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Babine River Salmon after Removal of the Rock Slide

BY
H. GODFREY, W. R. HOURSTON and
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Fisheries Research Board of Canada
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W. E. RICKER
N. M. CARTER
Editors

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ABSTRACT

The Babine River rock slide, which was an obstruction to salmon in 1951 and 1952, was removed during the winter of 1952-53, and the site permitted free passage to salmon in 1953. An estimate of the Babine sockeye escapement in 1953, based on the size of the commercial catch, was within 2500 fish (+0.3 percent) of the actual escapement counted at the fence just below Babine lake. This, incidentally, provides confirmation of estimates of losses at the Slide in 1951 and 1952.

In 1953, about 90 percent of tags applied to sockeye below the site of the former obstruction were recovered at the fence, about 40 miles up river. The 1953 Babine sockeye run was large—more than 700,000. Fish were in good condition, arrived at the fence at the normal time, and were normal in respect to sex ratios and sexual maturity, in contrast to the abnormality in these respects of the runs in 1951 and 1952. Further, there were no abnormal losses in unspawned fish observed on the Babine Lake spawning grounds in 1953: approximately 95 percent of a large sample of dead females had spawned successfully.

The number of sockeye smolts migrating from Babine Lake in 1954 was estimated as 2.8 millions. These represented a survival rate from the *potential* egg deposition in 1952 of 0.69 percent, as compared with rates of 0.48, 0.77 and 1.52 for the seedings of 1949, 1950 and 1951, respectively. However, the probable number of eggs *actually deposited* in 1952 was much smaller after deducting estimated losses in unspawned females on the beds. The 2.8 million smolts represent 1.46 to 2.03 percent of this estimated deposition.

INTRODUCTION

The results of investigations carried out in 1951 and 1952 to determine the effects of the rock slide in the Babine River upon its salmon runs in those two years, have been described (Godfrey, Hourston, Stokes and Withler, 1954: hereinafter referred to as "Bull. 101"). The present paper reports on studies carried out during 1953, subsequent to the removal of the Slide during the previous winter. Primarily they were conducted to make sure that the migrating adults had unobstructed passage at the site of the cleared channel, and also to compare the extent and success of spawning in 1953 with that of the two Slide years.

Personnel of the Fish Culture Development and Protection Branches of the Department of Fisheries, and of the Fisheries Research Board, again participated co-operatively. The Fish Culture Development Branch supplied crews to tag and sample salmon in the Babine River and, assisted by the local Fisheries Inspector, to examine dead fish and recover tags from the Babine Lake spawning streams. The Fisheries Research Board again operated the Babine counting fence where the live runs were sampled and enumerated, and dead fish that had drifted onto the fence were examined to determine to what degree they had spawned. During the spring of 1954 Fisheries Research Board personnel also estimated the number of sockeye smolts produced from the seeding of 1952 at Babine Lake.

APPEARANCE OF SLIDE AFTER REMOVAL OF FALLEN ROCK

The General Construction Company of Vancouver began to remove the fallen material of the Slide on January 1, 1953, and completed the job on April 11 of that year, nearly 3 weeks before the contracted time-limit. Approximately 144,000 cubic yards of rock were excavated from the river channel and face of the Slide, and removed to disposal areas. The main area, as it appeared after the job was completed, can be seen in Figure 1. A small amount of material was unloaded below the Slide, along the foot of the left bank (Fig. 1). This was used as a road-bed for the trucks carrying the excavated rock to the main disposal area.

A profile of the channel floor as it appeared after the rock had collapsed into the river, and as it now appears since the removal of the fallen material, is given in Figure 2. The maximum depth of excavation required was approximately 23 feet. The final grade was believed to approximate closely the original grade before the Slide occurred. The gradient of the river bed was relatively steep, about 2 percent. The water surface profile during the presence of the Slide (measured on August 26, 1952) is also included in Figure 2.

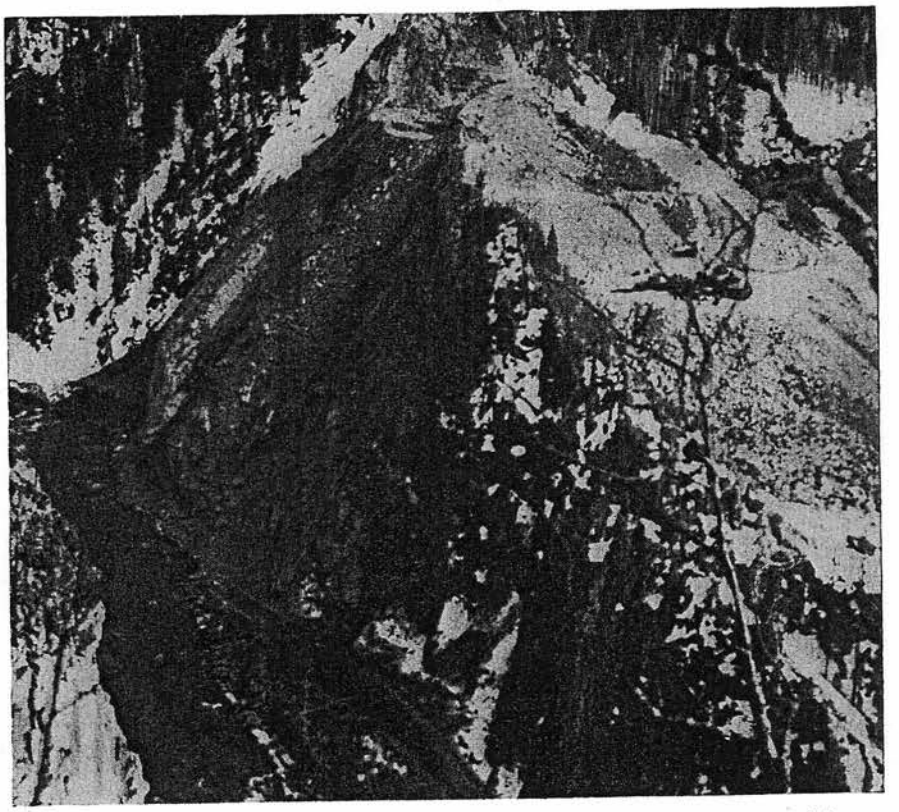

FIG. 1.—The Slide site upon completion of removal of the fallen material. Main disposal area at upper right; access road to river bed in centre foreground. April 12, 1953.

Figure 3 shows cross sections of the river channel both before and after the Slide had occurred, and also after the fallen rock had been removed. The mica lamprophyre dyke which was the prime cause of the collapse of the rock face is indicated at elevation 270 feet. A photograph of the Slide area taken on September 6, 1952 is shown in Figure 4. Figure 1 is a photograph of the same view, taken on April 12, 1953, after the job of returning the channel to approximately the original state had been completed. Two scenes of the removal operations are shown in Figures 5 and 6.

ESCAPEMENT OF BABINE SOCKEYE IN 1953

ESTIMATED AND OBSERVED ESCAPEMENT

A counting fence has been operated on the Babine River, 10 miles below Babine Lake, during the years 1946 to 1954, with the exception of 1948. In four years before the Slide (1946, 1947, 1949 and 1950) there was a very constant relationship between the fence counts of sockeye salmon and the annual com-

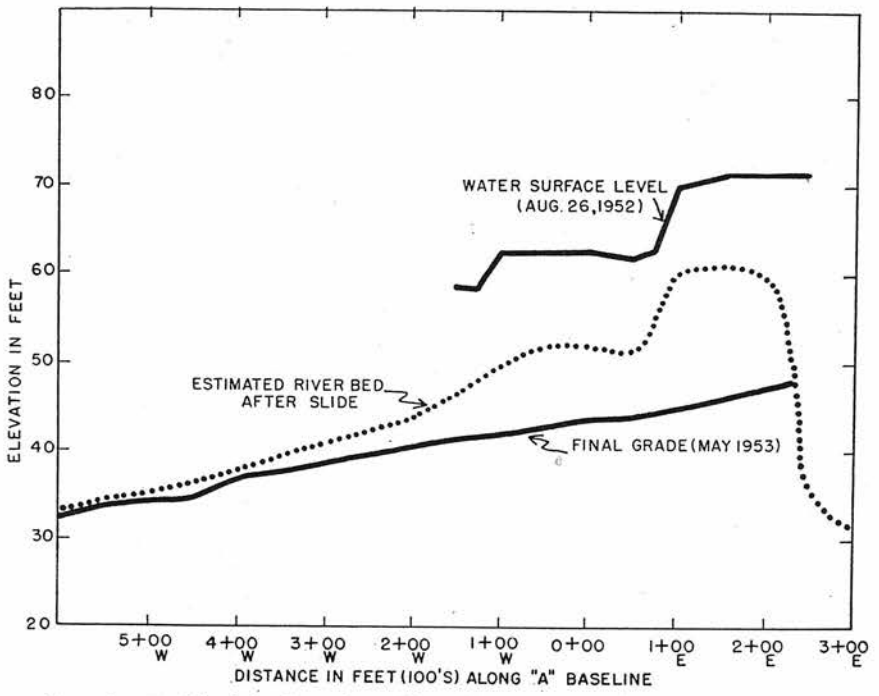

FIG. 2.—Profile of the river channel floor before and after removal of the Slide, and of the water surface level during its presence.

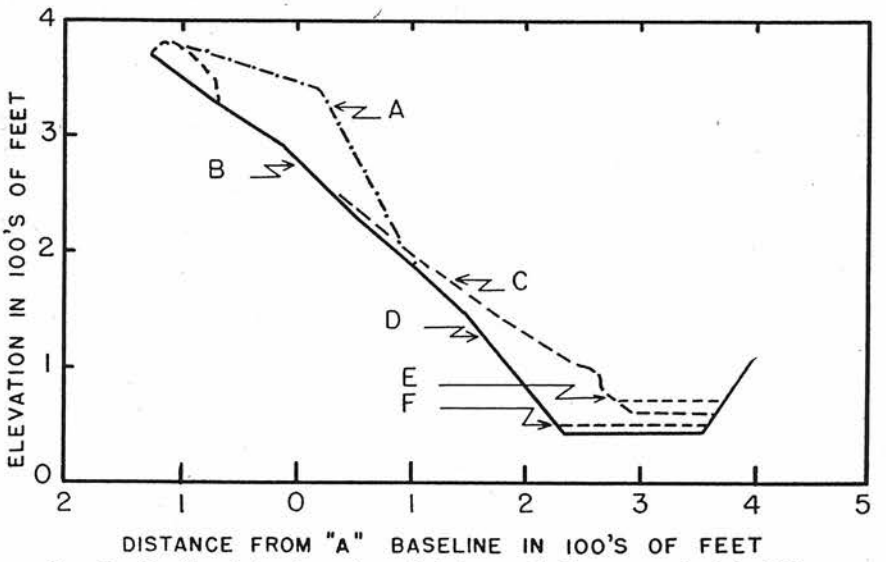

FIG. 3.—Profile of the river channel, before and after removal of the fallen rock. Section 1+00 East looking downstream. A—estimated ground line before Slide occurred; B—position of the lamprophyre dyke; C—ground line before removal of the fallen rock; D—ground line after removal of the fallen rock; E—river level before removal of rock; F—river level after removal of rock.

