Overwintering Chinook Salmon in the Upper Fraser River System.

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ABSTRACT

Scales were collected from spawned chinook salmon from rivers tributary to the Upper Fraser; in 1974 from the Nechako and in 1977 from the McGregor. Chinook spawning populations in these and other Upper Fraser River tributaries were considered to be returns of non-wintering "ocean-type" fish which smolt in their first year and then migrated to sea. Scale interpretations from these escapements indicate a major portion were from overwintering "stream-type" subpopulations that smolted in their second spring. Yearling chinook smolts were trapped from these rivers in May, 1977, and from the Upper Fraser River in May, 1962. Based on size, these smolts were determined to have overwintered; normally, scales from streamtype chinook would be expected to form a freshwater annulus. However, significant numbers of smolts from the colder glacial McGregor and Upper Fraser Rivers bore scales having no freshwater annulus, while the specimens from the warmer lake-fed Nechako River formed distinct freshwater annuli. If a freshwater annulus either does not form in fresh water or becomes masked by subsequent rapid estuarine growth, then previous methods employed in scale analysis could have misinterpreted the freshwater residency period and, ultimately, adult age of stream-type chinook. This situation could result in underappraisal of overwintering chinook production. An investigation on the streamtype contribution to the Fraser River chinook production is recommended before any regretable fisheries management decisions occur from the enactment of impending major hydro development schemes. Furthermore, it is critical for the evaluation of proposed Salmonid Enhancement projects in the Upper Fraser System.

Key words: chinook, overwintering, scale annulus, age, hydro-development, enhancement.

RÉSUMÉ

En 1974, dans le Nechako et en 1977 dans le McGregor, deux tributaires du haut Fraser, nous avons prélevé des écailles sur des saumons quinnat ayant frayé. Les populations de reproducteurs dans ces tributaires et autres du haut Fraser étaient considérées comme des saumons de remonte de type "océanique" non hivernant dont la smoltification a lieu à un an avant la migration vers la mer. D'après leurs écailles, ces reproducteurs viendraient en grande partie de sous-populations hivernantes de type "fluviatile" ayant smoltifié à leur deuxième printemps. Les saumoneaux quinnat d'un an, ont été capturés dans ces rivières en mai 1977 et dans le haut Fraser en mai 1962. D'après leur grosseur, ils avaient hiverné dans la région; normalement, les écailles des quinnats fluviatiles devraient comporter un annulus caractéristique du séjour en eau douce. Toutefois, une fraction significative des saumoneaux de la McGregor et des tributaires du haut Fraser, rivières d'origine glaciaire aux eaux plus froides, avaient des écailles sans annulus du genre, tandis que les sujets de la Nechako, plus chaude et alimentée par un lac, en portaient de bien distincts. Si les annulus caractéristiques des séjours en eau douce ne se forment pas dans cette dernière ou sont masqués par une croissance rapide ultérieure due à un séjour dans un estuaire, alors, il se peut que l'interprétation du séjour en eau douce à l'aide des méthodes antérieures ait été faussée et qu'en fin de compte on ait mal déterminé l'âge des quinnats adultes du type fluviatile. Cette situation pourrait amener une sous-estimation de la production des quinnats hivernants. L'étude de la contribution fluviatile à la production des quinnats du Fraser est recommandée avant la prise de décisions regrettable de gestion des pêches à la suite de l'adoption de schémas importants de développement hydroélectrique dont la réalisation est imminente. De plus, cette étude est essentielle pour l'évaluation des projets de mise en valeur du saumon dans le bassin supérieur du Fraser.

Mots-clés: quinnat, hivernation, annulus, âge, développement, hydroélectrique, mise en valeur des stocks

INTRODUCTION

The purpose of this report is to present scale data which indicates a high occurrence of "stream-type" chinook in the escapements to the Nechako River in 1974, and to the McGregor River in 1977. Particular attention is focused on identification of non-annulus-forming smolts captured from the McGregor and Upper Fraser Rivers.

Salmonid management and the protection of their freshwater habitat is based on life history data. Salmonid species identification, age, growth analysis, stock identification and freshwater residency periods may be determined from characteristics of Pacific salmon scales.

Scales of chinook salmon, *Oncorhynchus tshawytscha* (Walbaum, 1792) and other species of *Oncorhynchus,* are calcified structures lying in pockets arranged in diagonal rows in the skin. Osteoblasts in these pockets are responsible for scale growth, and growth of the scale roughly parallels linear growth of the fish (Clutter and Whitesel, 1956; Bilton and Robins, 1971). Scale surfaces become marked by concentric series of ridges called circuli. Freshwater growth is represented by fine, compact ridges (Neave, 1936) and is distinctly different from the more widely-spaced coarse circuli of marine growth patterns (McMurrich, 1912; Mosher, 1972). The close association of fish metabolism with food and temperature has been thought to reflect most directly in scale sculpturing (Simkiss, 1973; Bilton, 1973). Therefore, relatively slow winter growth, in association with low temperatures, has traditionally been interpreted as crowded bands of circuli laid down during the period, producing what is referred to as annulus (Clutter and Whitesel, 1956; Bilton and Ludwig, 1966). Later, during the spring and summer, the distance between circuli increases as rapid growth is renewed.

Early migrating predominantly red fleshed chinook salmon can travel as much as 1,000 km upstream to their spawning grounds in the Upper Fraser River. The complicated behavior of chinook salmon, combined with the diversity of races existing within the Fraser system, has resulted in difficult assessment of freshwater residency and adult age for many races. In the Upper Fraser system, total age is also difficult to determine from scales, due to substantial, marginal scale erosion. This phenomenon is a result of calcium stress during the spawning migration, and can be reflected by calcium resorption of the scale margins below the skin surface (Crichton, 1935; Garrod and Newell, 1958; Simkiss, 1973).

Freshwater residency is indistinct when the freshwater circuli approach the width and spacing of initial ocean circuli. These factors, and limited knowledge of stocks in the Upper Fraser Region, have confused understanding of chinook freshwater life histories in this area.

This report reviews recent chinook scale data from the Nechako and McGregor Rivers which are tributaries of the Upper Fraser River (Figures 1 to 3). Methods of adult scale interpretation are examined with a view that an under-estimation of the portion of overwintering chinook could occur.

