	25.0	24.9	24.9	24.6	23.9	22.0	17.6	13.9	11.9	11.7	10.3	10.1
8	Mean	25.5	25.6	25.5	25.1	24.5	22.7	17.2	n/a	12.2	12.0	10.5	10.3
	SD	0.4	0.4	0.4	0.4	0.4	0.3	0.1	n/a	0.1	0.1	0.2	0.2
	Min	25.0	25.1	25.1	24.6	24.1	22.3	17.1	n/a	12.0	11.8	10.4	10.1
	Max	25.9	25.9	25.8	25.5	24.8	23.0	17.2	n/a	12.3	12.1	10.7	10.5
Period Mean (N=40)	Mean	24.3	24.3	24.3	23.8	23.3	21.9	17.3	13.5	11.4	11.2	10.1	9.9
	SD	0.6	0.6	0.7	0.6	0.7	0.6	1.7	0.8	0.5	0.5	0.2	0.2
	Min	23.1	23.2	23.2	22.7	21.9	20.6	15.0	12.3	10.6	10.5	9.8	9.6
	Max	25.9	25.9	25.8	25.5	24.8	23.0	21.6	15.1	12.3	12.1	10.7	10.5

n/a = datalogger malfunction

Table 17. Temperature recordings by dataloggers under thermally stratified conditions (observation period #7-AM).

Expt #	(N = 5)	Temperature (°C) Datalogger Number: Top #1	#2	#3	#4	Thermocline #5	#6	#7	#8	Bottom #9	#10	#11	#12
1	Mean	24.5	24.6	24.5	24.1	23.6	23.1	21.6	14.1	10.7	10.5	10.1	n/a
	SD	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.6	0.1	0.1	0.1	n/a
	Min	24.3	24.4	24.2	23.9	23.4	22.8	21.3	13.6	10.5	10.5	9.9	n/a
	Max	24.8	24.9	24.8	24.3	24.1	23.5	21.8	14.8	10.8	10.6	10.1	n/a
2	Mean	23.6	23.6	23.6	23.0	22.7	21.6	16.0	12.9	10.9	10.7	10.1	n/a
	SD	0.4	0.5	0.4	0.5	0.4	0.4	0.3	0.2	0.1	0.1	0.1	n/a
	Min	22.9	22.8	22.9	22.2	22.1	21.0	15.7	12.7	10.8	10.6	9.9	n/a
	Max	23.9	24.0	23.9	23.4	23.1	22.0	16.3	13.1	10.9	10.8	10.1	n/a
3	Mean	21.8	21.9	21.8	21.3	20.7	19.3	14.6	12.3	10.8	10.7	10.0	9.8
	SD	0.1	0.2	0.1	0.2	0.2	0.2	0.3	0.1	0.1	0.1	0.1	0.1
	Min	21.7	21.7	21.7	21.1	20.6	19.1	14.2	12.2	10.8	10.6	9.9	9.6
	Max	22.1	22.2	22.0	21.6	21.1	19.5	14.9	12.5	10.9	10.8	10.1	9.9
4	Mean	21.4	21.5	21.3	20.9	20.0	19.0	17.0	14.8	11.4	10.9	10.1	10.0
	SD	0.3	0.3	0.3	0.3	0.3	0.2	0.5	1.0	0.3	0.3	0.2	0.1
	Min	21.0	21.0	20.8	20.4	19.6	18.7	16.5	13.9	11.1	10.6	10.0	10.0
	Max	21.8	21.9	21.7	21.3	20.2	19.2	17.8	16.1	11.9	11.2	10.4	10.3
5	Mean	24.0	24.0	24.0	23.6	23.1	21.6	17.1	13.0	11.0	10.8	10.1	9.9
	SD	0.3	0.3	0.3	0.3	0.3	0.3	0.6	0.3	0.1	0.1	0.0	0.0
	Min	23.6	23.7	23.7	23.3	22.7	21.3	16.5	12.7	10.8	10.8	10.1	9.9
	Max	24.3	24.4	24.4	23.9	23.4	22.0	18.0	13.6	11.1	10.9	10.1	9.9

Table 17. (cont.)

Expt #	(N = 5)	Temperature (°C) Datalogger Number: Top #1	#2	#3	#4	Thermocline #5	#6	#7	#8	Bottom #9	#10	#11	#12
6	Mean	23.4	23.4	23.4	22.7	21.2	20.0	18.5	16.2	13.0	12.6	11.0	10.8
	SD	0.3	0.4	0.3	0.4	0.4	0.1	0.4	0.9	0.6	0.7	0.4	0.4
	Min	23.1	23.0	23.0	22.4	20.9	19.9	17.9	14.8	12.2	11.5	10.4	10.2
	Max	23.9	24.0	23.9	23.4	21.9	20.2	18.9	16.9	13.6	13.4	11.5	11.3
7	Mean	25.0	25.0	25.0	24.8	23.9	21.5	16.9	13.4	11.2	11.1	10.0	9.8
	SD	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.3	0.1	0.2	0.2	0.2
	Min	24.8	24.9	24.9	24.6	23.7	21.3	16.6	13.1	11.1	10.9	9.8	9.6
	Max	25.2	25.1	25.1	24.8	24.1	21.7	17.6	13.9	11.2	11.2	10.3	10.1
8	Mean	23.0	23.0	22.9	22.3	21.6	20.2	16.0	n/a	12.0	11.8	10.4	10.2
	SD	0.8	0.9	0.9	1.0	1.0	0.9	0.3	n/a	0.4	0.4	0.2	0.2
	Min	21.9	21.8	21.7	21.1	20.4	18.9	15.5	n/a	11.6	11.4	10.1	9.9
	Max	23.9	24.0	23.9	23.4	22.7	21.2	16.3	n/a	12.5	12.3	10.7	10.5
Period Mean (N=40)	Mean	23.3	23.4	23.3	22.8	22.1	20.8	17.2	13.8	11.4	11.1	10.2	10.1
	SD	1.2	1.2	1.3	1.3	1.4	1.4	2.0	1.4	0.8	0.7	0.4	0.4
	Min	21.0	21.0	20.8	20.4	19.6	18.7	14.2	12.2	10.5	10.5	9.8	9.6
	Max	25.2	25.1	25.1	24.8	24.1	23.5	21.8	16.9	13.6	13.4	11.5	11.3

n/a = datalogger malfunction

Table 18. Temperature recordings by dataloggers under thermally stratified conditions (observation period #8-PM).

Expt #	(N = 5)	Top #1	Top #2	Top #3	Top #4	Thermocline #5	Thermocline #6	Thermocline #7	Thermocline #8	Bottom #9	Bottom #10	Bottom #11	Bottom #12
1	Mean	24.8	24.9	24.8	24.5	24.0	23.4	21.5	13.8	10.9	10.7	10.1	n/a
	SD	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.2	0.1	0.1	0.0	n/a
	Min	24.6	24.7	24.8	24.3	23.9	23.2	21.1	13.6	10.8	10.6	10.1	n/a
	Max	25.0	25.1	24.9	24.6	24.3	23.7	22.0	14.0	10.9	10.8	10.1	n/a
2	Mean	23.3	23.3	23.2	22.7	22.3	21.1	15.8	12.9	10.9	10.6	10.0	n/a
	SD	0.3	0.3	0.2	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	n/a
	Min	22.9	23.0	23.0	22.4	22.1	20.8	15.7	12.8	10.8	10.6	9.9	n/a
	Max	23.6	23.7	23.6	23.1	22.6	21.3	15.8	13.0	10.9	10.8	10.1	n/a
3	Mean	25.1	25.2	25.1	24.7	24.3	23.2	15.3	12.3	10.9	10.7	9.9	9.7
	SD	0.3	0.4	0.4	0.4	0.4	0.4	0.1	0.2	0.1	0.1	0.0	0.0
	Min	24.6	24.7	24.6	24.1	23.7	22.7	15.2	12.2	10.8	10.6	9.9	9.7
	Max	25.5	25.6	25.6	25.2	24.8	23.7	15.4	12.5	11.1	10.9	9.9	9.7
4	Mean	24.6	24.7	24.5	24.2	23.4	21.7	15.9	12.9	11.0	11.1	9.9	9.8
	SD	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1
	Min	24.3	24.4	24.2	23.9	23.1	21.3	15.5	12.8	10.9	11.1	9.8	9.6
	Max	25.0	25.1	24.9	24.6	23.9	22.1	16.2	13.1	11.2	11.2	10.1	10.0
5	Mean	24.5	24.5	24.5	24.1	23.4	21.7	16.9	13.1	11.2	11.0	10.0	9.8
	SD	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1
	Min	24.3	24.2	24.2	23.8	23.1	21.3	16.6	13.0	11.1	10.9	9.9	9.7
	Max	24.6	24.7	24.8	24.3	23.7	22.0	17.1	13.1	11.4	11.1	10.1	9.9

Temperature (°C), Datalogger Number

Table 18. (cont.)

