Water Temperature Monitoring in the Salmon River (Shuswap), B.C., 1995: Implications of Measured Temperatures for Anadromous Salmonids

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WATER TEMPERATURE MONITORING IN THE SALMON RIVER (SHUSWAP), B.C., 1995: IMPLICATIONS OF MEASURED TEMPERATURES FOR ANADROMOUS SALMONIDS

by

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Results of a water temperature monitoring program conducted in the Salmon River watershed in the southern interior of British Columbia suggest that the watershed suffers from high summer water temperatures. In the lower river reaches, maximum daily water temperatures approached or exceeded 20°C, the lower end of the lethal temperature threshold for Pacific anadromous salmon. However, problems with data loggers prevented data collection during the hottest part of the summer. Salmon River data were subsequently compared with water temperature data collected from the nearby Nicola River during the same months, and temperature trends appear to be similar for the two river systems. It is probable that temperatures on the Salmon River exceeded the maximums which were measured, during the time that data loggers were not recording. High water temperatures are likely a limiting factor for populations of coho and chinook salmon in the system. Restoration of riparian vegetation on the river system would likely reduce the maximum summer water temperatures, and also contribute to improvements in salmon spawning and rearing habitat.

RÉSUMÉ

Walthers, L. C., and J. C. Nener. 1997. Water temperature monitoring in the Salmon River (Shuswap), B.C., 1995: implications of measured temperatures for anadromous salmonids. Can. Manuscr. Rep. Fish. Aquat. Sci. 2424: 57 p.

Les résultats d'un programme de surveillance de la température dans le réseau de la rivière Salmon, dans la région intérieure sud de la Colombie-Britannique, permettent de penser que les températures de l'eau y sont élevées en été. Dans les parties inférieures des cours d'eau. les températures maximales quotidiennes approchaient ou dépassaient 20°C, limite inférieure de la plage de température létale pour les saumons pacifiques anadromes. Malheureusement, des problèmes d'enregistreurs ont empêché la collecte de données pendant la période la plus chaude de l'été. Les données recueillies sur la Salmon ont été comparées par la suite aux données sur la température de l'eau dans la Nicola, rivière proche, pendant les mêmes mois, et les tendances des températures semblent similaires pour les deux systèmes. Pendant la période où les enregistreurs ne fonctionnaient pas, les températures de l'eau dans la Salmon ont probablement dépassé les maximums mesurés. Des températures élevées de l'eau sont vraisemblablement un facteur limitant pour les populations de coho et de quinnat dans le réseau. Le reverdissement des berges devrait abaisser les maximums de température de l'été, et aussi contribuer à améliorer l'habitat de ponte du saumon.

1.0 INTRODUCTION

Salmon habitat has been impacted throughout the Fraser River basin by an increasing human population and the subsequent development of the land base. In areas such as the interior of British Columbia, rich soils and warm summers facilitated widespread agricultural development that has greatly modified the landscape. Removal of natural vegetation, channelization, utilization of streams for irrigation, erosion of stream banks due to loss of riparian vegetation, and the heavy application of fertilizers and chemicals on crops, has significantly altered many small aquatic ecosystems. While past practices are being modified in response to increasing knowledge and awareness, the cumulative effects of habitat degradation have had serious consequences for local salmonid populations.

On a regional scale the Salmon River was an important system for salmon. Anecdotal accounts describe an abundant salmon population in the Salmon River prior to the Hells Gate obstruction of 1913. Mitchell (1925) observed pre-1913 sockeye runs in the Salmon River that consumed all space. By contrast sockeye runs in 1913 were described as very poor with a return of only 1,000 spawners (Roos 1986). Trends in available escapement data since 1953, and observations of spawning migrations contrast strongly with pre-1913 historical accounts. Recent peak sockeye runs are limited to under 1,500 spawners, and trends in recent coho and chinook returns show variable but relatively low returns (Serbic 1991) (Appendix 3). Unstable populations and degraded habitats throughout the province, and concern within communities and many levels of government have propelled interest in reversing these trends. Present populations are clearly limited by the quality of available habitat.

Although many factors have contributed to decreasing salmon runs in the Salmon River, high water temperatures in this and other watersheds impose obvious barriers to restoration of stocks. Temperature monitoring in the nearby Nicola watershed during the summers of 1994 and 1995 indicated that salmon rearing or returning to spawn in this system are subjected to extended periods of temperatures that exceed lethal ranges (Walthers and Nener 1997). While these critical water temperature events in the Nicola may not translate directly to the Salmon River system, the watersheds share enough common features to suggest the presence of similar thermal regimes, and signal potential temperature concerns.

During the summer of 1995 water temperature monitoring on the Salmon River was attempted using Onset Stowaway Data Loggers. Lack of field presence and failure of equipment resulted in significant data gaps. Despite these data-acquisition problems, enough temperature data was collected to detect potential temperature concerns, and assess a number of differences between sites.

2.0 STUDY AREA AND METHODS

2.1 Salmon Watershed

Located in the Interior of British Columbia, the Salmon River originates in an area near the Douglas Lake Ranch, on the eastern slopes of Siwash Rock Mountains (Figure 1A, 1B, and 1C). The region is typical of most watersheds of the southern B.C. interior, and experiences warm, dry summers with low summer flows. The river initially flows northeast through an area which supports ranching and logging, and then east from Westwold past Falkland. It subsequently flows several kilometers through farm land, before curving north, to pass through the town of Salmon Arm. There, the river drains into the south arm of Shuswap Lake. The mainstem length spans 148.7 km with the watershed having an estimated drainage of 1510 km^2. The Salmon River is characterized by gentle gradients throughout most of the drainage. Upstream of spawning areas thick gravels and low flows (resulting at least in part from water withdrawals) precipitate seasonal sub-surface or underground flows for 3-4 km at Westwold, 56 km from the mouth, during normal and dry years. Licensed water withdrawals can account for more than 100% of August low flows (Rood and Hamilton 1995). Water is primarily used to irrigate agricultural land throughout the Salmon River Valley.

Anadromous salmon populations include sockeye, coho and chinook. Historical information suggests that sockeye populations were once abundant. Barriers to migration at Hells Gate from 1911 until construction of fishways in 1946 decimated a large number of indigenous stocks, including those of the Salmon River (Thompson 1945). During the 1950's local impacts to habitat, such as the use of pesticides and herbicides, removal of riparian vegetation, and sedimentation of spawning gravels placed more pressure on the troubled stocks. A recent study of the lower 80 km of the river (downstream from Westwold) revealed that 28% of the stream bank length has no woody riparian vegetation and an additional 22% has only a narrow riparian fringe. In addition to the lack of riparian vegetation the following factors likely limit the production of anadromous salmon in the Salmon River: warm summer temperatures, bank erosion, heavy siltation, nutrient loading, and low summer flows.

Prior to the Hell's Gate slide of 1913, the Shuswap-Adams district was described as having two distinct sockeye runs including an early summer run (July-August) and a late run (September-November) (Thompson 1945). While the summer run appears to be extinct recent records for the Salmon River describe a small late run sockeye population. Warm temperatures during the summer likely inhibit the existence of an early run, while recruitment, siltation and armoring of gravels may limit the expansion of the existing small late run population. Juvenile coho and chinook salmon utilize the system year round and are directly impacted by warm summer temperatures. Migrating adult chinook begin to appear in the system in July and August, with spawning occurring in September, so their reproductive success may also be affected by summer water temperatures, particularly in hot years. Coho enter the Salmon River in October and spawn from October through December, therefore spawning would not be affected by summer water temperatures.

2.2 Equipment and Installation

Onset Stowaway temperature data loggers were placed at various locations within the Salmon River watershed to obtain water temperature readings at 15 minute and 30 minute intervals. Data loggers were installed at selected locations on June 21, 1995.

As previously noted, equipment malfunction and a lack of field presence compromised data quality. Due to problems with data logger memory, no temperature data were collected for the period between July 12 and July 31, 1995. Re-installation and programming of the data loggers provided data for the period between August 1 and September 8, 1995. The available data was edited and checked for obvious errors, though a lack of hand-held temperature readings made it impossible to directly assess the precision of Stowaway temperature readings. While the temperature data characteristics were consistent with typical water temperatures for similar systems, intermittent data coverage and lack of on site temperature verification limits us to general data assessments.

2.3 Site Descriptions

Figure 1B illustrates the approximate location of the 7 temperature monitoring sites in the Salmon River.