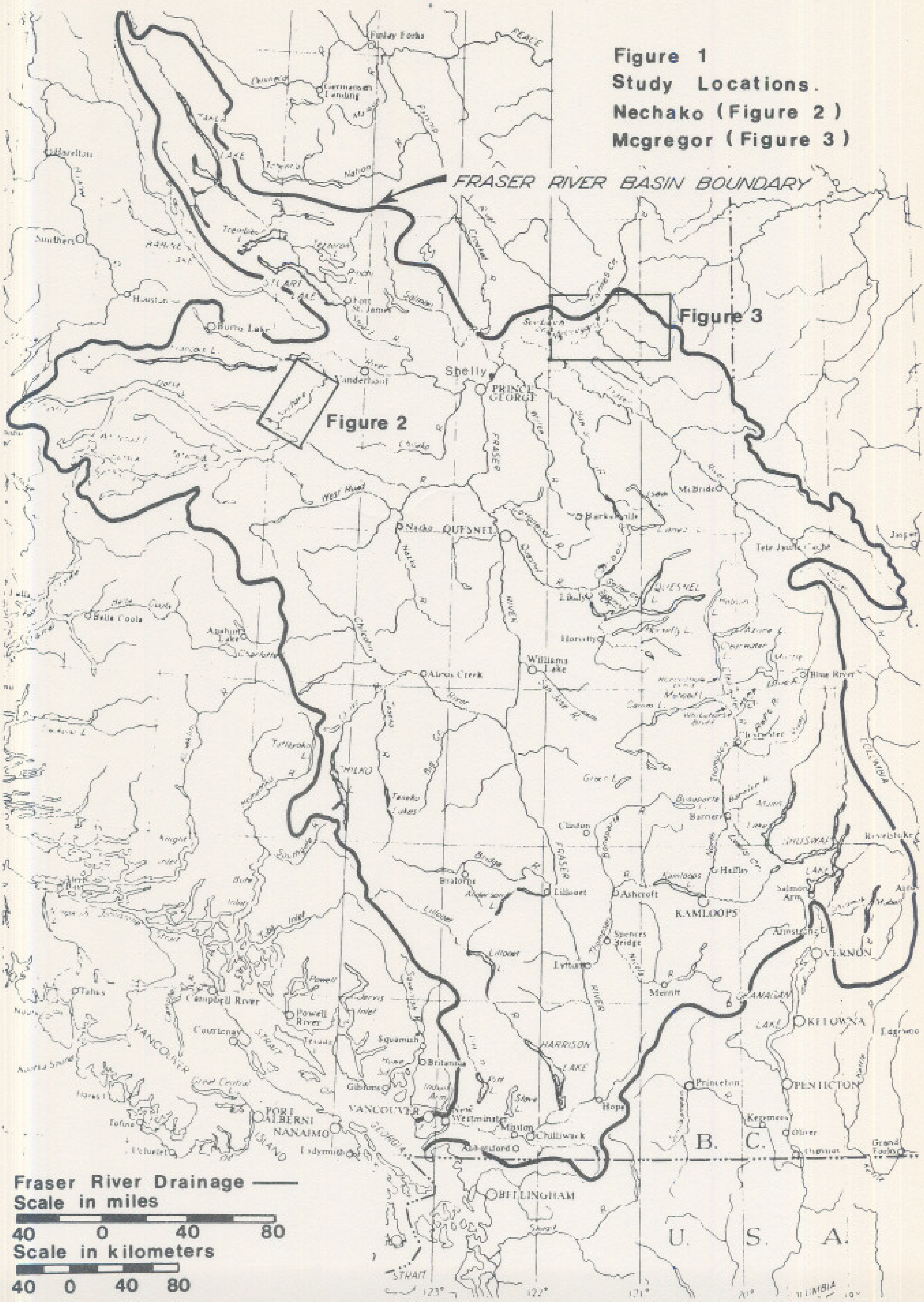

Figure 1
Study Locations.
Nechako (Figure 2)
Mcgregor (Figure 3)

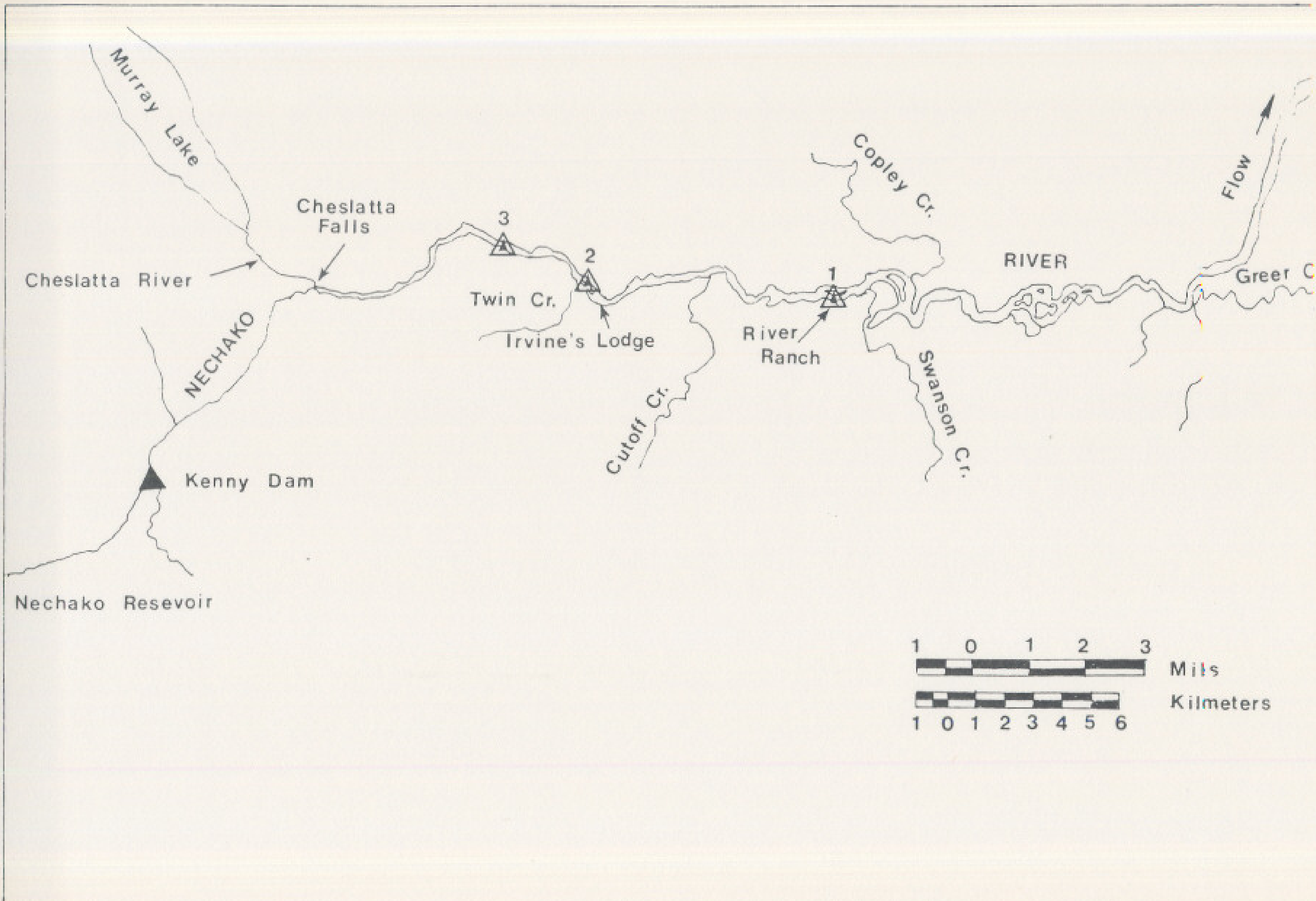

Figure 2. Upper Nechako River - Trapping Locations. △ No.1,2,3- Modified Fyke Net Traps

