PROBLEMS IN AGEING PACIFIC SALMON FROM THEIR SCALES AND NEED FOR DEVELOPMENT OF OBJECTIVE CRITERIA

H. T. Bilton

Department of Fisheries and Oceans
Fisheries Research Branch
Pacific Biological Station
Nanaimo, British Columbia
CANADA V9R 5K6

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER: Bilton, H.T. 1984. "Problems in Ageing Pacific Salmon from Their Scales and Need for Development of Objective Criteria". 26 p. (Document submitted to the Scientific Sub-Committee on Salmon, Annual Meeting of INPFC, Vancouver, Canada, October, 1984)

INTRODUCTION

For many years the age composition of the five species of Pacific Salmon has been estimated from examination of their scales. Information on the age, size and sex composition of salmon caught in fisheries is an important part of the vital statistics of these economically valuable fish populations. Such information along with data on the abundance of the catch and of spawning escapements in different parts of the Coast, provide the basis for assessing year-to-year variations in production and effects of management on the stocks.

Scale readers have and are currently required to provide their best estimates of ages of these fish based mainly on their subjective interpretation of the "markings" on the scales with little supporting data to verify the accuracy of their age determinations. Most scale readers have often heard the comment that scale reading is an art rather than a science. I think there is much truth to this comment. In the past and probably to a great extent today, most scale readers do not have available criteria upon which to base their age interpretations. Most ageing is based on subjective criteria which are usually passed on from an experienced scale reader to the novice reader. Certain scale characters are either designated as true annuli or are ignored. Often, designation of a mark on a scale as a year band or annulus among a group of scales readers can be the subject of vigorous discussion, with a concensus of opinions being the final basis for making the decision to either call it an annulus or not. The argument is often used that if agreement (precision[1]) among readers is high and within reader agreement is consistent then this very probably is indicative of a high degree of accuracy in aging. In reality this may be far from being a fact. Among and within reader agreement proves mainly that (a) that readers are using the same charactistics to define annuli; (b) they were all trained to recognize the same marks on the scales by the same person; (c) the marks interpreted as annuli were very well defined and easy to recognize (even though they might not be annuli) and hence agreement is high. Therefore, agreement among readers without age validation proves only that readers agree on what they see, but this may not necessarily represent the true age of the fish.

The purpose of this paper is to briefly review the most common problems associated with ageing of each species by their scales and to determine if there is a need for development of objective criteria for ageing.

---

[1] "Precision refers to the degree of reproducibility and thus relates to the variability between readers or between readings. Accuracy relates to the degree of closeness to the true value and thus relates to the departure from the true age" (Chilton and Beamish, 1982).

A. SOCKEYE SALMON

Young sockeye salmon usually reside for a period of 1, 2 or more rarely 3 years in freshwater before migrating to sea in the spring, at the beginning of their 2nd, 3rd, or sometimes 4th year of life. They remain in the ocean from 1 to 4 years before returning to their natal stream to spawn. Most fish are estimated to return in their fourth, fifth, and sixth year of life at ages $4_2, 5_3, 5_2$, and 6_3[1]. The range in ages are estimated to include the third to eighth years. The most common ages encountered in British Columbia, Alaska and the U.S.S.R. are given below.

	Source
B.C. - $3_2, 4_2, 5_2, 5_3, 6_3$	Clutter & Whitsel, 1956; Bilton et al, 1967
Alaska - $4_2, 5_2, 5_3, 6_3, 6_4$	*Eicher MS. 1957;*Rounsefell, 1958a; FRI, 1963
USSR - $4_2, 5_2, 5_3, 6_4, 6_4, 7_4$	*Krokhin & Krogius, 1937b; *Egerova et al, 1961
	*from Foerster (1968)

As can be seen there are a considerable number of freshwater ocean age combinations comprising the various stocks of salmon, which can quite often be difficult to age. Most particularly among

---

[1] The large Arabic numeral denotes the actual year of age in which the adult was taken, while the small subscript Arabic number indicates the age when the young fish went to sea e.g. a 4_2 indicates the fish was in its 4th year, having gone to sea in its second.

