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Effects of a Rock Slide on Babine River Salmon

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H. GODFREY, W. R. HOURSTON,
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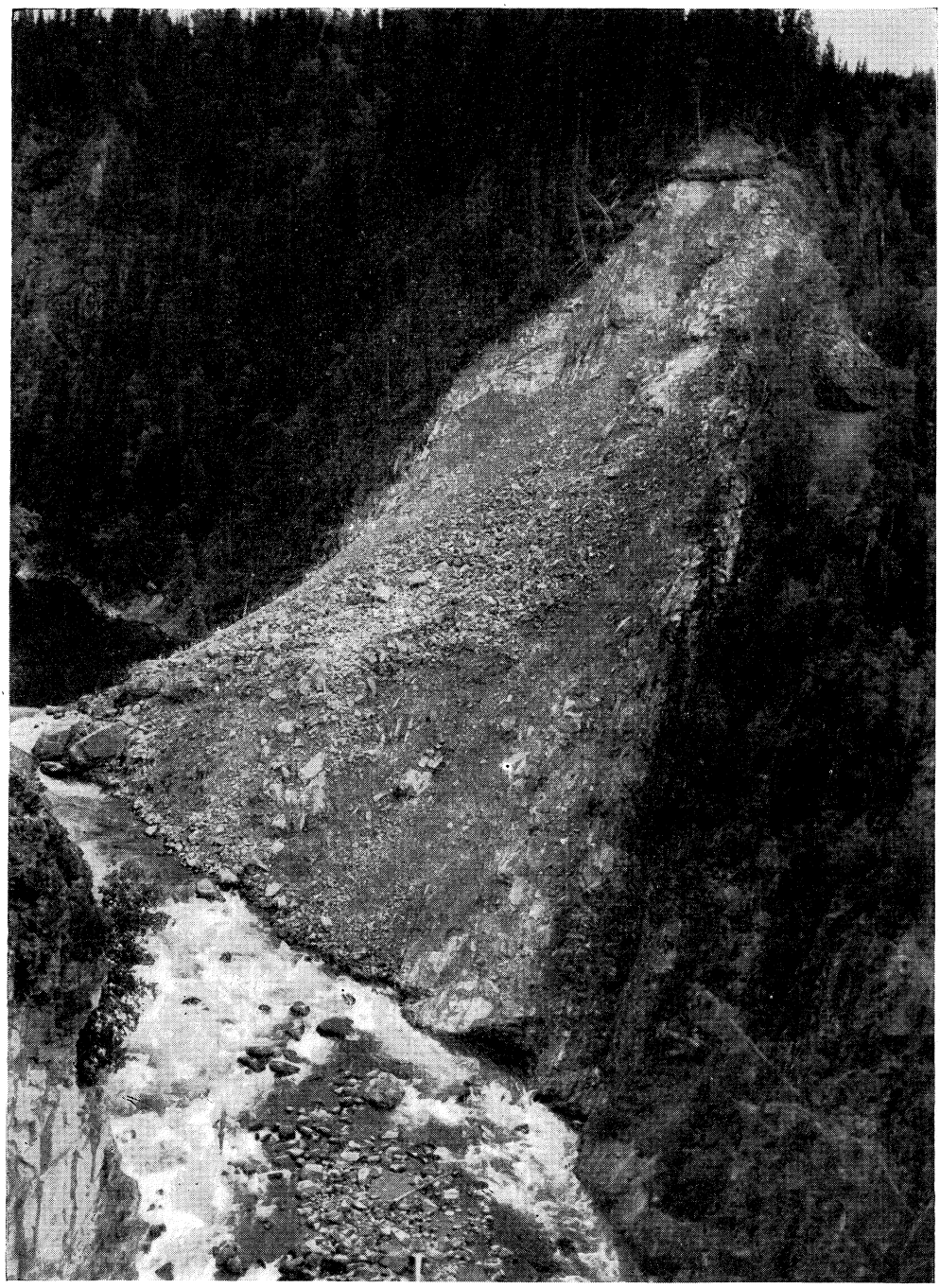

Babine Slide, viewed from downstream, September 6, 1952. The end of the access road is seen to the right of the hogsback at upper right of the picture.

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W. E. RICKER, Editor,
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Nanaimo, B.C.

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FOREWORD

The natural rock slide which blocked the Babine River early in 1951 occurred at a time and at a place where it could have caused maximum damage to the Skeena River salmon fishery. A saboteur with unlimited facilities could scarcely have done better. The slide was situated so as to cut off the only really large race of sockeye salmon in the river system, at the most remote and inaccessible point along its migration route. Its timing, in late spring or early summer, prevented any remedial measures being taken during the year it occurred, and indeed made it uncertain whether anything could be done in time to assist the next year's run.

This challenge was met by the combined efforts of two branches of the Department of Fisheries, the Conservation and Development Service and the Fisheries Research Board. From the discovery of the obstruction in 1951 to its final removal early in 1953, there has been intimate cooperation not only between these two branches, but also with the special consultants employed and with the construction company which did the job of removal. The result is that the least possible damage has been done to the sockeye and other salmon which use the Babine River.

The work of providing access to the slide, of determining its cause and the best remedy for it, and finally its actual removal—these have called for engineering and geological skills, and details of this phase of the project will be presented elsewhere. The present report is devoted to describing the salmon themselves: how they reacted to the obstruction and to the temporary improvements made in 1952, and to what extent future years' supply to the fishery will be affected.

Many individuals have contributed to this biological phase of the project, but the four whose names appear as authors of the present Bulletin are those who have worked with it most directly. Mr. Godfrey was responsible for assembling the various contributions, for much of the analysis of the data, and for preparing the first draft of the manuscript. Mr. Hourston had general supervision of the field work at the Slide and on the Babine Lake spawning grounds, and contributed largely to the interpretation of the data obtained. Mr. Stokes was immediately in charge of the tagging program on the river, and later spent much time in sorting and tabulating the tag recoveries. Mr. Withler was in charge of the counting fence near Babine Lake in 1951 and 1952, and assembled the pertinent data for those years and for the operations of earlier years. All four authors have had a hand in shaping the final version of the Bulletin, in consultation with other employees and officials of the Fisheries services.

A. L. PRITCHARD, *Director*,
Conservation and Development Service,
Department of Fisheries.

OTTAWA
January 10, 1954

CONTENTS

88878—2

CONTENTS—*Concluded*

ABSTRACT

The rock-slide which occurred in the Babine River in 1951 obstructed the salmon runs of that and the following year, and caused the loss of many thousands of fish. Fairly accurate estimation of sockeye salmon losses at and below the Slide was possible from a Fence count of those which reached Babine Lake, and from the rather constant relationship which was discovered between the annual Skeena sockeye catch and the Fence counts of earlier years. The Slide was discovered too late in 1951 to carry out remedial action, but water conditions were favourable and about a third of the sockeye run, or 150,000 fish, escaped above the Slide. In 1952 water conditions were extremely adverse, but remedial measures to maintain a marginal escape channel and eventually to open the block were effective. Again about a third of the sockeye, 350,000 fish, passed the Slide.

Examination of spawning grounds, and comparison of tag recoveries with earlier years, showed that 1952 losses in unspawned sockeye were heavy. In 1951 such losses were probably less severe. The effective spawning in 1952 was estimated as 30-42 percent of the number of female sockeye which reached the Babine spawning grounds that year, or 22-31 percent of the average for Babine Lake female sockeye; or 7-10 percent of the 1952 Babine escapement of female sockeye from the fishery.

Babine sockeye runs (excluding jacks) are made up largely of 4- and 5-year-old fish, so that only the year 1956 should have nearly all of its female fish come from the two spawnings affected by the Slide. Furthermore, the small spawning of 1951 has already been shown to have produced twice as many smolts, per female, as spawnings of ordinary size.

Spring salmon were affected by the Slide to about the same degree as sockeye. Pink salmon were much more seriously blocked than sockeye, particularly the females. The coho run of 1951 encountered considerable difficulty, but that of 1952 was little affected because most of it arrived late in the season after the Slide had been improved and water levels had moderated.

Tagging at and below the Slide in 1952 showed that male tagged sockeye passed the Slide more readily than females, large fish more readily than small ones, green fish more readily than more mature ones, and uninjured fish more readily than injured ones. The tagged fish as a group ascended the Slide only 30 to 60 percent as well as fresh, untagged fish.

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INTRODUCTION

The salmon of the Skeena River in British Columbia support one of the major fisheries of the Province. When a large slide of rock occurred in the main tributary of the Skeena, the Babine River, in the spring or early summer of 1951, it therefore occasioned immediate concern. In recent years, prior to the Slide, about half a million sockeye *(Oncorhynchus nerka)* annually have escaped the fishery and migrated to the Babine spawning grounds. They have amounted to as much as 70 percent of the total Skeena sockeye escapement. Large numbers of pink salmon *(O. gorbuscha)*, some cohoes *(O. kisutch)*, and a few spring *(O. tshawytscha)*, chum *(O. keta)* and steelhead *(Salmo gairdneri)* also spawn each year in the Babine system. These, too, make an important contribution to the Skeena fishery.

The first indications that the 1951 Babine runs had met with some catastrophe came from observations of dead and injured fish drifting in the Lower Skeena River, below its junction with the Babine, and from the late arrival and poor condition of fish entering Babine Lake. It was immediately suspected that somewhere along its course the river was blocked.

For almost all its length the Babine River flows through remote and isolated terrain. It was necessary to locate the obstruction from the air, which was done on August 17. A party, which included a Departmental engineer and biologist and two Fisheries Inspectors, reached the Slide by pack train on August 28. This party confirmed that a large fall of rock into the river had created extremely turbulent water, and was virtually blocking the narrow passage.

Nothing could be done to aid the runs of 1951. It was evident that the first step towards ensuring the unobstructed passage of future runs was to connect the Slide by road to the nearest community of Hazelton, for the transportation of the materials and heavy equipment that would be needed.

Following a later and more detailed examination of the Slide by engineers and biologists, it was decided that the best permanent action would be to remove the fallen material and return the river bed to its former natural state. Construction of a fishway was considered a much less satisfactory solution.

The 60-mile road from Hazelton to the Slide was begun in late September of 1951, and was completed during the first week of August in the following year. A tender for removing the rock was accepted from the General Construction Company, of Vancouver, who began the work in November of 1952. On-the-spot measures were carried out by Departmental engineers during the summer of 1952, to ease the passage of fish then migrating up the river. These allowed the escapement to beyond the Slide of a large number of fish which otherwise would not have reached the spawning grounds.

The salmon of the Skeena River watershed had been the subject of a survey by the Fisheries Research Board in the years 1944-48, during which time the Babine sockeye had had special attention (Pritchard *et al.*, MS 1948). After the survey was completed, continuing investigations involved maintaining a Fence 10 miles below Babine Lake, in order to obtain annually a count of salmon which would indicate the spawning potential of this important area. When the Slide occurred in 1951, the Fence was already in position and provided information on the number, condition and time of arrival of salmon in that year.

No additional studies were possible in 1951, but in 1952 a special program of investigation was carried out during the spring, summer and autumn months. It involved three main phases: a tagging program, the operation of the Babine Lake counting Fence, and surveys throughout the season of Babine salmon spawning streams. This called for the combined and cooperative effort of personnel of the Protection and the Fish Culture and Development Branches of the Department of Fisheries, and of the Fisheries Research Board.

The tagging program was designed to estimate losses, to measure the response of the runs to remedial action being carried out concurrently, and to accumulate a variety of data by which the characteristics and fate of the runs could be described—not only at the Slide, but up to the time of their dying in the streams.

At the Babine River Fence counts were made of the number of salmon entering that spawning system, and the sockeye run was sampled. Records were also kept of the number and condition of the many dead fish which drifted down onto the Fence.

The stream surveys were made to estimate the number of fish on the spawning grounds, to determine the success of spawning by the examination of dead fish, and to recover tags.

This report summarizes the results of these investigations, and defines some of the effects of the Slide on the Babine salmon runs of 1951 and 1952, but particularly the latter year.

The Slide in the Babine River was removed during the winter of 1952 and spring of 1953. Biological studies, including a tagging program, have been continued during 1953 to test whether any effects of the Slide remain. The results of this further investigation, and the conclusions reached through a re-examination of the whole problem will be presented in a second report.

LOCATION OF THE SKEENA AND BABINE RIVERS

Figure 1 shows the Skeena River system, and locates the Babine River, Babine Lake and other places mentioned in this report.

After fish enter the mouth of the Skeena they must travel a distance of almost 300 miles before they reach the Babine counting Fence. The Babine River, draining the 100-mile long Babine Lake joins the Skeena about 40 miles north of the community of Hazelton.

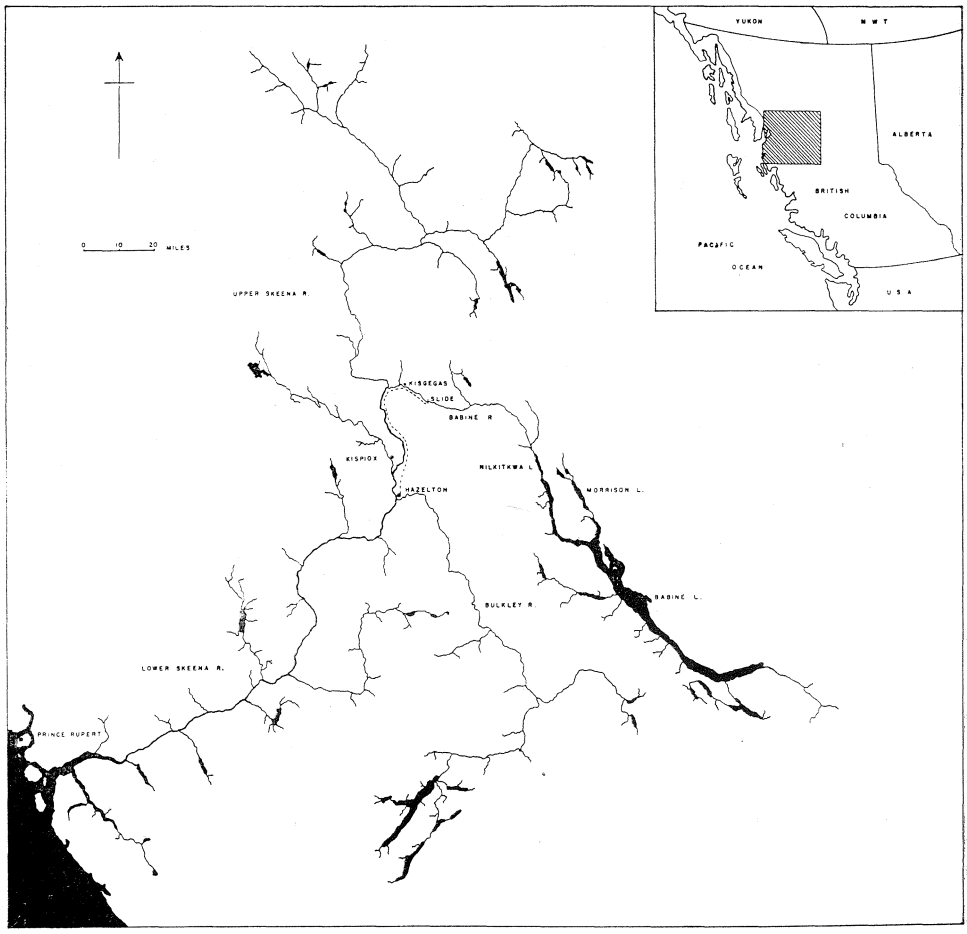

Figure 1. Location map of the Skeena and Babine Rivers.