- **SR2** - upper watershed (Douglas Lake Ranch area), near an active logging road. All attempts to obtain temperature information were unsuccessful due to theft of Stowaway data loggers. The site is characterized by a gravel bed stream 2-4 meters across and 0.5 meters deep, with low shrubs and overhanging banks. This section of stream winds through a shrubby area for several hundred meters.

- **SR3** - downstream of SR2 and near an active logging road. This site is located in a narrow, steep walled valley with fairly dense underbrush and deciduous trees covering much of the streambank. A narrow hay field is situated near the far bank.

- **SR4** - characterized by older deciduous and coniferous stands of trees, with a fairly open understory. The streambed here is seasonally dry with sub-surface water flows for several kilometers before re-surfacing. No data was collected for the period in June when surface flows occurred.

- **SR5** - an area of agricultural activity and minimal riparian vegetation. This site is located on the Salmon River just downstream of the re-emergence of sub-surface stream flow. It has a very low gradient with slow water velocities.

- **SR6** - the site is located at HWY 97 Bridge near Moffat Creek on the Salmon River. The channel is in relatively good condition with a healthy riparian buffer. This site is downstream of rural property (hobby farms).

- **SR7** - located in a fairly open and low velocity section of the river. This reach is adjacent to agricultural properties, and has recently been fenced to keep cattle from encroaching on the stream banks. The site has a thin band of riparian vegetation including sedges and a number of well established trees. Upstream and downstream areas are characterized by fairly intensive agricultural land use.

- **SR8** - this site is the furthest downstream and is located in an urban-rural area near Salmon Arm at the Trans Canada Highway bridge crossing at HWY 1. This reach of the Salmon River is near an urban area, but downstream of mixed agricultural land use (hobby farms and intensive agriculture). It is confined with a thin band of riparian vegetation.

3.0 RESULTS AND DISCUSSION

Summarized weekly water temperatures for SR3, SR5, SR6, SR7 and SR8 are included as Appendix 1. A summary of observed daily water temperature values (maximum, minimum, mean) for these same stations are also included as Appendix 2.

The intermittent data coverage makes between-site statistical comparisons impossible, however data summaries do describe several trends. Sites near the headwaters and immediately downstream of where surface flow re-emerges (SR3 and SR5) tended to have relatively cool water temperatures, with maximum values typically under 15°C during August (Figure 2). In contrast, the downstream sites SR6 to SR8 had maximum values that often approached 20°C, and sometimes exceeded 23°C, during the same period (Figure 2). Table 1 describes average maximum, minimum and mean temperatures for August and further illustrates the temperature divergence between upper and lower sites.

Table 1. Average maximum, minimum, and mean water temperatures (°C) for August at monitoring sites in the Salmon River watershed, 1995.

AUGUST	SR3	SR5	SR6	SR7	SR8	*NIR115
Avg. Max	14.04	13.16	16.65	18.15	18.31	19.11
Avg. Min	10.65	9.86	12.66	13.26	13.57	13.77
Mean	12.20	11.25	14.55	15.58	15.76	16.29

*Site NIR115 located immediately upstream of Nicola Lake is included for comparison.

While water temperatures appear to cool between SR3 and SR5 (flows become sub-surface between the two sites), there appears to be significant warming as the river flows downstream of SR5. Table 2 shows differences in average temperatures between upper and lower sites for August, 1995.

Table 2. Difference in average daily maximum, minimum, and mean water temperatures (°C) for August between upstream and downstream sites in the Salmon River watershed, 1995.

AUGUST		SR6	SR7	SR8
AVG. MAX	SR3	2.61	4.11	4.27
DIFFERENCE	SR5	3.49	4.99	5.15
AVG. MIN	SR3	2.01	2.61	2.92
DIFFERENCE	SR5	2.80	3.40	3.71
MEAN	SR3	2.35	3.38	3.56
DIFFERENCE	SR5	3.30	4.33	4.51

Values are in °C and describe the amount by which downstream sites (SR6, SR7, SR8) exceed upstream sites (SR3, SR5).

Hourly temperature fluctuations in Figure 3 suggest fairly consistent diurnal temperature patterns throughout the watershed. During August the average daily difference between maximum and minimum temperatures were: 3.4°C (SR3), 3.3°C (SR5), 4.0°C (SR6), 4.9°C (SR7), 4.7°C (SR8). Also, average times of maximum daily temperatures occurred around 16:30, while minimum daily temperatures tended to occur around 8:00, which is similar to the Nicola River (Walthers and Nener, *in prep.*).

Figure 4 compares measured average water temperatures in the Salmon River (SR7) with selected sites in the Fraser watershed (i.e. Fraser mainstem and Thompson (Brown et al. *in press*)), and Nicola River (Walthers and Nener, *in prep.*) during the summer of 1995. It is apparent from this figure that water temperatures in the Salmon River follow a pattern similar to those observed in other nearby systems. Temperatures appear to be intermediate to those observed in the other systems in June and early July, then were somewhat lower during August and September. This period of comparatively cooler temperatures in the Salmon River coincides with low flows which dry the riverbed at site SR4. Downstream cooling may result from the lack of warm surface flows, as it is essentially cool groundwater which re-emerges upstream of SR5. Unfortunately data for the upper site (SR3) was limited to August and early September, otherwise an assessment of the potential seasonal divergence in temperatures between sites (SR3 and SR7) could have been made.

Figure 2 describes maximum, minimum and mean water temperatures for all sites in the Salmon watershed. Significant temperature thresholds for anadromous salmon are displayed on the graphs at 25°C, 21°C and 16°C. Temperatures of 25°C and 21°C have been used previously to define the upper and lower lethal temperature range for anadromous Pacific salmon (Brett 1952; Reiser and Bjornn 1979; Armour 1991; Levy 1992; Walthers and Nener 1997). Preferred spawning migration temperatures were defined by a 16°C upper limit (Vernon 1958; Smirnov 1975; Reiser and Bjornn 1979; Wilson et al. 1987) with returning spawners becoming more susceptible to disease as water temperatures exceed this threshold (Snyder and Blahm 1968). Temperatures between 16°C and 21°C are believed to be detrimental to salmonids. Fatal events are subject to the condition of the fish, duration of exposure, quality of water and other factors.

If the Salmon River follows the same temperature patterns as the nearby Nicola River then the warmest summer temperatures would have occurred during mid-July when no data were collected. The Nicola River experienced temperature peaks (>24°C) during July 19th and July 20th (1995) with warm temperatures continuing into early August (Walthers and Nener, *in prep.*). Figures 5A to 5C display maximum, minimum and average daily water temperatures for selected sites on the Nicola and Salmon Rivers. Results suggest strong similarities between water temperatures recorded at the upper Nicola site (NIR115) and temperatures recorded at the lower Salmon sites (SR7 and SR8). Results of monitoring efforts on the Salmon River suggest temperatures which are detrimental to salmonids were experienced in the lower reaches of the Salmon River from July through August.

Interestingly, although no data were acquired at the upper most site (SR2), temperatures measured with a hand-held thermometer during site visits on August 1st (SR2-18.3°C) were similar to temperatures measured at the lower sites (SR7-18.6°C and SR8-19.0°C) and warmer than the site immediately downstream (SR3-15.3°C). It appears that cooling

occurred during downstream flow from SR2 to SR3, perhaps due to shading from riparian cover in the area surrounding SR3, or because of cool groundwater inputs.

While temperature data is intermittent there is enough evidence to suggest that temperatures in the Salmon River during 1995 reached levels known to be lethal to anadromous salmon. Future monitoring will likely confirm and better describe temperature concerns. It is apparent that significant warming occurs downstream from SR5 where water velocities are slow and there is little remaining riparian vegetation to shade the river. The shading provided by riparian vegetation is known to have a significant role in minimizing warming influences (Hall and Lantz 1969; Platts 1981). Restoration and protection of riparian vegetation is clearly required if strong anadromous salmon runs are to be re-established in the Salmon River watershed.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The Salmon River experiences summer water temperatures which exceed lethal thresholds for Pacific anadromous salmon. These elevated summer water temperatures are particularly problematic for chinook salmon which utilize the system year-round for rearing as juveniles, and which return to the Salmon River as adult spawners in July and August while water temperatures are high. Juvenile coho also use the Salmon River year-round for rearing, and hence are also likely impacted by elevated summer water temperatures.