Expt #	(N = 5)	Temperature (°C) Datalogger Number: Top #1	Top #2	Top #3	Top #4	Thermocline #5	Thermocline #6	Thermocline #7	Thermocline #8	Bottom #9	Bottom #10	Bottom #11	Bottom #12
6	Mean	24.8	24.9	24.9	24.3	23.3	21.2	16.7	13.8	11.9	11.7	10.1	9.9
	SD	0.3	0.3	0.3	0.3	0.4	0.5	0.2	0.2	0.2	0.2	0.0	0.0
	Min	24.5	24.6	24.6	23.9	22.9	20.7	16.5	13.6	11.7	11.5	10.1	9.9
	Max	25.2	25.2	25.1	24.6	23.7	21.8	17.1	14.0	12.0	11.8	10.1	9.9
7	Mean	24.2	24.2	24.2	23.7	23.1	21.2	16.6	13.6	11.7	11.5	10.0	9.8
	SD	1.0	1.0	1.0	1.0	1.1	1.0	0.4	0.0	0.1	0.1	0.1	0.1
	Min	22.9	22.8	22.9	22.4	21.6	19.7	16.3	13.6	11.6	11.4	9.9	9.7
	Max	25.3	25.4	25.3	24.8	24.3	22.3	17.2	13.6	11.9	11.5	10.1	9.9
8	Mean	24.6	24.7	24.6	24.0	23.1	21.3	16.1	n/a	12.1	11.9	10.3	10.1
	SD	0.4	0.4	0.4	0.5	0.6	0.9	0.2	n/a	0.4	0.4	0.2	0.2
	Min	24.1	24.2	24.1	23.4	22.4	20.3	15.8	n/a	11.6	11.4	9.9	9.7
	Max	25.2	25.1	25.1	24.6	23.7	22.3	16.5	n/a	12.6	12.5	10.6	10.4
Period Mean (N=40)	Mean	24.5	24.5	24.5	24.0	23.3	21.8	16.8	13.2	11.3	11.2	10.0	9.8
	SD	0.7	0.7	0.7	0.7	0.7	1.0	1.9	0.5	0.5	0.5	0.2	0.2
	Min	22.9	22.8	22.9	22.4	21.6	19.7	15.2	12.2	10.8	10.6	9.8	9.6
	Max	25.5	25.6	25.6	25.2	24.8	23.7	22.0	14.0	12.6	12.5	10.6	10.4

n/a = datalogger malfunction

Table 19. Temperature recordings by dataloggers under isothermal conditions (observation period #9-AM).

Expt #	(N = 5)	Temperature (°C)											
		Datalogger Number											
		Top				Thermocline				Bottom			
		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
1	Mean	10.6	10.6	10.6	10.5	10.5	10.4	10.5	10.3	10.5	10.4	10.1	n/a
	SD	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.0	n/a
	Min	10.6	10.6	10.6	10.5	10.5	10.4	10.4	10.3	10.5	10.3	10.1	n/a
	Max	10.6	10.6	10.6	10.5	10.6	10.4	10.5	10.3	10.5	10.5	10.1	n/a
2	Mean	10.0	10.1	10.1	10.1	10.2	10.1	10.2	10.1	10.2	10.1	10.0	n/a
	SD	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	n/a
	Min	10.0	10.1	10.1	10.0	10.1	10.1	10.2	10.0	10.2	10.1	9.9	n/a
	Max	10.1	10.1	10.1	10.1	10.3	10.1	10.2	10.2	10.2	10.1	10.1	n/a
3	Mean	10.0	10.1	10.1	10.0	10.2	10.1	10.1	10.1	10.2	10.2	10.1	9.9
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1
	Min	10.0	10.0	10.0	10.0	10.1	10.0	10.1	10.0	10.2	10.1	10.1	9.9
	Max	10.1	10.1	10.1	10.1	10.3	10.1	10.2	10.2	10.3	10.3	10.1	10.1
4	Mean	10.0	10.1	10.0	10.1	10.1	10.2	10.1	10.2	10.1	10.2	10.0	10.0
	SD	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.0
	Min	9.9	10.1	10.0	10.0	10.0	10.1	10.1	10.1	10.1	10.1	10.0	10.0
	Max	10.1	10.1	10.0	10.2	10.2	10.2	10.1	10.3	10.1	10.3	10.1	10.0
5	Mean	9.8	9.8	9.9	9.9	10.1	10.0	10.1	10.0	10.1	10.0	10.0	9.8
	SD	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1
	Min	9.8	9.8	9.8	9.8	10.0	10.0	10.1	9.9	10.0	10.0	9.9	9.7
	Max	9.8	10.0	10.0	10.0	10.1	10.0	10.1	10.0	10.2	10.1	10.1	9.9

Table 19. (cont.)

Expt #	(N = 5)	Temperature (°C) Datalogger Number Top #1	#2	#3	#4	Thermocline #5	#6	#7	#8	Bottom #9	#10	#11	#12
6	Mean	10.2	10.2	10.3	10.2	10.4	10.3	10.4	10.3	10.4	10.3	10.2	10.0
	SD	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.2	0.1	0.1
	Min	10.0	10.0	10.0	10.0	10.1	10.1	10.2	10.0	10.2	10.1	10.1	9.9
	Max	10.6	10.6	10.6	10.6	10.8	10.6	10.7	10.7	10.6	10.5	10.3	10.1
7	Mean	9.9	10.0	10.0	10.0	10.1	10.0	10.1	10.0	10.2	10.1	10.0	9.8
	SD	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1
	Min	9.8	10.0	10.0	10.0	10.0	10.0	10.1	10.0	10.2	10.1	9.9	9.7
	Max	10.0	10.0	10.0	10.0	10.1	10.0	10.1	10.0	10.2	10.1	10.1	9.9
8	Mean	10.3	10.3	10.4	10.3	10.3	10.2	10.3	n/a	10.4	10.2	10.0	9.8
	SD	0.1	0.1	0.1	0.1	0.1	0.1	0.1	n/a	0.1	0.1	0.1	0.1
	Min	10.3	10.3	10.3	10.1	10.3	10.1	10.2	n/a	10.3	10.1	9.9	9.7
	Max	10.4	10.4	10.4	10.3	10.5	10.3	10.4	n/a	10.5	10.3	10.1	10.1
Period Mean (N=40)	Mean	10.1	10.1	10.2	10.1	10.2	10.2	10.2	10.2	10.2	10.2	10.1	9.9
	SD	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
	Min	9.8	9.8	9.8	9.8	10.0	10.0	10.1	9.9	10.0	10.0	9.9	9.7
	Max	10.6	10.6	10.6	10.6	10.8	10.6	10.7	10.7	10.6	10.5	10.3	10.1

n/a = datalogger malfunction

Table 20. Vertical datalogger position in the WCS aquarium.

Datalogger Number	Vertical Depth in Tank (cm)
1	16.5
2	36.5
3	54.5
4	74.5
5	84.5
6	88.0
7	90.5
8	94.0
9	122.0
10	151.5
11	191.5
12	238.8

Table 21. Determinations of Total Gas Pressure (TGP) measured in the WCS aquarium during Experiments 1 - 8.

Observation Period		TGP (%)			TGP (ΔP)		
		TOP	MID	BOT	TOP	MID	BOT
1	MEAN	99.9	100.0	99.4	0	0	-5
	SD	1.8	1.6	1.5	13	12	12
	MIN	98.8	98.8	97.9	-9	-9	-16
	MAX	103.8	103.5	102.2	29	27	17
	N=	6	6	6	6 6	6 6	6 6
2	MEAN	98.7	99.0	98.3	-10	-8	-13
	SD	1.8	1.7	2.1	14	13	16
	MIN	97.0	97.0	95.9	-23	-23	-31
	MAX	101.8	101.9	101.7	14	15	13
	N=	6	6	6	6	6	6
3	MEAN	99.9	100.0	99.2	-1	0	-6
	SD	1.7	1.5	1.8	13	12	14
	MIN	97.9	98.3	97.0	-16	-13	-23
	MAX	103.0	102.8	101.7	23	21	13
	N=	8	8	8	8	8	8
4	MEAN	98.2	98.5	97.2	-14	-12	-21
	SD	1.3	1.3	1.0	10	10	8
	MIN	96.9	97.1	96.1	-24	-22	-30
	MAX	100.5	100.7	98.3	4	5	-13
	N =	6	6	6	6	6	6
5	MEAN	100.9	101.0	100.6	7	8	5
	SD	2.5	2.3	2.3	19	18	18
	MIN	99.1	99.3	98.9	-7	-5	-8
	MAX	102.6	102.6	102.2	20	20	17
	N =	2	2	2	2	2	2
6	MEAN	102.7	96.4	95.3	20	-27	-36
	SD	0.9	0.9	1.3	7	7	10
	MIN	101.2	95.6	94.2	9	-34	-44
	MAX	104.5	98.2	97.4	34	-14	-19
	N=	8	8	8	8	8	8

Table 21. (cont.)

Observation Period		TGP (%) TOP	MID	BOT	TGP (ΔP) TOP	MID	BOT
7	MEAN	102.5	97.0	96.0	19	-23	-31
	SD	1.1	0.9	1.4	8	7	11
	MIN	101.2	96.1	94.1	9	-30	-45
	MAX	104.5	99.1	98.4	34	-7	-12
	N=	8	8	8	8	8	8
8	MEAN	102.4	96.5	95.5	18	-27	-34
	SD	1.0	0.8	1.1	8	6	8
	MIN	100.8	95.8	94.2	6	-32	-44
	MAX	103.9	97.8	96.7	30	-17	-25
	N=	6	6	6	6	6	6
9	MEAN	101.0	101.1	100.3	8	8	3
	SD	2.3373	2.1519	2.3397	18	16	18
	MIN	97.2	97.5	96.4	-21	-19	-27
	MAX	105.5	105.1	103.8	42	39	29
	N=	8	8	8	8	8	8

TOP, MID, and BOT, represent 3 vertical zones of the WCS

Table 22. Weight and length of juvenile chum used in WCS and thermal resistance bioassay experiments.