The slide in the Babine River occurred at a point about 20 miles above the Skeena-Babine confluence. The counting Fence spans the river about half a mile below Nilkitkwa Lake, which is, in effect, an expansion of the Upper Babine River shortly after it leaves Babine Lake. The distance between the site of the Slide and the Fence is approximately 40 miles. Kisgegas, an old Indian village on the right bank of the river, is situated about 10 miles downstream from the Slide.

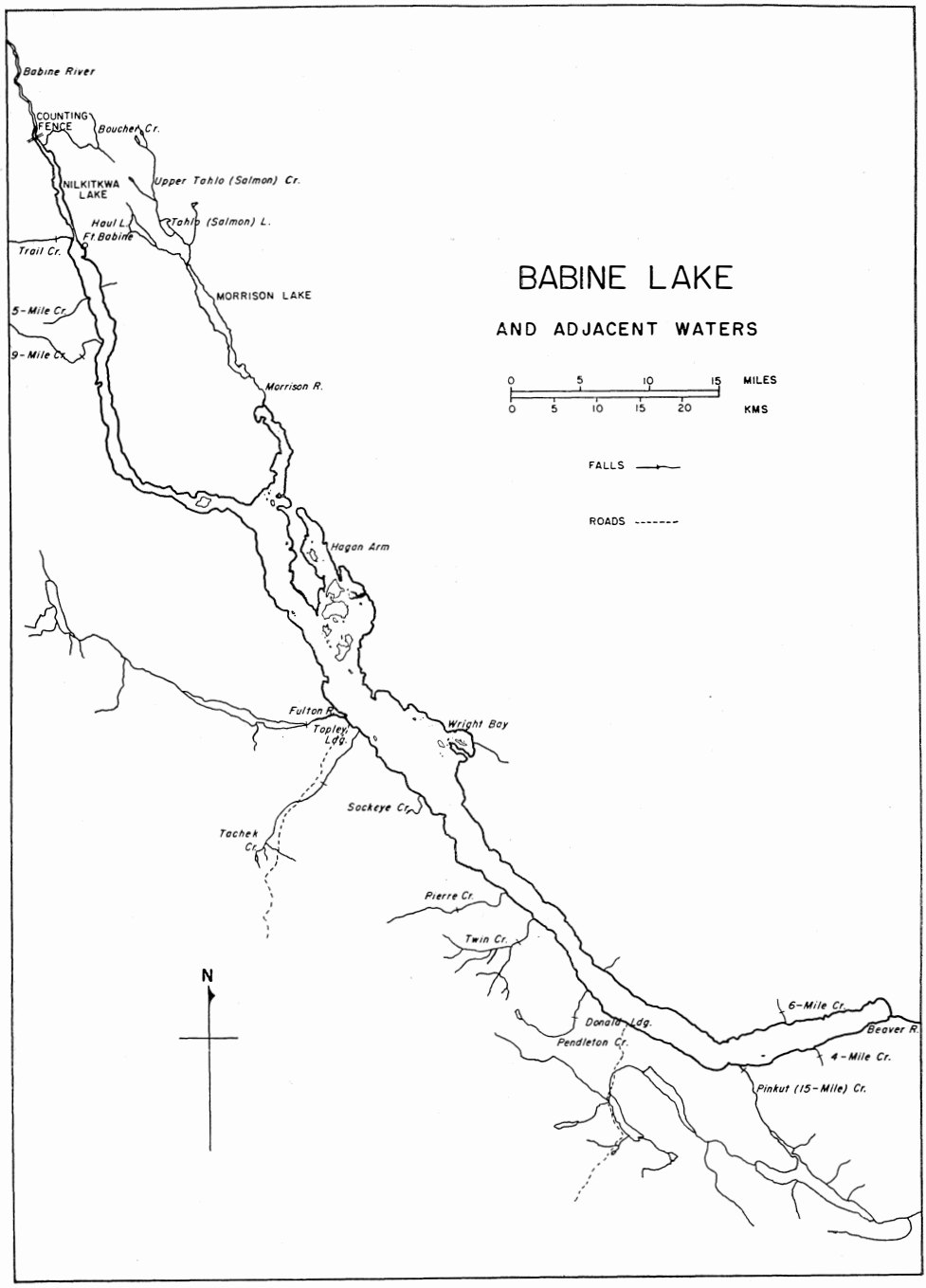

Figure 2. Babine and Nilkitkwa Lakes.

Figure 2 is a map of Babine and Nilkitkwa Lakes, and Figure 3 an enlarged outline of Nilkitkwa Lake. The first two miles of the Babine River, from where it flows out of Babine Lake to the point where it expands to become Nilkitkwa Lake, is conveniently referred to as the *Upper Babine River*. The term *Lower Babine River* will refer to that stretch of about half a mile between the lower limit of Nilkitkwa Lake and the counting Fence. The counting Fence is situated at the lower boundary of the sockeye spawning grounds in the river.

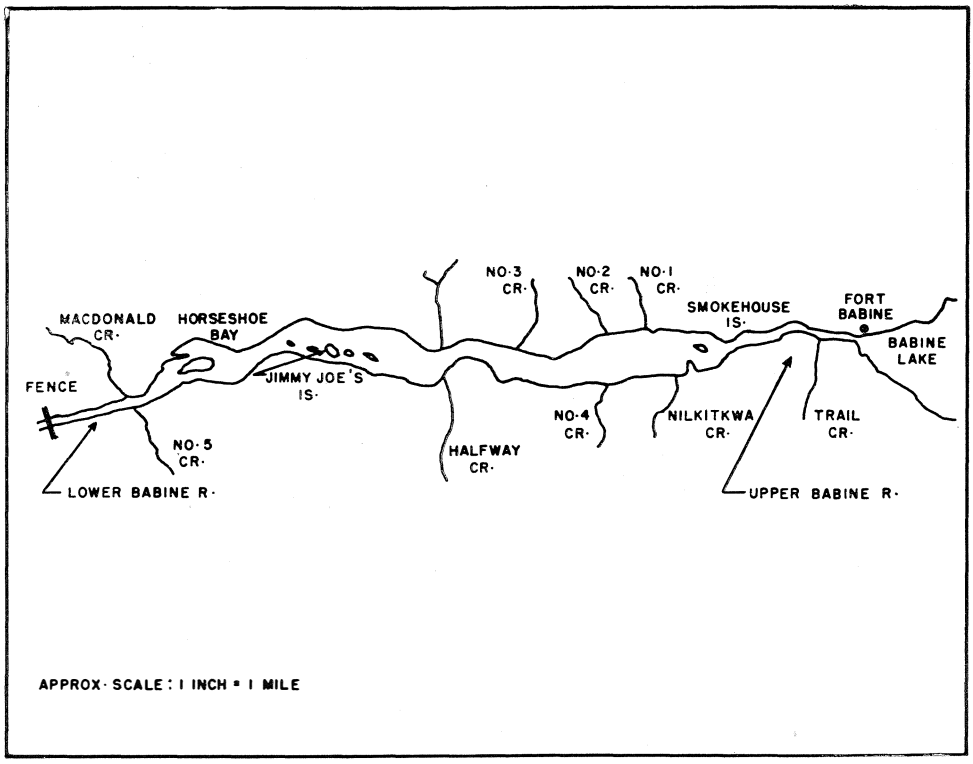

Figure 3. Nilkitkwa Lake, showing the Upper and Lower Babine Rivers and the counting Fence.

The spawning streams of Babine Lake are, in successive downstream order, Grizzly, 4-Mile, 6-Mile, 15-Mile or Pinkut, Pendleton, Twin, Pierre, Sockeye and Tachek Creeks; the Fulton and Morrison Rivers; 9-Mile, 5-Mile and Trail Creeks; and the Upper and Lower Babine Rivers. These streams vary considerably in respect to the numbers of sockeye which usually spawn in them. The more important ones are the Upper and Lower Babine Rivers, the Fulton and Morrison Rivers, and Pierre and 15-Mile Creeks.

Below Nilkitkwa Lake and the Fence, the Babine River has several tributaries which have a number of small lakes in their headwaters. A small run of sockeye has been reported from one of these, but most of the others are thought to be inaccessible to salmon. The total population which all these lakes might support must be negligible in comparison with the Babine Lake run.

DESCRIPTION OF THE SLIDE AND OF REMEDIAL MEASURES TAKEN IN 1952

Description of the Slide

Most of the following details have been extracted from a report submitted to the Department of Fisheries by Dr. Wm. H. White of the University of British Columbia (MS, 1953).

The Slide occurred at a point about 10 miles upstream from the old Indian village of Kisgegas. Here the gradient of the Babine River is at its steepest, averaging 50 feet per mile between Kisgegas and a point some 22 miles upstream. In this region the river has incised a youthful valley from 200 to 400 feet deep, the walls of which slope from 50 degrees to nearly vertical.

The principal rocks of the Skeena-Babine region are continental sediments, probably of the earliest Lower Cretaceous. A geologic feature peculiar to the Slide area is a mica lamprophyre dyke, a rare type of intrusive rock, composed mainly of medium grained biotite, and the only igneous body in the area. This rock is especially susceptible to weathering, and in its exposed areas is very soft and crumbly. The dyke is considered to have been the prime cause of the Slide.

The river is about 100 feet wide at the site of the Slide. The detached material, which fell from the left bank, consisted of that which tumbled down the valley wall, and of material which fractured and collapsed more or less in place. Part of the former was subsequently displaced downstream. It formed a fan-

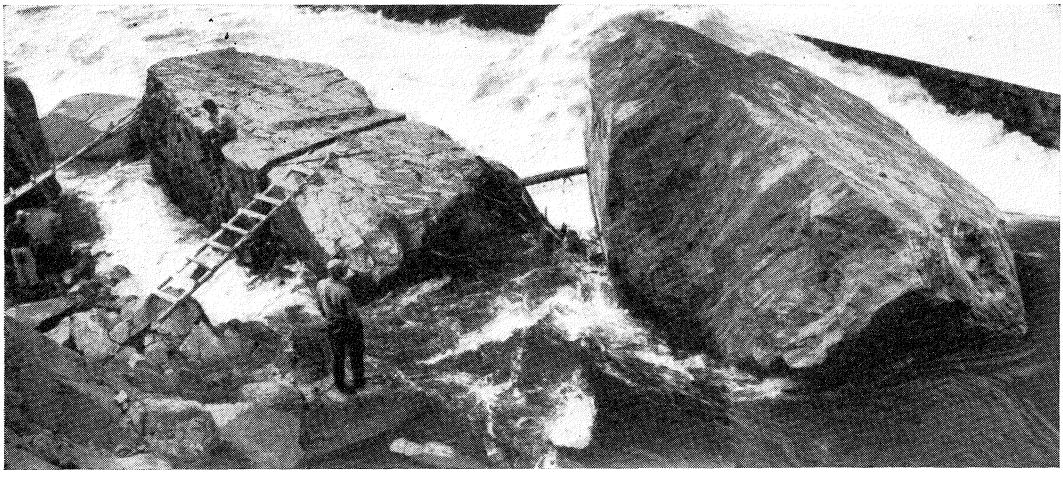

Figure 4. The three large rocks at the toe of the Slide, and the marginal channel along the left bank, about August 15, 1952. The lowermost rock is mostly out of the picture to the left.

shaped pediment with a curved base at river level some 420 feet long. The sizes of fragments increased from the apex of this pediment towards the river, where they averaged more than 2 feet, with some solid blocks of as much as 20 feet in length (Figs. 4, 5).

After the fall the river was dammed almost completely by rock, and the water backed up to more than 30 feet above its former ponded levels. The river soon cut part way through this dam, distributing the debris in the valley floor as bars and channel fill to at least as far as 500 feet downstream.

Figure 5. River at the head of the Slide, showing the upper large rock and ponded water above it, June 17, 1952. Near the end of June this rock was completely covered.

There was a pool immediately above the Slide which, in summer, and before the Slide was removed, was about a mile long, and with depths of as much as 60-65 feet (Fig. 6). Some rock also fell into this pool. Because water velocities at the site of the Slide prior to its occurrence were not known, and may already have been nearly critical for upstream migrating fish, this pool was not used as a disposal area for the fallen material.

Either high water velocities or excessive turbulence could have been the cause of delaying the fish and preventing the ascent of many of them. Engineers estimated water velocities up to 35 feet per second, but believed that the extremely turbulent flow was probably the more serious feature of the block.

Remedial Measures at the Slide

Throughout the salmon migrations in 1952, engineers and biologists worked constantly to ease the passage of fish. Rocks were removed by hand or were blasted with dynamite, and a marginal channel, through which the fish could move upstream, was maintained to suit the continually changing water conditions. Whenever the number of fish using the channel began to drop off, conditions were rectified by sandbagging or by erecting needle dams provided with baffles to reduce the water velocities (Figs. 4, 7).

