PENNY CHINOOK PILOT HATCHERY
OPERATIONAL HISTORY, 1980-1983

Internal Report
August 1988

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ABSTRACT

This report describes the operational history of the Penny Pilot Hatchery for the 1980-1982 brood years. Brood stocks consisted of the upper Fraser River chinook from Slim Creek, Bowron River and James Creek. The purpose of the operation was to evaluate enhancement strategies for the upper Fraser River chinook stocks, and provide tagged releases for testing an imprinting strategy and determining adult contribution to various fisheries.

The majority of chinook spawners from the Slim, Bowron and James streams were age 4_2 and 5_2 (96 - 100% of each year's sample), with sub-2 adults comprising 96 - 100% of the sampled fish. During 1980 to 1982, between 64,500 and 197,960 eggs were planted each year at the Penny Pilot Hatchery, resulting in annual releases of 57,478 to 178,126 fry. Egg to release survivals by brood year and stock ranged from 74% to 90%. Tagged fry were released in their natal streams in July at a mean size of 1.3 - 1.9 g. Better growth of the 1982 brood fry, compared to the 1980 and 1981 broods, was due to earlier ponding and the addition of euphausids to fish diet to stimulate the initial feeding response in cold water.

An imprinting experiment was conducted on the 1981 brood Slim Creek and Bowron River fry to determine whether holding fry at the release site for one week improved the homing to their natal stream.

Tag recoveries were very few for the 1980 and 1981 brood releases (1982 brood recoveries were incomplete), indicating 0-0.10% fry to adult survival. The imprinting experiment and fishery contribution could not be assessed from the few tag returns.

INTRODUCTION

Bio-engineering surveys were carried out in June 1980 on the upper Fraser River watershed, as part of the Department of Fisheries and Oceans (DFO) Salmonid Enhancement Program (SEP), to evaluate the enhancement potential for chinook salmon stocks (DFO memo 5830-13-14, June 1980). A potential site for development of a pilot hatchery was selected at Penny, B.C. (Fig.1), since that site had an existing water supply system which could support minor incubation and short term rearing without significant cost. The lack of other suitable sites in the area (DFO memo 5830-13-14, June 1980) made the above site the most desirable to assess chinook enhancement strategies for the upper Fraser River stocks. In particular, the purpose of the Penny Pilot Hatchery operation was to evaluate the effects of cold water rearing, and provide tagged releases for testing an imprinting strategy and determining adult contribution to various fisheries.

In the first two years of Penny Pilot Hatchery operation, the Slim Creek (1980 and 1981) and Bowron River (1981) provided the hatchery chinook brood stocks. In the late summer of 1982, these two chinook stocks were satellited to the Quesnel River Hatchery, and it was decided to obtain the 1982 brood stock for the Penny facility from James Creek on the MacGregor River system (Fig. 1).

This report describes the operational history of the Penny pilot facility for the 1980-1982 brood years, and summarizes tag recoveries from spawning grounds and from various sport and commercial fisheries until 1986. The Penny facility was initially operated under SEP but in 1983 became part of the Community and Economic Development Program (CEDP).

DESCRIPTION OF CHINOOK DONOR STREAMS

Chinook brood stocks used at the Penny Pilot Hatchery were obtained from Slim Creek, Bowron River and James Creek, all located in the upper Fraser River watershed (Fig. 1). Slim Creek originates from Pinkerton Peak in the Cariboo Mountain Range, and flows roughly in a northeasterly direction for about 50 km before merging with the Fraser River on the south side. This creek drains an area of approximately 860 km^2. Bowron River flows into Bowron Lake, then continues in a northwesterly direction for approximately 185 km where it joins the Fraser River on the south side. Bowron River drains an area of approximately 3,600 km^2 (Manzon and Marshall 1980). James Creek flows from Pacific Lake, southeast for approximately 13 km to join Herrick Creek which flows into the MacGregor River. The MacGregor River drains an area of 91,371 km^2 and flows past the Herrick Creek junction for another 60 km before joining the Fraser River on the north side.

SALMON RESOURCE

Annual salmon escapements to the Slim Creek, Bowron River and James Creek are shown for the period 1970 - 1983 in Table 1 . Historically, Slim Creek and Bowron River have been major chinook producers in the upper Fraser River, with an estimated mean escapement during 1970-1983 of 1,283 adults for Slim Creek and 1,661 adults for Bowron River. Sockeye also utilize the Bowron River, averaging 8,735 adults between 1970 and 1983 (range 1,170 - 35,000). James Creek in the MacGregor River system has only a small run of chinook which averaged 304 adults between 1970 and 1983.

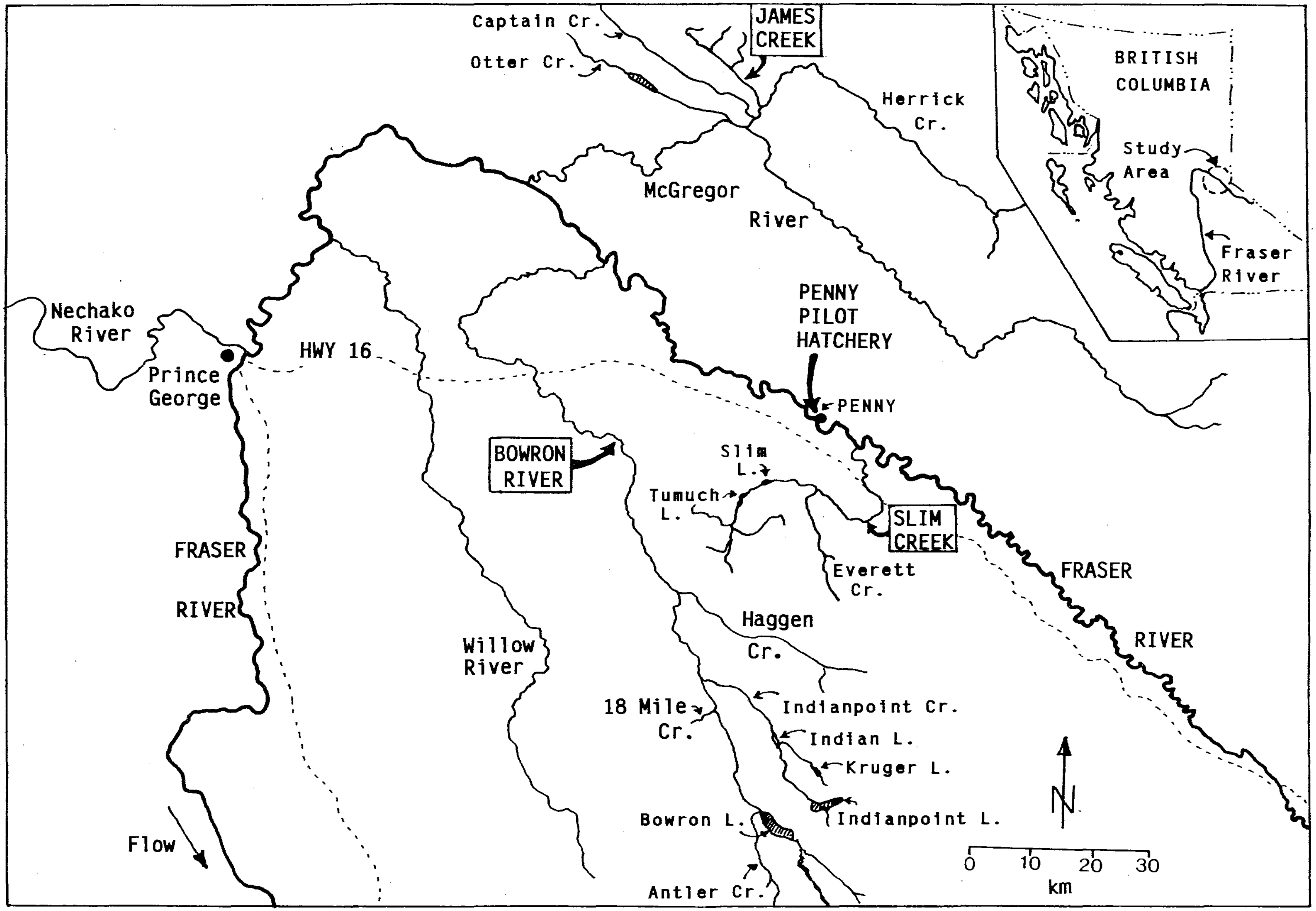

Fig. 1. Location of the Penny Pilot Hatchery and chinook donor streams - Bowron River, Slim Creek and James Creek.

Table 1. Annual salmon escapements to Slim Creek, Bowron River and James Creek, 1970-1983.[a]

Year	SLIM CREEK	BOWRON RIVER		JAMES CREEK
	Chinook	Chinook	Sockeye	Chinook
1970	750	3,500	1,341	N/R[b]
1971	750	1,200	25,497	N/R
1972	750	1,300	4,138	N/R
1973	750	1,000	4,700	N/R
1974	750	1,000	1,850	N/R
1975	750	1,200	29,700	N/R
1976	1,422	800	2,250	N/R
1977	1,900	950	2,500	N/R
1978	1,600	2,000	3,150	N/R
1979	1,500	1,350	35,000	380
1980	1,900	2,000	2,894	205
1981	1,335	1,260	1,170	135
1982	1,800	1,400	1,647	400
1983	2,000	4,300[c]	6,451	400
Mean	1,283	1,661	8,735	304

[a] From Farwell et al. 1987.
[b] N/R - no record.
[c] Hatchery reconnaissance(unpubl.).