WCS Expt Number	Date	Weight (g)				Fork Length (mm)			
		Mean	SD	Min	Max	Mean	SD	Min	Max
#1	Jun 7	1.4	0.4	0.7	2.3	56.3	4.3	49.0	67.0
#2	Jun 13	1.8	0.4	1.0	2.5	58.8	4.0	50.0	63.0
#3	Jun 20	2.5	0.5	1.6	3.5	67.7	4.4	57.0	73.0
#4	Jul 4	4.5	1.0	2.6	6.3	78.5	5.5	71.0	90.0
#5	Jul 25	10.0	1.8	7.2	13.9	103.8	5.4	96.0	114.0
#6	Aug 1	11.4	2.3	7.3	15.9	108.2	7.6	94.0	122.0
#7	Aug 8	13.4	3.5	8.0	19.7	111.7	8.7	97.0	125.0
#8	Aug 15	15.9	3.8	8.6	23.3	117.9	0.9	100.0	133.0

Bioassay Number	Date	Weight (g)				Fork Length (mm)			
		Mean	SD	Min	Max	Mean	SD	Min	Max
#1	Jun 30	4.0	1.4	1.5	6.3	76.4	9.4	56.0	92.0
#2	Jul 21	10.4	2.2	5.2	13.3	104.0	7.3	87.0	116.0
#3	Jul 25	10.8	2.5	6.3	16.0	104.5	7.9	89.0	120.0
#4	Jul 28	11.6	3.1	4.5	18.0	106.3	8.9	80.0	121.0
#5	Aug 1	13.7	2.0	9.9	16.8	114.0	5.4	103.0	122.0
#6	Aug 5	15.0	3.4	5.9	20.1	117.4	9.2	86.0	128.0
#7	Aug 12	16.4	3.5	9.3	23.0	120.2	8.1	100.0	134.0
#8	Aug 15	19.1	4.2	8.7	25.8	123.6	8.4	97.0	135.0

Table 23. Schedule of 9 observation periods per experiment during a 5 day sequence of events.

Observation Period	Day	Time	Conditions	
			Temperature	Feeding
1	Monday	AM	Isothermal	no Food
2	Monday	PM	Isothermal	no Food
3	Tuesday	AM	Isothermal	no Food
4	Tuesday	PM	Isothermal	Food
5	Wednesday	AM	Isothermal	no Food
6	Wednesday	PM	Stratified	no Food
7	Thursday	AM	Stratified	no Food
8	Thursday	PM	Stratified	Food
9	Friday	AM	Isothermal	no Food

Table 24. Percentage of juvenile chum salmon recorded in the top zone of the WCS aquarium during 9 observation periods (N = 8).

	% of Fish in Top Zone								
	Observation Period								
Expt #	1	2	3	4	5	6	7	8	9
1	52.0	36.2	37.8	75.1	0.4	3.8	1.8	17.0	78.2
2	31.8	31.8	21.9	89.4	39.8	1.5	1.2	39.8	9.7
3	9.5	6.8	14.4	72.2	17.7	3.0	8.6	25.8	6.8
4	45.8	21.9	11.2	65.4	0.2	3.9	16.4	34.1	36.0
5	24.3	40.8	35.2	71.6	5.5	2.6	1.3	34.2	36.7
6	9.0	7.1	13.8	12.4	2.3	0.6	1.0	18.5	71.0
7	71.9	51.4	25.7	88.3	86.7	2.0	1.6	33.8	57.5
8	19.5	22.8	20.8	21.6	4.2	0.3	2.9	35.6	61.1
Mean	33.0	27.4	22.6	62.0	19.6	2.2	4.3	29.8	44.6
Median	28.1	27.3	21.3	71.9	4.9	2.3	1.7	34.0	47.1
SD	22.1	15.8	9.8	29.1	30.2	1.4	5.5	8.4	26.9

Table 25. Percentage of juvenile chum salmon recorded in the thermocline zone of the WCS aquarium during 9 observation periods (N = 8).

	% of Fish in Top Zone								
	Observation Period								
Expt #	1	2	3	4	5	6	7	8	9
1	3.0	0.9	1.5	0.6	0.2	76.0	69.3	34.0	4.5
2	3.0	3.0	7.1	1.7	6.3	94.4	71.9	23.1	9.5
3	16.3	11.9	17.7	1.7	16.1	78.3	74.0	36.4	27.6
4	25.3	35.4	30.6	7.1	2.8	84.3	63.9	33.6	32.1
5	26.9	21.8	25.3	8.2	10.4	62.3	70.0	26.5	9.9
6	14.6	21.4	23.6	8.7	12.6	52.0	49.7	36.5	8.1
7	13.2	10.1	10.3	6.2	5.3	59.0	62.2	34.3	17.7
8	21.4	30.8	28.8	18.3	30.1	46.8	71.6	27.1	17.0
Mean	15.4	16.9	18.1	6.6	10.4	69.1	66.6	31.4	15.8
Median	15.4	16.6	20.6	6.7	8.3	69.1	69.6	33.8	13.4
SD	9.1	12.5	10.8	5.7	9.5	16.7	7.9	5.1	9.8

Table 26. Percentage of juvenile chum salmon recorded in the bottom zone of the WCS aquarium during 9 observation periods (N = 8).

	% of Fish in Top Zone								
	Observation Period								
Expt #	1	2	3	4	5	6	7	8	9
1	45.0	62.9	60.8	24.3	99.4	20.2	28.9	49.1	17.3
2	65.3	65.3	71.1	9.0	54.0	4.1	27.0	37.2	80.9
3	74.3	81.4	68.0	26.2	66.3	18.8	17.5	37.9	65.7
4	29.0	42.8	58.3	27.6	97.1	11.9	19.7	32.3	32.0
5	48.9	37.4	39.6	20.3	84.2	35.2	28.8	39.4	53.5
6	76.4	71.6	62.7	78.9	85.2	47.5	49.3	45.1	21.0
7	15.0	38.5	64.0	5.5	8.0	39.1	36.3	32.0	24.9
8	59.2	46.4	50.4	60.1	65.7	52.9	25.5	37.3	21.9
Mean	51.6	55.8	59.4	31.5	70.0	28.7	29.1	38.8	39.6
Median	54.1	54.7	61.8	25.2	75.2	27.7	27.9	37.6	28.5
SD	21.6	16.6	10.1	25.3	29.7	17.5	10.0	5.9	23.9

Table 27. Mean distances (cm) chum salmon travelled during 30 second observation periods in the WCS aquarium, Experiments 1 - 8.

Observation Period	Time	Conditions		Distance Travelled (cm) Experiment Number 1	2	3	4	5	6	7	8	Period Mean (cm)
1	AM	Isothermal No Food	MEAN	226.0	115.3	67.2	73.1	n/a	213.0	115.3	125.3	138.0
			SD	152.6	63.1	60.5	42.2	n/a	105.6	81.9	72.8	109.6
			N=	27	20	20	20	n/a	20	20	20	147
2	PM	Isothermal No Food	MEAN	193.6	121.5	134.9	58.0	107.7	80.6	160.4	98.6	120.3
			SD	118.2	58.9	113.3	28.4	64.8	50.6	54.6	104.2	89.4
			N=	22	20	20	20	20	20	20	20	162
3	AM	Isothermal No Food	MEAN	294.7	278.5	57.2	73.1	52.7	81.4	153.3	60.1	132.4
			SD	137.7	102.6	55.9	50.5	46.1	80.7	72.9	69.5	125.0
			N=	21	20	20	20	20	20	20	20	161
4	PM	Isothermal Food	MEAN	237.0	261.8	274.8	403.0	312.1	288.1	208.0	267.7	281.3
			SD	158.6	84.9	102.2	103.3	91.8	101.5	64.5	79.6	113.8
			N=	21	20	20	20	20	20	20	20	161
5	AM	Isothermal No Food	MEAN	76.6	157.9	109.4	64.3	110.2	93.5	109.4	48.6	95.7
			SD	77.1	89.8	97.4	35.7	95.4	70.6	62.8	63.6	81.2
			N=	24	20	20	20	20	20	20	20	164
6	PM	Stratified No Food	MEAN	136.6	119.9	130.6	152.4	63.3	145.3	128.6	88.5	120.6
			SD	66.2	79.6	97.3	40.2	59.0	71.0	129.9	75.2	84.2
			N=	20	20	19	20	20	20	20	20	159
7	AM	Stratified No Food	MEAN	126.1	168.3	117.3	196.3	57.1	68.9	88.1	78.2	112.5
			SD	66.0	72.7	60.9	90.4	49.4	59.3	97.3	58.1	83.5
			N=	20	20	20	20	20	20	20	20	160
8	PM	Stratified Food	MEAN	409.7	493.1	496.5	594.2	526.6	502.0	490.1	633.9	518.1
			SD	200.0	176.9	120.5	176.2	191.8	171.0	159.8	147.0	178.6
			N=	20	24	18	20	20	20	20	20	162
9	AM	Isothermal No Food	MEAN	146.6	96.9	99.0	66.0	317.9	121.1	121.5	47.6	127.1
			SD	112.5	57.5	88.0	53.4	144.3	100.0	96.3	51.2	120.0
			N=	20	20	20	20	20	20	20	20	160

n/a = instrument malfunction (data unavailable)

Table 28. Mean distances (bl) chum salmon travelled during 30 second observation periods in the WCS aquarium, Experiments 1 - 8.

