Predicted Impacts of Altered Water Temperature Regime on Glendale Creek Pink (*Oncorhynchus gorbuscha*) Fry

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PREDICTED IMPACTS OF ALTERED WATER TEMPERATURE REGIME ON GLENDALE CREEK PINK (*Oncorhynchus gorbuscha*) FRY.

by

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ABSTRACT

Shepherd, B.G. 1984. Predicted impacts of altered water temperature regime on Glendale Creek pink (Onchorhynchus gorbuscha) fry. Can MS Rep. Fish. Aquat. Sci. 1782: v + 55 p.

As part of the feasibility studies associated with the development of an enhancement program for the Knight Inlet region of British Columbia, the potential problem of premature emigration of pink fry from a proposed spawning channel was addressed. This problem was tentatively evaluated using onsite temperature and fry migration data collected over the 1982-83 incubation and emergence period. Water temperature monitoring studies confirmed that Tom Browne Creek surface water was consistently warmer by up to 4.5° than Glendale Creek water. Subgravel water temperatures were found to track surface water temperatures in a buffered fashion, with a diurnal lag of 2-4 hr. Subgravel temperatures could be as much as 4°C different than surface temperatures, but generally were 0.5 - 2.0°C colder May through September and 0.5 - 1.0°C warmer November through February. Juvenile trapping in the spring of 1983 indicated that pink and chum fry emigrated from the Tom Browne section 2-3 wk earlier than from the Glendale section; no significant differences or trends in fry length, weight, or condition were noted between systems or over time. Other species of salmon captured and sampled included coho fry and smolts and sockeye smolts. There were also incidental catches of juvenile and resident cutthroat and rainbow/steelhead trout, Dolly Varden fry, sticklebacks, cottids, and lamprey larvae and adults. Comparison of the subgravel temperature data and the fry migration data indicated that pink fry incubated in Tom Browne water could emigrate 3-7 wk in advance of pink fry incubated in Glendale water. A review of the available literature indicated that this degree of advancement should have a nil or perhaps even beneficial effect on survival. This conclusion is tempered by a call for more detailed studies to fill data gaps.

Key words: temperature, pink salmon, Oncorhynchus gorbuscha, chum salmon, Oncorhynchus keta, fry, migration.

RÉSUMÉ

Shepherd, B.G. 1984. Predicted impacts of altered water temperature regime on Glendale Creek pink (Onchorhynchus gorbuscha) fry. Can MS Rep. Fish. Aquat. Sci. 1782: v + 55 p.

Dans le cadre d'études de faisabilité liées au développement d'un programme de mise en valeur, dans la région de l'inlet Knight (Colombie-Britannique), on s'est penché sur le problème de la migration prématurée d'alevins de saumon rose d'un projet de frayères artificielles. Le problème a été étudié d'une façon estimative à l'aide de la température sur place et des données concernant la migration des alevins, recueillies pendant la période d'incubation et d'émergence en 1982-1983. Des études de contrôle de la température de l'eau ont confirmé que les eaux superficielles du ruisseau Tom Browne étaient uniformément plus chaudes (jusqu'à 4.5°C) que celles du ruisseau Glendale. Sous le gravier, la température de l'eau suivait celle de la surface de façon périphérique, avec un décalage diurne de 2 à 4 h. La première pouvait différer par jusqu'à 4°C de la seconde, quoiqu'en général elle était de 0.5 à 2.0°C plus froide de mai à septembre et de 0.5°C à 1.0°C plus chaude de novembre à février. La capture de juvéniles au printemps 1983 a révélé que les alevins de saumons rose et kéta ont émigré du secteur Tom Browne de 2 à 3 semaines avant ceux du secteur Glendale; aucune tendance ni différence significative de la longueur, du poids ou de la condition des alevins n'a été notée entre les systèmes ou les périodes. Des alevins et des saumoneaux de saumon coho et des saumoneaux de saumon rouge ont aussi été capturés et échantillonnés. Parmi les prises accessories, il y avait des truites fardées juvéniles et non migratrices, des truites arc-en-ciel anadrome, des alevins de Dolly Varden, des épinoches, des cottidés ainsi que des larves et des adultes de lamproie. La comparaison des températures de l'eau sous le gravier et des données sur la migration des alevins a révélé que les alevins de saumon rose incubés dans les eaux du ruisseau Tom Browne pouvaient migrer de 3 à 7 semaines avant ceux du Glendale. Une recherche dans les ouvrages publiés sur le sujet a montré que ce degré d'avancement devrait avoir une incidence nulle ou peut-être même avantageuse sur la survie. Cette conclusion a cependant moins de force du fait qu'il faudrait réaliser des études plus détaillées pour obtenir les données manquantes.

INTRODUCTION

BACKGROUND

Knight Inlet has been selected as a prime candidate for the construction of major enhancement facilities early in the proposed SEP Continuation plan. Current proposed enhancement plans for the area include a hatchery (initially pilot-scale) on the Devereux Creek tributary of the Kliniklini River, for Kliniklini and Ahnuhati chinooks and Glendale coho; a chum and possibly pink spawning channel on the Ahnuhati River; and a pink spawning channel on the Glendale River. The Glendale channel would have a gravity water supply from Tom Browne Lake. Alternatively, the Glendale site could also support a central hatchery for chinook, coho, and chum stocks from Knight Inlet, Loughborough Inlet, or Thompson Sound.

In support of this plan, a number of biological reconnaissance and feasibility studies have been implemented by the SEP New Projects Unit. An adult biophysical survey was done for Knight Inlet streams by Aquatic Resources Limited in 1981, and was reported by Fielden and Slaney (MS 1982). Aquatic Resources also examined the limnology of Tom Browne Lake in 1981, in order to evaluate its suitability as a water supply for salmon culture (Black and Birch, MS 1982). A second year of adult surveys was undertaken by E.V.S. Consultants Limited in the fall of 1983 (Whelen and Morgan, MS 1984).

In February of 1983, New Projects Unit staff reviewed the available water temperature data, and projected that use of the warmer Tom Browne water for incubation of Glendale pink salmon would result in fry emergence some 70 days earlier than normal. This could result in high marine mortality of pink fry from the spawning channel through starvation, if the normal fry migration is in synchrony with the spring blooms of food organisms. For instance, Bilton and Robins (1973) concluded that two weeks was the maximum period of starvation that emergent Babine sockeye fry could withstand without suffering significant mortality.

Factors which may act to reduce the severity of the problem of early emigration could include:

(1) The timing of fry emergence can be delayed beyond the button-up stage by other environmental cues (eg moon phase or low flows).

(2) The marine bloom of food organisms may occur in advance of the normal fry migration.

(3) Incubating fry are exposed to subgravel water temperatures which, similar to ground water, may be buffered in comparison to surface water temperatures.

(4) Significant numbers of pinks spawn in the areas within 0.5 km below the Tom Browne confluence and below Glendale Lake. Due to upwelling water at the lake outlet, Tom Browne eggs may be exposed to higher winter water temperatures than those in the lower portions of Glendale Creek, which are up to 7 km downstream of the lake. It is unknown which of the reaches is most productive of adult returns.

Item (1) should have a relatively minor effect of no more than a few weeks. Item (4) would require a large and costly fry marking and adult recovery program to assess properly.

THE PURPOSE OF THIS REPORT

This report summarizes previously unreported temperature data for the Glendale system over the period 1971-1983, and a contracted fry migration study done in the spring of 1983. As well, some relevant marine studies are reviewed. These data are applied to the hypotheses of Items (2) and (3) in the previous section, and some conclusions regarding the severity of the premature fry emigration problem are drawn.

DESCRIPTION OF THE STUDY AREA

The Glendale Creek watershed is situated 48 km south of the head of Knight Inlet, 200 km north of Vancouver (Fig. 1). The Glendale system includes two lakes; Tom Browne Lake (7 km long and 490 ha) and Glendale Lake (2 km long and 125 ha). Tom Browne Lake is drained by Tom Browne Creek (1.5 km long) which empties into Glendale Cove. Glendale Lake is drained by Glendale Creek (7.5 km long) which flows into Tom Browne Creek 1 km from its mouth (Fig. 2).

The area around Glendale Creek and Lake was logged in the 1950's, and currently the area around Tom Browne Lake and Creek is being logged. Roads extend from Heydon Bay in Loughborough Inlet; along Glendale Lake and Creek to within a few miles of Tom Browne Creek; and from Jackson Bay along Tom Browne Lake and Glendale Creek).

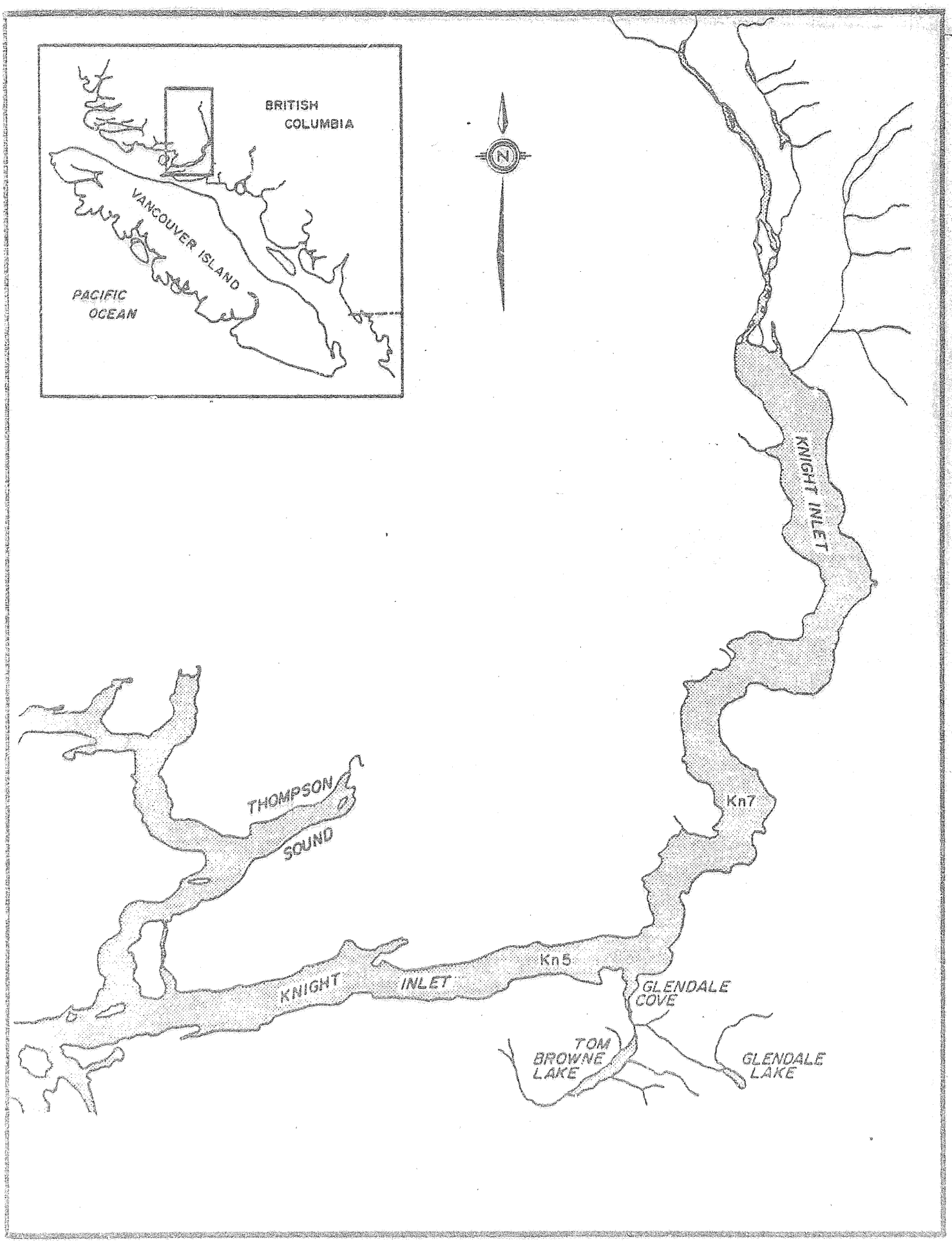

Figure 1. General location of Tom Browne and Glendale Creeks, Knight Inlet, B.C. (see p 34 for explanation of Kn 5 and Kn 7 stations).

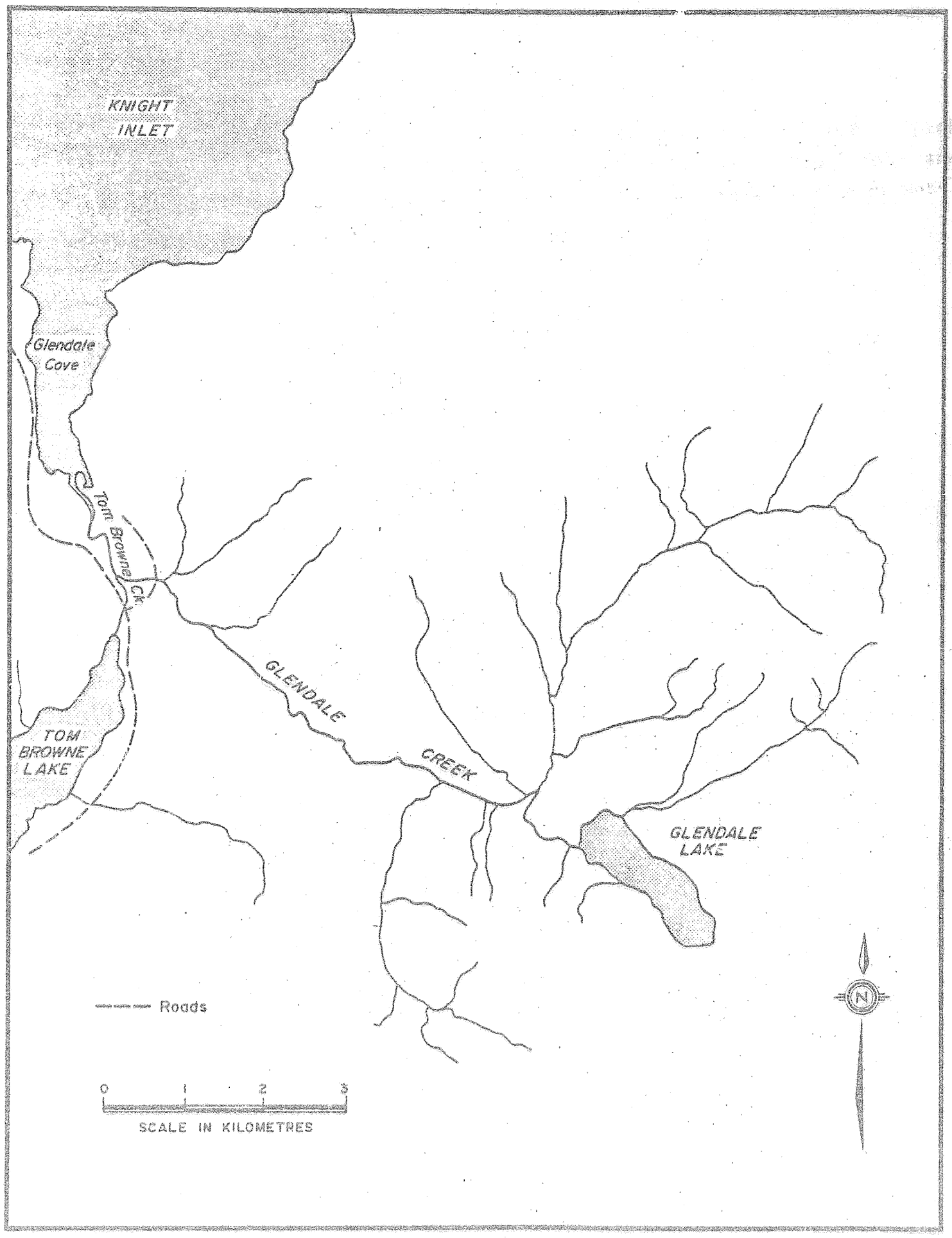

Figure 2. Tom Browne and Glendale systems.

The Glendale system has a strong even year and smaller odd year run of pink salmon, and a declining return of chum. Due to irregular surveying, coho and sockeye numbers are sporadic. Chinook, cutthroat and steelhead have been noted occasionally (Table 1).

TABLE 1. Glendale Creek Escapement Records (from Dept. Fish. Oceans spawning files.)

YEAR	SOCKEYE	CHINOOK	COHO	CHUM	PINK
1949	3500		7500	35000	15000
1950	3500		3500	35000	35000
1951	7500		3500	15000	15000
1952	3500		7500	15000	15000
1953	3500		7500	7500	7500
1954	1500		750	7500	15000
1955	1500		7500	3500	75000
1956	1500		3500	3500	75000
1957	3500		1500	7500	75000
1958	1500		7500	3500	75000
1959	750		3500	1500	175000
1960	1500		1500	1500	35000
1961	750		3500	7500	>100000
1962	N/O		3500	3500	>100000
1963	N/O		1500	35000	>100000
1964	N/O		1500	55000	150000
1965	N/O		400	75	50000
1966	N/O	25	400	15000	220000
1967			200	35000	75000
1968	N/O	N/O	400	15000	162500
1969			N/O	1000	50000
1970	25	25	200	35000	150000
1971			200	400	150000
1972	25		75	15000	9500
1973	10		50	40000	200000
1974				2000	30000
1975	100		25	400	150000
1976	200		N/O	1600	150000
1977			N/O	450	16000
1978			2000	1500	275000
1979			10	1500	160[illegible]
1980	N/O	N/O	N/O	1000	250000
1981	N/O	N/O	300	300	20000
1982	N/O	N/O	N/O	2000	150000

UNK=UNKNOWN; N/O=NONE OBSERVED

METHODS

WATER TEMPERATURE MONITORING

In February of 1981, a Peabody-Ryan three-month submersible thermograph was installed at the proposed intake site at the outlet of Tom Browne Lake (Fig 3). In May of 1981, it was replaced with a six-month thermograph, and a second six-month thermograph was installed in the channel of Glendale Creek just upstream of the confluence with Tom Browne Falls. Because of reduced flow in the channel, the Glendale thermograph was moved by a consultant in late August of 1981 downstream of the confluence, to the Fisheries Research Branch (FRB) weir site (Black and Birch, MS 1982). This machine jammed upon installation at the FRB site and was not operational until November of 1981. It should be noted that, judging from temperature cross-section surveys by SEP staff done in February of 1983, the FRB location would have been sampling largely Tom Browne water. Both machines were removed by the consultant in late January of 1982.