DESCRIPTION OF HATCHERY FACILITY

The Penny pilot chinook facility is located 105 km east of Prince George (Fig. 1) at Rankin Creek, a small ground fed stream joining the Fraser on the north side. The facility was constructed on property owned by C. Boudreau in Penny, B.C. and started operation in the summer of 1980. Initially, the Penny Pilot Hatchery consisted of a 50,000 egg-capacity upwelling gravel incubation box, one Capilano style rearing trough and two propane freezers for storage of fish food (Figs. 2 and 3). The pilot was expanded in 1981 to accommodate 200,000, 1.0-2.0 g fry, utilizing five 8-tray Heath stacks, two upwelling gravel incubation boxes, as well as two indoor and three outdoor Capilano style rearing troughs. Also, a settling pond measuring 6 m X 6 m X 1.5 m deep (Fig. 4) was constructed to remove prophylactic disease control chemicals and solid wastes from hatchery effluent. In 1981, individual aeration towers were installed for the incubation area and each rearing trough (see Water Supply section below).

WATER SUPPLY

Water supply for the Penny Pilot Hatchery was drawn from Rankin Creek. The creek originally provided a water supply for a sawmill, now dismantled, located adjacent to the Fraser River. Water for the hatchery was drawn from an existing pipeline originating from a reservoir near the upper end of Rankin Creek, approximately 1.6 km above the Fraser River confluence (Fig. 5).

The creek temperatures range from approximately 1°C during winter months to about 10°C during summer months (Table 2). The water has a dark tea colour due to organics from the surrounding forest, and in unaerated condition, is high in dissolved nitrogen (106.9%) and low in dissolved oxygen (77.0%, Table 3).

Table 3 summarizes the changes in the Penny facility aeration system and documents a decline in nitrogen and an increase in oxygen saturation levels with improved water aeration. In 1980 the water was supplied to the hatchery via a 5 cm pipeline which provided a low head of approximately 2 m and a flow of 270 lpm. Aeration of the water was difficult due to the low head available. At the start of hatchery operation, a small aeration unit (pail aerator) was suspended from the ceiling with water discharging through shower heads into three 10 cm diameter tubes mounted on the header tank of the incubation box. The tubes were filled with bio-rings and enclosed in a large diameter pipe to prevent splashing. Later, standard segmented packed columns were used to aerate the water supply to each rearing trough.

In May 1981, the reservoir dam was partially washed out. The lower water level caused air to be entrained at the intake, resulting in increased total dissolved nitrogen level (103.6%, Table 3) and a reduced water flow to the hatchery, from 270 lpm to 135 lpm. During repairs to the dam, a second 7.5 cm diameter pipeline was installed parallel to the original 5 cm supply line. This action increased the hatchery water supply to 1,000 lpm and allowed expansion of the incubation and rearing capacity of the facility.

In 1982 the hatchery water line was replaced with a 10 cm diameter pipeline thereby increasing the water flow to about 1,800 lpm with 3-4 m of head. As a result, the capacity of the pilot facility was again expanded to accommodate 200,000 fry. The increase in head allowed for improved aeration.

Fig. 2. Penny Pilot Hatchery site, 1981.

Fig. 3. Penny Pilot Hatchery building, 1980.

Fig. 4. Settling pond at the Penny Pilot Hatchery, 1982.

Fig. 5. Original water supply intake at the Penny Pilot Hatchery, 1980.

Table 2. Monthly water temperatures at the Penny Pilot Hatchery, 1981.

Month	Minimum daily temperature (°C)	Maximum daily temperature (°C)	Mean monthly temperature (°C)
January	0.0	0.5	0.8
February	0.0	1.0	0.2
March	0.0	2.0	1.0
April	1.6	2.4	1.9
May	5.3	6.8	6.1
June	6.8	8.2	7.5
July	5.9	10.6	10.0
August	-[a]	-	12.2
September	7.2	8.2	7.6
October	4.5	5.5	5.1
November	2.6	3.4	2.9
December	0.7	0.8	0.7

[a] No recorded data.

Table 3. Aeration system and gas saturation at the Penny Pilot Hatchery, 1980-1982.

Date	Aeration	Total gas pressure (%)	Nitrogen saturation (%)	Oxygen saturation (%)
1980				
September 22	Unaerated	100.6	106.9	77.0
October 16	Pail aerator	100.3	103.2	89.4
1981				
January 7	Segmented columns	100.1	100.9	97.2
May 12	Dam washed out	101.7	103.6	94.9
June 26	New dam	100.9	102.0	96.5
August 11	Screen aerator	101.3	102.9	95.3
1982				
July 12	Segmented columns	100.4	101.2	97.7

The two indoor rearing troughs and one outdoor trough were plumbed separately, while the two remaining outdoor troughs were run in-line. Outflow from the rearing troughs was diverted into the settling pond via a by-pass valve for the duration of rearing. Outflow from the incubation units entered directly into Rankin Creek.

METHODS

BROOD STOCK COLLECTION

Chinook brood stocks were obtained from Slim Creek in 1980, from Slim Creek and Bowron River in 1981, and from James Creek in 1982. The Slim Creek adults were captured in 1980 by beach seining and tangle gillnetting just below the Slim Lake outlet after the start of active chinook spawning. Ripe adults were spawned immediately on site and the gametes transported by helicopter to the Penny Hatchery.

The above approach was modified in 1981 when early capture and experimental holding of adults until ripe was attempted. The adult holding experiment was carried out to assess strategies for operation of the Quesnel River Hatchery since both the Bowron and Slim stocks were to be satellited out of the Quesnel facility the following year, with large egg take goals. Consequently in 1981, the Slim Creek adults were captured prior to the start of active spawning, between August 19 and 24, by drifting gillnets in a reach 1-3 km downstream from Slim Lake. Captured fish were placed directly into holding pens located at two sites below the Slim Lake outlet (Fig. 6). Within a week, the penned adults suffered heavy mortality associated with high water temperatures of 18 - 19°C, and the holding experiment was aborted. The remaining Slim Creek brood stock was collected between August 27 and September 2, after the start of active chinook spawning. Gillnets were drifted on the redds below Slim Lake and ripe adults were spawned immediately.

A similar adult holding experiment was attempted on the Bowron River in 1981. Unripe adults were captured during August 14 - 16, 1981 by gillnetting below Bowron Lake, then transported in an aerated fibreglass tank downstream by boat to holding pens installed at a river site with road access (Fig. 6). Within a week of holding, the penned adults suffered severe fungal infection and mortality, attributed largely to high water temperatures of 17 - 19°C. Subsequent collection of brood stock was delayed until after the start of active chinook spawning. Between August 30 and September 4, gillnets were drifted on the redds below Bowron Lake and ripe adults were spawned immediately.

Adult trapping in James Creek in 1982 was attempted using a temporary broomstick fence installed approximately 100 m above the confluence with Herrick Creek (Fig. 6). Since the fish were not entering the trap, gillnetting was undertaken below the fence to secure the required brood stock. Adults were transported in groups of 1 - 5 in rigid plastic or soft vinyl tanks by boat, from capture sites to the holding pens located at the confluence of the MacGregor River and Herrick Creek (Fig. 6).

ADULT SAMPLING

Chinook carcasses recovered on the spawning grounds and adults used for egg takes were sampled each year for postorbital - hypural (POHL) length, sex and age. Scales were interpreted at the DFO Scale Laboratory in Vancouver. In

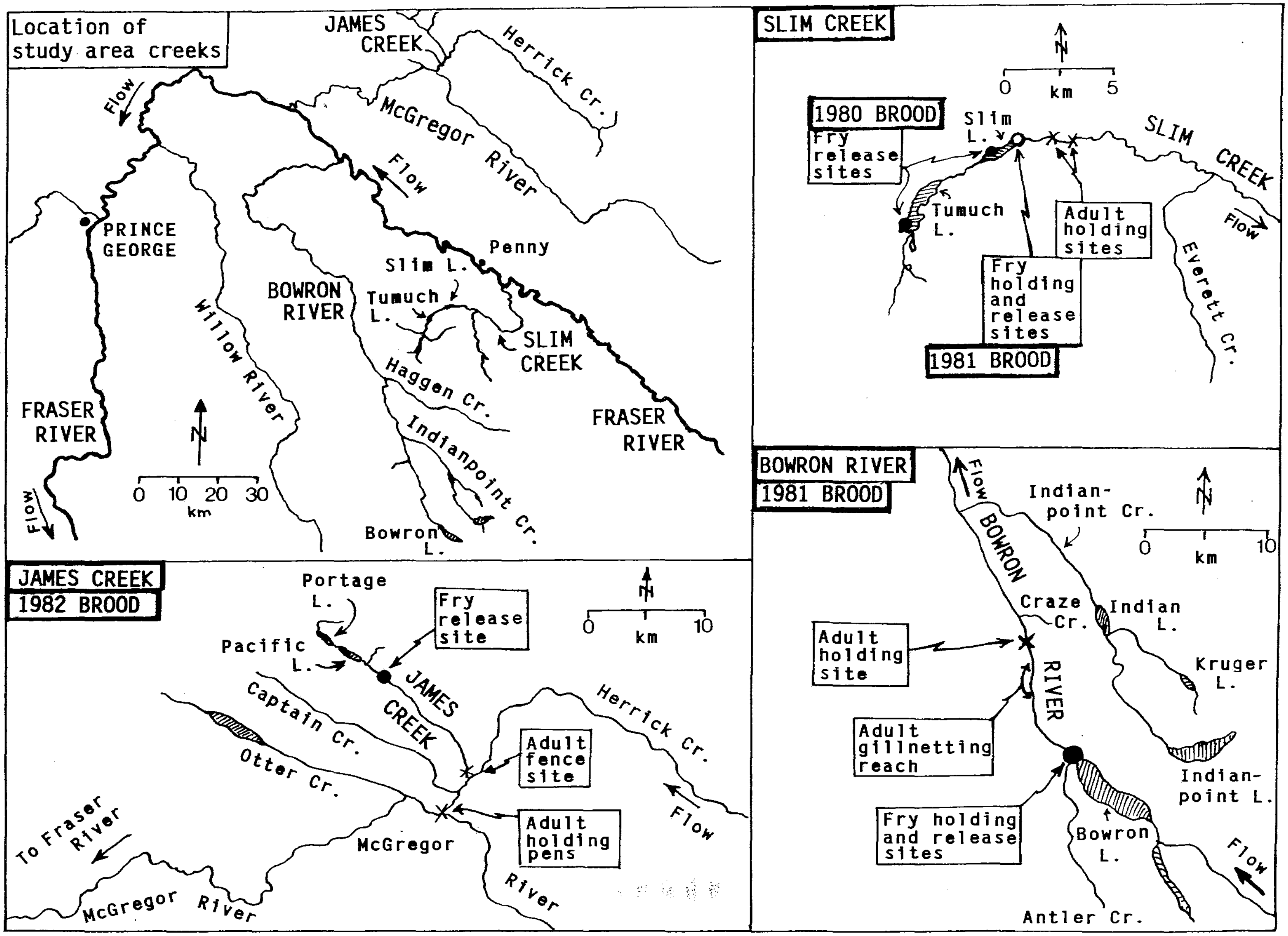

Fig. 6. Chinook brood stock collection and holding sites, and fry holding and release sites for Slim Creek, Bowron River and James Creek, 1980-1982 broods.

addition, a portion of the female brood stock was sampled each year for fecundity using a volumetric method.

