Canadian Technical Report of

Fisheries and Aquatic Sciences No. 1199

September 1983

TESTS ON THE ACCURACY OF AGEING NEW ZEALAND QUINNAT SALMON (ONCORHYNCHUS TSHAWYTSCHA) FROM THEIR SCALES

by

H. T. Bilton, M. Flain[1], F. Lucas[1], P. Kearton[1,2], and R. Gard[3]

Department of Fisheries and Oceans

Fisheries Research Branch

Pacific Biological Station

Nanaimo, B.C. V9R 5K6

---

[1]Ministry of Agriculture and Fisheries
Fisheries Research Division
Christchurch, New Zealand

[2]Deceased

[3]University of Alaska
Juneau, Alaska

Cat. No. Fs 97-6/1199 ISSN 0706-6457

ABSTRACT

Bilton, H. T., M. Flain, F. Lucas, P. Kearton, and R. Gard. 1983. Tests on the accuracy of ageing New Zealand Quinnat salmon (Oncorhynchus tshawytscha) from their scales. Can. Tech. Rep. Fish. Aquat. Sci. 1199: iv + 16 p.

The agreement with which five readers determined the freshwater and ocean ages of Rakaia River quinnat salmon from their scales averaged 72.7% and 68% on first and second readings, respectively in a test using scales from fish of unknown ages. Their consistency in assigning the same age to a scale on second reading averaged 78.8%. Agreement, for total age only, averaged 86.6% and 81.8% on first and second readings respectively. The levels of both agreement and consistency achieved in the test for the Rakaia stock indicate that experienced salmon scale readers can derive age composition data that are sufficiently consistent to make them useful in assessing both brood-year contribution and the freshwater life history types constituting the population. In a test in which five readers determined freshwater and ocean ages from a sample of scales from mixed stocks of known and unknown ages, agreement was 40.7% and 45.1% in the first and second readings respectively. Their consistency in assigning the same age to a scale on second reading averaged 56.0%. Agreement for total age averaged 65.3% and 64.3% on first and second readings, respectively. Results of the test using scales from mixed stocks indicated that readers had problems interpreting patterns on these scales. This likely resulted from the wide variety of environments from which the stocks originated. Development of criteria useful to readers in interpretation of scale patterns would help improve both the accuracy and consistency in ageing of these stocks.

Key words: scale reading test, Quinnat, New Zealand

RÉSUMÉ

Bilton, H. T., M. Flain, F. Lucas, P. Kearton, and R. Gard. 1983. Tests on the accuracy of ageing New Zealand Quinnat salmon (Oncorhynchus tshawytscha) from their scales. Can. Tech. Rep. Fish. Aquat. Sci. 1199: iv + 16 p.

Au cours d'un essai avec des écailles de poissons d'âge inconnu, cinq lecteurs ont déterminé le nombre d'années passées en eau douce ou marine par des saumons quinnats de la rivière Rakaia. En moyenne, la concordance s'élevait respectivement à 72,7% et à 68% après les premières et deuxièmes lectures. Après une seconde lecture, l'uniformité de l'âge donné à partir d'une écaille atteignait en moyenne 78,8%. La concordance, pour l'âge total seulement, s'élevait en moyenne à 86,6% et à 81,8% après les premières et deuxièmes lectures respectivement. Le taux d'uniformité et de concordance atteints pendant l'essai sur le stock de la Raakaia portent à croire que des lecteurs expérimentés d'écailles de saumon peuvent obtenir sur la composition par âge des données suffisamment uniformes pour être utiles dans l'évaluation du nombre de reproducteurs et d'individus dulçaquicoles qui composent la population. Au cours d'un essai où cinq lecteurs ont déterminé le nombre d'années passées en eau douce et marine à partir d'un échantillon d'écailles recueillies de stocks mixtes d'individus d'âge connu et inconnu, la concordance s'est élevée respectivement à 40,7% et à 45,1% après les premières et deuxièmes lectures. En moyenne, l'uniformité de l'âge donné à partir d'une écaille après une deuxième lecture atteignait 56,0%. La concordance pour l'âge total s'élevait en moyenne à 65,3% et à 64,3% après les premières et deuxièmes lectures respectivement. Les résultats de l'essai avec des écailles recueillies de stocks mixtes portent à croire que les lecteurs avaient de la difficulté à interpréter les schèmes présents sur ces écailles, difficulté probablement causée par la grande variété d'environnements d'où proviennent les stocks. L'élaboration de critères utiles aux lecteurs pour l'interprétation des schèmes des écailles améliorerait la précision et la concordance dans la détermination de l'âge de ces stocks.