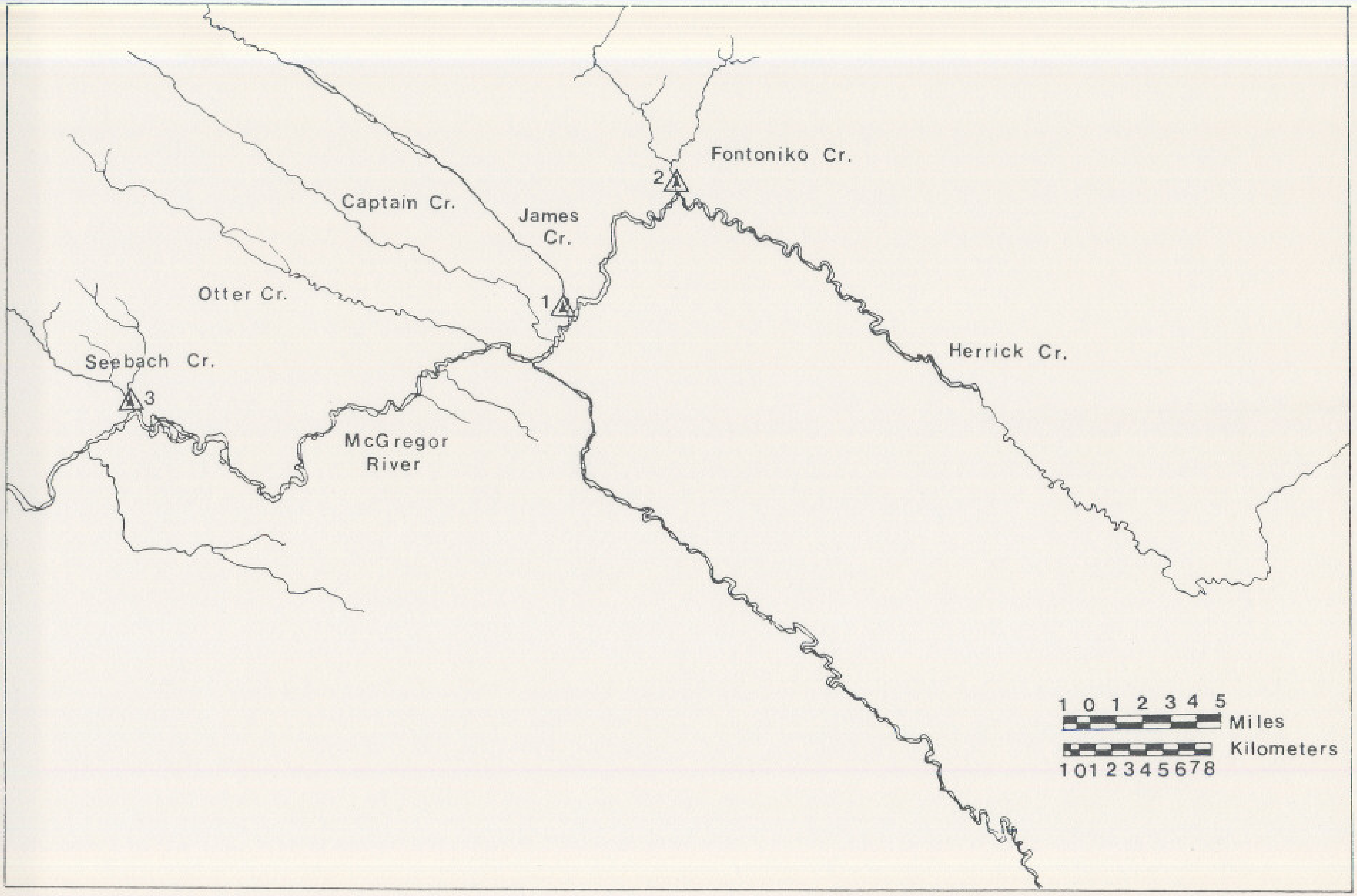

Figure 3. McGregor River – Trapping Locations. ▲ No. 1, 2, 3 – Modified Fyke Net Traps

2.0 MATERIALS AND METHODS

Scales were obtained from spent chinook spawners and carcasses during 1974 and 1977 from spawning areas in the Nechako and McGregor Rivers, respectively, as a result of investigations of the Kemano II and McGregor Diversion hydro development proposals. Additional scale samples from spawning fish were collected for bio-feasibility assessments of salmonid enhancement projects during 1975 and 1976, which supplement our data, (Fisheries and Environment Scale Bank, Vancouver, B.C.).

Smolting juvenile chinook were captured in May, 1977, from the Nechako and McGregor Rivers. Modified fyke net traps were employed, and their locations in the Nechako and McGregor Rivers are indicated in Figures 2 and 3. The trapping technique used to capture and hold these migrating chinook juveniles is displayed in Plates 1 - 4. The proportion of the smolt migration sampled in all systems cannot be calculated due to the small sample size and minor trapping effort extended.

Two independent readers analysed the 1974 Nechako R. chinook scales to establish a degree of confidence in similarity. Methodologies for salmon scale study have been set forth by Koo (1962) and Clutter and Whitesel (1956). The plastic impression procedure, as described by Bilton et al. (1964), was employed on projection equipment (described by Ryan and Christie, 1975).

3.0 RESULTS

Summaries of fyke net catch and effort for trapping operations conducted in the Nechako and McGregor Rivers during 1977 are contained in Table 1.

Plate 1: Modified fyke net installation, Seebach Creek, May 22, 1977.

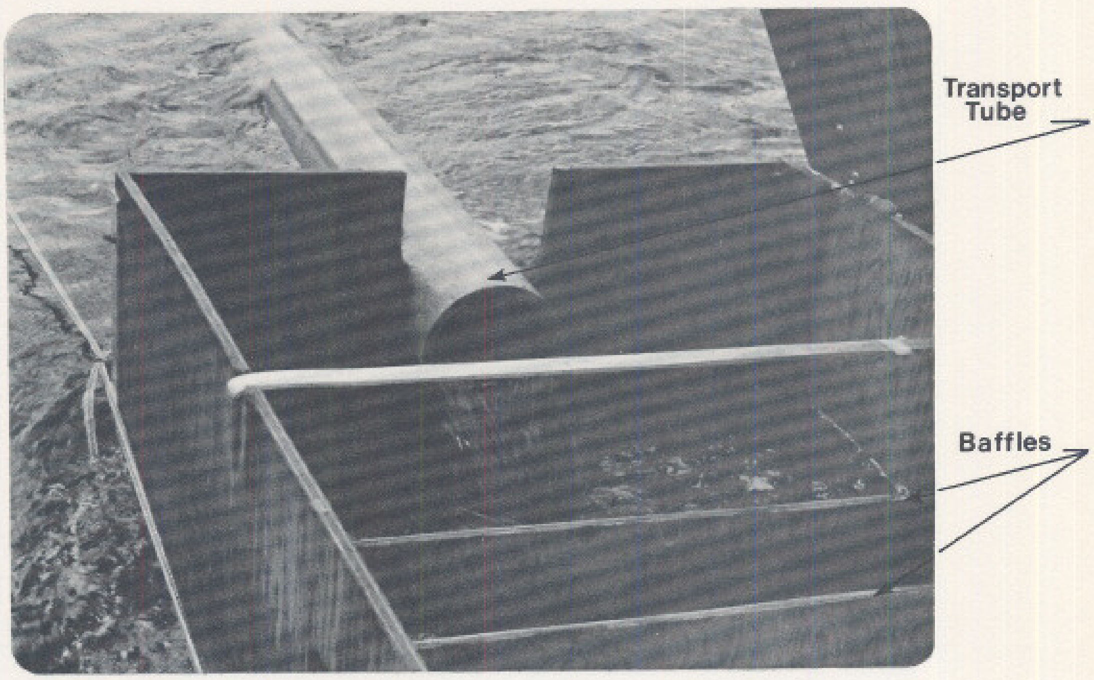

Plate 2: Interior of live box showing fyke net tube inflows.

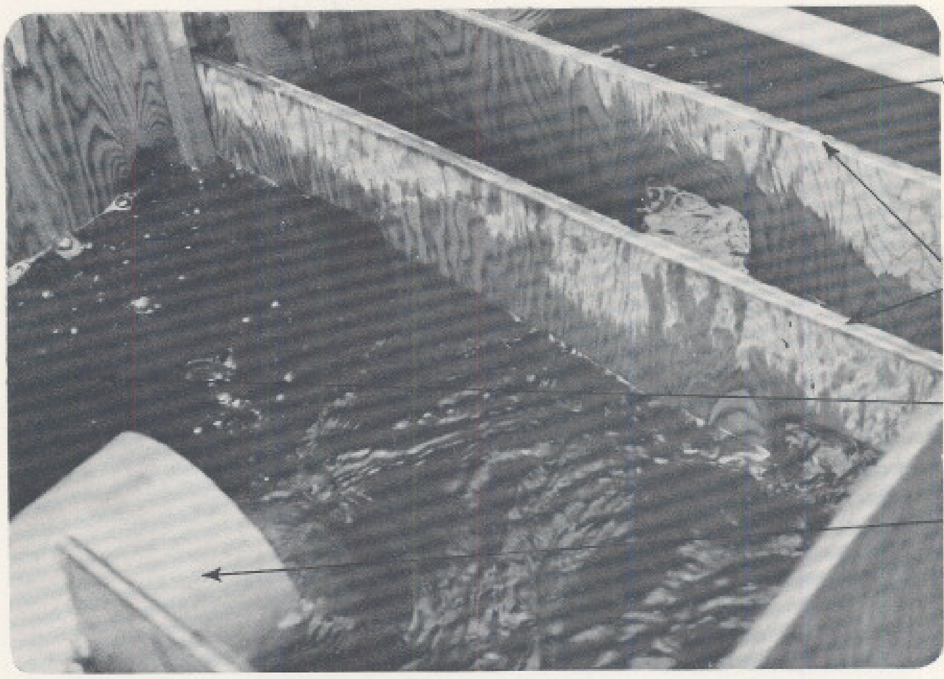

Plate 3: Interior of live box illustrating the staggered baffle arrangement which reduces turbulence and provides a sheltered holding region.

Plate 4: Twenty-two hour catch on Seebach Creek, May 22, 1977, 56 *Oncorhynchus tshawytscha,* 3 *Salmo gairdneri,* 2 *Salvelinus malma,* 2 Catostomidae.

Table 1: Fyke net capture and effort summary for trapping operations in the Nechako and McGregor Rivers during 1977.

