Canadian Technical Report of
Fisheries and Aquatic Sciences 1628

Fall, 1989

CRITERIA FOR IDENTIFYING FRESHWATER AGE FROM SCALES OF CHINOOK SALMON (*Oncorhynchus tshawytscha*) CAPTURED IN MIXED-STOCK FISHERIES OF BRITISH COLUMBIA

by

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Cat. No. Fs 97-6/1628E

ISSN 0706-6457

Correct citation for this publication:

F.Y.E. Yole. 1989. Criteria for identifying freshwater age from scales of chinook salmon (Oncorhynchus tshawytscha) captured in mixed-stock fisheries of British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 1628: viii + 46p.

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Freshwater age of chinook salmon (Oncorhynchus tshawytscha) captured in mixed-stock fisheries of British Columbia was estimated using scale characters reflecting early life history stages. As a result of numerous years of screening scales from chinook salmon of known age (coded-wire tags), 16 scale characters were identified as potentially useful in differentiating between sub_1 ("ocean-type") and sub_2 ("stream-stype") age-groups. Descriptions of each character are presented as an aid for identification.

Of the 16 scale characters assessed for their relative association with the two freshwater age groups, six were more strongly associated with sub_1 salmon, seven with sub_2 salmon and three occurred with similar frequency. Based on qualitative assessments of scale characters identified on each scale sample, 100% of sub_1 and 95% of sub_2 salmon were correctly aged by the author. Five test scale readers with varying experience correctly aged an average 90% of the sub_1 and 73% of the sub_2 chinook salmon. An alternative quantitative scoring procedure based on relative scale character presence resulted in slightly lower accuracy for both the author and the test readers. The test group of readers had some difficulty identifying scale characters. The more experienced readers recognized scale characters identified by the author more consistently than novice readers, indicating accuracy of the ageing procedure should improve with training and experience.

RESUME

F.Y.E. Yole. 1989. Criteria for identifying freshwater age from scales of Chinook salmon (Oncorhynchus tshwytscha) captured in mixed-stock fisheries of British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 1628. 46p.

L'auteur a estimé, à partir de caractéres scalimétriques reflétant les premiéres étapes de la vie, le nobre d'années passées en eau douce de saumons quinnats (Oncorhynchus tshawytscha) capturés au cours de pêches de stocks mixtes de la Colombia-Britannique. Suite à plusiers années d'examen d'écailles de saumons quinnats d'âges connus (marquage par fils codés), 16 caractères scalimétriques ont pu être déterminés comme pouvant servir à différencier deux groupes: sub_1 (type océanique) et sub_2(type fluvial). L'auteur décrit chacun des caractéres afin de faciliter l'identification.

Des 16 caractéres scalimétrioues évalués pour leur association relative avec les deux groupes de temps passé en eau douce, six étaient plus fortement associés au sub_1 et sept au sub_2. Trois présentaient des fréquences semblables. Des évaluations qualitatives des caractéres scalimétriques de

chaque échantillon d'écailles ont permis à l'auteur de déterminer correctement l'âge de 100% des échantillons du sub_1 et 73% de ceux du sub_2. L'utilisation d'une autre méthode d'éevaluation basée sur la présence relative des caractéres scalimétriques a donné des résultats léegèrement moins exacts tant pour l'auteur que pour les lecteurs. Les lecteurs du groupe d'essai ont éprouvé certaines dificultés à identifier les caractéres. Les lecteurs plus expérimentés avaient plus de facilité à reconnaître les caractères déterminés par l'auteur, ce qui montre que la précision de la procéedure de détermination des âges devrait augmenter à mesure que les lecteurs seront mieux formés et prendront de l'expérience.

INTRODUCTION

This technical report describes a new procedure based on scale characters to identify freshwater age of chinook salmon (Oncorhynchus tshawytscha) captured in mixed-stock fisheries of British Columbia.

With the exception of recent uses of dorsal fin rays (Chilton and Bilton 1986), scales are used almost exclusively to age chinook salmon. Unlike other salmon species (Bilton and Jenkinson 1968), chinook salmon otoliths have not been useful ageing structures due to poor resolution of annuli. Identification of freshwater age of chinook salmon has been particularly difficult for scale readers. The difficulty in determining freshwater age is generally attributed to the species' complex life histories (i.e., Rich 1920; Riemers 1973; Tutty and Yole 1978), and more recently, by the large increases in hatchery stocks with varying release dates and growth histories. Tutty and Yole (1978) have also reported that over-wintering chinook salmon stocks of the upper Fraser River do not necessarily produce a visible first-year scale annulus.

During the last 10 years of ageing approximately 200,000 chinook salmon scale samples per annum, I observed an assortment of scale growth characters recurring regularly with scale marks (i.e., annuli, stress checks, freshwater checks) associated with different known early life history stages. During this period of exploratory screening for characteristic scale growth features, 16 scale characters were identified as potentially useful in differentiating between sub_1 and sub_2 chinook salmon[1].

The primary purpose of this investigation was to develop a standard and reliable procedure to identify freshwater ages of chinook salmon for scale readers of the Fish Morphology Laboratory (FML), Department of Fisheries and Oceans, Vancouver, B.C. Typical of a management-oriented scale laboratory, large numbers of scales are read, and thus, the procedure must be quick and easy to use, yet relatively accurate. With these constraints in mind, selection of scale characters was based on their apparent discriminatory power and the ability to identify each scale character by general inspection as opposed to precise unit-specific measurement.

In the following sections of this report I describe each of the 16 scale characters observed on scales of chinook salmon during the past 10 years, examine the rate of occurrence of the characters on a subsample of 280 scales from sub_1 and sub_2 fish of known-age (based on coded-wire tags), assess the ability of five FML scale readers to identify the 16 scale characters, and test the accuracy of the scale character procedure to correctly identify freshwater age.

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[1] Age designation in this report follows the Gilbert-Rich (1927) system, where total age is referenced by the first digit and age at the time of migration from freshwater is indicated by the subscript. For comparision, the European system of age designation (Koo 1962) for sub_1 and sub_2 ages are 0.* and 1.*, respectively.

METHODS

SOURCE OF SAMPLES

Scales were sub-sampled from known-age chinook salmon of predominantly hatchery origin in 1983 and 1984. Sub-samples were obtained from salmon captured in mixed-stock commercial fisheries, and age and origin was determined from coded-wire nose tags (CWT) implanted in juveniles released at hatcheries and various experimental sites (wild fish) throughout the west coast (Table 1; Appendix A). From a total of 14,000 known-aged fish, 280 scale samples were selected during the two years in approximate proportion to numbers of CWT salmon recovered from each production area to represent a cross-section of early, mid-summer and late hatchery releases. Sampling of fish occurred at Vancouver, Prince Rupert and Port Hardy, to intercept northern and southern mixed stocks (Appendix A). Age composition consisted of one 2_2, 120 3_1, five 3_2, 103 4_1, 32 4_2, 15 5_1 and five 5_2 for a total of 238 sub_1 and 42 sub_2 fish.

Scales were taken from the preferred area of the body (Clutter and Whitesel 1956), cleaned and mounted in gummed booklets by field personnel as part of Department of Fisheries and Oceans' Mark Recovery Program.

SCALE PREPARATION AND DEFINITIONS

Acetate impressions of the scales were viewed at approximately 100X using a Wild-Leitz projector. The entire scale was assessed from projections to a flat surface using a light source with high contrast to allow close examination of growth rings.

Features of chinook salmon scales, similar to those described by Clutter and Whitesel (1956) for sockeye salmon, are defined below.

Annuli: zones of crowded, thin, or incomplete circuli, indicating a sudden decrease in growth rate; interpreted as indicating the period of winter growth.

Circuli: circular bony ridges, concentric around the focus, appearing primarily on the anterior part of the scale.

Freshwater Checks: a general term describing zones of crowded, thin or incomplete circuli or a single thin or incomplete line formed in freshwater which may resemble an annulus but may not be formed during the restricted winter growth period.

Focus: the small, well-defined area near the centre of the scale which lies within the first circular ridge.

Table 1. Percent stock composition of chinook salmon sub-sampled for scales relative to those recovered in the Mark Recovery Program (MRP) in 1983 and 1984.

Production Area	Scale Samples 1983	Scale Samples 1984	MRP 1983	MRP 1984
NORTHERN				
Southern Alaska	1	0	>1	>1
Queen Charlotte Is.	0	1	0	>1
Central Coast	8	0	2	1
Georgia Str. Mainland	8	3	16	9
Georgia Str. Vancouver Is.	10	6	28	22
Southwest Vancouver Is.	11	1	6	6
Lower Fraser R.	0	15	7	18
Thompson R.	1	1	>1	>1
Subtotal	37	26	59	56
CENTRAL				
Puget Sd. Area 01	8	2	8	5
Puget Sd. Area 04	5	8	6	7
Puget Sd. Area 05	0	1	1	1
Upper Washington	1	1	1	1
Columbia R. Brights	1	2	1	1
Lower Columbia R.	23	36	12	15
Snake River	1	4	1	2
Willamette R.	21	8	4	4
Subtotal	59	62	34	35
SOUTHERN				
Northern Oregon	1	4	4	3
Southern Oregon	0	1	>1	>1
Sacramento R.	1	6	2	2
California	0	1	>1	>1
Subtotal	2	12	6	5
Other Areas	0	0	1	3
Number of Fish Sampled	138	142	7,337	7,238

Source: Pacific Marine Fisheries Commission (1985), and L. Lapi (Pacific Biological Station, Nanaimo).

Nucleus: the portion of the scale that is formed in fresh water, exhibiting finely-etched, closely-associated circuli.

Spring Growth: a series of wider-spaced circuli after a defined freshwater annulus and followed by more widely-spaced marine circuli or transition growth. In this paper, spring growth and "plus" growth are synonymous.

Summer Circuli: a group of more widely spaced and slightly thicker circuli formed during active growth periods in spring and summer subsequent to annulus formation.

Winter Circuli: a group of closely spaced and slightly thicker circuli formed during slow growth periods in autumn and winter. Winter circuli typically become more crowded and appear as a dark band near the annulus.

Radial Striations: markings or ridges in the posterior or exposed portion of the scale.

Transition Zone: the area where freshwater growth ends and ocean growth begins, sometimes composed of circuli which are intermediate in character.

Circuli counts and examinations were made along a line passing through the focus and 45° from the longest axis of the scale. Clutter and Whitesel (1956) for sockeye salmon, and Reimers (1973) and Schluchtu and Lechatowich (1977) for chinook salmon used 20° from the perpendicular axis, but I found that the true marine annulus formation was most clear at the 45° angle.

DESCRIPTION AND IDENTIFICATION OF SCALE CHARACTERS

Sixteen scale characters were associated with three zones of the scale (Table 2):1) general area around the nucleus; 2) circuli before a freshwater check; and 3) circuli after a freshwater check. Occurrence of each scale character was identified by subjective inspection as opposed to unit specific measuring devices, and are illustrated throughout the text using scale samples from CWT recoveries. Generally for hatchery-produced chinook salmon, the freshwater check was identified with the stress of hatchery release and migration. A small percentage of fish may continue to rear in the wild prior to migration. For this odd event, one or two checks could result; one associated with stream acclimation, and the other with the period of migration (cf., Figs. 1-3).

General Area Around The Nucleus

The area around the nucleus refers to the early life history of the fish, encompassing both areas of freshwater and marine growth. Relative scale growth criteria for these two life history stages is described below by scale characters 1-4 (Table 2).

Table 2. Description of the 16 scale characters examined for their value in determining freshwater age of chinook salmon.

Number	Definition	Abbreviation
	GENERAL AREA AROUND THE NUCLEUS	
1	Presence of characteristic marine annulus formation, indicating the circuli of the first winter's growth in salt water.	Visual SWA
2	Distance from the focus to the first marine annulus is GREATER than the distance between the first and second marine annuli.	F-1SWA > 1SWA-2SWA
3	Distance from the focus to the first marine annulus is LESS than the distance between the first and second marine annuli.	F-1SWA < 1SWA-2SWA
4	Distance from the focus to the first marine annulus is EQUAL to the distance between the first and second marine annuli.	F-1SWA = 1SWA-2SWA
	CIRCULI BEFORE FRESHWATER CHECK	
5	LESS THAN 15 EVENLY-SPACED circuli before the first freshwater check.	Even < 15
6	GREATER THAN 20 EVENLY-SPACED circuli before the first freshwater check.	Even > 20
7	Presence of UNEVENLY-SPACED circuli, with visible summer/winter growth in freshwater.	Uneven
8	"CUT-OUT" appearance of freshwater circuli showing hatchery freshwater annulus, and/or spring growth distal to this freshwater annulus.	Cut-out-Circuli
9	Presence of STRIATIONS in the posterior zone, often associated with a check, annulus, or change of growth pattern in anterior zone.	Posterior Striations
10	ABSENCE OF A CHECK or marked difference in circuli spacing between freshwater and marine growth; gradual increase in circuli spacing.	No Freshwater Check
11	Presence of DIFFERENCES IN SCALE THICKNESS (indicated by light and dark circuli patterns) visible on separate areas of a single scale.	Optical Density
	CIRCULI AFTER FRESHWATER CHECK	
12	Presence of SPRING GROWTH after the freshwater annulus.	+Growth
13	Presence of MARKED CHANGE IN CIRCULI SPACING subsequent to freshwater growth.	Marked Change in Spacing
14	Presence of GRADUAL CHANGES IN CIRCULI SPACING where the area of widest spacing was approximately HALFWAY between the focus and the first marine annulus.	Widest Half F-1SWA
15	Presence of GRADUAL CHANGES IN CIRCULI SPACING where the area of widest spacing occurred near the first marine annulus.	Widest Near 1SWA
16	NO CHANGE IN CIRCULI SPACING; even, regular spacing throughout the zone containing marine circuli.	No change in spacing

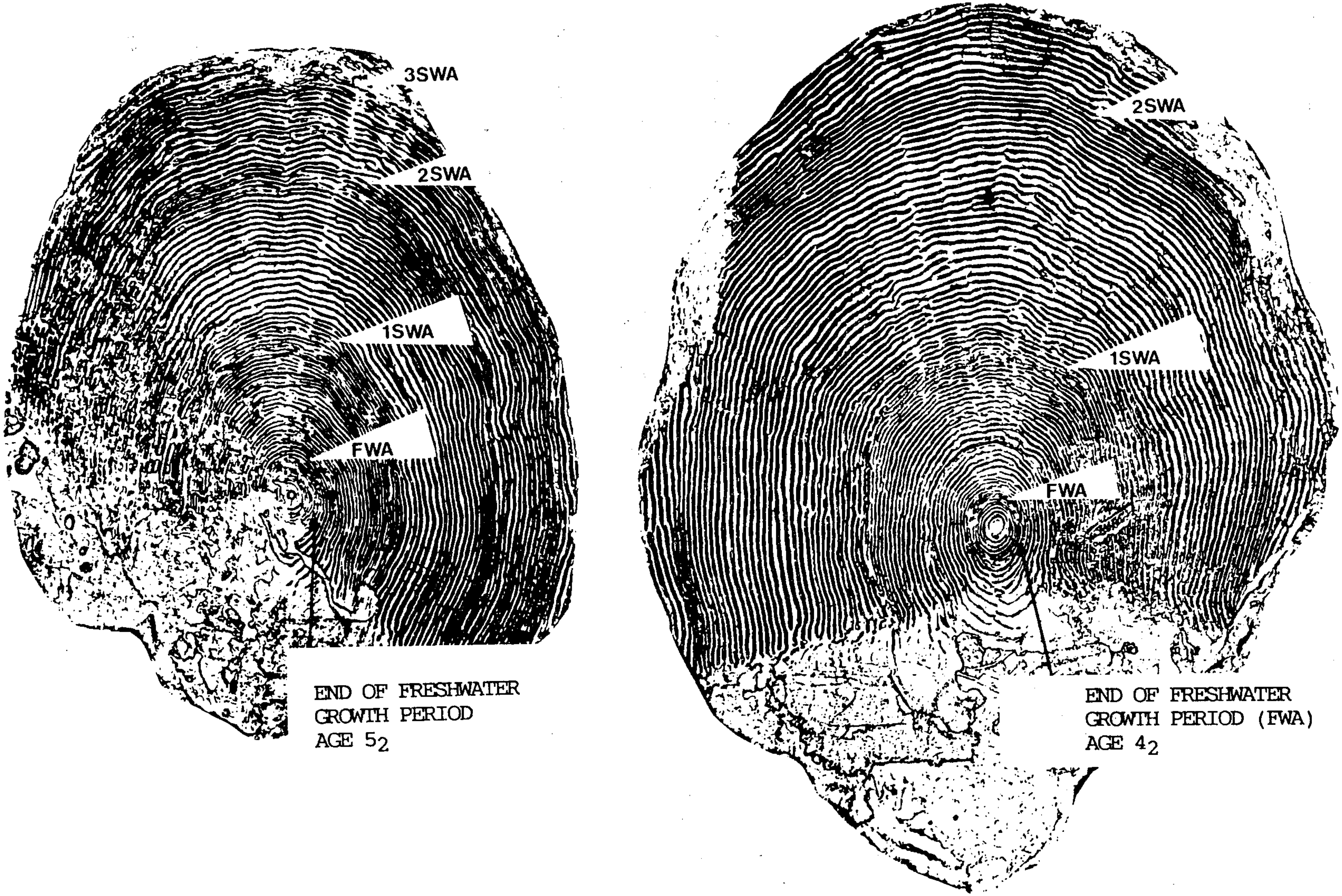

Figure 1. Scales of wild chinook salmon showing freshwater circuli spacing and end of freshwater growth period, fresh water annulus (FWA) and marine annuli (1SWA, 2SWA, 3SWA).

