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**ENUMERATION OF THE 1988 BROOD EARLY-TIMED  
STUART RIVER SYSTEM SOCKEYE SALMON FRY  
IN GLUSKE AND FORFAR CREEKS**

by

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## INTRODUCTION

A project to assess the sockeye salmon fry (*Oncorhynchus nerka*) production in the Takla Lake/Middle River watershed was conducted by the Department of Fisheries and Oceans (DFO) during the spring of 1989. Gluske and Forfar creeks were chosen as the study streams for the following reasons:

- i) they are major contributors to the Early Stuart sockeye stock, which has been identified as having under-utilized rearing capacity;
- ii) Gluske Creek is a candidate stream for a SEP sockeye enhancement facility;
- iii) the availability of reliable spawner escapement estimates for both streams (a counting fence was employed on Gluske Creek in 1988); and,
- iv) their close proximity to existing DFO camp facilities.

The general objectives of the downstream fry out-migration study were:

- i) to obtain an estimate of the daily abundance of emigrant sockeye fry in Gluske Creek and if possible from Forfar Creek;
- ii) to collect information on evidence of upstream movement of fry into Takla Lake or downstream migration out of Takla Lake;
- iii) to determine the migration timing and biological characteristics of emigrant sockeye fry; and, to provide measurements of stream water levels, air and water temperatures, as well as general environmental conditions on a daily basis throughout the study period.

## THE STUDY AREA

### Watershed Description

The Stuart River watershed consists of three major river and lake systems which drain south into the Nechako River near Vanderhoof, B.C. (Fig. 1). The upper watershed contains Takla Lake and its approximately thirty-three tributaries. The largest tributary is the Driftwood River which enters at the north end of the lake.



Takla Lake is drained by Middle River into Trembleur Lake. Both Middle River and Trembleur Lake (including Middle River) have five major tributary streams (Fig. 2). Trembleur Lake drains into Stuart Lake via the Tachie River which in turn empties into the Stuart River at Fort St. James, B.C.

Gluske Creek flows northeastward out of the Hogem Range of the Omineca Mountains and empties into lower Takla Lake near its outlet. Forfar Creek flows out of the same mountain range but empties into Middle River approximately four kilometres downstream from Gluske Creek (Fig. 2). The mountains of the Hogem Range have a vegetation cover of predominately mature spruce/pine forests. Higher elevations are predominately spruce while lower elevations are a spruce/pine mixed forest with some northern deciduous species. Logging activities in the area have been limited to a few cut-blocks in lower regions of Gluske Creek, Bivouac Creek and the Sakeniche River. Another larger cut block is located on the north side of Rossette Creek (Van Decar Creek). Present plans are for escalated logging throughout the area beginning in 1990 (Harder and Assoc. MS 1989).

The mountains of the lower Takla/Middle River watersheds have characteristically steep to moderately steep slopes with shallow soils covering patches of glacial till and bedrock. Where streams enter the main valley gradients decrease and sediments are deposited forming relatively large fluvial fans. The glacial till material deposited in the fluvial fan forms the spawning gravel used by the salmonid populations. These fluvial fans are often extremely unstable with large lateral stream movement and vertical gravel movement. The upper reaches of these watersheds are steep and, as a result, also often unstable. Evidence of this instability is illustrated by the former stream channels in the lower fluvial fans and old slides and areas of revegetated growth in the upper watersheds (Harder and Assoc. MS 1989).

Gluske Creek has a total watershed area of 55 sq km and is approximately 19 km long. The lower 0.8 km has a gradient of 1% to 2%, while the upper stream has a gradient of 11% or greater (Harder and Assoc. MS 1989). Fish have access to the lower 3.0 km at which point there is a falls halting further upstream migration. Several chutes and rapids exist between 1.5 and 3.0 km which may impede upstream migration during some years.

Forfar Creek has a total watershed area of 42 sq km and is approximately 18 km long. The lower fluvial fan area of the creek has a stream gradient of 1 to 2% for 2 km, while the upper creek above 2 km has a 5% or greater gradient (Harder and Assoc. MS 1989). A small waterfall at 3.2 km impedes upstream sockeye migration and a larger falls halts migration at 4.8 km. The lower fluvial fan section of the creek has extensive side channels and similar lateral scouring and sediment movement as Gluske Creek but with a shallower overall stream gradient.

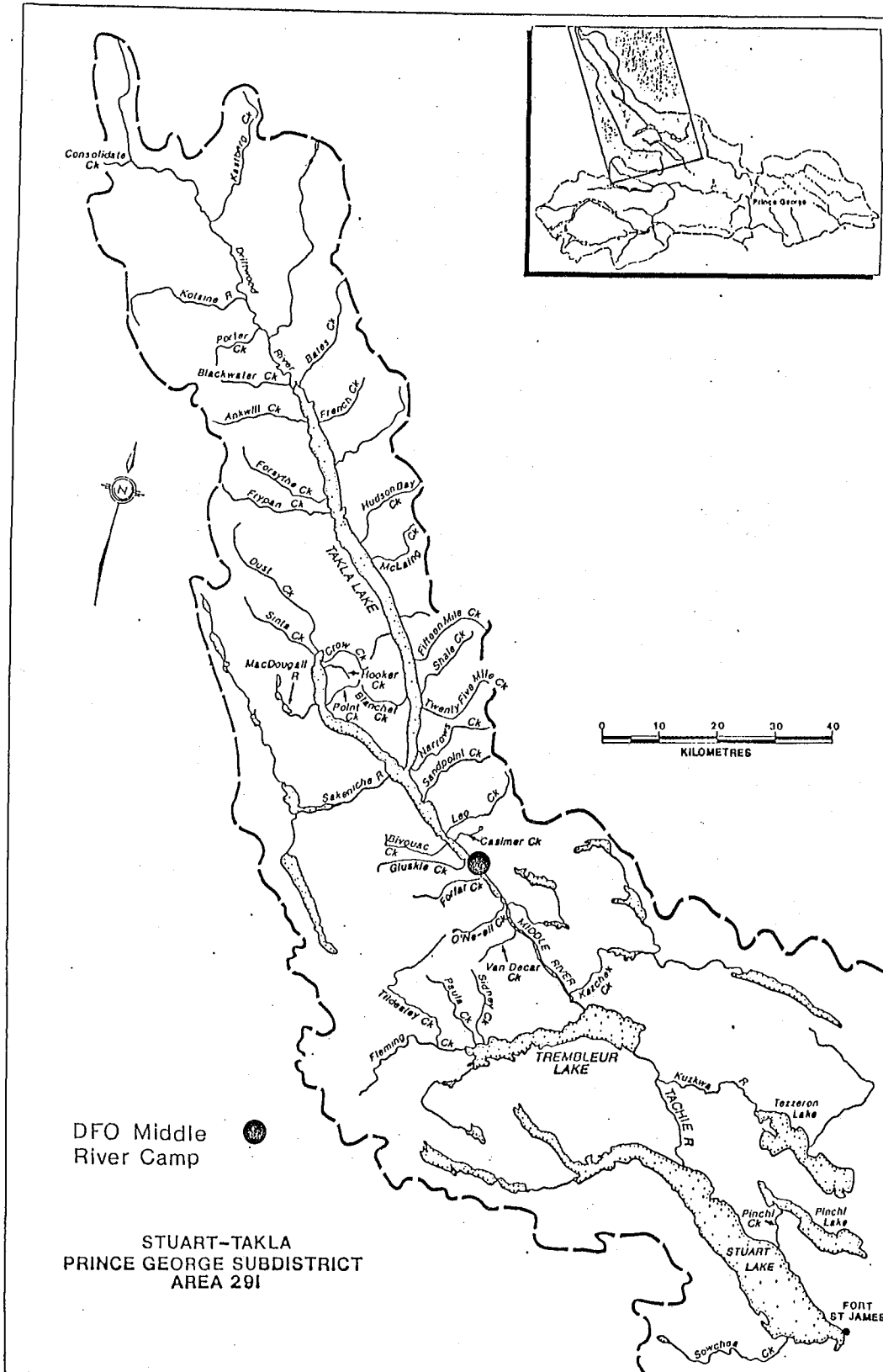


FIG. 2: Stuart River watershed showing location of Middle River camp and Gluske and Forfar creeks.

## Sockeye Salmon Production

The Stuart River watershed supports both early and late-timed sockeye stocks. Gluske and Forfar creeks are two of the approximately 30 separate stream populations that comprise the Early Stuart stock. Spawning typically takes place between July 27 and August 23. The majority of these populations spawn in the tributaries of Takla Lake with the exception of the three early-run creeks draining into Middle River and the four early-run tributaries of Trembleur Lake. The Late Stuart stock spawns mainly in Tachie and Middle rivers with the exception of small populations (<10%) in Kazchek Creek, Kuzkwa River and Sakeniche River. Spawning of the late run generally occurs between September 10 and 28 once water temperatures in these streams have declined. The majority of spawning in Middle River occurs at or below the mouth of early run creeks where gravel has been deposited.

The dominant year cycle on the Stuart system occurs during the cycle years 1985/89. Escapements for the dominant early cycle between 1951 and 1985 have averaged 167,000 sockeye with the largest population (37%) spawning in the Driftwood River. The other three cycle years have averaged between 17,000 and 51,000 sockeye with the majority of the spawning occurring in the lower Takla Lake, Middle River and Trembleur Lake streams and only small numbers in the Driftwood River and upper Takla streams (Department of Fisheries and Oceans 1988).

The total Early Stuart sockeye salmon spawning capacity has been estimated at 632,200 spawners (Fraser River Sockeye Task Force MS 1988). With average sockeye escapements of 167,000 or lower, there clearly exists under-utilized production capacity in the Stuart River system. The Sockeye Task Force also estimated lake rearing capacities for the Stuart River system lakes based on available lake area, water temperature, plankton, and pre-smolt data. Using these data, it was estimated that Takla and Trembleur lakes have the capacity to rear the juveniles from 3.4 million sockeye spawners (Fraser River Sockeye Task Force MS 1988). Based on these findings the Sockeye Task Force and others (Schouwenburg MS 1989) have concluded that production from the Stuart River system is clearly spawning habitat limited but still does contain unutilized spawning capacity.

The other suspected spawning habitat limitations that have been identified in the region include:

- i) high water temperatures during spawning;
- ii) restricted spawner access (low flows, obstructions);  
and,
- iii) over-wintering egg mortality (freezing, de-watering).

Gluske Creek has an estimated spawning capacity of 18,000 adult sockeye which represents 2.8% of the total estimated Early Stuart production capacity (Fraser River Sockeye Task Force MS 1988). Although this escapement has been exceeded in the past,

the average escapement on the four cycle years between 1951 and 1987 ranges between 2,500 and 11,500 fish. These escapements represent between 8% and 14% of the entire Early Stuart sockeye run over this same period, which is considerably larger than the 2.8% estimated Early Stuart spawning capacity found in Gluske Creek (Department of Fisheries and Oceans 1988). Although high water temperatures are not considered a major production constraint on Gluske Creek, it is suspected that spawning in some years has been at or near saturation because of the limited available spawning area. This production constraint is one of the major reasons Gluske Creek has been identified as a possible site for a spawning channel (SEP - Engineering 1988).

Forfar Creek has an estimated spawning capacity of 18,300 adult sockeye which represents 3.0% of the entire estimated spawning capacity of the Early Stuart system (Fraser River Sockeye Task Force MS 1988). This capacity estimate has been exceeded on a number of occasions but average escapements over the four cycle years since 1951 have ranged from 2,900 to 12,800 adults. These numbers represent between 9% and 18% of the entire Early Stuart escapement over this same period (Department of Fisheries and Oceans MS 1988). The only production constraint identified on Forfar Creek is limited spawning habitat which is predominate throughout the system (Fraser River Sockeye Task Force MS 1988; Schouwenburg MS 1989).

## STUDY METHODS

### Trapping sites, Facilities and Gear

At the time field personnel arrived at Gluske Creek, passage by water to the mouth of Gluske Creek was blocked by ice on Takla Lake and the only open water available for fry trapping was in the immediate mouth area. In order to check for the presence of sockeye fry a trap was deployed in the mouth of Forfar Creek which was accessible by boat via Middle River. Three days later, once a passage was cut through the ice on Takla Lake, a trap was installed in the mouth of Gluske Creek. During the first fifteen days of trap operation the traps were fished in the creek mouths and small numbers of fry were captured emerging under the ice. As water and ice conditions changed throughout the period of fry migration, trapping sites had to be moved to accommodate these variable conditions.