those stocks originating from northern British Columbia, Alaska and the U.S.S.R. where there is often more than one year of freshwater residence known to occur. Identification of freshwater annuli on their scales can often be debatable. This can be particularly so when readers from three countries are required to age high seas caught sockeye where their origin is unknown. Generally, the designation of checks in the central area of the scales (near the focus) as freshwater annuli is mostly a subjective process with little "hard" evidence to support the conclusion reached by the reader. Hence, the interpretation of freshwater growth can be a major area of disagreement among readers. Agreement among readers in identifying what they consider to be marine annuli is generally much higher. For the most part, the marks on the scales considered to be ocean annuli are more distinct and readily identified . Marks on the scales considered to be acessory checks appear occasionally, and are considered to be almost always recognizable by their unusual position in the pattern of scale growth. The degree of agreement (not the actual accuracy) between readers from Canada, Japan and the United States in ageing of sockeye was tested a number of years ago (Anon, MS 1956). The test indicated many cases of disagreement. The scales included, estimated freshwater ages from 1 to 4 years and total ages of from 2 to 7 years, among samples of Canadian, Japanese and United States origin. There was a consistently high rate of agreement with Canadian scales; from 82 to 92%. Much of this was probably related to the simple freshwater life history of these fish (see Table 1 below). However, the agreement among readers for scales from sockeye of United States and Japanese origin was much lower e.g. the agreement ranged from 50.2 to 78.4% and from 44.0 to 75.0% for United States and

Japanese scales, respectively, among five scale readers. This lack of agreement probably reflected the increased difficulty in interpreting the much more complicated life histories of these stocks, particularly the extend of the freshwater phase, where there was considerable disagreement in interpreting freshwater annuli on the scales. Because true ages of these fish were not known, the actual accuracy could not be compared.

Table 1. The percentage agreement achieved by pairs of readers who aged sockeye salmon scales of Canadian (100 scales), Japanese (100 scales), and United States (255 scales) origin* (from Godfrey et al, 1968).

Pairs of readers:	AB	AC	AD	AE	AF	BC	BD	BE	BF
Canadian sockeye	90.0	91.0	91.0	92.0	--	83.0	82.0	88.0	--
Japanese sockeye	45.0	76.0	75.0	75.0	67.0	46.0	47.0	46.0	44.0
U.S. sockeye	65.5	76.5	78.4	71.4	70.6	58.0	56.5	53.7	50.2

Pairs of readers:	CD	CE	CF	DE	DF	EF
Canadian sockeye	100.0	85.3	--	86.0	--	--
Japanese sockeye	87.0	83.0	75.0	85.0	81.0	78.0
U.S. sockeye	82.4	78.0	77.7	75.7	75.3	87.1

*Data from Anon. (1956). The Japanese sockeye were taken on the high seas, so that their actual origin is not known; it could have been either Asian or North American, or both.

To my knowledge, only in a few instances has the accuracy of ageing British Columbia sockeye from their scales been tested. In the early 1950s, returns of marked adults to the Fraser River were recovered from the fishery and their scales were examined (Clutter and Whitesel 1956). Forty recoveries were made of known age 4_2 fish, and the typical 4_2 scale pattern was exhibited on the scales. In the 1930s, eighty-nine Cultus lake sockeye fish had been marked as yearlings by the Fisheries Research Board of Canada in 1936 were recovered as 3_2s in fishery samples in 1937 (Foerster 1937). At the same time, seventy-two marked (marked as yearlings in 1935) 4_2 fish were recovered in 1937. The scales of the known age three-year-old fish exhibited the typical 3_2 pattern and the 4-year-old scales the 4_2 pattern.

Scales of 131 marked known age adult sockeye (returns from marked and nose-tagged juveniles released at Babine Lake in 1966, 67 and 68) that were recovered in the Skeena River commerical fishery in 1969 were recently examined by the author. Ages were determined from the scales (idependently) and were compared with the true ages (see Table 2 below).

Virtually all of the fish were correctly aged (127/131 or 96.9%). The only misclassifications occured among the 4_2 and 5_2 fish. Among the 4_2's, 3 were over-aged by one year. For the 5_2's, one was misclassified as a 4_3. Although only one year of data is available for Skeena sockeye, the high agreement does suggest that ageing of this stock may not be a problem. However, further tests using known age scales should be made before concluding this will always be the case.