The loss of riparian vegetation which has contributed to high summer temperatures has also resulted in serious erosion and sedimentation problems which further limit populations of coho, chinook and sockeye salmon, by smothering spawning gravels.

The restoration and protection of riparian vegetation, particularly in the lower watershed (downstream from SR5) would help to address both water temperature and erosion/sedimentation problems. It would eventually further benefit the river by providing a source of large woody debris. DFO has worked on numerous riparian restoration projects in the watershed, and needs to increase the awareness among other riparian land owners about the benefits achieved through these demonstration projects.

ACKNOWLEDGMENTS

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FIGURES

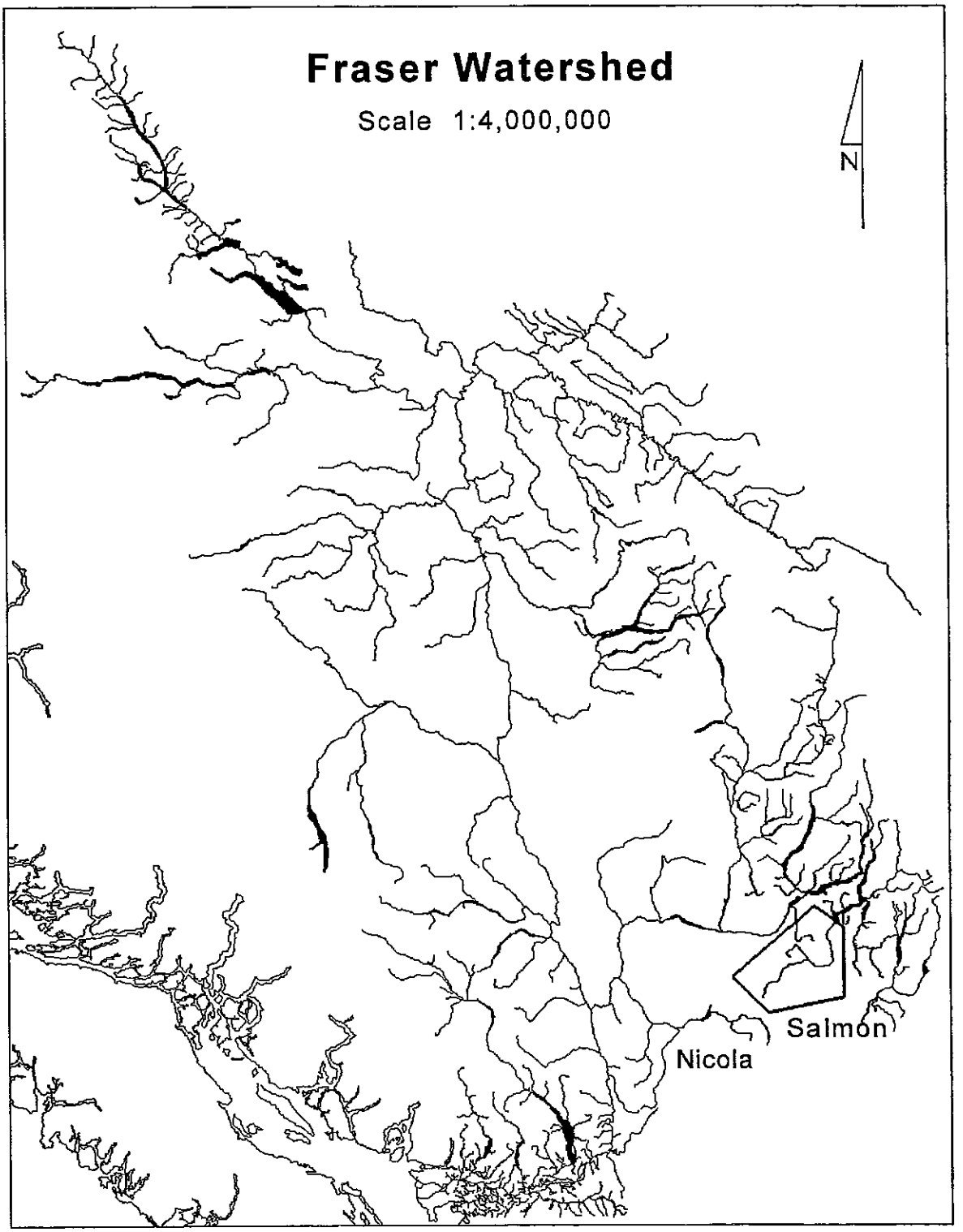

Fig. 1A. Fraser River basin, British Columbia.

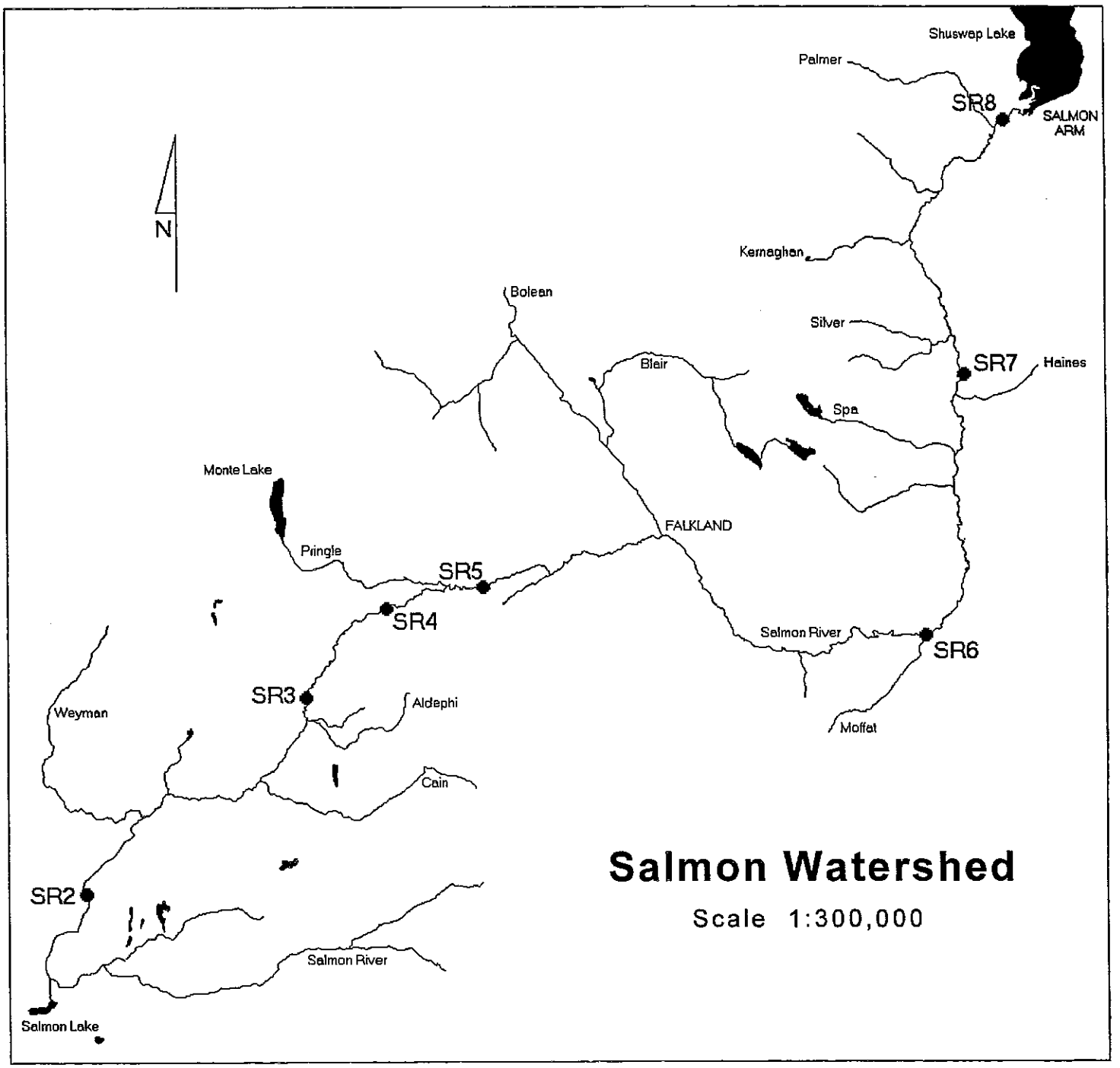

Fig. 1B. Location of temperature monitoring sites, 1995.