Gluske Creek had a total of seven trapping locations which were necessary to adjust to the changing stream conditions encountered. The first two trapping locations were in the creek mouth. Once the ice melted and water levels increased, the trap was moved approximately 40 to 60 m upstream into the lower creek. This site began to fill in with deposited sediment during peak freshet conditions and quickly became unsuitable for fry trapping. The trap was then moved upstream to a site approximately 100 m from the creek mouth. This site was above some utilized spawning gravel (<70 m; estimated 50 spawning pairs), but was the lowest available trapping site at the time and was fished for only ten days. Fry trapping continued at this site throughout the peak freshet, but once water levels subsided (May 13) the trap had to be moved downstream into the lower creek approximately 30 to 40 m above the mouth. These final two sites were not

available for fry trapping until the lake level increased resulting in adequate water depths for trap floatation (Fig. 3).

Forfar Creek had a total of four trapping locations, two in the mouth and two in the lower creek. The first trapping site was located in the mouth, which was the only area of open water in the entire creek. Because of the low water volumes at the beginning of trapping, the trap could not be floated in the shallow water at the mouth. Therefore, the pontoons on the trap were removed and the trap was dug into the gravel and anchored with steel rods. Later, once water volumes increased, the trap was refitted with pontoons and floated in the mouth. The third trapping site was located upstream from the mouth approximately 70 to 80 m and was only fished for one night after which trapping was abandoned for a nine day period during peak freshet conditions. The fourth trapping site was located approximately 350 to 375 m above the creek mouth. This site was fished throughout the remainder of the migration. All trapping locations on Forfar Creek were below any utilized spawning gravel (Fig. 4).

Migrating sockeye fry were captured using 0.6 m x 0.9 m x 2.75 m (2 ft x 3 ft x 9 ft.) floating inclined plane traps (IPT) (Fig. 5). Traps are constructed of angled and sheet aluminium. Floatation was provided by two 30.5 cm square x 2.75 m long welded aluminium pontoons that are adjustable at both the front and back of the trap. The permanent live box at the back of the trap was lined with a fine mesh, non-abrasive net bag to facilitate removal of trapped fry and to reduce trap induced mortality.

Traps were anchored from both shorelines with 1.25 cm nylon rope using existing natural anchors (trees, stumps, etc.) or by installing temporary steel anchor rods. This allowed for considerable flexibility in trap placement.

Facilities for counting, marking and sampling captured fry were set-up at the DFO camp on Middle River approximately 500 m from the mouth of Gluske Creek. Processing facilities were set up in the screened porch area of the Middle River trailer. The porch was furnished with a 1.8 m x 20 cm wooden trough which was used to count fry and separate them from debris. The trough was provided with a continuous supply of fresh water from Middle River. The processing area was also supplied with oxygen for aerating the water during fry marking, a triple beam balance for weighing nightly trap catches and temporary lighting for processing fry at night.

### Trap Operation

Trapping on Gluske Creek was conducted from April 18 to June 6, 1989, covering a total of 50 days of trap operation. A single trap was used on a daily basis throughout this period.

Trap operation on Forfar Creek was conducted from April 15 to June 6, 1989, with a nine day break in fishing during the peak freshet (April 30 to May 8). This break in trap operation was necessary because of the high manpower requirements on Gluske Creek during the peak freshet. Once water conditions stabilized, trap operation on Forfar Creek was continued. Trap operation on Forfar Creek covered a total of 44 days.

# LOWER GLUSKE CREEK

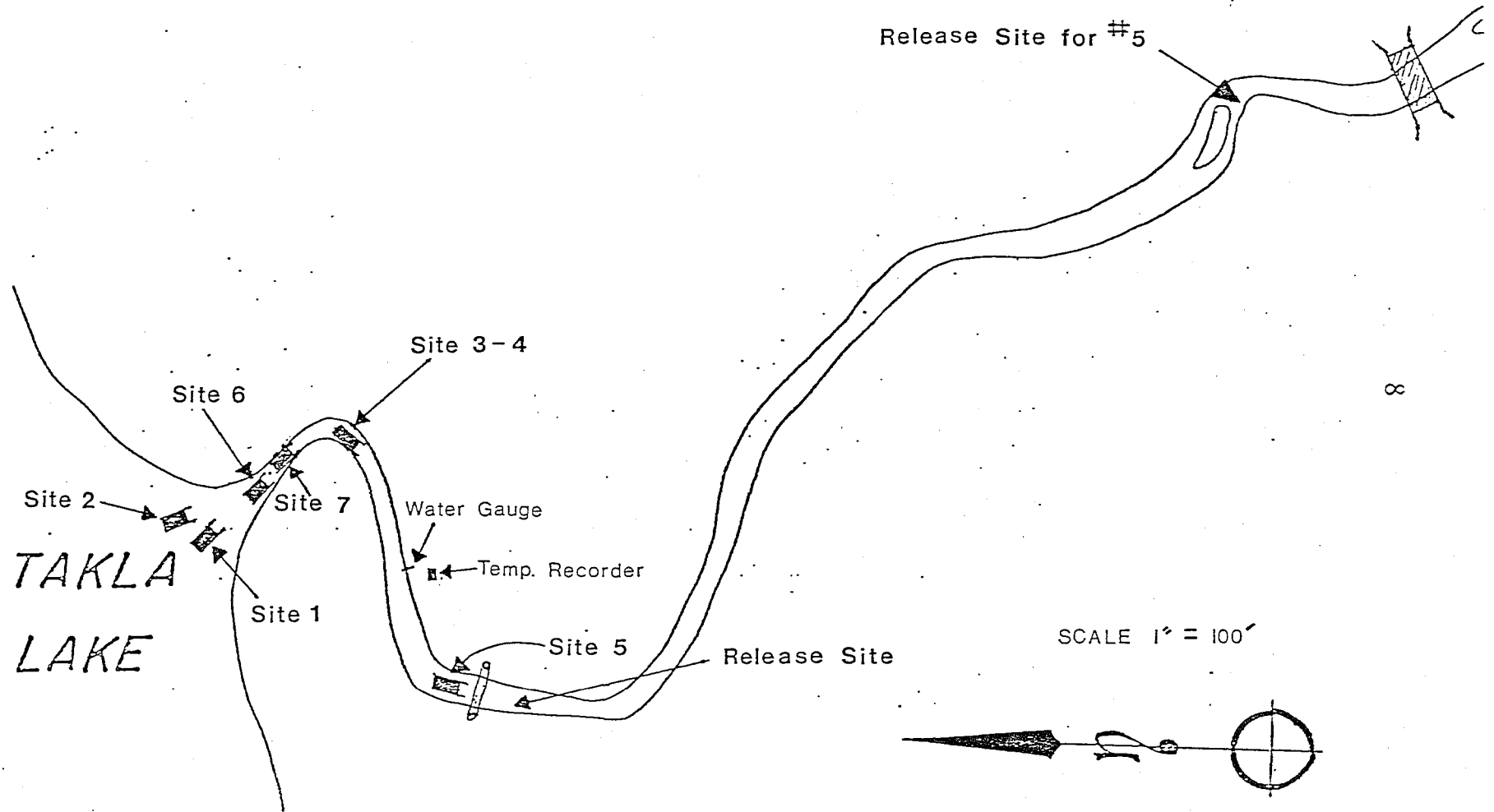


FIG. 3: Map of lower Gluske Creek showing locations of trap and release sites, stream gauge and thermograph.

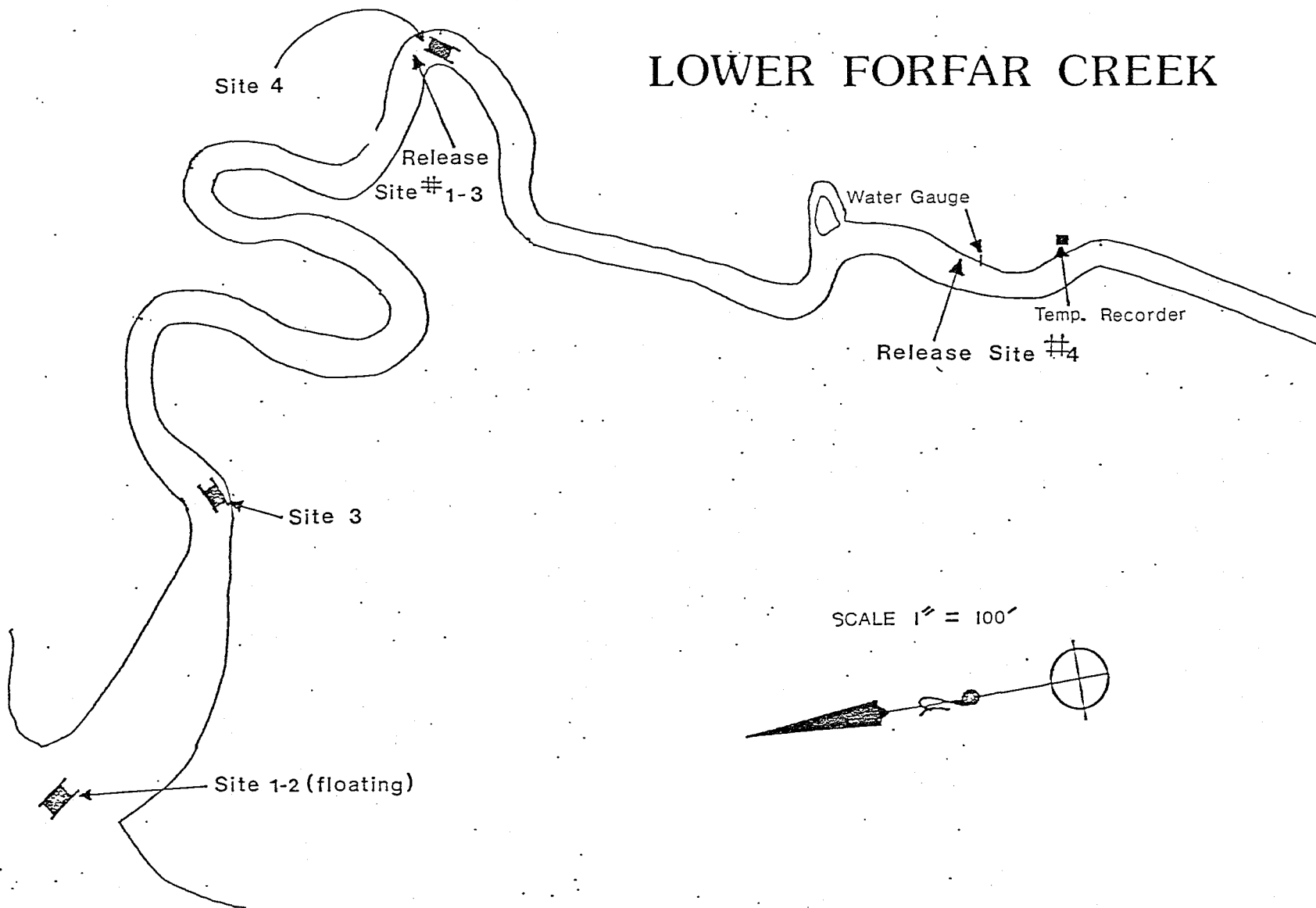


FIG. 4: Map of lower Forfar Creek showing locations of trap and release sites, stream gauge and thermograph.

Traps were normally installed at 1800 h and removed at 0800 h the following morning, fishing for the entire period of darkness. After April 26 traps were installed at 2000 h and beginning May 5 traps were installed at 2100 h. Changes in trap fishing times were made to adjust for the increased daylight hours. Nightly trap catches were recorded on the day that the trap was installed and included trap catches on the following day until that evening.