During a cold-weather period in February of 1983, SEP staff carried out more detailed temperature surveys, using a calibrated thermistor and a heavy steel pipe (3 mm wall, 25 mm I.D., 120 cm in length), with a pointed tip and with 24 2 mm perforations in the lower 12 cm. The pipe was driven by sledge hammer to a depth of 30 cm (the presumed maximum pink redd depth), and the weighted thermistor cable lowered to the bottom of the pipe. Initial testing indicated the probe temperature moved towards equilibration with the temperature of the surface water over a period of several minutes (presumably transmitted by the metal pipe). Thereafter, temperature readings were taken as rapidly as possible. Five cross-sections were selected within the reach from the FRB site to just upstream of the new logging bridge near the proposed spawning channel (Fig. 3). From one to five samplings were done at least three paces apart within each cross-section. Also for each sampling, water depth was measured with a steel tape, surface water temperature was measured with the thermistor, and surface water velocity was estimated by the floating-chip method.

Utilizing similar methods and locations, five additional subgravel-surface temperature surveys were done in April and May of 1983 as part of the fry migration study contracted to Aquatic Resources Limited (discussed in the next section). The contractor also measured daily water levels and surface temperatures with staff gauges, Ryan thermograph, and pocket and maximum-minimum thermometers over this period. Temperatures of groundwater seepages were measured with a pocket thermometer.

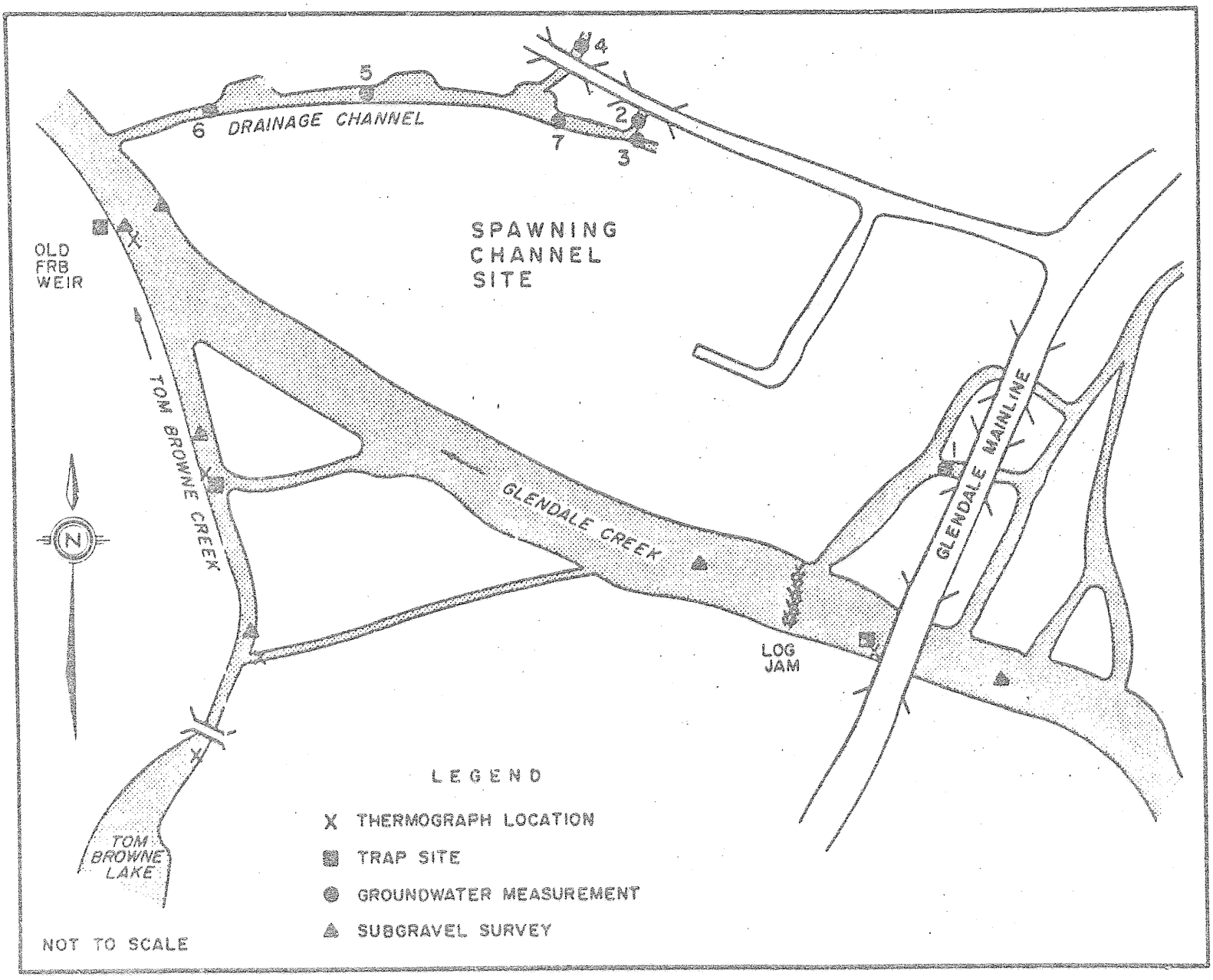

Figure 3. Sketch (not to scale) of 1982-83 sampling sites within Tom Browne and Glendale Creeks.

Two Peabody-Ryan three-month thermographs were placed in Tom Browne Creek opposite the FRB site in February, 1983. Both were weighted; one was placed on the bottom in a protected backwater, and the other was buried 3-4 m away in 30 cm of gravel. These machines were maintained through October, 1983 by Aquatic Resources Limited, who did the fry migration study, and by EVS Consultants Ltd, who conducted an adult biobaseline study of Knight Inlet streams for the New Projects Unit. The thermographs were removed in the spring of 1984 by Aquatic Resources Limited, during the second fry migration study.

The Department of Fisheries also monitored water temperatures in the Glendale and Tom Browne systems 1971-1975. The available charts were analyzed by New Projects Unit staff and are included in this review.

JUVENILE MIGRATION STUDY

Aquatic Resources Limited was contracted by the New Projects Unit to undertake a downstream fry trapping study in the Tom Browne and Glendale systems in the spring of 1983. Trapping began March 30 and ended May 16.

One 2x3 inclined plane trap (IPT) of the International Pacific Salmon Commission style was hung off the new logging bridge over Glendale Creek. A second IPT was set from a cable on the right bank of Tom Browne Creek just below the first Glendale confluence; the trap location was unaffected by Glendale water. The traps were fished continuously except for freshet periods during the days of March 31, April 2, May 27 and May 14, and the night of April 2 (Glendale trap only). On April 9, low water had impaired catches in the Tom Browne trap and the trap was dug in; on April 4 and 11, the Glendale trap had to be moved progressively upstream (7m maximum) to deeper locations and the Tom Browne trap had to be further trenched on April 12.

Staff gauges were installed at each trap site and were read daily, as were the pre-existing gauges at the old bridge over Tom Browne Creek and near the FRB weir (the latter was installed during the 1981 adult biobaseline study).

Up to 30 fish of each species of salmon were taken daily from the trap catches and measured as to fork length and wet weight. The fish were anaesthetised using a standard dosage of 2-phenoxyethanol, and their fork lengths were measured (± 0.5 mm). Individual weights were determined by cumulative addition of fish into a pre-weighed pan of water on an Ohaus Dial-O-Gram balance (accuracy ± 0.1 g). Condition factors were calculated as K_p for early fry and K for other juveniles.

All catches of salmon were identified to species and counted individually, except night catches of Glendale pinks from April 9-24 and night catches of Tom Browne chums on April 16, 18 & 19, which were volumetric estimates due to large numbers. Samples of up to 30 fish per species were measured for fork lengths and weights at each site each day.

RESULTS

WATER TEMPERATURES

Surface Water Records

All known surface water temperature records and estimated monthly means are summarized for Tom Browne Creek in Table 2 and Glendale Creek in Table 3. In Table 4, the recorded temperature differences between the two system are compiled and best estimates are made which consider general observations of system variables. For example, it has been observed that Glendale Lake freezes more often and more extensively during the winter than Tom Browne Lake (probably because it is less than a quarter the size of Tom Browne); this, plus the fact that Glendale Creek is some 7 km longer, infers that cold-weather periods would have a greater cooling effect on the Glendale system. Conversely, warm weather should have a greater heating effect on the Tom Browne system, due to the much larger surface area of its lake.

Water temperatures and levels measured at the Glendale and Tom Browne fry trapping sites during April and May of 1983 are summarized in Figure 4 and compiled in Appendix 1. As might be expected, Tom Browne water temperatures were increasingly warmer than Glendale throughout the April-May period. Tom Browne water levels fluctuated in a similar but less pronounced pattern compared to Glendale Creek.

Temperatures of groundwater seepages in the Glendale area (Fig. 3) varied from 6.5-8.5°C at site 1 to 7.5-11.5°C at site 6 (Table 5); sites 2 and 3 dried out during mid-April to early May.

Surface Versus Subgravel Water Temperatures

It has often been observed that, when collecting benthic invertebrate or gravel core samples by hand from streams, the water temperature is cooler in the

TABLE 2. **Average monthly temperatures (± 0.5°C) for Tom Browne Creek from various sources, 1971 - 1983. If monthly record incomplete, dates of period on record are given in parentheses.**

MONTH	1971	1972	1973	1974	1975	1981	1982	1983	ADJUSTED MEAN
JAN		1.0 (25-31)	2.0	2.5			2.0		2.0
FEB		1.0	2.5		2.0	4.0 (17-28)		4.5 (3)	2.5
MAR		1.5	3.5	3.0 (26-31)	2.7	4.5			3.0
APR	5.5 (22-30)	3.0	6.5	5.0	5.0	6.0		10.0	6.0
MAY	8.5	8.0	11.5	10.0	9.5	13.5		13.0 (1-16)	10.5
JUN	13.5	15.0	13.5	12.0 (1-17)	15.0	15.5			14.0
JUL	15.5	17.0	17.5 (19-31)		18.5	15.0			16.5
AUG		18.5	17.0		17.0	15.5			17.0
SEP		15.0	15.0		15.0 (10-30)	14.5			15.0
OCT		10.0	11.5		11.5	12.0			11.5
NOV		7.0	5.5		8.0	8.5			7.5
DEC		3.5	4.5			6.0			4.5
SOURCE	DFO tapes	DFO tapes	DFO tapes	DFO tapes	DFO tapes	Black & Birch (MS 1982)	Black & Birch (MS 1982)	see Appx 1	

TABLE 3. Average monthly temperatures (± 0.5°C) for Glendale Creek from various sources, 1971-83. If monthly record incomplete, dates of period on record are given in parentheses.

Month	1971	1972	1981	1983	Adjusted Mean
JAN		1.0 (25-31)			2.0
FEB		2.0 (1-27)		3.0[a]-3.5[c] (3) (3-28)	2.5
MAR		3.5 (28-31)		4.5[c]-7.0[b] (31)	4.0
APR	3.5 (23-30)	3.0 (1-10)		7.0[b,c]	5.0
MAY	4.0		10.0 (14-31)	8.0[c]-8.5[b]	7.5
JUN	9.5 (1-5, 20-30)		10.5		10.0
JUL	15.0 (1-28)		13.5		14.5
AUG	14.0 (26-31)				14.5
SEP	11.0				11.0
OCT	10.5 (1-6, 13-27)				10.5
NOV					(6.0)[d]
DEC	2.0 (1-11)				2.0
SOURCE	DFO tapes	DFO tapes	Black & Birch (MS 1982)		

[a] B.Shepherd
[b] see Appx 1
[c] @ FRB weir
[d] estimated from trends in Tom Browne data (Table 2)

TABLE 4. Actual and estimated temperature differences (°C) for Tom Browne and Glendale Creeks. Positive value means Tom Browne is warmer than Glendale.

Month	1971	1972	1981	1983	Diff. From Means Table 2-3	'Best Guess'
JAN		0.0		+1.5	0.0	+1.0
FEB		-1.0			0.0	+1.0
MAR					-1.0	0.0
APR	+2.0			+3.0	+1.0	+2.0
MAY	+4.0		+3.5	+4.5	+3.0	+4.0
JUN	+4.0		+5.0		+4.0	+4.5
JUL	+0.5		+1.5		+2.0	+2.0
AUG					+3.0	+3.0
SEP					+4.0	+4.0
OCT					+1.0	+1.0
NOV					+1.5	+2.0
DEC					+2.5	+2.0

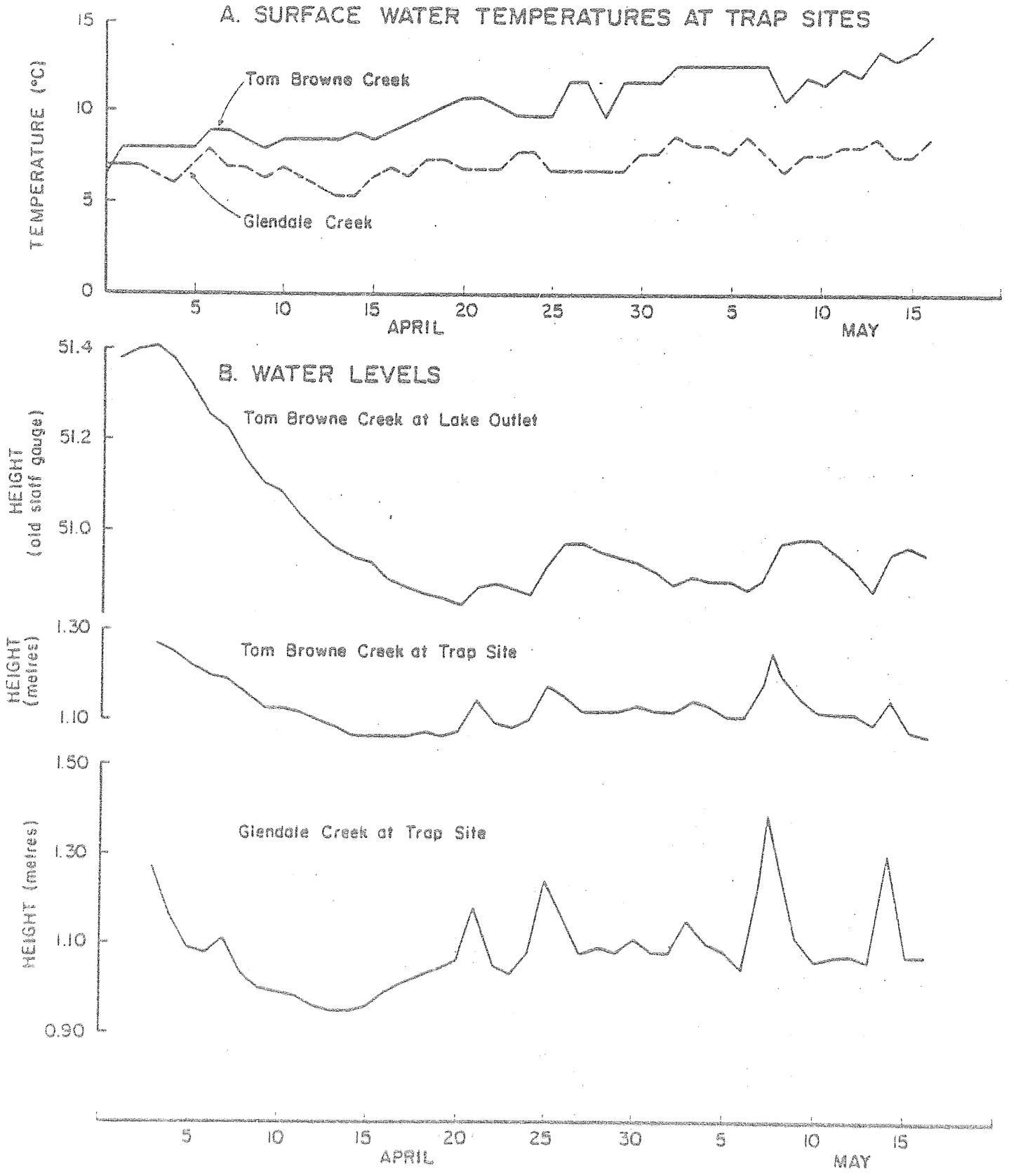

Figure 4. Water temperatures and levels measured at the Tom Browne and Glendale trapping sites during April and May of 1983.

TABLE 5. Temperature (°C) of groundwater seepage sites in the vicinity of the Glendale spawning channel site.