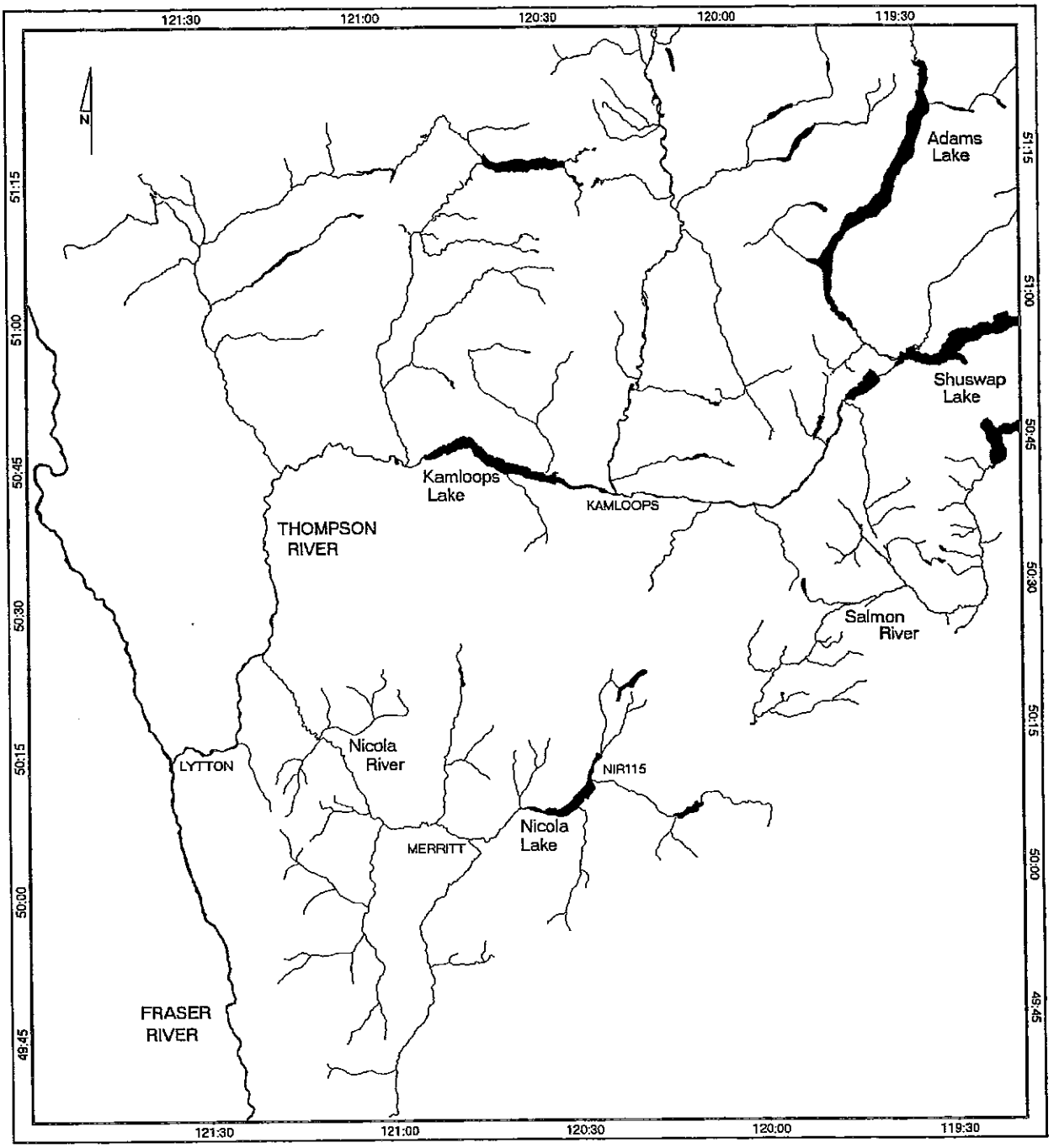

Fig. 1C. Location of the upper Nicola site - NIR115 in relation to the Salmon River, 1995.

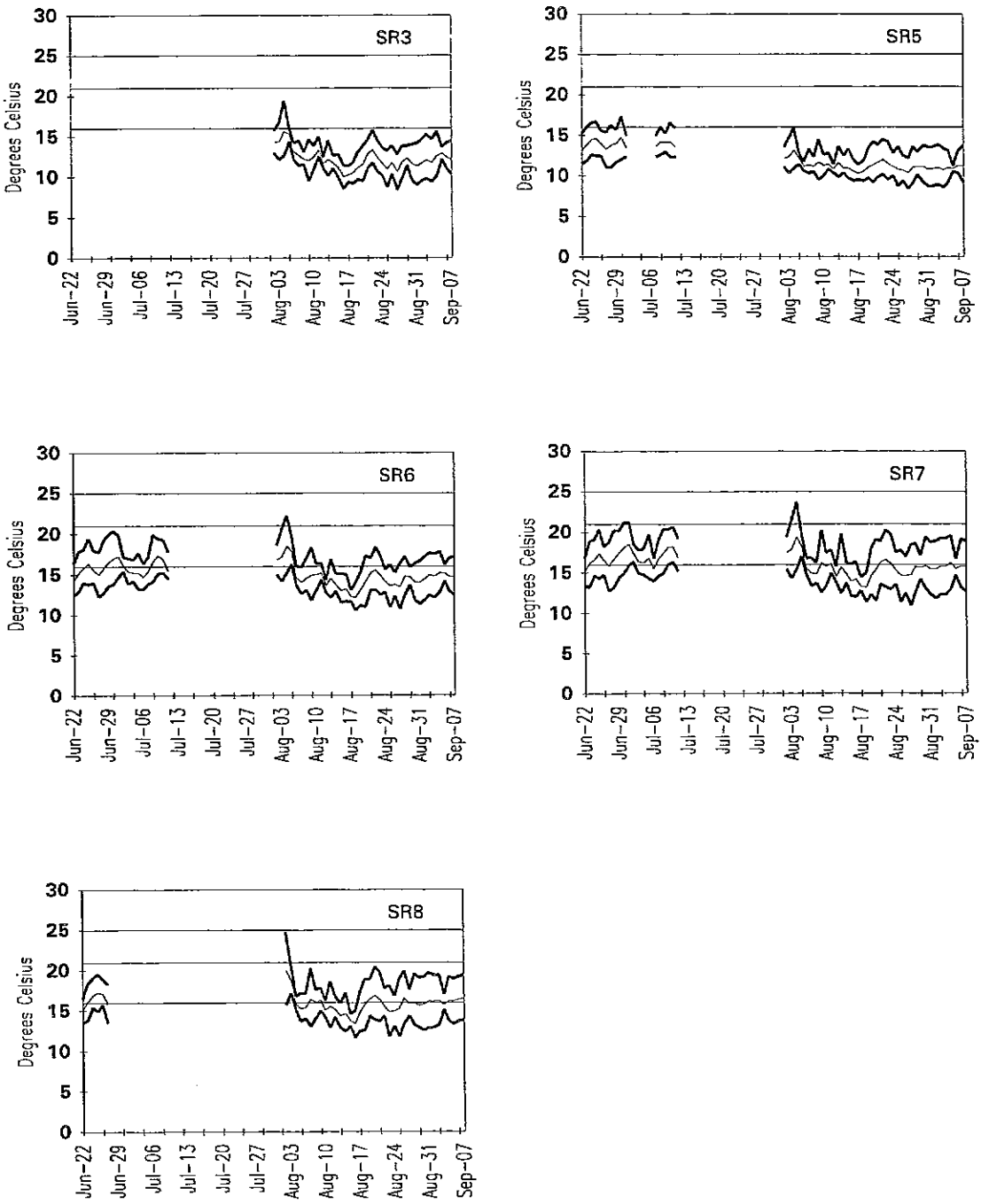

Fig. 2. Daily maximum, minimum and mean water temperatures for the Salmon River sites, 1995. Lines at 16°C, 21°C and 25°C correspond with (a) maximum preferred spawning migration temperature, (b) lower limit of LT_{50}, and (c) upper limit of LT_{50}, respectively.