Disease analysis was conducted on chinook carcasses recovered in 1980 in Slim Creek and Bowron River by Envirocon Ltd., and on carcasses recovered in 1981 in Slim Creek by Beak Consultants. In 1980 carcasses, including those used in egg takes, were shipped frozen to the Diagnostic Services Group at the Pacific Biological Station (PBS) in Nanaimo, B.C. The fish were examined there for all infectious disease agents and parasites which cause losses among cultured salmonids. In 1981 on-site disease analysis was conducted on Slim Creek adults, and only preserved gill samples of spawners were sent to the Pacific Biological Station in Nanaimo.

EGG TAKES AND PLANTING

In 1980 egg take at Slim Creek was conducted at the adult capture site, approximately 1 km below the Slim Lake outlet. Ripe females were killed with a blow to the head, and carcasses laid on the grass and opened for egg removal. The eggs were placed in plastic bags (2-3 females/bag) and the sperm from males placed in separate bags (1 male/bag). The gametes were kept on ice in coolers and transported immediately by helicopter to the hatchery.

Prior to fertilization, six 50 ml samples of eggs were counted to provide a volume index. The eggs were then split into five pails (2-3 females/pail) and each portion dry mixed with 30 ml of pooled milt, washed twice and water hardened for 1.5 hours. The eggs were then disinfected in a solution of buffered Wescodyne (6 ml/l water) for 10 minutes and placed on Vexar screens 5 cm above the gravel in the incubation box; this set-up allowed the alevins to swim down into the gravel upon hatching. After 24 hours of development, a random sample of 50 eggs was taken for a fertilization check (Murray et al. MS 1981). Using the above egg take method, the maximum period between killing females and planting eggs in the incubation box was less than 4.0 hours.

In 1981 the ripe chinook brood stocks from Slim Creek and Bowron River were stripped using a method similar to Banford and Bailey (1979). The eggs were collected into 2 liter plastic containers and the milt into glass jars. The gametes were kept on ice in coolers and transported to the hatchery by helicopter from Bowron River and by truck from Slim Creek. The eggs were split volumetrically into lots, fertilized and planted in Heath trays. After 10 minutes of water hardening, the Heath trays were partially withdrawn, the water drained, and the eggs disinfected by adding an Ovadine solution (11 ml/ 1 water) for 10 minutes. The trays were then repositioned for rinsing. Only Heath trays were utilized for planting in 1981.

A procedure similar to the 1981 method was used in 1982. The James Creek brood stock females were stripped at the holding site and the eggs stored in plastic containers. The males were spawned into glass jars and the milt transferred to whirl packs (1 male/bag). The gametes were kept on ice in coolers and flown to the Penny Hatchery for planting. In 1982, 27 Heath trays and one incubation box were utilized for planting. After shocking and picking on September 30, the eggs from 12 of the Heath trays were transferred to a second incubation box. Incubation boxes were used in order to delay fry emergence so that ponding could occur at somewhat warmer water temperatures compared to the Heath tray fry; the latter tend to emerge earlier than box fry.

During the 1981 and 1982 egg takes, Heath trays were planted at approximately 6,500 eggs/tray and the incubation boxes at 50,000-70,000 eggs/box. During the incubation in Heath trays, eggs were shocked and picked at an eyed stage, then repicked weekly until ponding. Eggs in the incubation boxes were shocked and picked once only.

EMERGENT FRY ENUMERATION AND PONDING

The 1980 brood Slim Creek fry, upon emerging from the incubation box, were directed through two 2.5 cm diameter syphon tubes into two 70 liter garbage containers fitted with cut out drain windows covered with 0.32 cm nylon netting. The fry were counted individually before ponding in the rearing trough.

The 1981 brood Slim and Bowron fry incubated in Heath trays were ponded into the rearing troughs after reaching the swim up stage. The numbers ponded were estimated by subtracting the mortality counts from the egg take volume estimates.

The 1982 brood James Creek fry incubated in Heath trays were handled in a manner similar to the 1981 brood fry; the box fry were counted individually before ponding in the rearing troughs.

FRY REARING

Random samples of 50 fry from each rearing trough were anesthetized in MS 222 weekly and bulk weighed on a triple beam balance to determine the feeding rate. Ponded fry were hand fed measured amounts of Oregon Moist Pellet (OMP) throughout rearing, according to the Stauffer feeding rates. At initial ponding, fry were fed nine times each day from 0800 to 1630 hours. Each trough was divided into small units to crowd the fry and thereby encourage the feeding response. Ponding of 1980 and 1981 brood fry commenced at very low water temperatures (1-2°C) and the initial feeding response was poor. W. Griffioen (West Coast Fish Culture Ltd.) observed that the addition of euphausid fines to fry diet may stimulate the initial feeding response in cases where difficulties are experienced due to low rearing temperatures. Accordingly, the 1982 brood James Creek fry were fed at initial ponding 75% OMP and 25% euphausid fines to stimulate the feeding response. When water temperatures reached 6°C, fry were fed 100% OMP.

FRY MARKING AND RELEASE

The release time each year was dictated largely by the time required to attain a tagging size of 1.0-2.0 g. Prior to release, the fry were adipose fin clipped and coded wire nose tagged. Immediately after marking, fry were immersed for 10 seconds in a malachite green solution at a concentration of 53mg/l. Juveniles were starved at least 24 hours before tagging and subsequent transport, to reduce stress when anaesthetized and to reduce the build-up of metabolic wastes during transport.

Total numbers of tagged fry released were obtained from the actual tagging counts. Untagged releases of box fry were determined by subtracting from the total fry ponded the rearing mortality counts and tagged numbers. Untagged releases of Heath tray fry were determined by subtracting from the eyed egg stage inventory the mortality counts and tagged numbers. To determine size at release, random samples of 50 fry were bulk weighed from each group prior to release.

Generally, the fry were transported from the hatchery to the natal stream directly at the end of each day's tagging. All fry were transported by helicopter in oxygenated, 360 liter transport tanks. In order to extend the fry imprinting period, all fry were released in the upper reaches of the donor streams; the release sites generally corresponded with the upper limit of chinook spawning area. The Slim Creek fry from the 1980 brood were flown to net pens located at two sites, one at the upper end of Tumuch Lake which represented the upper limit of chinook spawning in that stream (Murray et al. MS 1981) and one located approximately 1 km below the head of Slim Lake (Fig. 6). Fry were held in net pens for 24 hours prior to release. Lake releases occurred rather than creek releases due to the requirement for net pen sites with helicopter access in order to hold the fry for limited imprinting before release.

The 1981 brood Slim Creek fry were released at the Slim Lake outlet, while the 1981 brood Bowron River fry were released at the Bowron Lake outlet (Fig. 6, see Imprinting Experiment section below for details). Both these sites were known to be heavily utilized by chinook spawners (Murray et al. MS 1981). The 1982 brood James Creek fry were released directly into James Creek approximately 2.5 km below the Pacific Lake outlet (Fig. 6). Chinook spawners were known to utilize James Creek up to and above the Pacific Lake (Marshall and Manzon 1980).

IMPRINTING EXPERIMENT

An imprinting experiment was conducted on the 1981 brood Slim Creek and Bowron River fry. This study was designed to determine whether holding fry for an extended period at the release site improved the homing to their natal stream. Approximately half the fry from each stock were held in net pens at the release sites for one week while the other half were released directly into the stream of origin. Releases of imprinted and non-imprinted groups occurred on the same date for each stock, and each group was differentially coded wire tagged.

The Slim Creek "imprinted" group was transported in a helicopter monsoon bucket from the hatchery to the net pens located at the outlet of Slim Lake, and released after one week of holding. The control group was released directly from the monsoon bucket about 0.5 km below the Slim Lake outlet (Fig. 6). Similarly, the Bowron River "imprinted" group was held one week in net pens located at the outlet of Bowron Lake before release, while the control group was released directly into Bowron River about 0.8 km below the Bowron Lake outlet (Fig. 6).

MARK RECOVERY

Chinook tags were recovered in the B.C. commercial and sport fisheries and in Alaska, as well as on the spawning grounds. Dead pitches in Slim Creek were conducted by the Penny Salmonid Society, and generally included the Slim Creek mainstem from the outlet of Tumuch Lake to the confluence with Everett Creek. Recoveries in the Bowron River were conducted by the DFO Field Services and generally included the Bowron mainstem and Indianpoint Creek. No stream recoveries were conducted in James Creek. Marked chinook recovered in Slim and Bowron systems were sampled for POHL length, sex and age; scales were read in the DFO Scale Laboratory in Vancouver. The heads were removed for later dissection and CWT decoding.