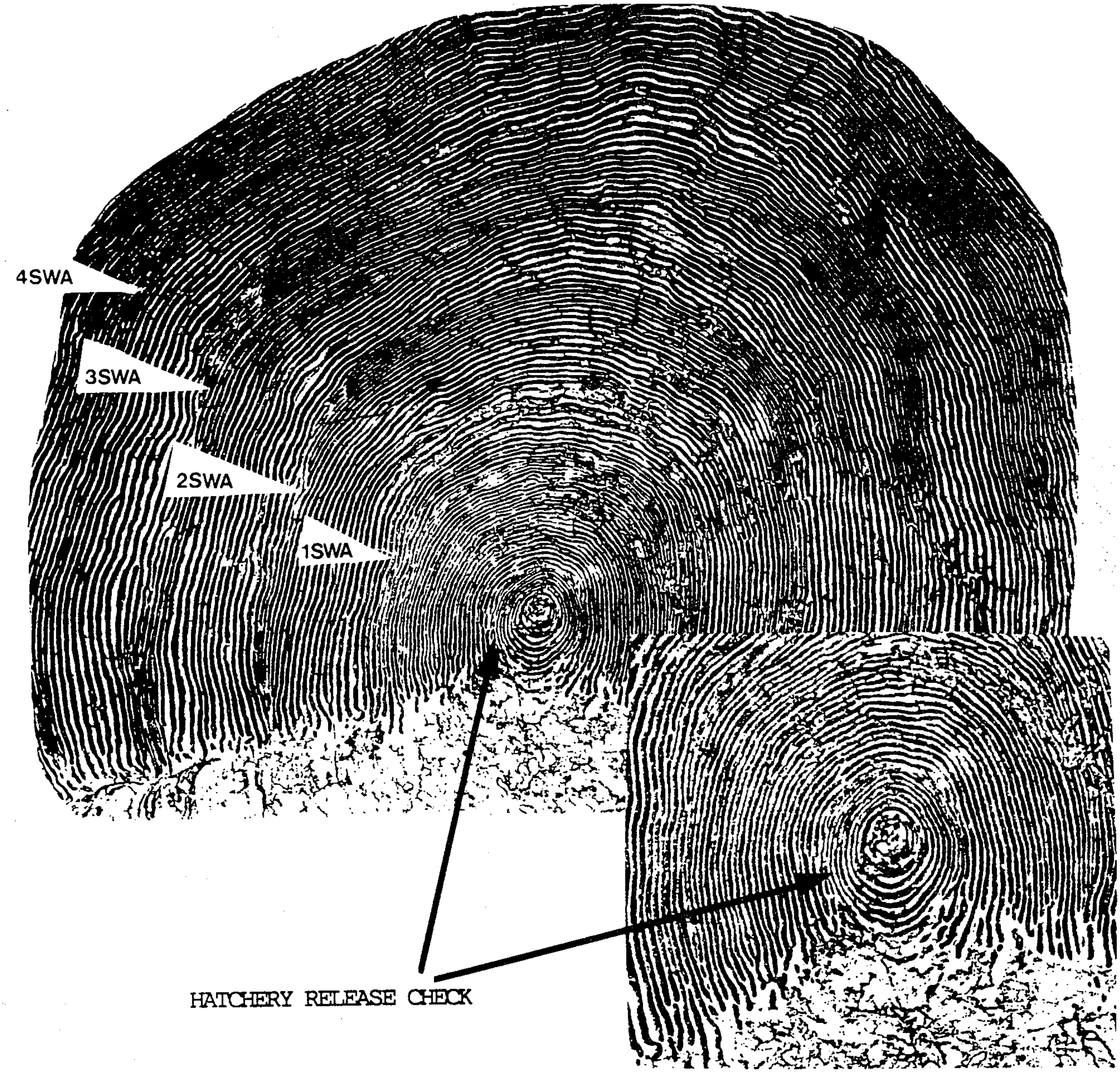

Figure 2. Scale of hatchery chinook salmon showing evenly spaced freshwater circuli at end of freshwater growth period (hatchery release check). (Age 5_1)

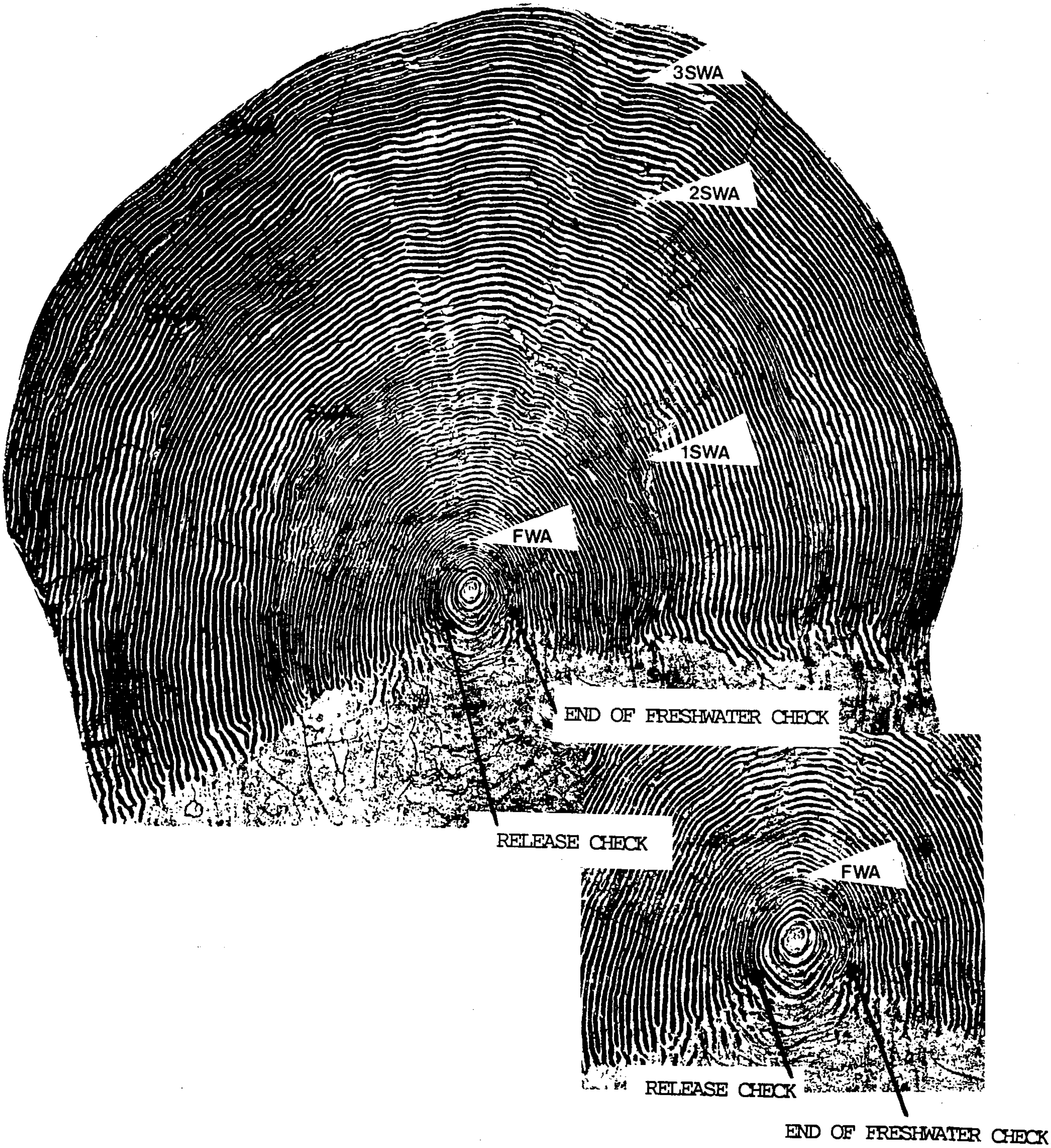

Figure 3. Scale of chinook salmon with evidence of overwintering in freshwater, showing evenly spaced circuli up to a release check (RC), freshwater annulus (FWA) with more closely spaced circuli and marine annuli (SWA). (Age 5_2)

The general area around the nucleus has been described by Gilbert (1912) and Rich (1920, 1925) as "the whole first year's growth". They, among others, believed that this area of growth around the nucleus, usually represented one-third of the total scale growth on four year-olds and approximately one-half the total scale growth on younger chinook (two and three years old). As a result, this area was closely inspected for a marine rather than freshwater annulus (first winter ocean circuli). If an annulus was observed in the general area, it was deemed a marine annulus (character 1).

For this study a marine annulus is described as a zone of crowded, narrow or incomplete circuli, and indicate an abrupt decrease in growth rate during ocean residence in winter. These narrow zones of winter growth tend to constrict or "pinch-in" at the anterior/posterior margin of the scale (Fig. 4). However, true marine annuli can be difficult to distinguish from hatchery release checks on scales of chinook salmon released late in the season (see also scale character 6).

The position of the first marine annulus relative to the scale focus and the second marine annulus, were considered to be three separate scale characters (characters 2-4). The distance from the focus to the first marine annulus was judged to be either greater than (character 2), less than (character 3), or equal to (character 4) the distance between the first and second marine annulus (Fig. 4). Scale measurements were made on a proportional basis by inspection, as opposed to unit-specific measurements, with the aid of a digitizing programme.

Examination of Freshwater Circuli Formation

Abundance and spacing of freshwater circuli may vary significantly between chinook salmon stocks and has been attributed to differences in food availability, temperature and genotype (Koo and Isarankura 1967; Godfrey et al. 1971; Ricker 1972; Reimers 1973). To examine the relationship between circuli formation and time of hatchery release, I enumerated freshwater circuli on scales of chinook salmon with various periods of hatchery residence. Hatchery chinook salmon, released from Canadian and U.S. hatcheries with coded-wire tags and later recovered in British Columbia fisheries in 1983, were divided into early (January to early June), mid-summer (late June to September) and late (October to December) release groups. Counts were made of all circuli between the focus and hatchery release check or to an abrupt change in circuli growth pattern if the check was not evident.

Scale Area Proximate to Freshwater Check

In this region of the scale, seven scale characters associated with numbers of circuli formed, and circuli spacing pattern relative to the freshwater check were identified (Table 2). Stress associated with release is often represented on scales of hatchery fish as a "release" check (Fig. 2). This frequently observed mark on scales of known-age chinook salmon of hatchery origin was an ideal reference point in the process of screening for characters.

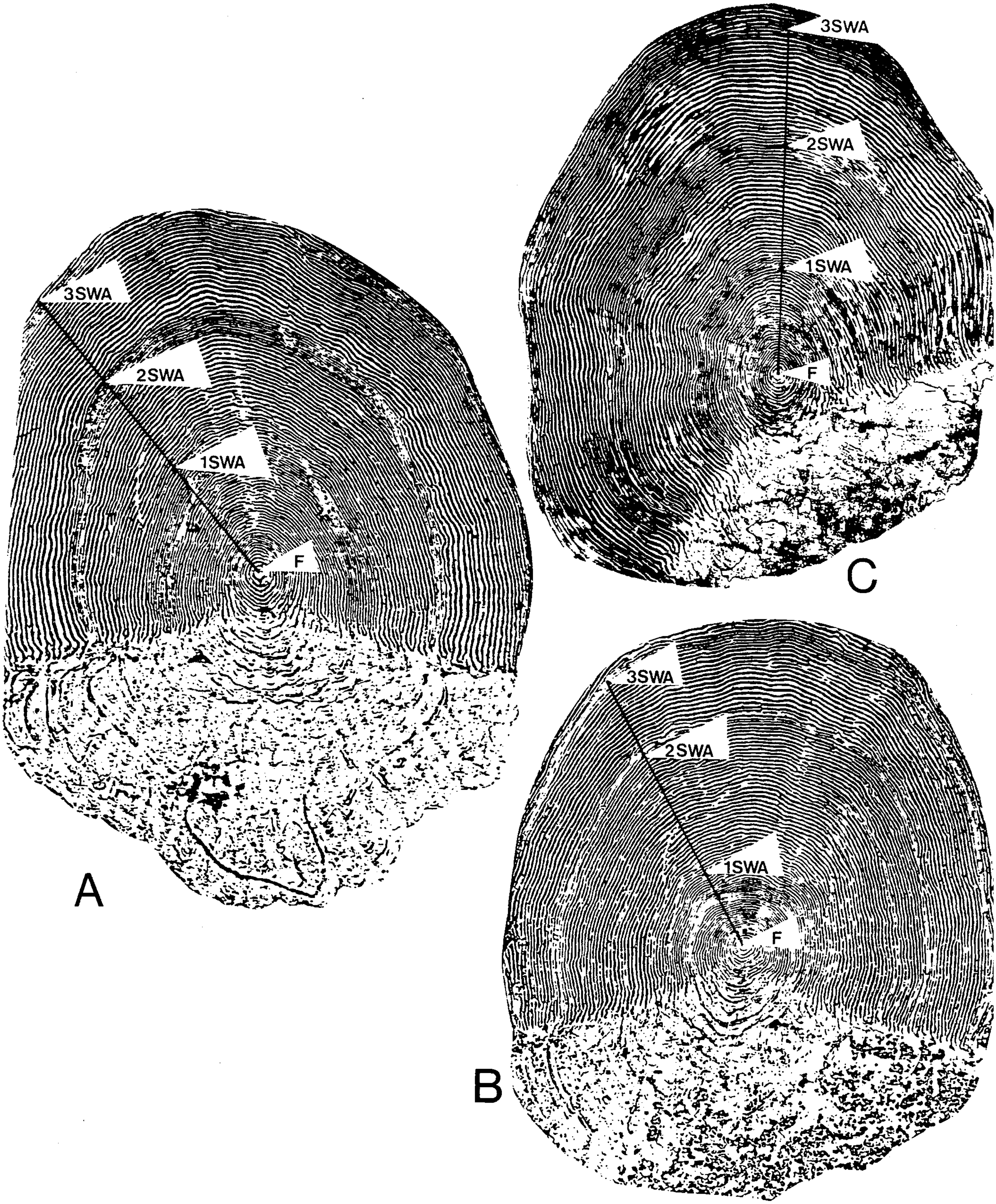

Figure 4. Position of the first marine annulus (1SWA) in relation to the focus (F) and the second marine annulus (2SWA): when the distance between the focus and the first marine annulus is (A) greater than, (B) less than and (C) equal to the distance between the first and second marine annulus.

Three characters were identified with circuli abundance and spacing. During numerous years reading scales of known-age hatchery and wild chinook salmon, I observed that scales of hatchery fish often contained evenly spaced freshwater circuli prior to the freshwater check (Fig. 2). Evenly-spaced circuli near the focus likely represents periods of more uniform growth rate common in a hatchery environment (i.e., due to regulated feeding and/or temperature regimes), as opposed to natural stream conditions where food and temperature are often more variable.

Evenly Spaced Circuli: As a result of the above examination of circuli formation (see Results), scales with less than 15 evenly-spaced circuli proximate to the freshwater check were assigned character 5. Character 6 was assigned to scales with more than 20 evenly-spaced circuli.

Unevenly Spaced Circuli: Scales showing unevenly-spaced circuli among the first three to five circuli between the focus and freshwater check with evidence of summer and winter growth in freshwater were assigned character 7. Although this report does not describe patterns of wild fish in particular, we (FML) have commonly observed character 7 on scales of wild chinook salmon that over-winter in freshwater (sub_2). Unlike hatchery chinook salmon that are reared under controlled conditions for accelerated growth, an uneven appearence of circuli is frequently observed on scales of wild fish (summer and winter circuli growth ridges)(cf., Figs. 2 and 3). Some circuli appear to be formed during periods of more rapid growth, as they are similar in appearance to typical "summer" circuli, and are followed by more closely-spaced "winter-type" circuli. This scale pattern often appeared on scales of wild stocks of known and unknown origin, and likely represents an entire seasons' growth (i.e., summer and winter growth as well as an annulus formation in freshwater).