The most important improvement was carried out on August 27, when a large rock at the head of the Slide was removed by blasting (Fig. 8). This rock had seemed favorable at higher water levels, as it protected the entrance to the side channel just mentioned. However, as the water level fell this channel grew

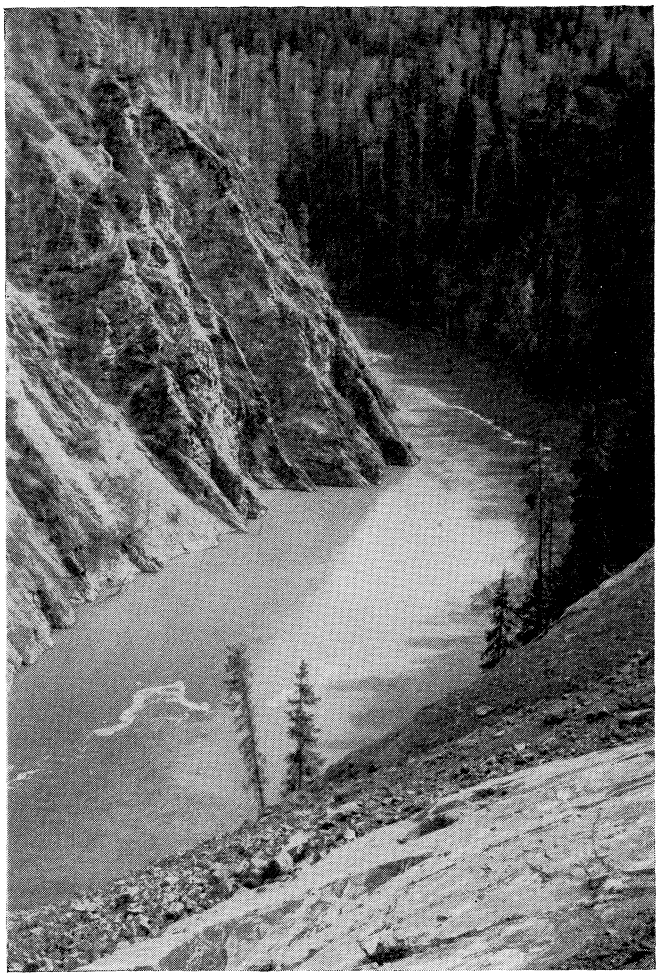

Figure 6. Ponded water above the Slide, May 29, 1952. This scene overlaps the panorama of Figure 39.

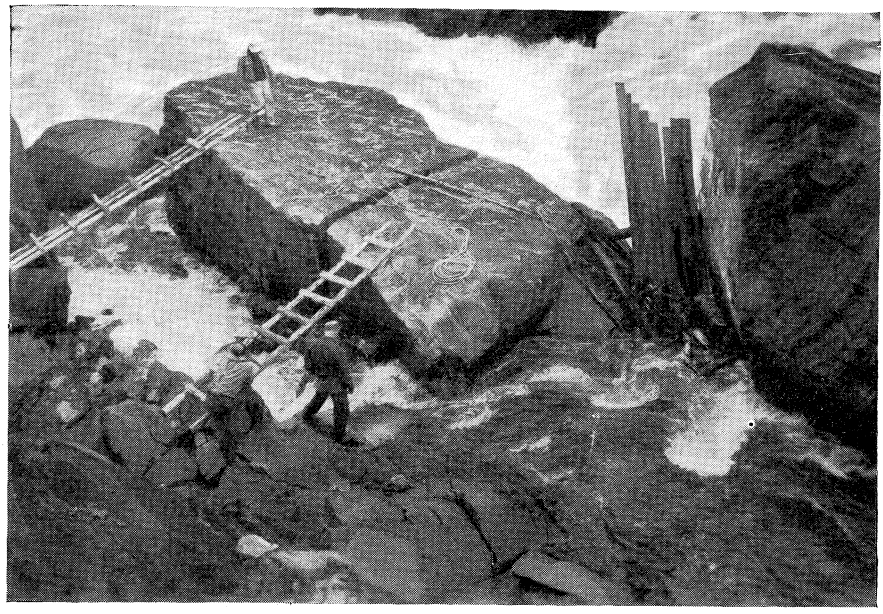

Figure 7. Marginal channel somewhat later than in Figure 4. The passage between the large rocks has been blocked to provide more flow in the channel. The white board over which salmon were counted is by the observer's right foot.

Figure 8. View of the lower part of the Slide, from the top of the cliff on the right bank, September 6, 1952. The upper rock was removed on August 27, leaving only two large rocks at the toe of the Slide.

shallower and difficult to maintain, and there seemed a good prospect that removal of the rock would permit establishing a broader navigable passageway. Simultaneously with its removal, the number of salmon surmounting the Slide increased sharply.

The erection of a brailer and flume to carry fish to the pool above the Slide was considered, and prefabricated parts were brought to the site for assembly. However, it was decided not to go ahead with this project except as a last resort. The reasons for this were that the flume might have saved only a few thousand fish, and also that once it was erected, all blasting and other efforts to maintain and improve marginal channels would have had to have been abandoned. It was felt that by these means many more fish would escape than could be passed over the obstacle by the brailer and flume.

OBSERVATIONS ON THE BLOCKED SALMON

Salmon Observed Below the Slide

The late arrival and poor condition of fish reaching the Babine Fence in 1951 were the first indications to fishery authorities that the Babine salmon runs were experiencing unusual difficulty in the river. During the second week in August, Fisheries Inspectors observed seriously damaged and weak fish in the Skeena River near Hazelton and Kispiox, and received reports from Indians in that area of injured fish among their gill-net catches. The fact that no injured fish were observed in the Bulkley River, which also joins the Skeena in the Hazelton area, indicated that the point of obstruction was somewhere on the Babine River. By August 15 injured and weak fish were in evidence as far as almost 100 miles below Hazelton.

In 1951 a sample of obstructed fish from the Hazelton area, consisting of 45 sockeye, 11 pinks and 1 spring salmon, was examined for sex, length and age determination (Foskett, 1952). Most of these were dead fish, the remainder being seriously damaged.

Weak and injured fish were observed at points in the Lower Skeena throughout the season of 1952. On September 21 an observer counted approximately one damaged sockeye per minute passing downstream under the Skeena River bridge near Hazelton. As in 1951, Indian gill-net catches in the Hazelton area included injured fish, which increased in numbers towards the end of the run.

At the Kisgegas tagging site, 10 miles below the Slide, and at points between Kisgegas and the Slide, numerous damaged and weak fish were observed in the river, usually drifting downstream. Toward the end of September it became almost impossible to catch uninjured fish for tagging at Kisgegas, and on occasions more than 90 percent of those taken for tagging had to be discarded.

No special search was made in 1952 for tagged fish in the wide reaches of the Lower Skeena, but Indian fishing sites were visited regularly to obtain information and reclaim tags.

Only 100 tags were recovered from the Lower Skeena in 1952; these came either from dead fish in eddies or from the Indian catch. Although this is only a small fraction of the 13,500 tags unaccounted for at the Fence, it is fairly large considering the small effort expended and the poor chances of recovery from the large, mostly isolated area concerned.

In both years it is evident that numerous blocked fish drifted downstream from the Slide. In view of the fact that many more fish failed to pass the Slide in 1952 than in 1951, it might be expected that more damaged or dead fish would have been seen that year at points along the Lower Skeena. However, it is not possible to make useful comparisons in this respect, firstly because of the very limited observations made in either year, and secondly, because of the much larger water discharge in the Babine and Skeena Rivers in 1952.

Salmon Observed at the Slide

In 1951 the only observations of fish at the Slide were made on the occasion when it was first reached by land on August 27. The salmon runs were almost over when the Slide was again visited late in October of that year. Throughout the 1952 season, the Slide, the river and the blocked fish were under continuous observation.

In 1952 sockeye began to accumulate below the obstruction during the latter half of July. These early arrivals were mostly pink in colour, but were in fairly good condition. Large numbers of green fish began to appear early in August, and soon filled the eddies and sides of the river below the block. For the rest of the season the river seemed full of fish. The proportions of red and pink colored sockeye increased gradually, and at the same time the condition of the accumulated fish deteriorated. More and more fish bearing injuries and fungus patches were observed as time went on.

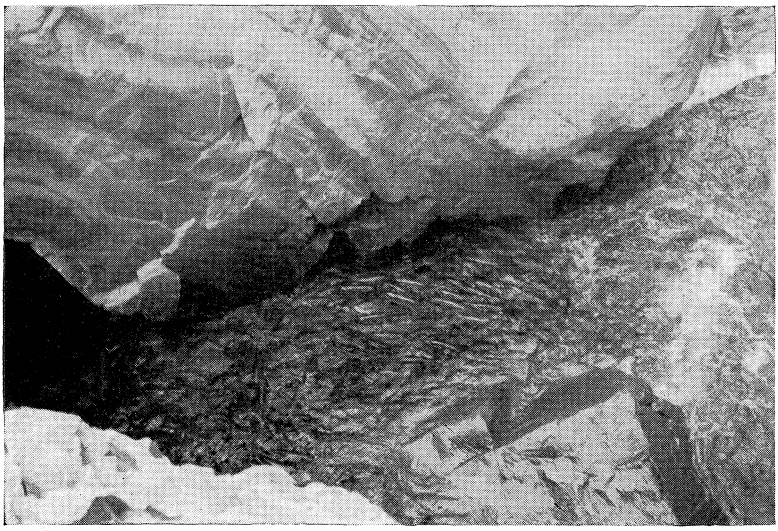

Figure 9. Salmon accumulated in an eddy at the Slide, September 6, 1952.

Pink *(gorbuscha)* salmon began to appear at the end of July, and reached their peak late in August. Coho salmon started about a week later than pinks, and became most abundant towards the end of the run. Spring salmon were observed throughout much of the season, but were always scarce. They stayed nearer mid-stream, and were seldom caught by dipnets.

The number of salmon present below the Slide began to decline sharply early in September. By the end of September the few fish in evidence below the obstruction were mostly coho salmon.

For a month or so at the height of the block, the sides of the river for at least a quarter of a mile below the obstruction contained dense accumulations of fish (Fig. 9). On August 21, near the peak of this accumulation, one observer

counted the fish in short linear sections of several eddies, and estimated that about 50,000 salmon of all species were actually in sight, two-thirds to three-quarters of them sockeye. Other observers at the same period guessed that there were as many or more than 100,000 salmon below the Slide in the three or four hundred yards of river they could observe.

There was marked stratification of the different species of salmon held up below the obstruction. Late in August 90 percent of the fish immediately below the Slide were sockeye salmon; 300 feet below it pinks were numerous, while 600 feet and more downstream pinks and sockeye were almost equally abundant. Usually, pinks tended to be closer to shore than sockeye. Spring salmon were usually observed farther toward mid-stream. Most of the coho salmon reached the Slide after the partial opening of the channel on August 27.

Injured sockeye were noticeably concentrated closer to shore. One observer noted jack sockeye making use of channels too shallow for larger salmon to move upstream.

ESCAPEMENTS FROM THE FISHERY AND LOSSES AT THE SLIDE

Sockeye Salmon

METHOD OF ESTIMATING ESCAPEMENT

From statistics of the Skeena catch and the Babine Fence counts shown in Table 1, it has proved possible to make estimates of the probable escapements and losses of sockeye salmon in 1951 and 1952. These depend upon the very constant relationship between the size of the commercial sockeye catch, and the numbers of sockeye which passed through the Babine counting Fence in former years. In the four years of counting Fence operation prior to the Slide, this relationship was as shown in Table 2.

TABLE 1

Salmon counted through the Babine Fence, 1946-52. 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 three days (in 1952, every day). The sample used for determining sex of the older fish was from 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 V. Aro, extending and correcting the preliminary tabulation of Aro (1952).

	1946	1947	1949	1950	1951	1952
Sockeye salmon						
Numbers						
Total	475,705	522,561	509,132	543,658	152,457	376,947
Females	236,158	144,171	274,153	204,985	68,053	143,457
Jacks	57,864	216,101	47,993	179,302	11,042	27,936
Large males	181,683	117,289	186,986	159,371	73,362	205,554
Percentages						
Females	49·6	27·6	53·8	37·7	44·7	38·1
Jacks	12·2	50·0	9·4	33·0	7·2	7·4
Large males	38·2	22·4	36·8	29·3	48·1	54·5
Percentages (jacks excluded)						
Females	56·5	55·1	59·4	56·3	48·1	41·1
Males	43·5	44·9	40·6	43·8	51·9	58·9
Pink salmon	28,161	55,421	13,663	38,728	50	2,706
Coho salmon	12,489[1]	10,252[1]	11,938[1]	11,654[1]	2,122	10,554
Spring salmon	10,528	15,614	7,433	6,838	2,778	5,915
Chum salmon	18	7	5	7	0	1

[1]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.

Jack sockeye have not been included in the Fence counts. The proportion of these small, three-year-old males has varied from 7 to nearly 50 percent (Table 1), but only very few are taken by the commercial gill-nets (Milne and Pritchard, 1948). For this reason, also, the estimates of losses at the Slide will not include jack sockeye.

Although the relationship between the *total* Skeena sockeye catch and the Fence counts will be used to estimate the Babine escapements of 1951 and 1952, a fairly constant relationship has also held between the Fence counts and the catch recorded by a "sample" cannery. Thus, in 1946, 1947 and 1950 the catch of this cannery was 33·8, 32·4 and 30·8 (average, 32·3) percent of the Babine Fence totals exclusive of jacks.

TABLE 2

Relation of Skeena sockeye catch to the number of sockeye put over the Babine Fence.

Year	Commercial sockeye catch	Fence count of sockeye, excluding jacks	Percentage relationship
	A	B	B/A × 100
1946	621,000	417,669	67·3
1947	385,000	261,450	67·9
1949	700,000	461,164	65·9
1950	530,171	364,355	68·7
Mean and standard deviation	.....	.....	67·5 ± 0·6

If the potential escapements of Babine sockeye in 1951 and 1952 are determined by employing the catch:escapement ratio described above, the losses at the Slide can be estimated by subtracting the actual numbers of fish which reached the Babine counting Fence. Furthermore, since one expected result of a block in the river would be the accumulation of fish below the obstruction, it should be possible to determine the number of fish accumulating each day, the periods of delay, and the response of the run to changes in water levels and to remedial action.