PHYSICAL SAMPLING

Water temperatures at the Penny facility were measured daily, using hand thermometers in 1980 and a thermograph in 1981 and 1982. For each egg plant, a cumulative thermal incubation history was maintained, and the accumulated thermal units (ATUs) were determined for the eyed egg, hatching and swim up stages.

Water samples were collected periodically for determination of nutrient and metal content, and pH levels. The samples were analyzed at the DFO Cypress Creek laboratory. Oxygen levels and total gas pressures were also monitored periodically and were analyzed on site.

RESULTS AND DISCUSSION

ADULT SAMPLING

Age and length composition

Chinook age composition for the 1980-1982 period is shown in Table 4. The majority of adults were age 4_2 and 5_2 fish with the two combined age groups accounting for 96-100% of each year's sample. The only other age groups were a few age 3_2 and 4_1 fish. Among males, age 4_2 and 5_2 fish were represented about equally in all streams; among females, age 5_2 was the dominant group in all streams. Sub-2 adults comprised 96-100% of each year's sample. A similar age structure was reported for upper Fraser River chinook populations in Walker Creek and Torpy, West Torpy, Holmes and Willow Rivers (Murray et al. MS 1981; Rosberg and Aitken MS 1982).

Table 5 shows the mean POHL length of chinook adults by sex and age for the 1980 - 1982 period. Comparing the different streams, age 4_2 and 5_2 chinook from James Creek had a larger mean size than the corresponding age groups from Slim Creek and Bowron River. However, the difference was not significant ($p > 0.05$) except for the age 5_2 chinook from Slim and James Creeks. Sample sizes for age 3_2 and 4_1 groups were too small for comparison.

Comparing lengths between sexes, males tended to be larger than females among the age 5_2 fish but the difference was not significant ($p > 0.05$). This situation was reversed in the age 4_2 group where females tended to be larger than males but again the difference was not significant ($p > 0.05$). This comparison was not valid for the Bowron River chinook where sample size was too small for analysis (Table 5).

The importance of the length of marine rearing period in determining the final adult size was apparent from the 1980 Slim Creek length data (Table 5), where a sufficiently large sample size was available for comparison. Fish that had spent three years rearing at sea (age 4_1 and 5_2) had similar sizes and were significantly larger ($p < 0.05$) than fish that had spent only two years at sea (age 4_2).

Fecundity

The mean fecundity for the 1980 - 1982 chinook brood stocks was 6,458 eggs/female with a mean range of 6,057 to 6,906 eggs/female (Table 7, Appendix 1).

Table 4. Chinook adult age composition for Slim Creek, Bowron River and James Creek, 1980-1982.

Year	System	Sex	Sample size	% Age Composition			
				3_2	4_1	4_2	5_2
1980	Slim Creek	Male	27	-	-	51.9	48.1
		Female	61	-	4.9	16.4	78.7
		Total	88	-	3.4	27.3	69.3
1981	Slim Creek	Male	48	2.1	-	45.8	52.1
		Female	90	-	-	12.2	87.8
		Total	138	0.7	-	23.9	75.4
1981	Bowron River	Male	3	-	-	33.4[a]	66.7[a]
		Female	9	-	-	11.1[a]	88.9[a]
		Total	12	-	-	16.7	83.3
1982	James Creek	Male	25	-	4.0	60.0	36.0
		Female	32	-	3.1	3.1	93.8
		Total	57	-	3.5	28.1	68.4

[a] Sample size too small to provide valid age composition.

Table 5. Mean postorbital - hypural (POHL) length of chinook adults by sex and age for Slim Creek, Bowron River and James Creek, 1980-1982.

Year	System	Sex	Sample size	Length (POHL, mm) at age ± 95% C.L.[a]			
				3_2	4_1	4_2	5_2
1980	Slim Creek	Male	27	-	-	524 ± 63	725 + 28
		Female	61	-	723 ± 69	605 ± 40	697 ± 10
		Total	88	-	723 ± 69	558 ± 41	703 ± 10
1981	Slim Creek	Male	48	305	-	568 ± 25	745 ± 24
		Female	90	-	-	622 ± 29	714 ± 10
		Total	138	305	-	586 ± 20	721 ± 10
1981	Bowron River	Male	3	-	-	584	734 ± 1,011[b]
		Female	9	-	-	730	734 ± 36
		Total	12	-	-	657 ± 928[b]	734 ± 38
1982	James Creek	Male	25	-	660	621 ± 43	774 ± 40
		Female	32	-	699	693	753 ± 14
		Total	57	-	680 ± 248[b]	625 ± 41	758 ± 14

[a] No confidence limits given where sample size is one.
[b] Sample size is two.

Sex ratio could not be determined due to the sampling biases, but was considered to be near a 1:1 ratio.

Disease analysis

The information on chinook adult diseases in the donor streams was extracted largely from the PBS Diagnostic Service memos No. 25-16-1, January 29, 1981 and November 6, 1981. Five disease agents were isolated (Table 6) with Ceratomyxa shasta and Myxidium sp. being the most prevalent pathogens. These are are described briefly below.

Ceratomyxa shasta is an intestinal protozoan parasite which has caused heavy losses among cultured salmonids. Its transmission appears to be temperature dependent, and the infective stage is active at water temperatures in excess of 15°C. The impact of C. shasta on fish reared in a system containing this parasite, such as the upper Fraser River, depends mainly on water supply to the hatchery and on release time as related to water temperatures (D. Kieser, pers. comm.). If a well water supply is used for the hatchery, neither C. shasta nor Dermocystidium sp. (see below) will be a problem during rearing, especially if eggs are surface disinfected. Also, if fry are released and migrate through the Fraser River before water temperatures reach 10°C, they are much less at risk of being infected with C. shasta than fry migrating after the river temperature has increased above 10°C.

Myxidium sp. is a protozoan found in the kidney and occasionally the liver of salmonids. No disease problems have been linked so far to this parasite.

Henneguya salminicola is a protozoan parasite that causes white cysts in the musculature of fish. This parasite does not seem to incapacitate the host but makes the flesh unattractive for human consumption.

Dermocystidium sp. may be considered a fungus or a protozoan and occurs as small white cysts on the gills of adult salmon. Severity of infection is directly linked to water temperature, and gill damage can be severe.

Aeromonas salmonicida is a bacterium that causes furunculosis (Wood 1974).

INCUBATION

The incubation data for the 1980-1982 broods are summarized in Table 7. Between 15 and 38 females from a given donor stream were used annually for egg takes. The number of eggs planted each year ranged from 64,500 in 1980 to 197,960 in 1982. Egg to ponding survival by brood year and stock ranged from 88.0% to 98.8%.

Incubation and ponding dates and accumulated thermal units for each brood are shown in Table 8. Eggs were planted in late August and early September. Eggs in Heath trays were shocked and picked in late September and early October at 283-360 ATUs. Hatching began in late October to mid-November at approximately 435-580 ATUs. Fry were ponded in April and May at 732-996 ATUs.

For the 1982 James Creek brood, the incubation box fry showed a later emergence and ponding time (April 5 - May 16) than the Heath tray fry (April 3-14, Table 8). As a result, the box fry experienced higher initial ponding temperatures which probably resulted in improved initial feeding response.

Table 6. Disease analysis on chinook adults from Slim Creek and Bowron River, 1980-1981.

Year	System	No. fish examined	No. fish with specific disease agent				
			Ceratomyxa shasta	*Myxidium* sp.	*Henneguya salminicola*	*Dermocystidium* sp.	*Aeromonas salmonicida*
1980	Slim Creek	24	7	3	0	0	0
1980	Bowron River	25	5	11	1	0	0
1981	Slim Creek	55	10	0	0	26[a] (at least)	1

[a] This parasite was also found in the five adult chinook gill samples examined from Slim Creek that year.

Table 7. Chinook egg take, incubation and ponding inventory for the Penny Pilot Hatchery, 1980-1982 broods.

Brood Year	System	Female broodstock				Eggs planted	Fry ponded	Date ponded	% Egg to ponding survival
		No. used for egg-take	Mean No. eggs/ml	Mean fecundity[a] (eggs/female)	Mean length[a] (POHL, mm)				
1980	Slim Creek	15	2.16	6,557	697	64,500[b]	63,739	Apr 25-May 15/81	98.8
1981	Slim Creek	19	3.99	6,057	718	90,707[c]	79,806	May 2-19/82	88.0
	Bowron River	21	3.84	6,313	724	107,079[c]	95,756	May 1-24/82	89.4
1982	James Creek	38	4.49	6,906	755	197,960[d]	190,938	Apr 3-May 10/83	96.5
Mean		-	-	6,458[e]	724[e]	-	-	-	93.5

[a] See Appendix 1 for data on individual females.
[b] Used one upwelling incubation box.
[c] Used Heath trays only.
[d] Used Heath trays and one incubation box at initial planting; on September 30 transferred 60,102 eggs from Heath trays to second incubation box.
[e] Mean of means.

Table 8. Timing of incubation and accumulated thermal units for all broods at egg planting, shocking and picking, hatching, and ponding at the Penny Pilot Hatchery, 1980-1982 broods.