The traps were emptied from one to twelve times per night depending on water and debris conditions and the numbers of fry captured. During periods of heavy debris loads and peak migration, traps required constant attention to prevent debris overload and fry were removed every 1 to 2 hours to reduce trap induced mortality. Fry were transferred to 20 l plastic buckets and transported by boat to the Middle River processing facilities where they were either held in the river until the next day or, during heavy debris loads, processed that night to prevent mortality. At 0800 h the trap live box was completely emptied of fry to separate night-time migrants from daytime migrants. The traps were either pulled out of the water in the morning or periodically, traps were left fishing to estimate the daytime migration. Generally, traps were left fishing during the days when water levels were stable and debris loads light since the traps required little attention under these conditions.

On three occasions, migrating fry were enumerated on a hourly basis for a full 24 hour period. The objective was to determine the peak migration periods and the proportion of migration outside the normal trapping period.

An effort was made at all times during trap operation to keep fishing conditions as consistent as possible. Slight alterations to the trap were made almost daily to adjust to the variable flow levels. The objective was to keep the trap fishing with strong enough flows to maintain trapping efficiency while limiting trap induced mortality caused by live box turbulence. Whenever possible, adjustments were made to the trap pontoons rather than the position of the trap but on several occasions, changing conditions forced movement of the entire trap. Whenever trap positions were altered, placement was documented and the new position was tested for trapping efficiency. During the nightly trap checks an effort was made to clean the traps and empty the catch as quickly as possible to minimize the amount of time the traps were artificially lighted.

### **Fry Enumeration and Gear Efficiency Testing**

Once fry were transported to the Middle River camp processing facilities the nightly catch was enumerated. Before counting the sockeye fry, all other species were separated from the catch and counted. All marked fry were also counted and removed from the remainder of the catch. The remaining fry were then separated from any debris and counted individually using hand tallies. After April 28, the trap catch from Forfar Creek was enumerated by weighing a known sub-sample and then using the average fry/gram calculation to determine the number of fry captured from the weight of the remaining catch. On two occasions, when large catches were obtained from both creeks, Gluske Creek trap catches were also enumerated using the average fry/gram estimation procedure.

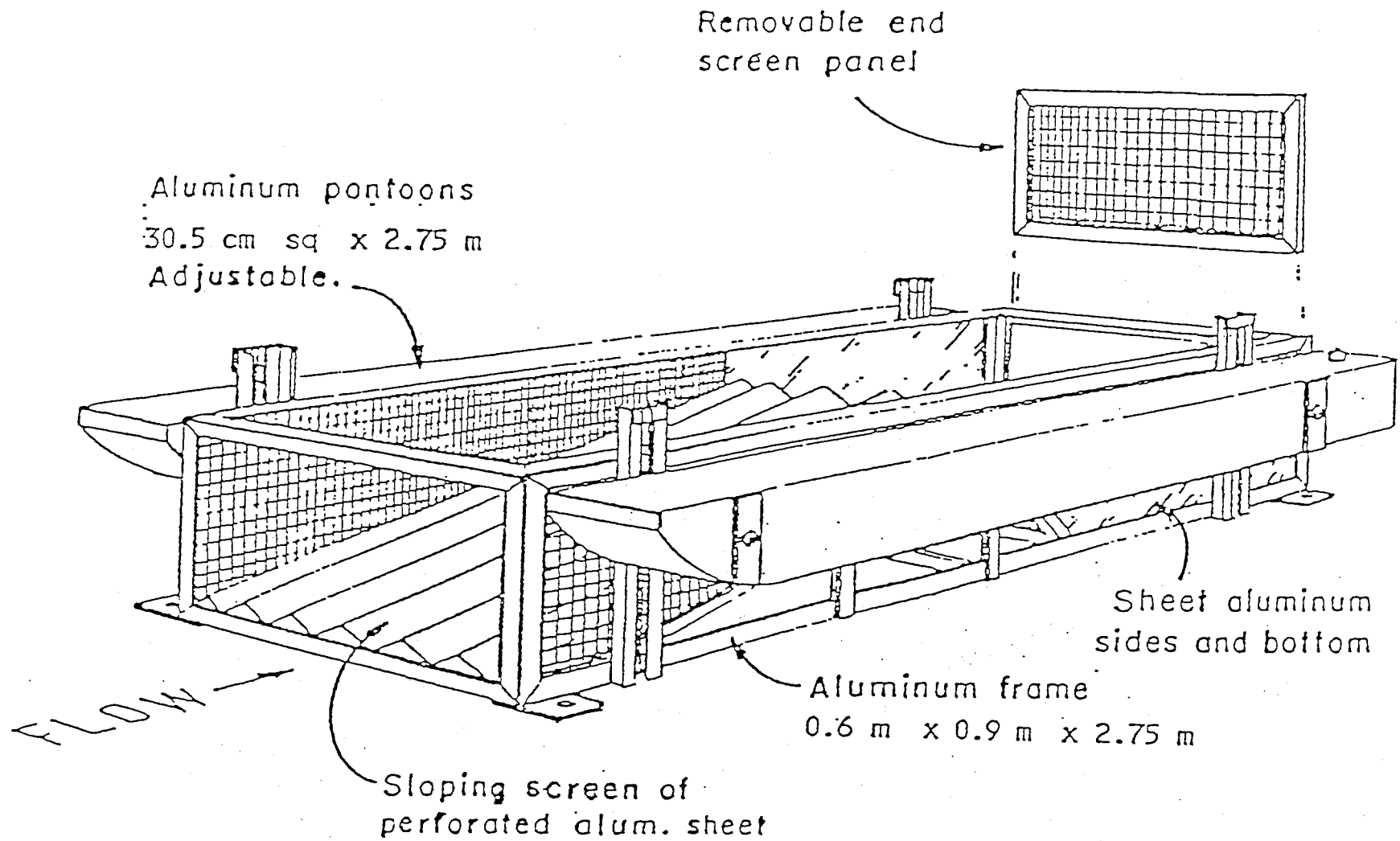


FIG. 5: Diagram of floating Inclined Plane Trap (IPT) used to catch migrating sockeye fry. (IPSFC drawing no. 53-55)

The proportion of sockeye fry captured by the IPT's was determined by releasing known numbers of marked fry upstream of the trapping location. Fry used for upstream release were obtained from the previous night's catch. Whenever possible, a known number of fry from each creek were held in reserve temporarily in case a trap catch was lost. Releases of marked fry were made early in the peak period of the nightly migration between 2200 and 2400 h.

Release sites ranged from 75 to 300 m above the trapping locations. An effort was made to have a minimum of two significant course changes in the creek between the release site and the trap site to ensure adequate distribution of fry (Figs. 3 and 4). Marked fry were transported to the release site in 20 l plastic pails and whenever possible these fry were dispersed from one shoreline of the creek to the other. Predation of marked fry between the release site and the trap was minimized by keeping the migration distances short and by releasing only after daylight hours.

Sockeye fry were marked by immersion in Bismark Brown Y dye prior to release. Fry were immersed in a solution of 1:80,000 (0.5 g to 40 l) concentration and dyed for a period of 2 to 3 hours depending on water temperatures and numbers of fry. While immersed, the holding water was aerated and an effort was made to keep water temperatures below 15 °C. Ice was used when temperatures rose above this level. After marking, fry were normally moved to their creek of origin for a period of 1 to 4 hours in order to adjust to water conditions. Prior to release, all dead fry and those exhibiting abnormal behaviour were removed and subtracted from the total number of marks released.

The initial gear efficiency testing objectives were to release known numbers of fry every second night and for recoveries of 1% or greater. However, because of the variable trapping conditions encountered and the trap adjustments required, it was decided that the best estimate of nightly migration would occur with releases every night. This was done throughout the peak migration on Gluske Creek, with the exception of four nights, and also on Forfar Creek, with the exception of two nights.

### **1988 Brood Year Escapement Estimates**

During 1988, the standard method of escapement estimation for the Early Stuart system (peak live count plus cumulative dead recovered to peak multiplied by an index) was re-assessed. This was done by installing adult counting fences on both Gluske and Rossette creeks to compare actual fence counts to the peak live count/dead recovery index method. This resulted in an adjustment of the previous index (expansion factor) of 1.9 to 1.44. The new index was a weighted mean index generated from Gluske and Rossette creeks which compared the actual fence counts to the peak live count plus cumulative dead times index estimate. The new index was used on the two other Middle River tributary streams (Kynoch and Forfar creeks) which received the same frequency of live count/dead recovery coverage as did Gluske and Rossette creeks (Appendix 3). The previous 1.9 index was employed on the other Takla and Trembleur Lake streams, which received a once-every-four-day frequency of coverage rather than every two days. The sex ratio of the population was determined from the sex ratio in the dead recovery.

Typically, in the range of 60% of the estimated population is handled in the dead recovery (Appendix 3).

### **Effective Females, Fecundity and Egg Deposition Estimates**

Once the total brood year escapements were calculated for a particular stream, the number of females was determined by the sex ratio of the recovered sockeye carcasses. This figure was adjusted by the weighted percent spawn obtained from the in-stream dead recovery data. Each female carcass recovered was rated as having 0, 50, or 100% spawned. The total number of females multiplied by the weighted percentage spawned produced an estimate of effective females or the estimated number of completely spawned-out females (Appendix 3).

To determine the net egg deposition on both Forfar and Gluske creeks the number of effective females was multiplied by the mean fecundity. Because no fecundity data were collected on the 1988 brood year, mean fecundity estimates were derived by calculating a length/fecundity regression equation for twenty-five 1989 fecundity samples on each of the two streams. The resulting equation was used to estimate the mean 1988 fecundity from the mean 1988 standard length of females from Takla Lake streams (Gluske Creek) and Forfar Creek. The 1988 mean fecundity estimates were calculated for both 4 yr-old and 5 yr-old females on Gluske Creek and then weighted by the corresponding 1988 age composition. Because no 5 yr-old females were contained in the 1988 Forfar Creek spawner samples, the mean 1988 fecundity was calculated from the mean 1988 4 yr-old standard length (Appendix 2).

### **Sockeye Fry Population Estimates and Egg-to-Fry Survival**

Trap catches were used to estimate the number of fry emigrating on a nightly basis. The proportion of the total nightly migration captured in the IPT was estimated by applying the proportion of the marked fry recaptured to the nightly unmarked catch. The sum of the nightly migration estimates was used to determine the total fry population emigrating from each creek (Appendix 1). On nights when no marked fry were released, the percentage recovery from the previous or following night's release, in the same trapping position and conditions, was applied to the catch to determine nightly migration.

When catch data were not available on a particular night, a linear interpolation between two known data points was used to estimate that night's migration. In the case of Forfar Creek, when no trap catch data were available for a nine-day period, daily population estimates were interpolated using a regression equation calculated from known daily fry migration estimates and stream gauge readings for the period immediately following the nine day break in trapping. Because of the relatively strong correlation between stream gauge levels and fry migration on both creeks it was felt that these data would best approximate the non-fishing day's fry out-migration between April 30 and May 8.



oven by baking for 24 hours at a mean temperature of 80 °C. Specimens were then re-weighed on a Mettler analytical digital scale to obtain a dry weight.

### **Stream Conditions**

Stream conditions on both Gluske and Forfar creeks were monitored on a daily basis throughout the study period. Water temperatures were recorded daily with both a hand thermometer at the trap site and a weekly (Forfar Creek) or monthly (Gluske Creek) continuous thermograph located at the water gauge site. Water levels were recorded daily generally, at the time of trap installation (1800 to 2100 h). The water level gauges were not installed until April 27, once the creeks opened up and were clear of ice. Gauges on Gluske and Forfar creeks were graduated in tenths of feet and were zeroed on April 27 at 1.05 and 0.50 ft, respectively.

### **Middle River Fry Migration Observations**

One of the objectives of the fry migration study was to determine if any fry incubated in Takla Lake streams migrate out of the lake into Middle River and eventually Trembleur Lake. There was concern that if an enhancement facility aimed at increasing fry production in Takla Lake was to be located on Gluske Creek, then some assurances were necessary that those fry would rear in Takla Lake. Because Gluske Creek is located at the outlet of Takla Lake, it was thought fry might move out of the lake into Middle River and eventually downstream into Trembleur Lake. Observations were also made to determine if any upstream migration of fry incubated in the Middle River tributary streams occurred. Because of limited manpower and financial resources available, no formal trapping program could be undertaken, therefore, observations were only made during daylight hours.