		Chinook	
		Fry-of-the-Year 0. (0+)	Smolts 1. (1+)
Nechako River	Period Fished	Mean Fork-Length 34.2 mm; S.D.=12.99; Sample size=30	Mean Fork-Length 102 mm; S.D.=8.46; Sample Size = 8
Fyke Net # 1 (Figure 2)	May 12, 1977	21	11
	May 13, 1977	62	5
	June 9, 1977	31	0
	June 10, 1977	13	0
Fyke Net # 2 (Figure 2)	May 13, 1977	18	0
	May 14, 1977	20	0
Fyke Net # 3 (Figure 2)	June 9, 1977	31	0
	June 10, 1977	38	0
McGregor River			
James Creek		**Mean Fork-Length 40.0mm; S.D. = 4.66; Sample Size=23**	**Mean Fork-Length 83.4 mm; S.D. = 10.7; Sample Size = 23**
Fyke Net # 1 (Figure 3)	May 7, 1977	0	8
	May 8, 1977	0	2
	May 9, 1977	0	3
	May 10, 1977	0	1
	May 13, 1977	3	3
	May 14, 1977	1	0
	May 21, 1977	0	4
	May 23, 1977	0	2
	June 16, 1977	3	0
	June 17, 1977	18	0
	June 18, 1977	21	0
	June 19, 1977	12	0
	June 20, 1977	13	0
	August 30, 1977		
Fontoniko Cr.			
Fyke Net # 2 (Figure 3)	May 20, 1977	0	1
	May 21, 1977	0	2
Seebach Cr. (fished 22 hours only)			**Mean Fork-Length 82.5mm; S.D.=7.68; Sample Size=56**
Fyke Net # 3 (Figure 3)	May 23, 1977	0	56

3.1 Nechako River

Scale age interpretations for adult chinook obtained from the Nechako River spawning grounds, between 1974 and 1977, are summarized in Table 2.

Nuclear-region scale circuli patterns on these scales indicate 92 percent contained a freshwater annulus. These winter annuli may have resulted from conditions experienced in either the Nechako or in the Lower Fraser River or its estuary. Fyke net captures of 16 chinook smolts trapped in the Nechako River during May 12 - 14, and on June 9, 1977, demonstrated some chinook juveniles overwinter within the headwater stream. Scales from all these samples contained a distinct freshwater annulus. This indicates they had overwintered which is further supported by their mean fork-length of 102 mm, whereas, fry-of-the-year had a mean fork-length of 34.7 mm.

Scale examination by two independent readers indicated an 88% agreement and does not necessarily assume the accuracy without doubt since no known age fish have as yet been recovered from the Upper Fraser System.

The main differences between the two scale readers occurred in assessment of total age, with resorption probably causing this discrepancy. Six fish (5.2 percent) aged 3_2 by reader A, were aged one year older (4_2) by reader B. Twelve fish (10.4 percent) aged 4_2 by reader A, were aged one year older (5_2) by reader B.

Other differences occurred with assessment of freshwater residency on four fish (3.4 percent).

Table 2: Summary of age composition and freshwater classification of scales from Nechako River chinook escapements.[1]

	AGE COMPOSITION[2]						
YEAR	0.2 (3_1)	1.1 (3_2)	0.3 (4_1)	1.2 (4_2)	0.4 (5_1)	1.3 (5_2)	TOTAL
1974	3	21	3	53		35	115
1975	–	–	–	–	–	–	0
1976	–	–	–	–	–	1	1
1977	2	2	3	5	–	6	18
TOTALS	5	23	6	58	–	42	134
PERCENT	3.7	17.2	4.5	43.3	–	31.3	100

[1]Data contained in Fisheries and Marine Service Kemano II Summary Report (in preparation) and also in the Fisheries and Environment Scale Bank, Vancouver, B.C. Average fork-length and male: female data of adults were not prepared in this report.

[2]In this report, ages are designated according to both the European and Gilbert and Rich (1927) systems. Thus, an 0.1 fish has no freshwater annulus, but has one ocean annulus; it is, therefore, in its second year of life, having gone to sea in its first. A 1.2 fish has one freshwater annulus and two ocean annuli; it is, therefore, in its fourth year of life, having gone to sea in its second. According to the Gilbert and Rich (1927) system, the fish in these two examples would have had ages designated as 2_1 and 4_2, respectively.

Table 3: Comparisons of scale aging by two independent readers for adult Nechako River chinook, sampled in 1974.

Age		0.2 (3_1)	1.1 (3_2)	0.3 (4_1)	1.2 (4_2)	0.4 (5_1)	1.3 (5_2)	Total Number
Reader A								
Card	I a	–	4	–	8	–	3	15
	I b	–	2	–	5	–	3	10
	II a	–	3	–	8	–	2	13
	II b	–	4	–	6	–	–	10
	III a	1	5	1	7	–	4	18
	III b	–	6	–	6	–	3	15
	IV a	–	1	–	10	–	6	17
	IV b	–	3	–	10	–	4	17
		1	28	1	60	0	25	115
Reader B								
Card	I a	–	4	1	6	–	4	15
	I b	–	1	–	5	–	4	10
	II a	–	2	–	8	–	3	13
	II b	–	4	–	6	–	–	10
	III a	2	3	1	6	–	6	18
	III b	–	4	–	8	–	3	15
	IV a	1	1	–	5	–	10	17
	IV b	–	2	1	9	–	5	17
		3	21	3	53	0	35	115

Comparison of reader A, where differences occurred between reader B.

	READERS:					
	A B	A B	A B	A B	A B	A B
Ages	$3_2 \rightarrow 3_1$	$3_2 \rightarrow 4_2$	$4_2 \rightarrow 5_2$	$4_2 \rightarrow 4_1$	$4_2 \rightarrow 3_1$	$5_2 \rightarrow 4_1$
Number of Occurrence	1	6	12	1	1	1
%	1.4%	5.2%	10.4%	1.4%	1.4%	1.4%

3.2 McGregor River

Age interpretations of spawning chinook captured in the McGregor River in 1977 (Table 4) are from a report by Tutty (in preparation). Based on scales, 63 percent (17 out of 27) were classified as stream-type. Fyke net samples of chinook captured between April 30 and June 20, 1977, in the McGregor River drainage, demonstrate that overwintering chinook are also present in this system. An unknown portion of smolts captured from Fontoniko, James and Seebach Creeks did not exhibit a freshwater scale annulus.

3.3.1 Fraser River (1962)

An earlier report by Chatwin et al. (1963) hypothesized that significant populations of stream-type chinook existed in the Upper Fraser River system. Their observations (Table 5) were based on juvenile chinook captures obtained from a single inclined-plane trap operating in the spring of 1962, near Shelley, on the mainstem Fraser River, above the confluence of the Nechako River. Of Chatwin's sample of 74 stream-type smolts, 40.5 percent did not exhibit a distinct scale annulus, although their very large size indicated overwintering (Fisheries and Environment, Scale Bank, Vancouver, B.C.).

3.3.2 **Fraser River (1975 - 76)**

Fraser River spawning ground recoveries of adult chinook during 1975, by Fisheries and Environment, Field Services Branch, indicated approximately 4 percent two-year-old's, 54 percent three-year-old's, 41 percent four-year-old's, and 1 percent five-year-old's for the Lower Shuswap, Tete Jeune, Chase, Chilko and Taseko Rivers, Fraser et al. (in preparation). Upper Fraser River sampling in 1976 was cited by those authors to be of 79.6 percent ocean-type (mostly 3's and 4's) and 20.4 percent stream-type (mostly age 4's and 5's). The data contained herein is more congruent with preliminary data collected by Milne and Ball (1961).

Table 4: Summary of age composition and freshwater classification from scales of of McGregor River chinook populations.

	AGE COMPOSITION							
Year	0.1 (2_1)	0.2 (3_1)	1.1 (3_2)	0.3 (4_1)	1.2 (4_2)	0.4 (5_1)	1.3 (5_2)	Total
August, 1977	–	3	–	7	10	–	7	29
Percent	–	11	–	26	37	–	26	100
Average Fork-Length (cm.)	–	49.7	–	77.8	52.2	–	65.5	–
Male/Female	–	3:0	–	4:3	4:4	–	3:4	

Fisheries and Marine Service, McGregor River Diversion Report (Tutty, in preparation), and Fisheries and Environment, Field Services data (F. & M.S., Scale Laboratory Scale Bank).