Table 2. The age composition derived from the scales compared with the true ages.

		Scale Age						Agreed	
True Age	No.	3_2	4_2	5_2	4_3	5_3	6_3	No.	%
3_2	1	1	--	--	--	--	--	1/1	100.0
4_2	106	--	103	3	--	--	--	103/106	97.2
5_2	22	--	--	21	1	--	--	21/22	95.4
5_3	1	--	--	--	--	1	--	1/1	100.0
6_3	1	--	--	--	--	--	1	1/1	100.0
Total	131	1	103	24	1	1	1	127/131	96.9

CONCLUSION

To my knowledge age validation for other British Columbia stocks of sockeye (e.g. Rivers and Smith Inlets, Nass River) has not been tested. Age validation for stocks outside of British Columbia (e.g. Alaskan, U.S.S.R. or Japanese stocks) may have been, or is being done, but I am not aware of the extent of this work. Hence, there is probably a need for age validation of this species for most major stocks.

B. CHUM SALMON

Young chum salmon fry migrate to sea during their 1st year of life where they remain in the ocean from 2 to 5 years before returning to spawn. Most fish are estimated to return in their third, fourth and fifth years of life at age 3, 4 and 5. The range in ages is estimated to include the second to sixth years. Because of relatively simple life history of chum salmon, where freshwater residency is not a factor, interpretation of ages of chums from their scales is generally considered by readers to be easier than ageing of chinook or sockeye salmon.

For the most part, checks on their scales, which are interpreted to be ocean annuli are usually well defined, resulting in a high degree of agreement among readers. Tanaka et al (1969) assessed the agreement of age determination achieved by three scale Canadian readers, using series of scales from three areas: the Fraser River in B.C., the Naknek - Kvichak area in Alaska, and the Chitose River in Japan. Regardless of the area of origin, for over 90% of the scales all three readers agreed on the age. In not one case did all three readers disagree (see Table 3, below).

Overall estimates of age compositions for the entire samples were very similar, the greatest absolute differences between readers for any age class within a sample being 6.3% (four-year-old, Chitose River), (see Table 4, below). Combining all samples, the agreement was very good, the greatest difference between two readers for any age clas (four-year-olds in this case) being only 1.8%.

Table 3. Extent of agreement of three scale readers estimating ages of chums sampled in three different cases in 1956 and 1957 (From Tanaka et al 1969).

		Percentage Agreement			
Location	Year	All Agree	Only Two Agree	No. Agree	No. Scales
Fraser River	1957	92.2	7.8	0	90
Nakmex-Kuichak	1956	91.0	9.0	0	78
Chitose River	1956	90.6	9.4	0	64
ALL		91.4	8.6	0	232

Table 4. Estimated percentage of composition of chums from three areas determined by three different readers (from Tanaka et al 1969).

			Age (percent)			
Location	Year	Reader	3	4	5	6
Fraser River (90)						
Samples	1957	1	26.7	71.1	2.2	0
		2	22.2	75.6	2.2	0
		3	27.8	71.1	1.1	0
Naknek-Kvichak (78)						
Samples	1956	1	7.7	80.8	11.5	0
		2	7.7	80.8	11.5	0
		3	7.7	78.2	14.1	0
Chitose River (64)						
Samples	1956	1	42.2	32.8	23.4	1.6
		2	42.2	32.8	25.0	0
		3	35.9	29.1	23.4	1.6
All (232 Samples)		1	24.6	63.8	11.2	0.4
		2	22.8	65.5	11.7	0
		3	23.2	64.7	11.7	0.4

Furthermore, estimates of year band widths and number of circuli within each year band by the three readers was very similar (see Table 5, below). Samples of four-year-olds from two areas (Bristol Bay and Fraser River) were used in a test. The results indicated estimates of average number of circuli and band width by the three readers fell within 3% of each other.

Table 5. Comparison of mean circulus counts and measurements of year band widths for four-year-old chums from two different areas as determined by three different scale readers (from Tanaka *et al* 1969).