Observation Period	Time	Conditions		Distance Travelled (body lengths) Experiment Number 1	2	3	4	5	6	7	8	Period Mean (bl)
1	AM	Isothermal No Food	MEAN	40.1	19.6	9.9	9.3	n/a	19.7	10.3	10.6	18.2
			SD	27.1	10.7	8.9	5.4	n/a	9.8	7.3	6.2	17.6
			N=	27	20	20	20	n/a	20	20	20	147
2	PM	Isothermal No Food	MEAN	34.4	20.7	19.9	7.4	10.4	7.5	14.4	8.4	15.6
			SD	21.0	10.0	16.7	3.6	6.2	4.7	4.9	8.8	14.3
			N=	22	20	20	20	20	20	20	20	162
3	AM	Isothermal No Food	MEAN	52.3	47.4	8.5	9.3	5.1	7.5	13.7	5.1	18.8
			SD	24.5	17.4	8.3	6.4	4.4	7.5	6.5	5.9	22.0
			N=	21	20	20	20	20	20	20	20	161
4	PM	Isothermal Food	MEAN	42.1	44.5	40.6	51.3	30.0	26.7	18.6	22.7	34.6
			SD	28.2	14.4	15.1	13.2	8.8	9.4	5.8	6.8	17.9
			N=	21	20	20	20	20	20	20	20	161
5	AM	Isothermal No Food	MEAN	13.6	26.8	16.2	8.2	10.6	8.7	9.8	4.1	12.3
			SD	13.7	15.3	14.4	4.5	9.2	6.5	5.6	5.4	12.0
			N=	24	20	20	20	20	20	20	20	164
6	PM	Stratified No Food	MEAN	24.3	20.4	19.3	19.4	6.1	13.5	11.5	7.5	15.2
			SD	11.8	13.5	14.4	5.1	5.7	6.6	11.6	6.4	11.6
			N=	20	20	19	20	20	20	20	20	159
7	AM	Stratified No Food	MEAN	22.4	28.6	17.3	25.0	5.5	6.4	7.9	6.6	15.0
			SD	11.7	12.4	9.0	11.5	4.8	5.5	8.7	4.9	12.6
			N=	20	20	20	20	20	20	20	20	160
8	PM	Stratified Food	MEAN	72.8	83.9	73.3	75.7	50.6	46.5	43.9	53.8	63.1
			SD	35.5	30.1	17.8	22.4	18.4	15.8	14.3	12.5	26.5
			N=	20	24	18	20	20	20	20	20	162
9	AM	Isothermal No Food	MEAN	26.0	16.5	14.6	8.4	30.6	11.2	10.9	4.0	15.3
			SD	20.0	9.8	13.0	6.8	13.9	9.3	8.6	4.3	14.1
			N=	20	20	20	20	20	20	20	20	160

n/a = instrument malfunction (data unavailable)

Table 29. Mean swim speeds (cm·s^{-1}) of chum salmon during 30 second observation periods in the WCS aquarium, Experiments 1 - 8.

Observation Period	Time	Conditions		Swimming Speed (cm·s^{-1}) Experiment Number 1	2	3	4	5	6	7	8	Period Mean (cm·s^{-1})
1	AM	Isothermal No Food	MEAN	7.5	3.8	2.2	2.4	n/a	7.1	3.8	4.2	4.6
			SD	5.1	2.1	2.0	1.4	n/a	3.5	2.7	2.4	3.7
			N=	27	20	20	20	n/a	20	20	20	147
2	PM	Isothermal No Food	MEAN	6.5	4.1	4.5	1.9	1.8	2.7	5.3	3.3	4.0
			SD	3.9	2.0	3.8	0.9	1.5	1.7	1.8	3.5	3.0
			N=	22	20	20	20	20	20	20	20	162
3	AM	Isothermal No Food	MEAN	9.8	9.3	1.9	2.4	1.8	2.7	5.1	2.0	4.4
			SD	4.6	3.4	1.9	1.7	1.5	2.7	2.4	2.3	4.2
			N=	21	20	20	20	20	20	20	20	161
4	PM	Isothermal Food	MEAN	7.9	8.7	9.2	13.4	10.4	9.6	6.9	8.9	9.4
			SD	5.3	2.8	3.4	3.4	3.1	3.4	2.1	2.7	3.8
			N=	21	20	20	20	20	20	20	20	161
5	AM	Isothermal No Food	MEAN	2.6	5.3	3.6	2.1	3.7	3.1	3.6	1.6	3.2
			SD	2.6	3.0	3.2	1.2	3.2	2.4	2.1	2.1	2.7
			N=	24	20	20	20	20	20	20	20	164
6	PM	Stratified No Food	MEAN	4.6	4.0	4.4	5.1	2.1	4.8	4.3	3.0	4.0
			SD	2.2	2.7	3.2	1.3	2.0	2.4	4.3	2.5	2.8
			N=	20	20	19	20	20	20	20	20	159
7	AM	Stratified No Food	MEAN	4.2	5.6	3.9	6.5	1.9	2.3	2.9	2.6	3.8
			SD	2.2	2.4	2.0	3.0	1.6	2.0	3.2	1.9	2.8
			N=	20	20	20	20	20	20	20	20	160
8	PM	Stratified Food	MEAN	13.7	16.4	16.5	19.8	17.6	16.7	16.3	21.1	17.3
			SD	6.7	5.9	4.0	5.9	6.4	5.7	5.3	4.9	6.0
			N=	20	24	18	20	20	20	20	20	162
9	AM	Isothermal No Food	MEAN	4.9	3.2	3.3	2.2	10.6	4.0	4.1	1.6	4.2
			SD	3.8	1.9	2.9	1.8	4.8	3.3	3.2	1.7	4.0
			N=	20	20	20	20	20	20	20	20	160

n/a = instrument malfunction (data unavailable)

Table 30. Mean swim speeds (bl·s^{-1}) of chum salmon during 30 second observation periods in the WCS aquarium, Experiments 1 - 8.

Observation Period	Time	Conditions		Swimming Speed (bl·s^{-1}) Experiment Number 1	2	3	4	5	6	7	8	Period Mean (bl·s^{-1})
1	AM	Isothermal No Food	MEAN	1.3	0.7	0.3	0.3	n/a	0.7	0.3	0.4	0.6
			SD	0.9	0.4	0.3	0.2	n/a	0.3	0.2	0.2	0.6
			N=	27	20	20	20	n/a	20	20	20	147
2	PM	Isothermal No Food	MEAN	1.1	0.7	0.7	0.2	0.3	0.2	0.5	0.3	0.5
			SD	0.7	0.3	0.6	0.1	0.2	0.2	0.2	0.3	0.5
			N=	22	20	20	20	20	20	20	20	162
3	AM	Isothermal No Food	MEAN	1.7	1.6	0.3	0.3	0.2	0.3	0.5	0.2	0.6
			SD	0.8	0.6	0.3	0.2	0.1	0.2	0.2	0.2	0.7
			N=	21	20	20	20	20	20	20	20	161
4	PM	Isothermal Food	MEAN	1.4	1.5	1.4	1.7	1.0	0.9	0.6	0.8	1.2
			SD	0.9	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.6
			N=	21	20	20	20	20	20	20	20	161
5	AM	Isothermal No Food	MEAN	0.5	0.9	0.5	0.3	0.4	0.3	0.3	0.1	0.4
			SD	0.5	0.5	0.5	0.2	0.3	0.2	0.2	0.2	0.4
			N=	24	20	20	20	20	20	20	20	164
6	PM	Stratified No Food	MEAN	0.8	0.7	0.6	0.6	0.2	0.4	0.4	0.3	0.5
			SD	0.4	0.5	0.5	0.2	0.2	0.2	0.4	0.2	0.4
			N=	20	20	19	20	20	20	20	20	159
7	AM	Stratified No Food	MEAN	0.7	1.0	0.6	0.8	0.2	0.2	0.3	0.2	0.5
			SD	0.4	0.4	0.3	0.4	0.2	0.2	0.3	0.2	0.4
			N=	20	20	20	20	20	20	20	20	160
8	PM	Stratified Food	MEAN	2.4	2.8	2.4	2.5	1.7	1.5	1.5	1.8	2.1
			SD	1.2	1.0	0.6	0.7	0.6	0.5	0.5	0.4	0.9
			N=	20	24	18	20	20	20	20	20	162
9	AM	Isothermal No Food	MEAN	0.9	0.5	0.5	0.3	1.0	0.4	0.4	0.1	0.5
			SD	0.7	0.3	0.4	0.2	0.5	0.3	0.3	0.1	0.5
			N=	20	20	20	20	20	20	20	20	160

n/a = instrument malfunction (data unavailable)

Table 31. Duration (s) of excursions of chum salmon into the top zone of WCS aquarium.