DATE	TIME	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6	SITE 7
April 7	0930	8	11.5	10.5	9	-	-	-
8	0630	8	11	10	9	-	-	-
9	0940	7	9	9.5	8	9	9	-
10	0930	6.5	8.4	8.6	7.5	7.5	7.7	-
11	0950	6.5	8	8.5	7.5	7.5	7.5	-
12	1015	6.5	8	8.5	8	8	8	-
13	0950	6	7.5	9	8.5	8.5	9	-
14	0950	8	7.5	11	8.5	8.5	8.5	-
16	1020	9	DRY	DRY	9.5	10	10.5	-
17	1030	8	DRY	DRY	9.5	11	11.5	-
18	1030	8.5	DRY	DRY	10	11	11.5	-
19	0950	8.5	DRY	DRY	10	11	12	-
20	0830	8.5	DRY	DRY	10.5	10	11.5	-
21	0800	7.5	DRY	DRY	9.5	8.5	9.5	-
22	0820	7.5	DRY	DRY	8.5	9	9.5	-
23	0725	7.5	DRY	DRY	8	9	10	-
24	0800	8	DRY	DRY	8	9	10.5	-
25	0800	7	DRY	DRY	9	9	10	-
26	0740	8	DRY	DRY	9	8.5	9	-
27	0725	7	DRY	DRY	8	7.5	8	-
28	0815	7	DRY	DRY	8	8	9	-
29	0830	8	DRY	DRY	8	8.5	10	-
30	0810	8.5	DRY	DRY	10	10	11.5	8
May 1	0810	8.5	DRY	DRY	10	10.5	11	-
2	0730	8.5	DRY	DRY	10	10	11	8
3	0820	8	DRY	DRY	10	10	11	8
4	0745	9	DRY	DRY	10	10	11	8
5	0745	9	DRY	DRY	10	10	11	8
6	0645	8.5	DRY	DRY	10	10	11	8
7	0810	8	DRY	DRY	9.5	9	10	8
8	0830	7.5	9	10	9	9	9	9
9	0825	7.5	9	10.5	9	9	9.5	9
10	0730	8	10	11	9	9	9.5	10
11	0720	8.5	12	12	10	10	11	9
12	0725	8	11.5	12.5	10	10	11	9
13	0730	8.5	12	11.5	10	9	11	8
14	0715	8	10	11	9	9	9	9
15	0715	8	9	11	9	9	9.5	9

subgravel. Presumably, the subgravel water temperature is buffered in a similar fashion to groundwater. Such a buffering action has to be considered whenever the duration of subgravel incubation is projected from temperature data. More rigorous measurement of this phenomenon has been done for the Terror Lake hydroelectric development project on Kodiak Island in Alaska, and for the Carnation Creek logging impact study on Vancouver Island. The Terror Lake studies (Wilson et al, MS 1979; MS 1980; MS 1981) employed continuous recorders and multiple temperature probes to compare surface water temperatures to subgravel temperatures down to 50 cm in depth. Probes were installed at a number of sites, and continuous recordings were made over 24 hr at intervals throughout the April-August period. The following conclusions were drawn from these studies:

(1) Intragravel temperatures ranged from 0.0 to 4.0°C warmer or cooler (usually 0.5-1.0°C cooler) than surface water temperatures.

(2) Subgravel temperature at some sites showed little relationship to surface temperature, possibly due to the influence of upwelling groundwater.

(3) Differences between shallow (10 cm) and deep (50 cm) subgravel temperatures were negligible.

(4) The largest temperature differences appeared to be due to diurnal heating of surface water; intragravel water temperature changes could lag behind surface changes by several hours.

(5) Over the summer, both subgravel and surface temperatures showed a parallel warming trend at most sites.

At Carnation Creek, subgravel temperatures were measured using a thermistor and 3 cm diameter plastic pipes set 30 cm into the gravel using a metal driving spud. On the basis of hundreds of measurements taken in the September-March period, the following observations were made (G. Hartman, pers. comm.):

(1) Measurement of subgravel temperature should be done immediately after the pipe is set. Some pipes were monitored over longer periods, and it was found that subgravel temperatures in these pipes equilibrated over time with surface water temperatures.

(2) Similar to the Terror Lake study subgravel temperatures were found to be up to 4°C warmer in winter or cooler in summer than the surface temperatures. On average, subgravel temperatures were cooler by 1°C or less in September and October; temperatures equilibrated about the end of October, and subgravel temperatures then became 1.0-1.5°C warmer than surface temperatures November through February; this had decreased to less than 0.5°C difference by the end of March, and presumably equilibrated shortly thereafter.

Both continuous recording thermographs and pipe sampling were done at Glendale (see Methods Section), and produced similar data to the studies reviewed above.

Data for February through November from the continuous recording thermographs (Appendix 2 and Table 6) confirmed that subgravel water temperature at approximately 30 cm depth could vary as much as 4°C from the surface temperature (eg. 14.9°C versus 18.8°C on July 29, 1983). In general, the subgravel temperature regime was buffered in comparison with surface water. Subgravel minimums were warmer in all months except June, July and October; subgravel maximums were cooler in all months. Average daily subgravel temperatures were approximately 0.5°C warmer in February, equilibrated in March or April, 0.5-2.0°C colder May through September, and equibrated again in October. As in the Terror Lake study, diurnal lags of 2-4 hr were common during the warmer months in Tom Browne Creek (Fig. 5).

Spot sampling using the driven pipe technique (see Appendix 2 for cross-section data) also gave comparable results. Sampling in February indicated that subgravel temperatures were 0.5°C warmer than surface; by early April, the situation had reversed (Table 7). It is of interest to note that the subgravel-surface equilibrium point does not appear to be determined by the point of greatest water density (4.0°C). For example, the February survey showed that Glendale surface water was 3.5°C and subgravel was 4.0°C; at the same time, Tom Browne surface water was 5.0°C and the subgravel temperature was 5.5°C. Probably this is because hydraulic turbulence and intragravel water flow dominate over density effects (R. Hamilton, pers. comm.). The greatest number of no-difference measurements in fact occurred in the mid-April survey at temperatures of 9-10°C. Save for a slight tendency for larger positive temperature differences to be associated with slower water, surface water flows and velocities at subgravel sample sites had no apparent relationship to the temperature differences observed on any survey date, or overall (Fig. 6).

TABLE 6. Extreme and average monthly temperatures for subgravel and surface water in Tom Browne Creek at the FRB weir (right bank) in 1983. Positive value indicates subgravel temperature is warmer than surface.

Month	MINIMUM °C			MAXIMUM °C			MEAN °C		
	SFC	SUB	DIFF	SFC	SUB	DIFF	SFC	SUB	DIFF
FEB (26)[a]	1.8	2.1	+0.3	4.4	3.8	-0.6	3.5	3.2	+0.3
MAR (31)	3.0	3.6	+0.6	6.2	5.0	-1.2	4.6	4.3	-0.3
APR (30)	4.8	4.9	+0.1	10.1	9.0	-1.1	6.9	6.9	0.0
MAY (28)	7.2	7.4	+0.2	14.8	13.5	-1.3	10.6	10.1	-0.5
JUN (30)	9.7	9.4	-0.3	14.0	13.7	-0.3	11.8	11.2	-0.6
JUL (31)	10.4	10.1	-0.3	18.8	16.4	-2.8	14.2	13.0	-0.8
AUG (10)	14.4	12.5	+0.1	18.4	16.2	-2.2	16.4	14.5	-1.9
SEP (18)	8.2	9.3	+1.1	14.0	12.9	-1.1	11.7	11.4	-0.3
OCT (31)	7.3	7.5	-0.2	11.5	10.9	-0.6	8.8	8.7	-0.1
NOV (6)	6.7	6.9	+0.2	8.0	7.8	-0.2	7.5	7.7	+0.2

[a] Number of days on record for both SFC and SUB

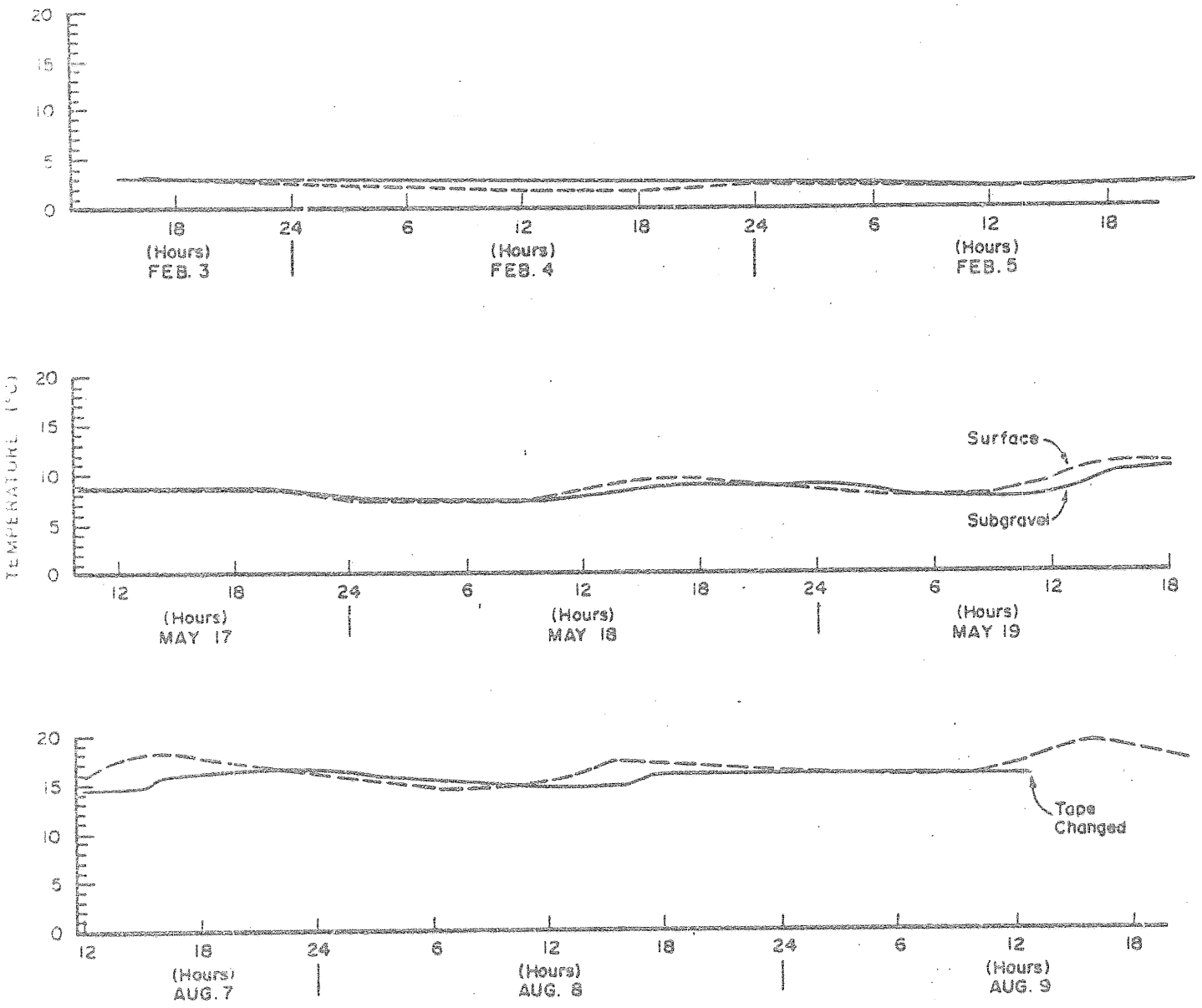

Figure 4. Excerpts from thermograph tapes selected to demonstrate diurnal lag and buffering effects in the subgravel thermal regime of Tom Browne Creek (at the FRB weir) in 1983.

TABLE 7. Average differences in subgravel and surface temperatures obtained during spot samplings of Glendale and Tom Browne Creeks in 1983. Positive value indicates subgravel temperature is warmer than surface.

Date	Sample Size	Mean °C Difference	Range
Feb 3	12	+0.6	-0.2 to +1.9
Apr 7-9	13	-0.5	-0.1 to -0.6
Apr 13-14	13	-0.3	0.0 to -1.5
Apr 19-20	13	-0.4	-1.0 to +1.0
Apr 26	15	-0.5	-0.3 to -1.0
May 10	14	-0.2	-0.5 to +0.5

TABLE 8: Best estimate of adjustments necessary to convert Glendale and Tom Browne surface water temperatures to subgravel water temperatures (see prior studies discussed in text and Tables 6 and 7).

Month	Adjust By	Month	Adjust By
Jan	+1.0°C	Jul	-1.0°C
Feb	+0.5°C	Aug	-2.0°C
Mar	0.0°C	Sep	-0.5°C
Apr	-0.5°C	Oct	no change
May	-0.5°C	Nov	+0.5°C
Jun	-0.5°C	Dec	+1.0°C

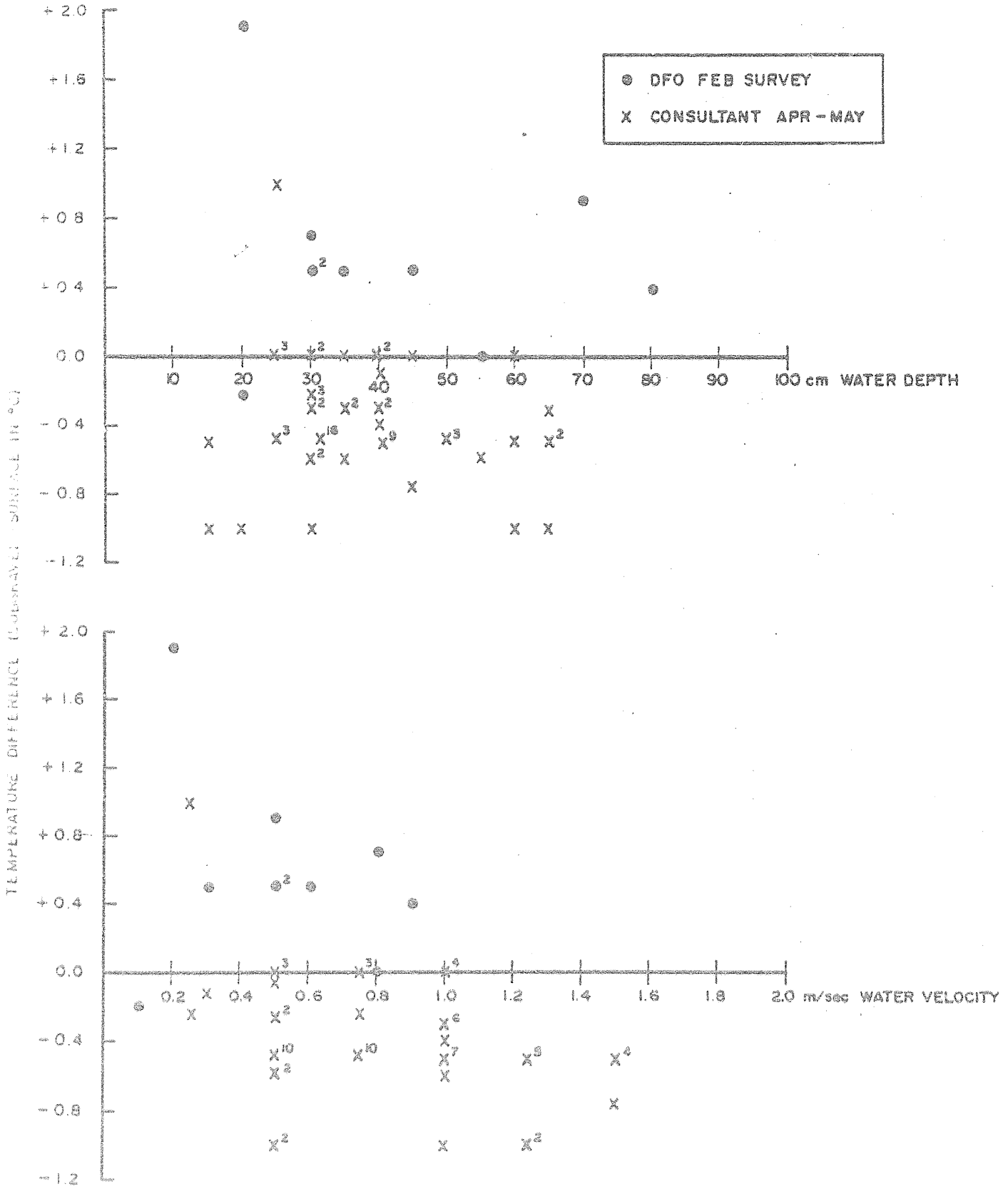

Figure 6. Plots of sample site water depth and velocity versus the observed subgravel-surface temperature difference. Superscribed numbers refer to number of identical site plots observed.

In summary, the subgravel-surface temperature behavior at Glendale appears to be similar to that obtained in the other two studies, despite the wide geographic separation. Use of the information obtained in all three studies allows conversion of Glendale and Tom Browne average monthly surface water temperatures into estimated subgravel water temperatures (Table 8).

JUVENILE MIGRATION STUDY

Abundance and Timing

Daily trap catches are provided for reference in Appendix 4. For all species of salmon, catches during the day were very minor compared to night catches (Table 9). It should also be recognized that the 2x3 IPT is an inefficient capture method for larger juvenile salmon.

Pink fry downstream migrations were underway in both systems when the study began on March 31 (Fig. 7A). At the beginning of the study, a few of the pink fry had a slight yolk slit, but most were well buttoned-up. Judging from the catches (see also Table 10), it is quite possible that migration peaked in Tom Browne Creek prior to March 31; therefore, little confidence is placed in the timing dates contained in Table 10 being indicative of that run's timing. Catches in Glendale Creek were much larger than in Tom Browne, and the timing data provided in Table 10 are considered indicative of the true migration.

Chum fry downstream migrations (Fig. 7B, Table 10) had also started prior to trap installation on March 31, but probably to a lesser degree. In this case, the relatively large number of fry caught in Tom Browne Creek gives some confidence that catches are indicative of the migration period. Considerably fewer fry were caught in the Glendale trap. Due to the later adult migration timing (August-October for pinks versus September-November for chums) and fewer numbers of spawners (150,000 pinks versus 2,000 chums according to the 1982 fishery officer report), it is hypothesized that these low catches reflected a concentration of chum spawning in Tom Browne Creek, rather than incomplete monitoring of fry migration. Observations by E.V.S. staff of chum spawning in 1983 confirms this hypothesis (M. Whelan, pers. comm.). Comparison of timing information (Table 10) for the two systems indicate that the Tom Browne run was advanced over the Glendale run by 2-3 wk.