				Circuli (no.)		Year band widths mm X 100	
Reader	Area	Year	No. Examined	1st Year Mean S.D.[1]	2nd Year Mean S.D.	1st Year Mean S.D.	2nd Year Mean S.D.
1	Bristol	1956	53	29.60±2.06	17.77±2.45	135.18±10.61	73.11±10.84
2	Bay			29.94±2.36	17.71±2.53	135.18±10.70	72.73±10.50
3				30.15±2.25	18.11±2.58	133.39±11.38	73.77±10.74
1	Fraser	1957	94	35.76±2.62	18.12±2.71	139.52±11.89	69.62±11.20
2	River			35.44±2.59	18.11±2.87	140.05±11.39	70.26±12.12
3				35.53±2.67	17.84±2.71	137.39±11.91	69.68±11.84

This high agreement among readers in ageing of chums and in defining the positions of the annuli, indicates there are few problems in interpretation of the scales of this species. For the most part, this was true in the past and may still be true, but a recent study of scales of chum adults of known age indicates problems in ageing. Several experimental groups of marked chum fry were released from the Rosewell Creek hatchery on Vancouver Island, B.C. Examination of the scales of returning adults from these releases indicated that in a number of cases the number of checks on these scales did not correspond with the true age of the fish (Dr. R. Bams, personal communication).

The reader in these cases had to classify one of the checks as a true annulus and the other as an accessory check to arrive at the true age of the fish. Although the proportion that these problem scales represented in the samples was not large, the question can be asked, would these have been recognized as such if information on the true age of the fish had not been available? As stated earlier, it may not follow that a high degree of agreement in ageing among readers also reflects a high degree of accuracy.

CONCLUSION

In general, there is a need to validate the ages of chums salmon as determined from their scales. To my knowledge there has been little if any effort to conduct studies of this nature either for B.C. stocks or for others.

C. PINK SALMON

Pink salmon are characterized by a very short life cycle and rapid growth when compared to the other species of pink salmon. In

North America it has long been accepted that pink salmon migrate to sea as fry early in their fist year of life, and nearly all mature in their second, returning to spawn at age 2, (Gilbert 1914, Anas 1959).

A typical pink salmon scale bears this out, it has widely spaced circuli near the center which is interpreted as representing the first summer's growth in the ocean. These are followed by a band of closely-spaced circuli interpreted to represent the growth in the ocean during the winter (the annulus). Outside of the annulus is a second group of widely spaced circuli interpreted as representing the growth in the second summer in the ocean prior to the spawning migration. However, on a number of their scales an additional check has been observed near the focus of the scale (e.g. 35-39% of scales from marked Bella Coola pink salmon, Bilton & Ricker, 1965). This inner check has been interpreted by most investigators as a supplementary check rather than an annulus. Miyaguchi (1959) uses the term "fry zone" to describe this check and the area inside it. He suggests that it is formed as a result of physical change in the environment. In the U.S.S.R. also, most authors have interpreted this inner check as something other than a true winter check, for example Eniutina (1962). However, two Russian scientists took a different view. Vedensky (1954) and Lapin (1963) both considered the inner check as neither a fry zone nor anything supplementary, but as actually a true winter annulus. Vedensky believed he could recognized on most scales not only this inner check, but still another check as well, and therefore considered pinks were usually age 4 at maturity. Lapin was more conservative; his intepretation of the scales of certain Asian stocks of pink salmon suggest that a variable but sometimes fairly large proportion of each brood matures at 3 years of age, the balance maturing at 2 years. These studies stimulated Bilton and Ricker (1965) to re-examine the hypothesis that the "inner" check on scales of B.C. pink salmon are not true annuli. They examined the scales from marked known age adult pinks, resulting from experimental releases of marked pink salmon fry of the 1960 brood year in statistical Area 8 of the central B.C. coast (Parker 1964). From the results of their examination they concluded that the check which is often found near the scale focus is not an annulus, but is a supplementary check. Lapin (1971) subsequently responded and concluded: "(a) great diversity in the rate of growth and development is observed in the pink salmon and this is at variance with the widely held opinion that it matures at one and the same age (1+); (b) direct determination of the age of pink salmon by marking has shown that the bulk of fish reach maturity in the second summer but that some mature at a later age; (c) a single zone of converged scelerites (ring) on the scale of a pink salmon reflecting a definite period of the ontogeny of this salmon (accelerated growth on transition to abundant food, does not invariably reflect its age; (d) the firmly established view that there is in practice only one life cycle of the pink salmon (1+ years) is, in our view, the main obstacle in study of the features of the population dynamics of this salmon, and therefore it is absolutely essential to work out a scientifically reliable method for determination of the age of the pink salmon on the basis of a precisely worked out and implemented marking program."