Observation Period (PM)	Conditions		Excursion Time (s) Experiment Number					Period Mean (s)
			4	5	6	7	8	
2	Isothermal No Food	MEAN	28.0	20.7	*8.21	36.4	*25.28	23.3
		SD	31.3	18.9	9.7	31.1	18.8	24.9
		N=	15	20	21	20	14	90
4	Isothermal Food	MEAN	*43.92	*32.44	15.7	*47.84	8.9	23.4
		SD	26.7	25.5	13.2	43.6	9.4	23.8
		N=	20	20	22	10	24	96
6	Stratified No Food	MEAN	2.2	5.9	2.1	3.8	0.7	3.2
		SD	1.4	5.4	1.3	2.5	0.3	3.3
		N=	22	20	20	20	8	90
8	Stratified Food	MEAN	10.2	13.8	8.1	11.7	10.4	10.7
		SD	6.2	9.8	5.4	10.3	7.6	8.0
		N=	46	30	30	24	24	154

* = data sets contain readings in excess of 120 seconds

Table 32. Determination of temperature (transition period) recorded by dataloggers in the WCS aquarium during experiments during Experiments 1 - 8.

DATE	TIME	TEMPERATURE (°C) Datalogger Number TOP #1	#2	#3	#4	THERMOCLINE #5	#6	#7	#8	BOTTOM #9	#10	#11	#12
4-Jun	9:15	10.0	10.1	10.1	10.0	10.1	10.0	10.1	10.0	10.2	10.0	10.1	n/a
11-Jun	9:15	10.1	10.1	10.1	10.0	10.1	10.0	10.1	10.0	10.2	10.0	10.1	n/a
18-Jun	9:15	10.4	10.4	10.4	10.3	10.5	10.3	10.4	10.3	10.5	10.3	10.1	9.9
2-Jul	9:15	10.1	10.3	10.1	10.3	10.2	10.4	10.3	10.3	10.3	10.1	10.0	10.0
23-Jul	9:15	10.0	10.0	10.0	10.0	10.1	10.1	10.2	10.0	10.2	10.1	9.9	9.7
30-Jul	9:15	10.3	10.4	10.4	10.3	10.5	10.4	10.5	10.3	10.5	10.3	9.9	9.9
13-Aug	9:15	10.3	10.3	10.3	10.3	10.3	10.3	10.4	n/a	10.3	10.3	9.9	9.7
	MEAN	10.1	10.2	10.2	10.2	10.3	10.2	10.3	10.2	10.3	10.2	10.0	9.8
	SD	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
4-Jun	9:30	11.8	11.8	11.7	11.2	10.8	10.6	10.7	10.7	10.6	10.6	10.3	n/a
11-Jun	9:30	11.8	11.7	11.7	11.1	10.8	10.6	10.7	10.5	10.5	10.5	10.1	n/a
18-Jun	9:30	11.8	11.8	11.7	11.2	11.1	10.7	10.8	10.8	10.8	10.8	10.1	9.9
2-Jul	9:30	11.6	11.7	11.5	11.2	10.8	10.8	10.7	10.8	10.6	10.3	10.0	9.8
23-Jul	9:30	10.7	10.7	10.8	10.5	10.5	10.3	10.4	10.3	10.3	10.3	9.9	9.7
30-Jul	9:30	10.9	10.9	10.9	10.8	10.8	10.6	10.7	10.7	10.8	10.6	10.1	10.1
13-Aug	9:30	11.4	11.3	11.4	10.9	10.8	10.6	10.5	n/a	10.5	10.5	9.9	9.7
	MEAN	11.4	11.4	11.4	11.0	10.8	10.6	10.7	10.6	10.6	10.5	10.1	9.8
	SD	0.5	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1

Table 32. (cont.)

		TEMPERATURE (°C)											
		Datalogger Number											
		TOP				THERMOCLINE				BOTTOM			
DATE	TIME	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
4-Jun	9:45	13.7	13.5	13.2	12.0	11.4	11.2	11.3	11.1	10.9	10.8	10.3	n/a
11-Jun	9:45	13.8	13.8	13.7	12.9	12.2	11.8	11.8	11.6	10.8	10.6	10.1	n/a
18-Jun	9:45	12.9	12.9	12.8	12.0	11.4	11.2	11.0	11.0	10.8	10.8	10.1	9.9
2-Jul	9:45	13.6	13.7	13.4	12.3	11.4	11.3	11.2	11.4	10.9	10.8	10.1	10.1
23-Jul	9:45	13.2	13.2	13.1	12.3	11.7	11.4	11.3	11.1	10.9	10.6	10.1	9.9
30-Jul	9:45	12.3	12.3	12.2	11.5	11.2	11.0	11.2	11.0	10.9	10.9	10.3	10.1
13-Aug	9:45	13.5	13.5	13.2	12.2	11.4	11.2	11.2	n/a	11.1	11.1	10.3	10.1
	MEAN	13.3	13.3	13.1	12.2	11.5	11.3	11.3	11.2	10.9	10.8	10.2	10.0
	SD	0.5	0.5	0.5	0.4	0.3	0.2	0.2	0.2	0.1	0.2	0.1	0.1
4-Jun	10:00	14.6	14.6	14.2	12.8	12.2	11.7	11.8	11.6	11.4	11.1	10.3	n/a
11-Jun	10:00	15.6	15.6	15.4	14.6	13.9	13.5	13.2	12.7	10.5	10.3	9.8	n/a
18-Jun	10:00	13.8	13.8	13.9	13.1	12.5	12.3	11.9	11.7	10.9	10.8	10.1	9.9
2-Jul	10:00	15.2	15.2	14.8	13.7	12.3	12.1	12.0	11.8	11.1	11.1	10.1	10.0
23-Jul	10:00	15.3	15.4	15.3	14.6	14.2	13.7	13.3	12.8	10.9	10.8	10.1	9.9
30-Jul	10:00	13.4	13.4	13.2	12.2	11.7	11.5	11.6	11.4	11.4	11.4	10.6	10.4
13-Aug	10:00	15.3	15.2	14.9	14.2	13.6	13.2	13.0	n/a	11.4	11.2	10.3	10.1
	MEAN	14.7	14.7	14.5	13.6	12.9	12.6	12.4	12.0	11.1	10.9	10.2	10.0
	SD	0.8	0.9	0.8	1.0	1.0	0.9	0.7	0.6	0.3	0.4	0.2	0.2

Table 32. (cont.)

		TEMPERATURE (°C)											
		Datalogger Number											
		TOP				THERMOCLINE				BOTTOM			
DATE	TIME	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
4-Jun	10:15	15.4	15.4	15.1	14.2	13.2	12.7	12.5	12.3	11.6	11.2	10.3	n/a
11-Jun	10:15	17.0	17.0	16.8	16.2	15.6	14.9	14.1	13.0	10.5	10.3	9.8	n/a
18-Jun	10:15	14.9	15.1	14.9	14.3	13.9	13.5	13.0	12.7	11.1	10.9	10.1	9.9
2-Jul	10:15	16.3	16.4	16.2	15.3	14.0	13.6	13.2	12.9	11.2	11.2	10.1	10.0
23-Jul	10:15	17.0	17.1	17.0	16.4	16.1	15.2	14.4	13.0	10.8	10.6	9.9	9.7
30-Jul	10:15	14.3	14.3	14.0	12.9	12.3	12.1	12.1	11.9	11.9	11.7	11.0	10.8
13-Aug	10:15	16.9	16.8	16.7	16.1	15.7	15.2	14.7	n/a	11.4	11.2	10.1	9.9
	MEAN	16.0	16.0	15.8	15.1	14.4	13.9	13.4	12.6	11.2	11.0	10.2	10.1
	SD	1.1	1.1	1.1	1.3	1.4	1.2	1.0	0.4	0.5	0.5	0.4	0.4
4-Jun	10:30	16.4	16.3	16.4	15.6	15.0	14.6	14.2	13.9	11.6	11.2	10.1	n/a
11-Jun	10:30	18.1	18.1	18.1	17.5	16.7	15.9	14.4	13.0	10.5	10.3	9.9	n/a
18-Jun	10:30	16.5	16.5	16.4	15.6	15.0	14.4	13.9	13.3	11.1	10.9	9.8	9.6
2-Jul	10:30	17.2	17.5	17.1	16.4	15.3	14.9	14.1	13.6	11.2	11.2	10.1	10.0
23-Jul	10:30	18.5	18.4	18.4	17.8	17.3	16.5	14.7	12.7	10.8	10.5	9.8	9.7
30-Jul	10:30	15.7	15.7	15.6	14.5	13.4	13.1	13.0	12.8	12.0	12.0	11.0	10.8
13-Aug	10:30	18.3	18.3	18.1	17.7	17.2	16.6	15.4	n/a	11.4	11.2	9.9	9.7
	MEAN	17.3	17.3	17.2	16.4	15.7	15.1	14.3	13.2	11.2	11.0	10.1	10.0
	SD	1.1	1.1	1.1	1.3	1.4	1.3	0.7	0.5	0.5	0.6	0.4	0.5

Table 32. (cont.)

