Blaney Creek Chum Project 1972 - 1977

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BY

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ABSTRACT

Banford, C. and D.D. Bailey. 1979. Blaney Creek Chum Project, 1972 - 1977. Fish. Mar. Serv. MS Rep. 1537: vii + 46 p.

From 1972 to 1977, upwelling gravel incubators have been utilized at Blaney Creek for the propagation of chum salmon (Oncorhynchus keta). The project involved taking a minor spawning run of 25 to 750 chum salmon and building it to an economically significant size of approximately 14,000 salmon in two generations.

From 1972 - 1977, the average number of adults returning to Blaney Creek was 850 with an annual range of 175 in 1976 to 2,764 in 1977. The largest escapement of 2,764 adults in 1977 included the 1973 brood incubator returns of four year olds.

The total number of eggs planted from 1972 to 1977 was 3,889,895 with an annual range of 163,407 in 1975 to 1,711,432 in 1977. The total number of fry released into Blaney Creek was 3,208,506 resulting in an average egg-to-fry survival of 82.3 percent with an annual range of 97.7 percent in 1972 to 68.5 percent in 1977.

Of the total fry released from the 1972 - 1975 broods, 838,760 (45 percent) were fin-clipped (adipose and left ventral) for identification as returning adults. This should provide valuable information on stock size, migration timing, and the contribution to commercial and Indian food fisheries. Future years' data, however, on marked adult returns are necessary in order to evaluate success of the Blaney Creek operation.

Key Words: upwelling gravel incubators, chum salmon, eggs, fry survival, migration timing, commercial fisheries.

RÉSUMÉ

Banford, C. and D. D. Bailey, 1979. Blaney Creek Chum Project, 1972 - 1977. Fish. Mar. Serv. MS Rep. 1537: vii + 46p.

De 1972 à 1977, on a utilisé des incubateurs a gravier avec courant ascendant pour augmenter la population de saumon kéta (Oncorhynchus keta) du ruisseau Blaney. Le projet consistait à s'intéresser a une remonte mineure de 25 à 750 saumons et de lui faire atteindre une taille exploitable d'environ 14,000 saumons en deux générations.

De 1972 à 1977, le nombre moyen d'adultes remontant au ruisseau Blaney était de 850, avec une amplitude annuelle allant de 175 en 1976 à 2,764 en 1977. Ce chiffre, le plus élevé qu'on ait noté, comprenait les saumons de quatre ans nés en incubateur.

Le nombre total d'oeufs incubés artificiellement de 1972 à 1977 se monte à 3,889,895, avec un minimum annuel de 163,407 en 1975 et un maximum de 1,711,432 en 1977. Au total, 3,208,506 alevins ont été libérés dans le ruisseau Blaney, ce qui représente un taux de survie des alevins par rapport au nombre d'oeufs de 82.3 %, avec un maximum de 97.7 % en 1972 et un minimum de 68.5 % en 1977.

Sur le total des alevins libérés des générations 1972 à 1975, on a étiqueté à la nageoire adipeuse et à la nageoire ventrale gauche 838,760 spécimens (soit 45%) afin de les identifier lors de leur retour à l'âge adulte. Cette opération doit apporter des informations intéressantes sur la taille du stock, le calendrier de la migration et le rôle de cette population dans la pêche commerciale et la pêche de subsistance des Indiens. Il est cependant nécessaire de continuer à recueillir dans les années qui viennent des données sur la remonte des adultes marqués afin d'évaluer le succès de l'opération du ruisseau Blaney.

Mots clés: incubation sur gravier avec courant ascendant, saumon kéta, oeufs, survie des alevins, calendrier de la migration.

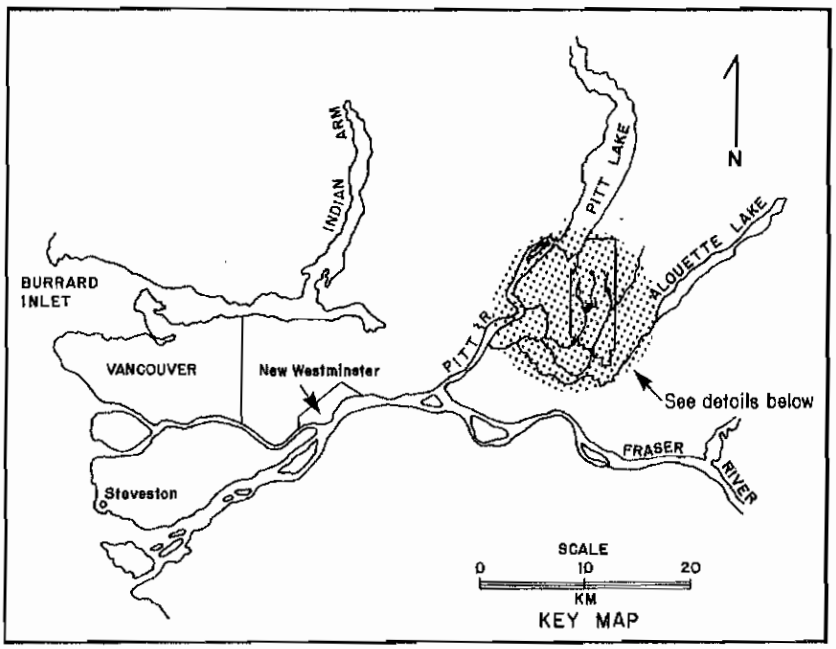
INTRODUCTION

From 1972 to 1977, gravel upwelling incubators have been utilized at Blaney Creek for the propagation of chum salmon (Oncorhynchus keta). This has been the first step at rehabilitating and enhancing the Fraser River chum salmon stocks.

Blaney Creek is a short, steep gradient stream which drains the Loon, Placid and Blaney Lake watersheds, and is a tributary to the North Alouette River. (Figure 1). Escapement records from 1948 - 1971, indicate that this small stream (0.1 to 11 cms) supported an average spawning run of 400 chum salmon (range: 25 - 750) on a spawning area of 1,000 square meters. The project involved taking this small, uneconomic race of chum salmon and building it to an economically significant size of 14,000 adults.

The upwelling gravel incubator has been studied over the years as a method of propagating Pacific salmon (Oncorhynchus); (Robertson, 1919; Wilson, 1967 - 1972; Bailey and Taylor, 1973; Bams, 1974; Ginetz, 1975; Hilland, 1977). The results of studies carried out by the International Pacific Salmon Fisheries Commission (1960), and pilot upwelling gravel incubator trials done at the Chehalis River (1967 -1968) , and later at the Big Qualicum River and Inches Creek (1970 - 1972), provided guidance to the Blaney Creek program.

The current operation utilizing upwelling gravel incubators is located on upper Blaney Creek in the University of British Columbia Research Forest (Figure 1). Adult chum are transported from the collection site and held at the incubation site for the egg-takes. Eggs are fertilized, water hardened, and planted between layers of gravel in the incubation units. The gravity-supplied water from Blaney Creek is delivered to a head tank and false bottom in each of the three incubators and upwells through alternating layers of eggs and gravel. Emergent fry are enumerated and released into Blaney Creek. A percentage of the fry are fin-clipped to determine adult migration timing and the contribution to commercial and Indian food fisheries.



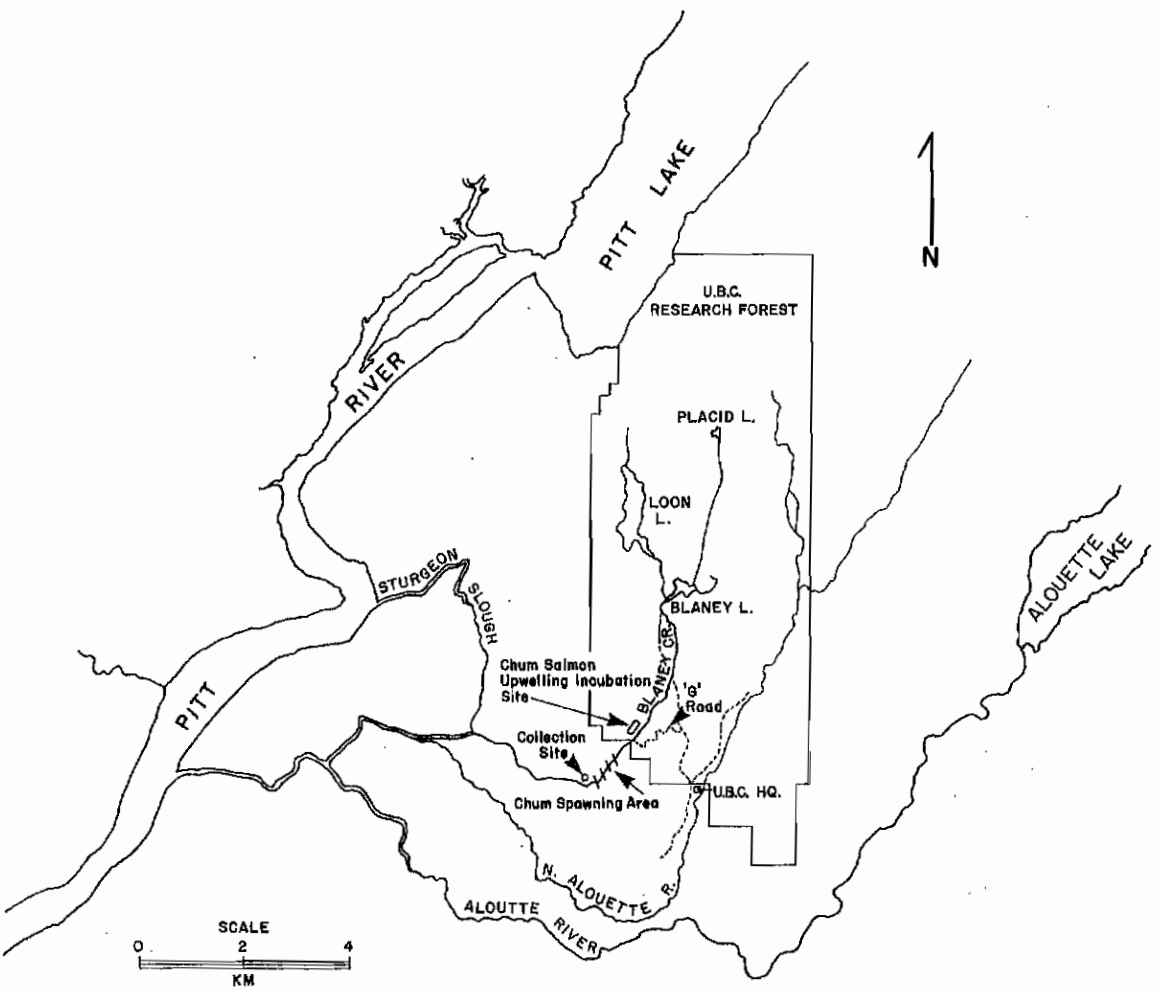


Figure 1: Location of Blaney Creek Chum Project showing collection site and upwelling incubation site.