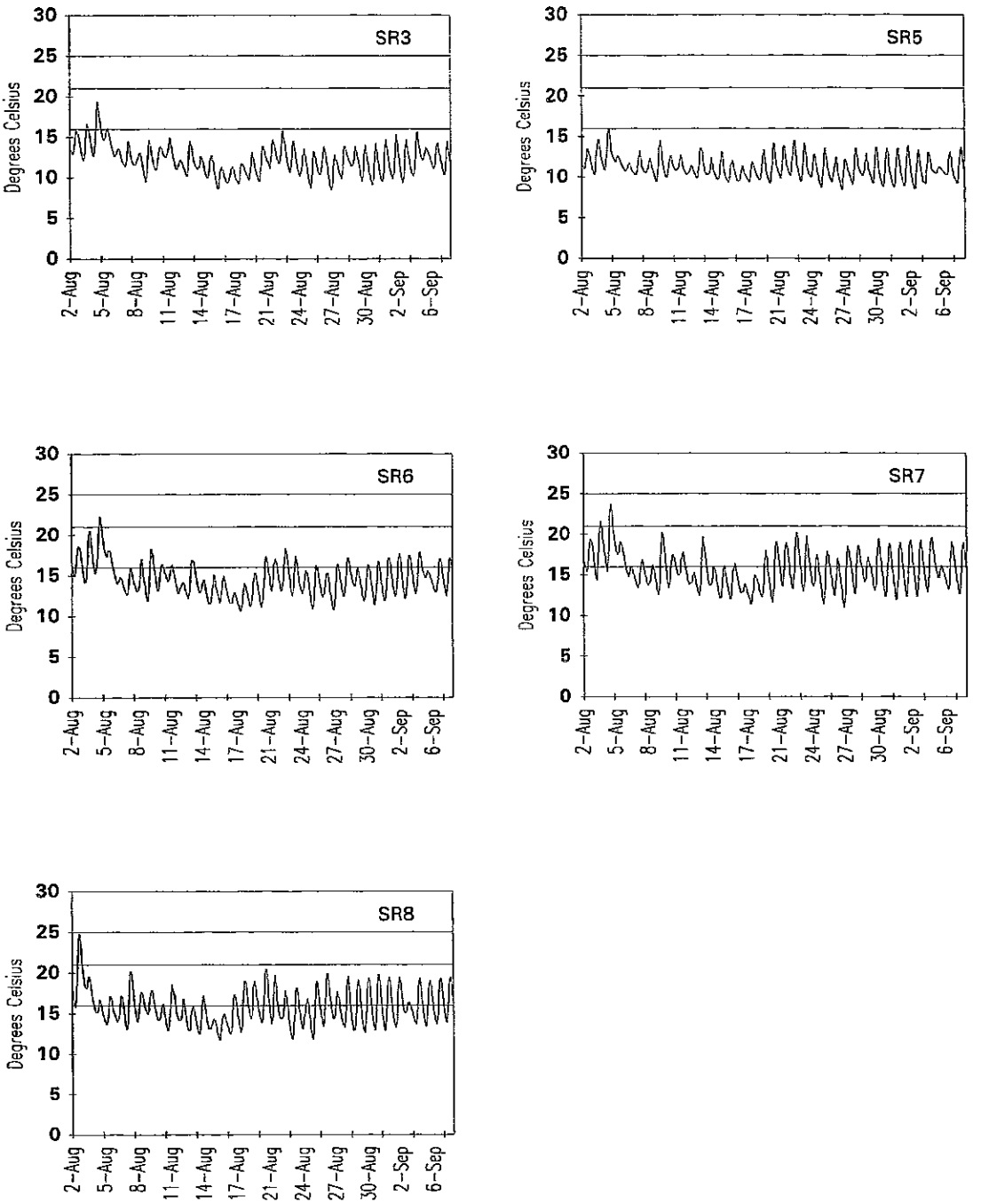

Fig. 3. Hourly water temperatures for Salmon River sites, 1995. Lines at 16°C, 21°C and 25°C correspond with (a) maximum preferred spawning migration temperature, (b) lower limit of LT_{50}, and (c) upper limit of LT_{50}, respectively.

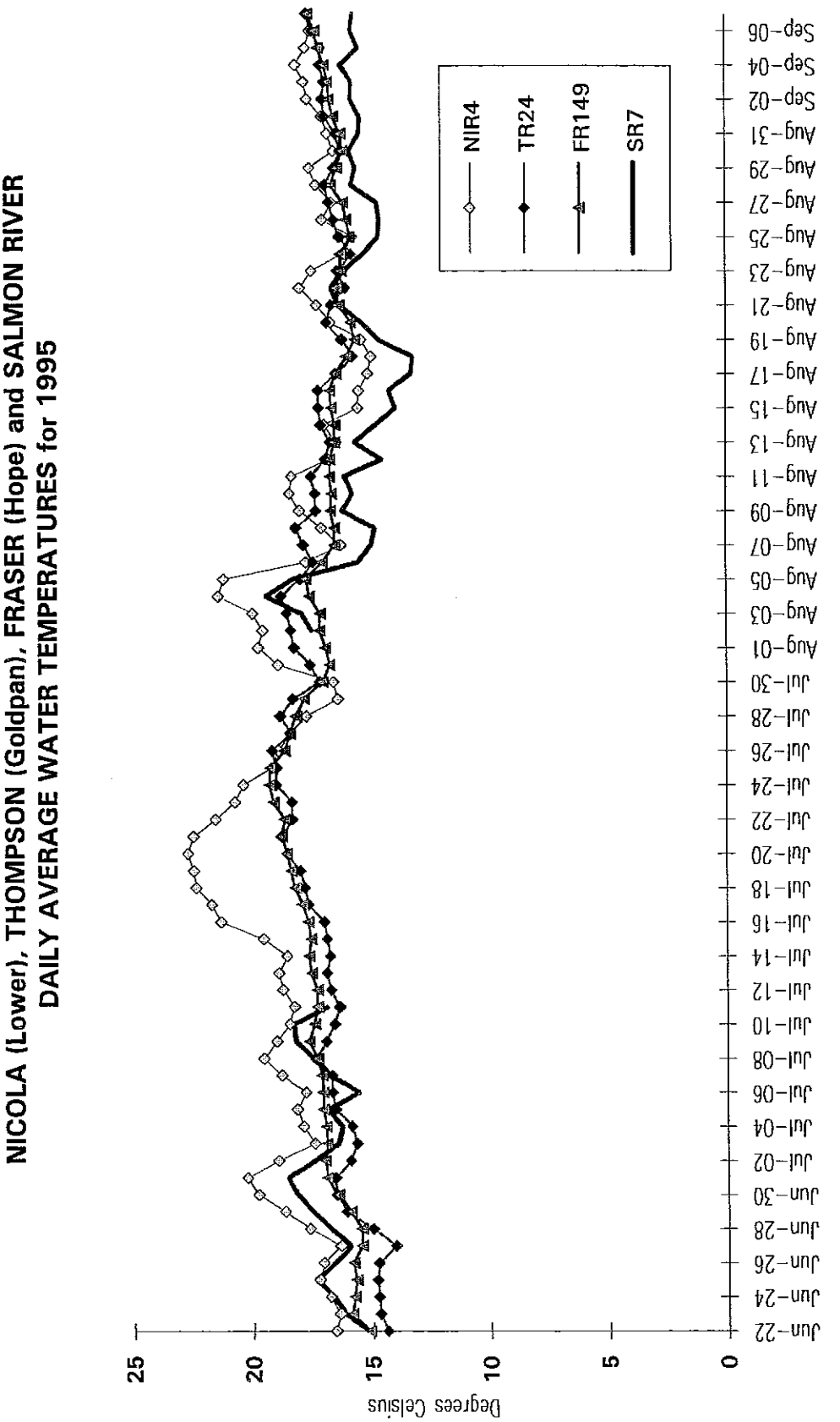

Fig. 4. Daily average water temperatures for selected sites in the Fraser watershed, 1995.

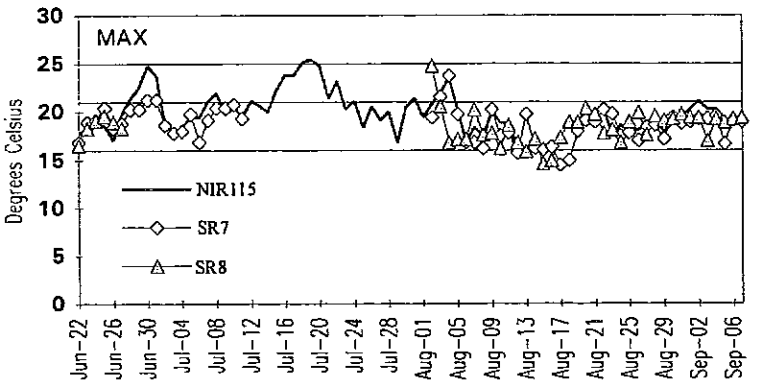

Fig. 5A. Daily maximum water temperatures at NIR115, SR7 and SR8, 1995.