Mots-clés: essai de scalimétrie, quinnat, Nouvelle-Zélande

INTRODUCTION

Quinnat salmon scales can be difficult to age with confidence because of the complexity of the quinnat salmon's history.

Quinnat salmon fry may migrate from fresh water to the ocean almost immediately after emergence, or after periods of freshwater residence varying anywhere from days, to months, to as much as one or more years. Once at sea they may remain several months to as long as 5 years. Hence, there is considerable variability in scale patterns with some fry only beginning to form scales, and others with the body fully covered with scales showing numbers of freshwater circuli. Early studies (1973-76) on the Rakaia River system (located on the east coast of the South Island of New Zealand) suggested that in the Glenariffe Stream, a tributary, juvenile salmon less than a day old left the stream in very large numbers (August-October) with the remainder believed to stay in the Stream Glenariffe for several months before migrating as fingerlings (Unwin 1981). In the Rakaia River below Glenariffe, survival of young salmon was probably low because of high turbidity and flooding. Most returning adults were considered to have originated from juveniles which had reared in the Glenariffe (or other tributary streams) for at least 3 months before migrating directly to the sea. Examination of scales from returning adults suggested that less than 1% had migrated to sea in their first few days of life.

Unwin (op. cit.) pointed out that three types of freshwater growth can be determined from examination of the scales. He refers to these as:

1. Ocean, little or no freshwater residence;
2. Intermediate: part of the first year spent in fresh water;
3. Stream: over 1 yr spent in freshwater.

He indicates that the stream type of freshwater growth is found on about 20% of Rakaia salmon. The intermediate type is thought to be most common making up about 80% of the Rakaia run. Ocean type scales account for less than 1% of the total run, suggesting very few early migrant fry survived. He suggests that the Rakaia has a greater role in the biological processes than just as an avenue linking Glenariffe with the ocean. He speculates that the Rakaia does in fact lend itself to rearing of the migrants and that a significant amount of growth occurs between Glenariffe and the mouth. This could vary annually depending upon flow conditions in the river. Further work is needed to assess to what extent migrants rear in the Rakaia before going to sea, and hence the importance of the river to the production of fish from the system. An important part of studies to assess the extent of rearing in the Rakaia includes the examination of adult scales to determine contributions of the three fresh water life history types to the total run. Therefore, because it was recognized that there was a problem in the ageing of quinnat salmon from their scales, tests were conducted to determine how well or how poorly quinnat salmon scales could be read for both freshwater life history type and for total age. The purpose of this report is to present the results of these tests.

METHODS

Two tests were made, each involving five scale readers, including one from a United States, one from a Canadian, and three from a New Zealand fisheries agency. In this report, the scale readers and the agencies to which they belong are not identified: instead a numeral serves to designate each individual reader.

In the first test 99 scales of unknown age from returning Rakaia River adults were used (100 scales were used, but only 99 were aged by all readers). No information other than that they were from the Rakaia River was provided to the readers. The individual who selected the scales was not otherwise involved in the test. It should also be pointed out that the conditions for the scale reading tests tended to differ from those encountered in normal scale reading practice. In the latter case, there is only a limited time to examine each sample whereby some of the obscure ones may slip through. Furthermore, normal scale readings are done on one population of the year. Thus, a pattern is built up in the readers mind by the process. In the tests only limited numbers of scales were available for examination. In the normal situation at least 20 scales from each fish might be available and examined.

One to two weeks later the same scales were arranged in a different order and were again sent to the readers. Thus, from this it was not only possible to compare age determinations between pairs of readers but also to assess the consistency with which each reader assigned a particular age to each scale in the two readings.

In the second test, 99 scales from a number of rivers were used (Silverstream hatchery, Glenariffe Stream, Winding Creek, and Waimakariri and Clutha rivers). Sixty-five scales were of unknown age, and 34 were of known total age determined from tagged salmon recovered in the returns to the Glenariffe stream. In this case, one of the individuals who selected the scales was involved in the test. One to two weeks later, the same individual arranged the scales in a different order and they were again sent to the readers. No information other than that the scales were a mixed group from a number of rivers was provided to the readers.