When chum escapements to Blaney Creek increase to 14,000 adults, the capacity of the facility will be increased from the present 1.5 million to 6.0 million eggs.

The following report discusses adult escapement, egg-takes, incubation and fry production at the Blaney Creek Chum Project, 1972 - 1977. Analysis of marked adult returns will be presented in a later report.

MATERIALS AND METHODS

Adult Chum Salmon Collection, Transport and Holding: Facilities and Procedures.

Collection

In 1972, adult collection facilities consisted of a wire fence and a trap located in the lower flood plain section of Blaney Creek. A new fence, completed in October 1973, consists of a removable superstructure which is attached to two permanent crib abutments and supported on a base of rock gabions (Figures 2 and 3). The superstructure is made up of two horizontal steel "A-frames" which support a number of steel pipe panels. At the top of the "A-frames" is a steel pipe trap. A plywood lead-in to the trap is fitted over the opening at the apex of the fence (Figure 4). The design of the lead-in allows entry of the adults but makes it difficult for them to escape once inside the trap. In 1975, when the fence was often underwater, removable fence panels were attached during periods of high water to prevent adult escapement over the fence.

Surplus males and females were released above the fence. The adults were enumerated and their sex recorded. Scale samples and lengths were taken regularly during the egg-takes.

Transport

Every morning during the spawning migration, adult chum salmon trapped the previous night were transported to holding tanks at the incubation site. If many (35 - 40) fish were to be transported, they were separated out by sex into the two compartments in a transport tank. During peak migration and when flows were high, adults were transported at night and the fence was continuously cleaned of debris.

Fish were transported a distance of 13 km to the incubation site in a 0.9 m x 0.9 m 0.6 m deep tank, divided into two compartments by a centre baffle and fitted into the back of a three-quarter ton pick-up truck. The tank was covered with a lid, hinged at the centre, so that either one or both compartments of the tank may be exposed. Three plastic lines (0.6 cm O.D.) with air stones supplied each compartment

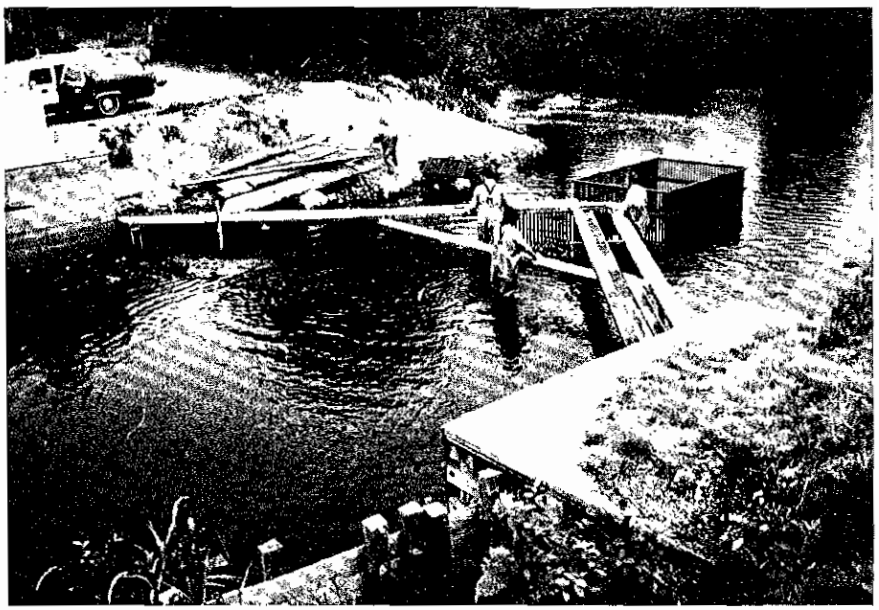


Figure 2: Fish fence and trap located at Blaney Creek, 1973 - 1977.

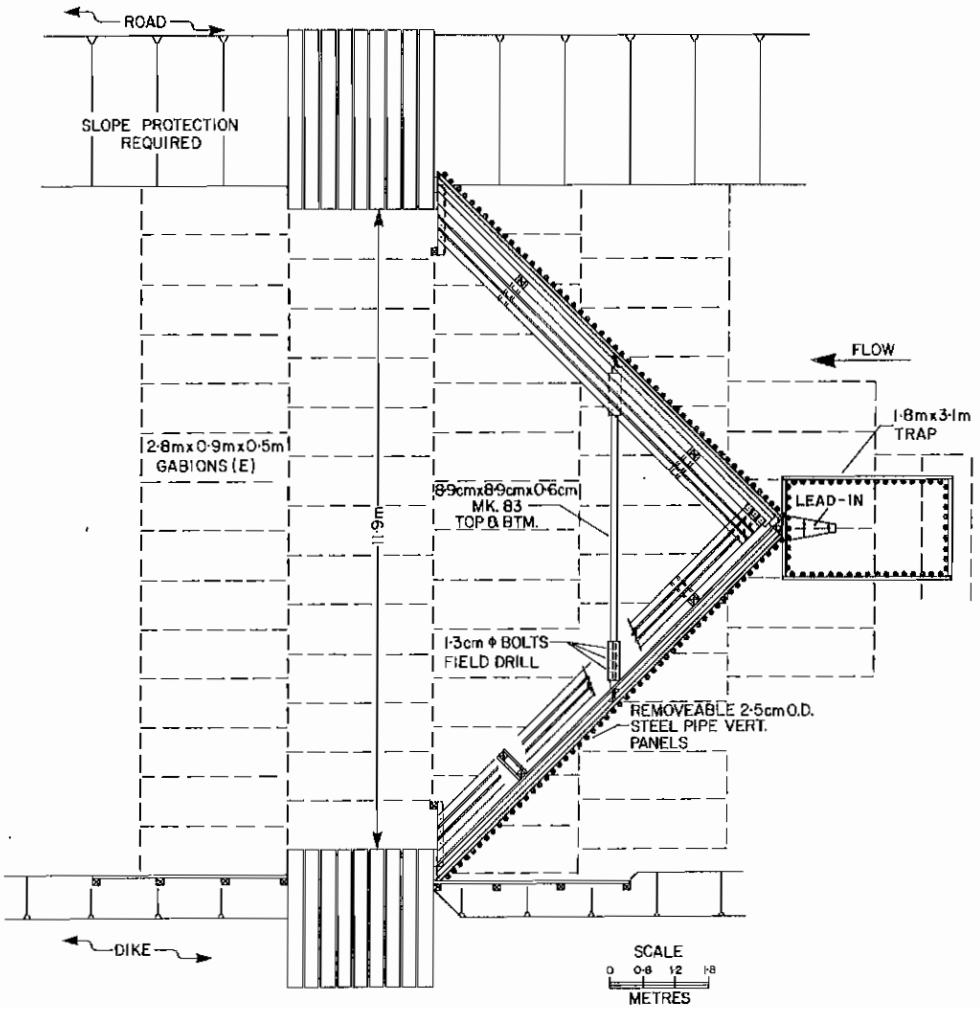


Figure 3 : Fish fence and trap located at Blaney Creek, 1973-1977.

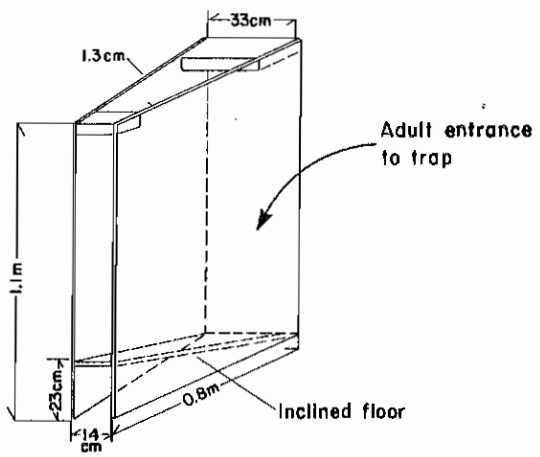


Figure 4 : Lead-in used to prevent the escape of chum salmon once inside the Blaney Creek trap, 1973-1977.

with air pumped from a 12-volt diaphragm pump connected to the vehicle battery. Approximately 35 to 40 fish could be transported safely on any one trip, given fresh water, good aeration, and efficient handling. At the incubation site, the fish were immediately transferred to circular holding tanks.

Holding

Holding facilities at the Blaney Creek incubation site consist of five circular fiberglass tanks (1.2 m high, 3.1 m diameter), each supplied with 250 lpm of creek water carried by a flexible plastic pipe, 5.1 cm I.D. (Figure 5).

Normal loading per tank was 200 adults with a maximum of 300. Males, mature and immature females were held in separate tanks. Dead fish were removed daily from the tanks and sampled for length and scales. A netting over the tanks prevented fish from jumping out.

Water supply and Water System

The water supply system consists of a coarse filter stream intake, 7.6 m x 1.8 m x 1.2 m deep, and a 20 cm I.D. gravity flow pipeline supplying water to a desilting unit, 7.6 m x 3.1 m x 1.8 m deep, (Figure 6). Water enters the desilting unit at one end where the velocity is reduced sufficiently to allow fine sand and silt to settle out (exchange rate: 1/2 hour with three incubators operating). At the bottom end a fine sand filter (3.1 m x 0.3 m x 0.3 m) filters the remaining sediment. This filter is backflushed for cleaning once or twice a week during incubation. A pipeline from the desilting unit supplies water to each incubator The upwelling supply to each incubator ranges from 250 lpm to 435 lpm, depending on egg development and oxygen levels; normal operating flow is 284 lpm (57 lpm/ 100,000 eggs/m^3). An alternate water system consisting of a propane gas-driven pump with a stream intake is available as a back-up water supply.