To measure the variability of the catch:escapement relationship throughout the fishing season the progression of fish through the fishery must be compared with their progression through the Babine Fence. This can be done by means of *(a)* plots of daily (or weekly) catch and count; or *(b)* plots of daily (or weekly) cumulative totals for fishery and Fence; or *(c)* time plots of percentages reached of final total catch and count.[1]

The daily Skeena sockeye catch and the escapement to the Babine Fence in a normal year (1950) are compared in Figure 10. To allow a more direct comparison, the Fence totals have been pre-dated 25 days, that being the average time taken by sockeye to pass from the fishing grounds to the Fence as shown

[1]The data used for this analysis are as follows. 1. Under the improved statistical system, records of daily catches of Skeena salmon have been obtained since 1950, and were made available by the Office of the Chief Supervisor of Fisheries in Vancouver. This Office publishes a summary of these data by weeks in the monthly "British Columbia Catch Statistics". 2. Prior to 1950, canneries reported their catch (or pack) to the Department of Fisheries only at the year's end, and the total canned pack of Skeena-caught salmon (regardless of where it was canned) is given in the Annual Reports of the Department of Fisheries. 3. The British Columbia Department of Fisheries issues a British Columbia Canned Salmon Pack Bulletin, which gives weekly the combined Nass and Skeena pack of salmon. 4. Milne (MS, 1948) has tabulated *(a)* the weekly total sockeye catch from a "sample" Skeena River cannery for several years up to and including 1947; and *(b)* the most probable annual catch of the five species of Skeena salmon. The same cannery has made available to the present investigation its weekly sockeye catch records for 1950, 1951 and 1952.

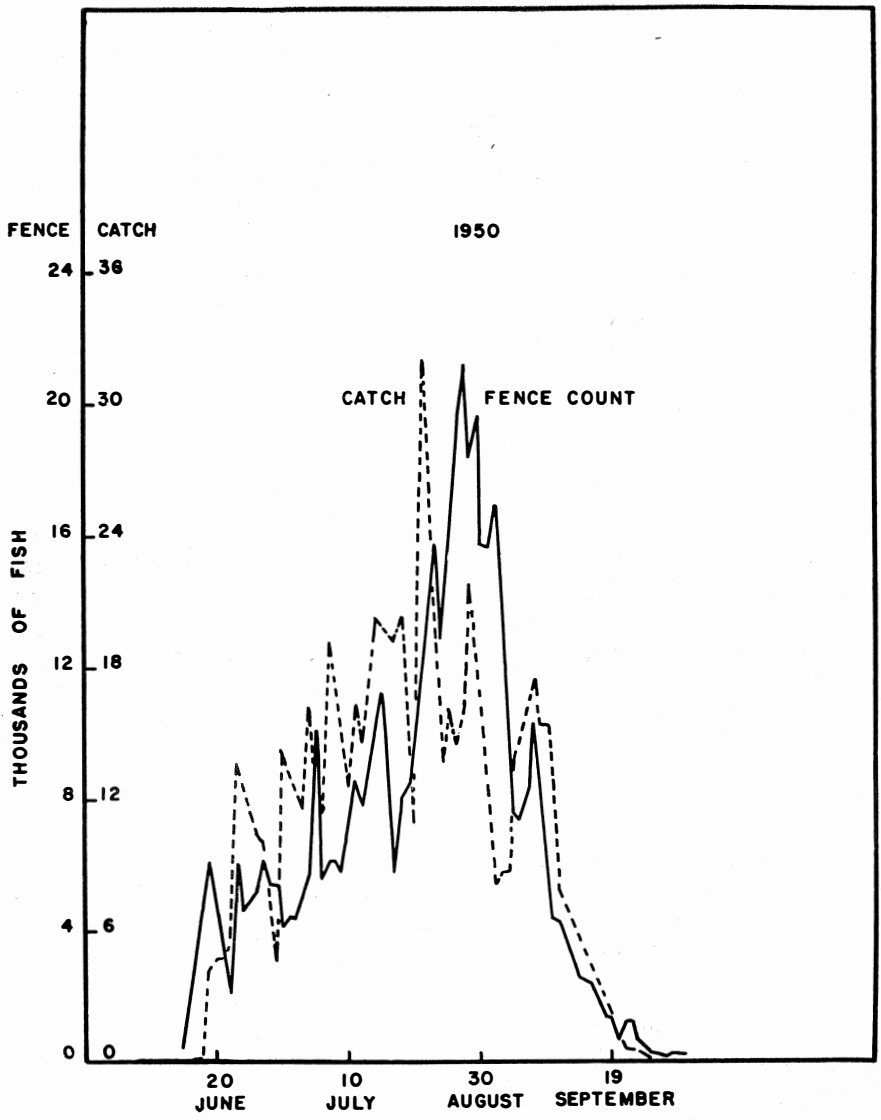

Figure 10. Daily Fence counts of sockeye salmon, pre-dated 25 days, compared with daily sockeye catch, 1950.

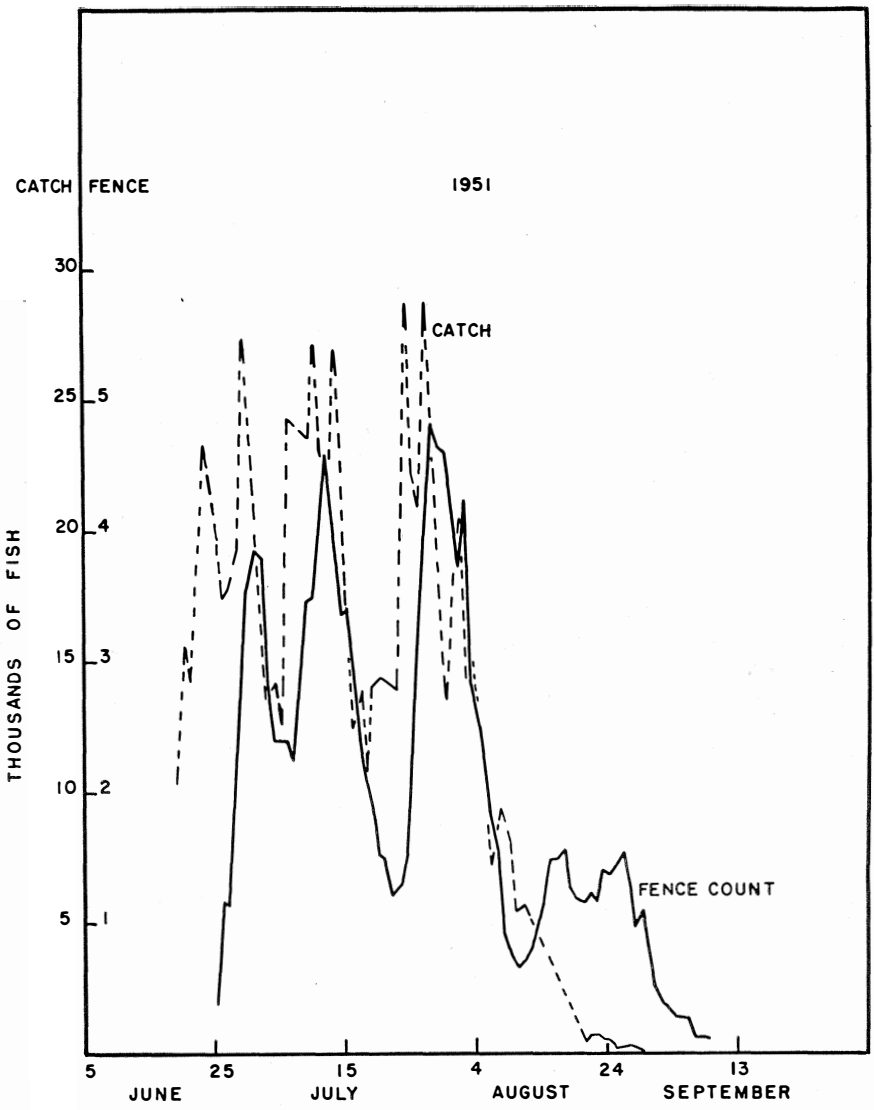

Figure 11. Daily Fence counts of sockeye salmon, pre-dated 25 days, compared with daily sockeye catch, 1951.

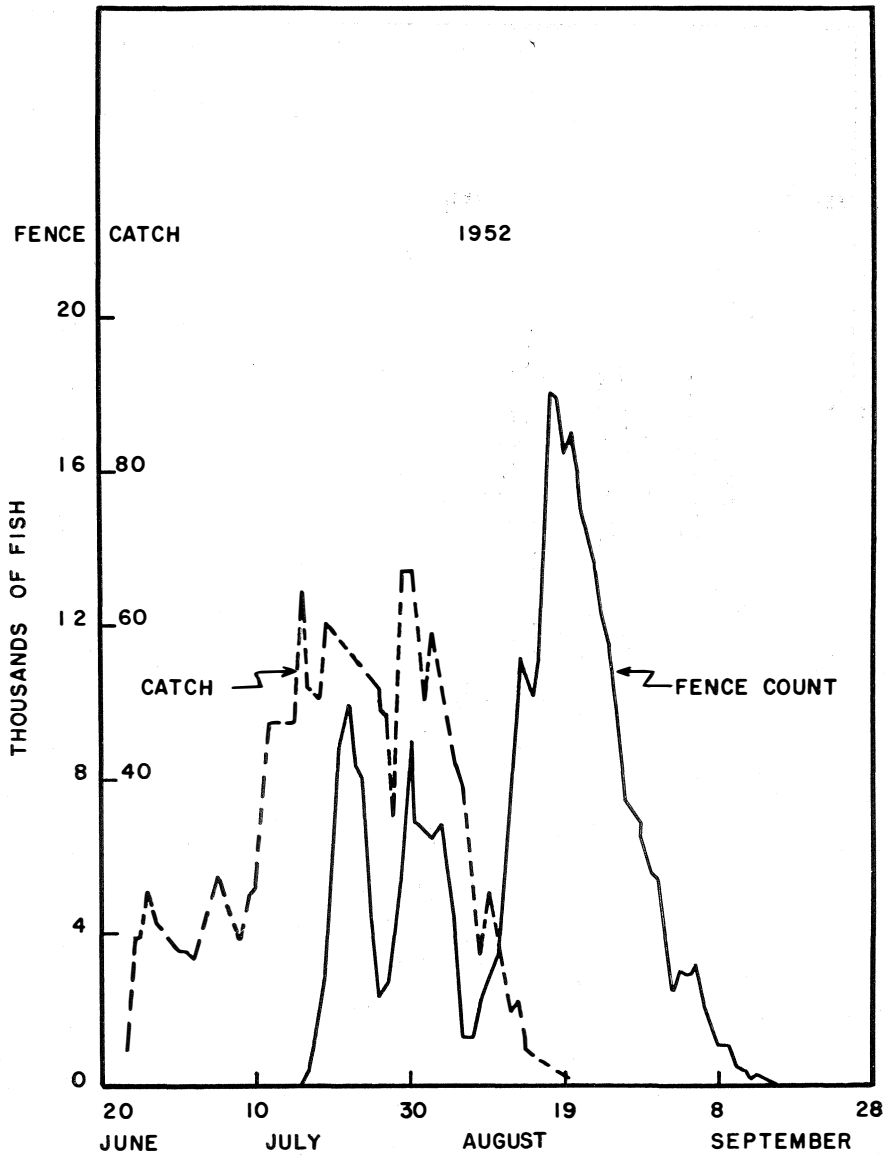

Figure 12. Daily Fence counts of sockeye salmon, pre-dated 25 days, compared with daily sockeye catch, 1952.

by tagging experiments of Pritchard (1948a) and Milne (1949). An intimation of the effects of the Slide in 1951 and 1952 may be gained by comparing this figure with Figures 11 and 12.

Daily records of total catch are not available before 1950, but weekly cumulative totals are shown in Figures 13-16, and compared with Fence counts of 1946, 1947, 1949 and 1950. These catches include Nass as well as Skeena packs; however, the bulk of the "Nass-Skeena" pack (from 50 to 80 percent in 1946 to 1950) represents Skeena fish. In addition, cumulative weekly catches

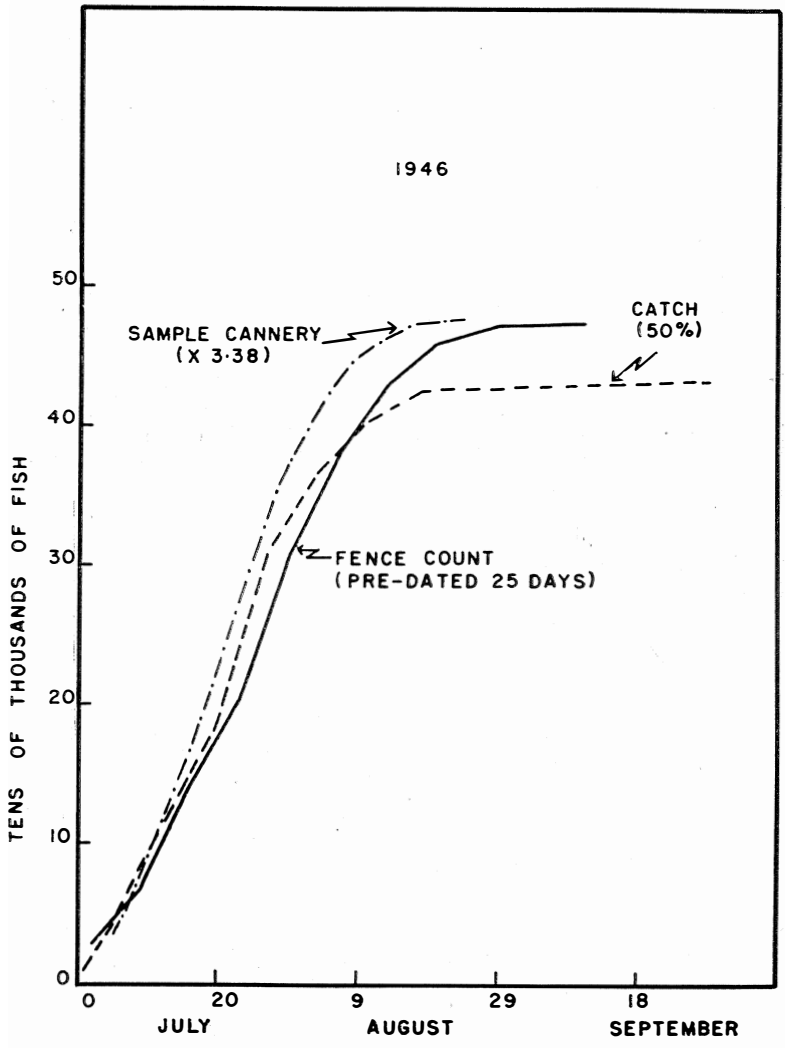

Figure 13. Comparison of the progression of sockeye through fishery and Fence, 1946. Weekly cumulative totals of Nass-Skeena pack, catch of the "sample" cannery, and Fence counts pre-dated 25 days.

of one cannery are available for 1946, 1947 and 1950, and are included on the appropriate graphs. In Figures 13-16 when the Fence totals are pre-dated by 25 days, the pairs of curves approximate each other fairly well. Not only has the final catch:escapement ratio been almost the same in each of the four years, but the relationship has been fairly constant throughout the season.