Two sites were chosen on either side of Middle River in front of the DFO camp. These two sites were checked periodically between April 15 and May 10 and twice daily between May 11 and June 6. Observations were made in the morning for 15 minutes during the period 0700 to 0900 h and again in the evening between 1800 and 2200 h. Periodic observations were also conducted on Middle River between the outlet of Takla Lake and the mouth of Forfar Creek.

## **RESULTS AND DISCUSSION**

### **Migration Timing**

The seasonal pattern of sockeye fry migration on Gluske and Forfar creeks was characterized by first emergence in early April, peak migration during early to mid-May and the end of migration during early to mid-June. The majority of migration took place during the month of May with an estimated 90% of the Gluske Creek fry and 93% of Forfar Creek fry emigrating out of their respective streams. A graph illustrating both estimated daily and cumulative fry migration for each creek is presented in Figs. 6 and 7 and a table of fry migration estimates is contained in Appendix 1. The graphs

illustrate the similarity in seasonal migration pattern between the two streams. This is also apparent when the dates of 10, 50 and 90% migration are compared as follows:

	<u>10%</u>	<u>50%</u>	<u>90%</u>
Gluske Creek	May 2	May 9	May 29
Forfar Creek	May 2	May 10	May 27

Since no IPT catch data were available for a nine-day period prior to 50% migration, nightly migration was interpolated resulting in some uncertainty in the Forfar Creek estimate. Despite the interpolated data, the seasonal migration patterns of both creeks appear to be very similar (Figs. 6 and 7).

The diel migration pattern of sockeye fry on Gluske Creek is presented in Table 1. The majority of fry migrated downstream between 2000 and 0200 h which corresponds closely to the period of darkness. The largest hourly trap catches occurred between 2300 and 2400 h. The increasing percentage of fry migrating between 0200 and 0800 h is likely a result of the later onset of darkness as the season progressed. This trend was likely amplified by the northerly latitude of the study area which near the end of May, was not dark until 2300 h and began to get light at 0400 h. The increasing daylight migration, during the 0800 - 2000 h time period, may be the result of increasing numbers of previously emerged fry present in the creek and being forced out of the creek during daylight hours.

**TABLE 1** Diel migration timing of sockeye fry in Gluske Creek for three dates, as indicated by the percentage of 24-hour migration.

Date	2000- 0200 h	0200- 0800 h	0800- 2000 h
April 26	89.7%	8.4%	1.9%
May 2	83.2%	14.3%	2.5%
May 9	81.0%	15.5%	3.5%

Although only one 24-hour migration study was completed on Forfar Creek a similar pattern emerged with percentages of 75.3, 20.7 and 4.0 corresponding to the three time periods noted above. On several occasions traps remained fishing outside of the normal period (2000-0800 h) to assess daytime migration. At no time did this daylight migration exceed 15% of the entire trap catch and only during the first ten days of migration, when trap catches were low, did daylight migration ever exceed 5% of the total catch.

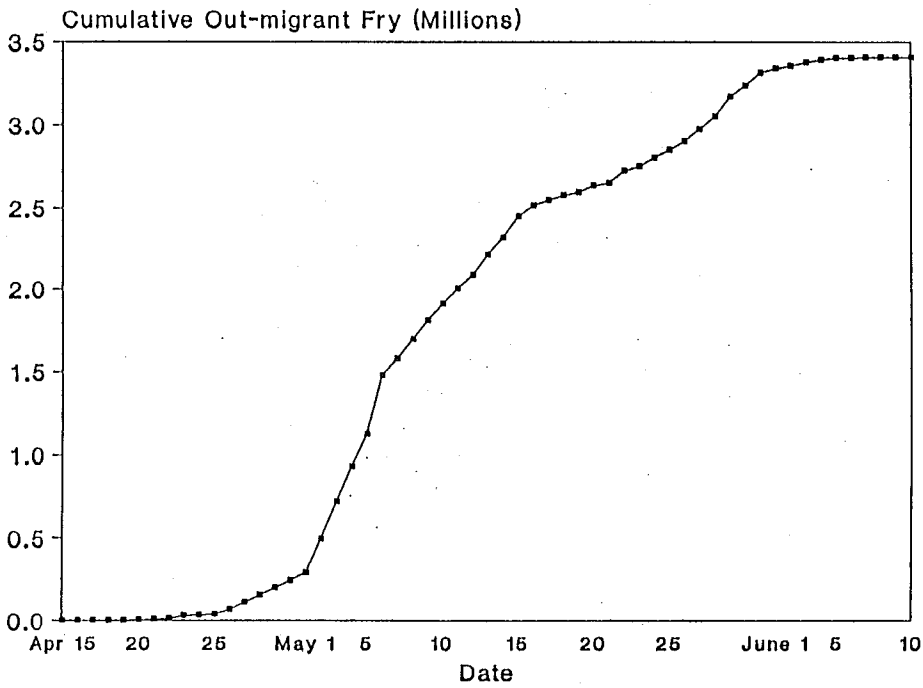
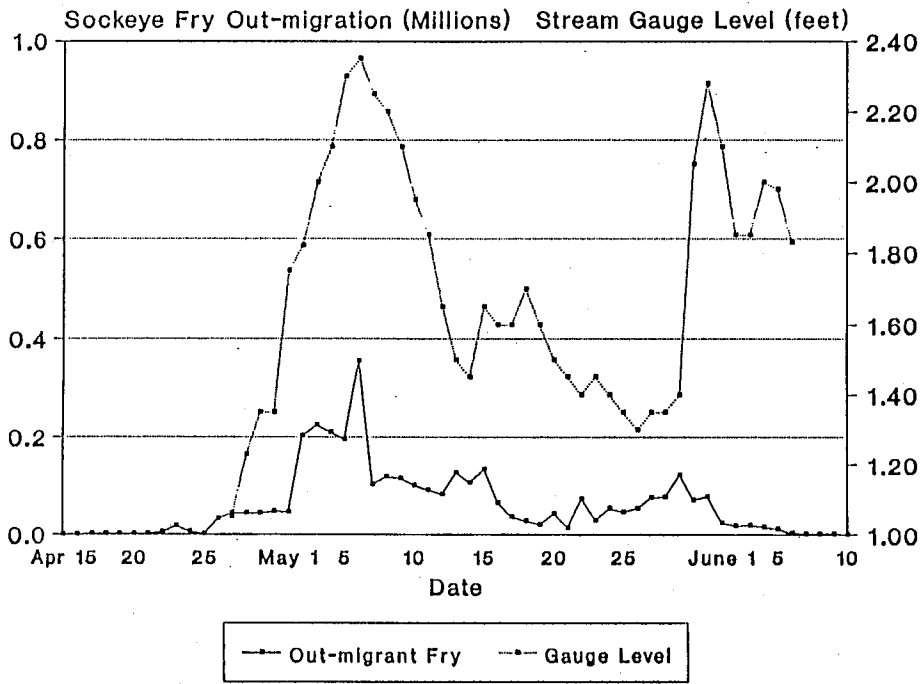
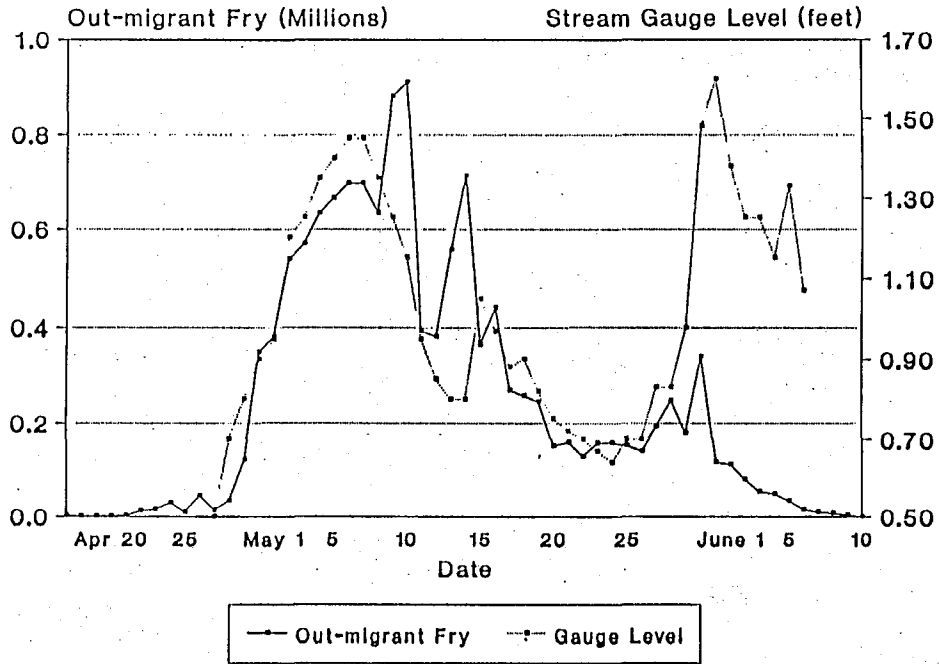
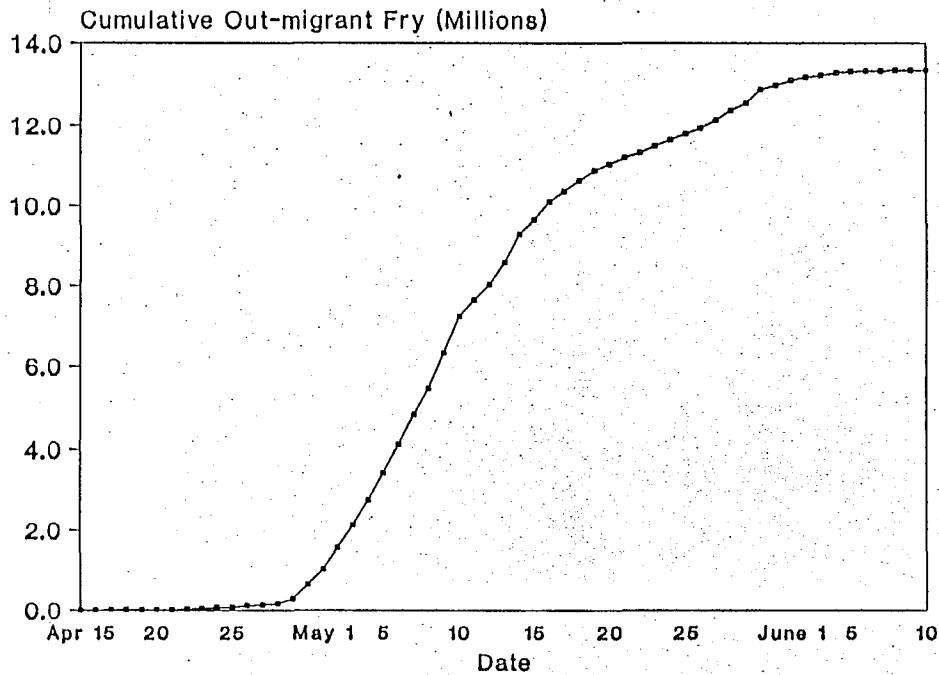


FIG. 6: Daily sockeye fry out-migration vs. stream gauge levels and cumulative fry out-migration estimates for Gluske Creek, 1989



Note: Out-migration from April 30 to May 8 are interpolated.



Note: Out-migration from April 30 to May 8 are interpolated.

FIG. 7: Daily sockeye fry out-migration vs. stream gauge levels and cumulative fry out-migration estimates for Forfar Creek, 1989.

## Population Estimates

Thirty-five fry releases were conducted on Gluske Creek and recovery data generated on all but one of these releases. The total number of fry released was 40,890 and the number recaptured was 2,314 (5.7%). Nightly releases ranged in size from 399 to 2,593 marked fry. Recovery percentages ranged from 1.4 to 31.1 and the mean recovery was 6.38%.

The total number of sockeye fry trapped on Gluske Creek was 147,391. Based on nightly trap catches and release/recapture data, the total estimated number of Gluske Creek out-migrant fry was  $3,410,000 \pm 231,000$  at the 95% confidence level. This number includes adjustments for fry migrating outside of the normal trapping period and interpolated data on days when IPT catch data were not available. No refinements to the population estimates were made on either stream to account for delayed fry recaptures. This decision was made based on the fact that the highest proportion of delayed re-captures was 1.75% on the first Gluske Creek release. After the first release, no higher than three tenths of a percent of marked fry were ever captured after 0800 h the following day. The majority of marks (95%+) were re-captured within two hours of release. The nightly fry out-migration estimates are presented in Appendix 1.