Using only the 34 scales of known ages it was possible to determine each reader's accuracy and consistency in assigning total age to a scale.

To conduct scale readings, the investigators used the following instruments:

(a) Reader 1 - Maruzen Zen micro-projector with screen (40x magnification);

(b) Readers 2, 4, 5 - Projecting micro-projector with screen (20x magnification); and

(c) Reader 3 - Nikon, profile micro-projector with screen, Model 66J2 (20x and 50x magnification).

Basic data produced by these tests are on file at Fisheries Research Division Laboratory at Christchurch, New Zealand.

RESULTS

Test 1. Rakaia scales of unknown age.

The main objective of this test was to compare the age assignments made by all of the readers by pairs using scales from a single stock.

Overall rate of agreement for both freshwater and ocean age[1] between pairs of readers on the first reading averaged 72.7%, and ranged from 62.6 to 89.9% among the ten different pairs (Table 1). On the second reading the overall average agreement dropped to 68%, and ranged from 46.5 to 86.9%. The rate of agreement for total age (i.e. assigning to year-class and not necessarily agreeing on freshwater age) between pairs of readers was considerably higher (Table 2). On the first reading the overall average was 86.6%, ranging from 74.7 to 97%. On the second reading the average agreement decreased to 81.8%, and ranged from 66.7 to 97%.

Age compositions derived by each reader during his first and second reading are given in Table 3. For the most part the numbers assigned to the different ages are fairly consistent between and within readers on their first and second readings. The overall average age composition for all readers between readings 1 and 2 was generally in quite close agreement.

Rates of consistency with which the five readers assigned a particular age to each scale in the second reading were 94.9, 72.7, 89.9, 63.6 and 72.7% with an average of 78.8% (Table 4). In other words they gave the same age assignment to 390 out of 495 determinations at the second reading as they had done at the first. The five readers achieved a high degree of consistency with scales which they interpreted to be age 0.1 (79.3-96.9%).

Age compositions based on total age only were derived by each reader during his first and second readings (Table 5). In general, the numbers assigned to the different ages were reasonably consistent between readers and within readers on their first and second readings. Average age compositions derived by all readers during the two readings were in very close agreement.

---

[1]The European system of age designation (Koo 1962) is used in this report. The first digit indicates the number of annuli formed in fresh water and the second digit indicates the number of annuli formed in the ocean.

Test 2. Mixed scales unknown and known age.

The main objective of this test was to compare the age assignments made by all of the readers by pairs using mixed scales from various stocks.

(a) Known and unknown ages

For the 99 scales from fish of known and unknown ages, the overall rate of agreement for both freshwater and ocean age between pairs of readers on the first reading averaged 40.7%, and ranged from 31.3 to 53.5% (Table 6). On the second reading the overall average agreement increased to 45.1% and ranged from 35.4 to 50.5%. The rate of agreement for total age (i.e. assigning to brood year and not necessarily agreeing on freshwater age) (Table 7), between pairs of readers was considerably higher. On the first reading the overall average was 65.3% ranging from 57.6 to 78.8%. On the second reading the average agreement remained about the same at 64.3% and ranged from 54.5 to 72.7%.

Age compositions (both freshwater and ocean age) derived by each reader on his first and second reading are given in Table 8. In general, the numbers assigned to the different ages are quite inconsistent between readers in both their first and second readings. Within readers there was a greater degree of consistency in assigning numbers to the various age-classes. Despite this amount of variability within and between readers the overall average age composition for all readers between readings 1 and 2 was generally in quite close agreement.

Rates of consistency with which the five readers assigned a particular age to each scale in the second reading were 62.6, 47.5, 66.7, 51.5 and 51.5% (Table 9). The average for the five readers was 56.0% (they gave the same age assignments to 272 out of 495 determinations at the second reading as they had done at the first). The five readers achieved their best degree of consistency with scales which they interpreted to be age 1.2 (57.9-90.9%).