Although the weight of the evidence supports the accepted view that nearly all pink salmon mature in their second year, I think point (d) of Lapin's conclusions should be considered. There is some indirect evidence that suggests 3-year-old pinks can occur naturally. Anas (1959) reported a pink salmon from the Skeena River in 1956 whose scales showed two completed annuli and substandard 3rd year growth. One other pink estimated to be a 3-year-old was reported by Turner and Bilton (1968). Further evidence to support the hypothesis may be shown from data for the Lake Superior pinks (Kwain and Chappel 1978). Pink salmon, have thrived in Lake Superior since their accidential introduction in 1956. Throughout 1956-1975, they retained their normal 2 year cycle, spawning only in odd-numbered years. However, in 1976 nine pinks were taken in a tributary to Lake Superior, the first known record of even-year freshwater pink salmon caught in the Great Lakes (Kwain and Chappel 1978). Ages were estimated from their scales. Scales had only one completed annulus and substantial summer growth, the same as the odd-year pinks. The source of the even-year pinks is unknown. However, Kwain and Chappel (1978) point out that since no other stock has been introducted they assume that during the last 20 years some odd-year fish must also have lived to 3 years in Lake Superior and spawned in the even-years to generate the new stock. A pink salmon estimated to be a 3-year-old was caught in 1976. The scale clearly indicated two completed annuli, plus summer growth (from Kwain and Chappel 1978).

CONCLUSION

Despite the general acceptance of a simple life history for pink salmon, I think the concept of virtually all pinks returning in their second year should be tested further and ages of pink salmon as determined from their scales validated, with particular reference to the central portion of their scales.

D. CHINOOK SALMON

Salmon scale readers generally agree that chinook salmon scales are the most difficult of the five species to age with confidence. The difficulty arises from the complexity of the chinook salmon's life history which can vary among stocks and races.

Wild stocks of young chinook salmon may migrate from freshwater to the ocean within hours of emergence, or often periods of residence that can vary from days, weeks, or months to as much as several years. Release of hatchery produced stocks from different sites at different times, and at different sizes throughout each year add further to the complexity. All may remain at sea for several months to as long as 6 or more years. Most fish making up the catch and the escapement are estimated to be in their 2nd to 5th year of life at ages 2_1, 3, 4_1, 5, 3_2, 4_2 and 5_2.

This variablity in the life history of the chinook salmon, particularly the early life history makes scales difficult to interpret for age because criteria are lacking upon which an interpretation can be based with confidence. Hence, the interpretation of freshwater growth and designation of checks as freshwater annuli is a major area of disagreement among readers. To a lesser but still significant extent there is disagreement among readers regarding the designation of checks in the marine area of the scales as marine annuli. Accurate ageing of chinooks from their scales continues to be a problem in North America

(Godfrey et al 1968). They conducted a test to determine how well chinook salmon scales could be read. The test was made involving experienced scale readers from a Canadian and several United States fisheries agencies. For a part of the test, scales of know age fish were used. The ages were known because the scales came from recaptured hatchery fish that had been marked when liberated. Four readers each read 200 scales on two separate occasions (see Table 6, below).

Table 6. Percentages of correct assignments for each age-class in two readings of first 200 scales by four readers (from Godfrey et al 1968).