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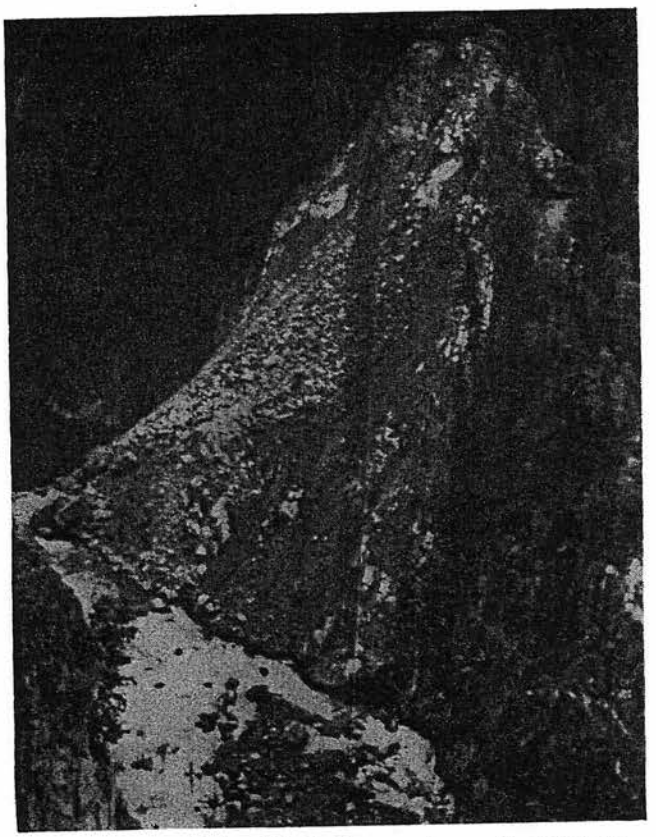

FIG. 4.—View of the Slide looking usptream, September 6, 1952. Compare with Fig. 1 of the same view in April, 1953.

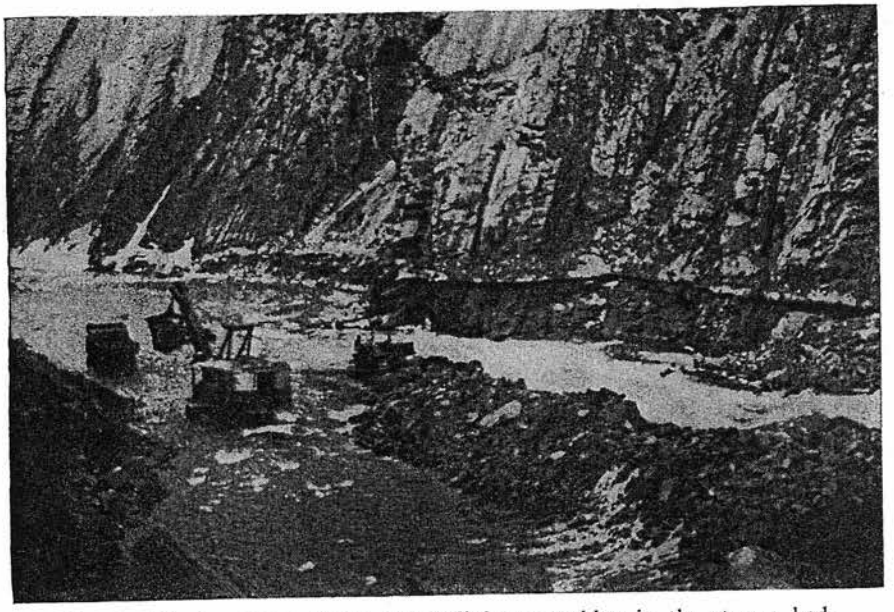

FIG. 5.—Truck, power shovel and bull-dozer working in the stream bed, removing the fallen rock. Looking downstream. April 7, 1953.

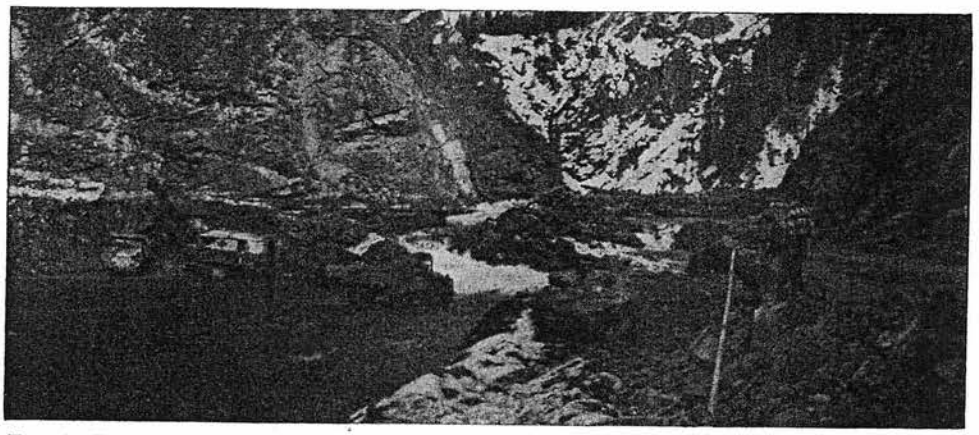

FIG. 6—Trucks and power shovel removing the fallen material from the river bed. Access road for equipment at right centre. Looking upstream. April 1, 1953.

mercial catch of Skeena sockeye. The fence counts (excluding jacks, the small, 3-year-old males) averaged 67.5 ± 0.6 percent (or approximately two-thirds) of the total catch of Skeena sockeye in each of four years (Bull. 101, Table 2). This relationship was therefore used to estimate the escapement of Babine sockeye from the fishery, and the losses at the Slide in 1951 and 1952 (Bull. 101, p. 26).

To test this method further, the 1953 escapement has been estimated in a similar manner, and may be compared with the actual escapement as determined by the 1953 fence count (Table 1).

In 1952 it was necessary to allow for a period of no fishing during a fishermen's strike (Bull. 101, p. 23)[1]. There was a similar period of no fishing at about the same time in 1953, when the Skeena area was closed to gill-netting for several days to allow additional escapement of sockeye to their spawning grounds. The closure was for five days between customary closed weekends. Immediately prior to the closure the catch had been approximately 30,000 sockeye per day. After the closure the catch was approximately 60,000 per day for two days, and then declined steadily during the remainder of the season. The peak of the sockeye run had apparently taken place during the period of no fishing. Allowing for the probable increased effort by fishermen when operations were resumed, a reasonable estimate of the "expected" catch during the five days of the closure (had there actually been fishing) is an average of 40,000 sockeye per day. The adjusted catch is the actual catch of 654,000 plus the estimated 200,000, or 854,000 sockeye. The 200,000 sockeye of the "expected" catch during the closure actually escaped the fishery. As in 1952, 60 percent of these are considered to be Babine fish, and the additional Babine escapement is therefore estimated as 120,000 sockeye. Following the observed 1946-50 ratio, the

[1]In 1953 there was a strike during the first two days of the fishing season, but it was compensated by a special open season during the following weekend. In any event the number of sockeye present at this time was very small.

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TABLE 1

Salmon counted through the Babine Fence, 1946–1953. The division of sockeye into jacks and larger fish is based on a sample of usually about 5 percent of the run, obtained by close inspection of all fish passing through each pen of the fence for 1 hour every 3 days (in 1952 and 1953, every day). The sample used for determining sex of the older fish was out-of-water inspection, each half-day, of 1 percent of the number of fish which had been counted the previous half-day. These were all obtained from a single pen of the fence, the same pen being used in all years. Data compiled by K. V. Aro, extending and correcting the preliminary tabulation of Aro (1952).

	1946	1947	1949	1950	1951	1952	1953
Sockeye salmon							
Numbers–							
Total	475,705	522,561	509,132	543,658	152,457	376,947	714,614
Females	236,158	144,171	274,153	204,985	68,053	143,457	383,451
Jacks	57,864	261,101[a]	47,993	179,302	11,042	27,936	28,028
Large males	181,683	117,289	186,986	159,371	73,362	205,554	303,135
Percentages							
Females	49·6	27·6	53·8	37·7	44·7	38·1	53·7
Jacks	12·2	50·0	9·4	33·0	7·2	7·4	3·9
Large males	38·2	22·4	36·8	29·3	48·1	54·5	42·4
Percentages (jacks excluded)							
Females	56·5	55·1	59·4	56·3	48·1	41·1	55·8
Males	43·5	44·9	40·6	43·8	51·9	58·9	44·2
Pink salmon	28,161	55,421	13,663	38,728	50	2,706	1,018
Coho salmon	12,489[b]	10,252[b]	11,938[b]	11,654[b]	2,122	10,554	7,648
Spring salmon	10,528	15,614	7,433	6,838	2,778	5,915	8,353
Chum salmon	18	7	5	7	0	1	17

[a] This figure erroneously given as 216,101 in Bull. 101 (Table 1, p. 14).

[b] In these years the fence count was discontinued early in October, when the coho run was still in progress; however at least 90 percent had arrived.

total 1953 escapement of Babine sockeye (excluding jacks) from the fishery is now estimated as two-thirds of the potential catch of 854,000, or 569,000; plus the 120,000 above or 689,000 sockeye in all.

The above estimate of 689,000 fish is to be compared with the actual Babine fence count of 1953 of 686,586 sockeye (other than jacks). Thus, application of the 1952 method of estimation to the 1953 situation yields an escapement estimate which is very close to the number which did actually reach Babine Lake. This result confirms the value of the catch: escapement ratio for estimating escapement during the two years of blockade, and hence the estimate of Slide losses.

Seasonal Movement of Sockeye

The progression of sockeye salmon to and beyond the site of the Slide in 1953 (Fig. 7) has been determined in the same manner as was done for 1951 and 1952 (Fig. 8). Using daily cumulative totals, the daily escapements from the fishery in 1953 (based upon the two-thirds ratio of fence count to commercial catch) have been advanced 20 days, while the fence counts have been pre-dated by 5 days (Bull. 101, p. 20). When the daily fence counts are subtracted from the daily escapement totals, the result is approximately zero throughout, so that there is no indication of any accumulation of fish at the Slide site in 1953.

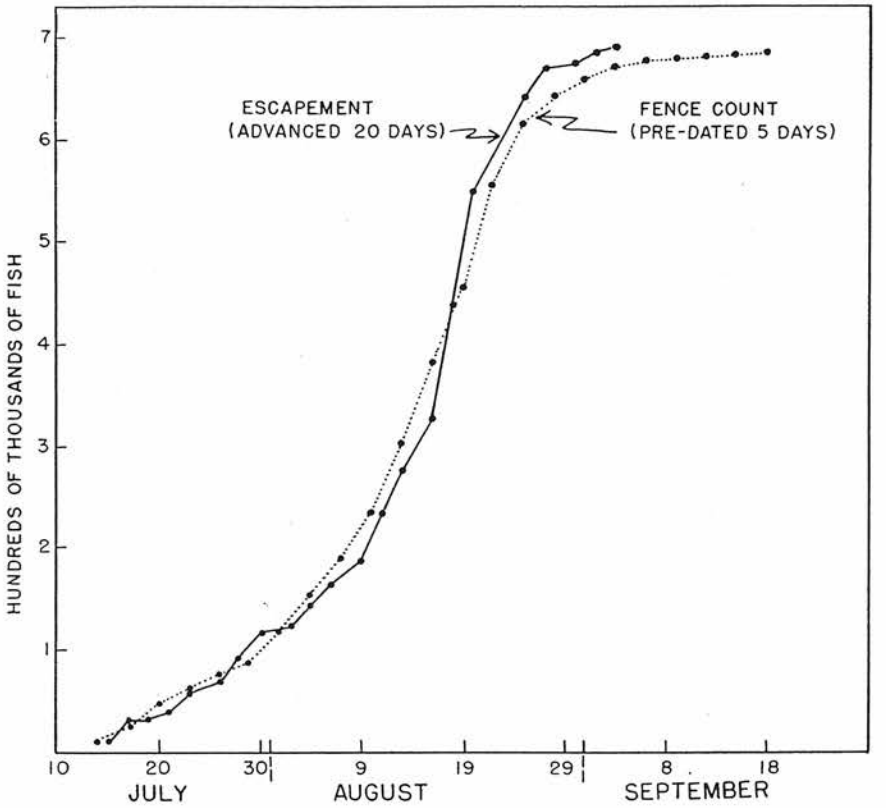

FIG. 7.—Progression of sockeye to and beyond the site of the Slide in 1953. Cumulative totals of two-thirds of catch advanced 20 days, and fence counts pre-dated 5 days.