Coho fry migrations for both systems (Fig. 7C, Table 10) were sporadic in pattern, perhaps due to the low numbers of fish caught. It was noted that the

TABLE 9. **Proportions of juveniles caught during the day compared to night (both systems combined).**

Species	Total No. Caught	Day Catch As % of Total	Night Catch As % of Total
Pink fry	508,940	0.05	99.95
Chum fry	119,140	0.24	99.76
Coho fry	16,326	<0.01	>99.99
Coho smolt	54	0.00	100.00
Sockeye Presmolt	98	0.00	100.00
Sockeye Smolt	53	15.09	84.91

TABLE 10. **Summary of timing of catches of downstream migrants in Glendale and Tom Browne Creeks in 1983. (Traps installed March 31 and removed May 16).**

Species	System	Total No. Caught	Est. Start	10% Catch	50% Catch	Peak Catch	90% Catch	Est. End
Pink Fry	Glendale	504,843	Before Mar 31	Apr 8	Apr 16	Apr 16	Apr 25	May 20
	Tom Browne	4,097	"	Apr 2	Apr 11	Apr 4 (or prior)	Apr 26	May 15
Chum Fry	Glendale	8,292	Apr 1	Apr 12	Apr 29	May 4	May 10	May 30
	Tom Browne	110,848	Before Mar 31	Apr 3	Apr 14	Apr 11	Apr 21	May 10
Coho Fry	Glendale	15,572	Apr 1	Apr 18	May 3	Apr 29/ May 4	May 11	After May 30
	Tom Browne	754	Apr 10	Apr 18	May 1	May 14	May 14	May 30
Coho Smolt	Glendale	54	Apr 13	Apr 22	May 4	May 8	May 11	May 15
	Tom Browne	0	-	-	-	-	-	-
Sockeye Presmolt	Glendale	96	Apr 19	Apr 28	May 9	May 9	May 16	After May 30
	Tom Browne	2				(Apr 17,29)		
Sockeye Smolt	Glendale	52	Apr 21	Apr 22	May 1	May 8	May 8	May 30
	Tom Browne	1				(Apr 13)		

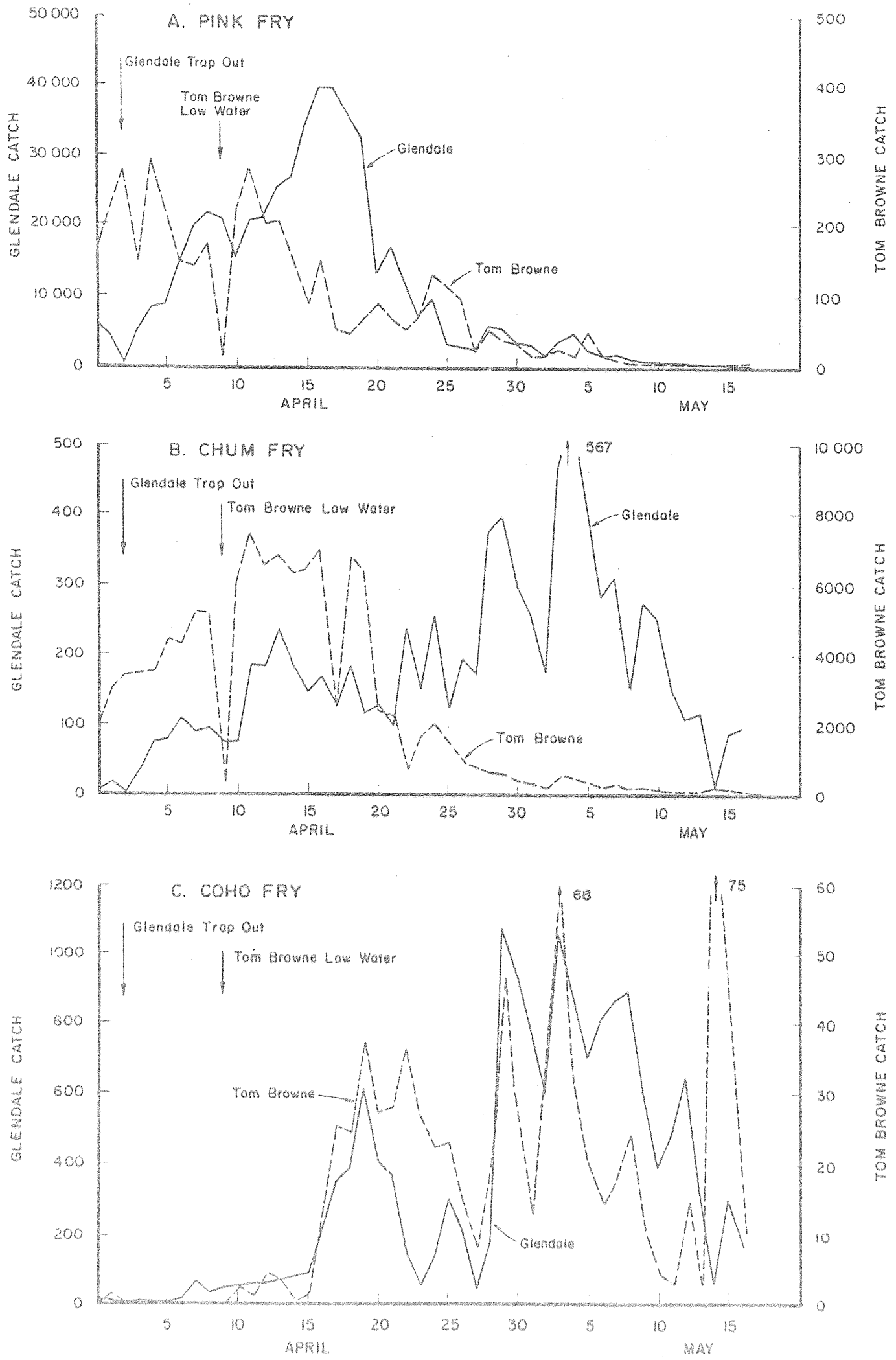

Figure 7. Daily trap catches of downstream migrant fry in the Tom Browne and Glendale systems during 1983.

Glendale total trap catches of coho fry were considerably higher than for Tom Browne. This result, together with the fact that no coho smolts were caught in the Tom Browne trap, indicates that coho make little use of the Tom Browne system.[a] Coho smolts were captured in low numbers in Glendale from mid-April to mid-May (peaking in the first week of May).

Sockeye (Table 10) were captured in small numbers mainly in the Glendale trap (148 smolts and presmolts versus a total of three from Tom Browne) from the third week of April to the end of the program, with peak catches in the first week of May.

Other Species caught throughout the trapping period included:

	Glendale	Tom Browne	Total
Steelhead (Kelt)	1	0	1
Trout[b]	38	27	65
Dolly Varden fry	3	2	5
Sticklebacks	0	13	13
Cottids	104	274	378
Lamprey - larvae	21	18	39
- adults	4	0	4

Most differences in presence and abundance of these other species can be attributed to the different habitats in each system. The Glendale has a longer reach of accessible stream, as opposed to the Tom Browne's short stretch of stream followed by a large cascade out of a large lake. Five live adult steelhead were also observed in the lower reaches of Glendale Creek during April.

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[a] During the fry migration study, personnel from Dougan Logging reported seeing coho in Tom Browne Creek above the lake.

[b] Resident cutthroat and trout fry (spp. unknown).

Fry Quality

Length, weight, and condition data (Appendix 5) are summarized in Table 11.

Pink fry had a mean fork length of 34 mm, a mean weight of 0.2 g and a mean K_D of 1.74. There were no significant differences between the two systems, and there were no trends noticeable over time.

Chum fry had a mean fork length of 38 mm, a mean weight of 0.3 g and a mean K_D of 1.82. No significant difference or trends between systems or over time was noticed.

Coho fry averaged 37 mm in fork length, 0.4 g in weight, and 0.79 K_D. Aside from a tendency for the smallest fish to come from the Tom Browne system, no other differences were noted. Glendale smolts averaged 75 mm in fork length, 5.1 g in weight, and 1.06 in K. No definite trends with time were noticed. No coho smolts were captured from Tom Browne Creek.

Sockeye smolts from Glendale averaged 80 mm in fork length, 4.6 g in weight, and 0.90 in K. No trends over time were noted.

DISCUSSION

TEMPERATURE CONTROL OF FRY EMIGRATION

In order to predict eyeing, hatching, and emergence dates for the purposes of facility design, we normally use the Accumulated Thermal Unit (ATU) approach. This is a reasonable method of prediction where the water temperature data used corresponds to that which the fish will experience in its incubation environment. A previous workup relating surface water temperatures to emigration of sockeye fry from the Babine spawning channels suggested that hatching and emigration occurred at lower ATUs (315 and 650-850 ATU, respectively) than the literature suggested (eg, Foerster, 1968, found that sockeye in a hatchery hatched at 480 ATU). Studies of subgravel temperatures at Terror Lake, Carnation Creek, and Knight Inlet (details of each are presented in the Results Section) confirm that the subgravel incubation environment is buffered in comparison to surface water temperatures.

It is now possible to relate the subgravel water temperature regimes to the

TABLE 11. Summary of fry quality data from 1983 IPT catches at Glendale (GD) and Tom Browne (TB) Creeks.

Species	System	Mean For Length in mm (Range)	Mean Wet Weight in g (Range)	Mean K_D (Range)
Pink fry	GD	34 (28-38)	0.2 (0.1-0.4)	1.74 (1.70-1.89)
	TB	34 (30-41)	0.2 (0.1-0.4)	1.75 (1.69-1.99)
Chum fry	GD	38 (35-39)	0.3 (0.2-0.5)	1.81 (1.70-1.98)
	TB	38 (35-42)	0.3 (0.2-0.6)	1.82 (1.77-1.97)
Coho fry	GD	37 (32-41)	0.4 (0.2-0.6)	0.79 (0.65-0.90)
	TB	36 (30-40)	0.4 (0.1-0.6)	0.79 (0.70-0.86)
Coho Smolts	GD	75 (46-110)	5.1 (0.9-12.0)	N/A
Sockeye Smolts	GD	80 (65-94)	4.6 (2.3 -8.1)	N/A

actual downstream migration data for Glendale and Tom Browne salmon fry in 1982-83. For pink fry, there is some uncertainty as to when peak spawning occurred in 1982. For the purposes of the analysis, it is presumed that spawning would have peaked between September 15 and 30. It is obvious from Table 12 that spawning on September 15 could result in fry migration being advanced by nine weeks in Tom Browne water and by three weeks in Glendale. This is because the September mean temperature incorporates the summer low-flow maximums. Staff from the Pacific Biological Station that were involved in pink salmon eggtakes in the 1960's observed that the pinks tended to hold near the mouth of Tom Browne Creek until the fall freshets (and cooler water) occurred. Thus the September 30 projections are considered more realistic (the freshet may occur earlier, but it is advised to use October temperatures in calculating the ATUs)[a]. The Glendale migration data from Table 10 matches very well with the projections made in Table 12:

Actual Peak of Migration	Projected Peak of Migration
April 13-16[b]	Apr 21 (could be 1-2 wk earlier)

Using the prediction from Table 12 would suggest that pink fry incubated in Tom Browne water would emerge 47 days earlier than if incubated in Glendale water.

A second check of the accuracy of this prediction method can be made using chum fry. If it is presumed that chums spawned October 10 in both systems in 1982[a] and that it requires 1000 ATU for emergence, the following projections and comparison are made for chum fry:

System	Actual Peak of Migration	Projected Peak of Migration
Glendale	Apr 29 - May 4	Apr 28
Tom Browne	Apr 11 - 14	Apr 10

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[a] In 1983, peak spawning was estimated to occur September 30-October 5 for pinks and October 10-15 for chums (Whelen and Morgan, MS 1984).

[b] In 1984, the date of peak pink fry migration was April 13 (Slaney, pers. comm.)

TABLE 12. Calculation of pink peak emergence dates based on 1982-1983 data where available, or adjusted averages from Tables 2-4 (TB = Tom Browne Creek; GD = Glendale Creek).

	Water Temp.		Subgravel Temp[c]		ATU Calculations			
	TB	GD	TB	GD	TB		GD	
Month (Days)	°C	°C	°C	°C	(Sep 15)	(Sep 30)	(Sep 15)	(Sep 30)
Sep (30)	15.0	11.0[b]	14.5	10.5	215	-	155	-
Oct (31)	11.5	10.5[b]	11.5	10.5	575	355	485	325
Nov (30)	7.5	5.5[b]	8.0	6.0	815	595	665	505
Dec (31)	4.5	2.5[b]	5.5	3.5	985 (Dec 25)[d]	765	770	615
Jan (31)	2.0	1.0[b]	3.0	2.0		855	835	675
Feb (28)	2.5	3.5[a]	3.0	4.0		940	895	735
Mar (31)	3.0	4.5[a]	3.0	4.5		1035 (Mar 5)[d]	985 (Mar 25)[d]	825
Apr (30)	10.0[a]	7.0[a]	9.5	6.5				1020 (Apr 21)[d]
May (6)	13.0[a]	8.5[a]	12.5	8.0				

[a] Actual 1983 data.

[b] Tom Browne data adjusting by 'best guess' of Table 4.

[c] Adjustment per Table 8 and associated text.

[d] Emergent stage at 950 ATU (date achieved).

The actual chum migration data match the projection for Glendale and Tom Browne extremely well.

In 1984, the Tom Browne pink fry migration peaked only nine days earlier than Glendale, and the Tom Browne chum peak was two days later than the Glendale peak (Slaney, pers. comm.). There could be a number of reasons for this result, but the essential point to be made is that, for pink fry, the 47-day difference should be considered as the maximum.

POTENTIAL FOR OVERLAP OF MARINE FOOD BLOOMS AND FRY MIGRATION

As salmon fry can experience significant mortality with just two weeks of starvation (see Introduction), migration occurring three to seven weeks prematurely remains a definite concern. The next factor to evaluate is the timing of the bloom of marine food organisms in relation to the timing of fry outmigrations. Fortuitously, Knight Inlet calanoid copepod seasonal populations have been studied by Stone (MS 1977). This group of zooplankton has been found to be of major importance to the diet of pink fry in several studies throughout the Pacific Northwest (eg, LeBrasseur, 1966; Manzer, 1969; Parker, 1969; Sibert and Parker, 1972; Parker and LeBrasseur, pers. comm.[a]; Feller, pers. comm.[a]; Allen, pers. comm.[a]).

Stone's results are summarized in Figure 8. Knight Inlet is classified as a dual-basin glacial run-off fjord, with Glendale Cove located near the mid-point of the inner basin. The dominant features of this system are a summer peak surface outflow of low-salinity turbid freshwater, and the replacement of deep waters by high-salinity intrusion associated with spring and summer upwelling along the outer Pacific Coast, in combination with uplifting and flushing actions via entrainment with the surface outflow. The latter, through dilution, also lessens the impacts of the freshwater run-off as one moves down the inlet (eg higher salinity, lower turbidity). In the vicinity of Glendale Cove, the seasonal profile of Inlet surface water (Fig. 8) was physically characterized in 1974-75 by:

(1) Declining salinity April into July, reaching a minimum of 5-10 ppt July through October, and recovering to 31 ppt after October.

(2) Increasing temperature March through to a June peak of 14°C, declining slightly to 12°C over the June - September period, then falling to the minimum of 6°C by December.

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[a] Proceedings of the 1974 Northwest Pacific pink and chum salmon workshop.

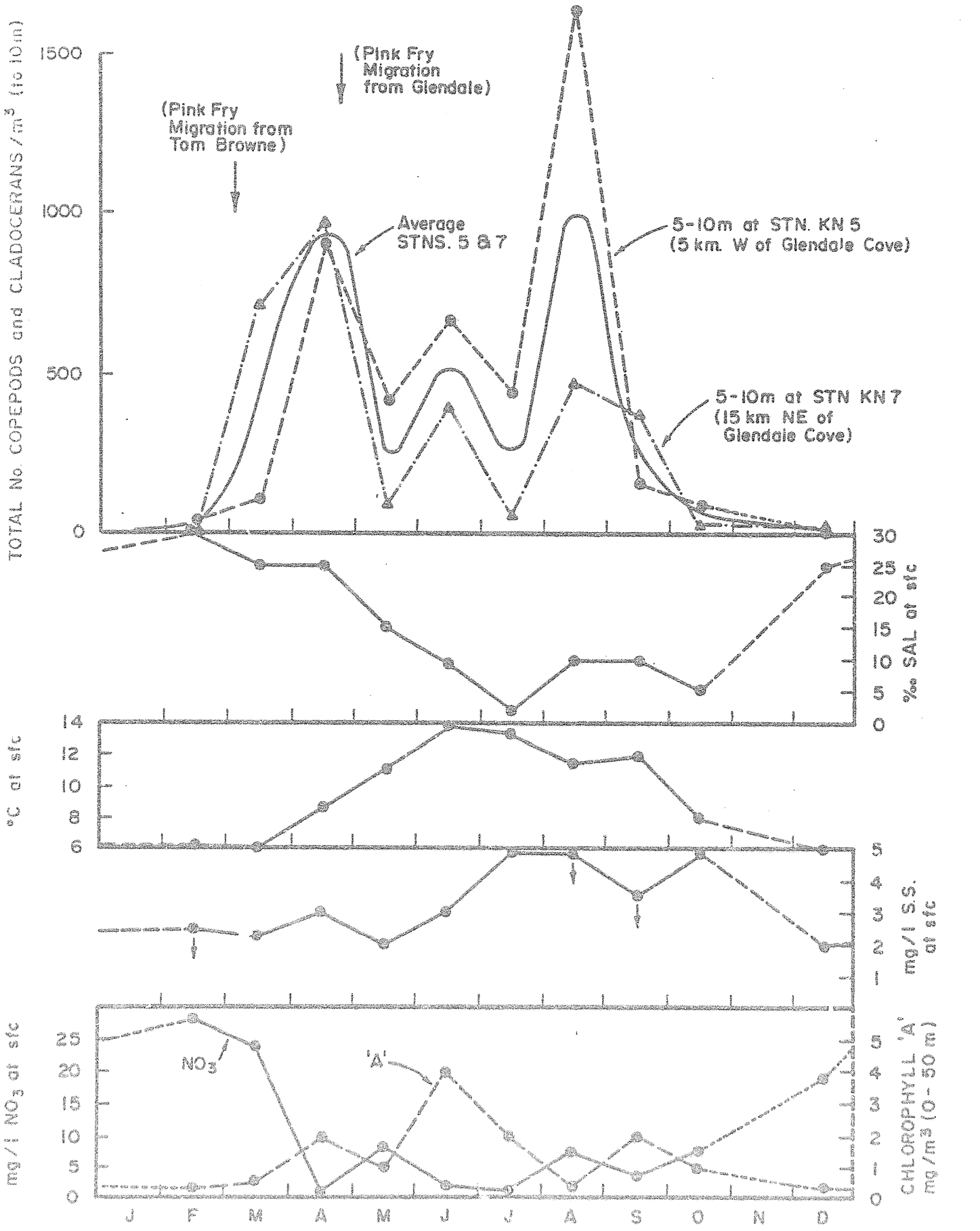

Figure 8. Graphical summary of Stone's (MS 1977) results with respect to the zooplankton and other biophysical characteristics of Knight Inlet.