True Age	No. of Scales	Reader A	A	B	B	C	C	D	D	Avg.
0.1[1] (2_1)	31	4.52	64.5	74.2	54.8	74.2	80.6	61.3	61.3	64.5
0.2 (3_1)	115	80.9	89.6	65.2	64.3	80.9	80.0	89.6	97.4	81.0
1.1 (3_2)	2	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
0.3 (4_1)	38	86.8	89.5	55.3	50.0	39.5	73.7	84.2	78.9	69.7
1.2 (4_2)	10	70.0	50.0	50.0	50.0	50.0	40.0	70.0	70.0	56.3
1.3 (5_2)	4	100.0	50.0	75.0	100.0	50.0	100.0	100.0	100.0	84.4
Total or Avg.	200	76.0	82.5	64.0	60.0	69.5	77.0	83.0	86.5	74.8

[1] The first digit is the number of winters the fish spent in freshwater after hatching, the second digit is the number of winters spent in the ocean.

In the first reading the correct assignments by the four reachers averaged 76.0, 64.0, 69.5 and 83.8 % of the 200 scales, and in the second reading 82.5, 60.0 77.0 and 86.5%. For the four readers and the two readings combined, the overall average was 74.8% correctly assigned. The rates of consistency with which the four readers assigned a particular age (correctly or incorrectly) to each scale in the second reading were 79.5, 69.0, 72.0 and 83.5% (see Table 7, below).

Table 7. The consistency with which the four readers assigned the same age to a scale in the second reading of the first 200 scales as they did in the first* (from Godfrey et al 1968).

	Consistency			Consistency	
Ages Assigned	No.	%	Ages Assigned	No.	%
	READER A			READER B	
0.1 (2_1)	13/15	86.7	0.1	17.27	63.0
0.2 (3_1)	93/109	89.9	0.2	67/88	76.1
1.1 (3_2)	3/3	100.0	1.1	1/2	50.0
0.3 (4_1)	34/51	66.7	0.3	37/57	64.9
1.2 (4_2)	9/7	52.9	1.2	12/50	60.0
1.3 (5_2)	2/5	40.0	0.4	1/1	100.0
Total	159/200	79.5	0.3	3/5	60.0
			Total	138/200	69.0
	READER C			READER D	
0.1 (2_1)	22/28	78.6	0.1	15/22	68.2
0.2 (3_1)	85/101	84.2	0.2	108/113	95.6
1.1 (3_2)	4/7	57.1	1.1	2/6	33.3
0.3 (4_1)	24/48	50.0	0.3	30/42	71.4
1.2 (4_2)	7/11	63.6	1.2	8/13	61.5
1.3 (5_2)	2/4	50.0	1.3	4/4	100.0
NR	0/1	0.0	Total	167/200	83.5
Total	144/200	72.0			

* The average for the four readers was 76.0% (e.g. among them they gave the same age assignments to 608 out of 800 determination at the second reading as they had done at the first.

In general the tests indicated an overall accuracy of approximately 75%. The degree of accuracy differed with the true age-class, and scales with both freswhater and ocean annuli were misaged more frequentlly than those with only ocean annuli. Further, testing of these scales when information on length of fish and time and place of capture was also provided, indicated some value in improving the intepretation of the 2_1 fish, but not significantly beneficial for the other age groups. Godfrey et al concluded that the age compositions derived by the readers were very similar and approximated the true age compositions. To some extent this resulted from cancelling out over-aging by under-aging, but was mainly due to the accuracy with which readers assigned ages to scale.

However, they also concluded the fund of reliable criteria used in making age determinations from scales must be increased, if improvements in both accuracy and consistency are to be achieved. This need has become even more urgent with the advent and increase in production hatcheries in B.C. in latter years.

CONCLUSION

Because of the complexity of the life history of chinook salmon, there is a real need to initiate age validation for all major stocks of this species. The increased production, of this species from B.C. hatcheries as well as past and current production from United States hatcheries have added to the all ready complex problems associated with ageing of this species from their scales. In order to meet the need for age validation, the author and Mrs. Y. Yole are currently making a detailed examination of the scales from nose-tagged, known-age chinooks recovered in the fisheries. It is anticipated these data will lead to the establishment of criteria that will be used in the ageing process. Two methods are currently being explored. One is the construction of objective criteria based on measurements of circulus number, circuli spacing and the widths between checks on the scales of know-age fish (the author). The other method is a more subjective one (Y. Yole), and perhaps complimentary to the first approach. This method involves the building of a key, where various descriptive features of the scale are scored as being either present or absent. The success rate of both methods in estimating the true age of the fish will be measured using additional scales from known age chinooks. If both methods are equally satisfactory, the second method because it will be easier to use, will likely be the one adopted by most scale readers. Hopefully, both methods will prove to be useful in ageing of chinook salmon of unknown age from their scales.