Age compositions (assigning to total age without necessarily agreeing on freshwater age) derived by each reader on his first and second reading are given in Table 10. In general, the within reader agreement for the numbers assigned to the different ages are quite consistent for readers 1 to 3 on their first and second readings, whereas there was a greater inconsistency for readers 4 and 5. Also, the between reader consistency was higher among readers 1 to 3 and less for readers 4 and 5. Overall average age composition for all readers between readings 1 and 2 were in close agreement.

(b) Known ages

In both readings of the 34 scales from fish of known total age, errors in assigned ages included two age-classes, and were sometimes high relative to the correct number of scales belonging to a particular age-class (Table 11). However, among the 340 determinations the total number of wrong assignments was only 57, or 16.8%.

The rates of consistency with which the five readers assigned a particular age (correctly or incorrectly) to each scale in the second reading were 73.5, 76.5, 91.2, 55.9, and 85.3% (Table 14). The average for the five readers was 76.5% (readers gave the same age assignments to 130 out of 170 determinations at the second reading as they had done at the first). Four of the five readers achieved a high rate of consistency with scales which they considered to be of the 3-yr-old age class (79.2-96.4%).

DISCUSSION

The tests that made use of scales of unknown age from the Rakaia River indicated the levels of agreement within pairs of readers in assigning both the freshwater and ocean ages were relatively high, averaging 70.3% among the five readers over both readings. Average rates of consistency of 78.8% on first and second reading by the five readers is considered to be adequate. Overall agreement between readers for total age only increased to 84.2% and is considered to be high. It is our opinion that if all the readers had had equal experience in the interpretation of the scales from this stock, the agreement both between readers and in the derived age compositions would have been higher.

Tests using scales from mixed stocks of both known and unknown ages indicated that readers had problems in assigning fresh water and ocean age. Agreement within and between readers in assigning of ages averaged only 42.6% over both readings. Concurrence improved only when total age was considered. However, even here agreement can only be described as fair at best (approximately 64% over both readings). This lower agreement on age between readers may have been due to the fact that (a) scales from some of the stocks were more difficult to interpret than others, and (b) readers had no prior knowledge of the stocks included in the sample.

Tests using scales from mixed stocks of known age indicated that: (a) the degree of accuracy achieved varied among readers, but the overall average of 88% can be considered quite high; (b) the degree of consistency in reading these scales was relatively high, averaging 76.5% among five readers. Four of the five readers achieved a high rate of consistency with scales which they considered to be 3-yr-old fish. Rates of accuracy and consistency with which the five readers assigned a particular age to each scale were considerably higher for these scales than for the mixed sample as a whole. Why this should be is not clear. Possibly the 34 scales of known age from the Rakaia River were easier to interpret than other scales in the mixed sample. This would also account for the higher degree of accuracy.

A further point must be discussed. Does the agreement and consistency achieved in assigning ages to quinnat salmon scales from New Zealand stocks differ significantly from that achieved with the scales of quinnat (chinook) salmon from North America? Tests on the accuracy of ageing Chinook salmon scales were carried out by Godfrey et al. (1968). For fish of known ages, the accuracy with which several readers determined the ages averaged 75%. Their consistency in assigning the same ages to scales presented on two occasions averaged 76%. When several pairs of readers assigned ages to scales of unknown ages, agreement within pairs was good (roughly 75%). Hence, for the Rakaia stock, the level of agreement and consistency between (70%) and within (79%) readers, was similar to that observed for North American chinook stocks. However, in the case of the mixed New Zealand stocks both the level of agreement and consistency within and between readers was considerably lower. Much of this was probably due to the inclusion of scales from quinnat stocks having widely differing freshwater life history patterns.

In this report no description is given of the different kinds of scale patterns encountered on the scales used in the tests, nor is any attempt made to indicate the specific characteristics of scales upon which there was or was not disagreement by the readers. There will probably always be considerable disagreement in the interpretation of individual quinnat salmon scales, even among experienced readers. The reasons for this, as has been mentioned, arise from the complexity and variability in the freshwater phase of the life history of quinnat salmon. However, there may be ways to improve the accuracy and/or consistency of ageing this species. First, to attain high levels of consistency in ageing, the readers should be trained and experienced in interpreting scales from the major New Zealand stocks. Secondly, reliable criteria that could be used in interpreting scale patterns could be developed and probably would improve both accuracy and consistency in ageing. This could be achieved best by examining scales of known-aged fish which had experienced a wide variety of environments. In conclusion, we believe that experienced salmon scale readers can derive age composition data for New Zealand stocks that are sufficiently accurate to make them useful in assessing both brood year contribution and freshwater life history type.