Brood year	System	Incubation unit	Eggs planted	Shocked and picked		Hatched		Ponded	
			Date	Date	ATUs (°C-days)	Date	Mean ATUs (°C-days)	Date	ATUs (°C-days)
1980	Slim Creek	Incub. box	Aug 30	Oct 16	360	Oct 24 - Nov 20	476	Apr 25 - May 15	743-830
1981	Slim Creek	Heath trays	Aug 21 - Sep 2	Sep 20, 28 Oct 9	293 320	Oct 7 - Nov 18	440	May 2-19[a]	733-769
	Bowron River	Heath trays	Aug 30, Sep 3, 4	Sep 28, 29 Oct 9, 10	283 301	Oct 28 - Nov 25	435	May 1-24	732
1982	James Creek	Incub. box 1	Aug 20-21	Sep 30	358	Nov 1	580	Apr 5 - May 1	885-982
		Incub. box 2	______	____[b]		Oct 24 - Nov 10	565	Apr 13 - May 10	855-996
		Heath trays	Aug 21-25	Sep 30	329	Oct 26 - Nov 8	538	Apr 3-14	852-879

[a] Also, on February 19, one tray with approximately 3,400 fry was ponded; this tray was from an early egg take on August 21.
[b] On September 30, a portion of shocked and picked eggs (60,102 eggs) from Heath trays was transferred into a second incubation box.

However, there were also advantages in using Heath trays for incubation rather than incubation boxes. When several egg takes were required to reach the egg targets, additional eggs could be planted in the Heath trays without disturbing the eggs already planted. Also, egg handling was reduced at planting and the eggs were more accessible in the trays for disinfection and dead picking, compared to incubation boxes.

The James Creek chinook required about 100 ATUs more to hatching and ponding compared to the Slim Creek and Bowron River chinook (Table 8). This difference may be related to the difference in the genetic make up of the stocks.

EMERGENT FRY MIGRATION TIMING FROM INCUBATION BOXES, 1980 AND 1982 BROODS

Daily fry migration from incubation boxes and mean daily water temperatures during migration are shown for the 1980 and 1982 broods in Figure 7 and Appendices 2-4. The migration period was defined as the time required to complete 99% of the total migration. The 1980 brood Slim Creek fry migrated between April 25 and May 15, 1981, a period of 21 days. Two major peaks were observed, one on April 25 and one during May 6-8. Water temperature during fry migration increased from 2°C to 6°C.

The 1982 brood James Creek fry migrated from box 1 between April 5 and May 1, 1983, a period of 27 days, and from box 2 between April 13 and May 10, a period of 28 days. The dominant migration peak for fry from both boxes occurred April 20 to 24, with box 2 fry showing a secondary peak on May 8. During fry migration from both boxes, water temperature increased from 2°C to 6°C.

The majority of the James Creek fry migrated about two weeks earlier than the Slim Creek fry. This was expected since the James Creek eggs were planted into boxes 8-10 days earlier than the Slim Creek eggs. Water temperatures during the dominant migration peak each year were 4-5°C and were similar for the Slim Creek and James Creek fry (Fig. 7).

FRY REARING

Mean fry weights and mean water temperatures during fry rearing are shown for each year in Figure 8 and Appendices 5-7. Fry were ponded at about 0.4 g at temperatures ranging from 1°C to 5°C. Although fry were feeding at temperatures below 4°C, the most effective feeding and growth occurred at approximately 6°C and above (Fig. 8). By July 1, mean fry weights were as follows:

Brood	System	Mean fry weight by July 1	Mean water temperature (Fig. 8, Appendix 8) in May
1980	Slim Cr.	1.4 g	6.0°C
1981	Slim Cr./Bowron R.	0.9 g	2.9°C
1982	James Cr.	1.8 g	7.0°C

The larger July size observed for the 1980 and 1982 brood fry, compared to the 1981 brood fry, was attributed mainly to differences in the initial rearing

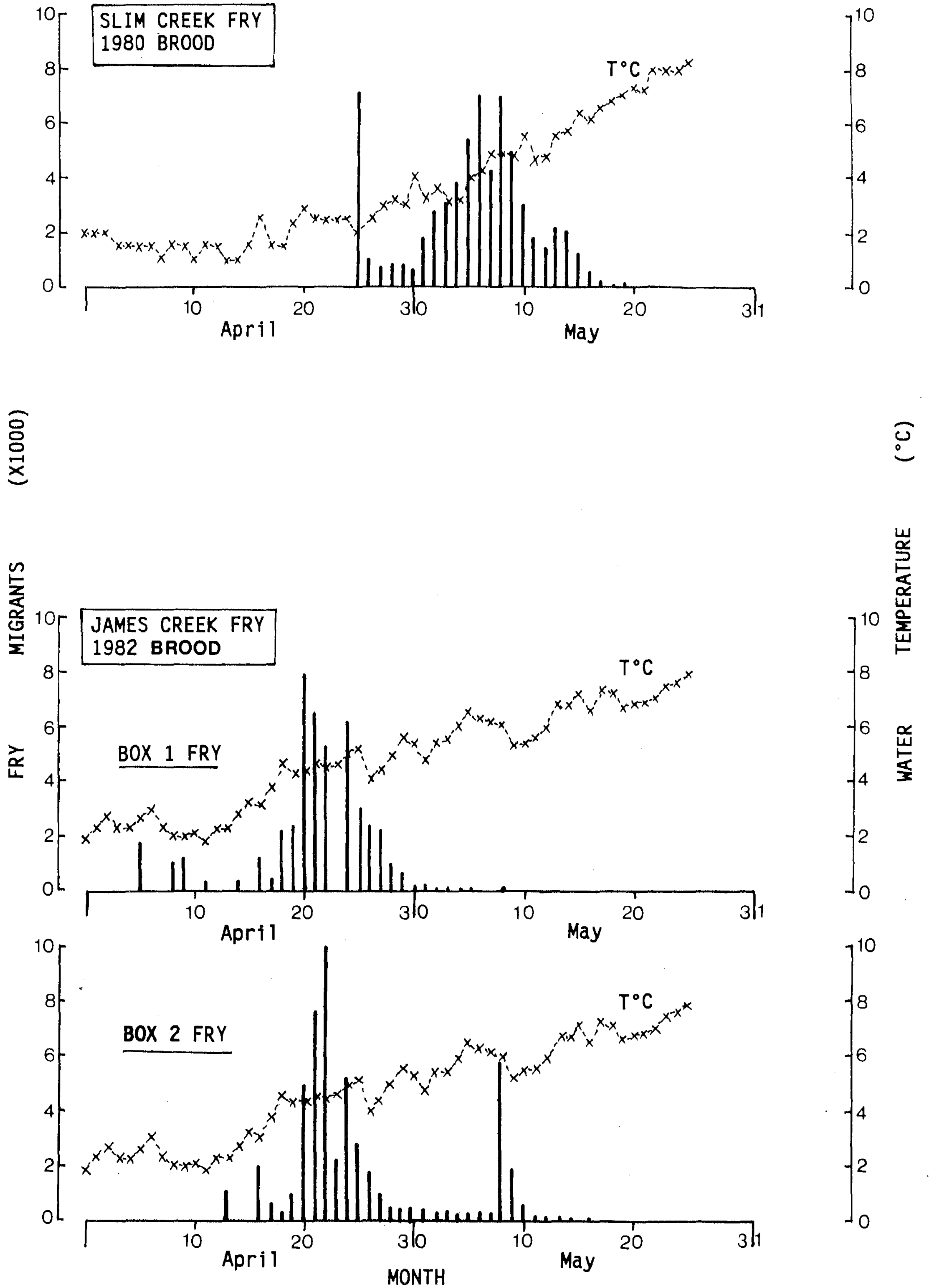

Fig. 7. Daily fry migration from incubation boxes and mean daily water temperatures at the Penny Pilot Hatchery, 1980 and 1982 broods.