TAGGING AND SAMPLING PROGRAM OF 1953

PURPOSE AND METHODS

During 1952 a program of tagging and sampling in the Babine River was conducted to determine some of the effects of the Slide upon salmon migrating up the river towards Babine Lake. A similar project was carried out in 1953 to make certain that the removal of the Slide material had left an unobstructed passage for fish, and that they were experiencing no delay there.

The methods of classifying, tagging and recovering the fish were the same as used in 1952 (Bull. 101, p. 36). Tags put on and recovered are shown in Table 2.

The principal difference between 1952 and 1953 was that salmon in the latter year were difficult to catch at the Slide. This was mainly because of the complete lack of good fishing locations. Only 200 sockeye were tagged there in 1953, whereas in 1952 salmon were available at the Slide in unlimited quantities.

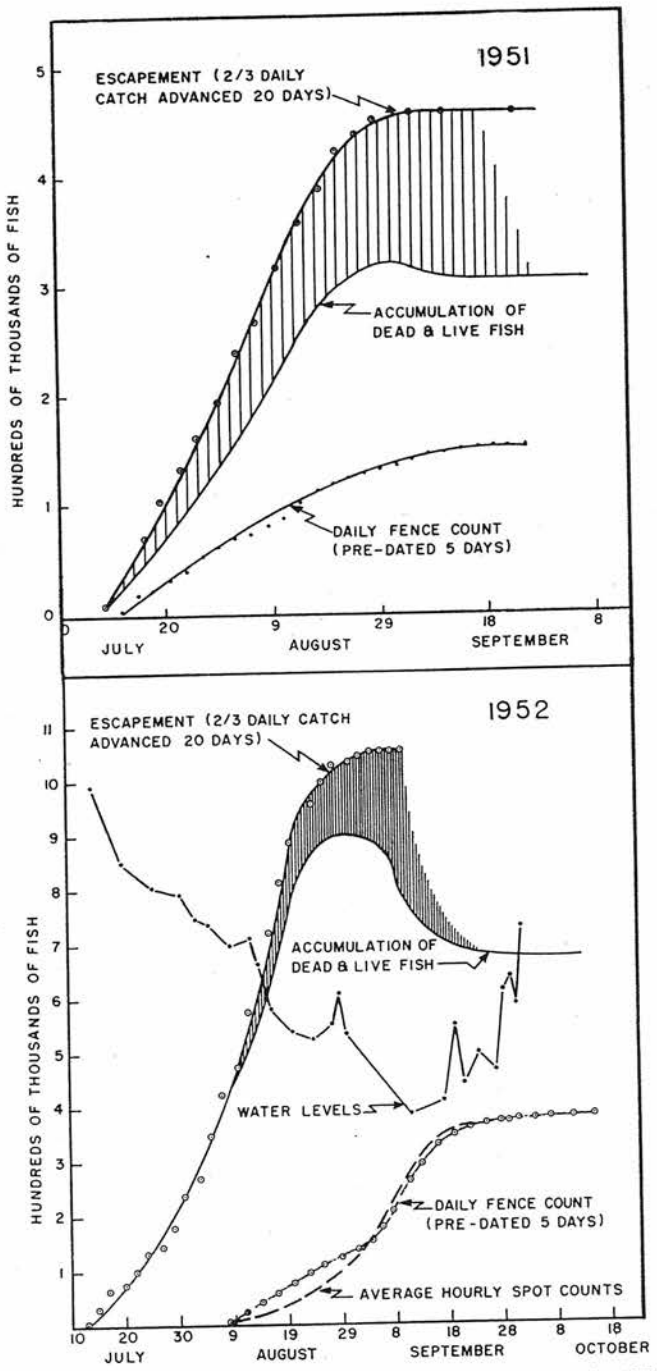

FIG. 8.—Progression of sockeye to and beyond the Slide in 1951 and 1952. Cumulative totals of two-thirds of catch advanced 20 days, and fence counts pre-dated 5 days.

TABLE 2

Number of salmon tagged at Kisgegas and the Slide, and numbers recovered at several locations, 1953.

Species	No. tagged		Recoveries							
			Below fence		At fence[a]	Above fence				
	Location	No.	Kisgegas	Slide		Streams	Fence-dead	Nilkitkwa L.	Indian Fishing	Combined
Sockeye	Kisgegas	2,038	13	1	1,834	239	138	3	199	579
	Slide	200	.....	.....	180	24	7	.....	26	57
		2,238	13	1	1,788	263	145	3	225	636
Pinks	Kisgegas	56	.....	.....	12	1	1	.....	1	3
	Slide	1	.....	.....	1	.....	1	.....	.....	1
Cohoes	Kisgegas	127	1	.....	69	2	3	.....	2	7
	Slide	2	.....	.....	.....	.....	.....	.....	.....	.....
Springs	Kisgegas	7	.....	.....	5	.....	3	.....	1	4
	Slide	0	.....	.....	.....	.....	.....	.....	.....	.....
Chums	Kisgegas	2	.....	.....	.....	.....	.....	.....	.....	.....
	Slide	0	.....	.....	.....	.....	.....	.....	.....	.....
Steelhead	Kisgegas	11	.....	.....	1	.....	.....	.....	.....	.....
	Slide	1	.....	.....	.....	.....	.....	.....	.....	.....

[a] Sockeye salmon recoveries at the fence have been adjusted as explained in the text, p. 10.

Furthermore, the sockeye tagged at the Slide in 1953 unavoidably received rough handling, and this probably delayed their upstream migration. However, in 1953, as in 1952, salmon were reasonably available at Kisgegas, and 2,038 tags were put on there.

Results for Sockeye Salmon

TOTAL RECOVERIES AT THE FENCE

Altogether 1,689 tagged sockeye reached the fence and had their tag numbers recorded there. Of these, 12 had their tags removed at the fence. In addition 233 tagged sockeye were seen to pass the fence, but their numbers were not read. (It is not possible to assign all of these to their tagging locations). There were probably also other tagged sockeye which passed through the fence unobserved, since of the 636 sockeye tag recoveries above the fence, 129 (20.3 percent) had not been read at the fence. Some of the difference between the two ratios of read to unread tags (i.e. at the fence and above the fence) doubtless resulted from recording tag numbers wrongly. Some may also have been due to a greater probability of recapture above the fence of unread over read tags, because of less handling of the former. For these reasons the number of tagged sockeye to reach the fence is arbitrarily set at 90 percent of the number tagged, or 2,014 instead of 2,116, the fully corrected figure ($=[(1689-12)/(1-0.203)]+12$), which would have amounted to 95 percent of the number tagged. This correction is of the same order as was made for the 1952 figures (Bull. 101, p. 80).

The 2,014 recoveries from the 2,038 tags applied at Kisgegas and the 200 affixed at the Slide will be divided according to the probable 90 percent recovery, as 1,834 Kisgegas tags and 180 Slide tags recovered at the fence. In actual fact, on the basis of tags actually *read* at the fence, the percentage recovery of Slide tags was slightly lower than that for Kisgegas tags. These adjusted figures of 1,834 and 180, respectively, are used wherever possible, but only the recoveries with numbers read at the fence can be employed when it is necessary to make analysis of recoveries according to time, sex, injuries, and degree of sexual maturity.

SEX RATIOS

Sex ratios among injured, uninjured, and combined injured and uninjured sockeye tagged at both sites are listed in Tables 3 and 4.

Within the large Kisgegas sample sex ratios among uninjured sockeye were very similar to those among the injured, with the exception that relatively more uninjured jacks were tagged than injured jacks (Table 3).

Among the combined injured and uninjured, and at both sites, approximately equal proportions of males and females were tagged. Jack sockeye in each case amounted to about 5 percent of the number tagged (Table 4).

TABLE 3

Sex ratios among injured and uninjured tagged sockeye, 1953.

Sex	Kisgegas				Slide			
	Injured		Uninjured		Injured		Uninjured	
	No.	%	No.	%	No.	%	No.	%
Males	275	47·2	685	47·1	37	46·8	57	47·1
Females	294	50·4	673	46·3	42	53·2	55	45·4
Jacks	14	2·4	97	6·7	0	0	9	7·4
Totals	583	100·0	1,455	100·0	79	100·0	121	100·0

TABLE 4

Sex ratios among combined injured and uninjured tagged sockeye, 1953.

Sex	Kisgegas		Slide	
	No.	%	No.	%
Males	960	47·1	94	47·0
Females	967	47·4	97	48·5
Jacks	111	5·5	9	4·5
Totals	2,038	100·0	200	100·0

SEXES AND RECOVERIES AT THE FENCE

Uninjured sockeye recoveries at the fence are listed in Table 5. Of the total number tagged, male sockeye were recovered more often than female sockeye by about 2 percent ([84.5−82.6]/0.826), and more often by 11 percent than jack sockeye. Female sockeye were recovered more often than jacks by 8 percent.

Recoveries of injured sockeye are given in Table 6. Injured male sockeye were recovered more often than injured females and jacks by 5 and 16 percent, respectively. Injured female sockeye were recovered more often than injured jacks by 10 percent.

TABLE 5

Numbers of uninjured sockeye tagged and numbers and percentages recovered at the fence, by sexes, 1953. (M.: large males; F.: females; J.: "jack" males.)

Tagged at:	No. tagged			No. recovered			Percentage recovered		
	M.	F.	J.	M.	F.	J.	M.	F.	J.
Kisgegas	685	673	97	578	552	73	84·4	82·0	75·3
Slide	57	55	9	49	49	8	85·9	89·1	88·9
Combined	742	728	106	627	601	81	84·5	82·6	76·4

TABLE 6

Numbers of injured sockeye tagged and numbers and percentages recovered at the fence, by sexes, 1953. (M.: large males; F.: females; J.: "jack" males.)

Tagged at:	No. tagged			No. recovered			Percentage		
	M.	F.	J.	M.	F.	J.	M.	F.	J.
Kisgegas	275	294	14	206	209	9	74·9	71·1	64·3
Slide	37	42	0	26	29	.....	70·3	69·1	.....
Combined	312	336	14	232	238	9	74·4	70·8	64·3

PROPORTIONS OF INJURED SOCKEYE

The numbers and proportions of injured sockeye in the tagged samples are listed in Table 7. Approximately 30 percent of the sockeye when tagged bore some sort of mark, scar, abrasion or fungus infection. Even small net marks were classified as injuries. A slightly higher proportion of females was injured than "normal" males. Relatively few of the jacks tagged were injured.

TYPES OF INJURIES

Tagged injured fish were described as having either *head*, *body*, or *head and body* injuries, regardless of the seriousness of the injury (Table 8). Among the 662 injured sockeye tagged at Kisgegas and the Slide, 11.9 percent had *head* injuries, 82.2 percent had *body* injuries, and 5.9. percent had *head and body* injuries.

There were only slight differences between large males and females in the distribution of the types of injuries among them. Only 14 injured jack sockeye were tagged, of which 7 had *head* injuries, 6 had *body* injuries, and 1 was injured in both *head and body*.

TABLE 7

Numbers and percentages of injured sockeye in the tagged samples, 1953.

Location	Males			Females			Jacks			Combined
	Total sample	Number injured	Percent injured	Total sample	Number injured	Percent injured	Total sample	Number injured	Percent injured	Percent injured
Kisgegas	965	275	28·5	964	294	30·5	109	14	12·8	28·6
Slide	94	37	39·4	97	42	43·3	9	0	0·0	39·5
Combined	1,059	312	29·5	1,061	336	31·7	118	14	11·9	29·6

TABLE 8

Numbers and percentages of sockeye with *head*, *body* and *head and body* injuries among injured tagged sockeye, by sexes, 1953.