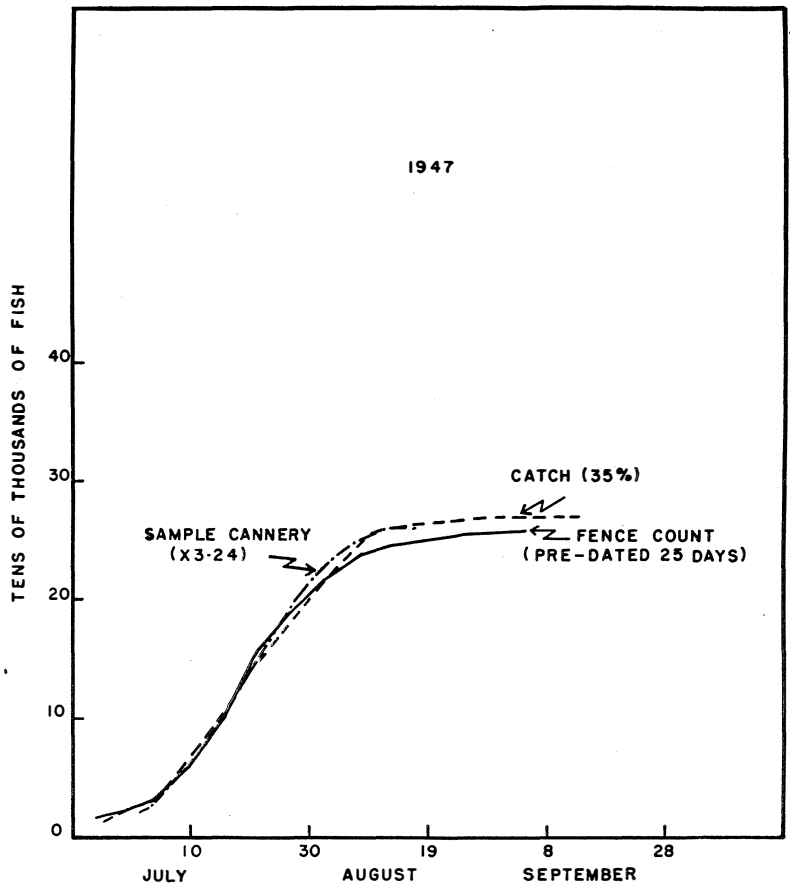

Figure 14. Comparison of the progression of sockeye through fishery and Fence, 1947. Weekly cumulative totals of Nass-Skeena pack, catch of "sample" cannery, and Fence counts pre-dated 25 days.

Daily figures of the total Skeena sockeye catch, and also the weekly totals of the "sample" cannery, are available for comparisons of catch and escapement in 1950 (Fig. 17). Here, to simulate the escapement of sockeye past the site of the Slide in a normal year, the catch totals have been advanced by 20 days, and the Fence totals pre-dated by 5 days—the latter being the approximate average time taken by sockeye to migrate to the Fence from immediately above the Slide, as determined by tagging. The "sample" cannery totals have been

adjusted (multiplied by 3·08) to correspond to the Fence totals exclusive of jacks. Two-thirds of the daily cumulative catch totals have been plotted, the fraction being that which will be used to estimate the escapements of 1951 and 1952. It will be seen that if allowances are made for the relatively small differences between the daily catch and Fence totals, then for 1950, when the Fence totals are subtracted from the potential escapement totals, essentially all the sockeye "escape" to above the Slide, and there is no accumulation of fish below it.

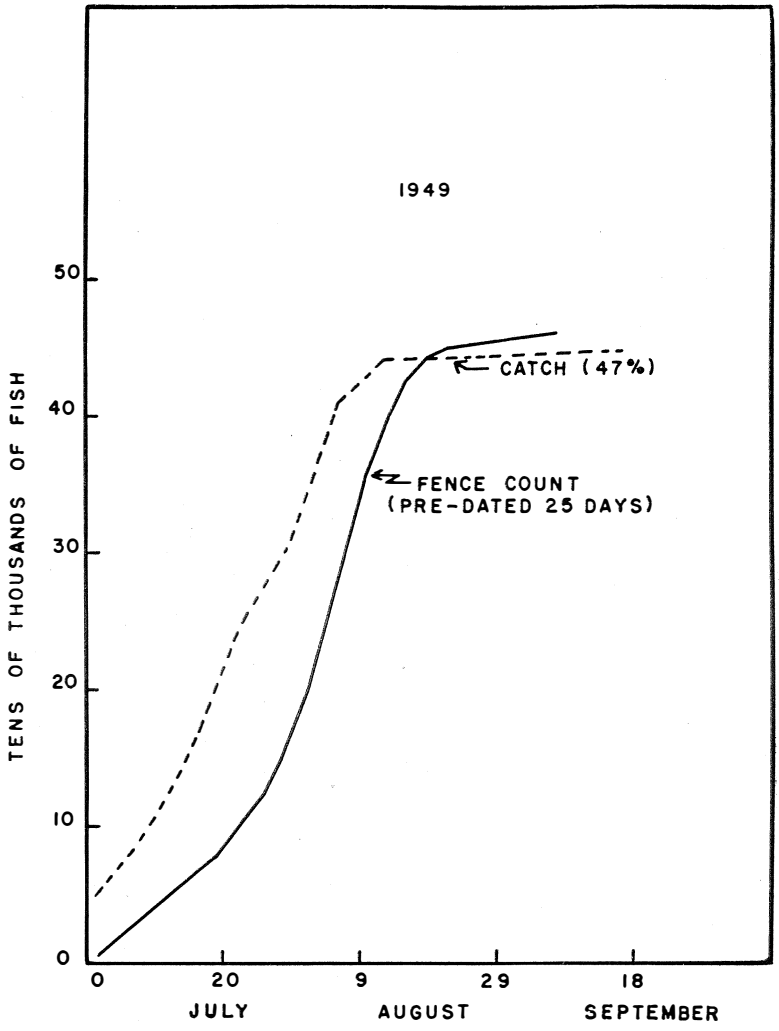

Figure 15. Comparison of the progression of sockeye through fishery and through the Fence, 1949. Weekly cumulative totals of Nass-Skeena pack, and Fence counts pre-dated 25 days.

88878—3

ADJUSTMENTS NECESSARY FOR 1952 ESTIMATE

Before the data of 1951 and 1952 can be analysed in a similar manner to estimate the effects of the Slide in those years, it is necessary to adjust for the effects of a strike of fishing crews in 1952, and to determine whether or not the sockeye run in the Babine River that year arrived at the usual time.

EFFECT OF THE STRIKE. The strike of fishermen on the Skeena in 1952 followed a customary closed week-end, July 19-20, and lasted four days, from

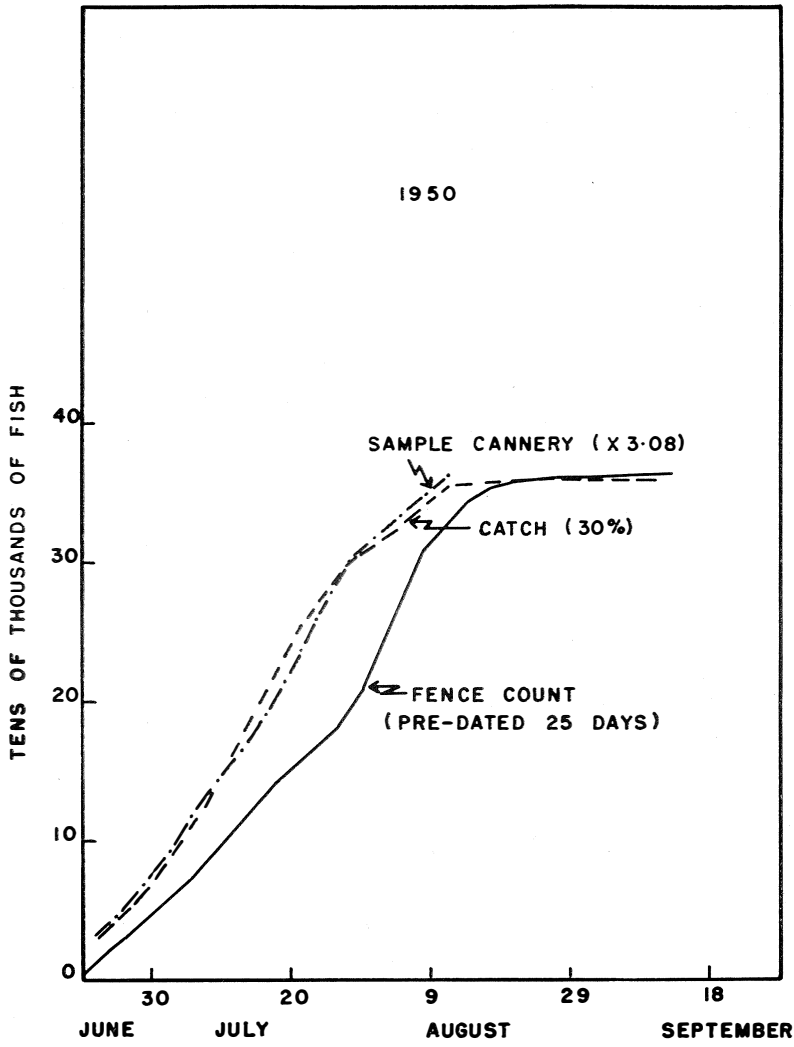

Figure 16. Comparison of the progression of sockeye through fishery and Fence, 1950. Weekly cumulative totals of Nass-Skeena pack, catch of the "sample" cannery, and Fence counts pre-dated 25 days.

the evening of July 20 to the evening of July 24. It might be expected, therefore, that in that year the Babine sockeye escapement would exceed the customary two-thirds fraction of the actual total catch of 1,268,951 fish. To allow for this extra escapement the potential catch during the strike, and the potential total catch were estimated as follows: the average catch during the several days immediately preceding and following the strike was approximately 54,000 sockeye per day (the strike occurred during the height of the run). In the four days

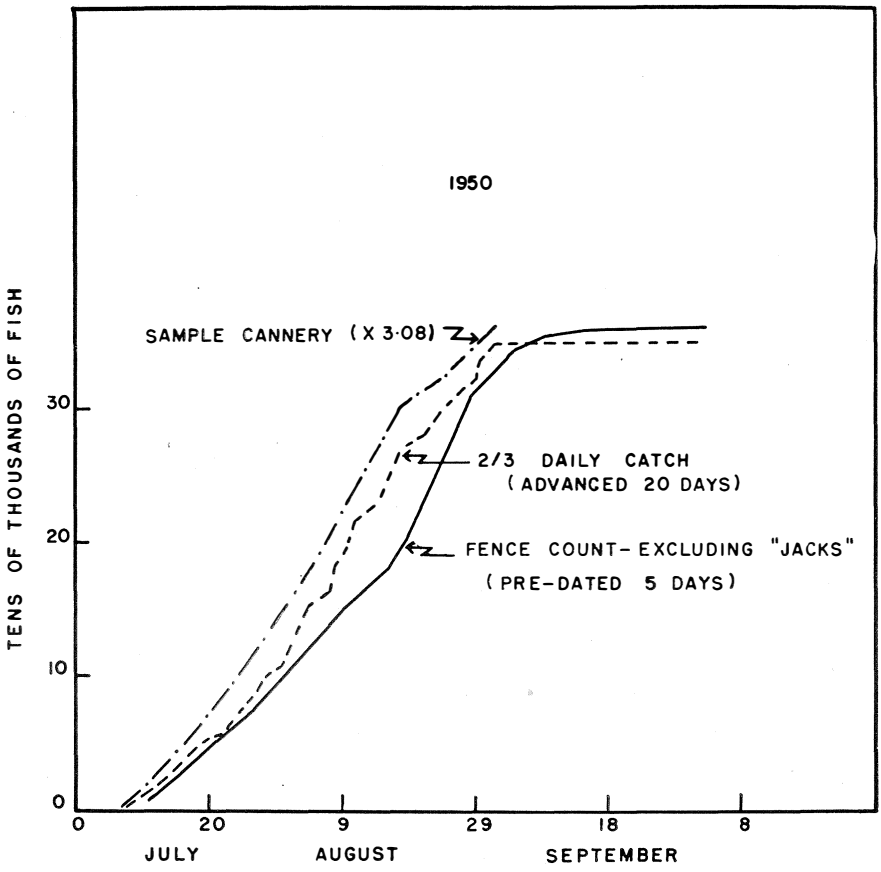

Figure 17. Progression of sockeye past the site of the Slide in 1950. Cumulative totals of the catch advanced 20 days, catch of "sample" cannery advanced 20 days, and Fence counts (excluding jacks) pre-dated 5 days.

of the strike, therefore, the expected catch would have been about 216,000 sockeye. However, allowance must be made for the probable increased effort on the part of fishermen after the strike to make up for some of the loss during the strike, and for the fact that, as after week-end closures, fishing probably began at the upper fishing boundary, in which case many fish would be taken before they moved out of the fishing grounds (Pritchard, 1948a; Pritchard *et al.*, MS

88878—3½

1948). With these points considered, the potential catch during the strike is estimated as 150,000 sockeye. The potential total catch therefore becomes 1,268,951 + 150,000 = 1,419,000.