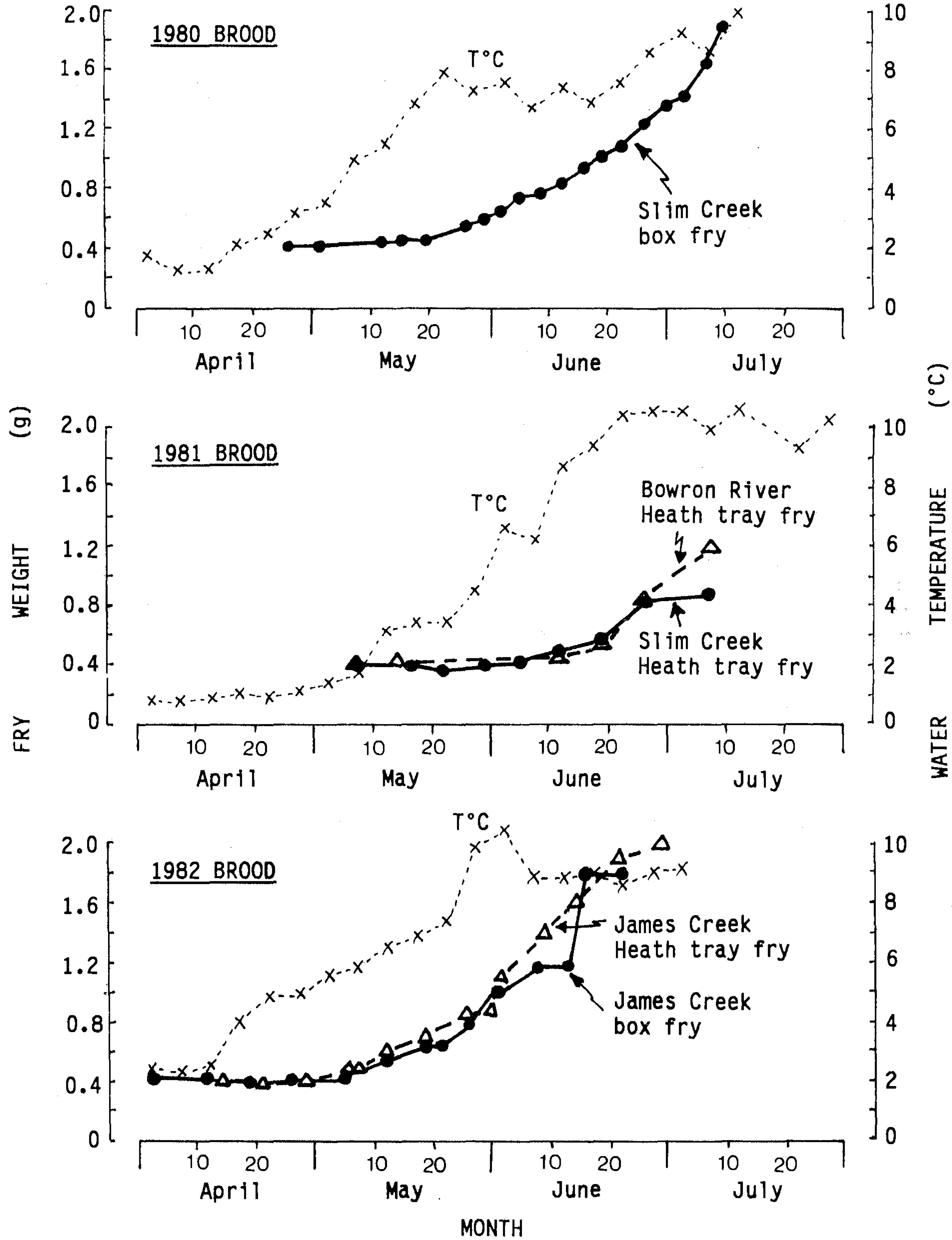

Fig. 8. Mean fry weights and mean (5-day) water temperatures during fry rearing at the Penny Pilot Hatchery, 1980-1982 broods.

temperatures. The 1980 and 1982 brood fry experienced mean May temperatures of 6°C and 7°C respectively compared to only 3°C for the 1981 brood fry.

The 1980 and 1981 brood fry reached a tagging size of 1.0-2.0 g in July, while the 1982 brood fry attained a tagging size approximately two weeks earlier. The more rapid increase in weight of the latter group was attributed to earlier ponding time (Table 8) and the addition of euphausids to fish diet to stimulate the feeding response. Within the 1982 brood, the Heath tray fry which were ponded one to two weeks earlier than the box fry, surpassed the box fry in weight before tagging commenced in July (Fig. 8).

With the exception of a few minor problems such as frayed fins and minor gas bubble disease, no major disease outbreaks occurred at the hatchery. Mortality was generally highest at the start and end of rearing. The latter mortalities were due to stress from high rearing temperatures (up to 12°C), as well as increased handling and crowding of fish into rearing troughs during tagging. Some chinook fry experienced cataract blindness in 1981, a problem reported in many other B.C. hatcheries that year. This problem was attributed to possible nutrient deficiency in the diet. In 1981 and 1982, a "dropout" disease was reported where a portion of the fry stopped feeding at about 0.7 g stage and eventually starved. No diagnostic reason was found for this problem, but it may have been related to a failure by emergent fry to initiate feeding. This failure was possibly due to the low water temperatures at the start of rearing (1-3°C, Appendix 8) and delayed ponding due to extended incubation period.

FRY MARKING AND RELEASE

The marking and release data are summarized in Table 9. During the 1981-1983 period, between 57,478 (1980 brood) and 178,126 (1982 brood) chinook fry were released into the donor streams each year, for an egg to release survival of 74% to 90% by brood year and stock.

Fry release sizes averaged 1.3-1.9 g for marked groups and 0.5-1.9 g for unmarked groups (Table 9). Most of the juveniles were released in July. The late release timing was the result of slow fish growth in the relatively cold hatchery water before reaching the tagging size of 1.0-2.0 g. The release time was also dictated by the rearing densities. As the water temperatures increased above 12°C, rearing densities were reduced to alleviate stress from overcrowding in the rearing troughs. Consequently, in addition to the tagged production groups, releases each year included unmarked juveniles released prematurely to reduce stress from overcrowding and/or those fry which had not reached a tagging size at release. The earlier release timing (July 4) of the marked 1982 brood James Creek fry, compared to the other broods, was attributed to earlier ponding time and the addition of euphausids to fish diet.

The imprinting experiment conducted using the 1981 brood fry yielded four differentially tagged groups. The imprinted and non imprinted Slim Creek fry were released on July 29, 1982 at an average size of 1.6 g and 1.7 g respectively. The imprinted and non imprinted Bowron River fry were released on July 23, 1982 at an average size of 1.3 g and 1.4 g respectively.

MARK RECOVERY

Chinook tag recoveries in the B.C. commercial and sport fisheries, in Alaska catches and on spawning grounds are shown for the Penny Pilot Hatchery

Table 9. Chinook release and marking inventory for the Penny Pilot Hatchery, 1980-1982 broods.

Brood year	System	Release site[a]	Release method	Release date	Release size (g)	Fry released	Mark type or CWT	% Egg to release survival by broodstock
1980	Slim Cr.	Slim Cr.	Imprinted 24 hours	July 10/81	1.9	12,240	Unmarked[b]	89.1
		Slim Cr.		July 11-18/81	1.9	44,053	02-19-52	
		Slim Cr.		July 11-18/81	1.9	1,185	Adipose only	
						57,478		
1981	Slim Cr.	Slim Cr.	Imprinted one week	July 29/82	1.6	26,533	02-23-18	73.9
		Slim Cr.		July 29/82	1.6	680	Adipose only	
		Slim Cr.		July 29/82	0.5	8,504	Unmarked (small)	
						35,717		
		Slim Cr.	Straight release	July 29/82	1.7	26,287	02-23-17	
		Slim Cr.		July 29/82	1.7	1,530	Adipose only	
		Slim Cr.		July 29/82	0.5	3,524	Unmarked (small)	
						31,341		
1981	Bowron R.	Bowron R.	Imprinted one week	July 23/82	1.3	34,017	02-23-19	78.9
		Bowron R.		July 23/82	1.3	1,234	Adipose only	
		Bowron R.		July 23/82	0.7	5,302	Unmarked (small)	
						40,553		
		Bowron R.	Straight release	July 23/82	1.4	31,851	02-23-20	
		Bowron R.		July 23/82	1.4	485	Adipose only	
		Bowron R.		July 23/82	0.7	11,546	Unmarked (small)	
						43,882		
1982	James Cr.	James Cr.		May 17/83	0.6	44,120	Unmarked[c]	90.0
		James Cr.	Straight release	June 19/83	1.1	22,351	Unmarked[c]	
		James Cr.		July 4/83	1.9	72,354	02-25-58	
		James Cr.		July 4/83	1.9	8,490	Adipose only	
		James Cr.		July 4/83	-	30,811	Unmarked (small)	
						178,126		

[a] See Methods - Fry Marking and Release section for details on release sites.
[b] The 12,240 fry were released on the first day of tagging unmarked to lessen stress from reduced water flow in the rearing troughs, as a result of a break in the main water supply pipeline.
[c] Unmarked releases to reduce rearing densities.

releases (1980-1982 broods) in Table 10. Only the 1980 and 1981 broods had complete tag recovery data. Complete results for the 1982 brood will not be available until the 1987/88 return year.

Very few tags were recovered for the 1980 and 1981 broods, indicating poor fry to adult survival (0-0.10%, Table 10). Little comparable information on the marine survival of upper Fraser River hatchery chinook is available at this time. However, the current SEP bio-standards (1985 revision) give an estimated survival rate of 0.75% for the upper Fraser River hatchery chinook. Due to the low tag returns in the present study, no conclusions could be drawn regarding harvest rates or catch contribution to the various fisheries. Also, the results of the 1981 brood imprinting experiment remain inconclusive.

The low mark recovery in the fisheries of the Penny Pilot Hatchery chinook (Table 10) was expected since the upper Fraser River chinook are considered an early run stock that enters the Fraser River from May to mid-July. The fish therefore avoid much of the troll and net fishing effort that occurs later in the season (N. Schubert, pers. comm.). The high "no pin" rate of 50% observed in the 1985 Slim Creek dead recovery (Appendix 10) cannot be readily explained. No unusual tag losses were observed at release (2.5% for the 02-23-18 CWT group and 5.5% for the 02-23-17 CWT group), and entire heads were apparently removed from carcasses for CWT analysis.

PHYSICAL SAMPLING

In 1981 the mean monthly water temperatures at the Penny Pilot Hatchery ranged from a low of 0.2°C in February to a high of 12.2°C in August (Table 2). Water temperatures varied somewhat from year to year as indicated by the temperature records during rearing. Figure 8 and Appendix 8 show that the 1981 brood fry experienced particularly cold water temperatures until the beginning of June (1-5°C) compared to the other two broods.

Results of the water quality analysis for nutrient and heavy metal content, carried out on Rankin Creek in 1980 (Appendix 13), indicated that most parameters were within the recommended fish culture limits (Sigma MS 1983). The high colour levels were due to the presence of tanunic acid. The relatively high aluminum levels (up to 0.16 mg/l compared to the recommended level of <0.1 mg/l, Sigma MS 1983) appeared to be non-toxic. Given the complex behaviour of aluminum in an aqueous solution (Freeman and Everhart 1981) it is assumed that the combined effect in hatchery water of a high pH of 8 and water hardness of 159-171 mg/l as $CaCo_3$ (Appendix 13), reduced the aluminum toxicity to non-lethal levels.

Water quality analysis of the hatchery effluent in 1982 (Appendix 14) indicated an increase in phosphorus levels. This increase was expected to have little, if any, effect on the water quality in Rankin Creek.