Sex	Head		Body		Head and body	
	Kisgegas	Slide	Kisgegas	Slide	Kisgegas	Slide
Male						
Number	34	7	226	27	15	3
Percent	12·4	18·9	82·2	73·0	5·5	8·1
Female						
Number	26	5	253	32	15	5
Percent	8·8	11·9	86·1	76·2	5·1	11·9
Jacks						
Number	7	.....	6	.....	1	.....
Percent	50·0	.....	42·9	.....	7·1	.....
Combined						
Number	67	12	485	59	31	8
Percent	11·5	15·2	83·2	74·7	5·3	10·1

RECOVERIES AND TYPE OF INJURY

Recoveries among sockeye with *head* injuries and sockeye with *body* injuries in the combined Kisgegas and Slide sample were similar (Table 9). Sockeye with *head and body* injuries, however, were recovered only about half as often as those with either *head* or *body* injuries.

TABLE 9

Recoveries at the fence of tagged sockeye with different types of injuries, by sexes, 1953.

Sex	Head		Body		Head and body	
	Kisgegas	Slide	Kisgegas	Slide	Kisgegas	Slide
Males						
Number tagged	34	7	226	27	15	3
Number recovered	23	4	176	20	7	2
Percentage recovered	67·6	57·1	77·9	74·1	46·7	66·7
Females						
Number tagged	26	5	253	32	15	5
Number recovered	21	2	183	26	5	1
Percentage recovered	80·8	40·0	72·3	81·3	33·3	20·0
Jacks						
Number tagged	7	.....	6	.....	1	.....
Number recovered	5	.....	4	.....	0	.....
Percentage recovered	71·4	.....	66·7	.....	0·0	.....
Combined						
Percentage recovered	73·1	50·0	74·8	78·0	38·7	37·5

TABLE 10

Number and percentages of combined injured and uninjured sockeye in different stages of sexual maturity, by sexes, 1953. (G=green; P=pink; R=red. No fish in the "mature" category were tagged.)

Location	Males			Females			Jacks			Combined		
	G	P	R	G	P	R	G	P	R	G	P	R
	Numbers											
Kisgegas	673	277	10	798	167	2	110	1	.....	1,581	445	12
Slide	51	35	8	53	40	4	8	1	.....	112	76	12
Combined	724	312	18	851	207	6	118	2	.....	1,693	521	24
	Percent											
Kisgegas	70·1	28·8	1·0	82·5	17·3	0·2	99·1	0·9	.....	77·6	21·8	0·6
Slide	54·3	37·2	8·5	54·6	41·2	4·1	88·8	11·2	.....	56·0	38·0	6·0
Combined	68·7	29·6	1·7	80·0	19·5	0·6	98·3	1·7	.....	75·7	23·3	1·1

PROPORTIONS IN DIFFERENT STAGES OF SEXUAL MATURITY

Approximately 76 percent of the sockeye tagged at the two locations were green fish, 23 percent were pink, and 1 percent were red (Table 10). No tagged fish belonged to the "mature" category.

The differences between the sexes in respect to degree of sexual maturity were not great, with the exception of jacks, among which less than 2 percent were not green fish.

RECOVERIES AND DEGREE OF SEXUAL MATURITY

Large green male sockeye and green female sockeye were recovered slightly more frequently than pink fish, among both samples (Table 11). Only 2 of the jacks tagged were not green fish. Both green and pink females and large males were recovered about twice as often as red males and females.

SEASONAL VARIATION IN PERCENTAGE RECOVERY

Percentage recoveries, by 3-day totals, with the dates shown referring to date of tagging, are plotted in Figure 9 for Kisgegas injured and uninjured sockeye. Tagging was not done on every day, so that for convenience the 3-day totals have been grouped for each 3 consecutive days of tagging.

Recoveries of uninjured sockeye were almost consistently higher than injured sockeye, and were also more constant throughout the season. Among the injured

TABLE 11

Recoveries at the fence of combined injured and uninjured sockeye according to degree of sexual maturity, 1953. (G=green; P=pink; R=red.)

	Kisgegas			Slide		
	G	P	R	G	P	R
Males						
Number tagged	673	277	10	51	35	8
Number recovered	555	226	3	43	28	4
Percent recovered	82·5	81·6	30·0	84·3	80·0	50·0
Females						
Number tagged	798	167	2	53	40	4
Number recovered	636	124	1	45	32	1
Percent recovered	79·7	74·2	50·0	84·9	80·0	25·0
Jacks						
Number tagged	110	1	.....	8	1	.....
Number recovered	81	1	.....	7	1	.....
Percent recovered	73·6	100·0	.....	87·5	100·0	.....
Combined						
Percent recovered	80·5	78·9	33·3	84·8	80·3	41·7

sockeye the proportions recovered rose from about 60 percent to a peak of about 90 percent during the latter half of August, and then declined again.

TIME FROM TAGGING TO RECOVERY

Among 1,121 uninjured sockeye tagged at Kisgegas, the time out from date of tagging to date of recovery at the fence averaged 7.7 days. The corresponding figure for 393 injured sockeye was 7.8 days. Fish tagged late in the season took about 1 to 2 days longer on the average to reach the fence than earlier ones (Fig. 10).

The time out from tagging to recovery at the fence for 63 uninjured and 20 injured sockeye tagged at the Slide averaged 10.5 days. Since the Slide site is above the Kisgegas tagging location (by about 10 miles), this indicates a delay after tagging among fish tagged at the Slide of 4 to 5 days, which was doubtlessly due to the unavoidable rough handling they received there.

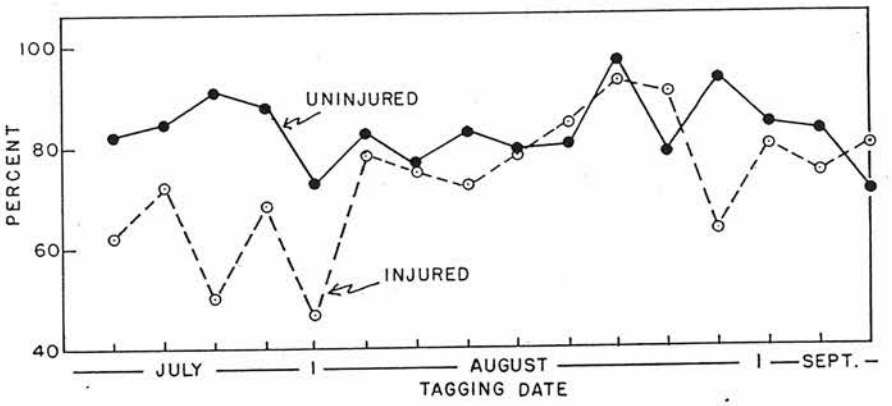

FIG. 9.—Seasonal variation in percentage recovery of injured and uninjured sockeye tagged at Kisegas and recovered at the fence, in 1953. Totals for 3 consecutive days of tagging, according to date of tagging.

RECOVERIES BELOW THE FENCE

Of the 2,038 sockeye tagged at Kisgegas 13 were recovered at Kisgegas and 1 at the Slide while capturing fish for tagging. No Slide-tagged fish were recovered below the fence. No dead sockeye, tagged or untagged, were observed anywhere in the river below the fence.

RESULTS FOR OTHER SPECIES

TAG RECOVERIES

The numbers tagged, and the recoveries made, of pinks, cohoes, springs, chums and steelhead are listed in Table 2. Percentage recoveries at the fence of Kisgegas-tagged fish were: pinks 21.4; cohoes 54.3; springs 71.4; chums 0; and steelhead 9.1. Only 4 fish other than sockeye were tagged at the Slide.

COMPARISONS WITH 1952 TAGGING

Sockeye Salmon

AVAILABILITY FOR TAGGING

During 1952 fish were blocked for long periods below the Slide. They crowded the available pools and eddies, and so were taken with the greatest ease. In 1953 only 200 sockeye and a few other salmon were caught at the Slide site, although almost 750,000 salmon passed it on their way upstream. Only a few hundred salmon were actually seen there throughout the season.

A little more than twice as many sockeye were tagged at Kisgegas in 1952 as in 1953. More were available for easy capture in the earlier year since there were many that had become weakened at the Slide and had drifted downstream. Indeed, many fish caught at Kisgegas in 1952 had to be discarded for tagging because of their poor condition.

INJURIES

The proportions of injured fish in the tagged samples of the two years are listed in Table 12.

TABLE 12

Percentages of injured sockeye, by sex, in the tagged samples of 1952 and 1953.

Location		Males	Females	Jacks	Combined
Kisgegas	1952	32·1	41·4	12·7	35·7
	1953	28·5	30·5	12·8	28·6
Slide	1952	22·0	27·4	35·1	24·6
	1953	39·4	43·3	0·0	39·5
Combined	1952	25·2	32·1	10·3	28·3
	1953	29·5	31·7	11·9	29·6

Because of their greater availability for capture it was impossible, in 1952, to avoid tagging disproportionate numbers of weak and injured fish at either of the two tagging sites. In 1953, also, there was a disproportionate number of damaged fish in the large Kisgegas sample. At that location the weaker individuals probably moved upstream close to the banks, by way of quiet pools and eddies, and so were more available for capture. Because of this, and because of the rejection of some injured fish in 1952, the tagged samples of the two years included approximately equal proportions of injured fish (Bull. 101, p. 43).

The kinds of injuries seen in the two years were similar, in general, in that body injuries were much more numerous than head injuries (Table 13). However, about 30 percent of the injured fish in 1952 had had a head injury, as compared with only 18 percent in 1953.

TABLE 13

Percentages of injured sockeye with *head*, *body*, and *head and body* injuries among injured sockeye in 1952 and 1953, by sexes.

Sex		Head		Body		Head and body	
		Kisgegas	Slide	Kisgegas	Slide	Kisgegas	Slide
Males	1952	26·0	43·1	66·9	52·7	6·9	4·2
	1953	12·4	18·9	82·2	73·0	5·5	8·1
Females	1952	21·5	35·6	71·9	61·2	6·5	3·2
	1953	8·8	11·9	86·1	76·2	5·1	11·9
Jacks	1952	16·7	.....	78·6	100·0	4·8	.....
	1953	50·0	.....	42·9	.....	7·1	.....
Combined	1952	23·1	38·6	70·2	57·8	6·6	3·6
	1953	11·5	15·2	83·2	74·7	5·3	10·1

SEXUAL MATURITY

Table 14 indicates that there were more mature fish among those tagged in 1953 than in 1952, despite the long delay below the obstruction which most fish experienced in 1952. This was mostly due to selective fishing at Kisgegas and the Slide in 1952, which was of two sorts: the application of relatively more tags early in the run when fish were less mature; and the discarding of many mature fish. The actual sockeye run upon its arrival at the fence in 1952 was distinctly more mature than the run at the fence in 1953 (Table 18, and text p. 16).

DELAY AFTER TAGGING

In 1952, delay below the obstruction was most prolonged during early August, and among tagged fish it averaged between 20 and 30 days after tagging. This does not include delay which may have taken place before fish were tagged. During the remainder of the season the delay decreased gradually (Bull. 101, fig. 27, 28). Delay was measured from date of tagging to date of recovery at the fence, allowing for a normal average period required for migration from tagging site to fence. This normal period of migration was estimated as approximately 8 days from Kisgegas, and 6 days from immediately above the Slide. Fig. 10 compares the seasonal change in time of migration (uninjured fish) from Kisgegas to the fence in 1952 and 1953.

There was no apparent delay in 1953 for Kisgegas sockeye. They averaged approximately 8 days from date of tagging to date of recovery at the fence, which is the "normal" time as estimated in 1952. Sockeye tagged at the Slide in 1953, however, averaged a longer time out from tagging to recovery, approximately 11 days. This apparent delay of 5 days was partly due to the rougher handling which fish unavoidably received when tagged at this site.

TABLE 14

Percentages of green, pink, red, and mature, uninjured sockeye tagged in 1952 and 1953, by sexes.
(G, green; P, pink; R, red; M, mature.)