Uneven spacing of freshwater circuli may also occur on scales from chinook salmon released from hatcheries that remain in the river or estuary for the entire winter (Fig. 3). Scales of some CWT chinook salmon originating from Snootli Creek (Bella Coola River) and Kitimat River hatcheries have shown this pattern, although over-wintering has not been verified at either location (R.T. Hilland, Manager, Snootli Creek Hatchery, and D. McNeil, Manager, Kitimat River Hatchery, pers. comm.)

Scales from chinook salmon deemed wild, or hatchery fish that reared in freshwater subsequent to release also typically contain a zone of freshwater growth following the first annulus and is termed: "spring growth" (Fig. 5). Spring growth is then followed by an "abrupt" increase in the circuli spacing on the scale attributed to increased growth rates in the marine environment. Thus, character 7 was deemed present if summer and winter freshwater circuli were observed.

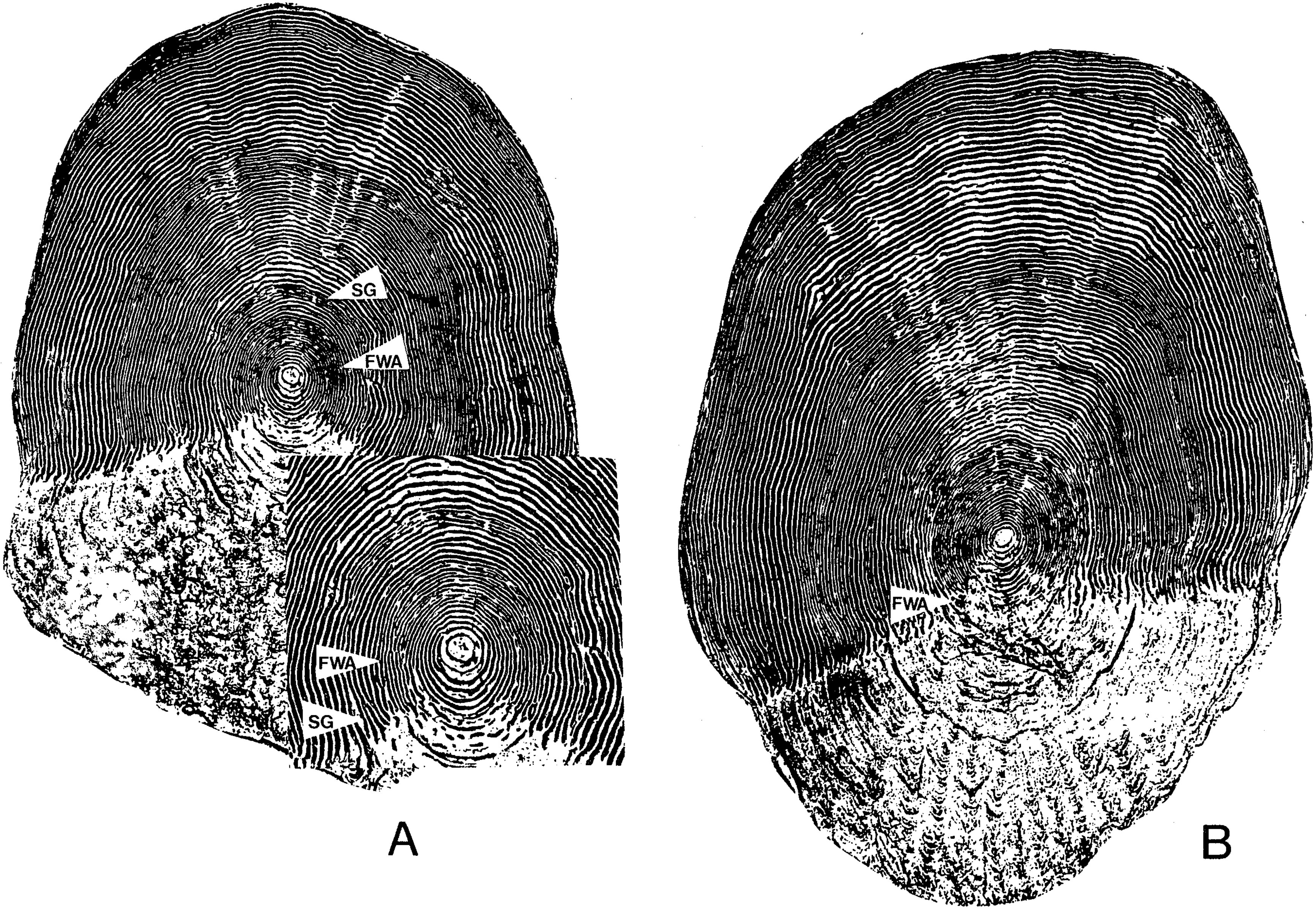

Figure 5. Scales of sub_2 hatchery chinook salmon showing a "cut-out" appearance (A) with freshwater circuli and spring growth pattern (SG), compared with (B) a scale of a sub_2 fish showing freshwater annulus (FWA) formation in the hatchery and no spring growth.

Complete Area Annulus (Cut-Out): Another area examined was the entire region between the focus and first visible annulus (Character 8). On scales of some hatchery fish the area of scale growth formed during its first year appears distinct from the rest of the scale growth pattern resulting in a "cut-out" appearance (Fig. 5). On the distal margin of the cut-out, circuli do not appear to gradually merge into the rest of the growth on the scale, but rather appear to "cross-over" throughout the entire circumference. Similarly, this portion of growth appears as a unit of its own (completely and separately formed), when compared to subsequently formed circuli. Hatchery sub_2 chinook salmon often display this cut-out appearance.

Striations in the Posterior Zone: The posterior zone of the scale is defined as the portion exposed to the elements: a clear area where the usual growth marks or circuli have been eroded. Noticeable markings or ridges on the posterior field, called radial striations (Mosher 1969), were observed on many scales of known-age sub1 and sub2 chinook salmon (Fig. 6). Striations were deemed present (character 9) when they were readily observed as complete, or nearly complete rings or ridges in the posterior zone. Striations usually extend from a check, annulus, or change in growth in the anterior portion of the scale.

Absence of Freshwater Check: Scale character 10 was the absence of a freshwater check (Fig. 7). The freshwater check (a disruption in scale growth) is likely associated with time of hatchery release and/or time of downstream migration and estuary/ocean entry. Scales without a freshwater check usually contain an uninterrupted series of circuli with a gradual increase in spacing. For these scales, the first observed mark, or growth disruption, would be considered the first marine annulus.

Scale Density Variation: Character 11 was the presence of differences in scale texture or thickness which appear as light and dark ridges in the early growth area of the scale (nucleus area). This difference in density has been reported by others, and is not believed to be an artifact of the acetate impressions (Major et al. 1972). Density variation seems to be most prevalent among wild chinook salmon, with hatchery stocks frequently showing a more uniform texture (Fig. 8).

Scale Area Distal to Freshwater Check

The ability to differentiate between a freshwater annulus and a check is critical to the recognition of scale characters 12-16. In addition to character descriptions, the following sections prescribe a means of identifying annuli and checks based on patterns of early marine scale growth.

Plus Growth: Scale character 12, presence of plus or spring growth, was identified on scales by the occurrence of 5 to 7 freshwater circuli following

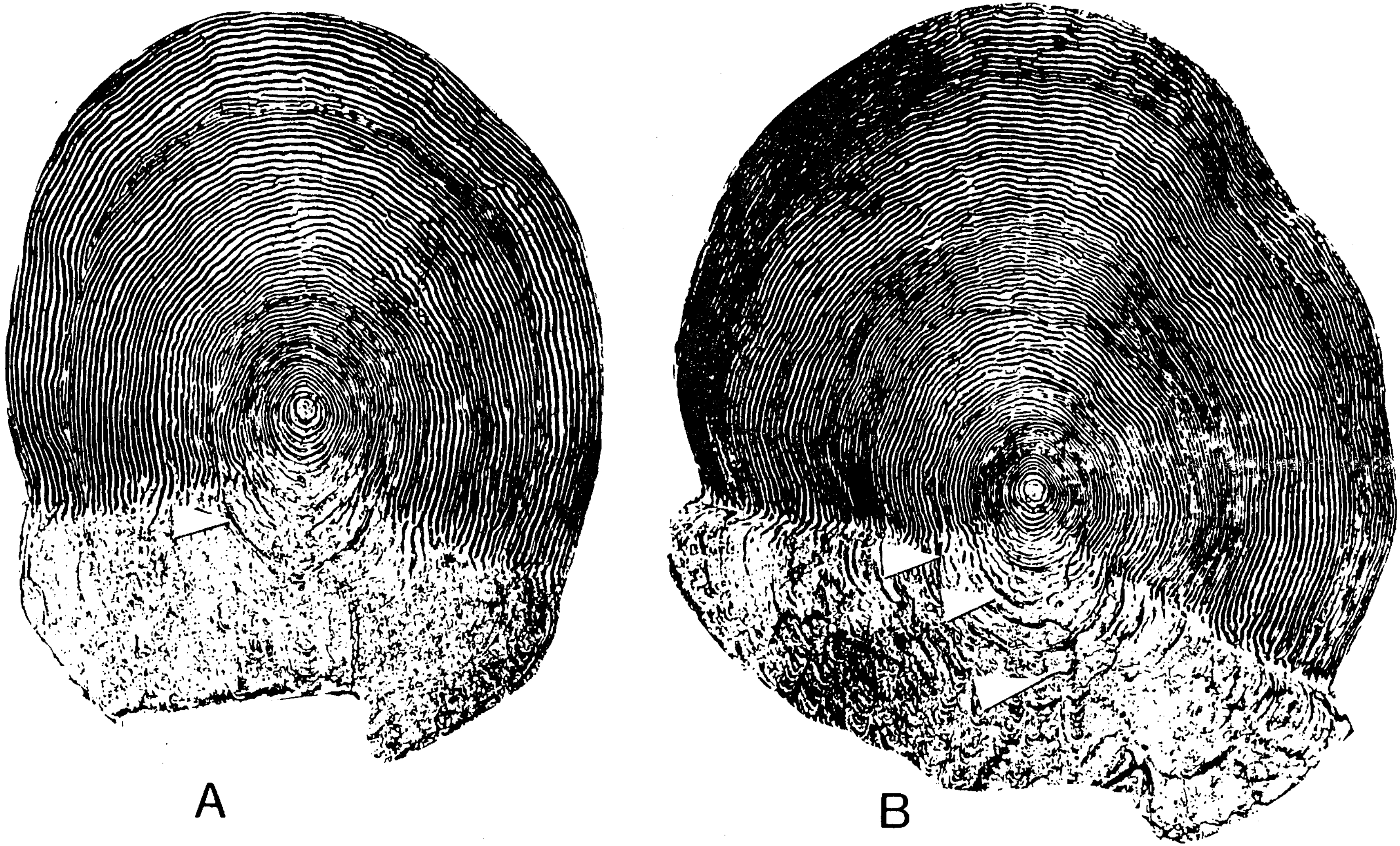

Figure 6. Chinook salmon scales showing a single (A) and numerous (B) striations in the posterior zone associated with growth checks in the anterior zone.

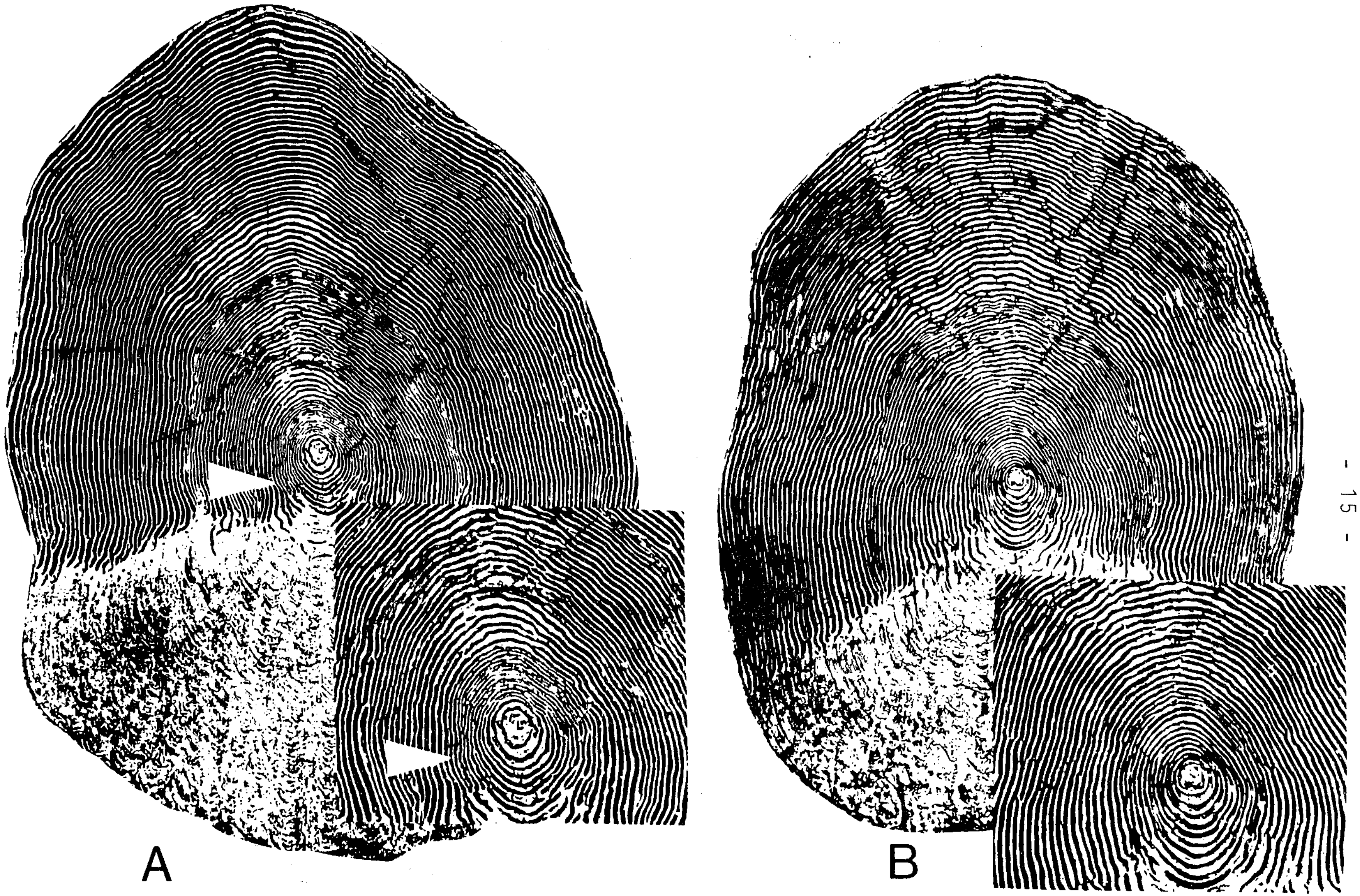

Figure 7. Comparison of sub_1 chinook salmon scales with (A) and without (B) a visible freshwater check (transition between freshwater and marine growth).