(3) Increasing turbidity after May to peaks of 5 mg/l in July and October (it should be noted that this is considered a low level and would have only minor impacts on plankton production), and returning to 2 mg/l by December.

(4) A sharp decline in nitrate levels between March and April, with only minor recoveries through October.

(5) An inverse relationship of chlorophyll 'a' with nitrate, save that chlorophyll 'a' peaked in July.

The calanoid copepod and cladoceran plankton populations in the upper 10 m of the water column began to increase after February and reached a spring peak in April, declined in May, recovered slightly in July, and peaked strongly again in August. It is worth noting that the abundance and composition of zooplankton changed down the inlet. For example, Station KN 5 had two to four times the May-September abundance of Station KN 7, despite KN 5 being only 20 km further down the inlet (Fig. 8). In addition, the dominant species during the April and August peaks were different for each station:

Peak (Month)	Station	Dominant Species	Species Association with Water Regime
Spring	5	Pseudocalanus elongatus	Migrant
(April)	7	Calanus marshallae Frost	Migrant
Summer	5	Pseudocalanus elongatus	Migrant
(August)	7	Acartia clausi Giesbrecht	Surface/Transitional

The projected pink fry migration peak from Glendale Creek would appear to occur at or just after the peak of the spring plankton bloom. The earlier migration peak resulting from incubation in Tom Browne (above the Glendale confluence) water would put fry into the marine environment as plankton populations were starting to build. The data unfortunately are on a monthly basis only, and do not allow a more detailed comparison of timings. Nevertheless, this earlier timing may be acceptable in light of a general recommendation that fry releases should occur during a period of increasing, rather than decreasing, plankton biomass (LeBrasseur, pers. comm.). In

addition, Sibert and Parker (1972) have suggested that a two-week 'head start' of pink fry over coho smolts theoretically could have a significant and beneficial effect through reduction of predation.

An additional argument in support of this conclusion is the case of the Kemano River. In 1954, the Aluminum Company of Canada completed the Kemano I hydroelectric project, which diverted water from a depth of approximately 6 m in Tahtsa Lake, into the Kemano River 16 km above the estuary. The diversion flow was gradually increased until maximum capacity for power generation was reached in 1979. This has tripled the mean annual flow in the lower Kemano River (Environocon Ltd, MS 1981). It also has resulted in warmer water temperatures in the fall (averaging 2.4°C higher in October of 1980, for example) and presumably through most of the winter; however unlike the Tom Browne-Glendale situation, tailrace water was 2°C cooler than the upper Kemano River by April (Envirocon Ltd, MS 1981). If emergence projections are made for Kemano pink and chum stocks in the same fashion as was done for Glendale stocks, Kemano pink salmon are only advanced by five weeks. Looking at the escapement records (Manzon and Marshall, 1981), both pink and chum salmon stocks in the Kemano have increased:

Species	1951-60	1961-70	1971-80
Chum	9,000	41,000	49,000
Pink	61,000	51,000	82,000

Judging from other streams nearby, these increases are not part of a general trend for the area (Envirocon Ltd, MS 1981). All or part of these upward trends could be due to increased wetted habitat and more stable flows during incubation (Envirocon Ltd, MS 1981); the point to be made here is that 'premature' emigration of up to five weeks would appear to have either nil or beneficial impact on Kemano runs.

CONCLUSION AND RECOMMENDATIONS

A number of data gaps remain, which do not allow conclusions to be made in complete confidence. Nevertheless it is felt that, despite the possibility that pink fry could emerge 3-7 wk earlier from the proposed Glendale spawning channel than from Glendale Creek, it is unlikely that this will have a major negative impact on survival.

The following therefore was recommended:

(1) Further feasibility studies should proceed.

(2) The biological studies should include observations of marine zooplankton as well as of marine migration and diet of pink fry. Also, a more detailed redd emergence timing investigation in Tom Browne and Glendale influenced water should be added to the program.

(3) In the event that the above studies indicate that earlier migration would result in lower survival, some thought must be given to the acceptability of selecting the later portion of the pink spawning run as channel broodstock. This raises some major questions with respect to genetic integrity and possible separation of the run into channel and natural stocks, both in the fishery and the escapement. The Regional Planning and Economics Group has been asked to provide an overview of these general concerns as the relate to the Knight Inlet situation. If such an approach is not deemed acceptable, consideration might have to be given to cooling channel water for at least a portion of incubation. This most likely would require pumping water from Glendale Creek, which would be both more complex and expensive, and would required re-evaluation of project viability.

ACKNOWLEDGEMENTS

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REFERENCES

Bilton, H.T., and G.L. Robins. 1973. The effects of starvation and subsequent feeding on survival and growth of Fulton Channel sockeye salmon fry (Oncorhynchus nerka). J. Fish. Res. Bd. Can. 30 (1): 1-5.

Black, G., and G. Birch. MS 1982. Baseline limnological survey of Tom Browne Lake. Consultant report, prepared by Aquatic Resources Limited for Dept. Fish. Oceans, Vancouver. 80 p.

Envirocon Limited. MS 1981. Kemano completion hydroelectric development baseline environmental studies. Volume 6. Fish resource studies, Kemano system. Prepared by Envirocon Limited for Aluminum Company of Canada, Vancouver. 99 p + appendices.

Fielden, R., and T. Slaney. MS 1982. 1981 survey of salmonids spawning in selected streams of Knight Inlet, British Columbia. Consultant report, prepared by Aquatic Resources Limited for Dept. Fish. Oceans, Vancouver. 89 p + appendices.

Foerster, R.E. 1968. The sockeye salmon, Oncorhynchus nerka. Fish. Res. Bd. Can. Bull. 162. 422 p.

LeBrasseur, R.J. 1966. Stomach contents of salmon and steelhead trout in the northeastern Pacific Ocean. J. Fish. Res. Bd. Can. 23 (1): 85-100.

Manzer, J.I. 1969. Stomach contents of juvenile Pacific Salmon in Chatham Sound and adjacent waters. J. Fish. Res. Bd. Can. 26 (8): 2219-2223.

Manzon, C.I., and D.E. Marshall. 1981. Catalogue of spawning streams and spawning escapements of Statistical Area 6 North (Kitimat Arm). Can. Data Rept. Fish. Aquat. Sci. No. 300. 173 p.

Parker, R.R. 1969. Foods and feeding of juvenile pink salmon in central British Columbia waters. I. 1966 diel series. Fish. Res. Bd. Can. Man. Rept. Ser. No. 1017. 70 p.

Sibert, J., and R.R. Parker. 1972. A model of juvenile pink salmon growth in the estuary. Fish. Res. Bd. Can. Tech. Rept. No. 321. 62 p.

Stone, D.P. MS 1977. Copepod distributional ecology in a glacial run-off fjord. Ph.D. thesis, Univ. British Columbia, Vancouver. 256 p.

Thelen, M.A., and J.D. Morgan. MS 1984. 1983 spawning salmonid studies in selected watercourses of Knight Inlet, B.C. Consultant report, prepared by E.V.S. Consultants Limited for Dept. Fish. Oceans, Vancouver. 172 p + appendices.

Wilson, W.J., and L.S. Underwood. MS 1979. An assessment of environmental effects of construction of the Terror Lake hydroelectric facility, Kodiak Island, Alaska. Prepared by Arctic Environmental Information and Data Center for Kodiak Electric Association Inc., Kodiak. 334 p (pp 207-214).

Wilson, W.J., C.D. Evans, and M.S. Wilson. MS 1980. Environmental studies of the proposed Terror Lake hydroelectric project, Kodiak Island, Alaska. Intragravel water temperature studies. Prepared by Arctic Environmental Information and Data Center for Kodiak Electric Association, Inc., Kodiak, 57 p (pp 1-38).

Wilson, W.J., E.W. Trihey, J.E. Baldrige, C.D. Evans, J.G. Thiele, and D.E. Trudgen. MS 1981. An assessment of environmental effects of construction and operation of the proposed Terror Lake hydroelectric facility, Kodiak Island, Alaska. Instream flow studies final report. Prepared by Arctic Environmental Information and Data Center for Kodiak Electric Association, Inc., Kodiak. 419 p (pp 270-278).

Appendix 1. Hydrology records for Glendale trap sites, 1983.

OLD BRIDGE SITE

DATE	TIME	TEMP (C)	GAUGE (Ft)	NOTES
MARCH				
31				
APRIL				
1	1015		51.38	RECORDING AFTER
[illegible]	1030	8	51.40	COUNTING CATCH
[illegible]	1000	8	51.41	
4	1030	8.5	51.39	
5	1015	9	51.33	
6	1010	9	51.26	
7	1130	9.5	51.23	
8	1230	9	51.16	
9	1040	8	51.11	
10	1145	8.5	51.09	
11	1145	9	51.04	
12	1210	9.5	51.00	
13	1210	8.5	50.97	
14	1230	9.5	50.95	
15	1020	8.5	50.94	RECORDING BEFORE
16	1100	9.5	50.90	COUNTING CATCH
17	1155	9.5	50.88	
18	1045	10.5	50.87	
19	1020	11	50.86	
20	0845	11	50.84	
[illegible]	0820	11.5	50.88	
[illegible]	0945	10.5	50.89	
[illegible]	0745	10	50.88	
[illegible]	0820	10	50.87	
[illegible]	0830	10	50.93	
[illegible]	0930	12	50.98	
[illegible]	0750	12	50.98	
[illegible]	0940	10	50.96	
[illegible]	0850	12	50.95	
[illegible]	0835	12	50.94	
MAY				
1	0830	12	50.92	
2	0750	13	50.89	
3	0945	13	50.91	
4	0810	1[illegible]	50.90	
5	0815	13	50.90	
6	0715	13.5	50.88	
7	0830	13	50.90	
8	0855	11	50.98	
9	0855	13	50.99	
10	0800	13	50.99	
11	0750	13	50.96	
12	0750	12.5	50.93	
13	0815	[illegible]	51.38	
14	0620	[illegible]	50.96	
15	0740	14	50.93	
16	0735	15.5	50.96	

TRAP SITE

DATE	TIME	TEMP (C)	GAUGE (M)	NOTES
MARCH				
31	0815	6.5		
APRIL				
1	0830	8		
2	0745	8		
3	0900	8	1.27	
4	0930	8	1.25	
5	0900	8	1.22	
6	0930	9	1.20	
7	1030	9	1.19	
8	1130	8.5	1.16	
9	1000	8	1.13	
10	1000	8.5	1.13	
11	1000	8.5	1.12	
12	1040	8.5	1.10	
13	1020	8.5	1.09	
14	1010	9	1.07	
15	1025	8.5	1.07	
16	1110	9	1.07	
17	1100	9.5	1.07	
18	1055	10	1.08	
19	1030	10.5	1.07	
20	0855	11	1.08	
21	0830	11	1.15	
22	0855	10.5	1.10	
23	0755	10	1.09	
24	0830	10	1.11	
25	0840	10	1.18	
26	0805	12	1.16	
27	0800	12	1.13	
28	0850	10	1.13	
29	0900	12	1.13	
30	0840	12	1.14	
MAY				
1	0835	12	1.13	
2	0810	13	1.13	
3	0855	13	1.15	
4	0820	13	1.14	
5	0825	13	1.12	
6	0725	13	1.12	
7	0840	13	1.19	EVENING = 1.25
8	0905	11	1.21	
9	0905	12.5	1.16	NEW STAFF GAUGE,
10	0805	12	1.13	RESET TO MARK
11	0800	13	1.13	
12	0755	12.5	1.13	
13	0820	14	1.10	
14	0605	13.5	1.16	
15	0745	14	1.09	
16	0740	15	1.09	

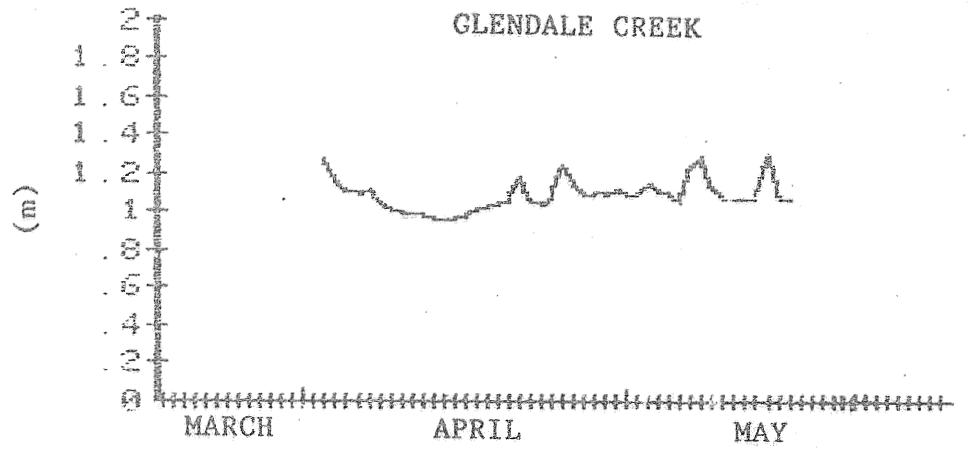
RECORD FOR GLENDALE 1983

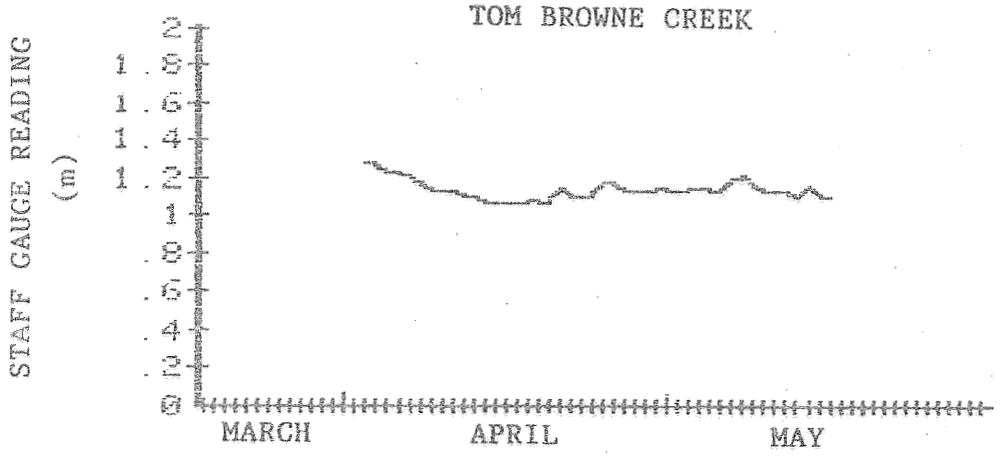
TRAP SITE

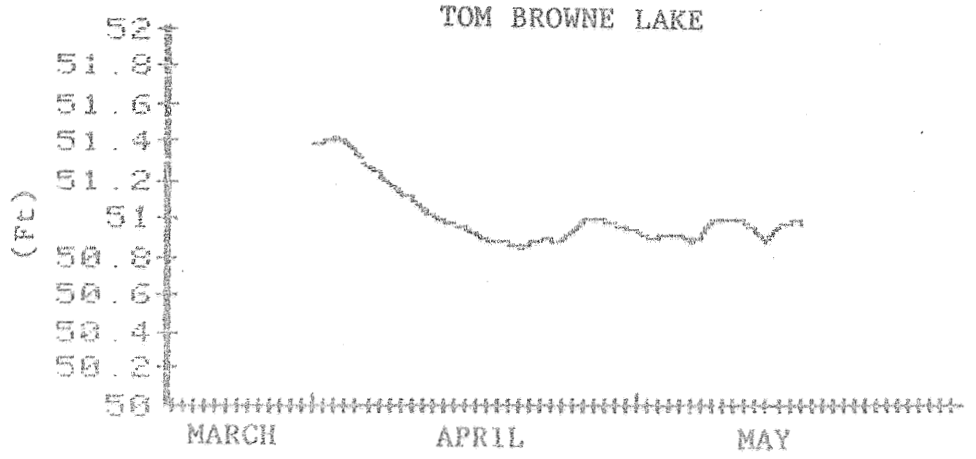
TIME	TEMPERATURE (C) MINIMUM	MAXIMUM	PRESENT	GAUGE (M)
0630			7	
0720			7	
0630			7	
0630	6	7	6.5	1.27
0630	6	7.5	6	1.16
0640	7	8	7	1.09
0630	6	9	8	1.08
0700	7	8	7	1.11
0730	8	9	7	1.03
0630	7	8.5	6.5	1.00
0700	6.5	8	7	0.99
0700	6.5	8	6.5	0.98
0650	6	8	6	0.96
0645	5.5	8.5	5.5	0.95
0630	5	8	5.5	0.95
0630	5.5	8.5	6.5	0.96
0630	6	9.5	7	0.99
0630	6.5	8.5	6.5	1.01
0700	6.5	9.5	7.5	1.03
0630	7.5	10	7.5	1.04
0600	6	9	7	1.06
0530	7	9	7	1.18
0630	6.5	8.5	7	1.05
0615	7	9	8	1.03
0630	7.5	10	8	1.08
0630	7	8.5	7	1.24
0620	7	8	7	1.15
0630	7	9	7	1.08
0630	6.5	10	7	1.09
0630	7	10	7	1.08
0630	7.5	11	8	1.11
0630	7	11	8	1.08
0630	8.5	9.5	9	1.06
0630	9	10	8.5	1.15
0630	8.5	9.5	8.5	1.10
0630	8	10	8	1.08
0600	7	10	9	1.04
0730	8	10	8	1.24
0730	7	7.5	7	1.28
0730	7	9	8	1.11
0630	7	9	8	1.06
0630	8	11.5	8.5	1.07
0630	8.5	11.5	8.5	1.07
0700	8	12.5	9	1.06
1635	8	11.5	8	1.30
0630	7.5	9.5	8	1.07
1630	8	11	9	1.07

FRB WEIR SITE

DATE	TIME	TEMP (C)	GAUGE (M)	NOTES
MARCH				
31				
APRIL				
1				
2	1530	7	1.10	
3				
4				
5				
6				
7				
8				
9	1600	8.2	0.94	SUB GRAVEL TEMP
10				
11				
12	1630	7.5	0.88	CHECK DFO RYANS
13	1635	10.5	0.84	SUB GRAVEL ANAL.
14				
15				
16				
17				
18				
19				
20	1650	11	0.89	AT GLENDALE BR
21				GAUGE = 1.08
22				
23				
24				
25				
26	1625	12	0.94	SUB GRAVEL ANAL.
27				
28				
29				
30	1900	13	0.90	
MAY				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10	1630	14	0.91	
11				
12				
13				
14				
15				
16	0815	15	0.91	


GLENDALE CREEK
(m)
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
0
MARCH
APRIL
MAY


TOM BROWNE CREEK
STAFF GAUGE READING
(m)
1.8
1.6
1.4
1.2
1
.8
.6
.4
.2
0
MARCH
APRIL
MAY


TOM BROWNE LAKE
(Ft)
52
51.8
51.6
51.4
51.2
51
50.8
50.6
50.4
50.2
50
MARCH
APRIL
MAY

Appendix 2. Surface and subgravel water temperature records from FRB weir area.