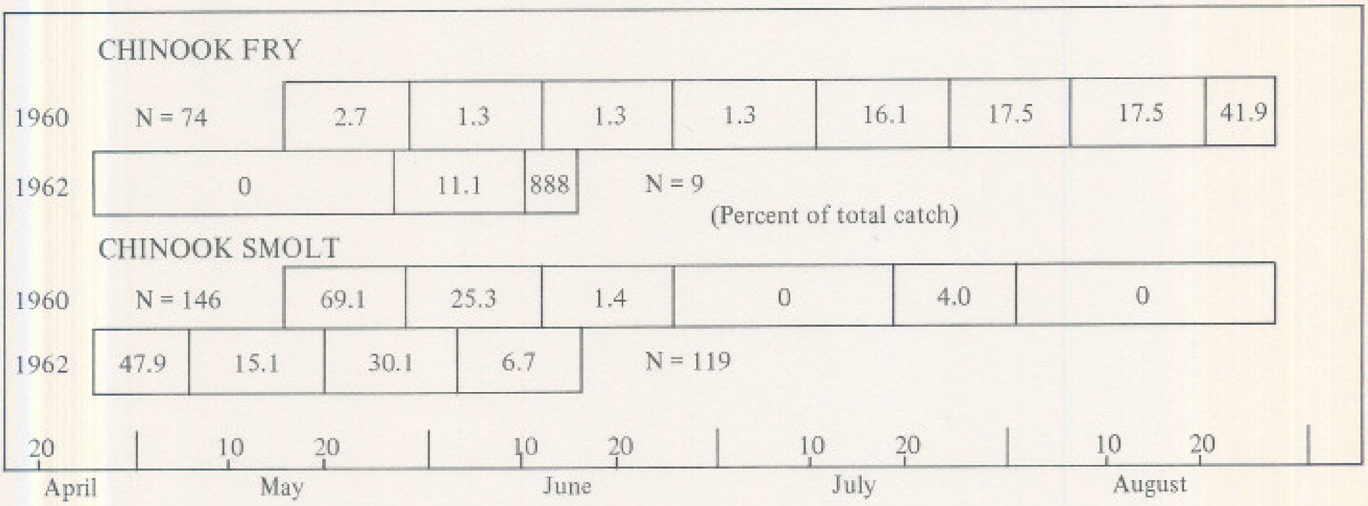

Table 5: Timing and capture summary of Fraser River inclined-plane trapping of chinook juveniles at Shelley, B.C. (Chatwin et al, 1963).

4.0 DISCUSSION

A report by Chatwin et al. (1963) postulated that significant populations of stream-type chinook overwinter in the Upper Fraser River system. Chinook captured by Chatwin near Shelley during the late-April to early-June period in 1962 were predominantly yearling progeny migrating from spawning systems upstream of that trapping location, such as the McGregor, Torpy, and Mainstem Fraser Rivers.

The timing of 1977 chinook juvenile movements from the McGregor and Nechako Rivers coincided with those observed by Chatwin et al. (1963). Recent inspection of scales from Chatwin's study revealed 40.5 percent of a sample of 74, which he had designated as stream-type juveniles, have scales with no apparent winter annulus (Plates 5 and 6). The overwintering smolt classification was based on the large size of these early migrating specimens. Similarly, smolts captured in 1977 from Fontoniko, James and Seebach Creeks in the McGregor drainage also show this same phenomenon of large size (mean F.L. 82.7 mm) and no annulus formation (Plates 7, 8 and 9). At the time of their capture in May, 1978, McGregor chinook fry of the year (mean F.L. 40.0 mm) were actively observed rearing, and reinforce the above overwintering smolt hypothesis.

The cold flow of the McGregor River and many other Upper Fraser tributaries are influenced by their glacial origins. These habitats may provide insufficient productivity and growing season to distinguish differential growth rates in scales of juvenile chinook rearing for one year. Indeed, periods of starvation have been shown to suspend circuli formed in sockeye salmon (Bilton, 1973).

Freshwater age designations interpreted from adult salmon scales are primarily based on the assumption that an annulus is discernable on the scale as a result of the reduced freshwater winter growth of juveniles. This winter annulus was distinct in scale patterns of overwintering smolts captured in May from the non-glacial Nechako River (Plate 10), as were 59.5 percent of the scale samples of overwintering smolts collected by Chatwin et al. (1963) in the Upper Fraser River (Plate 11). Ninety-two percent of the adult scale patterns from the 1974 Nechako escapement had a distinct annulus, as were 63 percent of the 1977 McGregor (Plates 12 and 13), based on existing Fisheries and Environment Scale Bank data, Vancouver, B.C. This data suggests that stream-type chinook residing in the Nechako River could represent a significant production component.

Freshwater aging depends on interpretation of annulus formation. Adult chinook scale patterns with no distinct annulus (Plate 14) indicate smolting prior to the onset of the first winter, and are normally classified ocean-type. Based on the observations of Chatwin on the Fraser mainstem, and on samples from the McGregor River, it is apparent that stream-type smolts migrating in April - May from the Upper Fraser systems do not necessarily produce a winter annulus before their departure. These smolts most probably arrive no later than June at the Fraser River estuary. We speculate that any scale annulus or check they do produce may become obscured by subsequent estuarine or marine growth. The ensuing lack of a discernable freshwater annulus in returning stream-type adults could then result in an overestimation of ocean-type fish. For example an adult with age 1.3 (5_2) misclassified as age 0.3 (4_1).

To improve the accuracy of freshwater residency interpretations on salmon scales, scale readers should understand all known factors of freshwater life history. Should this data be unavailable, other methods, such as proportional growth bands may be employed, to assist determination of adventitious scale patterns. We feel too much credence has been placed on the formation of an annulus as a sole indication of overwintering stock.

Scale interpretation could have underestimated the proportion of the stream-type chinook in the Upper Fraser system. Underappraisal of the contribution by stream-type subpopulations to the Fraser chinook production could ultimately lead to regrettable fisheries management decisions. Most chinook enhancement options are based on principles of coastal operations and technology developed for rearing chinook approximately 90 days. A full-year rearing period required to propagate overwintering Upper Fraser stocks would increase the disease risk and would substantially increase operating costs. No chinook production operation has been established in areas of the Upper Fraser system and would be subjected to severe winter conditions. Obviously, the bio-feasibility of such projects must be vigorously explored beforehand if successful enhancement of Upper Fraser chinook is to occur.

Nevertheless, compensation for the destruction of existing habitat or lost enhancement potential in conjunction with possible future water use development, must first be weighed in balance with chinook "stream" or "ocean" races to be sustained, production quotas, and the facility's chances for successful operation. Adult scale patterns suggest that existing chinook fishery production from the Nechako and McGregor Rivers predominantly arise from overwintering populations. It is the critical uncertainties of the stream-type component to the chinook recruitment system which must be addressed in any proposal for compensation or enhancement of the Upper Fraser chinook population.

5.0 SUMMARY

Scales were sampled from spawning chinook; during 1974 in the Nechako and 1977 in the McGregor River. Ninety-two percent in the Nechako and sixty-three percent of the McGregor escapement were determined to have spent a year in freshwater. Overwintering stream-type juveniles were trapped in the Upper Fraser mainstem during the spring of 1962, and in the Nechako and McGregor Rivers in the spring of 1977. Based on size and scales, Nechako smolts were stream-types. However, stream-type smolts trapped near Shelley in the Upper Fraser River by Chatwin et al. (1963), and later during 1977 in the cold McGregor watershed by the authors revealed no annulus formation. If a freshwater annulus either does not form in freshwater, or becomes masked by subsequent, rapid estuarine growth, then previous methods employed in scale analysis could have misinterpreted the freshwater residency period and ultimately, age of stream-type chinook.

There may be a general underappraisal of the chinook production contribution by the stream-type component. Investigations should be undertaken to critically examine and resolve these questions before compensation is considered from the enactment of hydro generation schemes. The evaluation of the proposed Salmonid Enhancement projects in the Upper Fraser system are also crucially dependent on such examinations.