A total of 30 releases were made on Forfar Creek totalling 54,934 marked fry. Recovery data were generated on all but one of these releases, when the trap catch was lost due to adverse weather conditions. Data from the first release were not used because a large number of marked fry were found frozen in the creek the following morning. Nightly releases ranged in size from 430 to 2,993 marked fry and the total number of marks recovered was 4,129 (7.5%). Recovery percentages ranged from 2.0 to 16.5 with a mean of 7.93%.

The total number of sockeye fry trapped on Forfar Creek was 469,491. Using the nightly release and recapture data, the total estimated number of out-migrant fry from Forfar Creek was  $13,356,000 \pm 1,273,000$  at the 95% confidence level. Because of the nine day gap in the IPT catch data, this number includes interpolated values during this period as well as adjustments for fry migration outside the normal trapping period. The regression equation used to calculate interpolated fry migration estimates on Forfar Creek is provided in Appendix 1.

### Egg-to-Fry Survival

Using the 1988 spawning ground escapement data, along with the estimated 1988 fecundity, and the above fry population estimates, the egg-to-fry survival rate for the two creeks were estimated at 12.1% and 31.7%, respectively. These estimates are derived from the following data:

	<u>GLUSKE CREEK</u>	<u>FORFAR CREEK</u>
Number of effective females	8,053	11,706
Mean fecundity (no. eggs)	3,494	3,603
Potential egg deposition	28,137,000	42,177,000
Fry production estimate	3,410,000	13,356,000
Percent Survival:		
- from potential deposition	12.1%	31.7%

The mean fecundity estimates used in the above calculations are derived from the calculated length/fecundity regression equation for the 1989 fecundity samples. The equation for Gluske Creek is:

$$Y = 111.1105 * X - 2501.48$$

where: Y = the calculated fecundity estimate

X = the mean standard length

111.1105 = the calculated X coefficient (m)

-2501.48 = the calculated constant (b)

The 1988 mean standard length for Takla Lake stream 4 yr-old females was 53.67 cm and the mean standard length for 5 yr-olds was 57.00 cm. Using the above formula, the calculated mean fecundity estimates are 3,462 and 3,832, respectively. These values were weighted for the 1988 Takla Lake streams age composition (91.23% 4 yr-olds and 8.77% 5 yr-olds) and resulted in an estimated 1988 weighted mean fecundity of 3,494 (Appendix 2).

The calculated length/fecundity regression equation for Forfar Creek is:

$$Y = 130.8433 * X - 3480.03$$

The mean standard length of 1988 Forfar Creek females was 54.13 cm. The mean length was calculated from 4 yr-olds which comprised 100% of the 1988 Forfar Creek female samples. Using the above equation, the 1988 calculated weighted mean fecundity on Forfar Creek is 3,603 (Appendix 2).

Although there exists some uncertainty in the total Forfar Creek fry estimate because of the nine day data gap, the interpolated fry migration data appears to follow a similar pattern to Gluske Creek. The relationship between fry migration and water gauge levels appears to demonstrate strong correlation and offered the best available method to estimate fry migration during this period (Fig. 6 and 7). The high egg-to-fry survival on Forfar Creek may be the result of over estimating fry migration during the nine day period, but even without including these interpolated data, which of course is not representative since we know fry migration did occur, egg-to-fry survival was 19.4%. It appears certain that egg-to-fry survival exceeded 20% on Forfar Creek and was significantly higher than Gluske Creek. The higher survival on Forfar Creek is likely attributed to a number of factors which may include:

1. The more abundant and better sized spawning gravel present in Forfar Creek vs. Gluske Creek.
2. The larger discharge and total water volume (especially over the winter months) in Forfar Creek which likely results in less mortality from de-watering and freezing and probably provides a more stable temperature regime.
3. The shallower stream gradient in Forfar Creek which results in less scouring during freshet conditions and more rearing habitat for newly emerged fry provided by the larger quantity of slower water or pool habitat.

The relatively high egg-to-fry survival on both creeks was possibly the result of several environmental and biological factors. The mild winter of 1988-89 may have helped fry survival since incubation may not have been hindered by cold temperatures until into January. The increased thermal units between July and December may have accelerated incubation rates and alevin development which could result in alevins being mobile prior to any threat of freezing. Once alevins are mobile, they are probably more able to avoid freezing or de-watering conditions. The large amount of gravel movement in both creeks during the spring freshet results in gravel being freshly deposited each spring and loosened-up again during spawning each summer. If alevins are mobile, the loose gravel they are incubated in may facilitate movement and result in fry being less susceptible to over-wintering mortality. Although not all factors affecting egg-to-fry survival in Gluske and Forfar creeks are known, both creeks had surprisingly high survival rates given their geographical location, their physical characteristics and the suspicion that production is limited by high rates of over-wintering mortality.

### **Biological Characteristics**

A total of 240 sockeye fry were sampled from Gluske Creek. The overall mean length was 26.8 mm and ranged from a low of 23.3 mm to a high of 28.9 mm. The overall mean wet weight was 0.13 g and ranged from a low of 0.08 g to a high of 0.17 g.

The fry samples from Gluske Creek demonstrated only slight variations in size over the period of migration. Mean sockeye fry lengths and weights by sample date are presented in Table 2 and illustrate the relatively consistent fry size throughout the migration period. There does appear to be a small increase in fry size during the second freshet (May 29 - June 1) which may reflect some post-emergent stream growth. The presence of these slightly larger fry during the second freshet is possibly the result of stream rearing fry being flushed out of the creek during the period of increased stream velocities. Little evidence of in-stream rearing in Gluske Creek was observed and no noticeably larger fry were captured in the IPT. Stream gradient is major factor in determining the amount of suitable fry rearing habitat (i.e. ponds, side channels, back eddies, etc.) and because Gluske Creek has a relatively steep gradient, rearing habitat may be limited.

Forfar Creek fry analyses included a total of 200 specimens. The overall mean length was 26.7 mm and ranged from a low of 24.5 mm to a high of 32.5 mm. The overall mean wet weight was 0.13 g and range from a low of 0.09 g to a high of 0.30 g. The wider range in fry sizes reflects the sampled fry specimens that demonstrated significant post-emergent stream growth.

A more obvious trend towards increased fry size over time is evident when mean fry lengths and weights on Forfar Creek are examined in Table 2. During the early stages of migration, fry size remained relatively stable but by mid-May the mean fry size began to slowly increase reaching a peak during the second freshet (May 29 - June 1). On both creeks, the final set of fry samples demonstrated a decrease in mean size which might reflect late emerging, less robust fry.

Stream rearing and post-emergent growth was evident on Forfar Creek both from visual stream observations and nightly trap catches. The first conclusive evidence of stream rearing appeared on May 30 when 10 to 15 large fry (0.30 g) were captured in the IPT. Although their numbers were low (<1% of total catch), these larger fry were trapped consistently over the final eight days of trap operation with the majority migrating out of the creek environment during the second freshet. The shallower stream gradient, resulting in more suitable rearing habitat, is likely the major factor in the higher numbers and larger body size, of stream rearing fry in Forfar Creek.

**Table 2** Length and weight of sockeye fry relative to bi-weekly sampling periods, Gluske and Forfar creeks, 1989.

GLUSKE CREEK

Sample Date	Sample Size	<u>Length (mm)</u>		<u>Wet Weight (g)</u>	
		Mean	Range	Mean	Range
Apr. 23	20	26.99	25 - 29	0.12	0.10 - 0.15
Apr. 27	20	26.71	26 - 28	0.13	0.11 - 0.16
May 1	20	27.12	26 - 28	0.13	0.11 - 0.15
May 5	20	26.39	23 - 28	0.13	0.11 - 0.15
May 9	20	26.56	25 - 28	0.13	0.10 - 0.15
May 12	20	26.93	26 - 28	0.13	0.11 - 0.16
May 17	20	27.04	26 - 28	0.13	0.10 - 0.16
May 21	20	26.78	25 - 29	0.13	0.10 - 0.16
May 25	20	26.84	26 - 28	0.14	0.11 - 0.15
May 29	20	27.01	26 - 29	0.15	0.12 - 0.17
May 31	20	27.36	26 - 28	0.14	0.10 - 0.17
June 4	20	<u>26.85</u>	25 - 29	<u>0.12</u>	0.08 - 0.16
Overall Mean		26.88		0.13	

FORFAR CREEK

Sample Date	Sample Size	<u>Length (mm)</u>		<u>Wet Weight (g)</u>	
		Mean	Range	Mean	Range
Apr. 23	20	26.37	25 - 27	0.12	0.10 - 0.14
Apr. 27	20	26.26	25 - 28	0.13	0.09 - 0.16
May 08	20	26.14	25 - 28	0.11	0.09 - 0.14
May 12	20	26.38	25 - 28	0.13	0.10 - 0.16
May 16	20	26.70	25 - 28	0.13	0.11 - 0.15
May 21	20	26.79	26 - 28	0.14	0.11 - 0.17
May 25	20	26.99	26 - 29	0.14	0.11 - 0.17
May 29	20	27.06	25 - 29	0.13	0.10 - 0.17
May 31	20	27.38	26 - 33	0.15	0.10 - 0.30
June 4	20	<u>26.92</u>	26 - 32	<u>0.14</u>	0.10 - 0.30
Overall Mean		26.70		0.13	

## Stream Conditions

A general record of stream conditions was recorded daily. This included information on ice conditions, turbidity, debris loads, gravel movement, daily peak flows and any other notable changes. In general, the greatest turbidity and debris loads coincided with peak water levels and occurred during the freshet conditions May 1 to 9 and again from May 29 to June 1 and with increases in nightly fry migrations (Figs. 6 and 7). During the remainder of the study period, the water remained relatively clear with the exception of some ice and debris during the first 14 days as ice began to break up on the creeks and water levels first began to rise. Diel fluctuations in water levels, debris loads, and turbidity were often quite large with peak water levels occurring in the late afternoon between 1400 and 1800 h. These diel fluctuations were most pronounced on days with clear skies resulting in warm daytime air temperatures and cool, often freezing, night-time temperatures.

Based on continuous thermograph data, water temperatures on Gluske Creek ranged from a low during mid to late April of 0 °C to a high on June 4 of 6.0 °C (Fig. 8). Water levels ranged from a low of 1.05 ft on the day of installation to a high of 2.35 ft on May 6. After May 6, water levels decreased slowly ranging between 1.30 and 2.00 ft until a second freshet occurred between May 29 and June 1 which peaked on May 31 at 2.28 ft. After May 31 water levels declined slowly, then increased again slightly on June 4, and afterwards declined (Fig. 8) (Appendix 4).

Forfar Creek stream conditions followed a similar pattern with water temperatures ranging from a low during mid to late April of 0 °C to a high of 5.3 °C on May 29 (Fig. 8). Water levels ranged from a low of 0.5 ft on the day of installation to a high 1.60 ft on May 31. The first freshet resulted in a peak water level of 1.45 ft after which water levels declined slowly ranging between 0.64 and 1.15 ft until the second freshet rising quickly over a two day period. Gauge levels then declined slowly, increased again on June 5, then decreased (Fig. 8) (Appendix 4).