TOM BROWNE - RIVER 1983

MONTH	MIN.C	MAX.C	MEAN.C	# OF DAYS
JANUARY		NO DATA		
FEBRUARY	1.8	4.4	3.53	26
MARCH	3	6.2	4.58	31
APRIL	4.8	10.1	6.89	30
MAY	7.2	14.8	10.54	28
JUNE	9.7	14	11.79	30
JULY	10.4	18.8	14.18	31
AUGUST	14.4	18.4	16.43	10
SEPTEMBER	8.2	14	11.7	18
OCTOBER	7.3	11.5	9.77	31
NOVEMBER	5.2	8	6.58	26
DECEMBER		NO DATA		

TOM BROWNE - SUBGRAVEL 1983

MONTH	MIN.C	MAX.C	MEAN.C	# OF DAYS
JANUARY		NO DATA		
FEBRUARY	2.1	3.8	3.24	26
MARCH	3.6	5	4.3	31
APRIL	4.9	9	6.89	30
MAY	7.4	13.5	9.96	19
JUNE	9.4	13.7	11 24	30
JULY	10.1	16.4	13.02	31
AUGUST	12.5	18.6	15.39	31
SEPTEMBER	9.3	14.9	11.98	30
OCTOBER	7.5	10.9	8.66	31
NOVEMBER	6.9	7.8	7.65	6
DECEMBER		NO DATA		

TOM BROWNE - RIVER 1983

J.D.	MIN.C	MAX.C	MEAN.C
FEBRUARY			
32			
33			
34	1.8	2.9	2.35
35	1.9	2.4	2.15
36	2.4	2.6	2.5
37	2.3	3	2.65
38	2.4	2.9	2.65
39	2.8	3	2.9
40	2.8	3	2.9
41	3	3.8	3.4
42	3.7	3.8	3.75
43	3.8	4	3.9
44	3.8	3.8	3.8
45	3.8	4.2	4
46	3.9	4.1	4
47	3.9	4.1	4
48	3.9	4.3	4.1
49	4	4	4
50	4	4.4	4.2
51	3.9	4.3	4.1
52	3.9	4.1	4
53	3.9	4.2	4.05
54	3.9	4.3	4.1
55	3.8	4.2	4
56	3.3	4.1	3.7
57	3.3	4	3.65
58	3.2	4	3.6
59	3	3.9	3.45
MARCH			
60	3.1	4	3.55
61	3.1	4.2	3.65
62	3	4	3.5
63	3.1	4	3.55
64	3.8	4	3.9
65	3.8	4.1	3.95
66	3.8	4.1	3.95
67	4	4.8	4.4
68	4.4	4.8	4.6
69	4.4	4.8	4.6
70	4	4.8	4.4
71	4	4.8	4.4
72	3.8	4.7	4.25
73	3.8	5	4.4
74	3.8	5	4.4
75	3.9	5.1	4.5
76	4	5.7	4.85
77	4	5.4	4.7
78	4.2	6.1	5.15
79	4.6	6	5.3
80	4.9	5.8	5.35
81	4.2	5.9	5.05
82	3.8	6	4.9
83	4	6	5
84	4.7	5.8	5.25
85	4.8	5.8	5.3
86	4.6	4.9	4.75
87	4.6	5.1	4.85
88	4.6	5.2	5
89	5	6.2	5.6
90	4.8	5.2	5

TOM BROWNE - SUBGRAVEL 1983

J.D.	MIN.C	MAX.C	M
FEBRUARY			
32			
33			
34	2.4	2.8	
35	2.1	2.5	
36	2.2	2.4	
37	2.3	2.5	
38	2.5	2.7	
39	2.7	2.7	
40	2.7	2.8	
41	2.8	3.2	
42	3.1	3.2	
43	3	3.3	
44	3.2	3.3	
45	3.2	3.3	
46	3.3	3.3	
47	3.2	3.4	
48	3.3	3.5	
49	3.5	3.6	
50	3.5	3.7	
51	3.6	3.7	
52	3.7	3.7	
53	3.7	3.7	
54	3.7	3.8	
55	3.8	3.8	
56	3.8	3.8	
57	3.8	3.8	
58	3.8	3.8	
59	3.7	3.8	
MARCH			
60	3.7	3.7	
61	3.7	3.7	
62	3.6	3.7	
63	3.6	3.7	
64	3.6	3.7	
65	3.6	3.7	
66	3.7	3.7	
67	3.7	3.8	
68	3.8	4	
69	4	4	
70	4	4	
71	4	4.1	
72	4	4	
73	4	4.1	
74	4	4.1	
75	4	4.1	
76	4.1	4.2	
77	4.2	4.6	
78	4.5	4.6	
79	4.6	4.9	
80	5	5	
81	4.9	5	
82	4.8	5	
83	4.7	5	
84	4.9	5	
85	4.9	5	
86	4.9	5	
87	4	5	
88	5	5	
89	5	5	

APRIL

	MIN.C	MAX.C	MEAN.C
[illegible]	4.8	5.2	5
[illegible]	4.9	6.4	5.65
[illegible]	5	6.8	5.9
[illegible]	5.5	7.2	6.35
[illegible]	5.5	7	6.25
[illegible]	4.8	6.8	5.8
[illegible]	5	6.8	5.9
[illegible]	5.2	6.2	5.7
[illegible]	5.4	6.2	5.8
[illegible]	5.2	7	6.1
[illegible]	4.9	8	6.45
[illegible]	5.2	8	6.6
[illegible]	5.6	8.8	7.2
[illegible]	5.9	9	7.45
[illegible]	5.8	9	7.4
[illegible]	6.2	8.8	7.5
[illegible]	6.3	9.1	7.7
[illegible]	6.5	8.3	7.4
[illegible]	5.6	6.8	6.2
[illegible]	5	7.3	6.15
[illegible]	6.4	8.2	7.3
[illegible]	6.3	9.4	7.85
[illegible]	6.1	7.3	6.7
[illegible]	6.2	7	6.6
[illegible]	6.5	8.1	7.3
[illegible]	6.8	9.3	8.05
[illegible]	7.2	10.1	8.65
[illegible]	7.8	10	8.9
[illegible]	7.4	10.1	8.75
[illegible]	7.8	8.6	8.2

	MIN.C	MAX.C	MEAN.C
91	4.9	5.8	5.35
92	5.1	6.2	5.65
93	5.5	6.7	6.1
94	6.4	6.7	6.55
95	5.4	6.7	6.05
96	5.2	6.4	5.8
97	5.5	6.5	6
98	5.9	5.9	5.9
99	5.9	6.5	6.2
100	5.5	7.2	6.35
101	5.1	7.2	6.15
102	5.4	7.8	6.6
103	5.8	7.9	6.85
104	6	7.9	6.95
105	5.8	7.9	6.85
106	6.6	8.1	7.35
107	6.7	8	7.35
108	6.8	7.8	7.3
109	6	6.9	6.45
110	6.3	7.5	6.9
111	7.4	8.6	8
112	6.9	8.5	7.7
113	6.4	7	6.7
114	6.6	7.7	7.15
115	6.8	8.5	7.65
116	6.9	8.9	7.9
117	7.1	9	8.05
118	7.9	9	8.45
119	7.7	9	8.35
120	7.8	8.2	8

MAY

	MIN.C	MAX.C	MEAN.C
[illegible]	7.4	8.9	8.15
[illegible]	7.4	8.2	7.8
[illegible]			
[illegible]			
[illegible]			
[illegible]	8.5	10.5	9.5
[illegible]	9	7.5	8.25
[illegible]	7.2	9.3	8.25
[illegible]	7.8	11	9.4
130	8.8	10	9.4
[illegible]	8.6	11	9.8
[illegible]	8.5	11.7	10.1
[illegible]	9.1	12	10.55
134	9	12.8	10.9
[illegible]	9.7	12.1	10.9
[illegible]	9.7	12.5	11.1
[illegible]	9.8	13.8	11.8
138	10.2	14.1	12.15
139	10.9	14	12.45
140	10.3	12.8	11.55
141	11.2	11.5	11.35
142	10.5	11.2	10.85
143	10.2	11.7	10.95
144	10.2	12.9	11.55
145	10.1	12.5	11.3
146	9.8	10.9	10.35
147	9.8	11.3	10.55
148	10.3	14.8	12.55
149	11.2	13.3	12.25
150	9.8	12	10.9
151	9.3	11.4	10.35

	MIN.C	MAX.C	MEAN.C
121	7.8	8.2	8
122	7.8	8	7.9
123	7.6	8.1	7.85
124			
125			
126			
127			
128			
129			
130			
131			
132			
133			
134			
135			
136	8.5	9.6	9.05
137	7.6	9.5	8.55
138	7.4	8.9	8.15
139	7.8	10.2	9
140	8.8	9.8	9.3
141	8.8	10.4	9.6
142	8.8	10.9	9.85
143	9.3	11.4	10.35
144	9	12.1	10.55
145	9.8	11.6	10.7
146	9.9	12	10.95
147	10	13.1	11.55
148	10.3	13.4	11.85
149	10.8	13.5	12.15
150	11.5	12.6	12.05
151	11.2	12.3	11.75

JUNE

	MIN.C	MAX.C	MEAN.C
152	11	12.8	11.9
153	11.8	12.8	12.3
154	11.9	12.6	12.25
155	10.5	12.3	11.4
156	10.6	11.7	11.15
157	9.7	10.7	10.2
158	9.7	11.3	10.5
159	10.6	12.2	11.4
160	11	12.5	11.75
161	11.5	14	12.75
162	11.8	13.7	12.75
163	10.4	12.6	11.5
164	10.4	10.9	10.65
165	9.9	10.8	10.35
166	10	10.9	10.45
167	10.9	12.6	11.75
168	12.1	13.9	13
169	11.4	12.7	12.05
170	11.5	12.6	12.05
171	11.5	12.9	12.2
172	11.5	12.4	11.95
173	10.9	11.6	11.25
174	11.2	12.5	11.85
175	11.8	12.5	12.15
176	11.6	13.8	12.7
177	12	13	12.5
178	10.8	13	11.9
179	11.2	13.9	12.55
180	12	13	12.5
181	11.2	12.5	11.85

JULY

	MIN.C	MAX.C	MEAN.C
182	10.4	10.8	10.6
183	10.8	12.9	11.85
184	11	12.6	11.8
185	11.3	11.8	11.55
186	11.6	12.6	12.1
187	12	14	13
188	12.6	15	13.8
189	13.4	15.9	14.65
190	14.4	16.4	15.4
191	15	15.6	15.3
192	13.9	15	14.45
193	14.1	16.9	15.5
194	14.7	16.7	15.7
195	15.3	17.5	16.4
196	15.5	17.3	16.4
197	12.5	15.5	14
198	11.5	12.5	12
199	11.9	12.8	12.35
200	12.2	14.8	13.5
201	13	16.4	14.7
202	14.2	16.3	15.25
203	14.4	15.4	14.9
204	12.2	14.8	13.5
205	12.2	13.7	12.95
206	12.8	15	13.9
207	13.4	15.5	14.45
208	14	16	15
209	14.4	17	15.7
210	14.4	16.1	15.25
211	15.6	18.8	17.2
212	14.8	18.1	16.45

JUNE

	MIN.C	MAX.C	M
152	10.8	11.2	11
153	10.5	11.3	10
154	10.5	12.2	11
155	10.4	11.5	10
156	9.9	11.1	10
157	9.8	10.8	10
158	10.5	13.7	12
159	11.3	12.8	12
160	9.8	12.3	11
161	9.8	10.1	9.
162	9.4	10.7	10
163	10.6	12	11
164	11.8	12	11
165	11.9	12	11
166	10.8	12	11
167	10.9	11.6	11
168	9.8	10.9	10
169	9.7	10.8	10
170	10.8	11.3	11
171	10.1	11.9	11
172	11.8	13.2	12
173	11.1	13.2	12
174	10.8	13	11
175	10.5	10.9	10
176	10.1	10.4	10
177	10.2	11.3	10
178	10.3	13.1	11
179	12.3	13	12
180	11.7	12.2	11
181	11.5	12.5	12

JULY

	MIN.C	MAX.C	ME
182	11.6	12.5	12
183	10.1	10.5	10
184	10.1	12	11
185	12	12	12
186	11.7	13	12
187	12.1	13	12
188	11	12.3	11
189	11.3	13.2	12
190	12.2	13.1	12
191	11.6	12.5	12
192	10.6	11.7	11
193	10.6	12.1	11
194	11.3	12.1	11
195	10.2	10.3	10
196	10.3	12	11
197	12	13	12
198	12.8	14.2	13
199	13.5	15	14
200	14.3	15.8	15
201	15.3	15.8	15
202	14.1	15.2	14
203	14.3	16	15
204	14.8	15.8	15
205	15.4	16.4	15
206	15.6	16.2	15
207	13.9	15.9	14
208	11.8	14.9	13
209	11.8	12.1	11
210	12.1	13.5	12
211	13	14.9	13
212	14.1	14.9	14

AUGUST

	MIN.C	MAX.C	MEAN.C
	15.2	18	16.6
	15.8	16.7	16.25
	15.6	17.7	16.65
	15	17.5	16.25
	15.2	17.7	16.45
	15.6	16.5	16.05
	15.2	17.8	16.5
	15.4	18.4	16.9
	14.4	17.7	16.05
	14.8	18.3	16.55

	MIN.C	MAX.C	MEAN.C
213	14.3	14.9	14.6
214	13	14.5	13.75
215	12.5	13	12.75
216	13	14	13.5
217	13.7	14.5	14.1
218	14.1	15.3	14.7
219	14.7	16.2	15.45
220	14.8	16.2	15.5
221	15.8	16	15.9
222	15.3	18.6	16.95
223	15.5	17.8	16.65
224	15.9	18.2	17.05
225	15.9	17	16.45
226	15.2	17.9	16.55
227	15.5	17.3	16.4
228	15.6	17.3	16.45
229	15.3	16	15.65
230	15.4	17.1	16.25
231	14.5	17.8	16.15
232	14.8	16.9	15.85
233	15	17.4	16.2
234	15.2	17.4	16.3
235	15.1	17.4	16.25
236	15.1	16.5	15.8
237	14.9	15.8	15.35
238	14.8	16.1	15.45
239	14.8	16.9	15.85
240	14.9	16.3	15.6
241	12.5	14.9	13.7
242	12.6	13	12.8
243	12.8	13.5	13.15

TEMBER

	MIN.C	MAX.C	MEAN.C
	12.3	12.9	12.6
	12.4	13.6	13
	12	13.8	12.9
	12	13.4	12.7
	10.4	12.1	11.25
	10.9	12.1	11.5
	8.9	13.2	11.05
	9.8	13	11.4
	9.7	13.5	11.6
	10.6	14	12.3
	11.5	13.8	12.65
	12.1	13	12.55
	11.9	13.2	12.55
	11.4	13.7	12.55
	9.3	11.4	10.35
	9.1	11.5	10.3
	8.2	11.6	9.9
	8.4	10.6	9.5

SEPTEMBER

	MIN.C	MAX.C	MEAN.C
244	13.2	14.9	14.05
245	13.7	14.1	13.9
246	13.3	14	13.65
247	13.4	13.9	13.65
248	13	13.9	13.45
249	11.4	13.8	12.6
250	11.5	12	11.75
251	11.8	12.5	12.15
252	12.1	13	12.55
253	12	13.5	12.75
254	11	12	11.5
255	11.1	11.6	11.35
256	11.6	12.4	12
257	12.4	12.9	12.65
258	12.2	12.9	12.55
259	12.1	12.7	12.4
260	10.9	12.1	11.5
261	10.9	11.4	11.15
262	10.8	11.8	11.3
263	10.9	11.8	11.35
264	11.1	11.9	11.5
265	11.2	12.3	11.75
266	11.6	12.2	11.9
267	12	12.3	12.15
268	12.2	12.3	12.25
269	11.5	12.6	12.05
270	9.5	10.5	10
271	9.6	10.3	9.95
272	9.4	10.3	9.85
273	9.3	10	9.65

OCTOBER

	MIN.C	MAX.C	MEAN.C
274	8.8	10.7	9.75
275	9.8	11.2	10.5
276	10.3	10.9	10.6
277	9.1	10.8	9.95
278	8.3	11.5	9.9
279	8.5	10.6	9.55
280	7.7	10.3	9
281	8.3	10.2	9.25
282	8.9	10	9.45
283	8.4	9.9	9.15
284	8.3	10.1	9.2
285	7.5	9.9	8.7
286	8.2	9.3	8.75
287	9.1	9.4	9.25
288	8.4	9.9	9.15
289	8.5	9.6	9.05
290	7.7	8.9	8.3
291	7.3	8.3	7.8
292	7.6	8.1	7.85
293	7.8	8	7.9
294	8.1	8.9	8.5
295	8.3	8.5	8.4
296	8.4	9	8.7
297	8.3	8.9	8.6
298	7.7	8.3	8
299	7.8	7.9	7.85
300	7.8	8.1	7.95
301	7.4	8.1	7.75
302	7.5	7.9	7.7
303	7.5	8	7.75
304	7.4	7.7	7.55

NOVEMBER

	MIN.C	MAX.C	MEAN.C
305	7.6	8	7.8
306	7.3	7.8	7.55
307	7.4	7.9	7.65
308	7.3	8	7.65
309	7.3	7.7	7.5
310	6.7	7.4	7.05
311	6.7	7.2	6.95
312	6.5	7.1	6.8
313	6.6	6.9	6.75
314	6.1	6.8	6.45
315	6.2	6.8	6.5
316	6.5	7	6.75
317	6.4	6.5	6.45
318	6.5	6.7	6.6
319	6.2	6.7	6.45
320	6.3	6.9	6.6
321	6.5	6.9	6.7
322	6.5	6.6	6.55
323	6.1	6.6	6.35
324	6.2	6.4	6.3
325	5.7	6.4	6.05
326	5.4	5.9	5.65
327	5.5	5.8	5.65
328	5.3	5.8	5.55
329	5.2	5.5	5.35
330	5.3	5.8	5.55
331			
332			
333			
334			

OCTOBER

	MIN.C	MAX.C	MEA
274	9.3	10	9.65
275	9.9	10.7	10.3
276	10.6	10.7	10.65
277	9.2	10.9	10.05
278	8.9	9.8	9.35
279	9	9.8	9.4
280	8.8	9.7	9.25
281	8.9	9.3	9.1
282	9.1	9.5	9.3
283	8.9	9.8	9.35
284	8.8	9.4	9.1
285	8.3	9.2	8.75
286	8.4	9	8.7
287	9	9.1	9.05
288	8.6	9.3	8.95
289	8.6	8.8	8.7
290	7.6	8.7	8.15
291	7.5	7.9	7.7
292	7.6	7.8	7.7
293	7.7	7.8	7.75
294	7.8	8.3	8.05
295	8.3	8.3	8.3
296	8.2	8.3	8.25
297	8.2	8.3	8.25
298	7.8	8.2	8
299	7.8	7.8	7.8
300	7.8	7.9	7.85
301	7.8	7.9	7.85
302	7.7	7.8	7.75
303	7.7	7.8	7.75
304	7.6	7.7	7.65

NOVEMBER

	MIN.C	MAX.C	MEAN.
305	7.7	7.8	7.75
306	7.7	7.7	7.7
307	7.7	7.7	7.7
308	7.7	7.8	7.75
309	7.6	7.7	7.65
310	6.9	7.8	7.35
311			
312			
313			
314			
315			
316			
317			
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Appendix 3. Cross-section surveys of subgravel and surface water temperatures.