		TEMPERATURE (°C)											
		Datalogger Number											
		TOP				THERMOCLINE				BOTTOM			
DATE	TIME	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
4-Jun	10:45	17.3	17.3	17.3	16.7	16.4	16.2	16.0	15.0	11.4	11.1	9.9	n/a
11-Jun	10:45	19.4	19.2	19.3	18.6	17.8	16.6	14.4	12.7	10.6	10.5	10.1	n/a
18-Jun	10:45	17.7	17.8	17.6	17.0	16.4	15.7	14.7	13.6	10.9	10.8	9.8	9.6
2-Jul	10:45	18.2	18.3	18.1	17.5	16.6	16.0	15.1	14.3	11.4	11.4	10.1	10.0
23-Jul	10:45	19.6	19.7	19.6	19.1	18.6	17.4	14.7	12.2	10.8	10.5	9.8	9.6
30-Jul	10:45	17.0	17.0	17.0	16.2	15.1	14.6	14.4	14.0	12.3	12.1	10.9	10.7
13-Aug	10:45	19.4	19.4	19.4	18.8	18.3	17.6	15.7	n/a	11.4	11.2	9.9	9.7
	MEAN	18.4	18.4	18.3	17.7	17.0	16.3	15.0	13.6	11.3	11.1	10.1	9.9
	SD	1.1	1.1	1.1	1.1	1.3	1.0	0.6	1.0	0.6	0.6	0.4	0.5
4-Jun	11:00	18.3	18.3	18.3	17.7	17.3	16.8	16.3	15.3	11.1	10.9	9.9	n/a
11-Jun	11:00	20.4	20.4	20.2	19.8	18.9	17.6	14.4	12.5	10.6	10.5	10.1	n/a
18-Jun	11:00	18.8	18.7	18.6	18.0	17.3	16.5	14.9	13.3	10.9	10.8	9.9	9.7
2-Jul	11:00	19.0	19.3	19.1	18.5	17.5	16.8	15.7	14.6	11.4	11.4	10.1	10.0
23-Jul	11:00	20.6	20.5	20.6	19.9	19.6	18.4	14.9	12.2	10.8	10.5	9.9	9.7
30-Jul	11:00	18.0	18.1	18.0	17.2	16.2	15.5	15.2	14.7	12.5	12.1	10.9	10.7
13-Aug	11:00	20.4	20.4	20.4	19.8	19.3	18.1	15.5	n/a	11.6	11.4	9.9	9.7
	MEAN	19.4	19.4	19.3	18.7	18.0	17.1	15.3	13.8	11.3	11.1	10.1	10.0
	SD	1.1	1.0	1.1	1.1	1.2	1.0	0.6	1.3	0.6	0.6	0.3	0.4

Table 32. (cont.)

		TEMPERATURE (°C)											
		Datalogger Number											
		TOP				THERMOCLINE				BOTTOM			
DATE	TIME	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
4-Jun	11:15	19.0	19.1	18.9	18.5	18.0	17.6	16.8	14.8	11.1	10.9	9.9	n/a
11-Jun	11:15	21.1	21.2	21.0	20.6	19.8	18.4	14.2	12.2	10.8	10.5	10.1	n/a
18-Jun	11:15	19.6	19.6	19.6	19.0	18.3	17.1	15.0	13.1	11.1	10.8	10.1	9.7
2-Jul	11:15	19.8	19.9	19.7	19.1	18.3	17.6	15.9	14.6	11.5	11.4	10.1	10.0
23-Jul	11:15	21.2	21.3	21.2	20.8	20.2	19.2	15.7	12.3	10.8	10.6	9.9	9.7
30-Jul	11:15	19.0	18.9	18.8	17.8	17.2	16.8	16.6	15.9	12.6	12.1	10.9	10.7
13-Aug	11:15	21.2	21.3	21.2	20.8	19.9	18.9	15.7	n/a	11.6	11.4	10.1	9.9
	MEAN	20.1	20.2	20.1	19.5	18.8	17.9	15.7	13.8	11.4	11.1	10.2	10.0
	SD	1.0	1.1	1.1	1.2	1.2	0.9	0.9	1.5	0.6	0.6	0.3	0.4
4-Jun	11:30	19.6	19.6	19.6	19.3	18.6	18.1	17.2	14.5	10.9	10.8	10.1	n/a
11-Jun	11:30	21.9	21.8	21.9	21.4	20.7	19.1	14.6	12.3	10.8	10.6	10.1	n/a
18-Jun	11:30	20.3	20.4	20.2	19.8	19.1	17.9	15.4	13.1	11.1	10.9	10.1	9.9
2-Jul	11:30	20.3	20.4	20.2	19.6	18.8	18.0	16.3	15.0	11.5	11.4	10.1	10.1
23-Jul	11:30	21.9	21.8	21.7	21.2	20.7	19.7	15.7	12.7	10.9	10.8	9.9	9.7
30-Jul	11:30	19.8	19.7	19.4	18.6	18.0	17.3	16.5	15.5	12.6	12.1	10.9	10.7
13-Aug	11:30	22.1	22.0	21.9	21.4	20.7	19.4	15.7	n/a	11.7	11.4	10.1	9.9
	MEAN	20.8	20.8	20.7	20.2	19.5	18.5	15.9	13.8	11.4	11.1	10.2	10.1
	SD	1.1	1.1	1.1	1.1	1.2	0.9	0.9	1.3	0.7	0.5	0.3	0.4

Table 32. (cont.)

		TEMPERATURE (°C)											
		Datalogger Number											
		TOP				THERMOCLINE				BOTTOM			
DATE	TIME	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
4-Jun	11:45	20.1	20.2	20.1	19.6	19.1	18.7	17.7	14.4	10.9	10.8	10.1	n/a
11-Jun	11:45	22.4	22.5	22.4	21.9	21.2	19.7	14.9	12.3	10.8	10.6	10.1	n/a
18-Jun	11:45	20.9	20.8	20.9	20.3	19.4	18.2	15.4	13.3	11.2	11.1	10.1	9.9
2-Jul	11:45	20.8	20.9	20.7	20.1	19.4	18.7	16.6	14.6	11.5	11.4	10.1	10.1
23-Jul	11:45	22.2	22.3	22.2	21.7	21.2	20.0	15.7	12.7	11.1	10.8	10.1	9.9
30-Jul	11:45	20.3	20.4	20.1	19.3	18.5	17.6	16.6	15.5	12.6	12.1	10.9	10.5
13-Aug	11:45	22.6	22.5	22.5	21.9	21.2	20.2	16.1	n/a	11.7	11.5	10.1	9.9
	MEAN	21.3	21.4	21.3	20.7	20.0	19.0	16.1	13.8	11.4	11.2	10.2	10.1
	SD	1.1	1.0	1.1	1.1	1.2	1.0	1.0	1.2	0.6	0.5	0.3	0.3
4-Jun	12:00	20.7	20.7	20.7	20.3	19.9	19.7	18.7	14.2	10.8	10.8	10.1	n/a
11-Jun	12:00	22.9	23.0	22.9	22.4	21.7	20.7	15.8	12.7	10.8	10.6	10.1	n/a
18-Jun	12:00	21.4	21.3	21.4	20.8	19.9	18.6	15.4	13.3	11.4	11.2	10.1	9.9
2-Jul	12:00	21.3	21.4	21.2	20.8	19.8	18.9	16.6	14.6	11.5	11.4	10.1	10.1
23-Jul	12:00	22.7	22.7	22.5	22.1	21.7	20.5	16.1	12.7	11.1	10.9	10.1	9.9
30-Jul	12:00	20.7	20.7	20.6	19.8	18.9	17.8	16.3	15.1	12.6	12.3	10.7	10.5
13-Aug	12:00	23.1	23.2	23.0	22.6	21.9	20.5	16.5	n/a	11.9	11.7	10.3	10.1
	MEAN	21.8	21.8	21.8	21.2	20.6	19.5	16.5	13.8	11.4	11.3	10.2	10.1
	SD	1.0	1.1	1.0	1.1	1.2	1.1	1.1	1.0	0.7	0.6	0.2	0.3

Table 32. (cont.)