Incubators, Gravel and Gravel Spreader

The three Blaney Creek incubators (Figure 7) are of timber-plywood construction (1.5 m x 3.7 m x 1.5 m deep, O.D.). Each incubator is divided into three sections

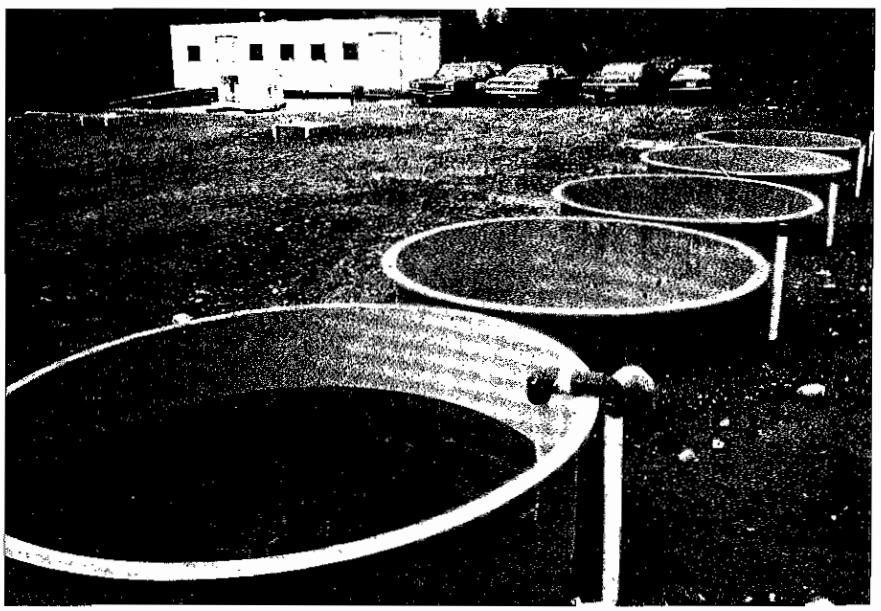


Figure 5: Fiberglass holding tanks for adult chum at the Blaney Creek incubation site, 1972 - 1977.

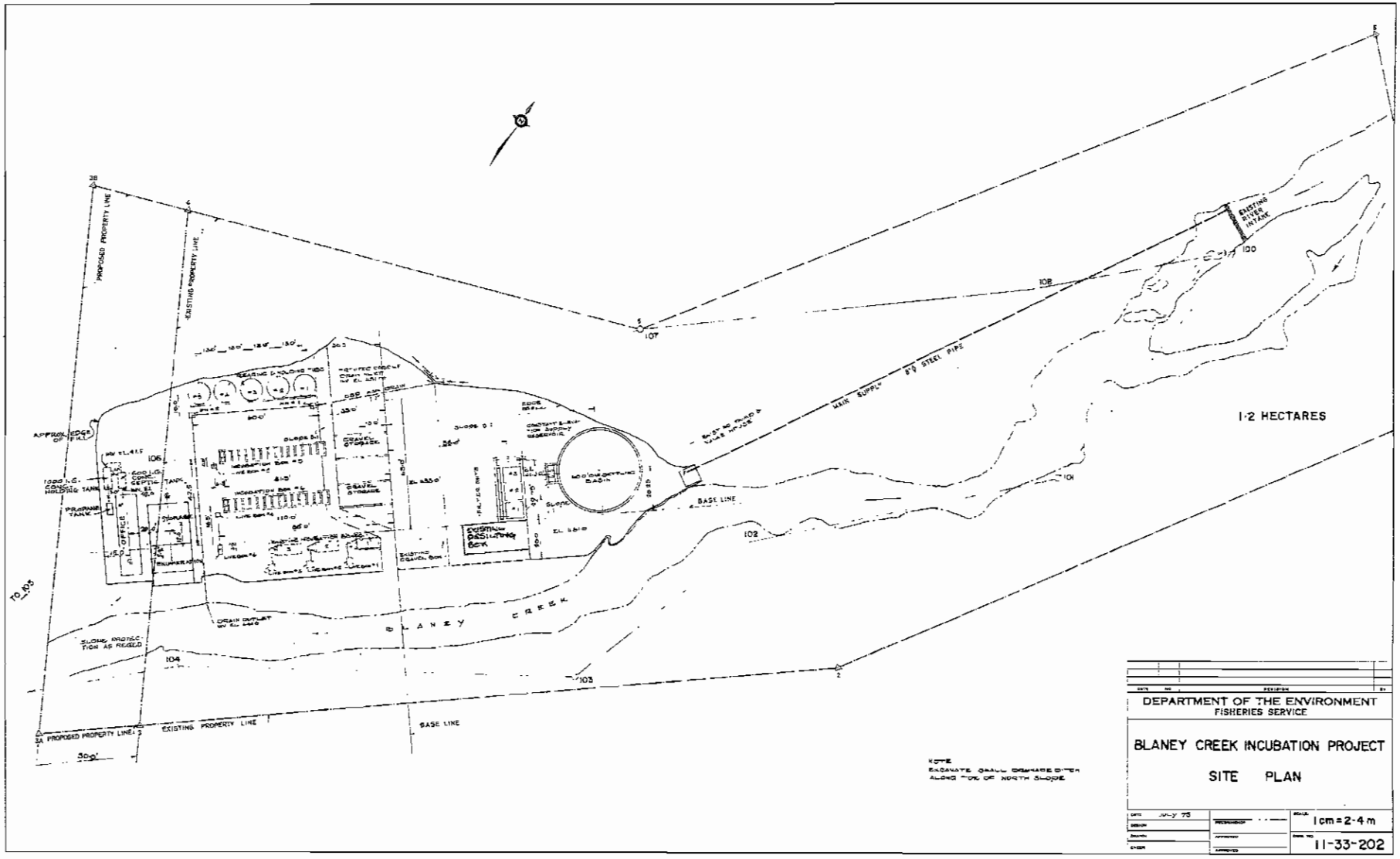


Figure 6: Blaney Creek incubation site showing gravity water supply system, existing desilting unit, gravel storage, incubators and circular tanks. Site plan includes the location of two additional incubators and the desilting basin after future expansion.

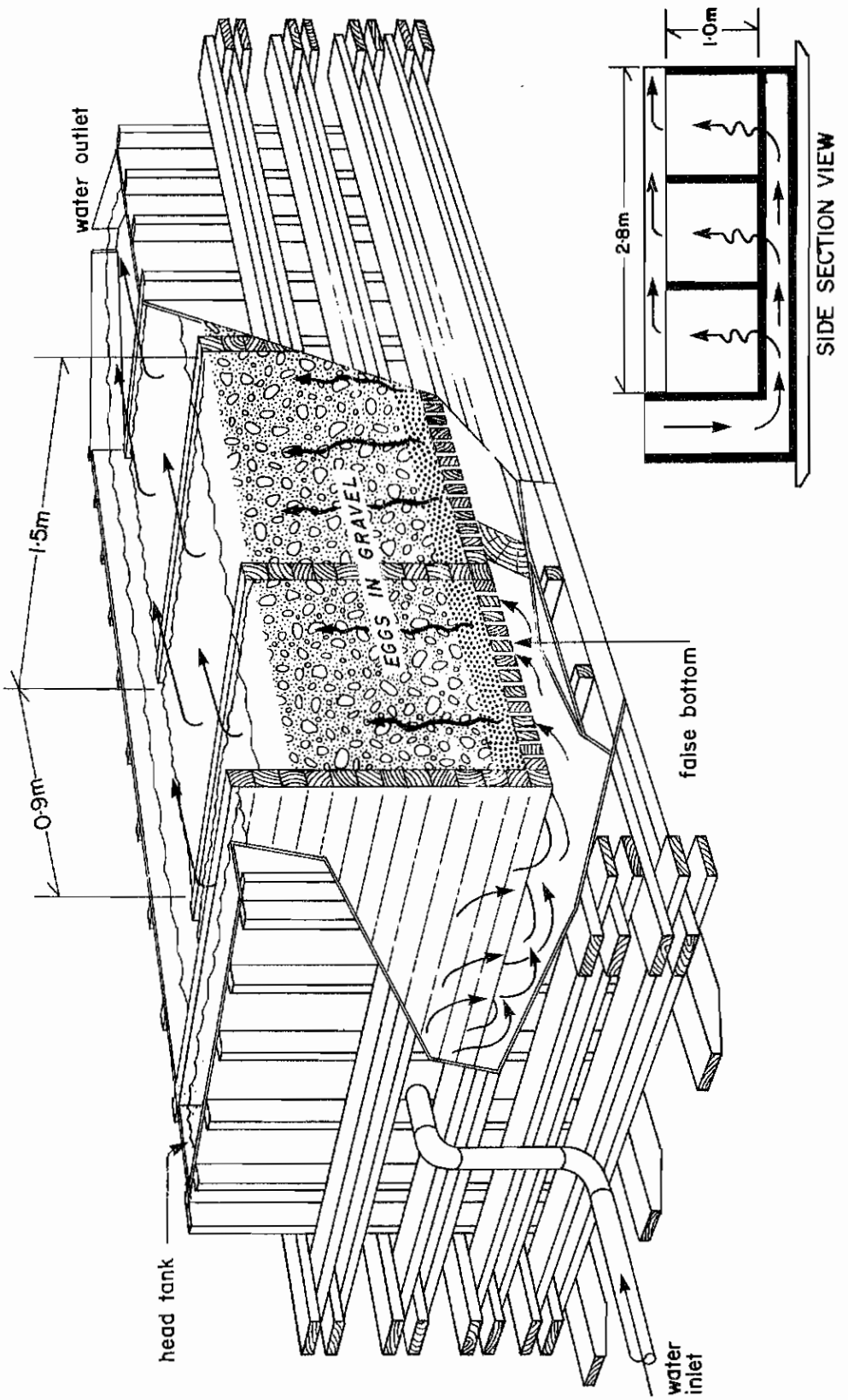


Figure 7: Cutaway diagram showing direction of water flow in upwelling incubator at Blaney Creek, 1972 - 1977.

and is supplied with water to a head tank (0.6 m x 1.5 m x 2.1 m deep) at the upper end. Water flows down to a false bottom and upwells through the gravel. Water outflow and fry outmigration is through a tapered throat outlet at the opposite end of the incubator. The entire unit is buried to a depth of approximately 1.0 meter to facilitate loading and insulate the contents from air temperature extremes. The head tanks and tops of the incubators are insulated with 5 cm thick styrofoam covers throughout the winter if necessary, to prevent freezing.

Gravel capacity of each incubator is 3.8 m^3 (smooth drain rock of 2 cm - 4 cm size range). Unpublished studies by Wilson (1967 - 1968) showed that this gravel size could accommodate chum eggs (7.5 mm - 8.0 mm diameter) without subjecting them to pressure abuse. The 0.9 m deep layer of planting gravel overlies 10 cm of "pea gravel" (0.6 cm - 1.0 cm diameter) which in turn rests on the false bottom of the incubator. Wilson found the "pea gravel" to serve two functions:

1) It acts as a three-dimensional filter which provides a minor but positive back pressure (head of 0.3 cm) that ensures a well distributed flow of water throughout the cross section of the incubator.

2) The small gravel size discourages downward penetration of chum alevins and fry.

A gravel spreader, designed to hold one layer of gravel, is placed over a compartment and the gravel dropped simulataneously through water onto eggs to prevent mechanical shock (Hilland, 1977). It is important that the gravel be spread evenly to prevent pockets of eggs from collecting in low areas of the incubator.