DATE: APRIL 7-9 1983

CALIBRATION: 7.6 POCKET: 8 YSI METER 6.5

CROSS SECTIONS:

SITE DESCRIPTION	WATER DEPTH (CM)	VELOCITY OF FLOW (M/SEC)	SURFACE TEMP (C)	SUBGRAV. TEMP (C)	DIFF
1. GLENDALE CREEK, U/S BRIDGE, LEFT BANK TO RIGHT BANK:					
3 PACES	31	.5	7.5	6.7	-.8
6 PACES	42	1	7.4	7	-.4
9 PACES	32	1	7.4	6.9	-.5
12 PACES	54	1	7.5	6.9	-.6
2. GLENDALE CREEK, DS OF BRIDGE, LEFT BANK TO RIGHT BANK:					
3 PACES	32	.75	7.5	7	-.5
6 PACES	39	.9	7.5	7	-.5
9 PACES	39	.9	7.5	7	-.5
12 PACES	41	.9	7.5	7	-.5
15 PACES	33	1	7.5	7	-.5
3. TOM BROWNE, 100 M DS OF FALLS:					
6 P FM RIGHT BANK	36	1	7.5	7.2	-.3
4. TOM BROWNE, 30 M DS OF FIRST GLENDALE CONFLUENCE:					
6 P FM LEFT BANK	42	1	7.5	7.2	-.3
5. A1 OLD PBS FENCE:					
5 P FM RIGHT BANK	36	.5	8	7.5	-.5
5 P FM LEFT BANK	39	.25	8	7.5	-.5

MEAN DIFFERENCE IN TEMP :

GLENDALE SUBGRAVEL TEMPERATURE SURVEY

DATE: APRIL 13-14 1983

CALIBRATION: 10.0 POCKET: 11 YSI METER 9.2

CROSS SECTIONS:

SITE DESCRIPTION	WATER DEPTH (CM)	VELOCITY OF FLOW (M/SEC)	SURFACE TEMP (C)	SUBGRAV. TEMP (C)	DIFF
1. GLENDALE CREEK, U/S BRIDGE, LEFT BANK TO RIGHT BANK:					
3 PACES	24	.5	9	9	0
6 PACES	23	.5	9	9	0
9 PACES	46	1	8.5	8.5	0
12 PACES	60	.5	8.5	8.5	0
2. GLENDALE CREEK, DS OF BRIDGE, LEFT BANK TO RIGHT BANK:					
3 PACES	29	.5	9.5	9	-.5
6 PACES	30	.75	9.5	9	-.5
9 PACES	42	.5	9.5	8.9	-.6
12 PACES	28	.5	9.5	9	-.5
15 PACES	17	.5	9.5	8.5	-1
3. TOM BROWNE, 100 M DS OF FALLS:					
6 P FM RIGHT BANK	35	1	7.5	7.2	-.3
4. TOM BROWNE, 30 M DS OF FIRST GLENDALE CONFLUENCE:					
5 P FM LEFT BANK	33	1	9.5	9.5	0
5. AT OLD PBS FENCE:					
5 P FM RIGHT BANK	29	1	9.5	9.2	-.3
5 P FM LEFT BANK	26	.5	10.5	10	-.5

MEAN DIFFERENCE IN TEMP : -0.32

DATE: APRIL 19-20 1983

CALIBRATION: 9.5 POCKET: 10.5 YSI METER 9

CROSS SECTIONS:

SITE DESCRIPTION	WATER DEPTH (CM)	VELOCITY OF FLOW (M/SEC)	SURFACE TEMP (C)	SUBGRAV. TEMP (C)
1. GLENDALE CREEK, U/S BRIDGE, LEFT BANK TO RIGHT BANK:				
3 PACES	22	.5	10	9
6 PACES	30	1	10.5	9.5
9 PACES	63	1.25	10	9
12 PACES	64	1.25	9.5	9
2. GLENDALE CREEK, DS OF BRIDGE, LEFT BANK TO RIGHT BANK:				
3 PACES	28	1	10	10
6 PACES	42	1.25	10	9.5
9 PACES	36	1.5	10	9.5
12 PACES	33	1.25	10	9.5
15 PACES	16	.5	10	9.5
3. TOM BROWNE, 100 M DS OF FALLS:				
6 P FM RIGHT BANK	23	.25	10	11
4. TOM BROWNE, 30 M DS OF FIRST GLENDALE CONFLUENCE:				
5 P FM LEFT BANK	39	.75	9	8.5
5. AT OLD PBS FENCE:				
5 P FM RIGHT BANK	26	.75	8	7.5
5 P FM LEFT BANK	28	.5	10	9.5

MEAN DIFFERENCE IN TEMP : -0

GLENDALE SUBGRAVEL TEMPERATURE SURVEY

APRIL 26 1983

9 POCKET: 10 YSI METER 8.5

CONDITIONS:

DESCRIPTION	WATER DEPTH (CM)	VELOCITY OF FLOW (M/SEC)	SURFACE TEMP (C)	SUBGRAV. TEMP (C)	DIFF
...CE CREEK, U/S BRIDGE, LEFT BANK TO RIGHT BANK:					
3 PACES	29	.5	9	8.5	-.5
6 PACES	38	.75	9	8.5	-.5
9 PACES	39	1	9	8.5	-.5
12 PACES	66	1.25	9	8.5	-.5
15 PACES	61	1.25	9	8	-1
...LE CREEK, DS OF BRIDGE, LEFT BANK TO RIGHT BANK:					
3 PACES	33	1.25	9	8.5	-.5
6 PACES	48	1.5	9	8.5	-.5
9 PACES	52	1.5	9	8.5	-.5
12 PACES	43	1.5	9.25	8.5	-.75
15 PACES	39	1.5	9	8.5	-.5
...BROWNE, 100 M DS OF FALLS:					
...M RIGHT BANK	31	.75	12	11.75	-.25
M LEFT BANK	37	.5	12	11.5	-.5
...BROWNE, 30 M DS OF FIRST GLENDALE CONFLUENCE:					
...M LEFT BANK	37	.5	12	11.5	-.5
...LD PBS FENCE:					
...M RIGHT BANK	29	.75	9	8.5	-.5
...M LEFT BANK	27	.5	12	11.5	-.5

MEAN DIFFERENCE IN TEMP : -0.53

DATE: MAY 10 1983

CALIBRATION: 12.1 POCKET: 13 YSI METER 10.5

CROSS SECTIONS:

SITE DESCRIPTION	WATER DEPTH (CM)	VELOCITY OF FLOW (M/SEC)	SURFACE TEMP (C)	SUBGRAV. TEMP (C)	DIFF
1. GLENDALE CREEK, U/S BRIDGE, LEFT BANK TO RIGHT BANK:					
3 PACES	26	.5	11.5	11.5	0
6 PACES	32	.5	11.5	11.25	-.25
9 PACES	48	.75	12	11.5	-.5
12 PACES	59	1	12	11.5	-.5
15 PACES	67	1	12	11.75	-.25
2. GLENDALE CREEK, DS OF BRIDGE, LEFT BANK TO RIGHT BANK:					
3 PACES	35	.75	11.5	12	.5
6 PACES	40	.75	12	12	0
9 PACES	38	.75	12	12	0
12 PACES	34	1	12	11.75	-.25
15 PACES	28	1	12	12	0
3. TOM BROWNE, 100 M DS OF FALLS:					
5 P FM RIGHT BANK	29	.5	14	13.75	-.25
4. TOM BROWNE, 30 M DS OF FIRST GLENDALE CONFLUENCE:					
5 P FM LEFT BANK	38	.75	14	13.5	-.5
5. AT OLD PBS FENCE:					
6 P FM RIGHT BANK	32	.25	12	11.75	-.25
6 P FM LEFT BANK	34	.5	13	12.5	-.5

MEAN DIFFERENCE IN TEMP : -.2

Appendix 4. Juvenile trap catches.

GLENDALE CATCH

DATE	PINK		CHUM		COHO FRY		COHO SMOLTS		TROUT		SOCKEYE	
	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY
MARCH 31	6321		2		12		0		0		0	
APRIL 1	4394	3	19		5	0	0	0	0	0	0	
2	226		0				0		0			
3	5465		36		8		0		0		0	
4	8234	0	75	0	8	0	0	0	1	0	0	0
5	3736	4	78	0	5	0	0	0	0	0	0	0
6	14959	9	107	0	16	0	0	0	0	0	0	0
7	19454	3	87	0	63	1	0	0	0	0	0	0
8	21561	3	94	0	35	0	0	0	0	0	0	0
9	20935	0	74	0	45	0	0	0	0	0	0	0
10	15296	14	74	0	52	1	0	0	1	0	0	0
11	20401	14	181	0	55	1	0	0	0	0	0	0
12	20849	1	180	0	52	0	0	0	0	0	0	0
13	25392	2	234	0	64	0	1	0	0	0	0	0
14	26959	7	181	0	74	0	0	0	0	0	0	0
15	34225	14	143	0	89	1	0	0	0	0	0	0
16	39479	9	166	0	209	0	0	0	0	0	0	0
17	39307	9	121	0	351	0	2	0	0	0	0	0
18	35910	5	183	0	381	0	1	0	1	0	0	0
19	32009	18	114	0	615	0	0	0	0	0	1	0
20	15361	1	125	0	401	0	1	0	0	0	2	0
21	16815	1	96	0	367	0	0	0	0	0	2	0
22	11748	15	238	0	148	1	4	0	0	0	3	0
23	6997	1	146	0	56	0	0	0	0	0	0	0
24	9301	0	254	0	138	0	1	0	0	0	13	0
25	3114	1	123	1	307	2	0	0	0	0	1	0
26	2921	5	192	0	220	0	0	0	0	0	3	0
27	2541	0	171	0	40	2	1	0	0	0	1	0
28	5797	5	374	0	179	0	1	0	0	0	12	0
29	5538	22	395	0	1064	2	1	0	0	0	7	0
30	3690	0	297	1	933	2	1	0	0	0	4	0
MAY 1	3575	2	256	0	783	1	1	0	0	0	8	0
2	1561	6	170	0	595	1	0	0	0	0	1	0
3	3951	6	468	0	1048	1	7	0	0	0	3	0
4	4443	1	567	0	882	3	7	0	0	0	7	0
5	2078	14	431	0	706	0	4	0	0	0	5	0
6	1891	11	281	1	816	0	0	0	0	0	0	0
7	1021		312		863		0		0	0	0	
8	937	5	148	4	880	5	12	0	0	0	25	0
9	649	2	273	2	578	2	1	0	6	0	13	0
10	928	0	253	1	395	0	1	0	6	0	5	0
11	515	2	148	0	491	0	4	0	13	0	4	0
12	368	1	109	0	649	1	0	0	6	0	4	0
13	415	2	114	0	320	0	0	0	2	0	2	0
14	99		16		59		0	0	0		5	
15	157	3	84	0	306	1	2	0	2	0	5	0
16	172		95	0	180		0	0	0	0	2	0

TOM BROWNE CATCH

	PINK		CHUM		COHO FRY		COHO SMOLTS		TROUT		SOCKEYE	
	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY
	167		1814				0		0		0	
	217	3	3037	67	1	0	0	0	0	0	0	0
	275	0	3368	17	0	0	0	0	0	0	0	0
	141		3414		0		0		0		0	
	292	0	3401	16	0	0	0	0	0	0	0	0
	210	0	4393	14	0	0	0	0	0	0	0	0
	141	0	4224	17	0	0	0	0	0	0	0	0
	140	0	5196	5	2	0	0	0	0	0	0	0
	174		5072		0		0		0		0	
	13		194		0		0		0		0	
	218	0	5832	7	2	0	0	0	0	0	0	0
	282	0	7371	16	1	0	0	0	0	0	0	0
	178	0	6443	7	4	0	0	0	0	0	0	0
	202	0	6753	3	3	0	0	0	0	0	1	0
	146	0	6265	3	0	0	0	0	0	0	0	0
	85	0	6375	11	1	0	0	0	0	0	0	0
	145	0	6904	3	14	0	0	0	0	0	0	0
	51	0	2476	1	25	0	0	0	0	0	1	0
	48	0	6716	2	24	0	0	0	0	0	0	0
	93	0	6384	15	37	0	0	0	0	0	0	0
	98	0	2267	2	27	0	0	0	0	0	0	0
	66	0	2175	0	28	0	0	0	0	0	1	0
	52	0	688	11	36	0	0	0	0	0	0	0
	75	0	1544	2	27	0	0	0	0	0	0	0
	128	0	1929	2	22	0	0	0	0	0	0	0
	114	0	1380	11	23	0	0	0	1	0	0	0
	89	0	876	2	15	0	0	0	0	0	0	0
	20	0	682	5	8	0	0	0	0	0	0	0
	46	0	523	6	18	0	0	0	0	0	0	0
	79	0	502	6	47	0	0	0	2	0	1	0
	31	1	289	0	28	0	0	0	1	0	0	0
	11	0	201	2	13	0	0	0	0	0	0	0
	14	1	115	2	28	0	0	0	3	0	0	0
	21	0	479	0	68	0	0	0	7	0	0	0
	13	1	382	1	31	1	0	0	3	2	0	0
	45	1	354	1	20	0	0	0	2	0	0	0
	16	0	126	1	14	0	0	0	2	0	0	0
	12	0	223	6	18	0	0	0	0	0	0	0
	7	0	29	1	24	0	0	0	0	0	0	0
	5	0	70	3	10	0	0	0	0	0	0	0
	1	0	22	0	4	0	0	0	2	0	0	0
	1	0	1	0	3	0	0	0	0	0	0	0
	4	0	8	0	15	0	0	0	2	0	0	0
	1	0	2	0	7	0	0	0	0	0	0	0
	1	0	115	0	75	0	0	0	4	0	0	0
	2	0	17	0	24	0	0	0	0	0	0	0
			4		11		0		0		0	

Appendix 5. Fry quality data.