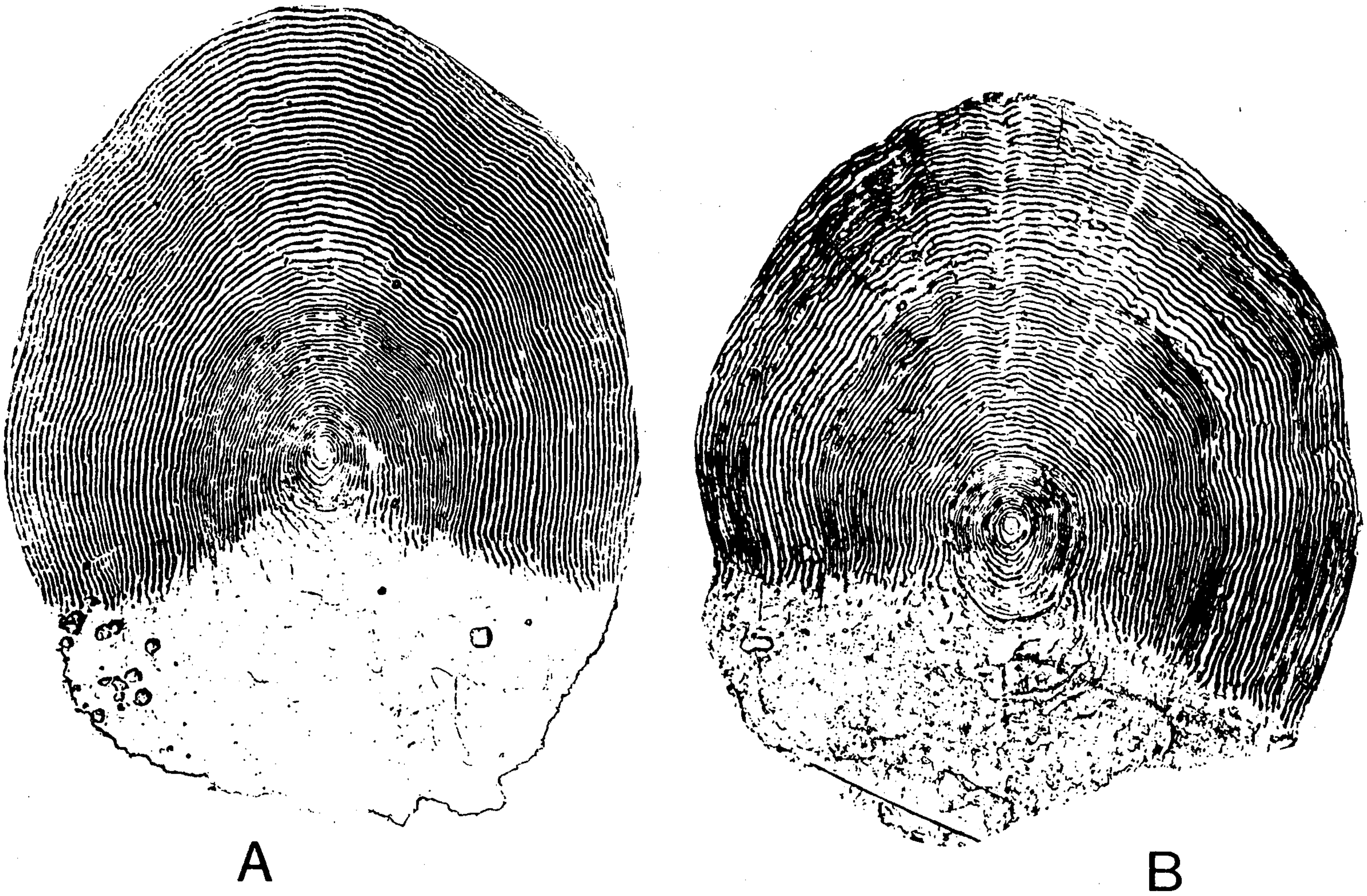

Figure 8. Chinook salmon scales showing no significant variation in scale texture or density (A) and a variation in scale density (B).

the freshwater annulus (Fig. 5). Although timing of annulus formation and subsequent plus growth may vary widely (ie., Major et al. 1972), scales of over-wintering wild or hatchery juvenile chinook salmon on file in the FML scale bank, consistently show evidence of annulus and/or spring growth formation among samples obtained in April and May. Spring growth is easily recognized by the change in spacing from the narrow winter circuli to much wider spacing associated with spring growth, particularly among scales of known-age sub_2 chinook that over-wintered in a hatchery and were released between March and May.

Marked Change in Circuli Spacing: Character 13 is the presence of an abrupt change in spacing of circuli resulting in a change in growth rate from fresh to salt water (Fig. 9). Time of hatchery release (ie., early, mid-summer or late) is generally associated with this marked change in circuli spacing. Circuli formed after release were often more widely spaced, similar to circuli spacing of scale growth during ocean residency.

Gradual Change in Circuli Spacing: Two scale characters were identified with gradual changes in circuli spacing: 1) gradual change in spacing with the point of widest spacing approximately mid-way between the focus and first marine annulus (character 14, Fig. 10); and 2) gradual change in spacing with widest spacing occurring near the first marine annulus (character 15). Increased spacing of circuli was assumed to have formed in the salmon's first year during the period of saltwater acclimation (estuary growth) and/or ocean residency (saltwater growth). The largest increase in circuli spacing occurs on scales of some chinook salmon at approximately one-half the distance from the focus to the first marine annulus (ie., mid-way through their first year), and close to the first marine annulus in others.

No Change in Circuli Spacing: Scale character 16 was identified as even, regular spaced circuli between the freshwater check and first marine annulus (Fig. 10). Where spacing of marine circuli does not change, circuli formed during the entire first year tend to give an even and regular appearance. Scales of some chinook salmon exhibited this even, regular circuli growth between the focus and the first marine annulus, with no evident widening of circuli at either mid-point or close to the first marine annulus.

TESTING OF SCALE CHARACTERS TO DIFFERENTIATE SUB_1 AND SUB_2 CHINOOK SALMON

The 280 chinook salmon scales were examined for each of the 16 scale characters and then assigned a total and freshwater age by the author without prior knowledged of true age and life history. Presence of each of the 16 scale characters and the designated age was then cross-referenced with the true freshwater age based on CWT records.

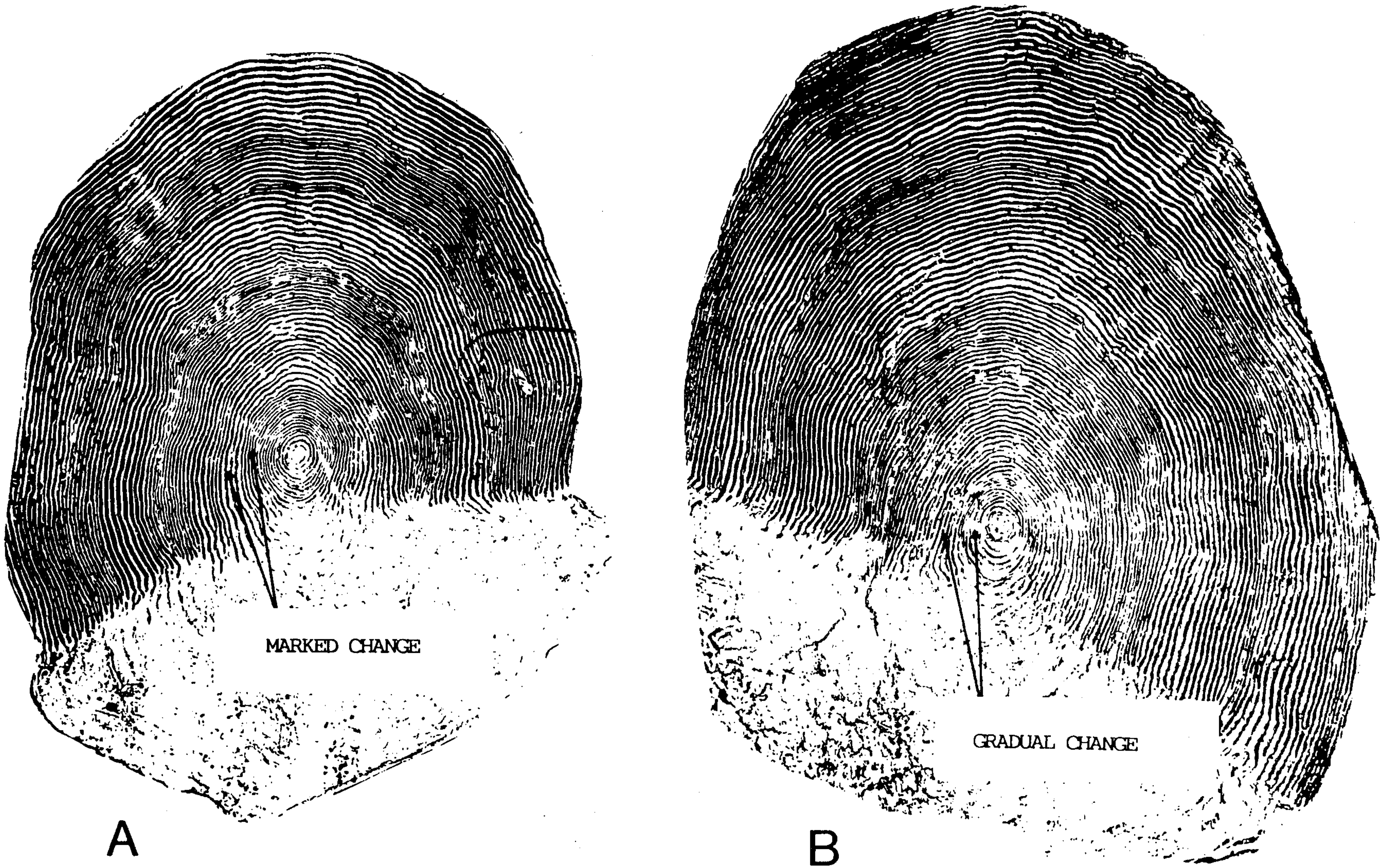

Figure 9. Chinook salmon scale showing a marked change in circuli spacing between freshwater and marine growth zones (A) compared to a scale showing a gradual change or increase in circuli spacing (B).

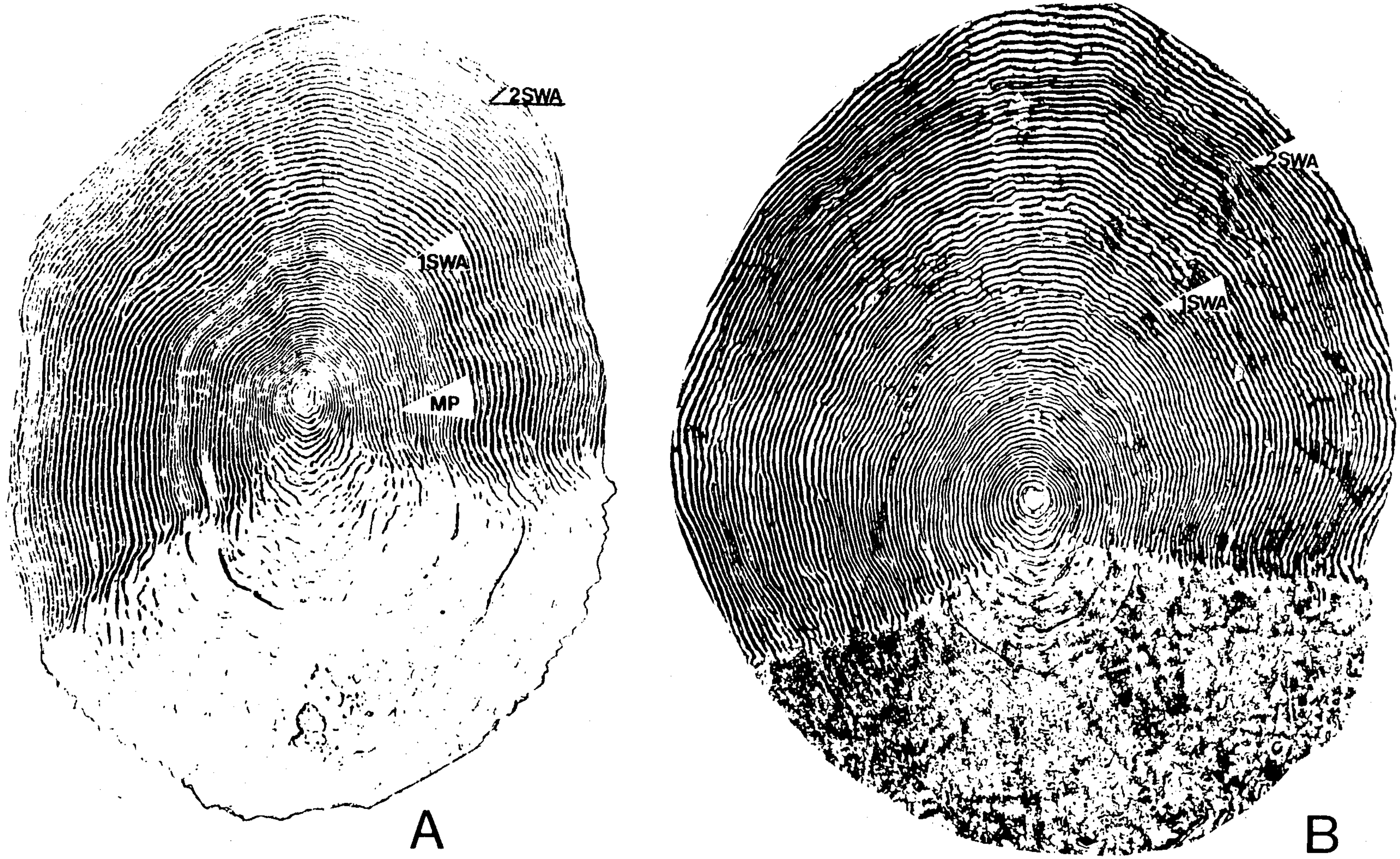

Figure 10. Chinook salmon scales showing a change in circuli spacing with position of widest circuli spacing midpoint (mp) (A), compared to a scale showing no change in circuli spacing (B).

To further assess the usefulness of the scale character procedure for our scale reading operations in particular, the same set of samples were also examined and aged by two experienced and three novice FML scale readers. Each reader independently examined the scales for each of the 16 scale characters and then assigned a freshwater (and total) age by general assessment of the scale characters deemed present without prior knowledge of the true age and life history.

A second freshwater age assignment was made based on a more quantitative procedure. Subsequent to character identification each of the 16 characters were assigned a score based on their relative occurrence on the 238 sub_1 and 42 sub_2 chinook salmon scales as identified by the author. A score of -2 and +2 was assigned to scale characters that were strongly associated with scales of sub_1 and sub_2 fish, respectively, and scale characters with moderate association were assigned scores of -1 and +1 (Table 3). Scale characters occurring with similar frequency were assigned a value of 0. The frequency distribution of the sum of individual character scores per scale was then compared to assess the degree of separation between the two age-groups.

Scale characters deemed present by each scale reader were assigned respective scores (Table 3) and then summed for each scale. Scales receiving a total score of zero or less were designated sub_1, and scales receiving a a total score greater than zero were designated sub_2 (see Results for the score range criteria used).

RESULTS

FORMATION OF FRESHWATER CIRCULI

As expected, there was an increase in the number of freshwater circuli formed with the length of hatchery residence (Figs. 11 and 12). Most (98%) scales of fish released in the spring from hatcheries in both Canada and USA had less than 15 freshwater circuli. Numbers of freshwater circuli ranged from 9 to 23 on scales of sub_1 chinook salmon released in mid-summer (late June to September), 15 to 36 on scales of sub_1 salmon released in late summer and fall, and 15 to 38 on scales of sub_2 chinook salmon released in the spring from hatcheries in the USA. Only early sub_1 chinook salmon were available from Canadian hatcheries because all juveniles are commonly released in May and June subsequent to hatching to more closely coincide with natural times of migration (E.A. Perry, Department of Fisheries and Oceans, Vancouver, pers. comm.). Although chinook salmon released as a sub_1 could overwinter in freshwater, this was not evident from the circuli counts (Fig. 11).

Scales with less than 15 evenly-spaced circuli prior to the freshwater check were therefore assigned character 5, and scales with more than 20 evenly-spaced circuli were assigned character 6. A minimum count of 21 as opposed to 15 were used as the criteria for character 6 because scales with 15-20 circuli were common to both late-release sub_1 and sub_2 salmon.

Table 3. Percentage of sub1 and sub2 chinook salmon scales exhibiting the 16 scale characters, and the score assigned to each scale character.

Scale Character[a]	Sub1 (%)	Sub2 (%)	Score
1. Visual SWA	92	7	-2
2. F-1SWA > 1SWA-2SWA	53	77	0
3. F-1SWA < 1SWA-2SWA	19	5	-1
4. F-1SWA = 1SWA-2SWA	27	5	-1
5. Even < 15	63	5	-2
6. Even > 20	13	77	+1
7. Uneven	1	16	+2
8. Cut-out Circuli	0	74	+2
9. Posterior Striations	13	81	+1
10. No Freshwater Check	6	2	0
11. Optical Density	2	35	+2
12. + Growth	1	40	+2
13. Marked Change in Spacing	15	86	+1
14. Widest Half F-1SWA	35	9	-1
15. Widest Near 1SWA	42	0	-2
16. No Change in Spacing	8	2	0
SAMPLE SIZE	238	42	

[a]Characters defined in Table 2.