REFERENCES

Godfrey, H., D. D. Worlund, and H. T. Bilton. 1968. Tests on the accuracy of ageing chinook salmon (Oncorhynchus tshawytscha) from their scales. J. Fish. Res. Bd. Canada 25: 1971-1982.

Koo, T. S. Y. 1962. Age designation in salmon, In T. S. Y. Koo (ed), Studies of Alaska red salmon. Univ. Wash., Seattle, Publ. Fish. N.S. 1: 37-48.

Mason, J. E. 1965. Salmon of the North Pacific Ocean, Part IX. Chinook salmon in offshore waters. Bull. Intern. North Pacific Fish. Comm., No. 16: p. 41-73.

Unwin, M. J. 1981. Aspects of the juvenile Quinnat salmon outmigration from the Glenariffe Stream. Proc. of the Salmon Symposium, Christchurch. 1980. Fish. Res Div. Occasional Publ. No. 30, p. 15-20.

Table 1. Comparisons between pairs of readers, who read scales of quinnat salmon of unknown age from the Rakaia River, for both freshwater and ocean age. Five readers each read the same 99 scales on two separate occasions.

	Agreement			
	Reading 1		Reading 2	
Pair	No.	%	No.	%
1x2	74	74.7	84	84.8
1x3	89	89.9	87	86.9
1x4	70	70.7	60	60.6
1x5	69	69.7	66	67.7
2x3	72	73.7	80	81.8
2x4	75	70.7	61	61.6
2x5	62	62.6	58	59.6
3x4	74	74.7	63	64.6
3x5	72	71.7	65	65.6
4x5	68	68.7	46	46.5
Average	72.5	72.7	67.0	68.0

Table 2. Comparisons between pairs of readers, who read scales of quinnat salmon of unknown age from the Rakaia River, ignoring the type of freshwater growth. Five readers each read the same 99 scales on two separate occasions.

	Agreement			
	Reading 1		Reading 2	
Pair	No.	%	No.	%
1x2	94	94.9	91	91.9
1x3	96	97.0	96	97.0
1x4	88	88.9	78	78.8
1x5	80	80.8	78	78.8
2x3	91	91.9	92	92.9
2x4	85	85.8	80	80.8
2x5	80	80.8	75	75.7
3x4	89	89.9	78	78.8
3x5	80	80.8	76	76.8
4x5	74	74.7	66	66.7
Average	85.7	86.6	81.0	81.8

Table 3. The age compositions (numbers) derived by each of the five readers who read scales of quinnat salmon of unknown age from the Rakaia River. Each reader read the same 99 scales on two separate occasions.

Reader	Reading	Age composition 0.1	0.2	0.3	1.0	1.1	1.2	1.3	Total
1	1	32	30	16	2	4	15	0	99
	2	33	31	17	1	2	15	0	99
2	1	30	20	11	4	12	22	0	99
	2	31	29	20	2	4	13	0	99
3	1	30	27	15	2	9	16	0	99
	2	30	30	12	2	6	19	0	99
4	1	29	19	8	6	13	23	1	99
	2	30	29	9	6	15	10	0	99
5	1	22	23	9	4	15	24	4	99
	2	21	22	11	4	13	23	4	99
Average	1	28.6	23.8	11.8	3.6	10.6	20.0	1.0	
	2	29.0	28.2	13.8	3.0	8.0	16.0	0.8	

Table 4. The consistency with which the five readers who read scales of quinnat salmon of unknown age from the Rakaia River assigned the same age to a scale in the second reading of the 99 scales as they did in the first.