Location		Males				Females				Jacks				Combined			
		G	P	R	M	G	P	R	M	G	P	R	M	G	P	R	M
Kisgegas.....	1952	80·8	15·8	3·3	0·2	88·5	11·1	0·2	0·2	96·6	3·5	.....	.....	86·0	12·4	1·5	0·1
	1953	72·6	26·7	0·7	.....	84·0	16·0	.....	.....	99·0	1·0	.....	.....	79·6	20·1	0·3	.....
Slide.....	1952	57·1	34·9	7·3	0·7	63·7	34·2	2·1	.....	80·4	19·6	.....	.....	60·8	34·3	4·5	0·4
	1953	68·4	26·3	5·3	.....	65·5	32·7	1·8	.....	88·9	11·1	.....	.....	68·6	28·1	3·3	.....

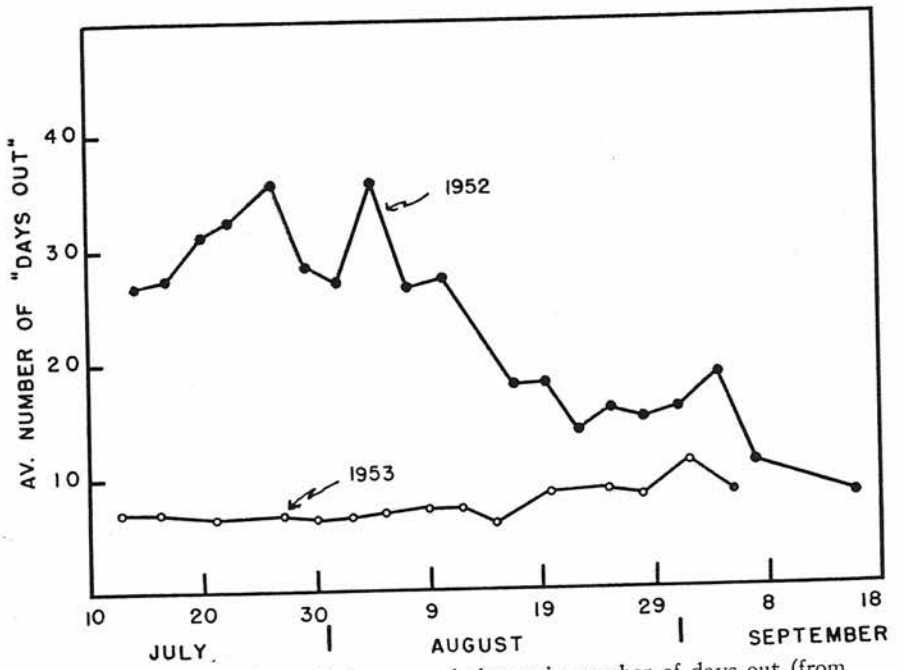

FIG. 10.—Comparison of the seasonal change in number of days out (from date of tagging at Kisegas to date of recovery at the fence) in 1952 and 1953. Sockeye (uninjured) are grouped into 3-day periods, according to date of tagging.

RECOVERIES IN BOTH YEARS

TOTAL RECOVERIES. Total sockeye recoveries from fish tagged below the obstruction were approximately 12 percent in 1952, as compared with approximately 90 percent in 1953.

Since recoveries in both years varied with sex, condition (injuries) and stage of sexual maturity, it is necessary to compare recoveries for similar groups. Furthermore, success in reaching the fence in 1952 was related to time of tagging. Thus, the earliest tagged fish experienced worse conditions at the Slide, and suffered greater losses. Highest recoveries were obtained from fish tagged shortly before and after the partial opening of the channel late in August.

In 1952 uninjured sockeye were recovered more frequently than injured sockeye, males more often than females, and green fish more often than maturer fish. Similar but much smaller differences were observed in 1953. Since the total recoveries in 1953 were so high (90 percent), it is considered sufficient for the purpose of comparing the two years, to deal with the recoveries of green, uninjured fish only.

RECOVERIES OF GREEN, UNINJURED, SOCKEYE. Table 15 lists the recoveries, by sexes, of green, uninjured, sockeye in the two years. Males were recovered only slightly more frequently (by 0.9 percent) than females in 1953, whereas in 1952 there was a marked difference. For the sexes combined the 1953 recoveries were 6 times as numerous as in 1952.

TABLE 15

Recoveries at the fence of green, uninjured sockeye in 1952 and 1953, by sexes.

Location		Males			Females			Jacks			Combined		
		Tagged	Recovered	Percentage recovery	Tagged	Recovered	Percentage recovery	Tagged	Recovered	Percentage recovery	Tagged	Recovered	Percentage recovery
Kisgegas.....	1952	1,016	142	16·7	1,182	95	9·0	280	32	13·3	2,478	269	10·9
	1953	497	416	83·7	565	466	82·5	96	72	75·0	1,158	954	82·4
Slide.....	1952	1,798	372	20·7	2,109	239	11·3	86	6	7·0	3,993	617	15·5
	1953	39	33	84·6	36	32	88·9	8	7	87·5	83	72	86·7
Combined.....	1952	2,814	514	18·3	3,291	334	10·1	366	38	10·4	6·471	886	13·7
	1953	536	449	83·8	601	498	82·9	104	79	76·0	1,241	1,026	82·7

SEASONAL CHANGE IN PERCENTAGE RECOVERY. The daily percentage recovery in 1952, for tagged fish of both sites, rose gradually to a peak in late August (directly after the channel was opened), and then declined fairly rapidly (Bull. 101, fig. 27, 28). The late decline was associated with the end of the sockeye run, and the poor condition of fish being tagged. In 1953, the percentage recovery of uninjured Kisgegas fish showed no significant seasonal trend, but fluctuated about a mean rate of approximately 85 percent (Fig. 9). This, of course, includes only those tags that were actually read at the fence.

OTHER SPECIES

PINK SALMON

Almost 2,000 pink salmon were tagged in 1952 but only 9 (0.5 percent) were recovered at the fence. In 1953, 56 pinks were tagged at Kisgegas and 1 at the Slide, of which 13 (23 percent) were recovered at the fence (Table 2). Pinks are known to spawn each year below the fence, in the main river and in tributary streams, and the missing 77 percent doubtless consist largely of such spawners.

COHO SALMON

There were 509 cohoes tagged in 1952, and 114 fence recoveries (22 percent). This was the highest rate of recovery for all the kinds of salmon tagged that year, probably because the cohoes arrived late at the Slide, after conditions there had improved. In 1953, 129 cohoes were tagged, and recoveries at the fence were 69, or 54 percent (Table 2). Cohoes, too, spawn below the fence as well as above it.

SPRING SALMON

None of the 20 spring salmon tagged was recovered at the fence in 1952. In 1953, 5 springs were recovered at the fence from among 7 tagged at Kisgegas (Table 2).

CHUM SALMON

None of the 21 tagged chums was recovered at the fence in 1952, nor was either of the 2 tagged in 1953 (Table 2).

STEELHEAD TROUT

In 1952, 77 steelhead were tagged, but no recoveries were made. One steelhead was recovered at the fence in 1953 from 12 tagged (Table 2).

RECOVERIES BELOW THE FENCE

SOCKEYE SALMON

In 1952, while catching fish for tagging, 61 sockeye were recaptured at Kisgegas, and 365 at the Slide. In addition, 78 sockeye recoveries were made from the Lower Skeena, mostly as dead fish. Altogether these amounted to 3.7 percent of the 13,488 tagged in the Babine River in 1952.

Only 14 sockeye were recovered below the fence in 1953, or 0.7 percent of the 2,238 tagged. All were Kisgegas fish; 13 were recovered there, and 1 at the Slide. No recoveries were made from the Lower Skeena.

OTHER SPECIES

Recoveries of other species below the fence in 1952 were; pinks—2.1 percent; cohoes—7.8 percent; chums—9.5 percent; springs—none; and steelhead—none.

Of the 207 fish other than sockeye tagged in 1953, only 1 coho was recovered below the fence (at Kisgegas).

COMPARISONS OF ANNUAL BABINE SALMON RUNS

Sockeye Salmon

SIZE OF RUNS

The sockeye counts at the fence in 1951, 1952, and 1953 were 152,000, 377,000, and 715,000 respectively.

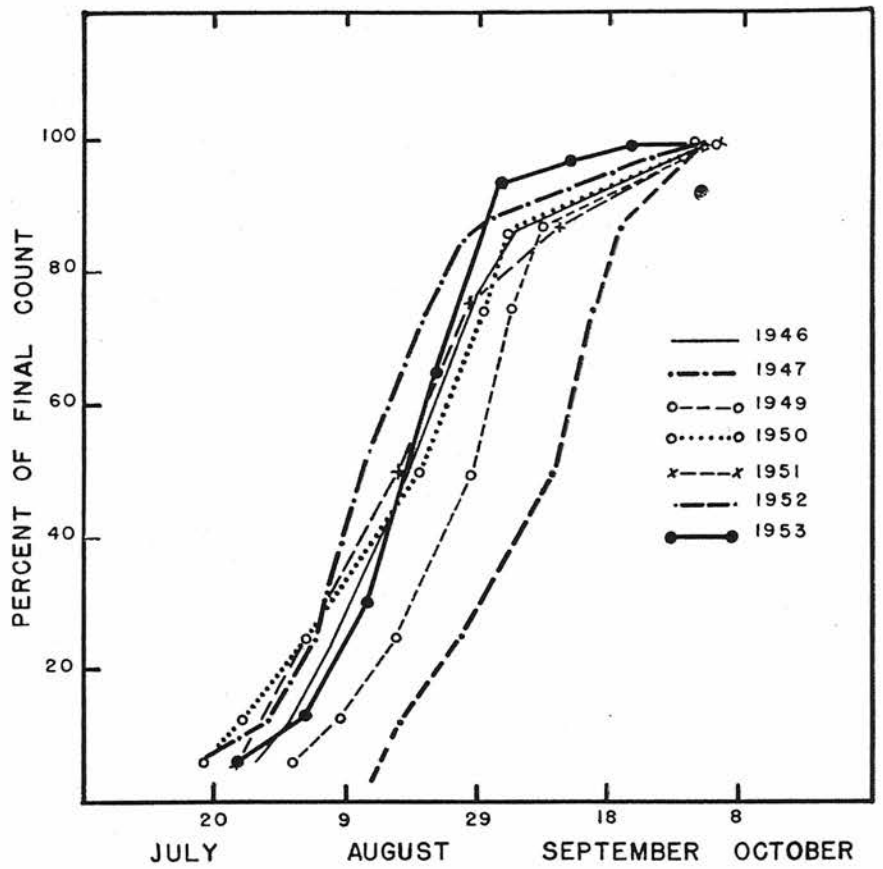

FIG. 11.—Comparisons of the times of arrival of sockeye at the fence for several years, by percentages of the final count achieved at various dates. (The years 1947 to 1951, inclusive, do not include jacks.)

The average count in the four pre-Slide years (1946, 1947, 1949 and 1950) was 513,000, so that the 1951 and 1952 counts were lower than this average by 360,000 and 136,000 respectively, while the 1953 count exceeded it by 202,000.

In two of the pre-Slide years, however, the sockeye runs contained a very large proportion of jacks—50 percent in 1947, and 33 percent in 1950. The pre-Slide average count of large males and females was 379,000, as compared with 141,000, 349,000, and 687,000 large males and females in 1951, 1952, and 1953, respectively (Table 1).

TIMES OF ARRIVAL

Despite the heavy losses at the Slide in 1951 the surviving sockeye arrived at the fence that year over a period of time corresponding closely to that of earlier years (Fig. 11). In 1952 fish were blocked for many days below the obstruction, with the result that the run as a whole was almost three weeks late at the fence, as compared with normal years. The large run of 1953 was very similar in its time of arrival to those of the pre-Slide years (Fig. 11).