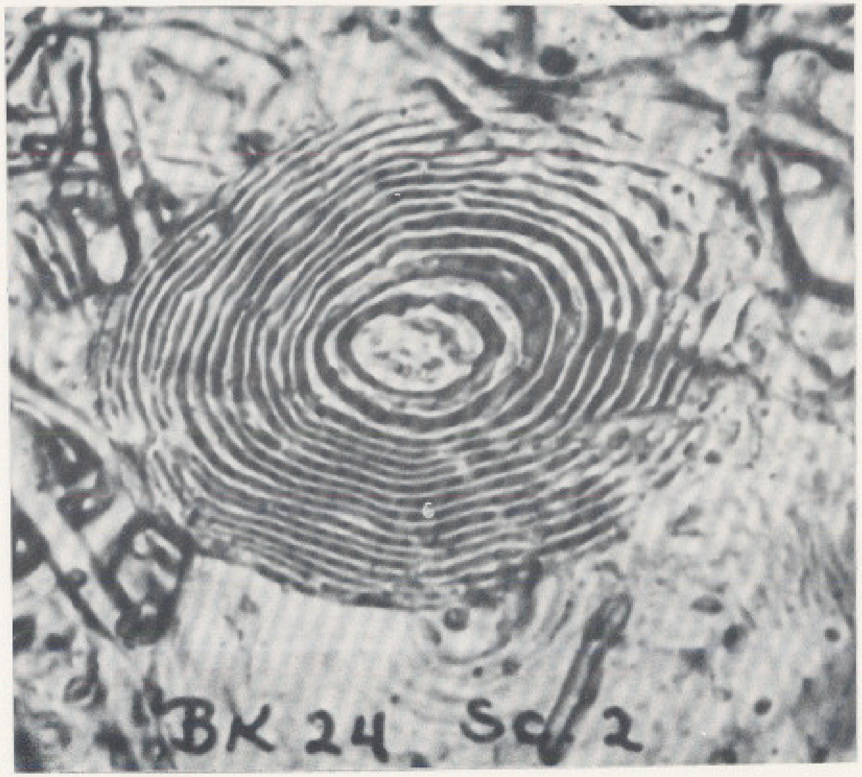

Plate 5: Scale from captured smolt in May, 1962, by Chatwin et al (1963) from Fraser River at Shelley, indicating no annulus formation (photographic enlargement from X250 magnification).

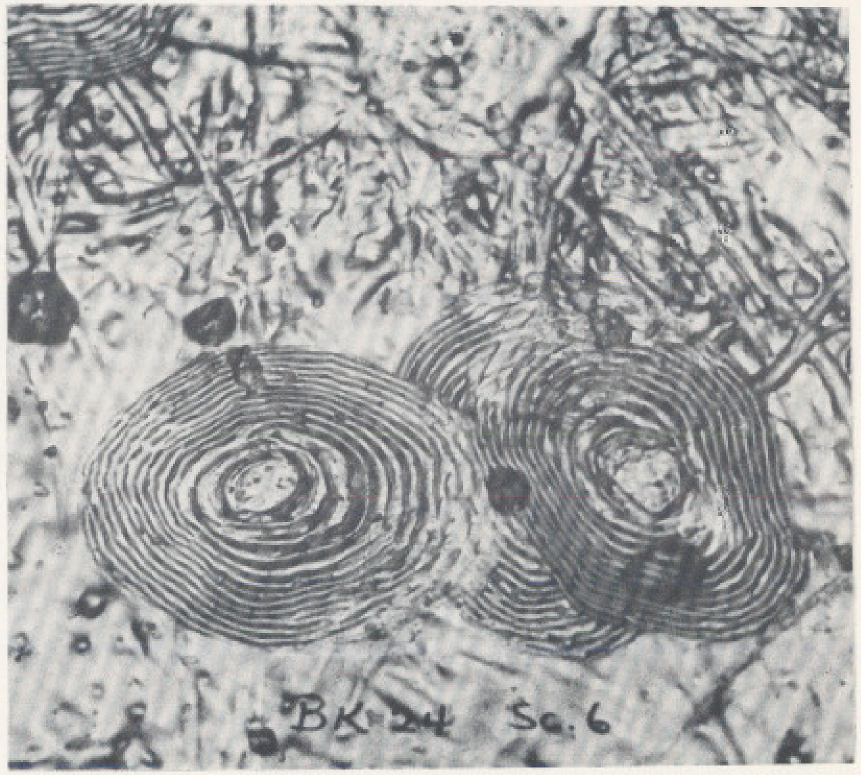

Plate 6: Scale from captured smolt in May, 1962, by Chatwin et al (1963) from Fraser River at Shelley, indicating no annulus formation (X250).

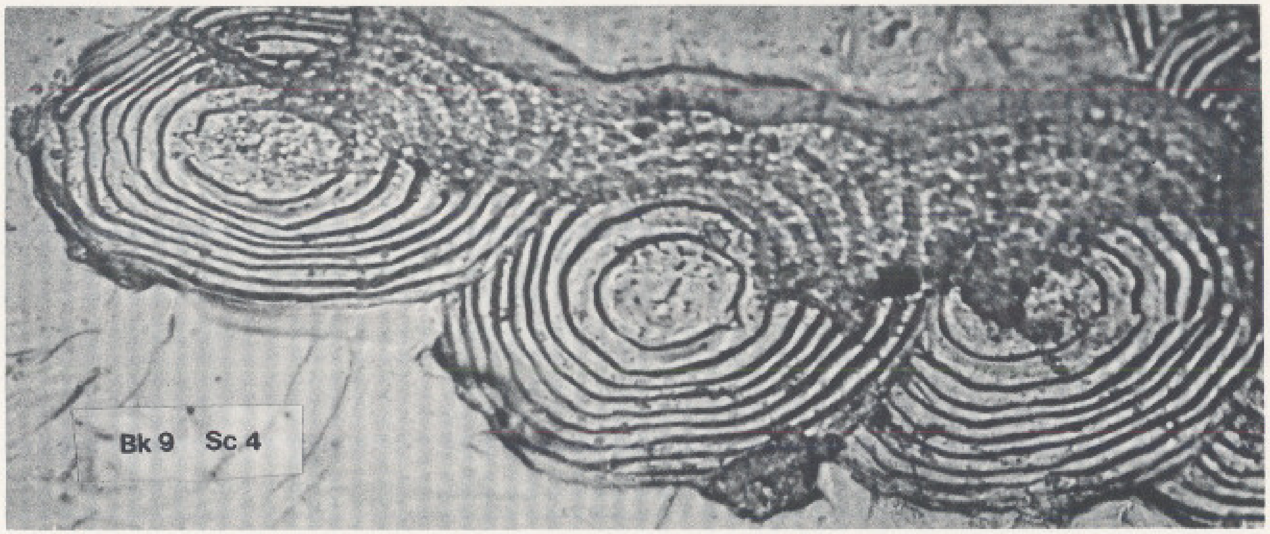

Plate 7: Scales from smolt captured in May, 1977, from Fontoniko Creek, indicating no annulus formation (X250).

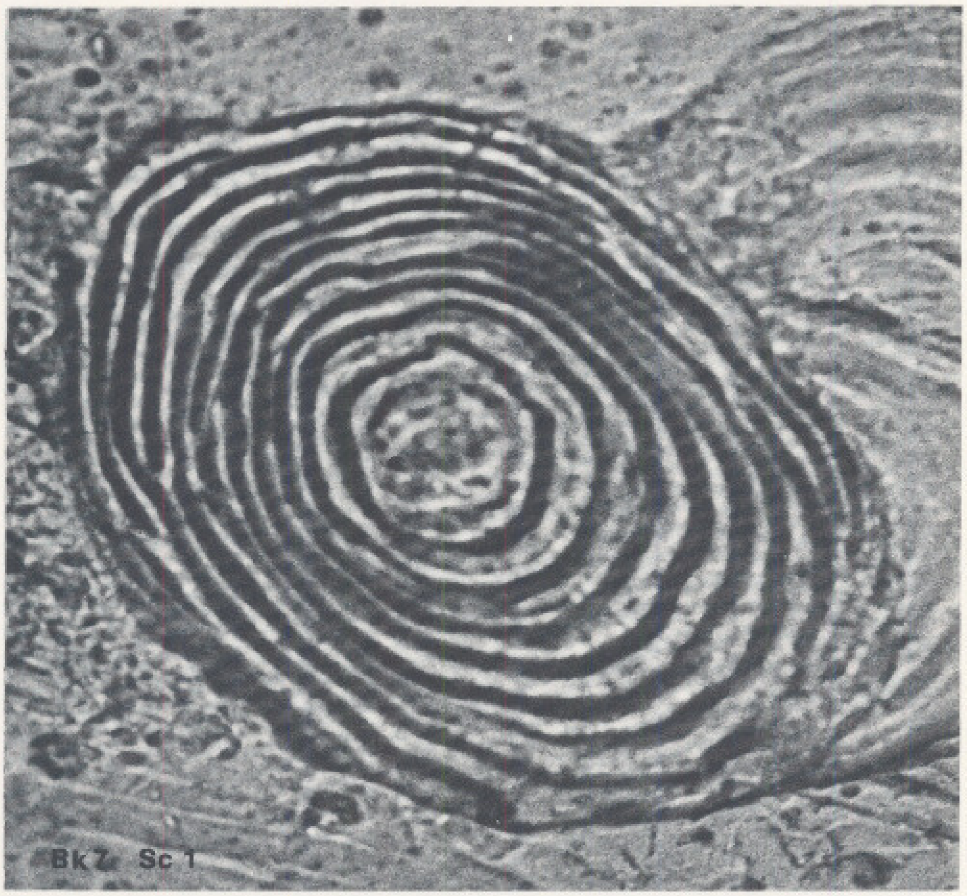

Plate 8: Scale from smolt captured in May, 1977, from James Creek, indicating no annulus formation (photographic enlargement from X250 magnification).