Egg-Take, Adult Sampling, Egg Planting and Incubation Monitoring.

Egg-Take

The three or four takes each year occurred from the end of October to mid-November. Ripe females were dipnetted from the holding tanks, killed by clubbing the head, hung head downwards on a rack, bled by severing the ventral aorta in the gills, and rinsed with water. After approximately 60 females were hung, 20 to 30 males were killed. Eggs from three to four females were placed in a basin and dry-mixed

with sperm from three to four males (Figure 8). Care was taken not to use females with water-hardened eggs. Eggs were poured into 10-liter buckets, and washed in creek water to remove excess sperm. Buckets of 23 l capacity were half-filled with washed eggs and filled to the top with water. The pails were sealed with a lid and set in flowing water where eggs were water-hardened for two hours.

Adult sampling

While eggs were water hardening, approximately 50 females and 50 males were sampled for post orbital-hypural lengths and scales. All spawned carcasses were cut in half and returned to Blaney Creek.

Egg planting

After water hardening, 250 ml subsamples of eggs were removed from the pails and counted to determine the number of eggs/liter. These calculations were used in estimating the number of eggs planted. Approximately 100 eggs were measured to determine the average egg diameter.

The planting density utilized was 131,000 eggs/m^3 of gravel or 120,000 eggs/m^2 of surface area for a total of 500,000 eggs/incubator. Each of the three sections in the incubator was planted with 17 layers of approximately 10,000 eggs/layer between layers of gravel, 4 - 5 cm deep. The top layer of eggs was covered with approximately 10 cm of gravel to eliminate light and prevent egg loss by predation.

Incubation monitoring

Water flow in the incubation boxes was recorded weekly. Flow rate was determined by the length of time required to fill a 450-liter outlet box which was placed at the outflow of each incubator. Water temperatures were recorded continuously by a thermograph located at the outflow of incubator No. 3. During incubation, deep inlet and surface outlet oxygen levels were checked to determine oxygen

Figure 8: Eggs being stripped from females and fertilized with milt from males, Blaney Creek, 1972 - 1977.

demand throughout incubation. When an estimated 2% of the fry had emerged, detailed oxygen sampling was performed at various depths and locations in the incubator. Flow and oxygen sampling was performed periodically during the outmigration period to determine general oxygen levels and flow characteristics throughout the boxes. Oxygen levels were obtained from a modified Winkler test (Hach) with 0.2 ppm accuracy (Taras et al, 1971).

For each egg plant a cumulative thermal incubation history was maintained. Samples of eggs were ~~siphoned out of the gravel~~ taken at the eyed stage and held suspended in ventilated plastic containers in the head tank of an incubator. These were examined frequently for hatching period and hatching peaks. Alevins were retained to follow the progress of yolk absorption.

Fry Migration and Enumeration

Depending on the number of eggs planted, fry were enumerated by one of three methods:

1. Low egg plant: nets were placed in the outlet boxes of each incubator and fry were enumerated individually as they were fin-clipped;
2. Moderate egg plant: fry were volumed out of the net with a pre-measured cup. Every day, three cups were individually counted to determine the mean number of fry per cup, which was used to estimate the daily migration;
3. High egg plant: a 1.2 m revolving cone sampler (modified from Davis and Hiltz, 1971) was used to enumerate migrating fry (Figure 9). The total outflow from the three incubators was passed through a flume entering the cone sampler (Figure 10). Sampling scoops directed a portion of the fry to be counted into the inside trough which passed to live boxes. These fry were then enumerated by method (1) or (2) as outlined above. The remaining fry passed directly into Blaney Creek, or when the sampler was being indexed, passed into another live box. After enumeration of the sampled portion, and from indexing results, an estimate of the total daily migration was made.

Fry were subsampled regularly to determine lengths, weights and developmental index, ($K_D = \frac{10\sqrt[3]{mg}}{mm}$) (Bams, 1970).

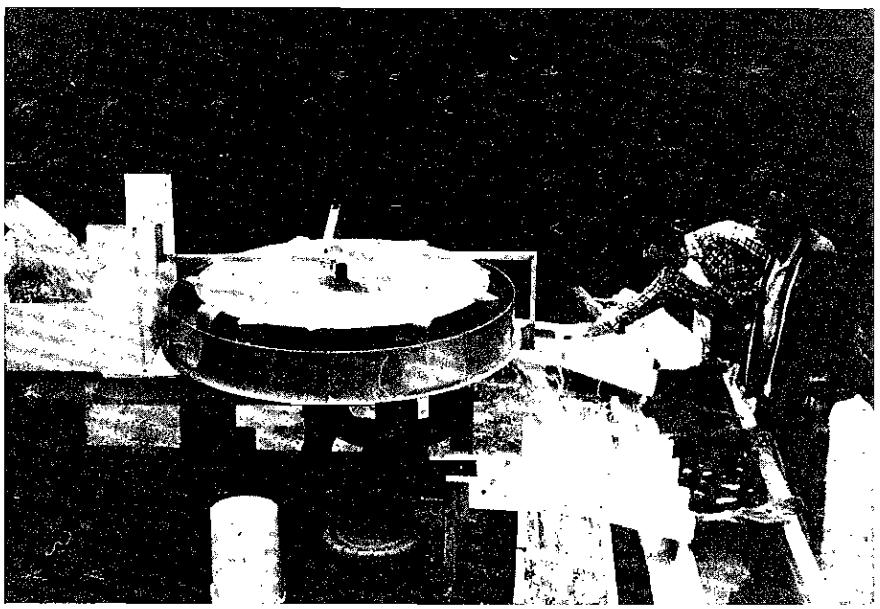


Figure 9: Revolving cone sampler (side view), Blaney Creek facility, 1974 and 1977.

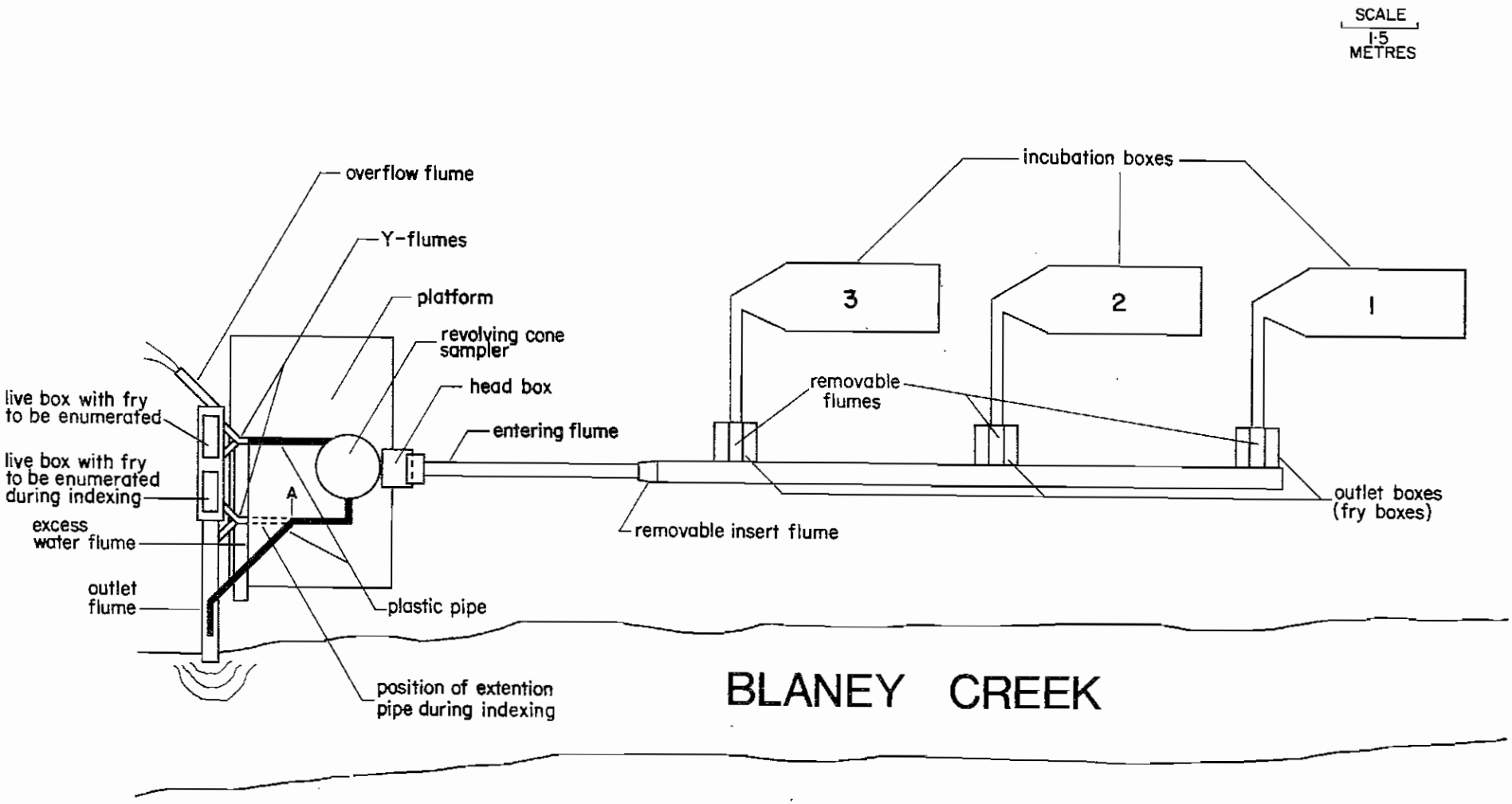


Figure 10: Fry sampling system during normal operation. During indexing, pipe is disconnected at "A" and extension pipe is attached to direct remaining major portion of fry into live boxes for counting, Blaney Creek facility, 1974 and 1977.

RESULTS

Adult Chum Salmon Program

Daily catches, estimated escapement, trapping efficiency and adult timing.

Daily catches of chum salmon, 1973 - 1977, are shown in Figure 11. A summary of the numbers trapped and transported and the estimated escapement and migration timing is given in Table 1. A temporary fence in 1972 resulted in approximately 55.0% of the run trapped. After installation of the new fence (1973 - 1976), trapping efficiency increased to an average of 78.0%. High water over the fence and trap in 1975 resulted in the escapement of fish above the fence, reducing trapping efficiency to 52.0%. In 1976, removable fence panels were installed to increase fence height, which increased the efficiency of trapping to 97.4%. In 1977, only 60.6% of the fish were trapped, as the majority of the run was not needed for the egg-takes.