The escapement to the Babine River now becomes two-thirds of 1,419,000 = 946,000, *plus* that proportion of the 150,000 potential catch during the strike which actually became additional escapement to the Babine River. According to Brett (1952) approximately 70 percent of the total escapement of Skeena sockeye go to Babine Lake, so that this additional escapement during the strike

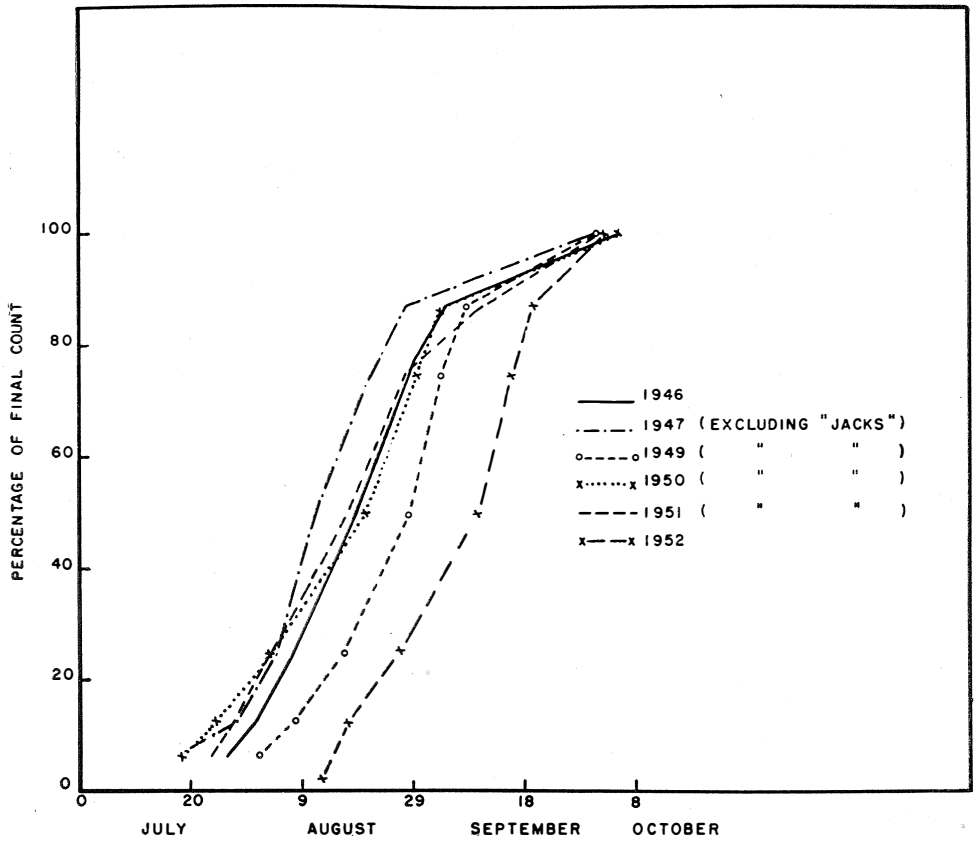

Figure 18. Comparison of the time of arrival of sockeye at the counting Fence for several years.

becomes 70 percent of 150,000 = 105,000 sockeye. The estimate of the total escapement to Babine Lake in 1952 is, therefore, 946,000 + 105,000 = 1,051,000 sockeye.

When the cumulative daily catch totals for 1952 are plotted there occurs a marked irregularity in the curve at the period of the strike. This curve is considerably smoothed when the additional "expected" catch is included and the potential catch totals plotted, and it conforms more closely to those of former years.

TIME OF MIGRATION. Sockeye in 1952 were decidedly late in reaching the Babine Fence (Fig. 18). Before ascribing all this delay to the Slide, it is desirable to be assured that the run was not naturally late in 1952.

In Figure 19, the passage of sockeye through the fishery has been defined for the years 1946, 1947, 1948, 1950, 1951 and 1952, by plotting the dates by which various percentages of the total catch had been made. It was necessary

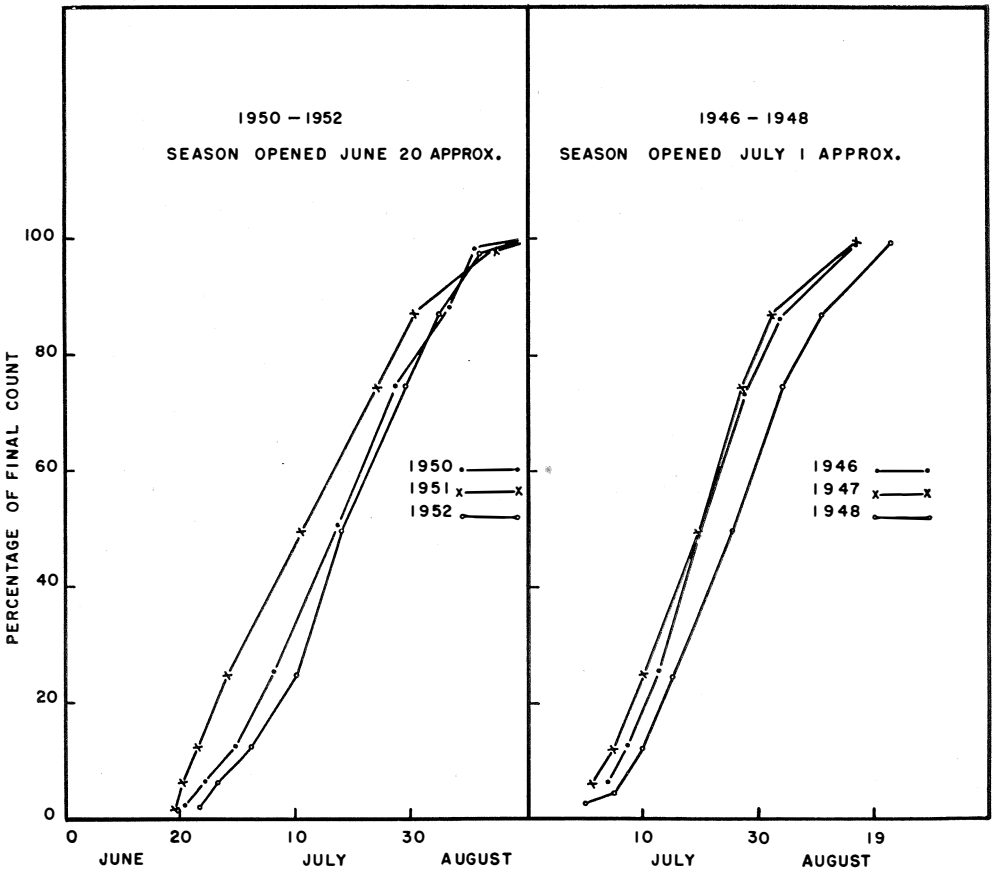

Figure 19. The passage of sockeye through the fishery for the years 1946-1948 and 1950-1952, as indicated by the dates by which various percentages of the total catch had been made.

to make two groups of plots because of the change in the opening dates of the fishery after 1948. (Data for 1949 are not available.) There is no indication in these plots that the sockeye in 1952 were especially late in arriving on the fishing grounds, although the earliest fish might have been so by a few days.

High water in the Skeena and Babine Rivers in 1952 may have delayed fish, particularly in the narrow canyons. The early part of the sockeye run could therefore have been later in reaching the site of the Slide than was usual for

years of more moderate water conditions. However, since there is no evidence that the run as a whole was particularly delayed, no adjustments allowing for a late run have been made in the following calculations.

ESTIMATES FOR 1951

In Figure 20, two-thirds of the daily cumulative catch-total for 1951 have been plotted, this fraction being that upon which the Babine escapement estimate is based. As in Figure 17, the conditions at the site of the Slide have been represented by advancing the catch totals by 20 days, and by pre-dating the Fence totals by 5 days.

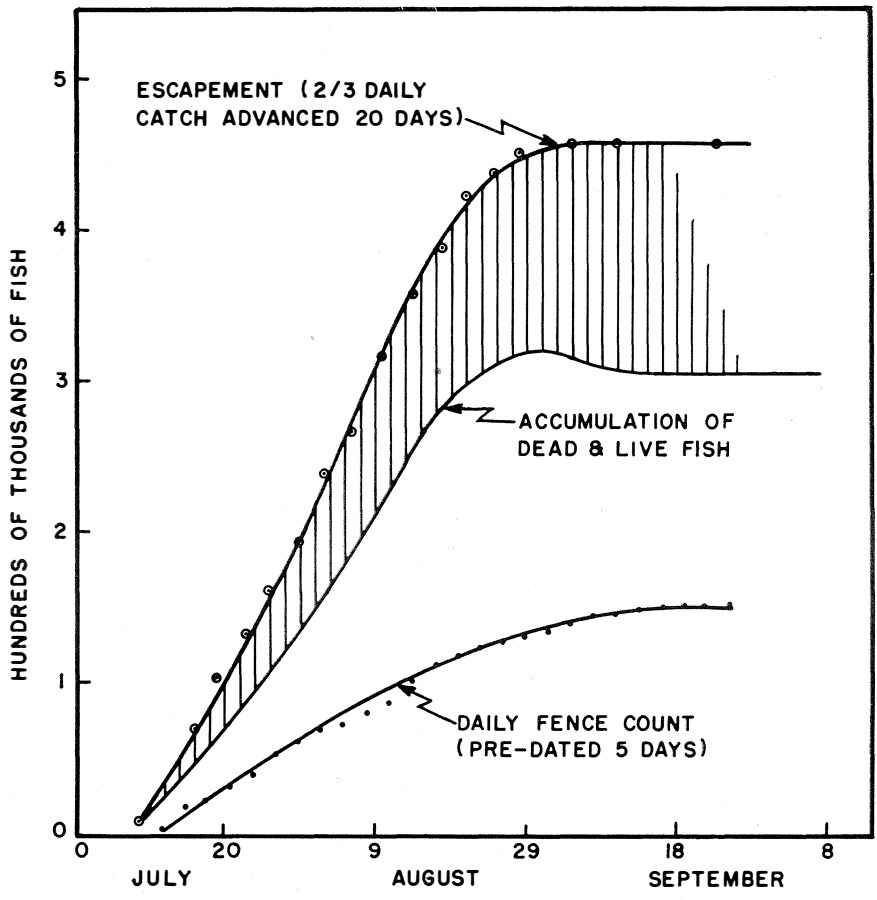

Figure 20. Progression of sockeye to and beyond the Slide in 1951. Cumulative totals of two-thirds of the catch advanced 20 days, and Fence counts pre-dated 5 days.

The escapement beyond the Slide is measured in the cumulative Fence counts. By subtracting these totals from their corresponding escapement totals the middle curve is derived, which is the accumulation of fish, *both dead and alive*, blocked below the barrier. The upper end point of the middle curve

provides the estimate of the final total loss, namely, 319,000 sockeye. The peak of this curve indicates the maximum accumulation of dead and live fish below the barrier, which was about 320,000 sockeye.

From Figure 20 it appears that in 1951 about one-third of the Babine escapement succeeded in passing the Slide to reach the counting Fence. At no time is there indication of any complete and persistent block; rather, *a fairly constant proportion of about one-third of the run* escaped daily above the Slide. This is explicable it the fish which got through were mainly the stronger individuals, these constituting a fairly constant fraction of the arrivals, and if passage was of about the same difficulty all through the migration.

ESTIMATES FOR 1952

The course of events at the Slide in 1952, shown in Fugure 21, appears to have been quite different from that of the previous year. Three conditions seem to have been mainly responsible: the very high water levels at the Slide, the effects of remedial action to clear the passage, and the large escapement.

In 1952 the June water discharges from Babine Lake (Fig. 22) were the highest observed in 10 years of record (1930, 1944-1952), and conditions at the Slide itself were further affected by freshets from tributary streams during the period of migration. Remedial measures, by blasting and removing rocks, were carried out during the season, and particularly later in the run. Finally, the 1952 catch of approximately 1,300,000 sockeye was the largest since 1940, and the Babine escapement was also large—very much larger than 1951.

EFFECTS OF HIGH WATER LEVELS AND REMEDIAL MEASURES. In Figure 21, the escapement to the Slide, or the potential Babine escapement, has been plotted as two-thirds of the cumulative totals of the potential catch (adjustments having been made, as described, for the strike). The middle curve was again derived by subtracting the Fence totals from corresponding catch totals.

After making allowance for the possible late arrival of the very earliest fish, there was a period of 10 to 16 days after the fish first reached the Slide during which only an occasional sockeye escaped above it. Thus, although the first sockeye were tagged at the Slide on July 8 and some had doubtless arrived there a few days earlier, the first 50 sockeye had not been counted through the Fence until July 30. Between 300,000 and 400,000 sockeye had reached the Slide before any appreciable number had escaped beyond it, about August 7 according to Figure 21. During this time many had died or had been diverted downstream where they subsequently perished.

Up to August 7 water levels at the Slide were still very high compared to the same periods in 1951 (Fig. 22). On August 6 the first successful attempt was made, by blasting, to alleviate the passage. On August 8 sockeye for the first time were seen to ascend to the pool directly above the Slide in sufficient numbers to permit a "spot count"—made by observing the passage of fish over a white board.

The spot counts have been plotted as a cumulative curve in Figure 21, on a scale which allows their direct comparison with the daily Fence count. Considering the difficulties involved in trying to maintain a spot count under standard conditions, the two curves correspond reasonably well.

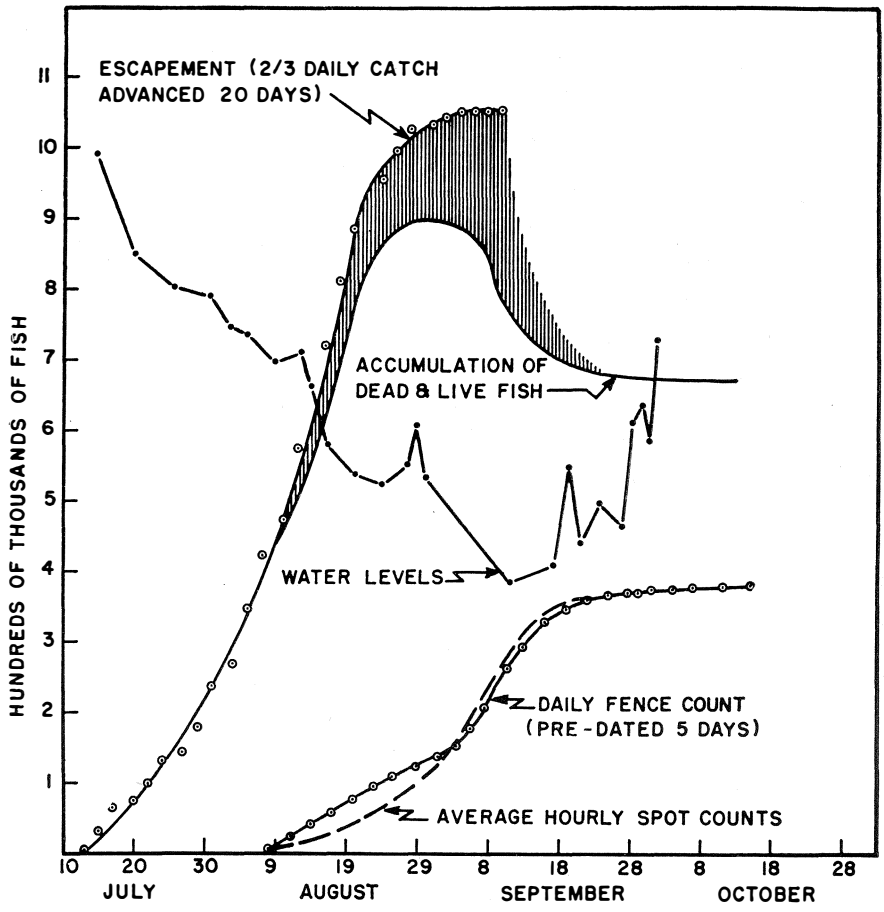

Figure 21. Progression of sockeye to and beyond the Slide in 1952. Cumulative totals of two-thirds of the catch advanced 20 days, average hourly spot counts, and Fence counts pre-dated 5 days.