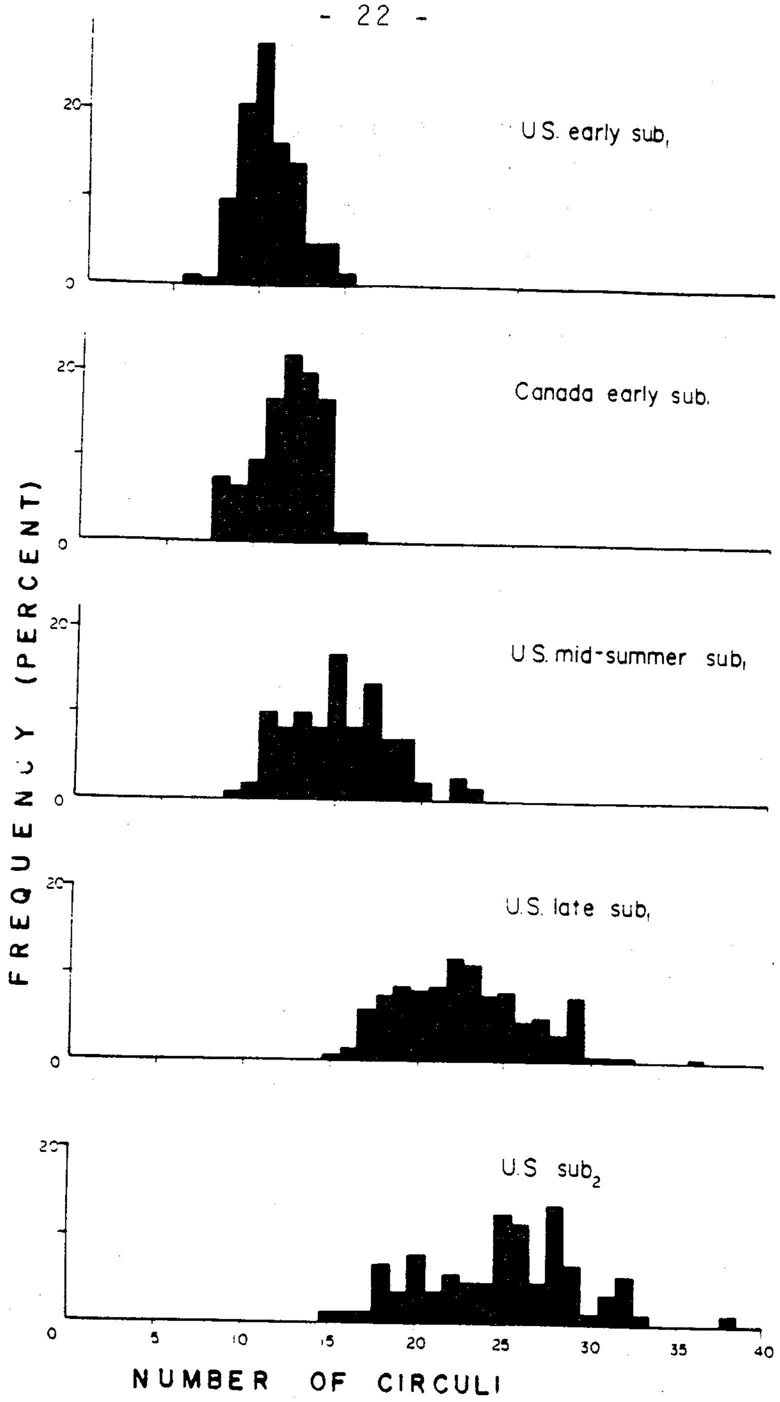

Figure 11. Frequency distribution of numbers of circuli formed before the freshwater check on scales of known-aged chinook salmon released from hatcheries in spring/early summer, mid-summer and late summer/autumn in Canada and USA.

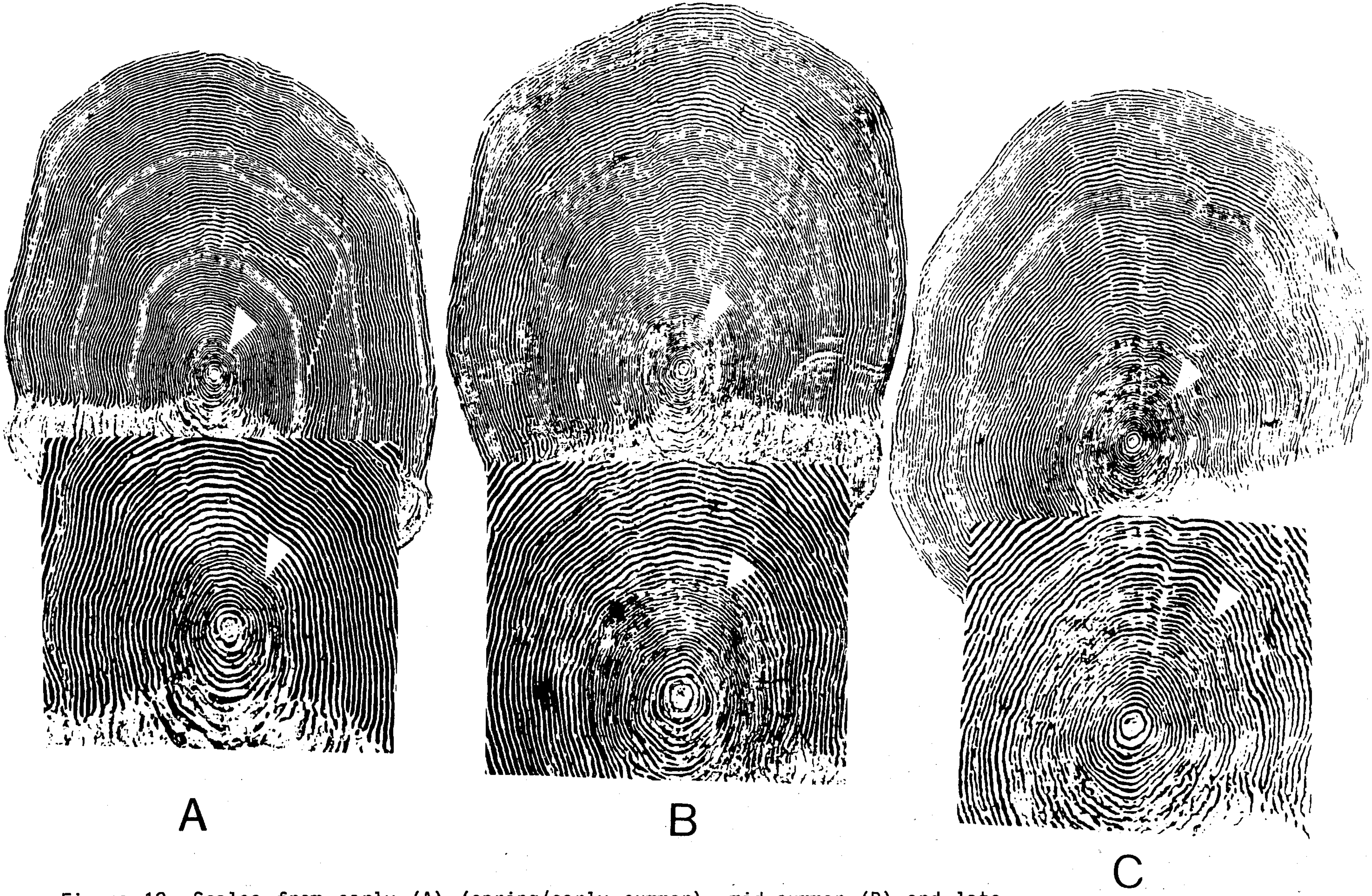

Figure 12. Scales from early (A) (spring/early summer), mid-summer (B) and late (fall) (C) releases of age 4_1 hatchery chinook salmon showing position of release check.

ASSESSMENT OF SCALE CHARACTERS

Of the 16 scale characters examined by the author, six scale characters were more frequently associated with sub_1 fish, seven with sub_2 fish, and three occurred with similar frequency (Table 3). Characters 1, 5 and 15 were found more frequently on scales of sub_1 fish, and characters 7, 8, 11 and 12 occurred much more frequently on sub_2 scales. Characters 3, 4 and 14, and characters 6, 9 and 13 were moderately associated with sub_1 and sub_2 scales, respectively. Scale characters 2, 10 and 16 were observed with similar frequency, and thus were not deemed useful in differentiating between the two freshwater age-groups.

General Area Around the Nucleus

Most (92%) sub_1 chinook salmon scales displayed the characteristic marine annulus (character 1), whereas only 7% of sub_2 chinook salmon scales were identified with a first marine annulus in the general area of the nucleus. The first marine annulus on scales of sub_2 fish was commonly observed at a much greater distance from the focus.

Scale character 2 (F-1SWA >1SWA-2SWA) was identified on 53% of sub_1 and 77% of sub_2 scales. The high frequency of occurrence on scales of both age-groups indicated that this scale character alone may be of little value in differentiating between the two freshwater age groups.

Scale character 3 (F-1SWA < 1SWA-2SWA) was identified on 19% of the sub_1 chinook and on 5% of the sub_2 chinook. The moderate frequency of occurrence among sub_1 fish and low occurrence among sub_2 fish indicates this character is more closely associated with growth characteristics of sub_1 salmon.

Scale character 4 (F-1SWA = 1SWA-2SWA) was also more indicative of sub_1 than sub_2 chinook salmon, with frequency of occurrences between the two age groups similar to that observed for character 3. Character 4 was identified on 27% of sub_1 and 5% of sub_2 scales.

Scale Area Proximate to Freshwater Check

Scale character 5 (EVEN < 15) was easily identified and more strongly asssociated with sub_1 (63%) than sub_2 (5%) chinook salmon. This character seemed to be indicative of early and mid-summer releases of sub_1 hatchery fish.

Although character 6 (EVEN > 20) was readily identified and strongly associated with sub_2 chinook salmon (77%), the character also occurred on 13% of sub_1 fish. The occurrence of the character on the sub_1 fish appeared to be associated with late hatchery release (Fig. 11 and 12).

As expected character 7, the presence of unevenly spaced ciruli with evidence of summer and winter growth within the freshwater zone (indicating overwintering in freshwater), occurred more frequently on scales of sub_2 than sub_1 fish. Although more strongly associated with sub_2 fish, character 7 was only identified on 16% of sub_2 scales compared to 1% of sub_1 scales. The low occurrence on scales of sub_2 salmon may be attributed to differences in growth characteristics between hatchery and wild chinook salmon. Character 7 has been frequently observed on scales of wild sub_2 chinook salmon in the FML.

Scale character 8 (cut-out appearance of freshwater circuli) occurred on 74% of sub_2 chinook salmon scales. Scales from sub_2 hatchery chinook salmon commonly released in the spring, showed evidence of spring growth after the formation of the fresh-water annulus. This spring growth occurred in 96% of the sub_2 scales read and was used to identify this scale characteristic. Many of these scales had circuli patterns which appeared to include a freshwater annulus plus additional freshwater growth. This added growth occurred immediately following the freshwater annulus, but prior to the release check. The appearance of these extra circuli added to the cut-out appearance, as they remained visibly intact and enclosed the first year's growth (Fig. 5).

Posterior striations (character 9) were more frequently observed on scales of sub_2 (81%), than sub_1 (13%) chinook salmon. Their occurrence did not appear to be associated with meaningful scale characteristics in the anterior zone and could indicated either an annulus or a release check.

Scale character 10 (absence of a freshwater check) was observed on very few scales, regardless of age-group, and thus was not used to differentiate between freshwater age-groups. Only 6% of sub_1 and 2% of sub_2 chinook had no visible check between the freshwater and marine growth zones. Some difficulty was encountered assessing the apparent change in circuli growth on scales of chinook salmon released as sub_2 from U.S. hatcheries in March. Hatchery growth evident on these scales did not indicate a definite release check or a freshwater annulus. I believe that in some cases, the formation of a freshwater annulus in the hatchery may coincide with time of release.

Scale texture or density differences (character 11) occurred on a moderate number of sub_2 scales (35%), but was rarely observed on scales of sub_1 chinook salmon (2%). The presence of this character was often indicated by a heavier, darker early freshwater growth. In contrast, most scales of sub_1 chinook salmon released during their first year had more lightly-coloured images or less "deeply-grooved" circuli (Fig. 8).

Scale Area Distal to Freshwater Check

Scale character 12 (plus or spring growth in freshwater) was observed on 40% of sub_2 scales, but on only 1% of sub_1 chinook salmon scales. Most wild and hatchery chinook salmon that over-wintered in freshwater showed a check on their scales at this time of growth and usually some spring or plus growth as shown in Figure 5. However, scales of some sub_1 chinook contained an evident check followed by several additional or transitional circuli at the approximate time of migration to the ocean. Therefore caution should be exercised to ensure this check and subsequent circuli are not interpreted as a freshwater annulus with plus growth.

A marked change in circuli spacing distal to the freshwater check (character 13) was one of the more easily identified characters and most strongly associated with sub_2 chinook salmon (86%). Slightly wider-spaced circuli were observed on the scales of sub_1 chinook of early, mid-summer and late releases, and accounted for the occurrence of this character on 15% of sub_1 scales. Most scales of sub_1 chinook salmon, however, had a more gradual increase in spacing between circuli, and did not show a "marked change".

Both scale characters 14 and 15, associated with gradual increases in circuli spacing, occurred more frequently on scales of sub_1 than sub_2 chinook salmon. Gradual increase to widest spacing at approximately halfway between the focus and first marine annulus (character 14) was identified on 35% of sub_1 and 9% of sub_2 fish. Gradual change with widest circuli spacing near the first marine annulus (character 15) was observed only on sub_1 fish, at 42% occurrence. Scale character 16 (no change in circuli spacing) was rarely observed on scales of either age-groups. Only 8% of sub_1 scales and 2% of sub_2 scales were identified without a change in spacing of circuli laid down after the freshwater check (Fig. 10). With the low incidence, character 16 was not considered useful in differentiating between freshwater age-groups.

CHARACTER IDENTIFICATION AND ACCURACY OF AGE DESIGNATION

Test scale readers did not identify the 16 scale characters at the same rate as the author. The (two) experienced readers having two to three years experience, identified seven scale characters at a rate similar to the author, whereas nine characters were observed at a significantly different rate (Table 4). The (three) inexperienced scale readers with approximately one month of training observed fifteen of the sixteen scale characters at frequencies that differed significantly (Table 4) from those observed by the author.

Despite the low agreement on the occurrence of individual scale characters, scale readers designated correct freshwater age by general assessment of characters with higher consistency (Table 5). Both freshwater age-groups were aged with a high degree of accuracy by the author, but both groups of test scale readers aged sub_1 with higher accuracy than sub_2 fish. The two experienced readers correctly aged 92% and 97% of the sub_1 age-group, but only 59% and 63% of the sub_2 scales. Accuracy by the three inexperienced readers ranged from 84% to 90% for sub_1 and 74% to 91% for sub_2 chinook salmon.

Table 4. Percentage of chinook salmon scales identified with each of 16 characters by two experienced and three inexperienced chinook salmon scale readers relative to readings by the author.

Scale[a] Character Number	Author	Experienced Readers				Inexperienced Readers				
		1	2	X^2	S[b]	1	2	3	X^2	S[b]
1	79	85	83	2.7	NS	28	53	80	210.9	*
2	56	43	28	37.8	*	41	54	26	61.3	*
3	17	34	50	57.8	*	15	12	11	5.9	NS
4	24	23	23	0.2	NS	39	35	62	85.0	*
5	54	48	66	14.5	*	72	43	57	47.7	*
6	22	39	8	52.5	*	19	13	37	47.6	*
7	4	14	1	33.8	*	6	15	12	29.7	*
8	11	14	17	3.0	NS	1	23	18	69.2	*
9	24	16	19	3.8	NS	12	21	20	12.9	*
10	6	3	1	9.4	*	7	23	2	77.6	*
11	7	9	9	1.0	NS	1	5	9	23.0	*
12	7	3	4	4.4	NS	1	10	11	26.5	*
13	26	25	2	5.9	NS	27	44	20	42.4	*
14	31	29	69	81.4	*	12	32	54	105.8	*
15	36	40	14	35.6	*	14	14	24	52.3	*
16	7	2	1	17.9	*	43	3	0	288.0	*
N	280	195	195			279	280	243		

[a]See table 2 for character descriptions.

[b]S=statistical significance: NS-not significant, *=P<0.05.

Table 5. Accuracy of freshwater and total age designations for chinook salmon of known age (CWT) by the author, two experienced scale readers, and three inexperienced scale readers based on: (a) general assessment of scale characters present; and (b) the scoring procedure.

Reader	Number of Scales Read	Percentage Correct				
		Sub1		Sub2		
		General	Score	General	Score	Total Age
		EXPERIENCED READERS				
Author	280	100	97	95	98	99
1	195	97	96	63	63	95
2	195	92	92	59	58	Not Assigned
		INEXPERIENCED READERS				
3	279	89	92	74	58	92
4	280	84	81	91	81	88
5	243	90	90	75	75	91
Average[1]		90	89	73	67	

[1]All readers combined (excluding author).