From 1972 - 1977, an average of 583 chum adults (range: 151 - 1,675) were trapped each year. The overall sex ratio of chum trapped between 1973 - 1977 was 48.7% male and 51.3% female. From 1972 - 1977, an average of 402 trapped adults (range: 105 - 1,124), 30% male and 70% female, were transported to the incubation site for holding. From 1972 - 1977, the average total estimated escapement (= adults observed above fence before installation + total trapped + estimated high water escapee + spawners below fence (Fisheries Officer and crew observation)) was 850 adults (range: 175 - 2,764). The largest escapement of 2,764 in 1977 included the 1973 brood incubator returns of four year olds.

The majority of the spawning run (10 % - 90%) generally occurred between October 14th and November 18th, with the average peak of the run occurring on October 30th.

Age and size composition

Results of scale sampling showed that the overall age composition (1972 - 1977) was 16% age three fish (range: 1% - 39%), 78% age four fish (range: 56% - 98%) and 6% age five fish (range: 0% - 22%). Average post orbital-hypural lengths were 55.0 cm for age three fish, 58.0 cm for age four fish and 58.7 cm for age five fish (Table 2).

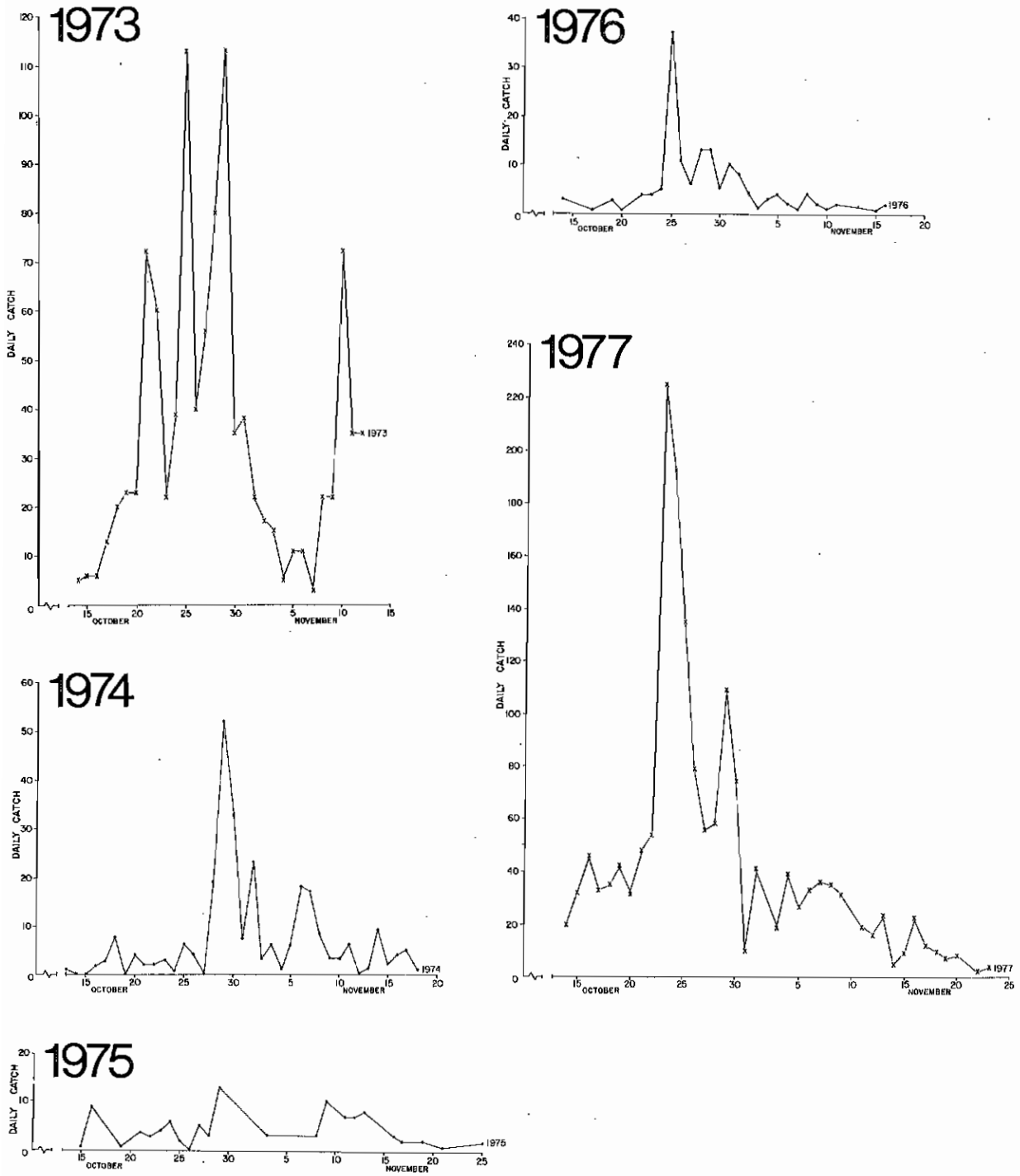


Figure 11: Daily numbers of chum adults trapped at Blaney Creek, 1973 - 1977. (No record available for daily numbers trapped in 1972).

Table 1: The estimated total chum escapement, numbers trapped and transported, and migration timing, Blaney Creek, 1972 - 1977.

Adult Year	Estimated Total Escapement	Number Trapped					Number Transported			Adult Migration Timing (10% - 90%)		
		Male	Female	Total	% Male	% of Est. Total Escapement	Male	Female	Total	50%	Peak	Duration
1972*	400			~200		~55	~55	~110	165	Oct. 30	Nov. 4	Oct. 16-Nov. 14
1973	1,150	479	555	1,034	46.3	89.9	212	541	753	Oct. 28	Oct. 25& Oct. 29	Oct. 14-Nov. 12
1974	318	149	114	263	56.7	82.7	45	90	135	Oct. 30	Oct. 29	Oct. 11-Nov. 18
1975	290	74	77	151	49.0	52.0	34	71	105	Nov. 1	Oct. 29& Nov. 13	Oct. 14-Nov. 25
1976	175	73	80	153	47.7	87.4	50	77	127	Oct. 28	Oct. 25	Oct. 14-Nov. 16
1977	2,764	738	937	1,675	44.0	60.6	316	808	1,124	Oct. 24	Oct. 24	Oct. 14-Nov. 23
TOTAL	5,097	1,513	1,763	3,496			712	169	2,409			
AVERAGE	850	303	353	583	48.7	71.3	119	282	402	Oct. 29	Oct. 30	Oct. 14-Nov. 18

* Data not available on number of males/females trapped.

Sex Composition
1977 - 1978

	n	% ♂	% ♀
BLANEY CR.	1935	40.8%	59.2 %
BLANEY CREEK	–	44.1%	55.9 %
N. ALOUETTE R.	1641	32.7%	67.3 %
S. ALOUETTE R.	5250	[illegible]	56.7%

Table 2: Adult chum length and age composition, Blaney Creek, 1972 - 1977.

Adult Year	Sample Size	Age Composition (percent) Age 3	Age 4	Age 5	Post-Orbital Hypural Length (cm) Age 3	Age 4	Age 5
1972	115	13.0	82.6	4.4	54.3	57.2	57.2
1973	193	1.0	94.3	4.7	58.1	57.8	59.9
1974	112	8.0	69.7	22.3	55.5	57.9	60.0
1975	88	39.3	56.4	4.3	54.5	58.0	58.0
1976	118	32.7	67.3	0.0	52.7	59.3	----
1977	430	1.4	97.9	0.7	54.8	57.9	58.2
Average		15.9	78.0	6.1	55.0	58.0	58.7
Range		(1.0-39.3)	(56.4-97.9)	(0.0-22.3)	(52.7-58.1)	(57.2-59.3)	(57.2-60.0)

Age Composition Note: S. Alouette is adjusted

	n	(age)	♂ 3	♀ 4	♀ 5
Blaney	439	9	1.4%	97.9%	0.7 %
N. Alouette	50	50	6.7%	93.3%	–
S. Alouette	55	7	32.2 %	58.1 %	9.7 %

Egg-Take, Planting Density and Incubation

Egg-take and planting density

From 1972 - 1977, the average number of females used for the egg-take was 268 (range: 63 - 764) with a mean measured fecundity of 2,644 eggs/female (range: 2,411 - 2,824). This is considered an underestimate of up to 5% due to egg loss throughout trapping, holding and/or spawning procedures. Since female lengths were not taken in conjunction with fecundity samples, length-fecundity relationships were not analysed. The average egg diameter was 7.96 mm (range: 7.71 mm - 8.12 mm). In each section of the incubators, the mean number of eggs planted/layer was 8,665 or 6,419 eggs/m^2, giving the average number of eggs planted per year as 648,316 (range: 163,407 - 1,711,432) (Table 3).

Incubation

Based on the 1972 and 1973 brood year data (Figure 12, Appendix 1) when egg hatching was monitored in gravel subsamples, eggs were 50% eyed, 54 days after egg planting at 260 T.U.^{o} C, and 50% hatched, 112 days after egg planting at 476 T.U.^{o}C.

Water quality

Water quality was analysed after 1% - 2% of the fry had emerged (Appendix 2). In 1972 and 1973, oxygen levels were all above 10.0 ppm; in 1973, the average carbon dioxide and pH levels were 11.3 ppm and 6.3, respectively. In 1974, oxygen levels in certain areas of the incubator were as low as 3.1 ppm, which was increased to 6.3 ppm after the flow was increased; all oxygen sampled at the inflow and outflow was above 8.0 ppm; maximum ammonia, nitrite and nitrate levels were 0.01 ppm, 0.02 ppm and 0.03 ppm, respectively; total phosphate was 0.005 ppm. Before fry migration in 1976, all oxygens sampled were above 13.0 ppm. In 1978, oxygen sampled in incubator No. 2 was as low as 5.0 ppm; all oxygens sampled at the inflow and outflow were above 10.0 ppm.

Table 3: Number of female chum used for egg-takes, volume counts, egg diameters, average fecundity, and total eggs planted in incubation boxes, Blaney Creek, 1972 - 1977.

Brood Year	No. of Females Used For Egg-take	Average Volume Counts (eggs/liter)	Average Egg Diameter (m m)*	Average Fecundity (eggs/female)	Layer of Eggs Planted Box #1	Box #2	Box #3	Total Layers	Average # eggs/layer	Average # eggs/m^2	Total # Eggs Planted*
1972	110	2,253	7.92	2,411	29	--	29	29	9,147	6,776	265,264±4.5%
1973	523	2,145	8.12 ± 1.1%	2,647	41	59	58	158	8,763	6,491	1,384,557±3.0%
1974	85	2,280	8.04 ± 3.9%	2,657	25	--	25	25	7,631	5,653	190,784±13.0%
1975	65	2,537	7.71 ± 2.9%	2,665	18	--	18	18	9,078	6,724	163,407±6.0%
1976	63	2,339	---	2,824	19	--	19	19	9,182	6,802	174,451±0.2%
1977	764	2,187	8.02 ± 3.7%	2,661	65	63	81	209	8,189	6,066	1,711,432±4.0%
Total	1,610										3,889,895
Average	268	2,290	7.96	2,644				458	8,665	6,419	648,316
Range	(63-764)	(2,145-2,537)	(7.71 - 8.12)	(2,411-2,824)				(18-209)	(7,631-9,182)	(5,653-6,776)	(163,407-1,711,494)

* ± 95% confidence intervals.