## Middle River Fry Migration Observations

Throughout the period of the study neither the permanent observation sites nor other locations between the camp and Forfar Creek yielded evidence of fry migration. Although fry were often present (in approximately 10 to 20% of the observations), no evidence of upstream or downstream migration was observed. The fry that were observed, displayed what appeared to be multi-directional rearing behaviour rather than uni-directional migratory behaviour. On days when fry were observed they were generally in schools of between 10 and 200 individuals and appeared to be feeding in the

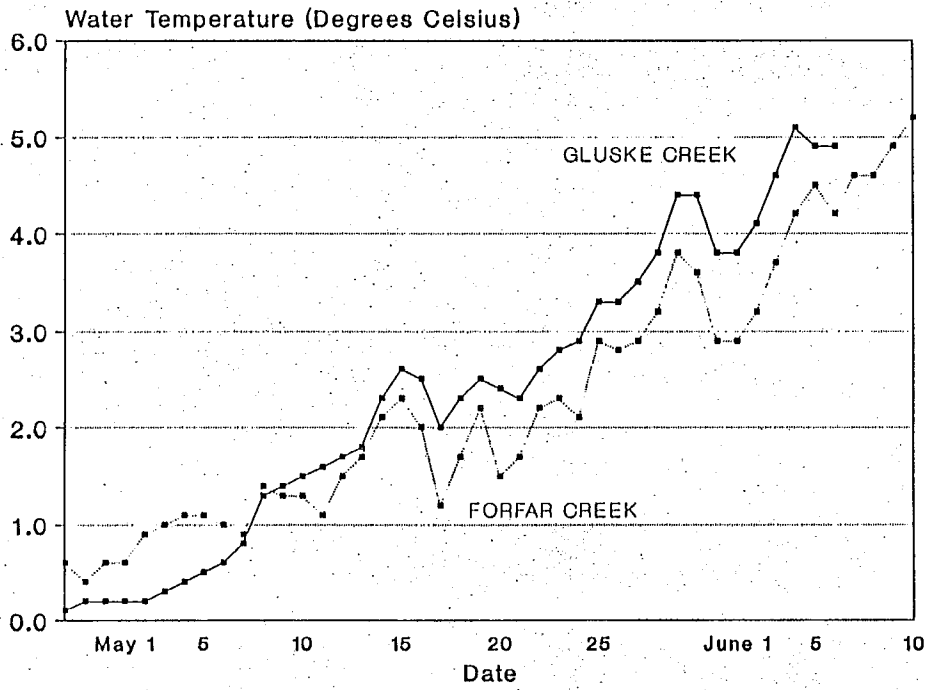
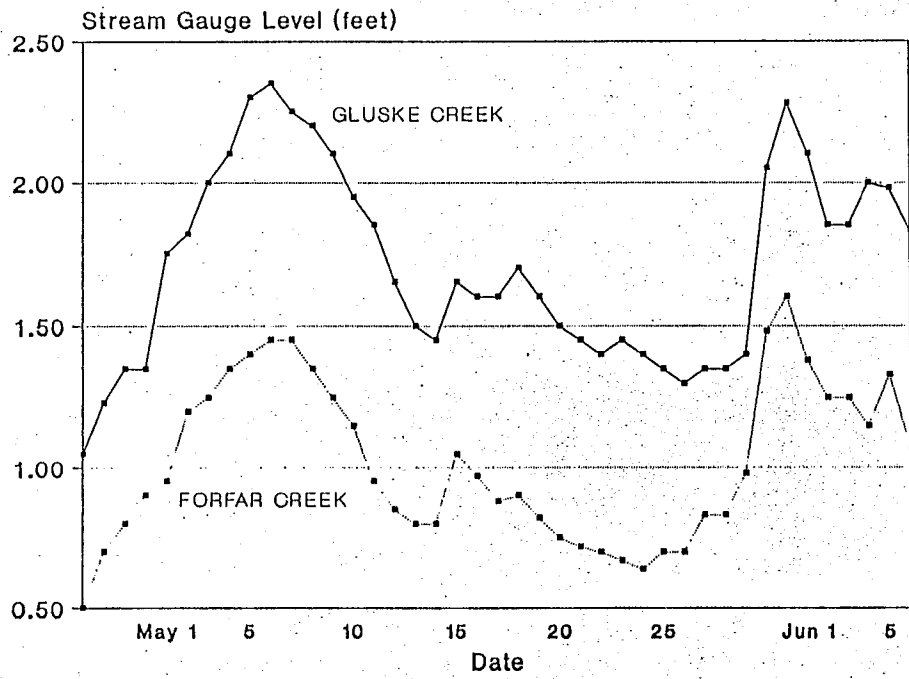


FIG. 8: Seasonal trends in creek gauge levels and mean daily water temperatures, Gluske and Forfar creeks, 1989.

shallow, warmer shoreline waters. It appears that some lower Takla Lake fry move into the upper sections of Middle River to feed prior to the first plankton bloom in the lake.

Observations below the camp were infrequent after May 10 as Middle River and Takla Lake water levels rose, flooding the shoreline area into the brush and tall grasses, and making visual observations difficult. No evidence of upstream or downstream migration was found during observations below the camp which appears to confirm that fry incubated in Middle River tributaries move downstream into Trembleur Lake and fry incubated in Takla Lake tributaries remain in Takla Lake or the upper portion of Middle River.

These observations concur with the findings of the fry studies conducted by the International Pacific Salmon Fisheries Commission (IPSFC) in the Stuart system during the years 1953-54. Based on upstream and downstream trapping between Narrows Creek and Tachie River the study reported that no upstream migration occurred in the lower sections of Middle River but fry were trapped consistently moving downstream throughout May and into June (Goodlad MS 1956). These results indicated that the early-run fry from Middle River tributaries rear in Trembleur Lake. Fry were observed rearing throughout Middle River, which was presumed to act as a nursery area for newly emerged fry until plankton becomes more abundant in the lakes. The study also found that an upstream migration of fry occurred in the upper limits of Middle River during late June and early July (Goodlad MS 1956). The numbers trapped moving upstream into Takla Lake were quite small indicating that these fry were likely incubated in Takla Lake tributaries and moved into Middle River to rear for 3 to 6 weeks after which they move back upstream into Takla Lake. During the 1989 study, no observations were made during this time period to confirm an upstream movement of fry in the upper section of Middle River but fry were observed rearing in this area throughout May and early June.

Although the results from both these studies are inconclusive, similar observations were made and no evidence of large upstream or downstream migration into or out of Takla Lake was noted. Some fry from Takla Lake appear to drift down into Middle River and spend time rearing there. The trapping done in 1953 and 1954 indicates the numbers of fry rearing in upper Middle River are low and that the majority of these fry migrate back upstream into Takla Lake during late June and early July. Further study is necessary to determine the magnitude of Middle River stream rearing and whether some of these fry remain in Middle River and/or continue downstream into Trembleur Lake.

## RECOMMENDATIONS

1. If a sockeye salmon enhancement facility is to be located on one of the Takla Lake tributaries, further downstream fry migration and bio-reconnaissance data should be collected to determine the best possible site.
2. A complete downstream sockeye fry migration program be conducted on Forfar and Gluske creeks to confirm the high egg-to-fry survival rates calculated in 1989.
3. If Forfar Creek is shown to have significantly higher egg-to-fry survival rates than Gluske Creek, then more extensive habitat assessments may be necessary to determine the factors effecting egg-to-fry survival.
4. In order to confirm observations of fry migration behaviour in the Stuart River system, further observations and an extensive trapping program are needed but may not practical from a cost/benefit perspective.
5. If further bio-reconnaissance data are collected on the Stuart system these data should include some stream hydrology information so that discharge regimes can be calculated.

## SUMMARY

1. A field program to estimate the sockeye salmon fry production from Gluske and Forfar creeks was conducted between April 15 and June 10, 1989 employing floating inclined-plane traps.
2. The first fry emerged in early April with peak migration occurring between early to mid-May and completion by mid-June.
3. Peak daily fry migration occurred between 2000 and 0200 h with only between 2% and 4% of the migration occurring during daylight hours.
4. The total out-migrant fry population for Gluske and Forfar creeks was estimated at 3,410,000  $\pm$  231,000 and 13,356,000  $\pm$  1,273,000 at the 95% the confidence level, respectively.
5. Egg-to-fry survival rates from potential egg depositions of 28,958,000 in Gluske Creek and 43,719,000 in Forfar Creek were calculated to be 12.1% and 31.7%, respectively.
6. The high egg-to-fry survival rate estimated for Forfar Creek, while containing some uncertainty due to a gap in trapping data, appears to be attributable to the more favourable incubation conditions present such as better spawning gravel, warmer water temperatures and lower stream gradient and associated stream habitat.

7. Lengths of sampled sockeye fry averaged 26.8 mm (range of 23.3 to 28.9 mm) and 26.7 mm (range of 24.5 to 32.5 mm) for Gluske and Forfar creeks, respectively.
8. Wet weights of sampled sockeye fry averaged 0.13 g (range of 0.08 to 0.17 g) and 0.13 g (range of 0.09 to 0.30 g) for Gluske and Forfar creeks, respectively.
9. Fry stream rearing and post-emergent growth was noted in both visual observations and trap catches during the latter stages of the out-migration on Forfar Creek. Small numbers (<1% of the trap catch) of larger fry were captured in the traps beginning on May 30.
10. Stream temperatures during the project began at 0 °C in both Gluske and Forfar creeks but peaked at 6.0 and 5.3 °C in early June, respectively.
11. Peak water levels on both creeks occurred during the freshet conditions experienced between May 1 and 9 and again between May 29 and June 1.
12. There was no evidence of a large migration of sockeye fry either into or out of Takla Lake based on limited river observations during the project. The observations suggest general rearing behaviour by the sockeye fry in the upper portion of Middle River.

#### ACKNOWLEDGEMENTS

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Assistance with data analyses and manuscript review was provided by R. Kent. C. R. Harrison, W. Saito and K. Peters also provided review comments. Graphics were produced by A. Chu.

Fry bio-sample measurements and fecundity determinations were made by V. Orenchuk.

Fish aging was conducted by B. Tasaka of the Pacific Salmon Commission, Vancouver, B.C.

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**APPENDICES**

## APPENDIX 1a - SUMMARY OF 1989 GLUSKE CREEK SOCKEYE FRY ENUMERATION PROGRAM

EGG DEPOSITION ESTIMATE = 28,137,000 Eff. Fem. = 8,053  
Fecundity = 3,494

DATE	GAUGE LEVEL (ft)	WATER TEMP. (C)	DAILY MIGRATION ESTIMATE	CUMULATIVE MIGRATION	CUM. % MIGRATION	% EGG TO FRY SURV.
15-Apr			0	0	0.00%	0.00%
16-Apr			0	0	0.00%	0.00%
17-Apr			1,000	1,000	0.03%	0.00%
18-Apr		0.0	1,000	2,000	0.06%	0.01%
19-Apr		0.0	1,000	3,000	0.09%	0.01%
20-Apr		1.0	2,000	5,000	0.15%	0.02%
21-Apr		1.0	2,000	7,000	0.21%	0.02%
22-Apr		1.0	5,000	12,000	0.35%	0.04%
23-Apr		1.0	17,000	29,000	0.85%	0.10%
24-Apr		1.0	6,000	35,000	1.03%	0.12%
25-Apr		1.0	2,000	37,000	1.09%	0.13%
26-Apr		1.0	32,000	69,000	2.02%	0.25%
27-Apr	1.05	1.0	43,000	112,000	3.28%	0.40%
28-Apr	1.23	1.0	43,000	155,000	4.55%	0.55%
29-Apr	1.35	0.0	43,000	198,000	5.81%	0.70%
30-Apr	1.35	0.0	47,000	245,000	7.18%	0.87%
01-May	1.75	0.0	45,000	290,000	8.50%	1.03%
02-May	1.82	0.0	203,000	493,000	14.46%	1.75%
03-May	2.00	1.0	225,000	718,000	21.06%	2.55%
04-May	2.10	0.0	210,000	928,000	27.21%	3.30%
05-May	2.30	2.0	195,000	1,123,000	32.93%	3.99%
06-May	2.35	2.0	354,000	1,477,000	43.31%	5.25%
07-May	2.25	1.0	102,000	1,579,000	46.30%	5.61%
08-May	2.20	1.0	118,000	1,697,000	49.77%	6.03%
09-May	2.10	1.0	114,000	1,811,000	53.11%	6.44%
10-May	1.95	2.0	190,000	1,911,000	56.04%	6.79%
11-May	1.85	3.0	90,000	2,001,000	58.68%	7.11%
12-May	1.65	3.0	82,000	2,083,000	61.09%	7.40%
13-May	1.50	3.0	126,000	2,209,000	64.78%	7.85%
14-May	1.45	4.0	106,000	2,315,000	67.89%	8.23%
15-May	1.65	4.5	134,000	2,449,000	71.82%	8.70%
16-May	1.60	3.0	64,000	2,513,000	73.70%	8.93%
17-May	1.60	3.5	35,000	2,548,000	74.72%	9.06%
18-May	1.70	3.5	27,000	2,575,000	75.51%	9.15%
19-May	1.60	3.0	20,000	2,595,000	76.10%	9.22%
20-May	1.50	3.0	41,000	2,636,000	77.30%	9.37%
21-May	1.45	3.0	14,000	2,650,000	77.71%	9.42%
22-May	1.40	4.0	72,000	2,722,000	79.82%	9.67%
23-May	1.45	3.0	28,000	2,750,000	80.65%	9.77%
24-May	1.40	3.0	53,000	2,803,000	82.20%	9.96%
25-May	1.35	3.0	45,000	2,848,000	83.52%	10.12%
26-May	1.30	4.0	53,000	2,901,000	85.07%	10.31%
27-May	1.35	4.5	74,000	2,975,000	87.24%	10.57%
28-May	1.35	4.5	75,000	3,050,000	89.44%	10.84%
29-May	1.40	5.0	121,000	3,171,000	92.99%	11.27%
30-May	2.05	5.0	69,000	3,240,000	95.01%	11.52%
31-May	2.28	4.0	77,000	3,317,000	97.27%	11.79%
01-Jun	2.10	4.0	24,000	3,341,000	97.98%	11.87%
02-Jun	1.85	6.0	17,000	3,358,000	98.48%	11.93%
03-Jun	1.85	5.0	19,000	3,377,000	99.03%	12.00%
04-Jun	2.00	7.0	15,000	3,392,000	99.47%	12.06%
05-Jun	1.98	6.0	11,000	3,403,000	99.79%	12.09%
06-Jun	1.83	6.0	3,000	3,406,000	99.88%	12.11%
07-Jun			2,000	3,408,000	99.94%	12.11%
08-Jun			1,000	3,409,000	99.97%	12.12%
09-Jun			1,000	3,410,000	100.00%	12.12%
10-Jun			0	3,410,000	100.00%	12.12%
TOTALS:			3,410,000 +/-		231.000 6.77%	