Although most scale characters were identified to some extent on scales of both freshwater age groups by the author (Table 3), the sum of the scale character scores produced a strong separation between the two freshwater age-groups (Fig 13). Most sub_1 scales received a negative cumulative score and the majority of sub_2 scales received a positive score. Six of 238 sub_1 fish (2.5%) and one of 42 sub_2 fish (2.4%) were incorrectly identified by the cumulative score procedure.

On average, age designation by general assessment was more accurate than by the cummulative score method (Table 5). Collectively, the test scale readers correctly aged 90% of sub_1 fish and 73% of the sub_2 fish using general assessment of scale characters. In comparison, 89% of sub_1 and 67% of sub_2 chinook salmon were correctly aged using the cumulative score method.

DISCUSSION

To our knowledge, the scale character procedure described in this report is the first favourable attempt to identify freshwater age of chinook salmon. Koo and Isarankura (1967) presented a single criterion method, (comparison of first and second year marine growth), for identifying freshwater age on scales of chinook salmon, but made no attempt in assessing accuracy of the technique. Godfrey et al (1968) concluded that there would always be considerable disagreement in interpretations, indicating the importance of trained and experienced readers, also suggesting that readers compare the processes each uses for interpretation. More recently, Meyers (1984) employed five scale characters to differentiate between freshwater age, but reported that no single character or set of characters accurately identified freshwater age.

Identification of scale characters in this study varied in difficulty among the 280 scales examined, and most characters occurred to some extent on scales of both freshwater age-groups. For example, characters such as a marine annulus in the general area of the nucleus (character 1), which has been documented as an indicator of sub_1 fish (Koo and Isarankura 1967), were also observed occasionally on scales of sub_2 fish. Similarly, the relatively high occurrence of scale character 2 (F-1SWA > 1SWA-2SWA) was unexpected among sub_1 fish, as this criteria has been used frequently to differentiate between freshwater age-groups of hatchery (Koo and Isarankura 1967; Van Alen and Marshall 1983; Meyers 1984) and wild chinook salmon (Tutty and Yole 1978). Generally, if the first marine annulus was near the focus it was identified as a sub_1 or "ocean-type" and if the first marine annulus was a large distance from the focus the scale was designated sub_2 or "stream-type". The appearance of a check demarcating the end of freshwater growth, however, can be mistaken for an annulus (Koo and Isarankura 1967). Using additional scale characters as prescribed in this report (i.e., characters 1, 8, 11 and 13) likely reduces such ageing errors by (inexperienced) scale readers.

Recognition of the 16 scale characters and derivation of freshwater age was not consistent among readers. Both groups of test readers, but particularly the inexperienced readers, had difficulty recognizing scale characters at the same rate as the author. However, it appears the inexperienced readers used the characters they recognized to make their aging designations, whereas the experienced readers appeared to have greater difficulty in putting aside their past experience in aging methods as demonstrated by test results

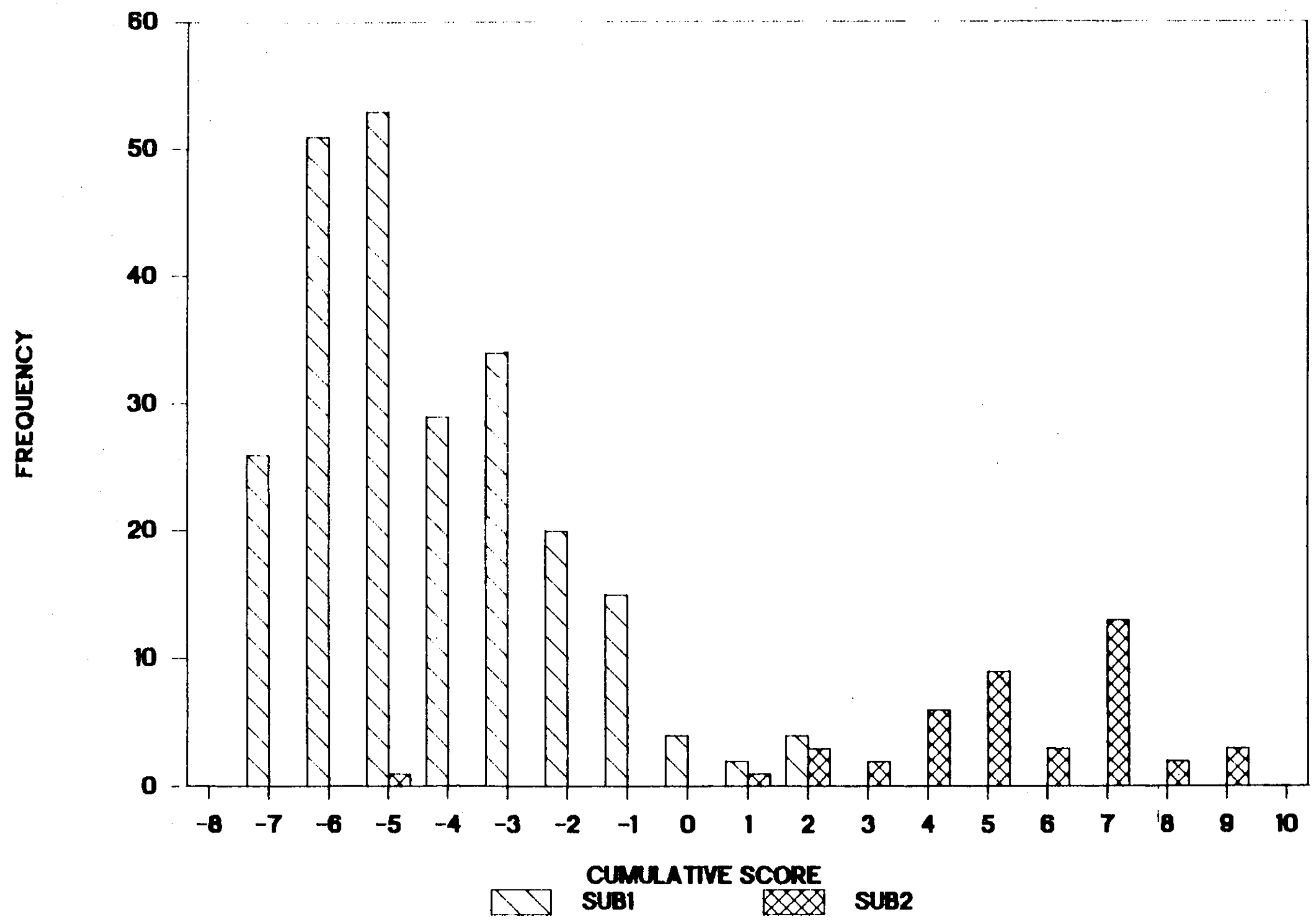

Figure 13. Frequency distributions of total scores of scale characters for known-age sub_1 and sub_2 chinook salmon.

(Table 5). These results indicate readers should be trained and experienced in interpreting scales of chinook salmon of known age and life history to improve their accuracy and precision in identifying scale characters, and in turn, freshwater age.

Although frequency of scale character observations differed significantly among readers, the accuracy with which they correctly aged chinook salmon was more consistent. Based on the collective results of all readers, the accuracy of the procedure to identify sub_1 salmon does not appear to be highly sensitive to moderate errors in identifying individual scale characters. Alternatively, errors in identifying characters may have caused the low accuracy in ageing sub_2 fish by four of the five test readers. The lower accuracy in ageing the sub_2 salmon by the scoring method indicates there may be a subset of the 16 (13) scale characters that differentiate between the two freshwater age-groups with higher consistency. A subsequent report will include the results of exploring combinations of scale characters for optimum discrimination of sub_1 and sub_2 chinook salmon.

A more precise means of scale character measurement using a digitizer would not likely have improved character identification. Several of the scale characters used are not amenable to conventional digitizing techniques. Most characters were simply identified by presence / absence. Other characters were not necessarily on the 45° angle, but rather, were examined for their presence by general inspection of the entire scale. Thus, I believe that the qualitative approach can be used successfully to identify freshwater age of chinook salmon once scale readers have acquired the necessary experience.

The procedure described herein seems most applicable for identifying freshwater age of mixed-stocks of hatchery origin. Once sufficient numbers are obtained, I plan to assess the procedure specifically with wild chinook salmon of known age. With the ever-increasing numbers of hatcheries, enhancement programs and changes in rearing procedures, characters on scales of chinook salmon of known age and life history should be re-examined regularly. Although improvements in identifying sub_2 salmon would be desirable, I believe that the procedure can identify freshwater age of chinook salmon with sufficient accuracy for assessing brood year production and freshwater life history for management purposes.

ACKNOWLEDGEMENTS

I thank S. Charkow and B. Chan for preparing the scale samples, N. Davidge, P. Von Hahn, D. Gillies, D. Herriott, and I. Ronalds for participating in the scale reading tests, and numerous staff of the Department of Fisheries and Oceans for obtaining the scale samples. L. Lapi provided coded-wire tag summaries, and the point score procedure was suggested by T. Webb. J. Hillaby, J. Sneva, C. Knudsen, B. Van Alen, F.E.A. Wood, and two anonymous reviewers offered comments and advice on former versions of the manuscript. This report was prepared by V. Lewynsky, Western Renewable Resources, 100 Mile House, B.C., and reviewed by M. Birch, J. Till and C. Gosselin.

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A P P E N D I X

Appendix Table 1. List of scale numbers, coded-wire tag codes and release information for 1983 chinook samples used in the age validation test.

Sampling Location	Scale Book	Scale No.	Coded-wire Tag Code Ag/D1/D2	Production Area	Hatchery (type)	Release Site	Release Date	Number Tagged	Release Weight (g)
Vancouver	30	8	02.16.00	GSVI	Nanaimo R. CDP (prod.)	Nanaimo	June 1981	72,600	4.4
Prince Rupert	104	17	02.16.00	GSVI	Nanaimo R. CDP (prod.)	Nanaimo R.	June 1981	72,600	4.4
Prince Rupert	18	4	02.16.01	THOM	Wild	Shuswap R. Lower	June 1980	45,400	2.4
Prince Rupert	6	14	02.16.06	SWVI	Robertson Cr. (expt.)	Robertson Cr.	June 1979	27,300	4.1
Prince Rupert	18	19	02.16.15	SWVI	Robertson Cr. (prod.)	Robertson Cr.	June 1979	76,400	5.5
Prince Rupert	13	4	02.16.35	SWVI	Robertson Cr. (prod.)	Robertson Cr.	June 1979	74,700	5.6
Prince Rupert	4	15	02.16.61	SWVI	Robertson Cr. (prod.)	Robertson Cr.	May 1981	151,300	6.1
Prince Rupert	13	20	02.16.61	SWVI	Robertson Cr. (prod.)	Robertson Cr.	May 1981	151,300	6.1
Prince Rupert	9	18	02.16.61	SWVI	Robertson Cr. (prod.)	Robertson Cr.	May 1981	151,300	6.1
Prince Rupert	9	23	02.16.61	SWVI	Robertson Cr. (prod.)	Robertson Cr.	May 1981	151,300	6.1
Prince Rupert	6	3	02.17.32	CCST	Snootli Cr. (prod.)	Atnarko R.	June 1979	79,800	3.2
Prince Rupert	17	9	02.17.32	CCST	Snootli Cr. (prod.)	Atnarko R.	June 1979	79,800	3.2
Prince Rupert	9	5	02.17.32	CCST	Snootli Cr. (prod.)	Atnarko R.	June 1979	79,800	3.2
Vancouver	44	5	02.17.35	GSML	Capilano R. (prod.)	Capilano R.	May 1981	74,300	5.9
Prince Rupert	9	4	02.17.35	GSML	Capilano R. (prod.)	Capilano R.	May 1981	74,300	5.9
Prince Rupert	18	13	02.17.58	GSVI	Quinsam R. (prod.)	Quinsam R.	June 1980	51,800	7.2
Prince Rupert	13	1	02.17.59	GSVI	Quinsam R. (prod.)	Quinsam R.	May-June 1979	97,300	6.5
Prince Rupert	18	3	02.17.59	GSVI	Quinsam R. (prod.)	Quinsam R.	May-June 1979	97,300	6.5
Vancouver	6	13	02.18.01	GSVI	Chemainus R. (expt.)	Chemainus R.	June 1980	28,300	6.8
Prince Rupert	9	20	02.18.05	SWVI	Robertson Cr. (expt.)	Robertson Cr.	June 1980	20,700	4.3
Prince Rupert	6	6	02.18.06	SWVI	Robertson Cr. (both)	Robertson Cr.	June 1980	20,900	4.5
Prince Rupert	17	14	02.18.06	SWVI	Robertson Cr. (both.)	Robertson Cr.	June 1980	20,900	4.5
Vancouver	30	20	02.18.27	SWVI	Robertson Cr. (prod.)	Robertson Cr.	June 1980	76,800	UK
Prince Rupert	13	19	02.18.29	SWVI	Robertson Cr. (prod.)	Robertson Cr.	June 1980	82,100	6.0
Prince Rupert	17	4	02.18.29	SWVI	Robertson Cr. (prod.)	Robertson Cr.	June 1980	82,100	6.0
Vancouver	44	10	02.18.30	GSML	Capilano R. (expt.)	Capilano R.	June 1980	73,000	5.7

Source: Pacific Marine Fisheries Commission (1985), and L. Lapi (Pacific Biological Station, Nanaimo).

Appendix Table 1. Continued.

Sampling Location	Scale Book	Scale No.	Coded-wire Tag Code Ag/D1/D2	Production Area	Hatchery (type)	Release Site	Release Date	Number Tagged	Release Weight (g)
Prince Rupert	4	13	02.18.30	GSML	Capilano R. (expt.)	Capilano R.	June 1980	73,000	5.7
Prince Rupert	17	13	02.18.31	GSML	Capilano R. (expt.)	Capilano R.	June 1980	75,500	5.6
Prince Rupert	6	17	02.18.34	GSVI	Big Qualicum R. (prod.)	Little Qualicum R.	June 1980	99,500	6.1
Prince Rupert	18	5	02.18.37	CCST	Conuma R. (prod.)	Conuma R.	May 1980	76,500	2.9
Prince Rupert	6	10	02.18.37	CCST	Conuma R. (prod.)	Conuma R.	May 1980	76,500	2.9
Prince Rupert	13	5	02.18.37	CCST	Conuma R. (prod.)	Conuma R.	May 1980	76,500	2.9
Prince Rupert	18	10	02.18.37	CCST	Conuma R. (prod.)	Conuma R.	May 1980	76,500	2.9
Prince Rupert	6	5	02.18.37	CCST	Conuma R. (prod.)	Conuma R.	May 1980	76,500	2.9
Prince Rupert	6	9	02.18.37	CCST	Conuma R. (prod.)	Conuma R.	May 1980	76,500	2.9
Vancouver	44	4	02.18.39	GSML	Capilano R. (expt.)	Indian R.	June 1980	102,500	6.2
Prince Rupert	18	11	02.18.44	CCST	Kitimat R. (prod.)	Kitimat R.	May 1981	25,700	5.4
Prince Rupert	4	4	02.18.49	SWVI	San Juan R. CDP (prod.)	San Juan R.	June 1980	39,100	3.3
Vancouver	30	2	02.19.40	GSML	Capilano R. (prod.)	Capilano R.	May 1981	37,300	7.6
Prince Rupert	9	3	02.19.41	GSML	Capilano R. (prod.)	Capilano R.	May 1981	42,100	7.6
Vancouver	44	6	02.19.48	GSVI	Puntledge R. (prod.)	Puntledge R. Lower	May 1981	104,000	4.6
Prince Rupert	4	10	02.19.48	GSVI	Puntledge R. (prod.)	Puntledge R. Lower	May 1981	104,000	4.6
Prince Rupert	18	14	02.19.55	GSML	Capilano R. (prod.)	Capilano R.	June 1981	107,125	5.7
Prince Rupert	13	16	02.20.03	SWVI	Robertson Cr. (expt.)	Robertson Cr.	June 1979	27,300	3.9
Vancouver	44	2	02.20.04	GSVI	Chemainus R. (expt.)	Chemainus R.	June 1980	77,600	6.6
Vancouver	44	12	02.20.04	GSVI	Chemainus R. (expt.)	Chemainus R.	June 1980	77,600	6.6
Vancouver	30	19	02.20.50	CCST	Wild	Kitimat R.	May-June 1978	1,600	UK
Vancouver	30	4	02.20.60	GSVI	Cowichan CDP (prod.)	Cowichan R. Upper	May 1980	32,000	2.8
Vancouver	44	8	02.21.51	GSML	Capilano R. (prod.)	Capilano R.	May 1981	35,100	7.7
Prince Rupert	6	21	02.21.52	GSML	Capilano R. (prod.)	Capilano R.	May 1981	36,000	7.8
Vancouver	30	9	02.22.44	GSVI	Big Qualicum R. (prod.)	Little Qualicum R.	May 1981	97,200	4.5
Vancouver	30	1	02.22.44	GSVI	Big Qualicum R. (prod.)	Little Qualicum R.	May 1981	97,200	4.5
Prince Rupert	23	9	03.17.33	LOCO	Wild	Col. R., Bonneville	July 1981	42,900	UK

Appendix Table 1. Continued.