SEX RATIOS

The percentage of females among "normal" sockeye (i.e., exclusive of jacks) in 1953 was 54; the average for the four pre-Slide years was 47 percent (Table 1). These compare with 48 percent females in 1951 and 41 percent females in 1952. These relatively small proportions of females in 1951 and 1952, were taken as an indication of the excess loss of female sockeye over males at the Slide in the two years. The 1953 figure is within the range observed in pre-Slide years (Table 1).

The number of jacks in the 1953 run at the fence was only 3.9 percent. This is the smallest proportion of jacks recorded in the seven years the fence has operated (Table 1).

INJURIES

Table 16 compares the proportions of injured, uninjured, and sockeye with net marks (injured and uninjured) in the runs at the fence in 1952 and 1953, as determined from the 1 percent proportionate samples. For each sex the proportion of injured fish was very much higher in 1952—for the sexes combined being 3.3 times that for 1953.

There were relatively more fish with net marks in 1953. This may reflect, principally, the long delay at the Slide in the earlier year, which would have given such marks a chance to heal or become obscured by Slide injuries.

In six of the seven years that the fence has operated the proportion of jacks in each run has been determined by the "jack count". During this operation injuries on females and large males are also noted, but only those that can be seen by an observer looking down on a fish in the counting pen. The "jack count" proportions of injured fish are shown in Table 17.

TABLE 16

Percentages of injured and uninjured sockeye at the fence in 1952 and 1953 as determined by the one percent proportionate sample. (N = normal; I = injured; NM = net marks. "Net marks" included normal and injured fish which had net marks.)

Year	Males			Females			Jacks			Combined		
	N	I	NM	N	I	NM	N	I	NM	N	I	NM
1952	55·3	42·9	1·8	52·5	45·2	3·3	77·5	21·8	1·0	56·0	42·1	1·9
1953	82·9	12·1	5·1	79·5	14·0	6·5	94·1	4·8	1·0	81·5	12·8	5·7

TABLE 17

Percentages of injured, netted and uninjured female and large male sockeye at the fence as determined by the "jack count" (see text), 1947–1953.

Year	Injured	Netted	Uninjured	Number in sample
1947	3·2	11·4	84·5	33,992
1949	6·8	6·2	87·0	30,185
1950	3·5	12·3	84·2	36,104
1951	30·0	18·3	51·6	7,951
1952	29·9	1·0	69·1	71,918
1953	2·7	4·3	93·0	133,954

The proportion of injured sockeye in 1953 was the lowest of the six years. The proportions of injured in the two Slide years were about equal, according to the sampling technique, and were about eight times greater than the average for the other years—30 percent as compared with 4 percent.

SEXUAL MATURITY

In 1952 and 1953 the 1 percent proportionate sample of the run at the fence provided estimates of the proportions of sockeye in different stages of sexual maturity. A comparison for the two years is made in Table 18. In 1953 almost 75 percent of the fish were green and pink, as compared with only about 25 percent in 1952. The difference reflects the delay experienced in 1952.

The effects upon sockeye of reaching Babine Lake in abnormally advanced sexual condition were no doubt serious, and probably contributed to the heavy loss in 1952 of fish that died without having spawned.

PINK SALMON

The numbers of pink salmon that reached the fence in 1953 and earlier years are given in Table 1. The loss, or at any rate the stoppage, in the two Slide years was evidently great. The average pre-Slide count (4 years) of pinks at the fence was 34,000 approximately. In 1951 and 1952 the pink counts were only 50 and 2,706 respectively.

In 1953 the count of pink salmon was 1,018. These fish were the product of the 1951 seeding, but did not necessarily all spring from the 50 that were put above the fence that year; some may have come from eggs laid below the fence.

A disproportionate loss or stoppage of female pink salmon at the Slide in 1951 and 1952 was indicated by the abnormal sex ratios of samples examined at the fence. Males were greatly in excess of females in those years, in contrast to more equal proportions or even an excess of females in normal years.

TABLE 18

Number and percentages of sockeye in the different stages of sexual maturity in the runs at the fence in 1952 and 1953.
(G=green; P=pink; R=red; M=mature.)

Year	Males				Females				Jacks				Combined			
	G	P	R	M	G	P	R	M	G	P	R	M	G	P	R	M
1952—number	2	432	1,303	308	15	426	982	7	1	43	130	115	18	901	2,415	430
percent	0·1	21·1	63·8	15·0	1·0	29·8	68·7	0·5	0·3	14·9	45·0	39·8	0·5	23·9	64·2	11·4
1953—number	158	1,879	969	21	382	2,542	803	2	28	232	22	8	568	4,653	1,894	31
percent	5·2	62·1	32·0	0·7	10·0	66·4	23·6	0·1	9·7	80·0	7·6	2·8	7·9	65·1	26·5	0·4

In 1953, among 634 dead pinks on the fence there were 382 females (60 percent) and 252 males (40 percent). Almost 99 percent of the females had spawned.

Coho Salmon

Table 1 gives the counts of coho salmon at the fence for the years 1946–1953. The average pre-Slide count was 11,583 cohoes. The counts of 1951 and 1952 were 2,122 and 10,554, respectively, while the 1953 count was 7,648.

The 1952 coho run at the fence was only 1,000 fish below the pre-Slide average. Cohoes arrived late at the Slide in 1952, after conditions there had improved, and as a result probably suffered less severely than sockeye and pinks.

The numbers of males and females in samples of dead on the fence in 1952 were almost equal, indicating that there had probably been no serious disproportionate loss of either sex. Among 160 dead cohoes on the fence in 1953, 54 percent were females, 42 percent were large males, and 4 percent were jack males.

Spring Salmon

The average count of spring salmon at the fence in the four years before the Slide was 10,553. In 1951 and 1952 there were 2,778 and 5,915 springs counted. The 1953 count of 8,353 was about 2,000 below the pre-Slide average (Table 1).

Among 1,058 dead springs on the fence in 1952, females made up 9 percent, large males 30 percent, and jack males 61 percent. Percentages for 1953 from a sample of 6,576 springs were, females 26, large males 35, and jack males 40 percent.

SOCKEYE LOSSES ABOVE THE FENCE IN 1952 AND 1953

Number and Spawning Condition of Dead Sockeye on the Fence

The half-mile long Lower Babine River, which extends between Nilkitkwa Lake and the fence is one of the most important of the Babine sockeye spawning streams. The spawning population is usually around 50,000 to 150,000 fish, most of which first spend from 2 to 4 weeks in Nilkitkwa Lake before coming down onto the beds. After spawning they die and drift downstream (although the fence operators have observed that most of them lie for at least several days on the river bottom). If the fence is still operating the drifters eventually come down onto it.

In 1952, 36,000 dead sockeye drifted onto the Babine fence. Some thousands, probably half the total number that had died in the river that year, still remained on the river bottom when fence operations were terminated on November 8. The dead fish appeared to have come from the whole of the live run through the fence (Bull. 101, fig. 33).

Approximately 70,000 dead sockeye were counted on the fence in 1953. These also amounted to about half the estimated number that had died in the river above the fence. There was a small number of earlier fish, but large numbers began to arrive on the fence only late in the season, and after the live

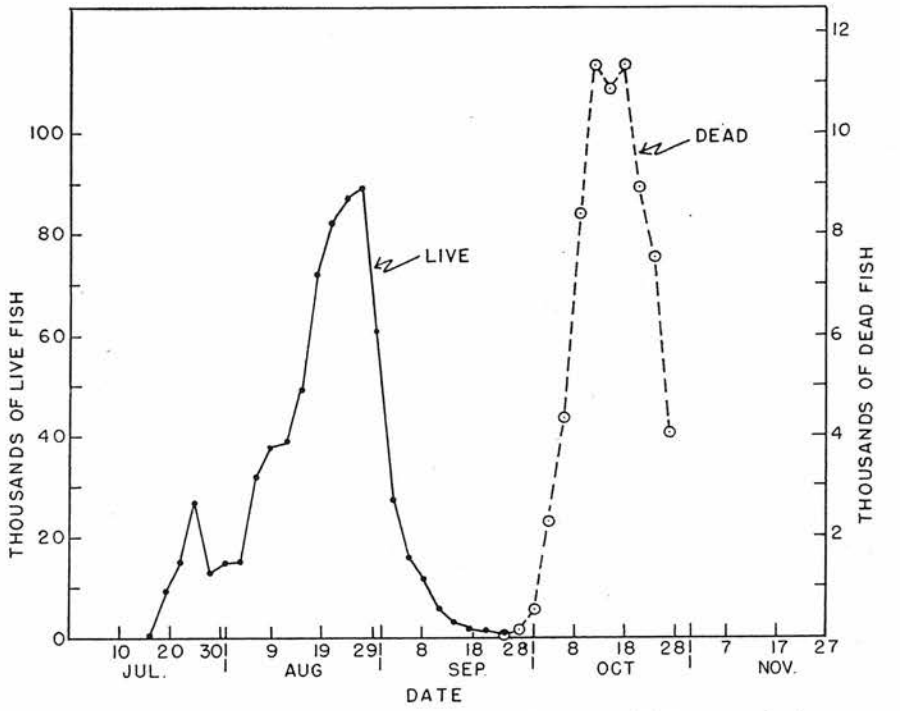

FIG. 12.—Three-day totals of the number of dead sockeye drifting onto the fence, compared with 3-day totals of live sockeye passing through the fence, 1953.

run was almost over (Fig. 12). The same pattern was apparent in 1946 and 1947, although in those years counts were stopped relatively early in the season (Bull. 101, fig. 32).

The most distinctive feature of the dead sockeye on the fence in 1952, as compared with 1953 and earlier years, was their spawning condition (Table 19). Approximately 12,000 females were among the 36,000 dead sockeye on the fence in 1952. Only 30 to 40 percent of these had spawned. During the first half of

TABLE 19

Comparison of spawning condition of dead female sockeye on the Babine fence in 1952 and 1953.

Spawning condition	1952		1953	
	Number	Percentage	Number	Percentage
Spawned	4,453	36·4	26,822	96·1
Unspawned	7,095	58·0	634	2·3
Partially spawned	695	5·7	460	1·6
Total	12,243	100·0	27,916	100·0

the count almost every female was an unspawned fish. Afterwards the proportion of spawned-out fish increased, and towards the end of the count most of the females were spawned-out. In 1953, among 27,916 females, 96.1 percent had spawned completely, 1.6 percent had spawned partially (75, 50 and 25 percent spawned-out), and only 2.3 percent were completely unspawned (Table 19). In years before the Slide, also, a very large proportion of the dead females on the fence had been spawned-out fish.

DEAD TAGGED SOCKEYE ON THE FENCE

There were 87 tagged sockeye among the dead on the fence in 1952. These amounted to 19.3 percent of the total recoveries above the fence, and to 4.3 percent of the tagged sockeye which reached the fence. In 1953, of the 636 sockeye tags recovered above the fence, 145 or 22.8 percent were found dead on the fence, and they made up 7.2 percent of the estimated 2,014 tagged sockeye that passed through the fence.