## APPENDIX 1b - SUMMARY OF 1989 FORFAR CREEK SOCKEYE FRY ENUMERATION PROGRAM

EGG DEPOSITION ESTIMATE = 42,177,000 Eff. Fem. = 11,706  
Fecundity = 3,603

DATE	GAUGE LEVEL (ft)	WATER TEMP. (C)	DAILY MIGRATION ESTIMATE	CUMULATIVE MIGRATION	% EGG TO FRY SURV.
14-Apr			0	0	0.00%
15-Apr		1.0	0	0	0.00%
16-Apr		1.0	0	0	0.00%
17-Apr		1.0	3,000	3,000	0.01%
18-Apr		1.0	1,000	4,000	0.01%
19-Apr		1.0	1,000	5,000	0.01%
20-Apr		2.0	1,000	6,000	0.01%
21-Apr		2.0	2,000	8,000	0.02%
22-Apr		2.0	12,000	20,000	0.05%
23-Apr		2.0	14,000	34,000	0.08%
24-Apr		2.0	29,000	63,000	0.15%
25-Apr		3.0	9,000	72,000	0.17%
26-Apr		3.0	44,000	116,000	0.28%
27-Apr	0.50	3.0	13,000	129,000	0.31%
28-Apr	0.70	2.0	32,000	161,000	0.38%
29-Apr	0.80	1.0	122,000	283,000	0.67%
30-Apr	0.90	2.0	349,000 *	632,000	1.50%
01-May	0.95	3.0	380,000 *	1,012,000	2.40%
02-May	1.20	3.0	539,000 *	1,551,000	3.68%
03-May	1.25	3.0	571,000 *	2,122,000	5.03%
04-May	1.35	3.0	634,000 *	2,756,000	6.53%
05-May	1.40	3.0	666,000 *	3,422,000	8.11%
06-May	1.45	2.0	698,000 *	4,120,000	9.77%
07-May	1.45	3.0	698,000 *	4,818,000	11.42%
08-May	1.35	3.0	634,000 *	5,452,000	12.93%
09-May	1.25	3.5	880,000	6,332,000	15.01%
10-May	1.15	4.0	910,000	7,242,000	17.17%
11-May	0.95	3.0	393,000	7,635,000	18.10%
12-May	0.85	4.0	381,000	8,016,000	19.01%
13-May	0.80	4.5	558,000	8,574,000	20.33%
14-May	0.80	5.0	713,000	9,287,000	22.02%
15-May	1.05	5.0	364,000	9,651,000	22.88%
16-May	0.97	4.0	440,000	10,091,000	23.93%
17-May	0.88	4.0	269,000	10,360,000	24.56%
18-May	0.90	4.0	257,000	10,617,000	25.17%
19-May	0.82	3.5	244,000	10,861,000	25.75%
20-May	0.75	4.0	153,000	11,014,000	26.11%
21-May	0.72	3.0	161,000	11,175,000	26.50%
22-May	0.70	4.0	130,000	11,305,000	26.80%
23-May	0.67	4.5	160,000	11,465,000	27.18%
24-May	0.64	4.0	159,000	11,624,000	27.56%
25-May	0.70	4.0	154,000	11,778,000	27.93%
26-May	0.70	4.0	141,000	11,919,000	28.26%
27-May	0.83	5.0	194,000	12,113,000	28.72%
28-May	0.83	5.5	247,000	12,360,000	29.31%
29-May	0.98	5.5	180,000	12,540,000	29.73%
30-May	1.48	5.0	338,000	12,878,000	30.53%
31-May	1.60	5.0	118,000	12,996,000	30.81%
01-Jun	1.38	5.0	113,000	13,109,000	31.08%
02-Jun	1.25	5.0	79,000	13,188,000	31.27%
03-Jun	1.25	5.5	53,000	13,241,000	31.39%
04-Jun	1.15	7.0	48,000	13,289,000	31.51%
05-Jun	1.33	7.0	33,000	13,322,000	31.59%
06-Jun	1.07	6.0	14,000	13,336,000	31.62%
07-Jun			10,000	13,346,000	31.64%
08-Jun			7,000	13,353,000	31.66%
09-Jun			3,000	13,356,000	31.67%
10-Jun			0	13,356,000	31.67%

TOTALS: 13,356,000 +/- 1,273,000

\* = interpolated values from gauge/migration regression  
9.53%

## APPENDIX 1c

## FORFAR CREEK MAY 9-30 GAUGE VS FRY ESCAPEMENT

## Regression Output:

Constant	-222875	Calculated Escapement:
Std Err of Y Est	198532	
R Squared	0.3116897306	Y=MX+B
No. of Observations	22	
Degrees of Freedom	20	348,511
		380,255
X Coefficient(s)	634874	538,974
Std Err of Coef.	210962	570,717
		634,205
		665,948
Regression Equation:		697,692
		697,692
Y = 634,874 (X) + (-222,875)		634,205

where:

Y = the calculated fry migration estimate  
 X = the creek gauge level  
 634,874 = the calculated X coefficient (M)  
 -222,875 = the calculated constant (b)

## FORFAR CREEK

## 1988 MEAN FECUNDITY CALCULATIONS

4 YR-OLDS:

$$Y = 130.8433 * 54.13 + (-3480.03)$$

$$Y = 3602.52$$

## 1988 FORFAR CREEK FEMALE AGE COMPOSITION:

4 YR-OLDS = 100%

5 YR-OLDS = 0%

## 1988 WEIGHTED MEAN FECUNDITY:

$$Y = 3602.52 * (1.00)$$

$$Y = 3602.53$$

## 1989 Forfar Creek Regression Output:

Constant	-3480.03
Std Err of Y Est	343.2590
R Squared	0.313731
No. of Observations	25
Degrees of Freedom	23

X Coefficient(s)	130.8433
Std Err of Coef.	40.35114

## GLUSKE CREEK

## 1988 MEAN FECUNDITY CALCULATIONS

4 YR-OLDS:

$$Y = 111.1105 * 53.67 + (-2501.48)$$

$$Y = 3461.82$$

5 YR-OLDS:

$$Y = 111.1105 * 57.00 + (-2501.48)$$

$$Y = 3831.82$$

## 1988 TAKLA FEMALE AGE COMPOSITION:

4 YR-OLDS = 91.23%

5 YR-OLDS = 8.77%

## 1988 WEIGHTED MEAN FECUNDITY:

$$Y = 3461.82 * (0.9123) + 3831.82 * (0.0877)$$

$$Y = 3494.27$$

## 1989 Gluske Creek Regression Output:

Constant	-2501.48
Std Err of Y Est	463.5051
R Squared	0.295222
No. of Observations	25
Degrees of Freedom	23

X Coefficient(s)	111.1105
Std Err of Coef.	35.79669

## APPENDIX 2b

## 1989 - Gluske Creek Sockeye Fecundities and Lengths

## COMBINED AGE CLASSES

Sample No.	Total Weight (g)	Sample Weight (g)	Eggs per gram	Sample Count (No.)	Loose Eggs (No.)	Calc. Fecundity Estimate	Actual Egg Count	Percent Diff-erence	Standard Length (cm)	P.O.-Hyp. Length (cm)	Age (oto.)
1	322.5	93.1	9.70	903	24	3,130	3,130	0.00%	52.3	47.5	42
2	317.9	108.2	10.30	1,114	12	3,285			59.5	55.2	0
3	210.0	89.5	13.15	1,177	32	2,794			49.0	45.0	42
4	205.8	74.7	15.11	1,129	6	3,116			50.5	46.4	0
5	254.2	96.7	11.91	1,152	26	3,054			50.6	46.4	0
6	374.8	134.2	9.92	1,331	7	3,714	3,714	0.00%	53.4	48.6	42
7	201.9	79.9	15.13	1,209	5	3,060			51.8	47.1	42
8	223.3	84.9	14.25	1,210	3	3,185			51.2	46.6	42
9	363.1	130.5	11.42	1,490	11	4,157			52.6	47.9	42
10	292.5	84.5	11.22	948	31	3,313			52.2	47.8	42
11	227.1	84.2	12.01	1,011	10	2,746	2,746	0.00%	51.0	46.9	42
12	253.8	88.7	12.02	1,066	23	3,073			51.5	47.4	42
13	263.6	80.7	13.63	1,100	119	3,712			51.4	47.1	42
14	326.1	105.6	10.92	1,153	44	3,605			53.4	48.6	42
15	436.6	147.5	10.23	1,509	21	4,488			57.0	51.9	52
16	318.0	113.0	12.25	1,384	7	3,948	3,948	0.00%	52.8	48.4	42
17	236.8	80.4	11.80	949	7	2,802			51.3	46.8	42
18	270.6	95.9	13.92	1,335	9	3,776			51.1	46.8	42
19	448.5	182.4	9.75	1,779	5	4,379			60.4	54.5	52
20	194.8	71.2	12.57	895	18	2,467			52.0	47.6	42
21	306.1	121.9	12.08	1,473	14	3,713			53.7	48.8	42
22	195.4	88.5	12.35	1,093	18	2,431			52.9	48.3	42
23	244.3	82.1	13.31	1,093	38	3,290			51.0	46.7	42
24	281.2	102.3	11.66	1,193	13	3,292			52.4	47.8	42
25	295.2	101.3	10.66	1,080	9	3,221	3,221	0.00%	51.6	46.9	42
No. =	Mean			Mean		Mean			Mean		
25	eggs/g =	12.05		fecundity =	3,350	Lengths =	52.7		48.1		