Sampling Location	Scale Book	Scale No.	Coded-wire Tag Code Ag/D1/D2	Production Area	Hatchery (type)	Release Site	Release Date	Number Tagged	Release Weight (g)
Prince Rupert	13	7	04.19.43	SOAK	Deer Mountain (prod.)	Ketchikan Cr. 101-47	May 1981	14,400	24.4
Prince Rupert	18	16	04.19.43	SOAK	Deer Mountain (prod.)	Ketchikan Cr. 101-47	May 1981	14,400	24.4
Vancouver	3	3	05.06.46	LOCO	Abernathy SCDC (prod.)	Abernathy Cr.	Apr-May 1980	114,900	6.5
Vancouver	23	4	05.07.22	WA04	Nisqually	Kalama Cr.	April 1980	33,500	3.9
Prince Rupert	13	11	05.07.25	UPWA	Quinault NFL (prod.)	Cook Cr.	Sept. 1980	7,700	15.1
Vancouver	23	24	05.07.42	LOCO	Spring Ck. HY (prod.)	Columbia R.	May 1981	63,100	6.9
Vancouver	30	11	05.07.43	LOCO	Spring Creek NFH (prod.)	Columbia R.	April 1981	25,700	6.1
Vancouver	31	3	05.07.45	LOCO	Abernathy SCDC (prod.)	Abernathy Cr.	May 1981	63,500	UK
Vancouver	23	13	05.07.46	LOCO	Spring Cr. NFH (prod.)	Columbia R.	April 1981	150,500	6.1
Vancouver	27	1	06.58.22	SACR	Feather R.	Vallejo	June 1981	39,900	9.5
Vancouver	25	1	06.62.15	SACR	Feather R.	Suisun Bay	June 1981	78,300	8.3
Vancouver	27	3	07.17.34	LOCO	Bonneville	Tanner Cr.	Nov. 1980	51,300	33.4
Vancouver	3	9	07.17.34	LOCO	Bonneville	Tanner Cr.	Nov. 1980	51,300	33.4
Vancouver	23	25	07.17.34	LOCO	Bonneville	Tanner Cr.	Nov 1980	51,300	33.4
Prince Rupert	4	11	07.17.34	LOCO	Bonneville	Tanner Cr.	Nov. 1980	51,300	33.4
Vancouver	3	16	07.20.55	WILL	Stayton Pond (prod.)	Willamette R & tribs.	April-June 1980	282,000	5.2
Vancouver	23	20	07.21.56	LOCO	Bonneville (prod.)	Tanner Cr.	April 1981	130,000	6.2
Vancouver	6	14	07.21.59	LOCO	Vanderveldt ponds (prod.)	Tucker Cr. (Young B.)	May 1981	48,900	6.5
Prince Rupert	6	25	07.22.07	LOCO	Bonneville	Tanner Cr.	June 1980	100,700	5.5
Prince Rupert	18	15	07.22.07	LOCO	Bonneville	Tanner Cr.	June 1980	100,700	5.5
Prince Rupert	23	8	07.22.07	LOCO	Bonneville	Tanner Cr.	June 1980	100,700	5.5
Prince Rupert	4	18	07.22.17	WILL	McKenzie	McKenzie R.	March 1981	30,200	75.7
Prince Rupert	109	19	07.22.20	WILL	McKenzie	McKenzie R.	March 1981	35,600	129.7
Vancouver	3	14	07.22.20	WILL	McKenzie	McKenzie R.	March 1981	35,600	129.7
Prince Rupert	76	5	07.22.20	WILL	McKenzie	McKenzie R.	March 1981	35,600	129.7
Vancouver	6	9	07.22.22	WILL	McKenzie	McKenzie R.	March 1981	36,000	49.3
Prince Rupert	9	12	07.22.37	WILL	Willamette (prod.)	Mid Fk Willamette R.	Nov. 1981	29,400	105.6

Appendix Table 1. Continued.

Sampling Location	Scale Book	Scale No.	Coded-wire Tag Code Ag/D1/D2	Production Area	Hatchery (type)	Release Site	Release Date	Number Tagged	Release Weight (g)
Vancouver	44	3	07.22.52	WILL	Marion Forks (prod.)	N. Santiam R., Minto	March 1981	39,700	31.5
Prince Rupert	13	12	07.22.53	WILL	Marion Forks (prod.)	N. Santiam R., Minto	March 1981	42,200	31.7
Vancouver	23	9	07.22.54	WILL	Marion Forks (prod.)	N. Santiam R., Minto	March 1981	48,300	23.0
Prince Rupert	9	1	07.23.03	WILL	Willamette	Mid Fk, Willamette R.	March 1981	31,200	116.4
Prince Rupert	109	15	07.23.05	WILL	Willamette	Mid Fk, Willamette R.	March 1981	29,900	61.4
Prince Rupert	9	14	07.23.05	WILL	Willamette	Mid Fk, Willamette R.	March 1981	29,900	61.4
Prince Rupert	17	12	07.23.05	WILL	Willamette	Mid Fk, Willamette R.	March 1981	29,900	61.4
Prince Rupert	6	22	07.23.05	WILL	Willamette	Mid Fk, Willamette R.	March 1981	29,900	61.4
Vancouver	30	6	07.23.07	WILL	Willamette	Mid Fk, Willamette R	March 1981	31,700	51.0
Prince Rupert	4	21	07.23.07	WILL	Willamette	Mid FK, Willamette R.	March 1981	31,700	51.0
Prince Rupert	104	7	07.23.07	WILL	Willamette	Mid Fk, Willamette R.	March 1981	31,700	51.0
Prince Rupert	6	20	07.23.07	WILL	Willamette	Mid Fk, Willamette R.	March 1981	31,700	51.0
Prince Rupert	6	13	07.23.07	WILL	Willamette	Mid Fk, Willamette R.	March 1981	31,700	51.0
Prince Rupert	13	14	07.23.07	WILL	Willamette	Mid Fk, Willamette R.	March 1981	31,700	51.0
Prince Rupert	6	19	07.23.07	WILL	Willamette	Mid Fk, Willamette R.	March 1981	31,700	51.0
Vancouver	23	3	07.23.29	LOCO	Bonneville	Tanner Cr.	May 1981	75,700	6.7
Vancouver	23	1	07.23.32	LOCO	Klaskanine (prod.)	N FK Klaskanine R.	May 1981	82,100	5.3
Vancouver	23	11	07.23.34	LOCO	Big Cr. (prod.)	Big Cr.	May 1981	46,000	5.9
Vancouver	6	15	07.23.35	WILL	Stayton Pond (prod.)	Willa, Santi Molalla	Apr - June 1981	245,500	6.1
Vancouver	23	16	07.23.35	WILL	Stayton Pond (prod.)	Willa, Santi Molalla	Apr - June 1981	245,500	6.1
Vancouver	31	2	07.23.46	LOCO	Bonneville	Tanner Cr.	May 1981	50,900	6.6
Vancouver	23	7	07.23.46	LOCO	Bonneville	Tanner Cr.	May 1981	50,900	6.6
Prince Rupert	76	18	07.24.19	WILL	Willamette	Mid Fk, Willamette R.	March 1982	30,700	92.7
Prince Rupert	109	18	07.24.19	WILL	Willamette	Mid Fk, Willamette R.	March 1982	30,700	92.7
Vancouver	23	21	07.25.06	LOCO	Bonneville	Tanner Cr.	June 1981	99,600	7.1
Prince Rupert	104	6	07.25.13	WILL	Willamette	Mid Fk, Willamette R.	March 1982	27,400	66.8
Prince Rupert	9	13	07.25.13	WILL	Willamette	Mid Fk, Willamette R.	March 1982	27,400	66.8

Appendix Table 1. Continued.

Sampling Location	Scale Book	Scale No.	Coded-wire Tag Code Ag/D1/D2	Production Area	Hatchery (type)	Release Site	Release Date	Number Tagged	Release Weight (g)
Prince Rupert	104	2	07.25.13	WILL	Willamette	Mid Fk, Willamette R.	March 1982	27,400	66.8
Prince Rupert	6	23	10.22.11	SNAK	Hagerman NFH (prod.)	Snake R.	May 1981	55,700	8.8
Prince Rupert	6	4	11.06.34	WA04	Coll Fisheries (expt.)	Portage Bay	May 1981	19,400	15.4
Vancouver	25	2	11.16.27	WA04	Coll Fisheries (expt.)	Portage Bay	May 1980	18,500	23.4
Vancouver	23	18	11.16.29	WA04	Coll Fisheries (expt.)	Portage Bay	May 1980	20,000	12.2
Prince Rupert	4	20	62.27.04	UPOR	Anadromous, Inc.	Coos Bay	Aug. 1981	7,000	18.5
Vancouver	30	21	63.18.59	LOCO	Wild	Lewis R.	June 1979	23,400	2.3
Vancouver	23	8	63.19.43	WA04	Issaquah (prod.)	Issaquah Cr.	May 1980	120,500	3.6
Vancouver	6	12	63.19.44	WA04	Green R. (prod.)	Green R.	May 1980	119,900	4.3
Prince Rupert	4	6	63.19.48	BRGT	Priest Rapids (prod.)	Columbia R.	May-June 1980	147,100	5.9
Vancouver	27	2	63.20.42	WA01	Samish (expt.)	Samish R.	May 1980	100,500	4.7
Vancouver	23	19	63.20.42	WA01	Samish (expt.)	Samish R.	May 1980	100,500	4.7
Vancouver	23	12	63.20.42	WA01	Samish (expt.)	Samish R.	May 1980	100,500	4.7
Prince Rupert	18	17	63.20.42	WA01	Samish (expt.)	Samish R.	May 1980	100,500	4.7
Vancouver	6	6	63.21.01	WA01	Samish (expt.)	Friday Cr.	May 1980	106,000	4.4
Vancouver	23	17	63.21.01	WA01	Samish (expt.)	Friday Cr.	May 1980	106,000	4.4
Prince Rupert	18	21	63.21.01	WA01	Samish (expt.)	Friday Cr.	May 1980	106,000	4.4
Vancouver	30	3	63.21.02	WA01	Samish (expt.)	Friday Cr.	May 1980	103,000	4.9
Vancouver	3	2	63.21.02	WA01	Samish (expt.)	Friday Cr.	May 1980	103,000	4.9
Vancouver	23	6	63.21.02	WA01	Samish (expt.)	Friday Cr.	May 1980	103,000	4.9
Vancouver	23	15	63.21.02	WA01	Samish (expt.)	Friday Cr.	May 1980	103,000	4.9
Vancouver	3	22	63.21.04	WA04	Minter Cr. (prod.)	Minter Cr.	June 1980	72,400	3.9
Vancouver	25	4	63.21.53	LOCO	Washougal (prod.)	Washougal R.	June 1980	374,600	4.6
Prince Rupert	6	7	63.21.53	LOCO	Washougal (prod.)	Washougal R.	June 1980	314,600	4.6
Prince Rupert	4	5	63.21.53	LOCO	Washougal (prod.)	Washougal R.	June 1980	314,600	4.6
Vancouver	44	11	63.22.54	LOCO	Lower Kalama (prod.)	Fallert Cr.	June 1981	155,300	4.7
Prince Rupert	109	7	63.25.06	LOCO	Cowlitz (expt.)	Cowlitz R.	April 1983	77,500	65.8

Appendix Table 1. Continued.

Sampling Location	Scale Book	Scale No.	Coded-wire Tag Code Ag/D1/D2	Production Area	Hatchery (type)	Release Site	Release Date	Number Tagged	Release Weight (g)
Prince Rupert	18	12	LB.YW.LG	LOCO	Wild	Col. below Bonneville	Jul-Aug 1979	40,400	UK
Prince Rupert	6	11	LB.YW.LG	LOCO	Wild	Col. below Bonneville	Jul-Aug 1979	41,200	UK
Prince Rupert	13	6	LB.YW.LG	LOCO	Wild 78 Br NMFS	Col. below Bonneville	Jul-Aug 1979	40,400	UK
Prince Rupert	17	11	HO	LOCO	Wild	Col. R., Dalton Pt.	Jul-Aug, 1980	40,700	UK
Prince Rupert	6	18	RD.PK.OR	LOCO	Wild	Col. below Bonneville	July 1979	25,600	UK

Appendix Table 2. List of scale numbers, coded-wire tag codes and release information for 1984 chinook samples used in the age validation test.

Sampling Location	Scale Book	Scale No.	Coded-wire Tag Code Ag/D1/D2	Production Area	Hatchery (type)	Release Site	Release Date	Number Tagged	Release Weight (g)
Vancouver	2156	6	02.16.00	GSVI	Nanaimo R. CDP (prod.)	Nanaimo	June 1981	72,600	4.4
Vancouver	2156	14	02.16.61	SWVI	Robertson Cr. (prod.)	Robertson Cr.	April 1981	151,300	6.1
Vancouver	2156	15	02.18.10	GSVI	Big Qualicum R. (expt.)	Big Qualicum R.	May 1981	60,300	4.2
Vancouver	2302	7	02.19.06	THOM	Loon Cr. BCFW (prod.)	Bonaparte R. Lower	May 1981	19,400	2.6
Vancouver	2154	10	02.19.45	GSVI	Chemainus R. (prod.)	Chemainus R.	June 1981	61,800	7.7
Vancouver	2302	20	02.21.34	QCI	Masset CDP (prod.)	Yakoun R.	June 1981	25,800	2.1
Vancouver	2156	3	02.21.50	GSML	Capilano R. (prod.)	Capilano R.	May 1981	37,400	7.7
Vancouver	2302	1	02.21.58	GSVI	Cowichan R. CDP (prod.)	Cowichan R.	June 1981	53,000	2.3
Vancouver	2156	8	02.21.58	GSVI	Cowichan R. CDP (prod.)	Cowichan R.	June 1981	53,000	2.3
Port Hardy	6022	11	02.21.63	LWFR	Chilliwack (prod.)	Chilliwack R.	June 1982	74,000	5.4
Vancouver	2085	18	02.21.63	LWFR	Chilliwack (prod.)	Chilliwack R.	June 1982	74,000	5.4
Vancouver	2093	11	02.21.63	LWFR	Chilliwack (prod.)	Chilliwack R.	June 1982	74,000	5.4
Vancouver	2093	1	02.21.63	LWFR	Chilliwack (prod.)	Chilliwack R.	June 1982	74,000	5.4
Vancouver	2184	10	02.21.63	LWFR	Chilliwack (prod.)	Chilliwack R.	June 1982	74,000	5.4
Vancouver	2156	22	02.21.63	LWFR	Chilliwack (prod.)	Chilliwack R.	June 1982	74,000	5.4
Vancouver	2190	8	02.21.63	LWFR	Chilliwack (prod.)	Chilliwack R.	June 1982	74,000	5.4
Vancouver	2156	21	02.21.63	LWFR	Chilliwack (prod.)	Chilliwack R.	June 1982	74,000	5.4
Vancouver	2190	11	02.21.63	LWFR	Chilliwack (prod.)	Chilliwack R.	June 1982	74,000	5.4
Vancouver	2093	17	02.21.63	LWFR	Chilliwack (prod.)	Chilliwack R.	June 1982	74,000	5.4
Vancouver	2202	5	02.22.05	LWFR	Chehalis (prod.)	Harrison R.	May 1982	43,500	1.6
Vancouver	2184	8	02.22.05	LWFR	Chehalis (prod.)	Harrison R.	May 1982	43,500	1.6
Vancouver	2202	7	02.22.05	LWFR	Chehalis (prod.)	Harrison R.	May 1982	43,500	1.6
Vancouver	2156	23	02.22.05	LWFR	Chehalis (prod.)	Harrison R.	May 1982	43,500	1.6
Vancouver	2190	7	02.22.05	LWFR	Chehalis (prod.)	Harrison R.	May 1982	43,500	1.6
Vancouver	2156	16	02.22.05	LWFR	Chehalis (prod.)	Harrison R.	May 1982	43,500	1.6
Vancouver	2085	10	02.22.05	LWFR	Chehalis (prod.)	Harrison R.	May 1982	43,500	1.6
Vancouver	2184	9	02.22.05	LWFR	Chehalis (prod.)	Harrison R.	May 1982	43,500	1.6

Source: Pacific Marine Fisheries Commission (1985), and L. Lapi (Pacific Biological Station, Nanaimo).