DATE	TIME	TEMPERATURE (°C) Datalogger Number TOP #1	#2	#3	#4	THERMOCLINE #5	#6	#7	#8	BOTTOM #9	#10	#11	#12
4-Jun	12:15	21.2	21.2	21.2	20.8	20.2	19.9	18.9	14.2	10.9	10.8	10.1	n/a
11-Jun	12:15	23.3	23.3	23.2	22.7	22.2	21.0	15.8	12.5	10.8	10.6	10.1	n/a
18-Jun	12:15	21.7	21.8	21.7	21.2	20.4	19.1	15.2	13.0	11.2	11.1	10.1	9.9
2-Jul	12:15	21.6	21.7	21.5	21.1	20.1	19.2	16.6	14.5	11.5	11.5	10.1	10.1
23-Jul	12:15	22.9	23.0	22.9	22.4	21.9	20.7	16.1	12.8	11.2	10.9	10.1	9.9
30-Jul	12:15	21.2	21.2	21.0	20.3	19.6	18.2	16.3	14.8	12.5	12.1	10.7	10.5
13-Aug	12:15	23.6	23.5	23.4	23.1	22.4	21.0	16.5	n/a	11.9	11.7	10.3	10.1
	MEAN	22.2	22.3	22.1	21.7	21.0	19.9	16.5	13.6	11.4	11.2	10.2	10.1
	SD	1.0	1.0	1.0	1.1	1.2	1.1	1.1	1.0	0.6	0.6	0.2	0.3
4-Jun	12:30	21.7	21.7	21.7	21.1	20.7	20.2	19.2	14.0	10.8	10.8	10.1	n/a
11-Jun	12:30	23.4	23.5	23.4	23.1	22.6	21.5	16.3	12.7	10.9	10.8	10.1	n/a
18-Jun	12:30	22.2	22.3	22.2	21.7	20.9	19.4	15.2	12.8	11.2	11.1	10.1	9.9
2-Jul	12:30	21.8	21.9	21.8	21.4	20.4	19.2	16.5	14.2	11.5	11.5	10.1	10.1
23-Jul	12:30	23.3	23.2	23.2	22.7	22.2	20.8	15.8	12.8	11.2	10.9	10.1	9.9
30-Jul	12:30	21.7	21.7	21.5	20.9	20.4	19.5	16.6	14.4	12.2	11.8	10.6	10.4
13-Aug	12:30	23.9	23.9	23.9	23.4	22.7	21.3	16.3	n/a	12.0	11.7	10.3	10.1
	MEAN	22.6	22.6	22.5	22.1	21.4	20.3	16.6	13.5	11.4	11.2	10.2	10.1
	SD	0.9	0.9	0.9	1.0	1.0	1.0	1.3	0.8	0.5	0.5	0.2	0.2

Table 32. (cont.)

		TEMPERATURE (°C)											
		Datalogger Number											
		TOP				THERMOCLINE				BOTTOM			
DATE	TIME	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
4-Jun	12:45	21.9	22.0	22.0	21.6	20.9	20.3	19.5	14.8	10.9	10.8	10.1	n/a
11-Jun	12:45	23.8	23.7	23.7	23.3	22.7	21.7	16.8	13.0	10.9	10.8	10.1	n/a
18-Jun	12:45	22.6	22.7	22.5	22.1	21.4	20.2	15.2	12.8	11.2	11.1	10.1	9.9
2-Jul	12:45	22.0	22.2	22.0	21.6	20.6	19.5	16.8	14.3	11.5	11.5	10.1	10.1
23-Jul	12:45	23.4	23.3	23.4	22.7	22.2	20.8	16.0	13.0	11.4	11.1	10.3	10.1
30-Jul	12:45	22.4	22.3	22.2	21.6	21.1	20.2	16.9	14.0	12.0	11.7	10.4	10.2
13-Aug	12:45	24.3	24.4	24.2	23.8	23.2	22.2	16.8	n/a	11.9	11.7	10.3	9.9
	MEAN	22.9	22.9	22.9	22.4	21.7	20.7	16.9	13.7	11.4	11.2	10.2	10.0
	SD	0.9	0.9	0.9	0.9	1.0	0.9	1.3	0.8	0.4	0.4	0.1	0.1
4-Jun	13:00	22.2	22.2	22.0	21.7	21.2	20.7	19.7	15.3	11.1	10.9	10.3	n/a
11-Jun	13:00	23.8	23.9	23.9	23.4	22.9	22.0	16.9	13.0	10.9	10.8	10.3	n/a
18-Jun	13:00	22.9	23.0	22.9	22.4	21.6	20.2	15.4	13.0	11.4	11.2	10.1	9.9
2-Jul	13:00	22.5	22.5	22.3	21.9	20.9	19.8	17.0	14.0	11.5	11.5	10.1	10.1
23-Jul	13:00	23.4	23.5	23.4	22.9	22.4	20.8	16.1	13.1	11.6	11.2	10.3	10.1
30-Jul	13:00	22.7	22.8	22.7	22.1	21.6	20.5	17.1	14.0	11.9	11.7	10.3	10.1
13-Aug	13:00	24.6	24.7	24.6	24.3	23.7	22.3	16.9	n/a	11.9	11.7	10.1	9.9
	MEAN	23.2	23.2	23.1	22.7	22.0	20.9	17.0	13.7	11.5	11.3	10.2	10.0
	SD	0.8	0.9	0.9	0.9	1.0	0.9	1.3	0.9	0.4	0.4	0.1	0.1

Table 32. (cont.)

		TEMPERATURE (°C)											
		Datalogger Number											
		TOP				THERMOCLINE				BOTTOM			
DATE	TIME	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
4-Jun	13:15	22.4	22.5	22.4	22.1	21.6	21.2	20.3	14.5	11.1	10.9	10.1	n/a
11-Jun	13:15	23.9	24.0	23.9	23.4	23.1	22.2	17.1	13.0	10.9	10.8	10.1	n/a
18-Jun	13:15	23.3	23.2	23.2	22.6	22.1	20.5	15.2	13.0	11.4	11.2	10.1	9.9
2-Jul	13:15	22.6	22.7	22.5	22.1	21.2	20.2	17.1	14.2	11.5	11.5	10.1	10.0
23-Jul	13:15	23.6	23.7	23.6	23.1	22.6	21.2	16.3	13.1	11.6	11.2	10.3	10.2
30-Jul	13:15	23.1	23.2	23.0	22.4	21.9	20.3	16.5	13.7	12.0	11.7	10.3	10.1
13-Aug	13:15	25.0	25.1	24.9	24.5	23.9	22.5	17.1	n/a	11.7	11.5	10.1	9.9
	MEAN	23.4	23.5	23.4	22.9	22.3	21.1	17.1	13.6	11.5	11.3	10.2	10.0
	SD	0.9	0.9	0.9	0.9	0.9	0.9	1.6	0.7	0.4	0.3	0.1	0.1
4-Jun	13:30	22.6	22.7	22.5	22.2	21.6	21.0	20.0	15.5	11.1	10.9	10.1	n/a
11-Jun	13:30	23.9	24.0	23.9	23.4	23.1	22.2	17.2	13.1	10.9	10.8	10.1	n/a
18-Jun	13:30	23.4	23.5	23.4	22.9	22.2	21.0	15.4	12.8	11.2	11.1	10.1	9.7
2-Jul	13:30	22.8	22.9	22.8	22.4	21.4	20.3	17.3	14.2	11.5	11.5	10.1	10.0
23-Jul	13:30	23.8	23.9	23.7	23.3	22.9	21.5	16.0	13.0	11.4	11.2	10.3	10.1
30-Jul	13:30	23.4	23.5	23.4	22.7	22.2	21.0	16.8	13.9	11.9	11.7	10.3	9.9
13-Aug	13:30	25.3	25.2	25.3	24.8	24.3	23.0	17.1	n/a	11.7	11.7	10.1	9.9
	MEAN	23.6	23.7	23.6	23.1	22.5	21.4	17.1	13.7	11.4	11.3	10.2	9.9
	SD	0.9	0.8	0.9	0.9	1.0	0.9	1.5	1.0	0.3	0.4	0.1	0.1

Table 32. (cont.)

DATE	TIME	TEMPERATURE (°C) Datalogger Number TOP #1	#2	#3	#4	THERMOCLINE #5	#6	#7	#8	BOTTOM #9	#10	#11	#12
4-Jun	13:45	22.7	22.8	22.9	22.4	22.1	21.5	20.8	15.8	10.9	10.8	9.9	n/a
11-Jun	13:45	23.9	24.0	24.1	23.6	22.9	22.0	16.9	13.0	10.9	10.8	10.1	n/a
18-Jun	13:45	23.6	23.7	23.7	23.1	22.6	21.3	15.4	12.8	11.2	11.1	10.1	9.7
2-Jul	13:45	23.0	23.1	22.8	22.6	21.6	20.2	17.0	14.0	11.5	11.5	10.1	10.0
23-Jul	13:45	24.1	24.0	24.1	23.6	23.2	21.8	16.3	12.8	11.2	11.1	10.3	10.1
30-Jul	13:45	23.8	23.7	23.6	22.9	22.4	21.3	17.4	14.0	11.9	11.7	10.1	9.9
13-Aug	13:45	25.5	25.6	25.6	25.2	24.6	23.0	16.8	n/a	11.9	11.7	10.3	10.1
	MEAN	23.8	23.8	23.8	23.3	22.8	21.6	17.2	13.7	11.4	11.2	10.1	9.9
	SD	0.9	0.9	0.9	0.9	1.0	0.9	1.7	1.1	0.4	0.4	0.1	0.1

Table 33. Determination of temperature (thermally stratified) recorded by dataloggers in the WCS aquarium during Experiments 1 - 8.