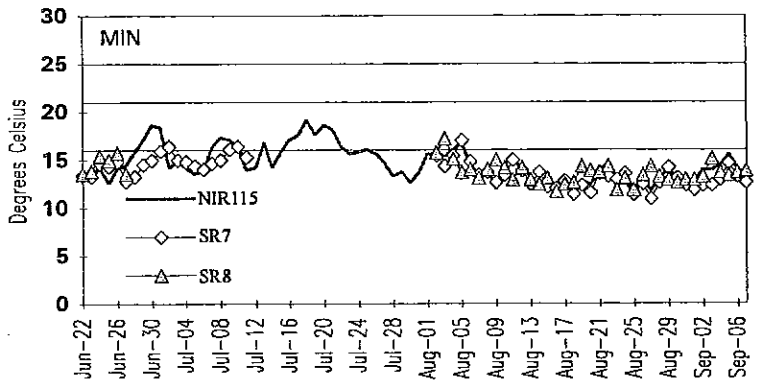

Fig. 5B. Daily minimum water temperatures at NIR115, SR7 and SR8, 1995.

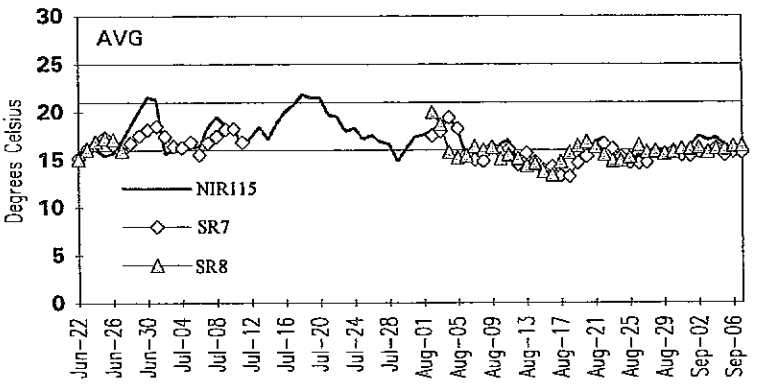

Fig. 5C. Daily average water temperatures at NIR115, SR7 and SR8, 1995.

APPENDIX 1

Appendix 1. Site summaries by week for the Salmon River watershed. N is number of available temperature records used in determining averages. Maximums and minimums are defined as the highest and lowest temperature peaks recorded during each week per site. Temperatures are in °C. (1995)

WEEK 5	SR3	SR5	SR6	SR7	SR8
N	N/A	630	630	630	397
AVG	N/A	14.14	16.02	16.99	16.65
MAX	N/A	17.34	20.40	21.23	19.59
MIN	N/A	11.07	12.32	12.78	13.56
			WATERSHED	MAX 21.23 SR7 MIN 11.07 SR5 *(06/24/95 - 06/30/95)*	

WEEK 6	SR3	SR5	SR6	SR7	SR8
N	N/A	117	630	630	N/A
AVG	N/A	13.54	15.62	16.83	N/A
MAX	N/A	14.96	19.92	21.23	N/A
MIN	N/A	12.32	13.25	14.02	N/A
			WATERSHED	MAX 21.23 SR7 MIN 12.32 SR5 *(07/29/95 - 08/04/95)*	

WEEK 10	SR3	SR5	SR6	SR7	SR8
N	156	160	158	161	157
AVG	14.72	12.47	17.48	18.26	18.41
MAX	19.43	15.91	22.23	23.74	24.78
MIN	12.16	10.31	14.18	14.33	15.12
			WATERSHED	MAX 24.78 SR8 MIN 10.31 SR5 *(07/29/95 - 08/04/95)*	

WEEK 11	SR3	SR5	SR6	SR7	SR8
N	336	336	336	336	336
AVG	13.00	11.44	15.16	15.96	15.72
MAX	16.07	14.49	19.59	20.24	20.24
MIN	9.53	9.53	11.85	12.63	12.94
			WATERSHED	MAX 20.24 SR7 MIN 9.53 SR5 *(08/05/95 - 08/11/95)*	

WEEK 12	SR3	SR5	SR6	SR7	SR8
N	336	336	336	336	336
AVG	11.07	10.79	13.23	14.24	14.54
MAX	14.49	13.56	16.86	19.76	18.95
MIN	8.59	9.37	10.61	11.38	11.69
			WATERSHED	MAX 19.76 SR7 MIN 8.59 SR3 *(08/12/95 - 08/18/95)*	

WEEK 13	SR3	SR5	SR6	SR7	SR8
N	336	336	336	336	336
AVG	11.97	11.33	14.37	15.58	15.76
MAX	15.75	14.49	18.31	20.24	20.40
MIN	8.75	8.75	10.92	11.38	11.85
			WATERSHED	MAX 20.40 SR8 MIN 8.75 SR5 *(08/19/95 - 08/25/95)*	

WEEK 14	SR3	SR5	SR6	SR7	SR8
N	336	336	336	336	336
AVG	11.59	10.83	14.18	15.35	16.02
MAX	14.64	13.71	17.18	19.43	19.92
MIN	8.44	8.44	10.77	10.92	12.63
			WATERSHED	MAX 19.92 SR8 MIN 8.44 SR5 *(08/26/95 - 09/01/95)*	

WEEK 15	SR3	SR5	SR6	SR7	SR8
N	301	299	297	296	300
AVG	12.26	10.95	14.91	15.79	16.19
MAX	15.59	13.87	17.82	19.59	19.43
MIN	9.37	8.59	12.16	12.32	13.25
			WATERSHED	MAX 19.59 SR7 MIN 8.59 SR5 *(09/02/95 - 09/08/95)*	

Weeks are consistent with those used in the 1995 Nicola Watershed Temperature Study. Gaps in temperature data between week 6 and 10 on the Salmon River are due to malfunctions of the Stowaway data loggers used for this project.

APPENDIX 2

Appendix 2. Observed daily water temperature values (°C) for the Salmon River watershed, 1995.

SR3

SUMMARY OF DAILY WATER TEMPERATURE RECORDS

DATE	MAX	MIN	MEAN
08/02/95	15.75	12.94	14.29
08/03/95	16.70	12.16	14.34
08/04/95	19.43	12.63	15.58
08/05/95	16.07	14.33	15.28
08/06/95	14.18	12.16	13.15
08/07/95	14.49	11.38	12.65
08/08/95	13.09	11.54	12.17
08/09/95	14.64	9.53	12.00
08/10/95	13.87	10.92	12.43
08/11/95	14.96	12.47	13.30
08/12/95	12.47	11.07	11.67
08/13/95	14.49	10.15	12.16
08/14/95	12.63	11.07	11.71
08/15/95	12.78	9.99	11.16
08/16/95	11.38	8.59	10.01
08/17/95	11.38	9.37	10.27
08/18/95	11.69	9.22	10.50
08/19/95	13.09	9.68	11.12
08/20/95	13.87	9.53	11.55
08/21/95	14.64	11.07	12.84
08/22/95	15.75	11.69	13.30
08/23/95	14.49	10.61	12.34
08/24/95	13.56	10.15	11.61
08/25/95	13.25	8.75	10.96
08/26/95	13.87	10.31	11.72
08/27/95	12.78	8.44	10.65
08/28/95	13.87	9.84	11.82
08/29/95	13.87	11.38	12.29
08/30/95	14.02	9.53	11.60
08/31/95	14.18	9.06	11.31
09/01/95	14.64	9.53	11.72
09/02/95	15.27	9.84	12.08
09/03/95	14.64	9.37	11.71
09/04/95	15.59	10.15	12.57
09/05/95	13.71	12.16	12.88
09/06/95	14.18	11.07	12.45
09/07/95	14.49	10.31	12.09
09/08/95	11.85	10.77	11.20