Plate 9: Scale from smolt captured in May, 1977, from Seebach Creek, indicating no annulus formation (photographic enlargement from X250 magnification).

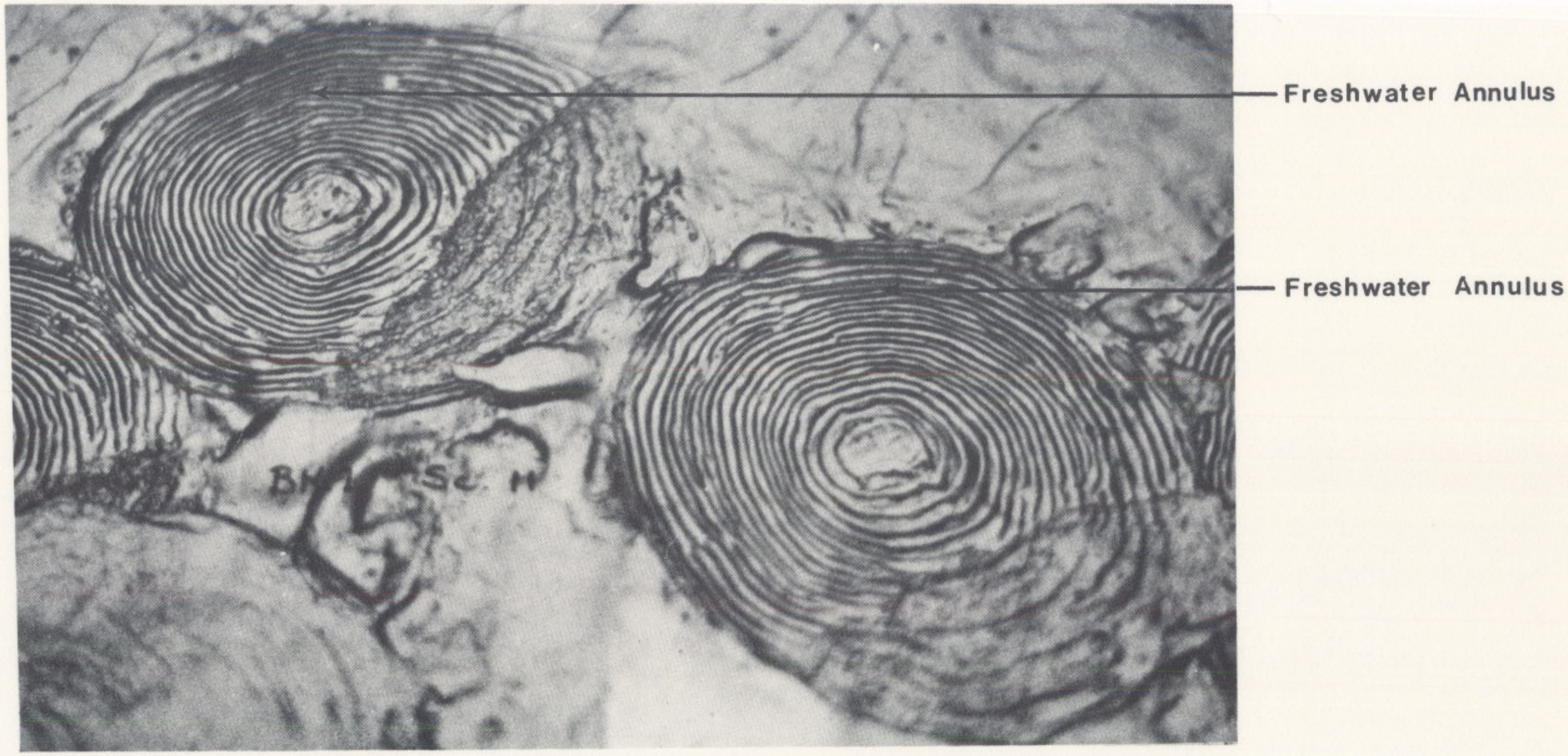

Plate 10: Scales from smolt captured in the Nechako River on June 9, 1977, indicating annulus formation. (X250).

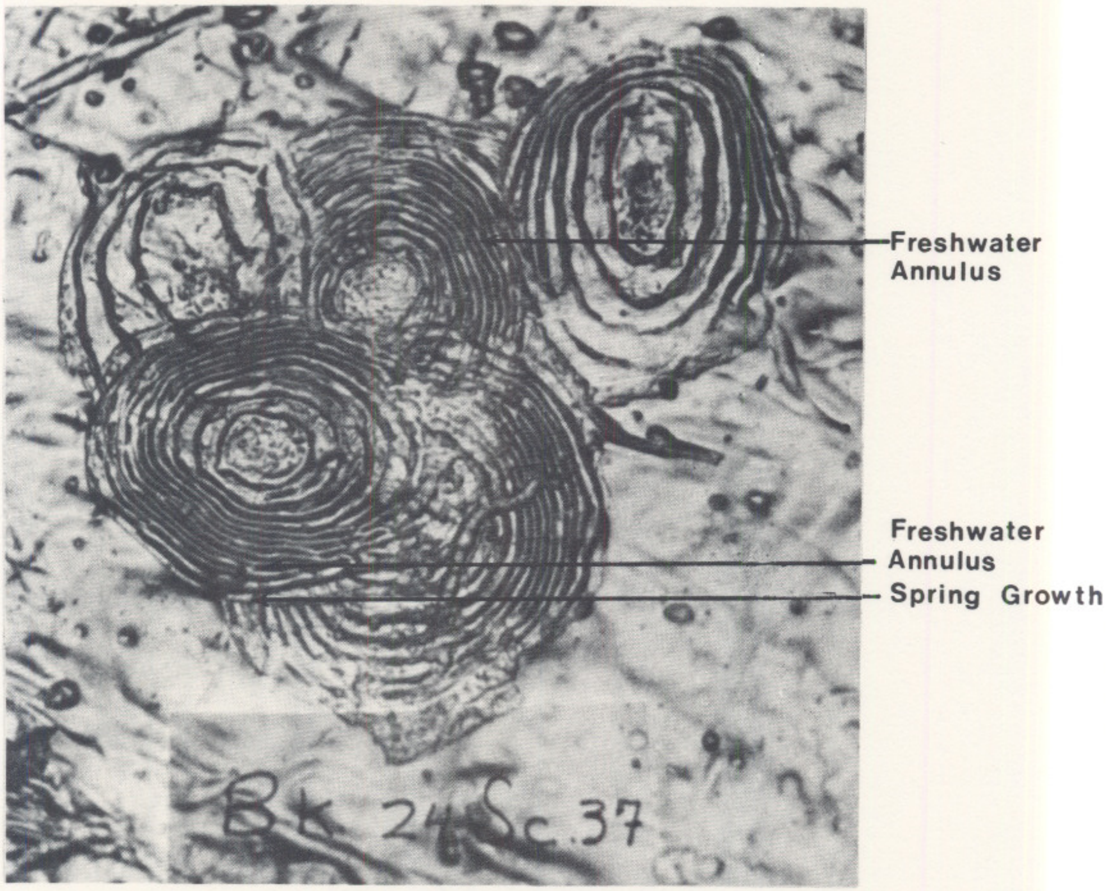

Plate 11: Scale from smolt captured in May, 1962, from Fraser River at Shelley, indicating annulus formation and 3 - 4 additional spring growth circuli (X250).