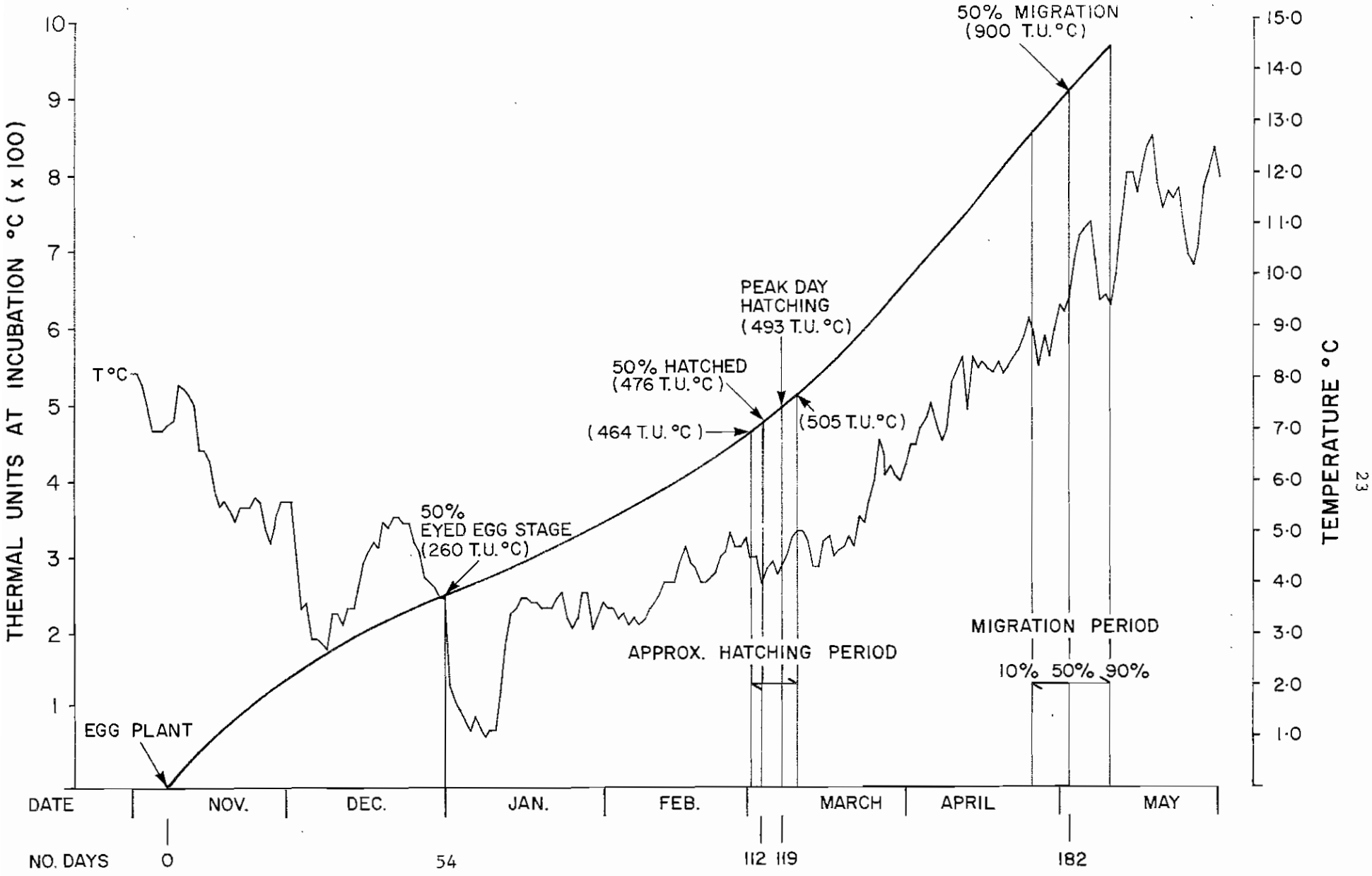


Figure 12: Mean daily incubation temperatures and thermal incubation history for the 1972 and 1973 chum salmon broods, Blaney Creek.

Fry Migration Timing, Enumeration, and Fry Quality

Comparison of migration timing and fry quality between wild and incubator fry is only available for the 1972 and 1973 broods. In 1977, a fyke net was used to capture wild fry for fry quality determination. Due to an obstruction of falls on Blaney Creek, below the incubation site, all incubator fry in 1972 were transported and released downstream of the natural spawning area, located below the falls. This allowed separate enumeration of incubator fry and wild fry for migration timing and fry quality. In 1973, a portion of the incubator fry was released directly at the incubation site above the falls to determine the effect of the falls on fry survival. The wild fry out-migration was then separately enumerated by placing a cage over a redd in the natural spawning area.

Results in 1973 indicated that fry mortality due to the falls was negligable, and in subsequent years all fry were released from the incubation site. The method used in 1973 for estimating wild fry migration timing was discontinued due to possible disturbances at adult trap installation which may have disruped the natural adult spawning timing and subsequent fry migration timing.

Fry migration timing

Daily fry migration and mean daily incubation temperatures for the 1972 - 1977 broods are shown in Figure 13. Wild fry migration data are available only for the 1972 -1973 broods. The average migration timing of incubator fry (10 - 90%) was April 25 - May 10, a period of 15 days; the peak migration occurred on April 30, and 50% migration on May 2, at which time the mean incubation period was 179 days (900 T.U.^{o}C); the mean temperature throughout incubation to peak fry migration was 5.0^{o}C (range: 4.4^{o}C to 5.9^{o} C), (Table 4).

Note: T - much later ... Hatch's C.

The 1972 and 1973 brood wild fry appeared to migrate up to one week earlier than the incubator fry (Figure 13). This discrepancy, as discussed previously, however, may be due to disturbances during wild fry trapping or natural spawning timing rather than differneces in the length of incubation of fry migration timing.

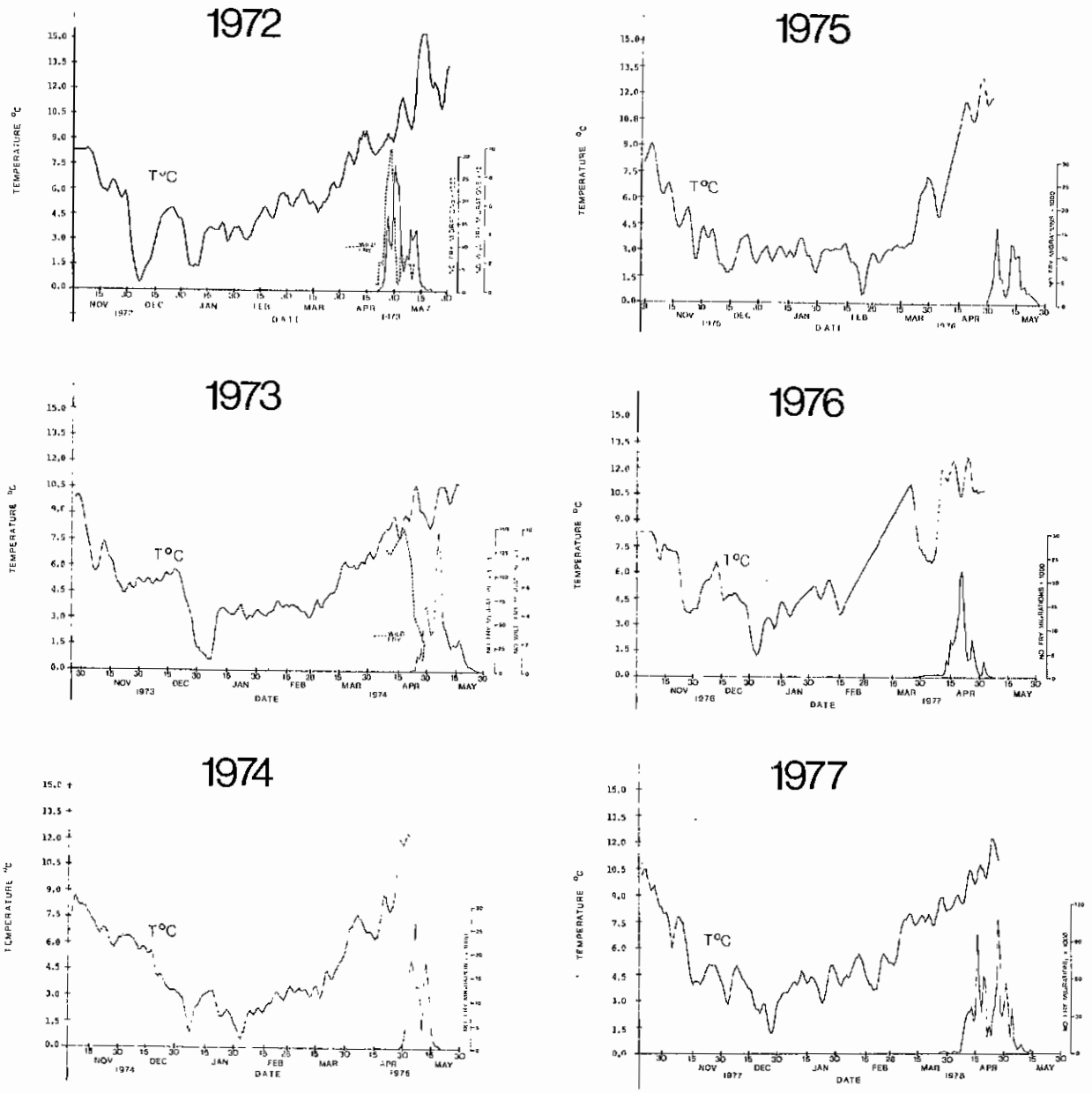


Figure 13: Mean daily incubation temperatures and daily chum fry migration (wild fry migration indicated by dotted line, 1972-1973) for 1972 - 1977 brood years, Blaney Creek.

Table 4: Chum fry migration timing, incubation period and thermal units (at 50% migration) and mean temperature throughout incubation period, Blaney Creek, 1972 - 1977.