SR5

SUMMARY OF DAILY WATER TEMPERATURE RECORDS

DATE	MAX	MIN	MEAN
06/22/95	15.27	11.54	13.17
06/23/95	16.07	11.85	13.85
06/24/95	16.54	12.63	14.46
06/25/95	16.70	12.47	14.61
06/26/95	15.59	12.47	13.97
06/27/95	15.43	11.07	13.32
06/28/95	16.22	11.07	13.79
06/29/95	15.75	11.69	14.02
06/30/95	17.34	12.01	14.75
07/01/95	14.96	12.32	13.38
07/02/95	-0-	-0-	-0-
07/03/95	-0-	-0-	-0-
07/04/95	-0-	-0-	-0-
07/05/95	-0-	-0-	-0-
07/06/95	-0-	-0-	-0-
07/07/95	14.96	12.32	13.59
07/08/95	16.07	12.63	14.22
07/09/95	15.27	12.94	14.16
07/10/95	16.54	12.32	14.20
07/11/95	15.91	12.32	13.56
07/12/95	-0-	-0-	-0-
07/13/95	-0-	-0-	-0-
07/14/95	-0-	-0-	-0-
07/15/95	-0-	-0-	-0-
07/16/95	-0-	-0-	-0-
07/17/95	-0-	-0-	-0-
07/18/95	-0-	-0-	-0-
07/19/95	-0-	-0-	-0-
07/20/95	-0-	-0-	-0-
07/21/95	-0-	-0-	-0-
07/22/95	-0-	-0-	-0-
07/23/95	-0-	-0-	-0-
07/24/95	-0-	-0-	-0-
07/25/95	-0-	-0-	-0-
07/26/95	-0-	-0-	-0-
07/27/95	-0-	-0-	-0-
07/28/95	-0-	-0-	-0-
07/29/95	-0-	-0-	-0-
07/30/95	-0-	-0-	-0-

SR5

SUMMARY OF DAILY WATER TEMPERATURE RECORDS

DATE	MAX	MIN	MEAN
07/31/95	-0-	-0-	-0-
08/01/95	-0-	-0-	-0-
08/02/95	13.56	11.07	12.09
08/03/95	14.64	10.31	12.32
08/04/95	15.91	10.92	13.10
08/05/95	12.78	11.38	12.19
08/06/95	11.69	10.61	11.13
08/07/95	13.25	10.31	11.30
08/08/95	12.32	10.46	11.15
08/09/95	14.49	9.53	11.63
08/10/95	12.63	9.99	11.24
08/11/95	12.78	10.77	11.40
08/12/95	11.38	10.31	10.78
08/13/95	13.56	9.84	11.55
08/14/95	12.47	10.31	10.88
08/15/95	13.25	9.68	10.91
08/16/95	12.01	9.37	10.57
08/17/95	11.38	9.53	10.25
08/18/95	11.85	9.37	10.55
08/19/95	13.40	9.68	11.05
08/20/95	14.18	9.22	11.31
08/21/95	13.87	9.84	11.61
08/22/95	14.49	10.15	11.97
08/23/95	14.18	9.53	11.46
08/24/95	12.78	9.99	11.08
08/25/95	13.56	8.75	10.79
08/26/95	12.47	9.37	10.63
08/27/95	12.16	8.44	10.31
08/28/95	13.56	9.06	11.04
08/29/95	12.94	10.15	11.09
08/30/95	13.71	9.22	11.10
08/31/95	13.56	8.75	10.79
09/01/95	13.56	8.75	10.84
09/02/95	13.87	8.91	10.99
09/03/95	13.40	8.59	10.73
09/04/95	13.09	9.22	10.94
09/05/95	11.23	10.46	10.85
09/06/95	13.09	10.31	11.24
09/07/95	13.71	9.22	11.11

SR6

SUMMARY OF DAILY WATER TEMPERATURE RECORDS

DATE	MAX	MIN	MEAN
06/22/95	16.38	12.47	14.24
06/23/95	17.82	12.94	15.19
06/24/95	18.14	14.02	15.82
06/25/95	19.43	13.87	16.37
06/26/95	17.98	14.02	15.58
06/27/95	17.82	12.32	15.02
06/28/95	19.27	12.78	15.82
06/29/95	19.92	13.56	16.48
06/30/95	20.40	13.87	16.98
07/01/95	19.92	14.64	17.26
07/02/95	17.18	15.43	16.11
07/03/95	17.02	13.87	15.39
07/04/95	16.86	14.18	15.22
07/05/95	17.66	13.25	15.20
07/06/95	16.38	13.25	14.72
07/07/95	17.18	13.87	15.38
07/08/95	19.92	14.18	16.58
07/09/95	19.43	15.12	17.37
07/10/95	19.27	15.27	16.87
07/11/95	17.82	14.49	15.50
07/12/95	-0-	-0-	-0-
07/13/95	-0-	-0-	-0-
07/14/95	-0-	-0-	-0-
07/15/95	-0-	-0-	-0-
07/16/95	-0-	-0-	-0-
07/17/95	-0-	-0-	-0-
07/18/95	-0-	-0-	-0-
07/19/95	-0-	-0-	-0-
07/20/95	-0-	-0-	-0-
07/21/95	-0-	-0-	-0-
07/22/95	-0-	-0-	-0-
07/23/95	-0-	-0-	-0-
07/24/95	-0-	-0-	-0-
07/25/95	-0-	-0-	-0-
07/26/95	-0-	-0-	-0-
07/27/95	-0-	-0-	-0-
07/28/95	-0-	-0-	-0-
07/29/95	-0-	-0-	-0-
07/30/95	-0-	-0-	-0-

SR6

SUMMARY OF DAILY WATER TEMPERATURE RECORDS

DATE	MAX	MIN	MEAN
07/31/95	-0-	-0-	-0-
08/01/95	-0-	-0-	-0-
08/02/95	18.63	14.96	16.79
08/03/95	20.57	14.18	17.19
08/04/95	22.23	15.27	18.49
08/05/95	19.59	16.22	17.85
08/06/95	16.07	13.71	14.61
08/07/95	15.91	12.63	14.06
08/08/95	17.02	13.09	14.53
08/09/95	18.31	11.85	14.88
08/10/95	16.38	13.09	14.97
08/11/95	16.38	14.33	15.18
08/12/95	14.33	12.78	13.63
08/13/95	16.86	12.16	14.50
08/14/95	15.12	12.94	13.76
08/15/95	15.12	11.54	13.00
08/16/95	14.96	11.69	13.20
08/17/95	13.09	11.69	12.28
08/18/95	14.02	10.61	12.21
08/19/95	15.27	11.23	13.11
08/20/95	17.34	11.07	14.15
08/21/95	17.02	13.09	15.19
08/22/95	18.31	13.09	15.52
08/23/95	17.34	12.47	14.86
08/24/95	15.59	12.78	14.14
08/25/95	16.22	10.92	13.57
08/26/95	15.27	12.32	13.79
08/27/95	16.38	10.77	13.47
08/28/95	17.18	12.47	14.78
08/29/95	15.91	13.71	14.69
08/30/95	16.38	11.85	14.04
08/31/95	16.70	11.38	14.04
09/01/95	17.18	11.85	14.44
09/02/95	17.66	12.47	14.92
09/03/95	17.50	12.16	14.77
09/04/95	17.82	12.78	15.17
09/05/95	16.22	14.18	15.13
09/06/95	17.02	12.94	14.71
09/07/95	17.18	12.47	14.77

SR7

SUMMARY OF DAILY WATER TEMPERATURE RECORDS

DATE	MAX	MIN	MEAN
06/22/95	16.86	13.40	15.17
06/23/95	18.95	13.25	16.19
06/24/95	19.11	14.64	16.63
06/25/95	20.40	14.33	17.39
06/26/95	18.31	14.80	16.57
06/27/95	18.79	12.78	15.91
06/28/95	20.24	13.25	16.74
06/29/95	20.24	14.49	17.50
06/30/95	21.23	14.96	18.15
07/01/95	21.23	15.91	18.54
07/02/95	18.63	16.38	17.42
07/03/95	17.82	14.96	16.41
07/04/95	17.98	14.80	16.26
07/05/95	19.76	14.33	16.84
07/06/95	16.86	14.02	15.54
07/07/95	19.11	14.64	16.77
07/08/95	20.40	14.96	17.44
07/09/95	20.40	16.07	18.18
07/10/95	20.73	16.38	18.25
07/11/95	19.27	15.27	16.86
07/12/95	-0-	-0-	-0-
07/13/95	-0-	-0-	-0-
07/14/95	-0-	-0-	-0-
07/15/95	-0-	-0-	-0-
07/16/95	-0-	-0-	-0-
07/17/95	-0-	-0-	-0-
07/18/95	-0-	-0-	-0-
07/19/95	-0-	-0-	-0-
07/20/95	-0-	-0-	-0-
07/21/95	-0-	-0-	-0-
07/22/95	-0-	-0-	-0-
07/23/95	-0-	-0-	-0-
07/24/95	-0-	-0-	-0-
07/25/95	-0-	-0-	-0-
07/26/95	-0-	-0-	-0-
07/27/95	-0-	-0-	-0-
07/28/95	-0-	-0-	-0-
07/29/95	-0-	-0-	-0-
07/30/95	-0-	-0-	-0-