Following the opening of the side channel on August 6, and probably also in response to more favourable water levels, there was a daily ascent of a rather small proportion of the accumulated fish until near the end of the month. During this period, according to Figure 21, the peak of the escapement from the fishery had reached the Slide.

During the latter half of August, as water levels moderated, the levels in the narrow escape channels on the left bank gradually dropped and finally became low enough to slow up the ascent of fish. To relieve this situation a large rock

was removed by blasting on August 27. In response there was an almost immediate upsurge in the number of ascending fish. This is indicated by the sudden increase in spot counts from about 40 per hour on August 27 to more than 1000 per hour on August 31, and also by a sharp rise in the daily count at the Fence at the appropriately later date of about 6 days. At approximately this

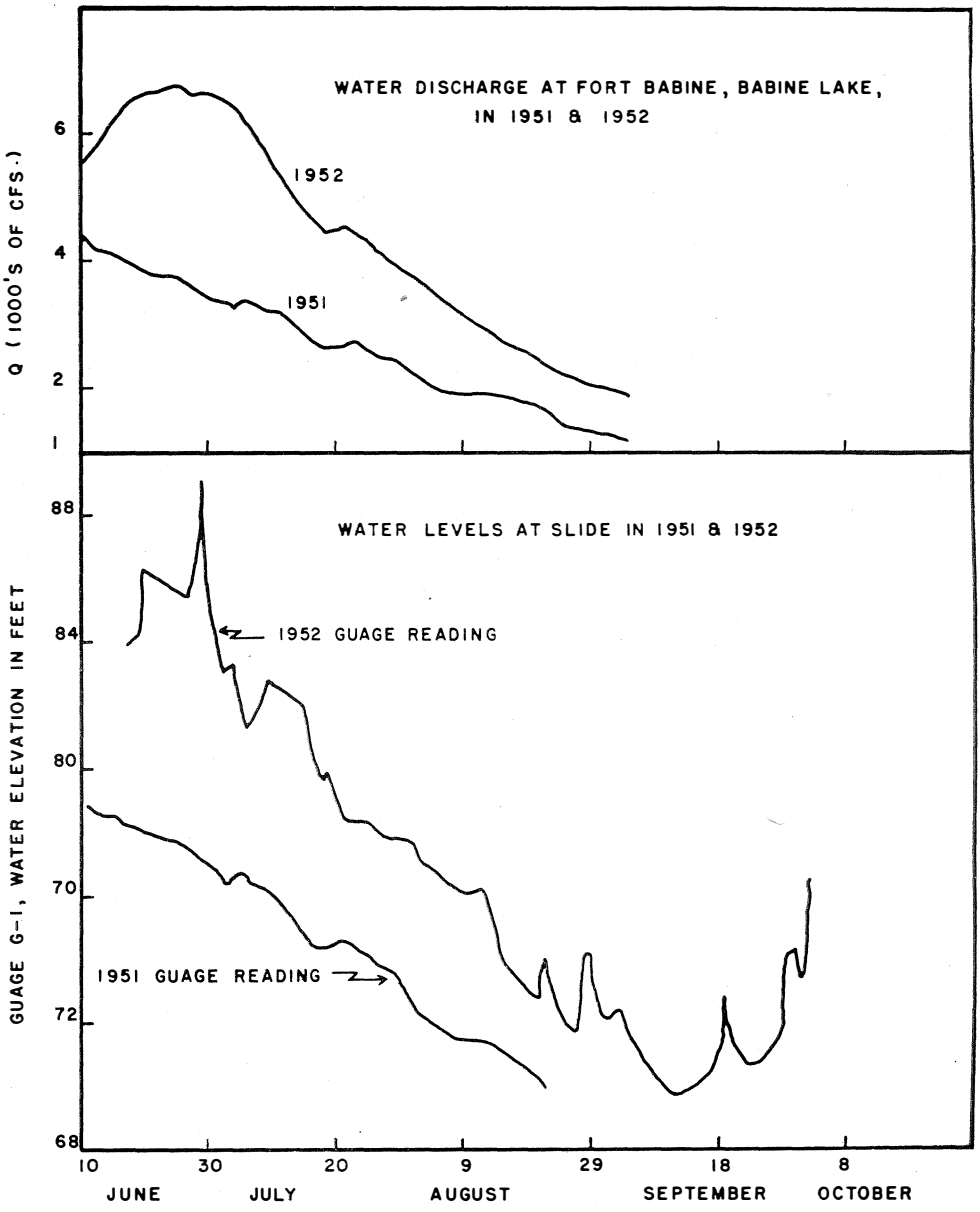

Figure 22. Water discharge at Fort Babine in 1951 and 1952, and water levels at the Slide in 1951 and 1952.

88878—4

same time the arrival of new sockeye at the Slide was virtually over, and the peak accumulation of 900,000 dead and live sockeye below the Slide had been reached (Fig. 21).

During the first week of September the sockeye passed the Slide in large and increasing numbers, and the number of fish accumulated below the Slide began to drop off rapidly (Fig. 21, middle curve). The final estimate is 700,000 permanently stopped, as compared with 351,000 that got through. Towards mid-September the number of fish passing the Slide declined sharply, and finally petered out towards the end of the month. Since the salmon that escaped after August 27 made the ascent after the arrival of sockeye at the Slide was essentially complete, they must have consisted mainly of fish which had already experienced some delay and resultant injuries. After clearing the passage, therefore, a larger proportion of injured and weak fish went up to the Fence than had done so earlier.

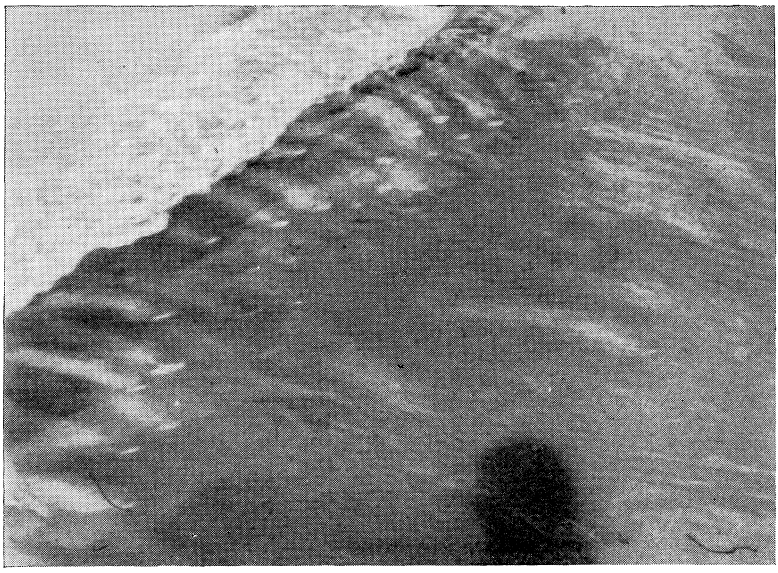

Figure 23. Sockeye that had ascended and were resting at the head of the Slide, September 6, 1952. A line of fish appeared in this position after removal of the upper large rock on August 27, and persisted for some time. The submerged remains of the large rock cause the turbulence in upper left.

EFFECT OF THE SIZE OF THE RUN. It was stated above that because of the extremely adverse water conditions at the Slide in 1952, possibly between 300,000 and 400,000 sockeye had accumulated below the Slide by August 7 (Fig. 21), before any appreciable numbers escaped above it. The number escaping increased as the water level fell, and after improvements to escape channels had been made. However, the rate of escapement does not seem to have increased as might have been expected from the numbers of fish which were arriving at the Slide at that time. Insufficient water in the actual escape channels was partly

responsible for a decline in the escapement, but there is also the possibility, which cannot be ignored, that, in themselves, the very large number of fish at the Slide constituted an obstacle to the migration. By mid-August many pink salmon and a smaller number of coho salmon were also reaching the Slide. Such a large number of fish may not have acted as a mere physical impediment. The pattern of migratory behaviour of the salmon, in their responses to the stimuli necessary for their displacement upstream, may have been seriously disturbed by the presence and the activity of many tens of thousands of delayed fish.

SUMMARY AND DISCUSSION

The accumulation of fish below the Slide, and the losses there in 1951 and 1952, have been described on the basis of estimates of the Babine escapement which depend upon the relationship (which has varied only very slightly during the four years of Fence operation prior to the Slide) between the total Skeena sockeye catch and the Fence counts. The catch, the estimated potential escapement, and the estimated losses in 1951 and 1952 were as follows:

Year	Sockeye catch	Potential escapement	Fence count exclusive of jacks	Loss at Slide	
				Number	Approximate fraction of escapement
1951	691,442	461,000	141,785	319,000	[illegible]
1952	1,419,000[1]	1,051,000[1]	350,561	700,000	[illegible]

[1] Adjusted as described on page 24.

These various estimates have depended upon certain assumptions. The first of these was that there was no reason to expect that the catch: escapement ratio in the two years of the blockage should have been very different from former years. This was not altogether true for 1952 because of the strike, but the catch was adjusted by 150,000 fish to allow for this. If this figure is too high, the estimates of escapement and losses in 1952 would also be high, but by no more than 100,000 sockeye at most.

The variability of the catch: escapement ratio could be measured from only four years' data. The catch of 1952 was much greater than during any of these four years; it was the highest since 1940, and before that since 1930. It might be that in 1952, therefore, the relationship was upset, and the escapement no longer quite the same proportion of the catch as during the earlier years. As the counting fence will be operated during 1953 and probably future years, the variability of this ratio can be studied further.

The use of cumulative frequency curves for the purpose of describing the events at the Slide in the accumulation and losses of fish depends to some extent upon the assumption that the fish move up the river in the same formation as they had passed through the fishery. This may not be altogether true because of a certain amount of passing and overlapping. However, the effect is probably

88878—4½

only a minor one, and in a general way the leading fish probably maintain their position throughout their migration up the river. In any event, in the four years prior to the Slide, the number of fish reaching the Babine Fence made up a fairly constant fraction of two-thirds of the numbers being taken by the fishery.

Finally, for convenience it has been assumed that the Fence counts in 1951 and 1952, for the purpose of estimating the accumulations and losses at the Slide, represented the escapement above the Slide. There can be no doubt that some of the sockeye which did escape the Slide, died before reaching the Fence. The middle curve of Figures 20 and 21, however, is meant to depict the accumulation of dead and live sockeye, and as such can be taken to include those fish which died between the Slide and the Fence, as well as those which perished at various distances below the Slide. The use of the Fence counts to represent the escapement above the Slide does presuppose that no Babine sockeye spawned effectively between the Fence and the Slide. There is evidence (below) that of approximately 300 sockeye which had already passed the Slide and were tagged immediately above it, about 70 percent were recovered at the Fence. Since some of these fish were very likely swept down through the Slide immediately after tagging, and since some probably perished before they reached the Fence, this high rate of return does indicate that nearly all of the sockeye which passed the Slide did migrate to the Fence. Furthermore, in the unlikely event that any did spawn in the main river at any great distance below the Fence, it is very improbable that such spawning would be effective in the production of smolts, in which case those adults also can be considered as lost at the Slide.

In the argument above it has been assumed that the estimated escapement from the fishery actually reached the Slide without abnormal losses on the way. There is a possibility, however, that in 1952 probably small but, nevertheless, abnormal mortalities and injuries were experienced even below the Slide, at points of ordinarily difficult passage, because of the adverse water conditions. The suggestion has already been made that the earliest fish in the 1952 run may have been held up between river mouth and the Slide. Furthermore, among the tagged fish, the proportions of injured fish (sockeye, pinks and coho) were higher at Kisgegas (below the Slide) than at the Slide. Much of this disproportion, and perhaps all of it, was the result of selection for uninjured fish at the Slide for tagging, and the presence at Kisgegas of fish which had been weakened or injured at the Slide and had drifted downstream. However, some injured fish may have been freshly arriving with scars inflicted downriver. In that event, estimates of the losses already described would remain unaffected, but their causes would have been not only effects of the Slide, but other adverse conditions in the lower river.

Other Species

It has not been possible to arrive at any very useful estimate of the Babine escapement, or of losses at the Slide, for species of salmon other than sockeye. There are three main reasons for this failure. In the first place the Babine escapements of pink, coho, chum and spring salmon form only relatively small

and (except possibly for springs) fluctuating proportions of the total Skeena escapements. Secondly, the intensity of fishing for these species has varied during the season, and the catch has not necessarily been proportional to their abundance. For instance, in some years pinks have been fished more intensively when sockeye catches were poor (Milne, 1948). Finally, the Fence counts very likely represent only small fractions of the Babine escapements past the site of the Slide, since these species also spawn in the main river, and doubtless in tributary streams below the fence.

Certain information concerning the Babine runs of these salmon is relevant, and is summarized below.

PINK SALMON

The Skeena catch of pink salmon, and the Fence counts, from 1946 to 1952, are shown in Table 3. Regardless of what the exact size of the Babine escapements from the fishery in 1951 and 1952 may have been, it is obvious that in each of these two years only a very small fraction of them reached the counting Fence. From direct observation and tagging results it is known that there were numerous pink salmon in the river and that some died from the effects of the Slide.

TABLE 3

Catches of Skeena pink salmon, and the number counted at the Babine Fence

Year	Catch	Fence count	Fence count as percentage of catch
1946	193,266	28,161	14·6
1947	237,330	55,421	23·4
1948	911,808	No count	—
1949	586,260	13,663	2·3
1950	390,026	38,728	9·9
1951	450,216	50	0·011
1952	1,450,769	2,706	0·19

The times of arrival of pink salmon on the fishing grounds, as indicated in the plots of the dates by which various percentages of the total catch had been made, were very similar in 1950, 1951 and 1952, the three years for which there are accurate daily catch records. By comparing the progression of pinks through the Fence in 1952 with former years, it appears that the bulk of the 1952 run was late in reaching the Fence by 10 to 15 days.