Ages assigned	Reader 1 No.	1 %	2 No.	2 %	3 No.	3 %	4 No.	4 %	5 No.	5 %
0.1	31/32	96.9	29/30	96.7	29/30	96.7	23/29	79.3	21/22	95.4
0.2	29/30	96.7	17/20	85.0	26/27	96.3	16/19	84.2	16/23	69.6
0.3	16/16	100.0	9/11	81.8	12/15	80.0	5/8	62.5	8/9	88.9
1.0	1/2	50.0	2/4	50.0	2/2	100.0	4/6	66.7	2/4	50.0
1.1	2/4	50.0	3/12	25.0	5/9	55.5	7/13	53.8	8/15	53.3
1.2	15/15	100.0	12/22	54.5	15/16	93.7	8/23	34.9	15/24	62.5
1.3	-	-	-	-	-	-	0/1	0.0	2/4	50.0
Total	94/99	94.9	72/99	72.7	89/99	89.9	63/99	63.6	72/99	72.7

Table 5. The age compositions (numbers) derived for quinnat salmon of unknown age from the Rakaia River by each of the five readers. The total age ignoring the type of freshwater growth was determined by each of the readers on two separate occasions.

		Age composition				
Reader	Reading	2	3	4	5	Total
1	1	34	34	31	0	99
	2	34	33	32	0	99
2	1	34	32	33	0	99
	2	33	34	32	0	99
3	1	32	36	31	0	99
	2	32	36	31	0	99
4	1	34	33	31	1	99
	2	36	43	20	0	99
5	1	28	37	30	4	99
	2	25	35	35	4	99
Average	1	32.4	34.4	31.2	1.0	
	2	32.0	36.2	30.2	0.8	

Table 6. Comparisons between pairs of readers who read scales of quinnat salmon of known and unknown age from mixed stocks for both freshwater and ocean age. Five readers each read the same 99 scales on two separate occasions.

	Agreement			
	Reading 1		Reading 2	
Pair	No.	%	No.	%
1x2	40	40.4	50	50.5
1x3	53	53.5	49	49.5
1x4	40	40.4	40	40.4
1x5	42	42.4	45	45.4
2x3	34	34.3	51	51.5
2x4	36	36.4	37	37.4
2x5	44	44.4	50	50.5
3x4	31	31.3	35	35.4
3x5	38	38.4	47	47.5
4x5	45	45.4	43	43.4
Average		40.7		45.1
Range		12.8		15.1

Table 7. Comparison between pairs of readers who read scales of quinnat salmon of known and unknown age from mixed stocks for total age, ignoring the type of freshwater growth. Five readers each read the same 99 scales on two separate occasions.

	Agreement			
	Reading 1		Reading 2	
Pair	No.	%	No.	%
1x2	62	62.6	66	66.7
1x3	78	78.8	72	72.7
1x4	60	60.6	58	58.7
1x5	68	68.7	65	65.6
2x3	59	59.6	67	67.7
2x4	57	57.6	54	54.5
2x5	69	69.7	68	68.7
3x4	59	59.6	61	61.6
3x5	75	75.7	68	68.7
4x5	60	60.6	58	58.6
Average	64.7	65.3	63.7	64.3
Range		21.3		18.2

Table 8. The age compositions (numbers) derived for quinnat salmon of known and unknown age from mixed stocks by each of the five readers who read scales of unknown age. Each reader read the same 99 scales on two separate occasions.

		Age composition														
Reader	Reading	0.1	0.2	0.3	0.4	1.0	1.1	1.2	1.3	2.0	2.1	3.0	3.1	3.2	4.0	Total
1	1	5	23	4	1	11	17	16	3	7	0	4	0	0	1	99
	2	6	20	3	1	10	19	13	0	8	1	15	0	0	3	99
2	1	8	10	12	0	7	25	17	0	11	5	4	0	0	0	99
	2	5	17	9	0	5	19	22	0	6	1	9	0	0	6	99
3	1	11	38	1	0	3	17	11	0	6	0	9	1	0	2	99
	2	10	41	1	0	1	17	13	0	2	0	9	0	0	5	99
4	1	12	16	5	0	8	36	19	0	2	1	0	0	0	0	99
	2	15	12	1	0	12	29	13	0	4	1	10	0	1	1	99
5	1	5	10	1	0	11	37	14	0	9	2	10	0	0	0	99
	2	6	16	4	0	8	22	29	0	8	0	5	0	0	1	99
Average	1	8.2	19.4	4.6	0.2	8.0	26.4	15.4	0.6	7.0	1.6	6.8	0.2	0.0	0.6	
	2	8.4	21.2	3.6	0.2	7.2	21.2	18.0	0.0	5.6	0.6	9.6	0.0	0.2	3.2	

Table 9. The consistency with which the five readers who read scales of quinnat salmon of known and unknown age from mixed stocks assigned the same age to a scale in the second reading of the 99 scales as they did in the first.