TOM BROWNE PINK FRY

DATE	LENGTH (CM) LOW	HIGH	MEAN	WEIGHT (GRAMS) LOW	HIGH	MEAN	KD
MARCH31	30	39.5	34.6	.23	.43	.33	1.99
APRIL 1	32.5	39	34.9	.17	.38	.24	1.78
2	32	35.5	34.1	.16	.25	.21	1.74
3	32	39	34.5	.11	.44	.22	1.75
4	33	37.5	34.5	.21	.28	.21	1.73
5	31.5	40	34.5	.14	.36	.21	1.73
6	32.5	40	34.6	.15	.39	.21	1.72
7	33	37.5	34.7	.17	.27	.2	1.69
8	32.5	36	34.4	.16	.33	.21	1.73
9	33	36.5	34.9	.14	.28	.21	1.7
10	33	40.5	34.8	.15	.37	.23	1.75
11	31	38	34.4	.15	.24	.22	1.75
12	31.5	39	33.8	.16	.35	.21	1.76
13	31	39	34.1	.14	.36	.23	1.79
14	32	39	34	.16	.34	.23	1.78
15	30	38	33.6	.15	.36	.22	1.78
16	31.5	37.5	34	.15	.31	.22	1.78
17	29.5	40	34.2	.12	.35	.22	1.77
18	32.5	39	35	.16	.37	.24	1.78
19	32	35	33.9	.15	.27	.21	1.76
20	32	37.5	34.3	.16	.27	.21	1.73
21	31.5	36	34.2	.17	.37	.22	1.76
22	32	38.5	33.9	.16	.34	.21	1.75
23	32	37	34.3	.17	.27	.22	1.75
24	31.5	35	34	.18	.25	.21	1.75
25	31.5	36.5	34.1	.15	.25	.21	1.73
26	30.5	35	33.2	.14	.24	.2	1.74
27	31	36	33.6	.17	.24	.2	1.74
28	32.5	37	33.8	.15	.31	.2	1.73
29	32	36	33.8	.16	.25	.21	1.75
30	32	35	33.9	.16	.25	.21	1.74
MAY 1	32.5	36	33.8	.19	.23	.21	1.76
2	31	40	34.1	.13	.34	.21	1.75
3	32	40.5	34.3	.18	.31	.22	1.75
4	32.5	39.5	33.9	.18	.32	.21	1.75
5	32	35.5	33.9	.16	.29	.21	1.74
6	33	38	34.9	.17	.33	.23	1.74
7	32.5	39	34.5	.16	.39	.23	1.77
8	32	34	33.2	.18	.21	.2	1.75
9	33	34.5	33.8	.17	.22	.2	1.72
10	33	33	33	.18	.18	.18	1.71
11	33.5	33.5	33.5	.2	.2	.2	1.75
12	31.5	35	33	.16	.23	.19	1.75
13	34	36	35	.2	.22	.21	1.7
14	34	34	34	.21	.21	.21	1.75
15							

TOM BROWNE CHUM FRY

DATE	LENGTH (CM) LOW	HIGH	MEAN	WEIGHT (GRAMS) LOW	HIGH	MEAN	KD
MARCH31	36.5	40.5	38.7	.34	.55	.44	1.97
APRIL 1	36	39	37.6	.25	.44	.34	1.86
2	38	40.5	39.2	.3	.4	.34	1.79
3	36.5	41	38.9	.28	.41	.35	1.8
4	37.5	39.5	38.6	.24	.42	.34	1.8
5	36.5	41	38.4	.29	.37	.34	1.81
6	38	40	39	.29	.40	.35	1.8
7	37	42	39.8	.31	.42	.36	1.78
8	38	40.5	39.4	.31	.39	.35	1.78
9	38	41	39	.3	.48	.36	1.83
10	36.5	40	38.4	.27	.4	.36	1.84
11	35.5	40	37.7	.22	.36	.32	1.81
12	36	42	38.2	.3	.43	.35	1.85
13	36	39	37.7	.29	.38	.32	1.82
14	35	39	37.4	.23	.38	.32	1.82
15	37	41	38.4	.33	.39	.36	1.86
16	36	40.5	39.1	.31	.45	.37	1.84
17	36	40.5	37.9	.26	.4	.34	1.83
18	35.5	40.5	37.5	.27	.42	.34	1.86
19	36	40	37.7	.29	.39	.34	1.85
20	35	40.5	38	.27	.42	.35	1.85
21	36	39.5	37.9	.26	.38	.32	1.81
22	35.5	40	37.4	.29	.4	.33	1.84
23	35	38	36.5	.26	.38	.32	1.85
24	34.5	39	37.1	.25	.38	.31	1.83
25	36	39.5	37.2	.26	.4	.3	1.81
26	36	39	37.7	.27	.42	.33	1.82
27	35.5	39	37.5	.25	.38	.32	1.81
28	36.5	41	38.3	.25	.37	.32	1.78
29	36	40	38	.28	.42	.33	1.82
30	36	39	37.5	.28	.38	.32	1.81
MAY 1	36	40	38	.25	.38	.31	1.78
2	37	40	38.2	.26	.44	.34	1.83
3	36	42	38.1	.25	.44	.33	1.81
4	35.5	40	37.8	.23	.42	.33	1.81
5	37	40	38.7	.3	.44	.35	1.81
6	36	40	37.9	.26	.41	.33	1.83
7	36.5	40	38.7	.28	.41	.35	1.82
8	36.5	41	38	.29	.45	.33	1.81
9	36	42	38	.24	.37	.32	1.79
10	36	39.5	38	.23	.39	.31	1.78
11	37.5	37.5	37.5	.34	.34	.34	1.86
12	37.5	40	38.5	.3	.39	.35	1.83
13	36	36.5	36.3	.25	.28	.27	1.77
14	36	40.5	38.3	.29	.39	.31	1.79
15	36.5	39	37.7	.27	.36	.32	1.8

GLENDALE PINK FRY

DATE	LENGTH (CM) LOW	HIGH	MEAN	WEIGHT (GRAMS) LOW	HIGH	MEAN	KD
MARCH31	30.5	36.5	34	.16	.43	.27	1.89
APRIL 1	32.5	37.5	34.7	.14	.29	.22	1.75
2	29	36	33.9	.1	.33	.21	1.74
3	32.5	36	34.4	.13	.26	.21	1.73
4	33	36.5	34.4	.17	.29	.21	1.73
5	31	37	34.8	.19	.28	.22	1.73
6	33	37	34.6	.13	.31	.22	1.73
7	32	37.5	34.9	.17	.28	.22	1.74
8	32	36	34.2	.18	.26	.21	1.74
9	32.5	37	34.8	.16	.36	.23	1.76
10	32.5	37	34.5	.17	.27	.22	1.74
11	32.5	37	34.5	.17	.28	.22	1.74
12	32	36	34.3	.16	.29	.23	1.79
13	32	36	33.7	.16	.28	.21	1.76
14	31	36	33.4	.16	.28	.22	1.79
15	32.5	36.5	33.8	.18	.26	.22	1.77
16	30	36	33.7	.16	.25	.21	1.75
17	32	37	34.5	.18	.29	.23	1.76
18	28	35	33.5	.11	.26	.21	1.77
19	32	36.5	34.2	.16	.26	.21	1.75
20	32	37	34	.14	.28	.21	1.75
21	31.5	36	34.2	.16	.27	.21	1.73
22	32	36	34.1	.15	.26	.2	1.71
23	31.5	36	34	.13	.27	.21	1.74
24	31	36.5	33.7	.15	.26	.21	1.76
25	31	36.5	33.9	.15	.27	.21	1.75
26	31.5	36	34	.17	.26	.21	1.74
27	32	36	34.2	.16	.24	.21	1.73
28	32.5	35	34.1	.15	.27	.21	1.73
29	32.5	35.5	34.1	.16	.27	.21	1.74
30	32	36	34.1	.17	.26	.21	1.74
MAY 1	32.5	37	33.8	.17	.26	.2	1.73
2	32	36	33.7	.16	.24	.2	1.74
3	32	35.5	33.8	.15	.24	.2	1.72
4	32.5	35.5	34.1	.16	.25	.21	1.74
5	31.5	36	34.2	.16	.27	.21	1.73
6	31.5	36	34	.13	.28	.21	1.74
7	32	36	34.1	.16	.25	.21	1.73
8	31.5	35.5	33.8	.16	.28	.22	1.77
9	32	37	34.3	.13	.27	.2	1.71
10	30.5	36.5	34.1	.14	.31	.2	1.72
11	32	36	34	.15	.25	.2	1.72
12	32	36.5	33.7	.14	.25	.19	1.7
13	31.5	35.5	33.7	.12	.27	.2	1.72
14	32.5	36	34.1	.16	.25	.2	1.72
15	32	37	34	.16	.25	.2	1.72

GLENDALE CHUM FRY

DATE	LENGTH (CM) LOW	HIGH	MEAN	WEIGHT (GRAMS) LOW	HIGH	MEAN	KD
MARCH31	36.5	36.5	36.5	.37	.39	.38	1.98
APRIL 1	34.5	41	39	.29	.42	.37	1.84
2							
3	38	41.5	40	.32	.45	.38	1.81
4	38.5	41	40.1	.31	.41	.36	1.77
5	36.5	41	39.3	.3	.39	.35	1.8
6	37.5	42	39.8	.28	.41	.35	1.76
7	36.5	41	38.4	.28	.42	.36	1.85
8	37	40	38.6	.26	.34	.3	1.74
9	37	47	39.6	.27	.51	.34	1.75
10	36.5	40	38.5	.3	.39	.34	1.8
11	37	39	37.8	.29	.37	.32	1.8
12	36.5	39	37.8	.27	.35	.32	1.8
13	37	42	38.1	.28	.4	.33	1.81
14	35.5	37.5	36.7	.27	.34	.3	1.83
15	36	40.5	37.9	.28	.43	.35	1.87
16	37	41.5	38.4	.3	.42	.34	1.82
17	36.5	39.5	38.2	.28	.41	.35	1.84
18	36	42	38.7	.28	.43	.34	1.79
19	37	41	38.6	.31	.4	.35	1.83
20	36	41	38.8	.27	.38	.33	1.79
21	36	40.5	38.7	.28	.42	.33	1.78
22	35.5	40.5	38.1	.25	.43	.33	
23	36	41	38.7	.27	.42	.35	1.82
24	36	40	38.1	.28	.43	.34	1.82
25	36	41.5	37.4	.27	.45	.31	1.8
26	36.5	41.5	38.1	.28	.46	.34	1.82
27	36.5	42	37.9	.23	.44	.33	1.83
28	36.5	40	37.9	.29	.42	.33	1.82
29	35	40.5	37.9	.27	.37	.33	1.82
30	36.5	41.5	38.6	.26	.42	.34	1.81
MAY 1	36	39.5	37.7	.28	.37	.33	1.83
2	37	40.5	37.9	.25	.43	.31	1.78
3	36	39.5	37.8	.27	.37	.32	1.81
4	37	40	38	.27	.39	.33	1.82
5	37	41	38.5	.27	.4	.32	1.78
6	37	40	38.3	.27	.39	.33	1.81
7	37	40	38.2	.28	.38	.33	1.8
8	35	40.5	37.6	.28	.39	.32	1.82
9	37	41.5	38.6	.27	.43	.33	1.7
10	36.5	39.5	37.9	.27	.34	.31	1.78
11	36	39.5	37.9	.26	.35	.31	1.73
12	34.5	39.5	37.9	.28	.39	.32	1.8
13	37	39.5	38.4	.27	.38	.33	1.79
14	36.5	39.5	38	.27	.36	.32	1.8
15	34.5	40.5	38	.22	.39	.32	1.79

GLENDALE COHO FRY

DATE	LENGTH (CM) LOW	HIGH	MEAN	WEIGHT (GRAMS) LOW	HIGH	MEAN	KD
MARCH31	33	39	37.1	.3	.59	.46	.9
APRIL 1	34	40.5	36.6	.23	.44	.33	.65
2							
3	34.5	38.5	37.3	.24	.44	.37	.72
4	34	41	37.1	.28	.47	.39	.77
5	33	40.5	37.5	.28	.43	.38	.72
6	36	40	38.2	.38	.54	.45	.81
7	37.5	39.5	38.3	.42	.6	.48	.86
8	35	39	37.7	.36	.5	.42	.79
9	36	41	37.3	.34	.6	.42	.8
10	36	39	37.6	.33	.53	.42	.79
11	35.5	39	37.6	.33	.5	.43	.8
12	35	39	37.4	.31	.59	.44	.84
13	35.5	40	37.3	.33	.5	.41	.8
14	35	38	36.4	.35	.46	.4	.83
15	34	38	36.4	.35	.47	.4	.83
16	35.5	38	36.8	.33	.42	.38	.76
17	35.5	38	36.6	.38	.43	.4	.81
18	34	37.5	35.6	.3	.4	.33	.73
19	34.5	38	36.8	.3	.51	.4	.81
20	35	39	37	.29	.44	.38	.74
21	34	39	36.6	.28	.5	.38	.77
22	35	40	37.2	.32	.51	.41	.79
23	32	38.5	36.2	.28	.48	.37	.78
24	34.5	37	36.3	.34	.44	.38	.79
25	34	39	36.4	.31	.43	.38	.79
26	34.5	38	36.1	.32	.45	.37	.79
27	35	38.5	36.8	.32	.51	.41	.81
28	33	38	36.7	.25	.46	.37	.75
29	35	39	37	.34	.47	.4	.79
30	36	39	37.3	.38	.46	.41	.79
MAY 1	34.5	39	36.8	.29	.53	.4	.79
2	34.5	38.5	36.7	.34	.46	.4	.81
3	34	38.5	37	.35	.47	.4	.79
4	33	39	36.5	.24	.5	.38	.78
5	33	40	37.7	.28	.56	.44	.81
6	34	39	37	.23	.51	.39	.77
7	36	40	37.4	.35	.53	.41	.78
8	35	40	37.5	.34	.54	.44	.83
9	35	38	36.6	.29	.41	.37	.76
10	33.5	38.5	36.5	.24	.44	.37	.76
11	36	38.5	37.2	.34	.52	.4	.76
12	34	40.5	37.3	.27	.58	.41	.78
13	32	38	35.6	.2	.44	.35	.76
14	35	40.5	37.5	.3	.57	.42	.79
15	34	38	36.2	.31	.43	.36	.75

GLENDALE COHO SMOLTS

DATE	LENGTH (CM) LOW	HIGH	MEAN	WEIGHT (GRAMS) LOW	HIGH	MEAN	K
MARCH31							
APRIL 1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13	58	58	58	2.01	2.01	2.01	
14							
15							
16							
17	62.5	73.5	68	2.71	4.38	3.55	1.11
18	79.5	79.5	79.5	5.24	5.24	5.24	1.04
19							
20	46	46	46	.85	.85	.85	.87
21							
22	76	90.5	82	3.63	5.64	4.61	.83
23							
24	84	84	84	6.56	6.56	6.56	1.11
25							
26							
27	73	73	73	4.14	4.14	4.14	1.06
28	90	90	90	8.11	8.11	8.11	1.11
29	85	85	85	7.23	7.23	7.23	1.18
30	109.5	109.5	109.5	10.83	10.83	10.83	.82
MAY 1	87	87	87	7.34	7.34	7.34	1.11
2							
3	52.5	89.5	70.9	1.42	7.06	4.31	1.08
4	67.5	91	78.7	3.62	8.16	5.64	1.14
5	56	67	61.8	1.48	3.22	2.49	1.02
6							
7							
8	78	100.5	94.9	5.8	12.04	9.69	1.13
9	84	84	84	7.24	7.24	7.24	1.22
10	52	52	52	1.56	1.56	1.56	1.11
11	45.5	68.5	56.5	.93	3.98	2.3	1.09
12							
13							
14							
15	50	91.5	68.5	1.25	6.22	3.52	1

TOM BROWNE COHO FRY

	LENGTH (CM)			WEIGHT (GRAMS)			KD
	LOW	HIGH	MEAN	LOW	HIGH	MEAN	
[illegible]							
[illegible]	36.5	36.5	36.5	.39	.39	.39	.8
[illegible]	33	33	33	.36	.36	.36	1
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]	38	38.5	38.3	.42	.47	.45	.79
[illegible]							
[illegible]							
[illegible]	36	36	36	.33	.37	.35	.75
[illegible]	37.5	37.5	37.5	.43	.43	.43	.82
[illegible]	34.5	38	36.6	.37	.45	.42	.85
[illegible]	36	39	37.7	.37	.49	.44	.82
[illegible]							
[illegible]	36.5	36.5	36.5	.38	.38	.38	.78
[illegible]	34	39	36.3	.21	.47	.37	.76
[illegible]	33.5	37.5	35.8	.31	.42	.35	.78
[illegible]	34.5	37.5	36.5	.34	.42	.39	.8
[illegible]	32.5	38	36.3	.25	.43	.36	.75
[illegible]	34.5	39	36.2	.32	.41	.37	.78
[illegible]	30	38	35.8	.21	.43	.37	.8
[illegible]	30	38	33.8	.16	.44	.31	.78
[illegible]	30	37	34.6	.16	.42	.33	.77
24	30	38	35.2	.2	.43	.35	.79
25	30	39	35.8	.18	.54	.37	.77
26	30	38	35.5	.15	.45	.35	.76
[illegible]	34.5	40	36.8	.32	.52	.39	.78
[illegible]	29	38	34.6	.16	.46	.32	.74
29	34.5	38	37.1	.37	.51	.43	.84
30	33	39	36.4	.29	.43	.37	.77
MAY 1	35	39.5	37.4	.29	.53	.43	.81
2	35	39	37.2	.34	.48	.4	.77
3	32	40	37.9	.22	.57	.47	.86
4	35	38	36.7	.33	.48	.41	.82
5	34	39.5	37.1	.26	.51	.4	.77
6	35	40	37.1	.38	.49	.43	.84
7	35.5	39.5	37.8	.35	.5	.44	.81
8	29	39	36.8	.18	.5	.4	.81
9	33	38.5	36.2	.23	.45	.38	.79
10	36	38.5	37.1	.34	.46	.4	.77
11	36	38.5	37.2	.37	.48	.43	.83
12	30	37.5	31.2	.18	.5	.24	.72
13	31	38	35.3	.11	.52	.34	.7
14	31	39	36.5	.19	.5	.39	.8
15	34.5	38	36.9	.36	.49	.41	.82

GLENDALE SOCKEYE SMOLTS

	LENGTH (CM)			WEIGHT (GRAMS)			K
DATE	LOW	HIGH	MEAN	LOW	HIGH	MEAN	
MARCH31							
APRIL 1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19	70	70	70	3.24	3.24	3.24	.94
20	77	81	79	4	4.61	4.31	.87
21	68	81	74.5	2.5	4.86	3.68	.85
22	73.5	79	76.2	4.89	5.78	5.26	1.19
23							
24	72.5	88	79	3.47	6.15	4.31	.87
25	74	74	74	2.97	2.97	2.97	.73
26	81	87.5	85.2	4.82	6.02	5.61	.9
27	79.5	79.5	79.5	4.47	4.47	4.47	.89
28	66	87.5	78.7	2.68	5.71	4.42	.89
29	76.5	87	82.4	3.84	5.8	4.97	.88
30	78.5	86	81.8	4.56	5.68	5.19	.95
MAY 1	75	86	80.9	3.98	5.71	4.77	.9
2	79.5	79.5	79.5	4.23	4.23	4.23	.84
3	77	84	79.5	3.65	5.42	4.38	.86
4	66.5	86	79.9	2.86	5.49	4.65	.9
5	80.5	92.5	84.3	4.75	7.14	5.4	.9
6							
7							
8	73	94	82.3	3.66	8.08	5.32	.94
9	78	94	86.5	4.54	7.68	6.09	.93
10	65.5	83.5	79.4	2.31	5.42	4.58	.89
11	77	87.5	82	4.06	7.55	5.39	.96
12	71.5	87.5	80.1	3.15	5.19	4.27	.83
13	65	79.5	72.3	2.26	5.05	3.66	.91
14	72	80	77.3	3.67	4.61	4.21	.91
15	77.5	92	84.1	4.29	6.85	5.46	.86