Appendix Table 2. Continued.

Sampling Location	Scale Book	Scale No.	Coded-wire Tag Code Ag/D1/D2	Production Area	Hatchery (type)	Release Site	Release Date	Number Tagged	Release Weight (g)
Vancouver	2005	6	02.22.05	LWFR	Chehalis (prod.)	Harrison R.	May 1982	43,500	1.6
Vancouver	2085	1	02.22.05	LWFR	Chehalis (prod.)	Harrison R.	May 1982	43,500	1.6
Vancouver	2093	2	02.22.05	LWFR	Chehalis (prod.)	Harrison R.	May 1982	43,500	1.6
Vancouver	2160	8	02.23.02	GSVI	Puntledge R. (prod.)	Puntledge R. Upper	June 1982	50,400	6.3
Vancouver	2154	5	02.23.08	GSML	Capilano R. (expt.)	Capilano R.	May 1982	40,000	3.8
Vancouver	2083	11	02.23.09	GSML	Capilano R. (expt.)	Capilano R.	May 1982	42,500	3.9
Vancouver	2156	12	02.23.09	GSML	Capilano R. (expt.)	Capilano R.	May 1982	42,500	3.9
Port Hardy	6022	3	02.24.05	SWVI	Robertson Cr. (prod.)	Robertson Cr.	May-June 1982	51,800	5.1
Vancouver	2154	6	02.24.19	GSVI	Big Qualicum R. (prod.)	Little Qualicum R.	June 1982	81,100	7.0
Vancouver	2302	14	02.24.19	GSVI	Big Qualicum R. (prod.)	Little Qualicum River	June 1982	81,100	7.0
Vancouver	2302	22	03.17.32	BRGT	Wild	Col. R., McNary	July 1981	42,600	UK
Vancouver	2197	10	03.17.33	LOCO	Wild	Col. R., Bonneville	July 1981	42,900	UK
Vancouver	2190	10	03.17.33	LOCO	Wild	Col. R., Bonneville	July 1981	42,900	UK
Vancouver	2093	7	03.17.33	LOCO	Wild	Columbia R.	July 1981	42,900	UK
Vancouver	2197	3	05.05.59	SACR	Tehama Colusa FF (prod.)	Coyote Cr.	April 1981	10,300	2.7
Vancouver	2157	3	05.08.36	UPWA	Quinalt NFH (prod.)	Cook Cr.	July 1981	51,300	9.5
Vancouver	2202	6	05.08.57	WA01	Skookum Cr.	Lummi Bay	June 1982	48,800	5.6
Vancouver	2157	2	05.08.57	WA01	Skookum Cr.	Lummi Bay	June 1982	48,800	5.6
Vancouver	2202	4	05.10.22	SNAK	Hagerman NFH (prod.)	Snake R.	June 1982	78,300	12.1
Vancouver	2160	3	05.10.22	SNAK	Hagerman NFH (prod.)	Snake R.	June 1982	78,300	12.1
Vancouver	2093	12	05.10.22	SNAK	Hagerman NFH (prod.)	Snake R.	June 1982	78,300	12.1
Vancouver	2157	4	05.10.22	SNAK	Hagerman NFH (prod.)	Snake R.	June 1982	78,300	12.1
Port Hardy	6022	10	05.10.23	SNAK	Hagerman NFH	Snake R. Lower Granite	June 1982	80,400	12.1
Vancouver	2085	16	05.10.47	WA04	Grovers Cr.	Grovers Cr.	May 1982	47,500	9.5
Vancouver	2301	2	05.10.50	LOCO	Spring Cr. NFH (prod.)	Spring Cr.	March 1982	151,400	4.1
Vancouver	2156	9	05.10.50	LOCO	Spring Cr. NFH (prod.)	Spring Cr.	March 1982	151,400	4.1
Vancouver	2160	7	05.10.50	LOCO	Spring Cr. NFH (prod.)	Spring Cr.	March 1982	151,400	4.1

Appendix Table 2. Continued.

Sampling Location	Scale Book	Scale No.	Coded-wire Tag Code Ag/D1/D2	Production Area	Hatchery (type)	Release Site	Release Date	Number Tagged	Release Weight (g)
Vancouver	2085	4	05.10.54	LOCO	Spring Cr. NFH	Spring Cr.	Apr-May 1982	48,500	6.5
Vancouver	2184	6	05.10.54	LOCO	Spring Cr. NFH	Spring Cr.	Apr-May 1982	48,500	6.5
Vancouver	2156	25	05.10.55	LOCO	Spring Cr. NFH	Spring Cr.	April 1982	41,300	6.1
Vancouver	2190	15	05.10.57	LOCO	Spring Cr. NFH (prod.)	Umatilla R.	April 1982	102,300	5.7
Vancouver	2093	16	05.10.57	LOCO	Spring Cr. NFH (prod.)	Umatilla R.	April 1982	102,300	5.7
Vancouver	2202	1	05.10.58	LOCO	Abernathy SCDC (prod.)	Abernathy Cr.	Apr-June 1982	90,600	8.3
Vancouver	2093	9	05.10.58	LOCO	Abernathy SCDC (prod.)	Abernathy Cr.	Apr-June 1982	90,600	8.3
Vancouver	2160	9	05.10.58	LOCO	Abernathy SCDC (prod.)	Abernathy Cr.	Apr-June 1982	90,600	8.3
Vancouver	2302	9	06.46.28	SACR	Merced R.	San Joaquin R.	April 1982	48,200	3.4
Vancouver	2190	9	06.58.21	SACR	Feather R.	S.F. Bay, Tiburon	June 1981	46,300	10.1
Vancouver	2202	2	06.58.24	SACR	Feather R.	Vallejo	Aug. 1981	45,200	12.6
Vancouver	2190	4	06.58.30	SACR	Feather R.	Sacra. R. Rio Vista	July 1982	26,300	11.1
Vancouver	2031	2	06.59.05	CALI	Iron Gate	Klamath R., Iron Gate	June 1981	185,900	6.1
Vancouver	2005	4	06.60.27	SACR	Coleman NFH	Battle Cr.	May 1982	41,700	5.7
Vancouver	2302	10	06.60.31	SACR	Coleman NFH	Sacra R., Knights LD	May 1982	44,500	5.9
Vancouver	2085	9	06.62.19	SACR	Coleman NFH	Suisun Bay	May 1982	86,900	6.4
Vancouver	2093	5	06.62.20	SACR	Feather R.	Sacra R., Discov. Pk.	May 1982	85,900	4.8
Vancouver	2154	13	07.17.34	LOCO	Bonneville	Tanner Cr.	Nov. 1980	51,300	33.4
Port Hardy	6022	12	07.21.41	LOCO	Bonneville	Tanner Cr.	Nov. 1981	49,800	48.8
Vancouver	2197	7	07.21.41	LOCO	Bonneville	Tanner Cr.	Nov. 1981	49,800	48.8
Vancouver	2025	22	07.21.41	LOCO	Bonneville	Tanner Cr.	Nov. 1981	49,800	48.8
Vancouver	2197	2	07.21.41	LOCO	Bonneville	Tanner Cr.	Nov. 1981	49,800	48.8
Vancouver	2160	1	07.21.42	LOCO	Bonneville	Tanner Cr.	Nov. 1981	50,700	39.5
Vancouver	2154	2	07.21.43	LOCO	Bonneville	Tanner Cr.	March 1982	50,600	63.1
Vancouver	2157	6	07.21.58	LOCO	SF Klaskanine Pd. (prod.)	SF Klaskanine R.	May 1981	73,200	6.1
Vancouver	2156	4	07.22.07	LOCO	Bonneville	Tanner Cr.	June 1980	100,700	5.5
Vancouver	2031	4	07.22.44	UPOR	Elk River (prod.)	Elk River	Oct. 1980	26,200	40.9

Appendix Table 2. Continued.

Sampling Location	Scale Book	Scale No.	Coded-wire Tag Code Ag/D1/D2	Coded-wire Tag Production Area	Hatchery (type)	Release Site	Release Date	Number Tagged	Release Weight (g)
Vancouver	2156	7	07.23.35	WILL	Stayton Pond (prod.)	Willa, Santi Molalla	Apr-June 1981	245,500	6.1
Vancouver	2184	7	07.23.35	WILL	Stayton Pond (prod.)	Willa, Santi Molalla	Apr-June 1981	245,500	6.1
Vancouver	2031	3	07.23.35	WILL	Stayton Pond (prod.)	Willa, Santi Molalla	Apr-June 1981	245,500	6.1
Vancouver	2302	23	07.24.07	LOCO	Bonneville (prod.)	Tanner Cr.	April 1982	105,900	5.7
Vancouver	2184	3	07.24.07	LOCO	Bonneville (prod.)	Tanner Cr.	April 1982	105,900	5.7
Vancouver	2025	18	07.24.07	LOCO	Bonneville (prod.)	Tanner Cr.	April 1982	105,900	5.7
Vancouver	2301	5	07.24.10	LOCO	Big Cr. (prod.)	Big Cr.	May 1982	131,200	6.1
Port Hardy	6022	2	07.24.25	LOCO	Bonneville	Tanner Cr.	June 1982	100,100	8.9
Vancouver	2083	10	07.25.01	UPOR	Rock Cr.	N Umpqua R.	Oct. 1981	25,500	82.5
Vancouver	2160	5	07.25.06	LOCO	Bonneville	Tanner Cr.	June 1981	99,600	7.1
Port Hardy	6022	7	07.25.07	LOCO	Bonneville	Tanner Cr.	July 1981	102,200	13.0
Port Hardy	6022	16	07.25.07	LOCO	Bonneville	Tanner Cr.	July 1981	102,200	13.0
Vancouver	2301	4	07.25.17	WILL	McKenzie (prod.)	McKenzie R.	Nov. 1981	38,600	82.5
Vancouver	2093	6	07.25.17	WILL	McKenzie (prod.)	Mckenzie R.	Nov. 1981	38,600	82.5
Vancouver	2085	11	07.25.30	WILL	Marion Forks (prod.)	N Santium R.	March 1982	49,200	30.3
Vancouver	2190	13	07.25.35	UPOR	Elk R.	Elk R.	Sept. 1981	14,400	30.5
Vancouver	2302	6	07.25.38	UPOR	Elk River (prod.)	Elk River	Oct. 1981	15,100	43.2
Vancouver	2085	15	07.25.39	UPOR	Elk R.	Chetco R.	Sept. 1981	27,200	32.7
Vancouver	2085	21	07.26.24	LWOR	Cole Rivers	Rogue R.	Nov. 1982	22,200	52.2
Vancouver	2085	12	07.26.62	WILL	Stayton Pond (prod.)	Willa, Santi Molalla	May 1982	265,800	5.2
Vancouver	2093	10	07.26.62	WILL	Stayton Pond (prod.)	Willa, Santi Molalla	May 1982	265,800	5.2
Vancouver	2085	3	07.26.62	WILL	Stayton Pond (prod.)	Willa, Santi Molalla	May 1982	265,800	5.2
Vancouver	2085	5	07.26.62	WILL	Stayton Pond (prod.)	Willa, Santi Molalla	May 1982	265,800	5.2
Vancouver	2085	14	07.26.62	WILL	Stayton Pond (prod.)	Willa, Santi Molalla	May 1982	265,800	5.2
Vancouver	2184	1	07.26.63	LOCO	Bonneville (prod.)	Umatilla R.	April 1982	102,400	4.9
Vancouver	2154	7	07.26.63	LOCO	Bonneville (prod.)	Umatilla R.	April 1982	102,400	4.9
Vancouver	2093	8	07.26.63	LOCO	Bonneville (prod.)	Umatilla R.	April 1982	102,400	4.9

Appendix Table 2. Continued.

Sampling Location	Scale Book	Scale No.	Coded-wire Tag Code Ag/D1/D2	Production Area	Hatchery (type)	Release Site	Release Date	Number Tagged	Release Weight (g)
Vancouver	2197	6	10.22.11	SNAK	Hagerman NFH (prod.)	Snake R.	May 1981	55,700	8.8
Vancouver	2157	1	11.16.46	WA04	Coll Fisheries (expt.)	Portage Bay	April 1982	17,200	6.5
Vancouver	2197	1	11.16.48	WA04	Coll Fisheries (expt.)	Portage Bay	May 1982	13,000	11.9
Vancouver	2302	12	23.16.14	LOCO	Wild	Col. R., Bonneville	Jul-Aug 1982	15,500	UK
Vancouver	2302	18	60.35.04	UPOR	Oregon Aqua-Foods (prod.)	Coos Bay	Nov. 1981	25,000	96.6
Vancouver	2154	1	63.19.43	WA04	Issaquah (prod.)	Issaquah Cr.	May 1980	120,500	3.6
Vancouver	2184	5	63.21.01	WA01	Samish (expt.)	Friday Cr.	May 1980	106,000	4.4
Port Hardy	6022	17	63.21.34	LOCO	Cowlitz (both.)	Cowlitz R.	April 1982	24,000	54.7
Vancouver	2154	9	63.21.34	LOCO	Cowlitz (both)	Cowlitz R.	April 1982	24,000	54.7
Vancouver	2302	15	63.21.34	LOCO	Cowlitz (both.)	Cowlitz R.	April 1982	24,000	54.7
Vancouver	2156	1	63.21.48	LOCO	Washougal (prod.)	Washougal R.	Jul-Sept 1981	28,700	13.2
Vancouver	2302	21	63.21.55	BRGT	Priest Rapids (prod.)	Columbia R.	June 1981	194,600	5.0
Vancouver	2025	21	63.21.55	BRGT	Priest Rapids (prod.)	Columbia R.	June 1981	194,600	5.0
Vancouver	2156	13	63.21.56	LOCO	Cowlitz (prod.)	Cowlitz R.	June 1981	153,200	5.2
Vancouver	2085	6	63.21.56	LOCO	Cowlitz (prod.)	Cowlitz R.	June 1981	153,200	5.2
Port Hardy	6022	5	63.21.58	WA04	Green River (prod.)	Big Soos Cr.	May 1982	211,900	3.5
Vancouver	2160	10	63.22.14	LOCO	Wild	Lewis R.	July 1980	26,400	3.8
Vancouver	2156	5	63.22.33	WA04	Issaquah (prod.)	Issaquah Cr.	April 1981	141,600	3.1
Vancouver	2025	20	63.22.33	WA04	Issaquah (prod.)	Issaquah Cr.	April 1981	141,600	3.1
Vancouver	2085	2	63.22.33	WA04	Issaquah (prod.)	Issaquah Cr.	April 1981	141,600	3.1
Vancouver	2085	13	63.22.35	WA05	George Adams (prod.)	Purdy Cr.	May 1982	73,600	4.4
Vancouver	2302	4	63.22.54	LOCO	Lower Kalama (prod.)	Fallert Cr.	June 1981	155,300	4.7
Vancouver	2156	17	63.22.54	LOCO	Lower Kalama (prod.)	Fallert Cr.	June 1981	155,300	4.7
Vancouver	2160	2	63.22.54	LOCO	Lower Kalama (prod.)	Fallert Cr.	June 1981	155,300	4.7
Vancouver	2093	15	63.22.55	LOCO	Cowlitz (prod.)	Cowlitz R.	June 1981	121,300	5.7
Vancouver	2197	12	63.22.55	LOCO	Cowlitz (prod.)	Cowlitz R.	June 1981	121,300	5.7
Vancouver	2301	1	63.22.56	WA04	Issaquah (prod.)	Issaquah Cr.	May 1982	158,200	3.5

Appendix Table 2. Continued.

Sampling Location	Scale Book	Scale No.	Coded-wire Tag Code Ag/D1/D2	Coded-wire Tag Production Area	Hatchery (type)	Release Site	Release Date	Number Tagged	Release Weight (g)
Vancouver	2197	13	63.22.56	WA04	Issaquah (prod.)	Issaquah Cr.	May 1982	158,200	3.5
Vancouver	2156	18	63.23.07	UPWA	Soleduck (both)	Soleduck R.	May 1982	29,100	69.8
Vancouver	2085	17	63.23.10	LOCO	Cowlitz (expt.)	Cowlitz R	April 1982	23,300	54.7
Vancouver	2197	5	63.23.15	LOCO	Wild	Clearwater R.	Feb-May 1983	6,500	22.7
Vancouver	2154	14	63.24.57	LOCO	Sea Resources (prod.)	Chinook R.	Apr-May 1982	45,000	4.7
Vancouver	2302	13	63.24.59	LOCO	Grays River (expt.)	W FK Grays R.	June 1982	45,400	5.2