## APPENDIX 2c

## 1989 - Forfar Creek Sockeye Fecundities and Lengths

## COMBINED AGE CLASSES

Sample No.	Total Weight (g)	Sample Weight (g)	Eggs per gram	Sample Count (No.)	Loose Eggs (No.)	Calc. Fecundity Estimate	Actual Egg Count	Percent Diff-erence	Standard Length (cm)	P.O.-Hyp. Length (cm)	Age (oto.)
1	297.2	112.1	10.33	1,158	38	3,146	3,146	0.00%	52.2	48.2	0
2	255.9	85.9	15.18	1,304	13	3,898			51.5	47.1	42
3	286.2	102.1	11.52	1,176	410	3,706			53.7	48.8	42
4	365.7	129.7	10.48	1,359	15	3,847			53.7	48.7	42
5	311.7	98.4	11.30	1,112	39	3,561			53.3	48.4	42
6	309.3	114.5	10.58	1,211	17	3,332	3,332	0.00%	50.0	46.0	0
7	158.4	61.0	16.36	998	17	2,609			49.9	46.2	42
8	198.1	78.2	12.92	1010	15	2,574			48.5	44.7	42
9	260.1	100.2	13.15	1,318	13	3,434			51.3	46.9	42
10	294.5	108.8	12.15	1,322	12	3,590			52.9	48.7	42
11	199.8	81.1	12.24	993	206	2,661	2,661	0.00%	51.0	46.9	42
12	260.4	90.2	14.47	1,305	38	3,805			51.1	47.2	42
13	166.9	55.2	15.22	840	54	2,594			48.9	35.7	42
14	205.2	86.5	15.06	1,303	86	3,177			52.7	48.5	42
15	293.5	107.3	10.62	1,140	34	3,152			50.9	46.4	42
16	227.3	82.1	14.64	1,202	99	3,471	3,471	0.00%	51.3	47.1	42
17	249.1	91.3	12.53	1,144	9	3,130			50.2	46.6	42
18	251.8	94.3	13.58	1,281	38	3,459			52.3	47.8	42
19	246.9	95.3	12.16	1,159	68	3,071			52.6	47.4	42
20	240.9	89.6	14.71	1,318	31	3,575			54.3	50.5	42
21	252.6	106.0	12.25	1,299	73	3,174	3,174	0.00%	54.5	49.5	42
22	177.8	62.2	17.78	1,106	20	3,182			49.7	46.7	42
23	274.7	99.8	12.95	1,292	70	3,626			54.5	50.6	42
24	318.8	114.3	11.90	1,360	73	3,866			52.3	47.9	42
25	269.6	98.0	11.13	1,091	49	3,050			53.6	48.2	42
No. =	Mean			Mean		Mean			Mean		
25	eggs/g =	13.01		fecundity =	3,308	Lengths =	51.9		47.2		

02-Nov-88

APPENDIX 3a

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1988	SOCKEYE	EARLY STUART	GLUSKE CREEK	HEAD OPERATIONS: R. KENT	TECH: K. PETERS	CARD: D. HICKEY
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POPULATION TOTAL: 17,700

MALES:	9,354	FEMALES:	8,288	JACKS	58
	52.85%		46.82%		0.33%

METHOD OF ENUMERATION: Fence Count = 17,542 + 158 below fence = 17,700  
Peak live count 11,961 + Cumulative dead 377 = 12,338 x 1.44 Index = 17,767

SEX RATIO: Best Est. . . . . 53.02% Male 46.98% Female  
Dead Recovery . . . . . 53.02% . . . . . 46.98%  
Separate Pop. Calc.  
Other Methods

PEAK DAYS OF SPAWNING: Jul 30 - Aug 6, 1988.

ARRIVAL DATES: Jul 17, 1988.

WEIGHTED PERCENT SPAWN: 97.16% EFFECTIVE FEMALES: 8,053

LOCATION OF SPAWNING: To 4 km up creek.

REMARKS: Jul 17, 1988 - 100+ fish observed off mouth. Fence installed today.  
Aug 15, 1988 - fence removed.  
The index for 1988 has been revised to 1.44 based on fence data for Gluske and Rossette creeks.

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1988	SOCKEYE	EARLY STUART	FORFAR CREEK	HEAD OPERATIONS: R. KENT	TECH: K. PETERS	CARD: D. HICKEY
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POPULATION TOTAL: 24,640

MALES:	12,366	FEMALES:	12,134	JACKS	140
	50.19%		49.25%		0.57%

METHOD OF ENUMERATION: Peak live count 15,750 + Cumulative dead 1,361 = 17,111 x 1.44 Index = 24,640

SEX RATIO: Best Est.	50.47% Male	49.53% Female
Dead Recovery	50.47%	49.53%
Separate Pop. Calc.		
Other Methods		

PEAK DAYS OF SPAWNING: Aug 4 - 8, 1988

ARRIVAL DATES: Jul 17, 1988

WEIGHTED PERCENT SPAWN: 96.47%      EFFECTIVE FEMALES: 11,706

LOCATION OF SPAWNING: From the mouth upstream for about 4.0 km to falls.

REMARKS: Jul 17, 1988 - 300+ sockeye off mouth.  
 Aug 1, 1988 - Sockeye observed spawning on Forfar Bar in Middle River.  
 In order to obtain fresh jack samples for aging, only sacrificed fish were used.

The index for 1988 has been revised based on fence data for Gluske and Rossette creeks.  
 (see narrative)

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## APPENDIX 4a

## GLUSKE CREEK STREAM TEMP. AND GAUGE LEVEL

DATE	MEAN DAILY TEMP. (C)	STREAM GAUGE LEVEL
		1.05
	0.1	1.23
	0.2	1.35
MAY 1	0.2	1.35
	0.2	1.75
	0.2	1.82
	0.3	2.00
	0.4	2.10
5	0.5	2.30
	0.6	2.35
	0.8	2.25
	1.3	2.20
	1.4	2.10
10	1.5	1.95
	1.6	1.85
	1.7	1.65
	1.8	1.50
	2.3	1.45
15	2.6	1.65
	2.5	1.60
	2.0	1.60
	2.3	1.70
	2.5	1.60
20	2.4	1.50
	2.3	1.45
	2.6	1.40
	2.8	1.45
	2.9	1.40
25	3.3	1.35
	3.3	1.30
	3.5	1.35
	3.8	1.35
	4.4	1.40
	4.4	2.05
JUNE 1	3.8	2.28
	3.8	2.10
	4.1	1.85
	4.6	1.85
	5.1	2.00
5	4.9	1.98
	4.9	1.83
	5.3	
	5.3	
	5.3	
10	5.6	

## FORFAR CREEK STREAM TEMP. AND GAUGE LEVEL

DATE	MEAN DAILY TEMP. (C)	STREAM GAUGE LEVEL
		0.50
	0.6	0.70
	0.4	0.80
	0.6	0.90
MAY 1	0.6	0.95
	0.9	1.20
	1.0	1.25
	1.1	1.35
5	1.1	1.40
	1.0	1.45
	0.9	1.45
	1.4	1.35
	1.3	1.25
10	1.3	1.15
	1.1	0.95
	1.5	0.85
	1.7	0.80
	2.1	0.80
15	2.3	1.05
	2.0	0.97
	1.2	0.88
	1.7	0.90
	2.2	0.82
20	1.5	0.75
	1.7	0.72
	2.2	0.70
	2.3	0.67
	2.1	0.64
25	2.9	0.70
	2.8	0.70
	2.9	0.83
	3.2	0.83
	3.8	0.98
	3.6	1.48
	2.9	1.60
JUNE 1	2.9	1.38
	3.2	1.25
	3.7	1.25
	4.2	1.15
5	4.5	1.33
	4.2	1.07
	4.6	
	4.6	
	4.9	
10	5.2	

## APPENDIX 4b

## GLUSKE CREEK DAILY WATER TEMPERATURE DATA (DEGREES CELSIUS)

YEAR: 1989

LOCALE: RECORDER POOL (APPROX. 50 M FROM MOUTH)

DAY	APR			MAY			JUN		
	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
1	0.0	0.0	0.0	0.3	0.0	0.2	4.2	3.3	3.8
2	0.0	0.0	0.0	0.4	0.0	0.2	5.0	3.2	4.1
3	0.0	0.0	0.0	0.5	0.0	0.3	5.3	3.8	4.6
4	0.0	0.0	0.0	0.7	0.0	0.4	6.0	4.1	5.1
5	0.0	0.0	0.0	0.9	0.0	0.5	5.5	4.2	4.9
6	0.0	0.0	0.0	0.9	0.3	0.6	5.5	4.2	4.9
7	0.0	0.0	0.0	1.2	0.3	0.8	5.7	4.8	5.3
8	0.0	0.0	0.0	2.0	0.6	1.3	5.5	5.0	5.3
9	0.0	0.0	0.0	1.8	1.0	1.4	5.6	5.0	5.3
10	0.0	0.0	0.0	1.8	1.1	1.5	6.2	5.0	5.6
11	0.0	0.0	0.0	2.0	1.1	1.6	6.9	5.2	6.1
12	0.0	0.0	0.0	2.0	1.4	1.7	7.1	6.1	6.6
13	0.0	0.0	0.0	2.7	0.8	1.8	6.3	6.5	6.4
14	0.0	0.0	0.0	3.1	1.5	2.3	7.1	6.1	6.6
15	0.0	0.0	0.0	3.1	2.1	2.6	6.6	5.9	6.3
16	0.0	0.0	0.0	3.1	1.9	2.5	6.1	5.5	5.8
17	0.0	0.0	0.0	2.1	1.9	2.0	5.9	5.2	5.6
18	0.0	0.0	0.0	2.5	2.0	2.3	5.5	5.0	5.3
19	0.0	0.0	0.0	3.0	2.0	2.5	5.2	5.0	5.1
20	0.0	0.0	0.0	2.8	1.9	2.4	6.1	5.2	5.7
21	0.0	0.0	0.0	2.5	2.1	2.3	6.0	5.9	6.0
22	0.0	0.0	0.0	3.1	2.1	2.6	7.0	5.9	6.5
23	0.0	0.0	0.0	3.4	2.1	2.8	8.0	6.7	7.4
24	0.1	0.0	0.1	3.4	2.4	2.9	8.7	7.2	8.0
25	0.1	0.0	0.1	3.9	2.6	3.3	8.9	8.0	8.5
26	0.2	0.0	0.1	3.9	2.6	3.3	8.0	7.1	7.6
27	0.1	0.0	0.1	4.2	2.7	3.5	7.1	6.9	7.0
28	0.1	0.0	0.1	4.8	2.7	3.8	7.1	6.5	6.8
29	0.3	0.0	0.2	5.2	3.6	4.4	7.2	6.6	6.9
30	0.3	0.0	0.2	4.9	3.8	4.4	7.1	6.9	7.0
31				4.2	3.3	3.8			
MONTHLY MAX.			0.3			5.2			8.9
MONTHLY MIN.			0.0			0.0			3.2
MONTHLY MEAN			0.0			2.1			6.0

## APPENDIX 4c

## FORFAR CREEK DAILY WATER TEMPERATURE DATA (DEGREES CELSIUS)

YEAR: 1989

LOCALE: STREAM GAUGE SITE (APPROX. 500 M FROM MOUTH)

APR				MAY			JUN		
DAY	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
1				1.1	0.0	0.6	3.3	2.5	2.9
2				1.7	0.0	0.9	3.6	2.8	3.2
3				1.9	0.0	1.0	4.2	3.1	3.7
4				2.2	0.0	1.1	4.7	3.6	4.2
5				2.2	0.0	1.1	4.7	4.2	4.5
6				1.7	0.3	1.0	4.7	3.6	4.2
7				1.7	0.0	0.9	5.0	4.2	4.6
8				2.5	0.3	1.4	5.0	4.2	4.6
9				1.9	0.6	1.3	5.3	4.4	4.9
10				2.2	0.3	1.3	5.6	4.7	5.2
11				1.9	0.3	1.1	6.4	5.0	5.7
12				2.2	0.8	1.5	6.7	5.8	6.3
13				3.3	0.0	1.7			
14				3.8	0.3	2.1			
15				3.1	1.4	2.3			
16				3.1	0.8	2.0			
17				1.7	0.6	1.2			
18				2.5	0.8	1.7			
19				3.3	1.1	2.2			
20				2.7	0.3	1.5			
21				2.2	1.1	1.7			
22				3.3	1.1	2.2			
23				3.8	0.8	2.3			
24				3.3	0.8	2.1			
25				4.2	1.6	2.9			
26				4.4	1.1	2.8			
27				4.7	1.1	2.9			
28	1.1	0.0	0.6	5.3	1.1	3.2			
29	0.8	0.0	0.4	5.3	2.2	3.8			
30	1.1	0.0	0.6	5.0	2.2	3.6			
31				3.1	2.7	2.9			

MONTHLY MAX.	1.1		5.3	6.7
MONTHLY MIN.	0.0		0.0	2.5
MONTHLY MEAN	0.5		1.9	4.5