E. COHO SALMON

Almost all coho from both North America and Asia spend one or two years in freshwater before migrating to sea. Also, most spend two summers in the ocean, returning to spawn in the year following that in which they entered the sea, as either age 3_2 or 4_3 fish (Godfrey 1965) and some at ages 2_1, 2_2, 3_3, 4_1, 4_2, 4_3, 5_2 and 5_3.

Among the two major age groups (3_2 or 4_3 fish), the predomenance of one over the other varies geographically. According to Gribanov's determination (1926-36) 4_3 fish were predominant along the east coast of Kamchatka and 3_2 fish along the west coast. Gilbert (1914) indicated that in North America the proportion of 4_3 fish increased from south to north reaching a ratio of 60:40 in the Yukon River. In British Columbia it is estimated more than 95 percent of coho are 3_2 fish, and all but a few go to sea as one-year-old smolts.

As can be seen there are a considerable number of freshwater ocean age compositions. Most particularly among those stocks originating from Northern British Columbia, Alaska, and the U.S.S.R. where there is often more than one year of freshwater residence is known to occur. Identification of freshwater annuli on their scales can often be debatable, and particularly so for coho caught on the high seas. Generally designation of checks in the central area of the scales as freshwater annuli is mostly a subjective process with little firm evidence to support the interpretation made by the reader. As indicated earlier, most B.C. coho are considered to spend only one year in freshwater before going to the ocean. For the most part the freshwater area on their scales support this and present no problem in aging, but in some cases a second check is laid down in the freshwater zone of the scales which may or may not be a true annulus. This check has been integrated by some as a mid-summer check rather than a true annulus. Hence, I suspect the major problem area in ageing coho from their scales is that of correctly determining the freshwater age of these fish. This becomes more of a problem with the ageing of the northern stocks and in ageing of high seas catch samples. For the most part designation of marine annuli on their scales has not been a problem. To my knowledge age validation for B.C. stocks of coho has not been tested. Age validation for stocks outside of B.C. may have been done, but to my knowledge have not been published. There is need for studies to validate the scale method for ageing most major coho stocks.

SUMMARY

For all five species of Pacific salmon there is a need to validate the ages as determined from examination of their scales. Over the past few years scales from nose-tagged known-age adults of several salmon species recovered in the fishery have been collected. Thus, for the first time, validation and development of objective criteria for aging major stocks of chinook, chum, coho and possibly sockeye can be realized. In order to facilitate studies of this kind, an exchange of scales of known-age fish (both of juveniles and adults) of each species and pertinent data will be essential. Further, communication either verbally or in the form of informal or formal publications will also be desirable. A further aid, would be the holding of workshops, bringing together salmon scale readers, for discussion and presentation of their latest findings on ageing of Pacific salmon. Hopefully, the effects of these tactics will have the desired result of moving the process of ageing of salmon from the area of mostly an art towards that of a science.

REFERENCES

Anas, R.E. 1959. Three-year-old pink salmon. J. Fish. Res. Bd. Canada, 16(1): 91-92.

Anon, MS, 1956. Salmon scale readings by biologists of three countries. Interm. North Pacific Fish. Comm., Manuscript. 21p.

Bilton, H.T. and W.E. Ricker. 1965. Supplementary checks on the scales of pink salmon (Oncorhynchus gorbuscha) and chum salmon (O. keta). J. Fish. Res. Bd. Canada, 22(6): 1477-1489.

Bilton, H.T., E.A.R. Ball and D.W. Jenkinson. 1967. Age, size and sex composition of British Columbia sockeye salmon catches from 1912 to 1963. Fish. Res. Bd. Canada, Biological Station, Nanaimo, B.C., Circular (Stat. Series), No. 25, 4p; 163 Tables.