SR7

SUMMARY OF DAILY WATER TEMPERATURE RECORDS

DATE	MAX	MIN	MEAN
07/31/95	-0-	-0-	-0-
08/01/95	-0-	-0-	-0-
08/02/95	19.43	15.43	17.50
08/03/95	21.56	14.33	17.94
08/04/95	23.74	15.43	19.42
08/05/95	19.76	17.02	18.29
08/06/95	16.86	14.80	15.52
08/07/95	16.86	13.40	14.98
08/08/95	16.22	13.71	14.82
08/09/95	20.24	12.63	16.20
08/10/95	17.50	13.40	15.76
08/11/95	17.82	14.96	16.11
08/12/95	15.75	13.87	14.52
08/13/95	19.76	12.47	15.66
08/14/95	16.22	13.71	14.81
08/15/95	16.07	12.16	13.93
08/16/95	16.38	12.01	14.23
08/17/95	14.49	12.78	13.30
08/18/95	14.96	11.38	13.22
08/19/95	17.98	12.32	14.65
08/20/95	19.11	11.54	15.34
08/21/95	18.95	13.56	16.30
08/22/95	20.24	13.25	16.63
08/23/95	19.76	12.94	16.13
08/24/95	17.50	13.56	15.28
08/25/95	17.82	11.38	14.66
08/26/95	17.02	12.47	14.60
08/27/95	18.47	10.92	14.71
08/28/95	18.63	12.63	15.78
08/29/95	17.18	14.18	15.60
08/30/95	19.43	13.09	15.89
08/31/95	18.79	12.32	15.44
09/01/95	18.95	11.85	15.41
09/02/95	19.27	12.32	15.82
09/03/95	19.27	12.32	15.78
09/04/95	19.59	12.94	16.23
09/05/95	16.70	14.64	15.46
09/06/95	19.11	13.25	15.80
09/07/95	18.95	12.63	15.71

SR8

SUMMARY OF DAILY WATER TEMPERATURE RECORDS

DATE	MAX	MIN	MEAN
06/22/95	16.54	13.56	15.08
06/23/95	18.31	13.87	16.10
06/24/95	19.11	15.43	16.94
06/25/95	19.59	14.96	17.30
06/26/95	18.95	15.75	17.14
06/27/95	18.31	13.56	15.97
06/28/95	16.38	14.02	14.81
06/29/95	-0-	-0-	-0-
06/30/95	-0-	-0-	-0-
07/01/95	-0-	-0-	-0-
07/02/95	-0-	-0-	-0-
07/03/95	-0-	-0-	-0-
07/04/95	-0-	-0-	-0-
07/05/95	-0-	-0-	-0-
07/06/95	-0-	-0-	-0-
07/07/95	-0-	-0-	-0-
07/08/95	-0-	-0-	-0-
07/09/95	-0-	-0-	-0-
07/10/95	-0-	-0-	-0-
07/11/95	-0-	-0-	-0-
07/12/95	-0-	-0-	-0-
07/13/95	-0-	-0-	-0-
07/14/95	-0-	-0-	-0-
07/15/95	-0-	-0-	-0-
07/16/95	-0-	-0-	-0-
07/17/95	-0-	-0-	-0-
07/18/95	-0-	-0-	-0-
07/19/95	-0-	-0-	-0-
07/20/95	-0-	-0-	-0-
07/21/95	-0-	-0-	-0-
07/22/95	-0-	-0-	-0-
07/23/95	-0-	-0-	-0-
07/24/95	-0-	-0-	-0-
07/25/95	-0-	-0-	-0-
07/26/95	-0-	-0-	-0-
07/27/95	-0-	-0-	-0-
07/28/95	-0-	-0-	-0-
07/29/95	-0-	-0-	-0-
07/30/95	-0-	-0-	-0-

SR8

SUMMARY OF DAILY WATER TEMPERATURE RECORDS

DATE	MAX	MIN	MEAN
07/31/95	-0-	-0-	-0-
08/01/95	-0-	-0-	-0-
08/02/95	24.78	15.75	20.00
08/03/95	20.57	17.18	18.73
08/04/95	16.86	15.12	15.80
08/05/95	17.18	13.71	15.23
08/06/95	17.18	14.02	15.40
08/07/95	20.24	13.09	16.41
08/08/95	17.66	14.02	16.04
08/09/95	17.82	14.96	16.31
08/10/95	16.22	14.18	15.08
08/11/95	18.63	12.94	15.54
08/12/95	16.86	14.18	15.14
08/13/95	15.91	12.94	14.36
08/14/95	17.18	12.47	14.58
08/15/95	14.64	13.09	13.73
08/16/95	14.96	11.69	13.40
08/17/95	17.34	12.47	14.76
08/18/95	18.95	12.63	15.77
08/19/95	18.95	14.33	16.48
08/20/95	20.40	13.87	16.89
08/21/95	19.76	13.71	16.35
08/22/95	17.82	14.33	15.50
08/23/95	18.14	11.85	14.87
08/24/95	16.86	13.09	14.94
08/25/95	18.95	11.85	15.26
08/26/95	19.92	13.40	16.54
08/27/95	17.66	14.33	15.83
08/28/95	19.59	13.25	15.95
08/29/95	19.11	12.94	15.64
08/30/95	19.27	12.63	15.85
08/31/95	19.76	12.94	16.19
09/01/95	19.43	12.94	16.13
09/02/95	19.43	13.25	16.25
09/03/95	17.02	15.12	15.75
09/04/95	19.27	13.71	16.19
09/05/95	18.95	13.40	16.13
09/06/95	19.27	13.71	16.42
09/07/95	19.43	13.87	16.53

APPENDIX 3

Appendix 3. Salmon River (rabcode: 03-5200) escapement data for sockeye, coho and chinook.

YEAR	SOCKEYE	COHO	PINK	CHUM	CHINOOK
1953	-2	400	-2	-2	750
1954	-3	-3	-3	-3	-3
1955	-2	7500	-2	-2	200
1956	-2	400	-2	-2	200
1957	-2	1500	-2	-2	25
1958	-2	3500	-2	-2	200
1959	-2	750	-2	-2	200
1960	-2	1500	-2	-2	200
1961	-2	1500	-2	-2	25
1962	45	750	-2	-2	400
1963	-2	1500	-2	-2	200
1964	-2	750	-2	-2	75
1965	-2	3500	-2	-2	200
1966	-2	400	-2	-2	200
1967	-2	200	-2	-2	200
1968	-2	1000	-2	-2	200
1969	-2	1500	-2	-2	200
1970	-2	750	-2	-2	200
1971	-2	1500	-2	-2	400
1972	-2	2000	-2	-2	200
1973	-2	600	-2	-2	150
1974	92	1800	-2	-2	250
1975	-2	900	-2	-2	200
1976	-2	900	-2	-2	150
1977	-2	1588	-2	-2	300
1978	434	1500	-2	-2	350
1979	-2	2000	-2	-2	300
1980	-2	1300	-2	-2	360
1981	-2	500	-2	-2	300
1982	1602	800	-2	-2	700
1983	50	1000	-2	-2	300
1984	-2	1197	-2	-2	585
1985	-2	3414	-2	-2	1302
1986	1465	2187	-2	-2	852
1987	75	1945	-2	-2	461
1988	-1	3769	-2	-2	1055
1989	-2	2516	-2	-2	1456
1990	1300	780	-2	-2	866
1991	41	294	-2	-2	477
1992	-2	2250	-3	-3	300
1993	-2	500	-3	-3	1850
1994	-3	376	-3	-3	800
1995	-3	-3	-3	-3	-3

Escapement codes are interpreted as follows: (-1) stream inspected no fish observed; (-2) stream not inspected or not inspected for this species or species present but no estimate made; (-3) no record for stream in this year (Serbic 1991).