SUMMARY

The Penny chinook pilot hatchery is located 105 km east of Prince George, on Rankin Creek at Penny, B.C. The pilot facility started operation in 1980 and was expanded in 1981 to accommodate 200,000, 1.0-2.0 g fry. The purpose of the operation was to evaluate enhancement strategies for the upper Fraser River

Table 10. Chinook mark recovery for the Penny Pilot Hatchery production, 1980-1982 broods.[a]

Brood year	System	CWT	Release date	Release size (g)	Total released	Valid Ad+CWT	Recovery age	Estimated Recoveries[b]: B.C. Commercial and sport catch	Alaska catch	Escapement (Actual)	Escapement Est.	Total re-covered	% Release to adult survial[c]
1980	Slim Cr.	02-19-52	July 11-18/81	1.9	57,478	44,053	3	0	0	N/A[d]	N/A	0	
							4	0	0	(0)	0	0	
							5	0	0	(0)	0	0	
							Total	0	0	-	0	0	0
1981	Slim Cr. (Imprinted)	02-23-18	July 29/82	1.6	35,717	26,533	3	0	0	(0)	0	0	
							4	3[e]	0	(7)	12	15	
							5	4[f]	0	(4)	8	12	
							Total	7	0	-	20	27	0.10
1981	Slim Cr. (Not Imprinted)	02-23-17	July 29/82	1.7	31,341	26,287	3	0	2[g]	(0)	0	2	
							4	0	0	(4)	7	7	
							5	0	0	(9)	18	18	
							Total	0	2	-	25	27	0.10
1981	Bowron R. (Imprinted)	02-23-19	July 23/82	1.3	40,553	34,017	3	2	0	(0)	0	2	
							4	0	0	(1)	10	10	
							5	0	0	(2)	4	4	
							Total	2	0	-	14	16	0.05
1981	Bowron R. (Not Imprinted)	02-23-20	July 23/82	1.4	43,882	31,851	2	1	0	N/A	N/A	1	
							3	0	0	(0)	0	0	
							4	0	0	(0)	0	0	
							5	0	0	(3)	6	6	
							Total	1	0	-	6	7	0.02
1982	James Cr.	02-25-58	July 4/83	1.9	178,126	72,354	3	0	0	Stream recovery		0	
							4	0	0	not conducted in		0	
							5	N/A[h]		James Creek			
							Incomplete Recovery						N/A

[a]Tag recovery data available only up to the 1986 return year. Tag recoveries in catches from K. Pitre (pers. comm.); spawning ground recoveries for Slim Creek from L. Greba (pers. comm) and for Bowron River from L. Kalnin (pers. Comm.).

[b]Estimated tags in catches = actual tags in sample corrected for recovery rate; estimated tags in escapement = actual tags in sample corrected for recovery rate (see mark expansion factor in Appendix 9).

[c]No. estimated tags recovered ÷ No. valid tags released.

[d]Not available.

[e]From Southwest troll fishery.

[f]From Northwest troll fishery.

[g]From groundfish troll fishery in Gulf of Alaska.

[h]Data not available until 1977/78 return year.

chinook stocks, and provide tagged releases for testing an imprinting strategy and determining adult contribution to various fisheries.

Chinook brood stocks were obtained from Slim Creek in 1980, Slim Creek and Bowron River in 1981 and James Creek in 1982. Majority of chinook spawners from all streams were age 4_2 and 5_2 (96-100% of each year's sample), with sub-2 adults comprising 96-100% of each year's sample. James Creek adults were somewhat larger than the Slim Creek and Bowron River adults. Mean fecundity for the 1980-1982 chinook brood stocks was 6,458 eggs/female.

During 1980 to 1982, between 64,500 and 197,960 eggs were planted each year, resulting in annual releases of 57,478 to 178,126 fry. Egg to release survivals by brood year and stock ranged from 74% to 90%.

Fry were ponded from incubation boxes and Heath trays during April and May when the water temperatures measured 1-5°C. Earlier ponding time and the addition of euphausids to fish diet to stimulate the initial feeding response in cold water, resulted in better growth of the 1982 brood fry compared to other broods.

Tagged fry were released in their natal streams in July. The late release timing was due to initial slow fry growth in the cold hatchery water. Fry release sizes averaged 1.3-1.9 g for tagged groups and 0.5 - 1.9 g for untagged groups.

An imprinting experiment was conducted using the 1981 brood fry to determine whether holding fry at the release site for one week improved the homing to their natal stream.

Tag recoveries were very few for the 1980 and 1981 brood releases (1982 brood recoveries were incomplete) indicating 0-0.10% fry to adult survival. The imprinting experiment and fishery contribution could not be assessed from the few tag returns.

The Penny Pilot Hatchery operation resulted in successful rearing of chinook fry in relatively cold water, with an egg to release survival of 74-90%. However, the apparently very low release to adult survival indicates that the production strategy should be reassessed and possibly modified to increase the post-release survival.

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Appendix 1. Fecundity, postorbital - hypural (POHL) length and age of chinook females from Slim Creek 1980, and James Creek 1982.[a]

Female No.	No. eggs/ female	POHL (mm)	Age (years)
SLIM CREEK 1980			
1	675	5,953	5_2
2	705	9,065	5_2
3	705	8,526	5_2
4	710	6,907	5_2
5	675	4,317	5_2
6	695	5,612	5_2
7	740	6,031	R[b]
8	670	6,044	5_2
Mean	697	6,557	-
JAMES CREEK 1982			
1	699	5,615	5_2
2	744	6,288	5_2
3	808	7,860	R
4	795	8,085	5_2
5	749	6,962	5_2
6	782	7,636	R
7	724	6,738	5_2
8	737	6,064	5_2
Mean	755	6,906	-

[a]Similar data were not available for the 1981 brood Slim Creek and Bowron River chinook.

[b]Scale resorbed.

Appendix 2. Daily fry migration and mean daily water temperatures for 1980 brood Slim Creek box fry.

Date 1981	Fry migration	Cumulative fry migration	Temperature (°C)
April 25	7,150	7,150	2.0
26	883	8,033	2.5
27	692	8,725	3.0
28	790	9,515	3.1
29	780	10,295	3.0
30	595	10,890	4.0
May 1	1,890	12,780	3.3
2	2,759	15,539	3.6
3	3,003	18,542	3.1
4	3,826	22,368	3.1
5	5,429	27,797	4.0
6	6,986	34,783	4.3
7	4,286	39,069	4.9
8	7,003	46,072	4.8
9	5,011	51,083	4.9
10	3,020	54,103	5.6
11	1,847	55,950	4.6
12	1,535	57,485	4.8
13	2,201	59,686	5.5
14	2,097	61,783	5.7
15	1,319	63,102	6.3
16	589	63,691	6.1
17	148	63,839	6.6
18	26	63,865	6.8
19	27	63,892	7.0
20	6	63,898	7.3
21	0	63,898	7.3
22	11	63,909	8.0
23	7	63,916	8.0
24	2	63,918	8.0
25	2	63,920	8.3
26	2	63,922	8.3
27	3	63,925	6.8
28	1	63,926	6.4
29	3	63,929	7.3
30	4	63,933	8.0
31	1	63,934	7.3
June 1	1	63,935	7.5
2	1	63,936	7.8
3	0	63,936	7.5
4	0	63,936	7.3
5	0	63,936	7.3
6	1	63,937	7.1
7	1	63,938	6.5
8	1	63,939	6.4
9	0	63,939	6.5
10	0	63,939	6.8

Appendix 3. Daily fry migration and mean daily water temperatures for 1982 brood James Creek box 1 fry.

Date 1983		Fry migration	Cumulative fry migration	Temperature (°C)
April	5	1,800	1,800	2.6
	6	6	1,806	3.0
	7	3	1,809	2.3
	8	1,000	2,809	2.0
	9	1,360	4,169	2.0
	11	345	4,514	1.8
	14	433	4,947	2.8
	16	1,224	6,171	3.1
	17	461	6,632	3.8
	18	2,300	8,932	4.6
	19	2,384	11,316	4.3
	20	7,910	19,226	4.4
	21	6,539	25,765	4.6
	22	5,319	31,084	4.5
	24	6,185	37,269	5.0
	25	2,981	40,250	5.2
	26	2,362	42,612	4.0
	27	2,226	44,838	4.4
	28	1,077	45,915	5.0
	29	744	46,659	5.6
	30	262	46,921	5.3
May	1	226	47,147	4.8
	2	94	47,241	5.4
	3	83	47,324	5.5
	4	75	47,399	6.0
	5	55	47,454	6.5
	6	15	47,469	6.3
	7	23	47,492	6.2
	8	43	47,535	6.0
	9	0	47,535	5.3
	10	8	47,543	5.4
	11	31	47,574	5.6
	12	2	47,576	6.0
	13	6	47,582	6.8

Appendix 4. Daily fry migration and mean daily water temperatures for 1982 brood James Creek box 2 fry.

Date 1983	Fry migration	Cumulative fry migration	Temperature (°C)
April 13	1,081	1,081	2.3
16	1,982	3,063	3.1
17	720	3,783	3.8
18	362	4,145	4.6
19	1,076	5,221	4.3
20	5,018	10,239	4.4
21	7,614	17,853	4.6
22	9,976	27,829	4.5
23	2,246	30,075	4.6
24	5,200	35,275	5.0
25	2,750	38,025	5.2
26	1,795	39,820	4.0
27	1,094	40,914	4.4
28	496	41,410	5.0
29	505	41,915	5.6
30	564	42,479	5.3
May 1	436	42,915	4.8
2	328	43,243	5.4
3	281	43,524	5.5
4	340	43,864	6.0
5	310	44,174	6.5
6	345	44,519	6.3
7	376	44,895	6.2
8	5,666	50,561	6.0
9	1,877	52,438	5.3
10	569	53,007	5.4
11	128	53,135	5.6
12	71	53,206	6.0
13	38	53,244	6.8
14	33	53,277	6.8
16	18	53,295	6.6
18	1	53,296	7.2
19	2	53,298	6.7

Appendix 5. Mean fry weights and mean daily water temperatures for 1980 brood Slim Creek fry.