Ages assigned	Reader 1		Reader 2		Reader 3		Reader 4		Reader 5	
	No.	%	No.	%	No.	%	No.	%	No.	%
0.1	2/5	40.0	4/8	50.0	7/11	63.6	3/12	25.0	3/5	60.0
0.2	17/23	73.9	5/10	50.0	30/38	78.9	6/16	37.5	5/10	50.0
0.3	1/4	25.0	5/12	41.7	0/1	0.0	0/5	0.0	1/1	100.0
0.4	1/1	100.0	-	-	-	-	-	-	-	-
1.0	9/11	81.8	4/7	57.1	1/3	33.3	8/8	100.0	7/11	63.6
1.1	11/17	64.7	14/25	56.0	9/17	52.9	22/36	61.1	17/37	45.9
1.2	11/16	68.7	12/17	70.6	10/11	90.9	11/19	57.9	12/14	85.7
1.3	0/3	0.0	-	-	-	-	-	-	-	-
2.0	2/7	28.6	2/11	18.2	2/6	33.3	1/2	50.0	4/9	44.4
2.1	-	-	0/5	0.0	-	-	0/1	0.0	0/2	0.0
3.0	7/11	63.6	1/4	25.0	6/9	66.7	-	-	2/10	20.0
3.1	-	-	-	-	0/1	0.0	-	-	-	-
3.2	-	-	-	-	-	-	-	-	-	-
4.0	1/1	100.0	-	-	1/2	50.0	-	-	-	-
Total	62/99	62.6	47/99	47.5	66/99	66.7	51/99	51.5	51/99	51.5

Table 10. The age compositions (numbers) derived by each of the five readers who read scales of quinnat salmon of unknown age for mixed stocks. The total age ignoring the type of freshwater growth was determined by each of the readers on two separate occasions.

		Age composition					
Reader	Reading	2	3	4	5	6	Total
1	1	16	47	31	5	0	99
	2	16	47	32	4	0	99
2	1	15	46	38	0	0	99
	2	10	44	39	6	0	99
3	1	13	62	22	2	0	99
	2	11	60	23	5	0	99
4	1	20	54	25	0	0	99
	2	27	45	25	1	1	99
5	1	16	56	27	0	0	99
	2	14	46	38	1	0	99
Average	1	16.0	53.0	28.6	1.4	0.0	
	2	15.6	48.4	31.4	3.4	0.2	

Table 11. The age assigned for Quinnat salmon of known total age from mixed stocks by five readers for each of the readings separately as percentages of the number of known age scales of each of the two age classes in the sample.

Known age total	No. of scales	First reading				Second reading			
		2	3	4	5	2	3	4	5
				Reader 1					
2	7	100.0				71.4	28.6		
3	27	3.7	88.9	3.7	3.7	7.4	74.1	14.8	3.7
				Reader 2					
2	7	71.4	28.6			71.4	28.6		
3	27	11.1	74.1	14.8			85.2	11.1	3.7
				Reader 3					
2	7	85.7	14.3			71.4	28.6		
3	27		100.0				100.0		
				Reader 4					
2	7	57.1	42.9			85.7	14.3		
3	27	7.4	81.5	11.1		29.6	59.3	11.1	
				Reader 5					
2	7	100.0				100.0			
3	27	3.7	88.9	7.4			85.2	14.8	

Table 12. The consistency with which the five readers who read scales of Quinnat salmon of known total age from mixed stocks assigned the same total age to a scale in the second reading of the 34 scales as they did in the first.

Ages assigned	Reader 1		Reader 2		Reader 3		Reader 4		Reader 5	
	No.	%	No.	%	No.	%	No.	%	No.	%
2	6/8	75.0	5/8	62.5	4/6	66.7	4/6	66.7	7/8	87.5
3	19/24	79.2	20/22	90.9	27/28	96.4	14/25	56.0	21/24	87.5
4	0/1	0.0	1/4	25.0	-	-	1/3	33.3	1/2	50.0
5	1/1	100.0	-	-	-	-	-		-	
Total	25/34	73.5	26/34	76.5	31/34	91.2	19/34	55.9	29/34	85.3