Although the proportions recovered on the fence appear very much the same, they are not truly comparable. In neither year were the numbers of tagged fish passing above the fence a constant proportion of the run, nor did the proportions vary in the same manner in the two years (Fig. 13). In 1953, more than 90 per-

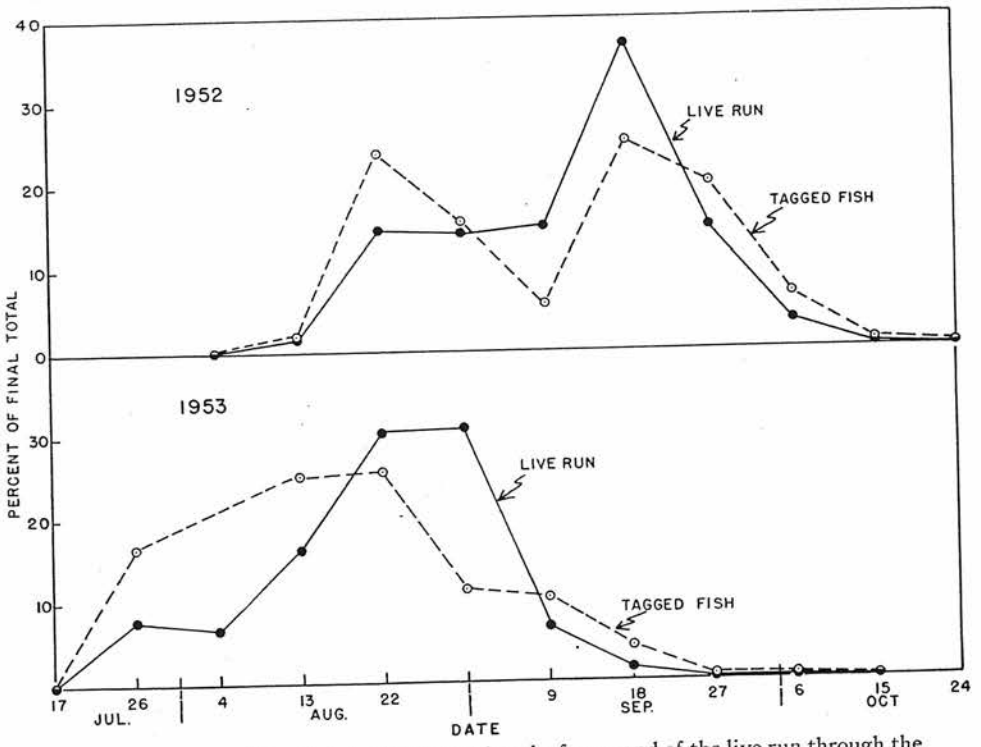

FIG. 13.—Percentages of final totals of tags passing the fence, and of the live run through the fence grouped in 9-day periods, for 1952 and 1953.

cent of the tagged dead sockeye on the fence had spawned successfully in the Lower Babine River. Fifty percent or more of the tagged sockeye found dead on the fence in 1952 had not spawned, and many of them probably did not belong to the Lower Babine River spawning population, as shown by timing (Bull. 101, p. 73). The fishing closure on the Skeena in 1953 permitted the additional escapement of a large number of Babine sockeye (estimated at 120,000 p. 5), a large proportion of which was undoubtedly Lower Babine River fish. This part of the run tended to have a relatively large proportion of tags, so that for this reason relatively more tags might be expected among the dead on the fence in that year. Therefore, it is felt that the two groups of recoveries do not represent the same effect, but rather that the 1952 recoveries were from fish other than, as well as, those belonging to the Lower Babine spawning population, whereas those of 1953 were almost exclusively Lower Babine River fish.

In 1952 the average time out for tagged sockeye which spawned, from the day they passed through the fence to the day when they were recovered dead on the fence, was about 20 days. The corresponding figure for 1953 was approximately 50 days. Sockeye in 1952 arrived later at the fence, and were more sexually advanced at the time of their arrival, than in 1953. They appear to have spent less time (presumably in Nilkitkwa Lake) before spawning on the beds of the Lower Babine River. In 1953, later arrivals at the fence tended to be back as dead fish on the fence within a shorter period of time than earlier arrivals (Fig. 14).

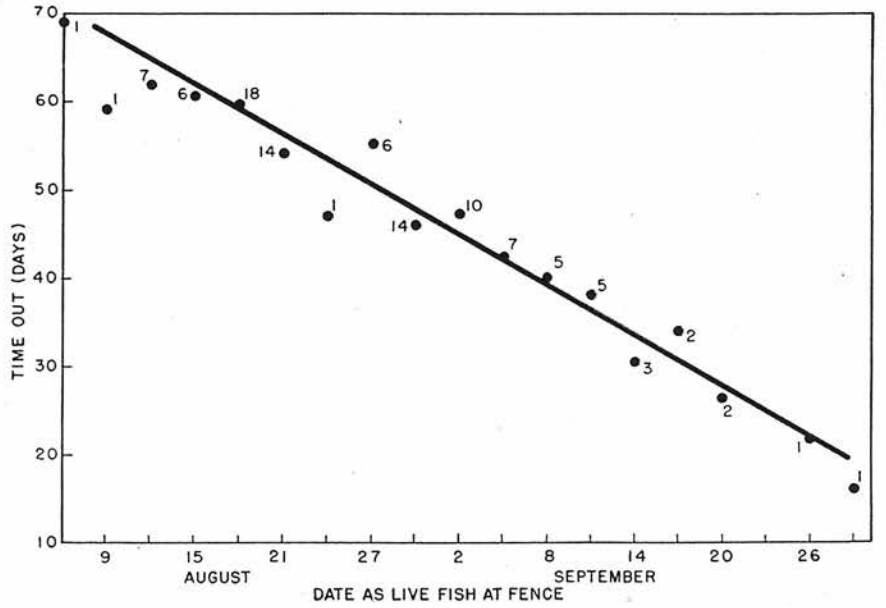

FIG. 14.—Seasonal change in average time out for spawned-out sockeye (excluding jacks), from time of arrival at the fence to time of recovery as dead on the fence. Three-day totals; number of fish in samples noted against corresponding points.

DEAD SOCKEYE IN NILKITKWA LAKE

Numerous dead sockeye were seen along the shores and among the weeds of Nilkitkwa Lake in 1952. Although a large number spawn each year in the two miles of the Upper Babine River between Nilkitkwa and Babine lakes, and many then drift downstream into Nilkitkwa Lake, the number seen in 1952 appeared abnormally high. Bulletin 101 (p. 70) gives 25,000 as the probable minimum number of unspawned dead in Nilkitkwa Lake in 1952, exclusive of dead that had first spawned in the Upper Babine River.

In 1953 the numbers of dead sockeye appearing in Nilkitkwa Lake were estimated at frequent intervals, from the time of their earliest occurrence until spawning on the Upper Babine River was almost over. From direct observations, and from the results of marking dead floating sockeye in the Upper Babine River, it was evident that the dead in the lake had come from this stream. The floating dead drifted out of the river, first tended to become concentrated along the shores at the head of the lake, and later were gradually shifted further downstream. The total number of dead in the lake up to the time of the last estimate was placed at 16,000.

Because surveys and estimates were not made in the same manner in the two years, they cannot be compared reliably as to number of dead. However, the 25,000 cited as the probable minimum number of dead in the lake in 1952, that had not first spawned in the Upper Babine River, still seems a reasonable estimate. The total sockeye run through the fence, and the spawning population in the Upper Babine River, in 1953, were much larger than in 1952. Had there then not been abnormal mortalities in the earlier year, the counts and estimates of 1953 should have indicated a distinctly larger number of dead in the lake. There was no indication that this was so.

There was a marked difference between the spawning condition of dead fish in the two years. In 1952 the probable proportion of unspawned dead females in the lake was set at 30 to 40 percent. In 1953, among 1,220 females examined throughout the season, 95 percent had spawned, 3 percent had spawned partially and 2 percent had not spawned (Table 20).

THE CATCH OF THE INDIAN FISHERY

Babine Lake Indians catch salmon each year for food, mostly in Nilkitkwa Lake. Their sockeye catch in 1953 was 25,560, only a few hundred of which were discarded as unsuitable. In 1952 the Indians caught about 42,000 sockeye, of which about 8,000 were in such poor condition that they could not be used as food.

DEAD SOCKEYE IN SPAWNING STREAMS

In 1953 the examination of dead sockeye in streams was extensive, covering the whole of the spawning period and most streams (Table 20). Excluding the dead on the fence and in Nilkitkwa Lake, almost 68,000 sockeye were examined

TABLE 20

Sex ratios, and spawning condition of females in samples of dead sockeye at Babine Lake, 1953.

Place	Examined for sex				Females examined for condition	Proportion of spawned females		
	Males	Females	Jacks	Combined	Number	Complete	Partial	Unspawned
Streams:								
Grizzly Cr.	74	239	12	325	33	100·0	0·0	0·0
4-Mile Cr.	486	756	14	1,256	64	90·6	4·7	4·7
6-Mile Cr.	1,337	1,269	57	2,663	.....	.....	.....	.....
15-Mile Cr.	2,565	2,957	256	5,778	103	94·2	0·0	5·8
Pendelton Cr.	605	797	77	1,479	58	70·7	3·4	25·8
Twin Cr.	3,191	4,246	149	7,586	237	93·3	2·1	4·6
Pierre Cr.	4,630	6,476	556	11,662	274	96·3	1·0	2·5
Kew Cr.	69	53	0	122	15	73·3	13·3	13·3
Sockeye Cr.	133	132	8	273	31	93·5	0·0	6·4
Tachek Cr.	648	804	51	1,503	68	85·3	4·4	10·3
Donalds Cr.	114	171	28	313	66	90·9	4·5	4·5
Fulton R.	13,741	15,357	1,411	30,509	251	89·6	3·6	6·7
Morrison R.	562	608	91	1,261	15	100·0	0·0	0·0
9-Mile Cr.	516	578	2	1,096	41	85·4	7·3	7·3
5-Mile Cr.	103	82	0	185	10	90·0	0·0	10·0
Tahlo Cr.	298	300	2	600	18	100·0	0·0	0·0
Upper Babine R.	564	580	3	1,147	582	97·4	1·5	1·0
Total	29,636	35,405	2,717	67,758	1,866	93·3	2·3	4·4
Sex Ratio	43·7	52·3	4·0					
Fence	35,890	33,742	597	70,229	27,916	96·1	1·6	2·3
Sex Ratio	51·1	48·0	0·9					
Nilkitkwa L.	1,569	1,171	7	2,747	1,220	94·8	3·0	2·2
Sex Ratio	57·1	42·6	0·3					
Total	67,095	70,318	3,321	140,734	31,002	95·9	1·7	2·4
Sex Ratio	47·7	50·0	2·4					

TABLE 21

Calculation of weighted mean percentage recovery of tagged sockeye on spawning streams in 1953. "Tags put on" refer to the number of tagged sockeye seen and recorded by tag numbers passing the fence during the 9-day period indicated.

The mean percentage recoveries is 100 times column 8, divided by column 6, or 8·8%.

Column No. 9-day period ending	2 Tags put over the Fence	3	4 Stream recoveries	5	6 Fence count	7	8 Column 5 times Column 6
	No.	%	No.	%	No.	%	
July 17	0	0·0	0	0·0	700	0·1	0
26	278	16·5	92	33·1	56,000	7·8	18,536
Aug. 4	116	6·9	22	19·0	46,500	6·5	8,835
13	424	25·1	59	14·2	115,300	16·1	16,373
22	426	25·2	34	8·0	218,400	30·6	17,472
31	188	11·1	1	0·5	219,000	30·7	1,095
Sept. 9	172	10·2	3	1·7	45,500	6·4	774
18	67	4·0	0	0·0	9,300	1·3	0
27	6	0·4	0	0·0	1,800	0·3	0
Oct. 6	11	0·7	0	0·0	1,500	0·2	0
15	1	0·0	0	0·0	400	0·0	0
Total	1,689	100·0	211	12·5	714,400	100·0	63,085

from 17 streams (not including the Lower Babine River). Among the 68,000 the sex ratios were: males 43.7 percent; females 52.3 percent; and jacks 4.0 percent. These proportions were very similar to those among the live run at the fence (Table 1). A total of 1,866 females from the 17 streams was examined to determine how they had spawned. Of these, 93 percent were spawned-out, 2 percent had spawned partially, and only 4 percent had not spawned. These values are very similar to those for the dead on the fence and in Nilkitkwa Lake. The highly efficient spawning of female sockeye in the Babine area in 1953 is indicated by the proportion of approximately 95 percent spawned-out females in a sample of nearly 30,000.

In 1952 only a small sample of dead sockeye from Babine Lake spawning streams was examined. Exclusive of the dead on the fence and in Nilkitkwa Lake, the total sample from streams was only 338, of which 173 were females. Allowing for the effect of sampling late in the season in 1952, after the proportions of fish spawning completely or almost so had increased, it was estimated that the overall average proportion of females that had spawned was between 60 and 70 percent (Bull. 101, p. 88), as against a normal figure of 90 to 95 percent.