Date		Mean fry weight (g)	Mean daily temperature (°C)
1981		SLIM CREEK BOX FRY	
Apr	26	0.40	2.5
May	1	0.41	3.3
	12	0.43	4.8
	15[a]	0.44[a]	6.3
	19	0.45	7.0
	26	0.55	8.3
	29	0.59	7.3
June	2	0.66	7.8
	5	0.73	7.3
	9	0.78	6.5
	12	0.85	7.3
	16	0.93	7.3
	19	1.02	7.0
	23	1.10	7.5
	26	1.23	8.9
	30	1.38	9.1
July	3	1.41	10.0
	7	1.66	8.5
	10	1.89	8.0

[a] Fry ponding completed by May 15, 1981.

Appendix 6. Mean fry weights and mean daily water temperatures for 1981 brood Slim Creek and Bowron River fry.

Date		Mean fry weight (g)	Mean daily temperature (°C)
1982		SLIM CREEK HEATH TRAY FRY	
Feb	19[a]	0.36[a]	1.3
Apr	30	0.47	1.4
May	14	0.44	3.5
	16	0.41	3.6
	22[b]	0.38[b]	3.7
	29	0.40	4.7
June	5	0.43	6.5
	12	0.51	8.4
	19	0.53	9.9
	26	0.83	10.7
July	7	0.88	10.1
1982		BOWRON RIVER HEATH TRAY FRY	
May	7	0.40	1.5
	14	0.42	3.5
June	12[c]	0.49[c]	8.4
	19	0.58	9.9
	26	0.84	10.7
July	7	1.20	10.1

[a]Approximately 3,400 fry were ponded on February 19, 1981. These fry increased from 0.36 g at ponding to 0.47g by April 30, 1982; daily water temperatures during that period measured 1.0 - 1.4°C.
[b]Fry ponding completed by May 19, 1982.
[c]Fry ponding completed by May 24, 1982.

Appendix 7. Mean fry weights and mean daily water temperatures for 1982 brood James Creek fry.

Date		Mean fry weight (g)	Mean daily temperature (°C)
1983		JAMES CREEK BOX FRY	
April	5	0.42	2.6
	12	0.41	2.3
	19	0.39	4.3
	26	0.40	4.0
	28	0.40	5.0
May	5	0.41	6.5
	12[a]	0.54[a]	6.0
	19	0.63	6.7
	21	0.63	6.9
	26	0.78	8.7
June	2	1.05	11.7
	8	1.17	8.9
	13	1.17	8.5
	16	1.72	9.7
	22	1.70	8.5
1983		JAMES CREEK HEATH TRAY FRY	
April	14[b]	0.42[b]	2.8
	21	0.42	4.6
	28	0.43	5.0
May	5	0.49	6.5
	7	0.49	6.2
	12	0.60	6.0
	19	0.68	6.7
	26	0.84	8.7
	30	0.84	11.1
June	2	1.10	11.7
	9	1.40	9.0
	15	1.60	9.4
	22	1.90	8.5
	29	2.00	9.4

[a] Fry ponding completed by May 10, 1983.
[b] Fry ponding completed by April 14, 1983.

Appendix 8. Water temperatures (5-day means) during fry rearing at the Penny Pilot Hatchery, April-July, 1980-1982 broods.

Date		Temperature (°C)		
		1980 Brood	1981 Brood	1982 Brood
		1981	1982	1983
April	1-5	1.7	0.8	2.4
	6-10	1.3	0.8	2.3
	11-15	1.3	0.9	2.5
	16-20	2.1	1.0	4.0
	21-25	2.4	0.9	4.8
	26-30	3.1	1.1	4.9
May	1-5	3.4	1.4	5.6
	6-10	4.9	1.7	5.8
	11-15	5.4	3.1	6.5
	16-20	6.8	3.4	6.9
	21-25	7.9	3.4	7.4
	26-31	7.3	4.5	9.8
June	1-5	7.5	6.6	10.4
	6-10	6.7	6.2	8.8
	11-15	7.4	8.6	8.8
	16-20	6.9	9.4	9.0
	21-25	7.6	10.4	8.6
	26-30	8.6	10.5	9.0
July	1-5	9.2	10.5	9.2
	6-10	8.5	9.9	-
	11-15	10.0	10.6	-
	16-20	-	-	-
	21-25	-	9.2	-
	26-31	-	10.2	-

Appendix 9. Chinook stream recoveries and estimated escapements for Slim Creek (1980 and 1981 broods) and Bowron River (1981 brood).[a]

Year	Recovery date	Total dead pitch	Actual Ad marks observed	Estimated escapement	Mark expansion factor[b]
			SLIM CREEK[c]		
1983	Not Done			2,000[d]	-
1984	Sep	882	0	1,800[d]	2.0
1985	Aug27-Sep 19	2,920	26[e]	5,000[d]	1.7
1986	Aug 25-Sep 19	2,707	32[f]	5,500[g]	2.0
1987	Aug 29-Sep 16	1,762	0	3,750[g]	2.1
			BOWRON RIVER[h]		
1984	-	329[i]	0	4,510[j]	13.7
1985	-	732[k]	6[l]	7,002[d]	9.6
1986	Jul 2-Sep 24	4,786[k]	27[m]	9,315[n]	1.9

[a]Stream recovery not conducted in James Creek.
[b]Mark expansion factor=Estimated escapement÷Total dead pitched.
[c]Slim Creek dead pitch and mark recovery data from L. Greba (DFO, pers. comm).
[d]From Farwell et. al. (1987).
[e]See Appendix 10 for details.
[f]But only 28 heads received at Head Recovery Laboratory; see Appendix 11 for details.
[g]From R. Elson (Fishery Officer, pers. comm.).
[h]Bowron River system dead pitch and mark recovery data for 1984-1986 from L. Kalnin (DFO, pers. comm.)
[i]Bowron River only; Indianpoint Creek not dead pitched.
[j]Bowron River only (L. Kalnin, pers. comm.).
[k]Fence count and dead pitch programs.
[l]Four Ad clips from Bowron mainstem (02-23-19, 02-24-11* and two no pin heads), two Ad clips from Indianpoint Creek but only one head collected (02-24-12*).
*indicates fish are Bowron stock satellited out of Quesnel River Hatchery.
[m]See Appendix 12 for details; 24 CWT's recovered.
[n]Bowron River and Indianpoint Creek (L. Kalnin, pers. comm.).

Appendix 13 (cont'd)

Parameter	Values (mg/l) Recommended	Toxic	Just above hatchery May 7	July 23		Just below hatchery July 23	Aug 19	
Filterable	70-400		170	185		250	-	
Non-filterable	<3 incub. <25 rear.		<5	-		<5	-	
Salinity $^0/_{00}$			-	-		-	-	
Salica (SiO_2)	<10-60		2	2.5		2.5	-	
Sulfate (SO_4)	<90		7	-		8	-	
Taste/Odour	odour free OK taste		OK	-		OK	-	
TDS-minerals	500-1000	15000	-	-		-	-	
Turbidity	1-60 JTU	1000	<1.0	2.3		1.5	-	
Al-aluminum	<.1	5	<.09	.16		.14		
As-arsenic	<.5	1	<.15	-		<.15		
Ba-barium	domestic water (<1)		0.1	-		0.1		
Ca-calcium	4-150	300	39	42		42		
Cd-cadmium	<.0004(soft) <.003 (hard)		<.001	<.001		<.001		
Co-cobalt			<.015	-		<.015		
Cr-chromium	<.05 trival. <.01 hexavl.		<.015	-		<.015		
Cu-copper	<.006 (soft) <.03 (hard)		<.001	<.001		<.001		

Appendix 13 (cont'd)

Parameter	Values (mg/l) Recommended	Toxic	Just above hatchery May 7	July 23		Just below hatchery July 23		
Fe-iron	<.3		.036	.152		.113		
Hg-mercury	<.00005	>.0002	<.0002	<.0002		<.0002		
K-potassium		50	0.3	0.2		0.2		
Magnesium	<10	>100	15	16		16		
Manganese	<.05	>15	.004	.010		.005		
Mo-molybdenum			<.15	->		<.15		
Na-sodium		20 NaOH 500 Na+	0.4	0.5		0.4		
Ni-nickel	<.01 of 96hr LC50		<.08	->		<.08		
P-phosphorus	<.0001 for saltwater		<.3	->		<.3		
Pb-lead	<.01		<.001	<.001		<.001		
Sb-antimony			<.08	->		<.08		
Se-selenium	<.001 of 96hr LC50	>2.5	<.15	->		<.15		
Si-silicon	<10-60		2	3		3		
Sn-tin			<.2	->		<.2		
Sr-strontium			.0982	.111		.112		
Ti-titanium			<.009	->		<.009		
V-vanadium			<.05	->		<.05		
Zn-zinc	<.005(soft) <2 (hard)		.0022	<.001		.0019		

[a] Malfunction of pH meter suspected.

Appendix 14. Water quality analysis for Rankin Creek and Penny Pilot Hatchery effluent, June 17, 1982.

Parameter	Hatchery effluent	Rankin Creek upstream[a]	Rankin Creek downstream[b]
pH	8.2	8.3	8.3
Total suspended solids (mg/L)	2.0	10.0	6.0
Nitrogen (mg/L)	0.04	0.047	0.035
Phosphorous (mg/L)	0.029	0.006	0.007
Nitrogen: Phosphorous	1:4.1	8:1	5:1
Chlorophyll (mg/L)	2.4	2.6	2.5

[a]Immediately upstream of the hatchery outflow into Rankin creek.

[b]Downstream of hatchery outflow.