Brood Year	Fry Timing			Incubation Period (Days)	Thermal Unit (°C) (at 50% migration)	Mean Temperature (°C)
	Peak	50%	10-90%			
1972	May 1	May 2	April 26-May 12	178	955	5.4
1973	May 7	May 6	April 29-May 16	185	907	4.9
1974	May 6	May 7	May 3-May 13	180	824	4.6
1975	May 4	May 11	May 3-May 17	184	802	4.4
1976	April 21	April 20	April 15-April 27	168	990	5.9
1977	April 16, 27	April 25	April 12-May 2	176	921	5.2
Average	April 30	May 2	April 25-May 10	179 (± 3.6%)*	900 (±8.6%)*	5.0 (± 11.4%)*

*± 95% confidence intervals.

Fry enumeration and fry quality

Eggs planted from the 1972 - 1977 brood years produced an average of 534,751 fry (range: 139,683 in 1975 - 1,282,228 in 1973), giving a mean egg-to-fry survival of 82.3% (range: 68.5% in 1977 - 97.7% in 1972), (Table 5). Since all fry were marked in the 1972, 1974 and 1975 broods, there was essentially no error in fry enumeration for those years. Volumetric enumeration of the 1976 brood and revolving cone sampler/volumetric enumeration of the 1973 brood , resulted in an error of approximately 2.5% (95% confidence limits). Mechanical failure of the cone sampler during enumeration of the 1977 brood resulted in an enumeration error of $\pm$ 11.3% (95% confidence limits). Of the fry produced from 1972 - 1975 brood years, an average of 209.690 (45%) were adipose and left ventral fin-clipped (range: 138,472 in 1975 - 257,355 in 1972), (Table 5). No fry were fin-clipped for the 1976 - 1977 brood years.

Results of lengths, weights, and developmental index (K_D) for incubator fry and wild fry are shown in Table 6. The average length, weight and developmental index for incubator fry (1972 - 1977) was 38.8 mm, 357.8 mg and 1.9 K_D, and for wild fry (1972, 1973 and 1977) was 39.3 mm, 373.0 mg and 1.8 K_D respectively. For those years where both incubator and wild fry were sampled (1972, 1973 and 1977), length, weight, and developmental index were similar (incubator: 39.3mm, 368.0 mg, 1.8 K_D; wild: 39.3 mm, 373.0mg, 1.8K_D).

Table 5: Chum egg plants, egg-to-fry survival, and number of fry marked (AdLV) before release, Blaney Creek, 1972 - 1977.

Brood Year	Date of Egg Plant 50%	Date of Egg Plant Range	No. Eggs Planted*	No. Fry Produced*	% Egg-to-Fry Survival	No. Fry Marked (AdLV) (% of Total Migration)
1972	Nov. 5	Oct. 31-Nov. 15	265,264 ± 4.5%	258,924±0.0%	97.7	257,355 (97%)
1973	Nov. 2	Oct. 25-Nov. 14	1,384,557 ± 3.0%	1,282,228±2.5%	92.6	252,900 (20%)
1974	Nov. 8	Nov. 4-Nov. 22	190,784 ± 13.0%	190,784±0.0%	84.5	190,033 (100%)
1975	Nov. 9	Oct. 30-Nov. 21	163,407 ± 6.0%	139,683±0.0%	85.5	138,472 (99%)
1976	Nov. 4	Nov. 2-Nov. 22	174,451 ± 0.2%	158,837±2.6%	91.0	0
1977	Oct. 26	Oct. 20-Nov. 8	1,711,432 ± 4.0%	1,171,710±11.3%	68.5	0
Totals			3,889,895	3,208,506±5.06%		838,760 (44.8%)
Average	+Nov. 4	+Oct. 29-Nov. 17	648,316	534,751	82.3	209,690

* ± 95% confidence interval.

+ Averages determined for: 50% egg plant and range of egg plant.

Table 6: Mean length, weight and developmental index ($K_D = \frac{10\sqrt[3]{mg}}{mm}$) of wild and incubator fry, Blaney Creek. 1972 - 1977.

Brood Year (Sample Date)	WILD FRY				INCUBATOR FRY			
	Sample Size	$\bar{x}$ Length*mm	$\bar{x}$ Weight*mg	K_D*	Sample Size	Length*mm	Weight*mg	K_D*
1972 (Apr. 27-May 11)	180	39.1±1.5	359.8±48.7	1.8±.06	180	39.4±1.3	372.5±46.3	1.8±.17
1973	100	40.0±1.1	401.0±64.9	--	220	39.7±1.3	364.0±31.7	1.8
1974 (May 4-May 15)	--	--	--	--	120	39.5±1.1	364.1±33.2	1.8±.02
1975	--	--	--	--	--	37.7	333.0	--
1976 (Apr. 16-Apr. 28)	--	--	--	--	140	37.9±1.2	344.2±40.6	1.9±0.00
1977 (Apr. 25-May 6)	119	38.8±1.3	358.1±32.4	1.8±.04	300	38.8±1.4	368.9±34.0	1.9±.05
Average		39.3	373.0	1.8		38.8	357.8	1.9

* ± 95% confidence interval.

Adults were held in tanks for up to two weeks before an egg-take which may have contributed to low egg fertility. McNeil and Bailey (1975) found that adult sockeye and chinook tend to delay their maturation when confined, and eggs from fish reaching maturity may have low fertility. Whenever possible, therefore, mature fish should be collected for spawning.

The slight delay between killing and spawning procedures may have contributed to poor fertilization rates. When fertilization is delayed, the viability of ova and sperm decreases over time. This tendancy is accelerated by exposure of the ova and sperm to higher temperatures (Withler et al., 1967 and 1968). Delays between killing and spawning procedures should therefore be avoided.

Possible disturbance of the eggs and/or time delay between fertilization and planting procedures may have contributed to egg mortality. At temperatures between 8°C and 9°C, Smirnov (1955) reported fertilized chum eggs to be resistant to mechanical shock for the first 15 minutes, sensitive to shock for the next 1.75 hours, and resistant to shock from 2 to 8 hours after fertilization (from completion of water hardening to the first cell division). Therefore, care must be taken to avoid any jolting of eggs during the water hardening process, and eggs must be planted as soon as possible after water hardening.

Chum egg and fry development

The number of days required for incubation to various developmental stages will depend on the average daily temperatures and will differ among stocks (Hilland, 1979; pers. comm.). At Blaney Creek, the accumulated thermal units to 50% eyed egg stage, 50% hatching, and 50% fry migration were 260 T.U.°C, 476 T.U.°C, and 900 T.U.°C, respectively. This compares well with the chum incubation data from other facilities (Table 8).

Fry quality for Blaney Creek compares well with that determined for other chum fry stocks (Table 9).

Based on size and developmental index, Blaney Creek incubator and wild fry are similar in quality and should therefore have similar survival potential.

Table 8: Comparison of chum egg and fry development (A.T.U.^{o}C) Between Blaney Creek and various chum fry stocks.

Location	50% Eyed T.U.^{o}C	No. Years	Days	50% Hatched T.U.^{o}C	No. Years	50% Migration No. Days	T.U.^{o}C	No. Years	Method of Incubation +	Reference
Chehalis	270	1	91	472	1	155	949	1	1	
Thornton	260	1	77	530	1	151	984	1	2	
*Bella Coola	300	1	111	500	1	230	1,031	1	2	Hilland, 1979, pers. com.
Conuma	240	1	107	480	1	182	820	1	2	Anderson, 1979, pers. com
Inches	-	-	62	505	5	126	964	6	1	
Pallant	290	1	71	515	1	176	955	1	1	Shepherd, 1979, pers. com
Big Qualicum	-	-	-	-	-	186	893	1	1	
Average	265		90	497		~~138~~ 172	~~933~~ 942		1+2	
Blaney Creek	260	2	112	476	3	180	900	6	1	
Average (including Blaney & excluding Inch's)	270		95	496		180	933			

* Biological characteristics may be different as these are summer run chum.

\+ Method of incubation: 1. Upwelling gravel incubator

...ors to the hatching stage;
...on to the fry stage.

Table 9: Comparison of incubator and wild fry lengths, weights and developmental indices ($K_D = \frac{10\sqrt[3]{mg}}{mm}$) between Blaney Creek and various chum fry stocks.

Location	Method of Incubation[+]	Mean Length (mm)	Mean Weight (mg)	Developmental Index (K_D)	Number Years Data
Conuma - box	2	39.8	443	1.9	1
wild		42.6	454	1.8	
Chehalis - box	1	35.3	370	2.0	1
wild	Qualicum →	42.6	454	1.8	
Thornton - box	1 ✓	40.9	480	1.9	1
Inches - box	1	38.5	340	1.8	7
wild		39.3	360	1.8	6
Big Qualicum - box	1	38.2	360	1.9	1
wild		39.0	350	1.8	7
Average - box	1 + 2	38.5	399	1.9	
- wild		39.2	386	1.9	
Blaney Creek - box	1	38.8	358	1.9	6
- wild		39.3	373	1.8	2

+ Method of incubation: 1. Upwelling gravel incubators

2. Japanese style, modified Atkins incubators to the hatching stage; lateral flow, one layer gravel incubation to the fry stage.

Chum fry migration timing

Comparison of chum fry timing between Blaney Creek and other chum fry stocks is shown in Table 10. Fifty percent migration for Blaney Creek incubator and wild fry occurred on May 2 and April 25 respectively, and for Fraser River wild fry, on April 18. It appears that Blaney Creek fry migration (incubator and wild) occurs eleven days later (April 29) than Fraser River wild fry migration. Average migration timing (10% - 90%) for Blaney Creek fry (incubator and wild) was April 20 - May 7 and for Fraser River wild fry was March 28 - May 8.

Water quality for fish culture

All water quality parameters measured at the inflow to the incubators were within acceptable limits for fish culture (Wedemeyer et al, 1977; Shepherd, 1978). Oxygen sampled at the inflow and outflow of the incubators was above 8.0 ppm in each year. All the low oxygen values recorded were sampled within the gravel, indicating a restriction of water flow in some areas of incubators. Maintaining oxygen levels at or above 7 ppm becomes more critical with the onset of hatching and fry migration (Alderdice et al, 1958).

Table 10 : Comparison of chum fry timing between Blaney Creek and other chum fry stocks.