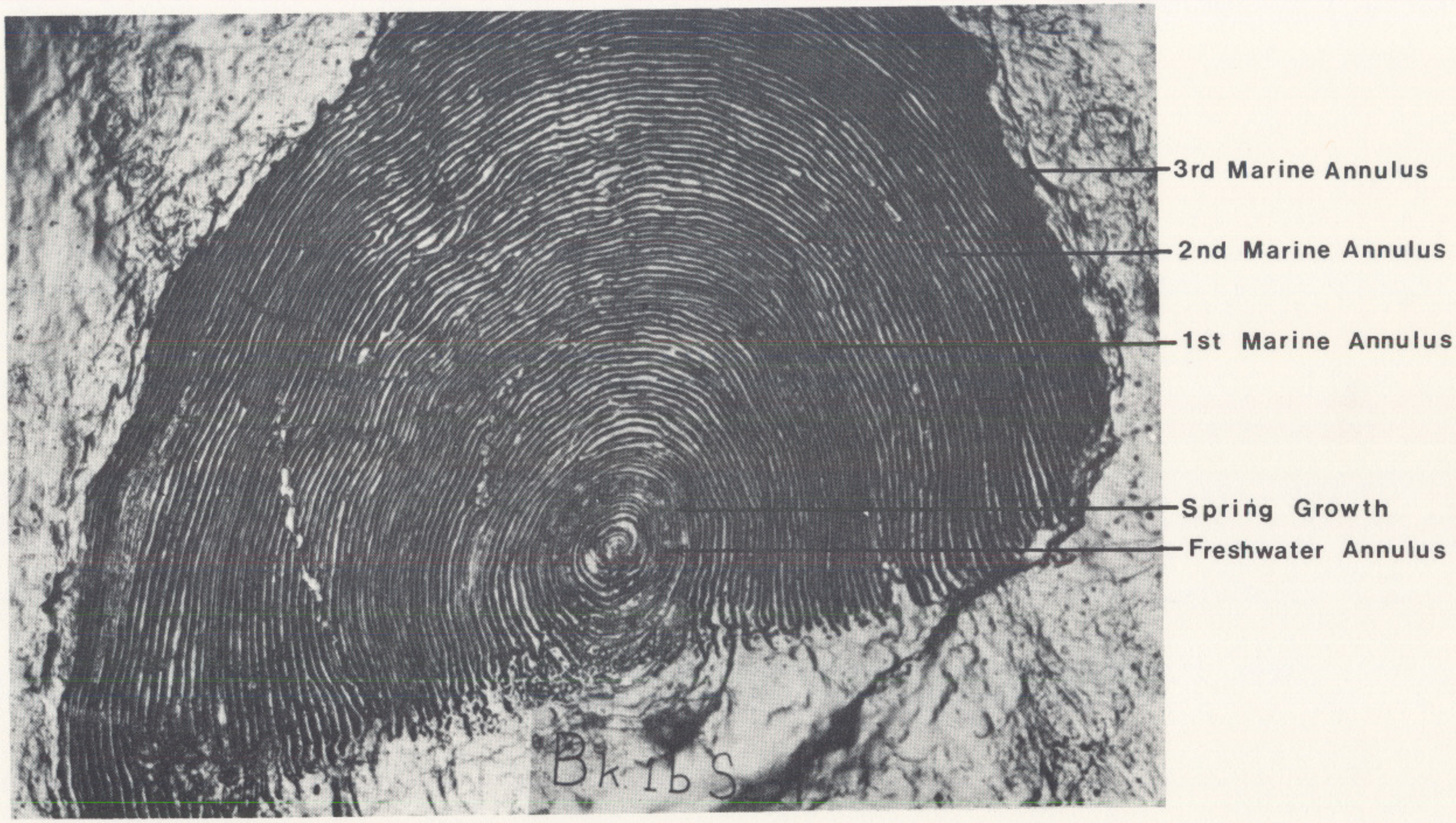

Plate 12: Nechako River adult, aged 1.3 (5_2), sampled in September, 1974, indicating winter growth check, with four spring growth circuli. Some resorption on outer edge of scale is evident (X100).

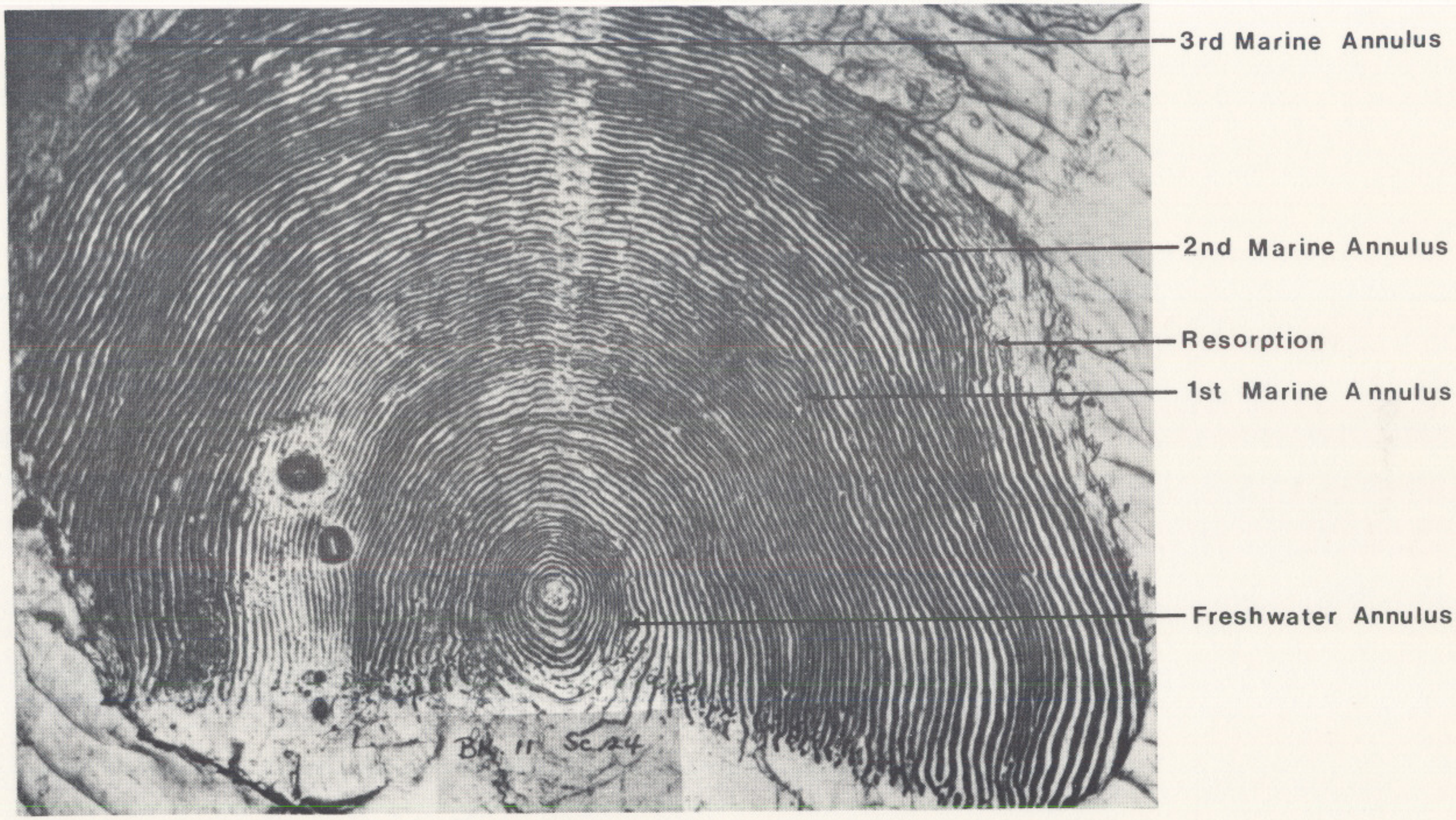

Plate 13: McGregor River adult, aged 1.3 (5_2), sampled in August, 1977, indicating a freshwater annulus and two circuli of spring growth (X100). Some resorption is evident.

Plate 14: McGregor River adult, aged 0.3 (4_1), sampled in August, 1977, indicating no freshwater annulus. Twelve evenly-spaced freshwater circuli are apparent. The scale is extremely resorbed throughout the margin (X100).

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