		TEMPERATURE (°C)											
		Datalogger Number											
		TOP				THERMOCLINE				BOTTOM			
DATE	TIME	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
5-Jun	12:00	23.9	24.0	23.9	23.4	23.2	22.3	20.3	14.5	10.9	10.8	10.1	n/a
12-Jun	12:00	24.3	24.4	24.2	23.8	23.1	21.8	16.8	13.4	11.1	10.9	10.1	n/a
19-Jun	12:00	22.7	22.8	22.7	22.1	21.4	20.3	15.0	13.0	11.4	11.2	9.9	9.7
3-Jul	12:00	23.8	23.9	23.9	23.4	22.6	21.0	16.0	13.1	11.2	11.2	10.1	10.0
24-Jul	12:00	25.7	25.8	25.6	25.3	24.9	23.3	17.4	12.8	10.9	10.8	9.9	9.7
31-Jul	12:00	24.5	24.6	24.6	23.9	22.9	20.5	16.6	14.4	12.5	12.3	11.0	10.8
7-Aug	12:00	23.4	23.3	23.4	23.1	22.1	19.4	15.5	12.8	11.1	10.9	9.9	9.7
14-Aug	12:00	25.3	25.4	25.3	25.0	24.3	22.8	15.5	n/a	11.7	11.5	10.3	10.1
	MEAN	24.2	24.3	24.2	23.7	23.0	21.4	16.6	13.4	11.4	11.2	10.2	10.0
	SD	1.0	1.0	1.0	1.0	1.1	1.4	1.7	0.7	0.5	0.5	0.4	0.4

Table 34. Temperature record from dataloggers and TGP measured during thermal resistance bioassays (N = 8).

Bioassay #		Temperature (°C) Treatment Heat	Heat + TGP	Control
1	MEAN	25.0	25.3	10.8
	SD	0.3	0.4	0.3
	MIN	23.4	24.3	10.6
	MAX	25.5	26.0	11.5
	N =	86	86	86
	TGP (%)	100.1	108.8	98.3
2	MEAN	24.9	24.9	12.5
	SD	0.5	0.5	0.7
	MIN	22.7	22.6	11.2
	MAX	25.5	25.5	13.6
	N =	158	158	158
	TGP (%)	100.5	107.4	99.1
3	MEAN	24.9	25.0	11.0
	SD	0.2	0.2	0.2
	MIN	24.4	24.3	10.7
	MAX	25.3	25.7	11.4
	N =	104	104	104
	TGP (%)	100.4	109.6	98.9
4	MEAN	24.9	25.0	11.9
	SD	0.3	0.3	0.4
	MIN	24.0	24.6	11.2
	MAX	25.7	25.9	13.4
	N =	150	150	150
	TGP (%)	101.9	109.3	99.2
5	MEAN	25.0	25.2	12.4
	SD	0.2	0.1	0.6
	MIN	24.4	24.9	11.5
	MAX	25.4	25.5	13.3
	N =	104	104	104
	TGP (%)	100.2	108.9	97.9

Table 34. (cont.)

Bioassay #		Temperature (°C) Treatment: Heat	Heat + TGP	Control
6	MEAN	25.0	25.0	12.5
	SD	0.2	0.3	0.7
	MIN	24.3	24.4	11.3
	MAX	25.5	25.8	13.4
	N =	138	138	138
	TGP (%)	100.6	109.9	99.9
7	MEAN	25.0	25.0	11.9
	SD	0.1	0.1	0.4
	MIN	24.2	24.6	11.4
	MAX	25.3	25.1	12.7
	N =	100	100	100
	TGP (%)	100.8	109.9	99.4
8	MEAN	24.9	25.0	12.0
	SD	0.2	0.1	0.4
	MIN	24.3	24.6	11.3
	MAX	25.5	25.1	12.8
	N =	124	124	124
	TGP (%)	100.0	109.2	98.8
Treatment Stats for Expt #1-8	MEAN	24.9	25.0	12.0
	SD	0.3	0.3	0.8
	MIN	22.7	22.6	10.6
	MAX	25.7	26.0	13.6
	N =	964	964	964
	TGP (%)	100.6	109.1	98.9
	TGP SD	0.6	0.8	0.6

Table 35. Time to death of individual juvenile chum salmon exposed to heated salt water at air saturation (N = 8).

	Time to Death (minutes)															
	Bioassay Expt #															
Fish #	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	7a	7b	8a	8b
1	87	50	124	129	65	65	85	82	93	122	122	118	151	76	160	180
2	93	62	136	159	119	120	86	86	115	123	136	121	156	159	164	194
3	94	90	143	171	122	125	88	100	124	130	136	145	159	160	169	196
4	109	92	152	178	147	129	108	104	136	132	140	153	159	173	219	196
5	111	115	156	178	150	130	114	105	157	142	160	158	162	188	238	207
6	113	123	174	183	154	135	123	105	160	146	169	169	166	191	244	224
7	114	127	179	186	166	143	134	120	162	153	175	187	169	193	245	247
8	117	129	198	193	185	155	156	134	183	160	185	203	169	195	255	258
9	138	134	215	198	188	168	164	139	185	165	194	209	178	209	258	281
10	157	136	219	207	190	174	185	155	300	186	194	219	179	220	258	304

Table 36. Time to death of individual juvenile chum salmon exposed to heated salt water at air supersaturation (N = 8).

	Time to Death (minutes)															
	Bioassay Expt #															
Fish #	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	7a	7b	8a	8b
1	72	65	156	219	102	109	73	70	102	95	119	125	163	97	147	138
2	94	72	163	220	116	122	83	94	106	104	124	129	167	132	167	175
3	100	81	187	233	123	127	89	97	110	108	126	129	175	141	170	198
4	101	99	189	250	127	128	92	101	133	125	147	148	175	167	174	201
5	103	100	208	270	136	132	93	105	138	130	148	152	175	177	177	207
6	105	105	215	288	156	135	94	119	138	131	150	152	183	179	183	225
7	106	108	224	307	159	142	96	129	149	150	155	165	192	189	202	232
8	119	112	236	308	159	150	98	132	164	153	162	171	200	199	207	243
9	124	121	273	316	162	152	114	133	166	168	182	204	211	229	227	263
10	126	132	337	343	171	165	137	155	218	171	196	264	223	238	242	282

Table 37. Summary of time to death data for juvenile chum salmon exposed to heated salt water at air saturation and at supersaturation.

Date	Bioassay #	Conditions	Time to Death (minutes) Mean	SD	Median	Min	Max	N	TGP (%)
30-Jun	1	Heat	109.6	26.0	113.5	50.0	157.0	20	100.1
		Heat + TGP	102.3	18.5	104.0	65.0	132.0	20	108.8
21-Jul	2	Heat	173.9	27.7	178.0	124.0	219.0	20	100.5
		Heat + TGP	247.1	56.0	234.5	156.0	343.0	20	107.4
24-Jul	3	Heat	141.5	34.7	145.0	65.0	190.0	20	100.4
		Heat + TGP	138.7	19.8	135.5	102.0	171.0	20	109.6
28-Jul	4	Heat	118.7	29.7	111.0	82.0	185.0	20	101.9
		Heat + TGP	105.2	22.5	97.5	70.0	155.0	20	109.3
1-Aug	5	Heat	153.7	42.4	149.5	93.0	300.0	20	100.2
		Heat + TGP	138.0	30.5	135.5	95.0	218.0	20	108.9
5-Aug	6	Heat	164.7	30.7	164.5	118.0	219.0	20	100.6
		Heat + TGP	157.4	34.4	151.0	119.0	264.0	20	109.9
12-Aug	7	Heat	170.6	29.0	169.0	76.0	220.0	20	100.8
		Heat + TGP	180.6	33.2	178.0	97.0	238.0	20	109.9
15-Aug	8	Heat	224.9	40.4	231.0	160.0	304.0	20	100.0
		Heat + TGP	203.0	38.0	201.5	138.0	282.0	20	109.2

Bioassay #	Condition	Time to Death Mean	SD	Median	Min	Max	N	TGP (%) Mean	SD
1 - 8 combined	Heat	157.2	46.8	157.0	50.0	304.0	160	100.6	0.6
1 - 8 combined	Heat/TGP	159.0	56.9	150.0	65.0	343.0	160	109.1	0.8

Table 38. Fish distribution data and determination of water quality parameters during preliminary trial experiments (September 24 and 25, 1997).

Conditions		% Fish in Zone			Temperature (°C)			TGP (%)		DO_2 (% sat.)		Salinity
Isothermal	MEAN	65	10	25	10.1	10.4	9.8	99.7	99.9	96.1	95.7	27.4
	SD	23	4	25								
Thermal stratification	MEAN	87	3	10	18.6	10.4	9.8	102.8	98.7	93.8	94.6	27.4
	SD	9	5	8								
Thermal stratification TGP	MEAN	66	14	20	18.6	10.7	10.0	113.5	100.8	93.4	93.6	27.4
	SD	7	6	4								
Thermal stratification TGP, Food	MEAN	83	2	14	18.0	10.8	9.9	113.1	101.5	92.2	93.1	27.4
	SD	6	3	5								
Thermal stratification TGP*, Food	MEAN	89	1	11	18.5	10.6	9.7	111.4	100.6	86.9	92.8	27.4
	SD	3	3	2								
Thermal stratification	MEAN	78	6	16	18.2	11.1	9.9	99.2	95.6	88.1	91.1	28.1
	SD	22	5	22								
Thermal stratification TGP, Food	MEAN	51	11	38	25.4	11.0	9.9	112.2	97.3	91.1	91.8	28.1
	SD	13	6	15								
Thermal stratification TGP	MEAN	0	21	78	30.4	11.6	9.9	110.6	98.7	87.1	91.4	28.1
	SD	1	7	7								
Thermal stratification TGP, Food	MEAN	32	11	57	30.4	11.6	9.9	109.0	98.4	85.5	91.3	28.1
	SD	22	5	22								

TOP = Top zone, THM = thermocline zone, MID = middle zone, BOT = bottom zone, * = no air injection