ESTIMATION OF EFFECTIVE ESCAPEMENT

Estimate for 1953

The method of estimating the effective escapement is similar to that used in 1952 (Bull. 101, p. 82). As in 1952, the number of tagged sockeye passing the fence was not a constant fraction of the run there, so the mean percentage recovery from streams has been weighted as the run to the fence for successive 9-day periods (Table 21).

The tags recovered from streams, exclusive of recoveries from dead on the fence, included 211 of the 1,689 whose numbers were read at the fence, or 12.5 percent. The weighted mean percentage recovery was 8.8 percent (Table 21). However, this figure must be adjusted because a small number of tags was taken from *live* sockeye, whereas the standard method of recovery was to have been from dead fish. Twenty-four tags were recorded as live recoveries, and a few were not especially noted, but probably no more than 40 such live recoveries were made. Some of these tags, had they not been removed, would have been recovered later from dead fish, but it is estimated that about half would not. This reduces the total recaptures from 211 to 191, and the weighted rate of recovery is accordingly reduced to 191/211 of 8.8 percent, i.e. 8.0 percent.

Comparison with Other Years

The weighted mean percentage recovery of tags on spawning grounds for the several years are:

1946	7.0
1947	8.4
1952	4.6
1953	8.0

The 1946 and 1947 figures are slightly low because some live fish were still in certain streams at the time of the last inspections, but they are in good general agreement with the 1953 figure. The 1952 rate of recovery is distinctly lower, and confirms the view that only 50 to 60 percent of the sockeye which passed the fence in that year reached their customary streams (Bull. 101, p. 88).

PRODUCTION OF SMOLTS FROM THE 1952 SEEDING

The sockeye smolt run from Babine Lake in 1954 was produced from the seeding of 1952, and has been assessed as 2.8 million smolts. This compares with 4.2 millions in 1951, 4.5 millions in 1952, and 3.0 millions in 1953.

In 1952, the number of female sockeye passed through the fence was 143,457. Of these, about 12,500 were taken by Indians for food, leaving a potential spawning population of roughly 131,000. At approximately 3,140 eggs each, the potential number of eggs available was 410 millions. The 2.8 million smolts produced represent 0.68 percent of the eggs, as compared with 0.48, 0.77 and 1.52 percent in 1949, 1950 and 1951, respectively (Table 22).

On the basis of the 43,000 to 60,000 females estimated to have spawned successfully, the 2.8 million smolts represent a production of 1.48 to 2.07 percent. Thus, while the egg deposition was only 1/5 to 1/4 of the average for the pre-Slide years, the number of smolts was more than 1/2 their average number.

A similar calculation for the 1951 spawning cannot be made because the losses of spawning females are not known, but the percentage smolt production was probably even greater than in 1952 (Table 22).

TABLE 22

Estimates of sockeye smolts leaving Babine Lake from four spawnings, related to potential egg deposition (eggs in females passing the fence, less Indian catch). The 1954 smolt run is also related to *probable* egg deposition, based upon estimates of losses in unspawned females (see text) beyond the fence in 1952.

——	1949	1950	1951	1952
Potential female spawners	260,342	192,563	60,982	131,000
Eggs potentially available (millions)	876	583	197	410
Smolts produced (millions)	4·2	4·5	3·0	2·8
Smolts produced, as percentage of eggs	0·48	0·77	1·52	0·68
Eggs probably available (millions)[a]	876	583	.....	135·0-188·4
Smolts produced as percentage of probable number of available eggs	(0·48)	(0·77)	.....	1·48–2·07

[a] Assuming no abnormal loss in unspawned females in 1949 and 1950. The 1952 values are based upon upper and lower limits of estimates of losses in unspawned females.

STATUS OF BABINE SALMON

Sockeye

In pre-Slide years, and since 1946, the Babine sockeye escapements have averaged roughly 376,000 annually, exclusive of jacks. On the basis that the escapements in those years have been approximately equal to the catches of Babine sockeye, the average production of Babine sockeye has been in the order of 750,000 normal adults annually. Thus, Babine Lake (with an area of 172 sq. mi.) has produced sockeye salmon at the rate of about 4.5 thousand adults per sq. mi. of lake surface, per annum. This production is very low—lower than most if not all of other important sockeye lakes in the Province. For example, rough estimates of sockeye production (excluding jacks) at Long Lake (Smith Inlet) and Owikeno Lake (Rivers Inlet) are 60 and 51 thousand per sq. mi. of lake surface, per annum, respectively (based upon known catches, and escapements estimated as $\frac{1}{4}$ and $\frac{1}{3}$ of the total adult returns to Smith Inlet and Rivers Inlet, respectively).

The rock slide in the Babine River in 1951 and 1952 has reduced the Babine stocks of sockeye salmon quite seriously, since the numbers of spawners in both years were cut by about two-thirds. Next year, 1955, will see the return of 4-year-old fish from the 1951 seeding, and the size of the run of this age-class must be expected to be small. The number of 5-year-old fish that will return in 1955 (which will come from the "normal" seeding of 1950) cannot be predicted at this time, since it is not known how ocean conditions have affected the survival of the smolts that entered the sea in 1952. However, the trend of recent catches does suggest that, regardless of the effects of the ocean environment, the return of Skeena 5-year-old fish in 1955 probably will not be very great. In the immediate future, the run of 1956 will be most seriously affected by the Slide, since it will consist of both 4- and 5-year-old fish that are the progeny of seedings in each of the two Slide years. The year 1957 can be expected to have a poor return of 5-year fish from the 1952 spawning, but in respect to 4-year fish it may be as good or even better than "normal", because of the enhanced escapement in 1953, provided that environmental conditions during 1953-57 are not particularly adverse. To summarize, then: the Babine stocks during the next half decade probably will be reduced to about two-thirds of their former pre-Slide level. However, during this time, and certainly immediately after, special fishery regulatory measures may change this situation to an important degree.

In the late fall of 1954 a Committee on Management for the Skeena River Salmon Fisheries was established. One of the first objectives of this Committee will be the early rehabilitation of the Babine sockeye stocks to levels of abundance at least equal to those prior to the Slide's occurrence. Doubtless too, the Committee will pay particular attention to the problem of low sockeye production at Babine Lake. In terms of available water for growth and survival to the smolt stage, Babine Lake is a relatively poor producer of sockeye salmon. Investigations will be required to determine what factors are restricting further production, and how they may be circumvented.

Other Species

Pink salmon also suffered very heavy losses at the Slide in the two years. However, the proportion of the total Skeena escapement of pink salmon that utilizes that part of the Babine River spawning area blocked by the Slide, is almost certainly not very great. The overall production of this species in the Skeena system, therefore, probably will be little affected by the event. Furthermore, in the case of pink salmon, which frequently spawn in main rivers as well as their tributaries, the losses to the stock above the Slide probably will be recuperated at an early date, through recruitments both from survivors that spawned, and from spawnings that took place below the point of blockage.

The coho stock affected by the Slide is normally a very small fraction of the total Skeena stock. Also, losses among this species were very light, because of their more timely arrival at the obstruction. The Babine stock of coho salmon should be back to normal within a very short period of time—probably within one generation.

Extremely few chum salmon usually spawn above the site of the Slide. Spring salmon stocks at Babine were slightly depressed by the block, but are expected to regain their former level of abundance fairly rapidly.

SUMMARY

Bulletin No. 101 of the Fisheries Research Board of Canada describes the effects of the rock slide in the Babine River upon the salmon runs of 1951 and 1952.

The channel was cleared of the fallen material during the winter and spring of 1952-1953. During the summer and autumn of 1953 investigations were conducted to ascertain whether or not fish had unobstructed passage through the cleared channel, and to compare the sockeye spawning in 1953 with that of the obstructed run of 1952.

A method used to estimate the Babine sockeye escapements in 1951 and 1952, involving a catch: escapement ratio determined for earlier years, was applied again in 1953. The 1953 estimate of the Babine escapement was 689,000 fish, as compared with the actual enumeration at the Babine Lake counting fence of 686,586 (both excluding jacks). This close agreement supports the method employed to estimate the losses in 1951 and 1952. The similarity between the estimated escapement from the fishery and the count at the fence demonstrates that the slide site was no longer an obstacle in 1953.

In 1953, as in 1952, salmon were tagged at the site of the Slide and at Kisgegas, 10 miles farther downstream. However, it proved difficult to catch fish at the Slide, and only 200 sockeye were tagged there, as compared with 2,038 at Kisgegas.

Recoveries were made at the Babine fence, and amounted to approximately 90 percent of the number tagged. This high rate of recapture, plus the fact that no delay was indicated in time out from date of tagging to date of recovery, was another indication that fish were passing the former obstacle with ease. The 10 percent loss of tagged fish can be ascribed mainly to the observed fact that the fish available to taggers included a larger fraction of weak, injured and/or more mature individuals, which were less able to withstand the harmful effects of being tagged. In 1952, only about 10 percent of the salmon tagged below the obstruction were recovered at the fence. Even though the disproportionate loss of tagged over untagged fish was large, the recovery at the fence in 1952 of but 10 percent of all tagged fish was still extremely low.

Both in 1953 and in 1952, uninjured fish were recovered more frequently than injured, males more often than females, and greener fish more often than more mature fish. Also, in both years, injured fish with *head* or with *body* injuries were recovered more frequently than those with *head and body* injuries. However, whereas in 1952 sockeye with *body* injuries gave better returns than those with *head* injuries, the recoveries in 1953 from these two categories were very similar.

The 1953 sockeye run at Babine was approximately 715,000—almost twice that of 1952. The fish arrived at the usual time, were in very good condition, with relatively few injured, and were normal in respect to sex ratio and degree of sexual maturity. By comparison, the 1952 run was 3 weeks late in arriving at the fence, contained many injured fish, included a larger than normal fraction of males (other than jacks), and was more advanced in sexual condition.

In 1953 there were no indications of abnormal losses of sockeye beyond the fence, and an estimated 95 percent of dead females on the streams had spawned. In 1952, only 50 to 60 percent of the run at the fence reached their customary spawning streams, and only 30 to 42 percent of the females in the run had spawned.

An estimated 2.8 million smolts, produced from the seeding of 1952, left Babine Lake in 1954. These represent 0.69 percent of the potential eggs available, as compared with 0.48 and 0.77 percent for the seedings of 1949 and 1950. However, allowing for the females which died unspawned in 1952, the rate for that year becomes 1.45 to 2.03 percent. A similar higher-than-normal rate of smolt production of 1.52 percent was observed for the blocked run of 1951. The smolts produced from the two blocked runs were somewhat larger than normal: this may increase their chances of survival to adult size.

Returns of 4- and 5-year-old Babine sockeye during 1955 to 1957 will almost certainly be small, and 1956 will be the most seriously affected year, because it will have both age-classes produced from the spawnings of the two Slide years. Although the total Skeena returns in those years will also depend upon the sizes of the runs to other parts of the spawning system, they, too, will probably be less than average, because under normal conditions the contribution of the Babine stock is so great a proportion of the total Skeena run. Babine pink salmon suffered very serious losses at the Slide in both years, but are expected to recuperate at an early date, mainly from spawnings in the main river. The Babine pinks probably are not a very important fraction of the total Skeena stocks of this species. Babine stocks of other species of salmon should regain their pre-Slide levels of abundance within a very few years.

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REFERENCES

ARO, K. V. 1952. The Babine River salmon escapement in 1951. *Fish. Res. Bd. Canada, Pacific Prog. Rept.*, No. 90, pp. 3–8.

GODFREY, H., W. R. HOURSTON, J. W. STOKES and F. C. WITHLER, 1954. Effects of a rock slide on Babine River salmon. *Bull. Fish. Res. Bd. Canada*, No. 101, ix+100 pp.