Chilton, Doris E., and Richard J. Beamish. 1982. Age determination methods for fishes studied by the Groundfish program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60: 102 p.

Clutter, R.I. and L.E. Whitsel. 1956. Collection and interpretation of sockeye salmon scales. Bull. Int. Pacific Salmon Fish. Comm., No. 9, 159p.

Eniutina, R.I. 1962. [Concerning the supplemntary ring in the nuclear portion of the scales of pink salmon, Oncorhynchus gorbuscha(Walb.).] Voprosy lkhtiologioi, 2(4): 740-742 (Old Series No. 25). [Fisheries Board of Canada Translation Series No. 510.]

Foerster, R.E. 1937. The return from the sea of sockeye salmon Oncorhyunchus nerka) with special reference to percentage survial, sex proportions and progress of migrations. J. Fish. Res. Bd. Canada, 3(1): 26-42.

Foerster, R.E. 1968. The sockeye salmon (Oncorhynchus nerka). Fish. Res. Bd. Canada., Bull 162: 422p.

Gilbert, C.H. 1914. Age at maturity of the Pacific Coast salmon of the genus Oncorhynchus. Bull. U.S. Bureau of Fish., Vol. 32, 1912 (Doc. 767 issued March 20, 1913).

Godfrey, Harold. 1965. Salmon of the North Pacific Ocean - Part IX coho, chinook and masu salmon in offshore waters. 1. Coho salmon in offshore waters. Int. North Pacific Fish. Comm., Bulletin, No. 16: 1-39.

Godfrey, H., D.D. Worlumd and H.T. Bilton. 1968. Tests on the accuracy of aging chinook salmon (Onchoynchus tshawytscha) from their scales. J. Fish. Res. Bd. Canada, 25 (9): 1971-1982.

Gribanov, V.I. 1948. Coho (Oncorhynchus kisutch Walb.)(General Biology) Izvestiia TINRO, Vol. 28. (Translation by W.E. Ricker, Fisheries Research Branch of Canada, Translation Series, No. 370 (FRB No.370).

Kwain, W., and J.A. Chappel. 1978. First evidence for even-year spawning pink salmon, Oncorhynchus gorbuscha, in Lake Superior, J. Fish. Res. Bd. Canada. 35: 1373-1376.

Lapin, Yu. Ye. 1963. [On the age and population dynamics of the Pacific pink salmon Oncorhynchus gorbuscha (Walbaum)] Voprosy lkhtiologii, 3(2): 243-255 (Old Series No. 27)[Fisheries Research Board of Canada Translation Series No. 509.]

--------1971. New Data relating to direct determination of the age of the pink salmon [Oncorhynchus gorbuscha (Walbaum)] by marking. A.N. Severtsov Institute of Evolutionary Morphology and Animal Ecology, U.S.S.R. Academy of Sciences, Moscow. Journal of lchthyology, Am. Fish. Society, Vol. II, No. 1: p49-58.

Miyaguchi, Kiichi. 1959. on the so-called "fry zone" appearing in the scale of pink salmon, Oncorhynchus gorbuscha (Walbaum), Bull. Hokkaido Regional Fisheries Lab., 20: 104-108.

Parker, R.R. 1964. Estimation of sea mortality rates of the 1960 brood year pink salmon of Hook Nose Creek. J. Fish. Res. Bd. Canda, 21(5): 1019-1034.

Tanaka,, S., M.P. Shepard and H.T. Bilton. 1969. Origin of chum salmon (Oncorhynchus keta) in offshore waters of the North Pacific in 1956-1958 as determined from scale studies. int. North Pac. Fish. Comm. Bull. 26: 57-155.

Turmer, C.E. and H.T. Bilton. 1968. Another pink salmon (Oncorhynchus gorbuscha) in its third year. J. Fish. Res. Bd. Canada, 25: 1993-1996.

Vedensky, A.P. 1954. [Age of pink salmon and the pattern of their fluctuations in abundance.] Izvestia tikhookeanskogo nauchnoissledovatel' skogo Instituta Rybnogo khozyaistua i Okeanografii, 41: 111-195. [English version: National Science Foundation, Washington, D.C.]