Location	Migration Timing 50%	10 - 90%	No. Years Data	Reference
Fraser River stocks				
* Fraser River - wild	Apr. 18	Mar. 28 - May 8	13	
Barnes Creek - wild	May 17	Apr. 28 - May 26	3	
Chehalis River-box [1]	May 13	May 9 - May 16 Δ = 7day	1	
Inches Creek - box [1]	Apr. 19	Apr. 9 -29	8	
- wild	May 5	Apr. 19 - May 23	3	
Jones Creek - channel	Apr. 30	Apr. 20 - May 13	2	
Average - box [1]	May 1	May 24 - May 8		
- channel	Apr. 30	Apr. 20 - May 13		
- wild	May 4	Apr. 24 - May 25		
all	May 2	Apr. 23 - May 15		
Thornton Creek - box [1]	Mar. 27	Mar. 23 - Apr. 5	1	
Salmon Creek - wild	Apr. 9	Mar. 22 - Apr. 22	1	
Conuma River - wild	May 2	Apr. 11 - May 12		Hilland, 1979, pers. com.
Hooknose Creek - wild	May 5	Apr. 18 - May 17		
Pallant - box [1]	Apr. 25	Apr. 18 - May 6	1	Shepherd, 1979, pers. com.
Big Qualicum - box [1]	June 3	May 31 - June 6	1	
- channel	May 19	Apr. 25 - June 5		
- wild	May 11	Apr. 25 - June 1		
Average - box [1]	May 1	May 11 - May 7		
(all stocks) - channel	May 10	Apr. 23 - May 19		
- wild	May 2	Apr. 18 - May 20		
All	May 2	Apr. 21 - May 14		
Blaney Creek - box [1]	May 2	Apr. 25 - May 10 Δ 15 days	6	
- wild	Apr. 25	Apr. 15 - May 4	2	
Average	Apr. 29	Apr. 20 - May 7		

* Downstream enumeration of Fraser River chum stocks above the Mission highway bridge.
1. Upwelling gravel incubator

CONCLUSIONS

From 1972 - 1977, the upwelling incubation facility at Blaney Creek has produced and released into Blaney Creek a total of 3,208,506 fry. This resulted in an egg-to-fry survival of 82.3%. Of the fry produced, 838,760 (45%) were fin-clipped (adipose and left ventral) for identification as adults. The average length, weight and developmental index (K_D) of released fry was 38.8 mm, 357.8 mg and 1.9 K_D, respectively. Size and developmental index of wild and incubator fry were similar.

The average number of adults returning to Blaney Creek (1972 - 1977) was 850. A maximum return of 2,764 adults in 1977 included the 1973 brood incubator returns of 4 year olds.

Upwelling gravel incubation at Blaney Creek has been successful up to the fry stage, although low adult escapement in some years reduced the number of eggs planted below capacity.

It is too early to determine success of the Blaney Creek Chum Project; this will depend on the assessment of adult returns to Blaney Creek to be presented in a future report.

RECOMMENDATIONS

If the method of layer-planting eggs in upwelling incubators is to be continued at Blaney Creek, some recommendations for incubation and fry assessment should be considered:

1. Regular and frequent monitoring of dissolved oxygen throughout the boxes.
2. Regular and frequent monitoring of water quality.
3. Regular malachite treatments to prevent fungus growth, as recommended by Woods (1974).
4. The use of fiberglass or concrete incubators to reduce possible deterioration of the plywood incubators.
5. The effectiveness of the desilting box and filter.
6. Soft egg-planting to reduce handling and eliminate the time delay between fertilization, water-hardening and planting.
7. Annual record of wild fry migration and fry quality for comparison with incubator fry.
8. Proper evaluation of fry survival over falls.
9. Possible fry rearing before release to reduce predation on marked and unmarked fry (described by Parker, 1971), and the effect of late migration timing on competition with other chum stocks (late migration of reared fry may be avoided if egg-takes are performed early in the adult migration, which would promote early fry emergence).
10. Evaluation of the magnitude of predation on fry survival (marked and unmarked) from the time of fry release until the time fry have migrated to the Fraser River estuary. The majority of predators throughout lower Blaney Creek, Sturgeon Slough, North and South Alouette and Pitt River systems include coho, sculpins, squawfish, dolly varden, whitefish, catfish, grebes, mergansers, herons, bittern, goldeneye, and cormorants (R. Godin, pers.comm.).
11. Transplanting of eggs from the South Alouette River in order to utilize full egg capacity of 1.5 million eggs at Blaney Creek; this would require an additional 400 females for the egg-take.

12. An alternate method of incubation at Blaney Creek would be surface egg-planting. This may resolve a number of problems and discrepencies with incubation and fry assessment as experienced with layer-planting eggs in gravel. When eggs are stripped and fertilized, they are volumed into baskets (mesh size retains eggs but allows alevins to pass through) which are immersed in the upwelling water supply and placed 5-8 cm above a gravel layer. Baskets are immediately covered to eliminate light and eggs are left to harden and develop to the eyed-egg stage, at which time dead eggs are picked. When hatching occurs, alevins pass through the screen and into the gravel and remain there until fry emergence. Some obvious advantages of this method as compared to layer-planting are:

- Little or no time delay between fertilization and planting.
- Less handling of eggs between fertilization and planting.
- Eggs may be examined and possibly treated for signs of disease.
- Dead eggs may be picked, which would enable a more accurate assessment of fry survival.
- Dead eggs may be examined for developmental stage (ie. unfertilized, fertilized, eyed, etc.) to determine possible reasons for mortality.
- Gravel may be placed on the bottom of the incubator just prior to hatching; this would help to eliminate a build-up of silt in the gravel.
- Gravel handling and cleaning may be reduced.

* - rear fry prior to release to produce larger sized fry less vulnerable to predators.

- trucks fry to Pitt R. for release to bypass the clean, shallow Alouette system & its many predators (but must do fry apps to prove the value of this)

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APPENDICES

1. Timing of hatching of the 1972 and 1973 brood years.

2. (a) Laboratory analysis of intensive oxygen sampling using Hach reagents (a modified Winkler test with 0.2 ppm accuracy) at Blaney Creek, 1972 - 1975 and 1978.

   (b) Laboratory analysis of various parameters of water quality using Hach reagents at Blancey Creek, 1973 - 1974.

3. Statistical comparison of fry quality between wild and box fry using analysis of variance (F-test) and test for differences between means (t-test), Blaney Creek, 1972, 1973 and 1977.

Appendix 1

Timing of hatching of the 1972 and 1973 brood years (Refer to Figure 12)

Brood Year	Egg Plant[1] Number	Date of Egg Plant	Hatching Date Peak	Hatching Date Range	T.U.^{o}C Hatching Peak	T.U.^{o}C Hatching Range	Mean Temp^{o}C	Days Incubation
1972	# 1	Oct. 31	Feb. 22	Feb. 14-25	491	455-508	4.3	114
	# 3	Nov. 15	Mar. 21	Mar. 14-26	523	485-550	4.1	126
	Average	Nov. 8			507	470-520	4.2	120
1973	# 2	Nov. 1	Feb. 23	Feb. 21-25	482	474-490	4.2	114
	# 4	Nov. 14	Mar. 17	Mar. 8-20	476	441-489	3.9	123
	Average	Nov. 8			479	458-490	4.1	118
1972-73	Average	Nov. 8	Mar. 7	Mar. 1-10	493	464-505	4.2	119

[1] Depending on the availability of adults, egg plants would occur on different days until the desired number of eggs were taken (hence plant # 1, #2, etc.).

Appendix 2

(a) Laboratory analysis of intensive oxygen sampling using Hach reagents (a modified Winkler test with 0.2 ppm accuracy), at Blaney Creek, 1973, 1975 and 1978.

Date		Box No.	Flow ℓpm	Temp. °C	Number Samples	Range of D.O. Values ppm	No. Values Below 7 ppm	Inflow ppm	Outflow ppm	[1]Recommended Value for Fish Culture ppm
1972	April 21	1	235	6.9	16	8.6 - 10.0	0	10.7	9.4	7.0
		2	235	6.9	16	8.8 - 10.2	0	10.7	9.4	7.0
		3	235	6.9	16	9.4 - 10.0	0	10.7	9.4	7.0
1973	April 6	3	275	7.8	32	11.2 - 12.5	0	12.0	11.3	7.0
	April 25	3	287	10.6	32	10.0 - 11.7	0	11.7	10.5	7.0
1974	April 24	3	291	9.4	50	3.1 - 11.4*	13	11.0	8.7	7.0
	April 25	3	435	8.3	8	6.3 - 7.8*	3	Not recorded		7.0
	April 26	2	322	7.8	50	7.7 - 11.9	0	12.0	10.9	7.0
	May 3	2	322	8.9	5	6.8 - 9.1**	2	Not recorded		7.0
	May 3	1	322	8.9	50	8.2 - 11.5	0	11.9	11.1	7.0
1975	Feb. 5	2	291	1.4	10	13.8 - 14.0	0	13.9	13.9	7.0
	Feb. 5	3	291	1.4	50	13.6 - 14.2	0	13.9	13.9	7.0
1978	May 1	1	420	11.0	5	10.4 - 11.0	0	10.6	10.9	7.0
	May 2	2	420	11.0	5	5.0 - 11.0	2	11.0	10.6	7.0
	May 2	3	420	11.0	5	6.5 - 10.6	1	10.6	10.4	7.0

* Only 8 of the lowest values recorded (all those below 7 ppm) on April 24 were sampled in box 3 on April 25.
** Only 5 of the lowest values recorded on April 26 were sampled in box 2 on May 3.

(b) Laboratory analysis of various parameters of water quality using Hach reagents (a modified Winkler test) at Blaney Creek, 1973 - 1974.

		Box Number	Parameter	Flow ℓpm	Temp. °C	Inflow ppm	Outflow ppm	[1]Recommended Value for Fish Culture ppm
1973	April 6	3	CO_2	275	7.8	10.0	12.5	10.0 maximum
			pH	275	7.8	6.3	6.3	6.5 - 8.0
1974	April 9	3	NH_3	292	6.4	0.01	0.02	0.5 maximum
			NO_2	292	6.4	0.02	0.005	0.1 maximum
			NO_3	292	6.4	0.03	0.04	3.0 maximum
			OPO_4	292	6.4	0.005	0.005	0.05 maximum

[1] Shepherd, 1978.

Appendix 3

Statistical comparison of fry quality between wild and incubator fry using analysis of variance (F - test) and test for differences between means (t - test), Blaney Creek, 1972, 1973 and 1977.

	ANALYSIS OF VARIANCE BETWEEN WILD AND INCUBATOR FRY (F - test)			t - TEST FOR DIFFERENCES BETWEEN MEAN FOR WILD AND INCUBATOR FRY		
Brood Year	Length Fcalc. F(.05)	Weight Fcalc. (F(.05)	K_D Fcalc. F(.05)	Length tcalc. t(.05)	Weight tcalc. t(.05)	K_D tcalc. t(.05)
1972	5.3* >2.0	6.35* >2.3	1.6* >1.0	2.03* >1.65	2.54* >1.65	0.0** <1.65
1973	1.2** >1.31	2.1* >1.0	---	2.00* >1.65	6.85* >1.65	---
1977	1.16** < 1.25	1.1** <1.25	0** <1.25	0.0** <1.65	2.97* >1.65	19.03* >1.65

* significantly different at 95% confidence level.

** no significant difference at 95% confidence level.