In 1950 the Fence counts constituted a moderately constant proportion of approximately 10 percent of the daily catch of the fishery. In that year too, pinks apparently took about 27 days, on the average, to pass from the fishing grounds to the Fence. These estimates were obtained by comparing their progression through the fishery and the Fence, using percentage and cumulative frequency curves, similar to Figures 18, 19 and 20 for sockeye.

In normal years pinks would be expected to arrive at the site of the Slide during the last days of July or very early in August, and the peak of the run would probably pass there during mid- to late August. They arrived at the Slide at about the same time in 1952. This would suggest that in 1952 the peak of the pink run at the Slide followed that of the sockeye by about a week or ten days, and would have preceded the completion of the sockeye run to the Slide by roughly the same period. Thus at the time of the greatest accumulation of sockeye below the Slide, pink salmon were also arriving there in important numbers.

COHO SALMON

British Columbia waters have been divided into Fisheries Statistical Areas, of which Area 4 is essentially that of the Skeena River fisheries. Unlike sockeye and pink salmon, which are taken almost wholly by gill-nets, a large proportion of the coho catch of Area 4 is by trolling. The trolling grounds are well offshore, up to 50 miles from the mouth of the Skeena, and near the outer (western) boundary of the area. An unknown, but probably large fraction of this troll catch does not belong to the Skeena River system.

By contrast, because the coho *gill-net* fishery takes place either close to or within the mouth of the Skeena, the fish caught are very likely to be Skeena-bound. Yet although daily gill-net catches of cohoes are available since 1950, escapement and loss estimates for 1951 and 1952 have not been possible, for reasons similar to those given for pinks. Furthermore, the fishing season has closed in some years before the coho run was over.

The more pertinent information that has been derived from analysis of the catch and Fence data is as follows:

The gill-net catches in the years of Fence operation before the Slide probably varied considerably (as they had done in 1950-52), yet the Fence totals remained much the same—11,500 plus or minus about 1,000 fish.

In 1951 the Area 4 troll and the gill-net catches were both about 100,000 fish, the total catch being the largest of several recent years. Furthermore, the rate of catch was still high when the season closed. As in former years, Fence operations were terminated early in October, at which date the total coho count was only 2,122 fish.

In 1952 the total coho catch was 150,000, the gill-net catch 46,000 and the Fence count 10,550. The Fence count that year was only about 1,000 less than the average of the normal years, but the Fence remained operating until November 13—a month later than in previous years. During the last two weeks only one or two cohoes daily passed through the Fence. The run as a whole was about 10 days later at the Fence than the average of the pre-Slide years.

Dating back from arrivals at the Fence, it appears that in normal years cohoes probably began to arrive at the site of the Slide by mid-August, and the peak of the run came during early to mid-September. In 1952 the first coho was tagged on August 8, but only scattered individuals were seen at the Slide until late in August, and the peak came during mid-September, much as in

former years. By this time the sockeye run to the Slide had ended, and the accumulation of *live* sockeye, which had declined rapidly since the first of the month, was almost gone (Fig 21). Thus, also at the time of the peak accumulation of sockeye below the Slide, some cohoes as well as the large numbers of pink salmon, were arriving there.

Coho spawning has been observed above and below the counting Fence, and probably also takes place in the main river and its tributary streams, between the Slide and the Fence.

SPRING SALMON

There are much the same difficulties in making estimates of escapements and losses of spring salmon as with cohoes and pinks. A large proportion of the Skeena catch of springs is taken by trolling, and it is not possible to make an accurate separation of the ocean from the Skeena fish.

The 1950 catch statistics separate the gill-net from the trolling catches, and serve to indicate that the Babine escapement is probably an important fraction of the total Skeena escapement. In that year the gill-net catch was approximately 23,000 fish, and the Fence count almost 7,000—the ratio being roughly 3:1.

The fishery for spring salmon begins in late April or early May, earlier than for the other salmon, and by mid-August the catch is almost complete. Only occasional springs are taken during the rest of the season.

Springs have begun to arrive at the Fence in the pre-Slide years by about mid-July. By the time the Fence operations were terminated, in early October, the runs were almost, though not quite, over. In 1952 the count ended on November 13, and only three or four springs had gone through the Fence during the preceding month and a half.

The first half of the 1952 run of springs was apparently somewhat late in arriving at the Fence, as compared to former years. The small run of 1951 was approximately on time.

The Skeena spring catch, according to Milne (1948), has probably remained fairly constant over the years. The Fence counts, also, have not varied much (Table 1), the average being 10,103 fish.

The Fence counts for 1951 and 1952 were 2,761 and 5,915 springs, which, if the escapements had remained fairly constant, would indicate a loss of between two-thirds and three-quarters in 1951, and less than one-half in 1952.

Some spring salmon probably spawn each year between the Fence and the Slide, and in tributaries of this section of the river.

CHUM SALMON

In the four pre-Slide years of Fence operation the number of chum salmon counted through the Fence varied from 5 to 18. None entered the Fence in 1951, and only one in 1952.

TAGGING AND SAMPLING PROGRAM OF 1952

Purpose and Method

The program of tagging and sampling was undertaken in 1952 with the expectation of obtaining information on some or all of the following points:

1. The numbers of fish in the runs migrating up the Babine River towards the Slide.
2. Losses at the Slide.
3. Periods and duration of delay below the Slide, as related to changes in water levels, and to remedial measures taken.
4. Changes, which would be attributable to the Slide, in condition of fish, in proportions injured, and in degree of sexual maturity.
5. Differences in the ability of fish to pass the obstruction due to variations in size, sex, injuries and degree of sexual maturity.
6. Estimation of the number of fish on the Babine spawning grounds, and of losses above the Fence, from the distribution of tagged and untagged fish.

Tagging crews, which consisted of two men each, operated at the Slide, and also approximately 10 miles below the Slide at Kisgegas.

At the Slide, fish were caught in pools created by the fallen material (Fig. 24). Approximately 300 were also caught and tagged in the ponded water by the left bank immediately above the obstacle. These fish had successfully made the ascent above the Slide.

When planning the experiment, it had been appreciated that fishing at the Slide might be unavoidably selective for injured, weak and/or delayed fish. A second tagging site was therefore desired, which would be far enough downstream from the Slide that the inclusion of fish that had already reached the Slide, and had fallen back, would be avoided (Fig. 25). The Kisgegas sample of fish, it was hoped, would be reasonably representative of the Babine escapement from the fishery.

When the fish began to accumulate at the Slide, and the water cleared sufficiently to see them well, it became apparent that the inshore fish, which were easiest to secure, included a disproportionately large number of injured fish. Accordingly the taggers tended to favour uninjured fish, especially during the latter half of the sockeye run, in an attempt to tag freshly arrived fish as well as, and as distinct from, those that had already experienced delay. Furthermore, many weak and injured fish did drift downstream to the Kisgegas site. There was some selective fishing for green and uninjured fish at Kisgegas also, though to a much smaller extent, and only during the last few days of the run there.

Fish were caught by means of long-handled, Indian type dip-nets. At Kisgegas fish were taken from a relatively narrow and swift passage (Fig. 25). Fishing at the Slide was, of necessity, mostly from pools in which the salmon were resting (Figs. 9, 24).

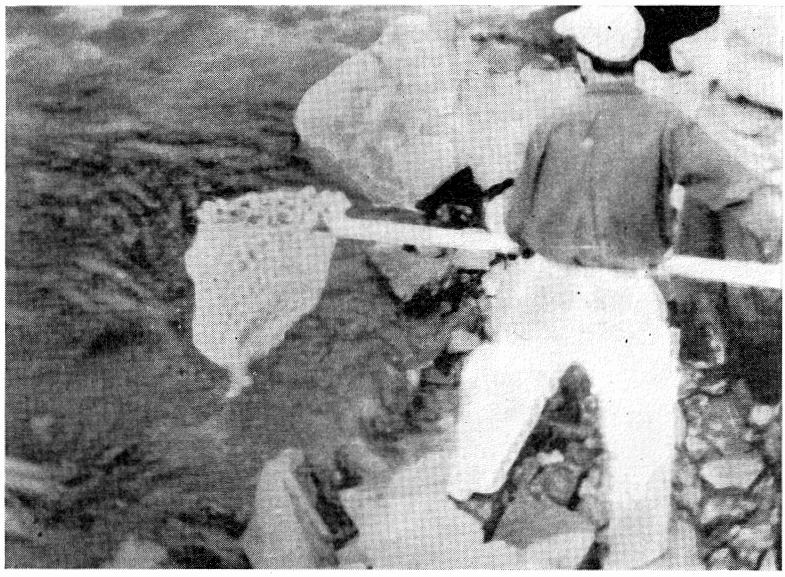

Figure 24. Dipping blocked salmon for tagging at the Slide.

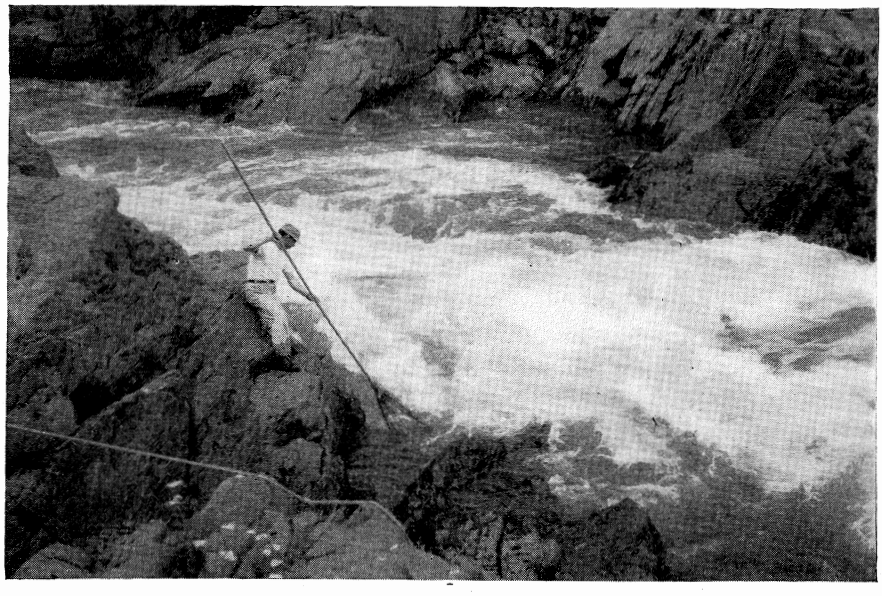

Figure 25. Dipping salmon for tagging at Kisgegas.

Petersen-type tags were used, consisting of two white plastic baffles 13 millimeters in diameter, attached by means of a non-corrosive metal pin. They were placed either below the dorasl fin ("dorsal" tags), or, in the case of approximately every fourth sockeye, vertically through the nose ("nose" tags). The latter position had been used on spring salmon in Alaska, and it was desired to compare it with the usual dorsal position.

Records kept for each fish included tag number, species, sex, length, injuries evident and sexual condition. Sex recognition was close to 100 percent accurate for sockeye and pinks, but was less easy for springs and cohoes.

Fish were classified according to their sexual condition as green, pink, red or mature, the order being that of increasing sexual ripeness. "Mature" fish were not only deeply red, but would exude milt or eggs upon slight pressure.

At the tagging sites, all fish were described as injured that bore any mark, scar, abrasion and/or fungus infection. They were further classified as having *head*, *body*, or *head and body* injuries. A somewhat different system was followed at the counting Fence. There, fish were described as "gaffed" if they bore the mark of a gaff; "netted", if they carried gill-net marks; and "injured", if they bore any scar, abrasion and/or fungus infection, excluding gaff and net marks. A combination of the three categories, "injured", "gaffed" and "netted" at the Fence, therefore corresponded to the "injured" category employed below the Slide.

Daily records of air and water temperature, and of water levels were maintained at the Slide throughout the season.

When the program was designed, it was believed that it might be necessary to tag as many fish daily as possible, to ensure getting large enough samples of the runs. Early in the season, therefore, all the fish that could be caught were tagged, which, in the case of sockeye salmon, amounted to as many as 300 or more on some days. At both sites catching fish was easier than had been anticipated. When the numbers of tagged fish reaching the Fence each day became too many for the crew there to record and examine, a limit was set of 75 sockeye tagged per day at each of the two main sites. Thus many more salmon were tagged in the early part of the run than later on.

Most of the recoveries of tagged fish were made at the Babine counting Fence, and smaller numbers at the Slide and at Kisgegas whilst catching fish for tagging. A few recoveries were also made at points on the Lower Skeena.

From among the fish which had passed the counting Fence, second recoveries were made from the Indian fishery, from the dead in the spawning streams and on the shores of Nilkitkwa Lake, and from dead fish which had drifted back onto the counting Fence.

During the winter of 1952-53, the details pertaining to each fish were transferred from the field record books to individual punch cards. The analysis of data relating to the approximately 18,000 tagged fish has been facilitated through the use of the keysort method.

TABLE 4

The numbers of salmon tagged, the numbers and percentages recovered at various sites, and the total Fence counts for 1952

Species	Tagged at:			Recovered at:								Fence counts
	Kisgegas	Slide	Above Slide	Fence[1]		Kisgegas		Slide		Lower Skeena		
				No.	%	No.	%	No.	%	No.	%	
Sockeye	4,471	8,710	307	1,650	12·2	61	0·5	365	2·7	78	0·6	376,947
Pink	1,585	403	9	9	0·5	10	0·5	21	1·1	11	0·6	2,706
Coho	197	312	5	114	22·2	—	—	30	5·8	10	1·9	10,554
Spring	10	10	—	—	—	—	—	—	—	—	—	5,915
Chum	18	3	—	—	—	1	4·8	—	—	1	4·8	1
Steelhead	19	58	—	—	—	—	—	—	—	—	—	245

[1]Does not include tagged fish observed passing the Fence, but whose tag numbers were not recorded. See text.

Number of Salmon Tagged and Recovered

The number of salmon of the different species that were tagged at each site, and the numbers and percentages recovered at various sites are listed in Table 4. The total Fence counts for 1952 are also shown. Some of the fish recaptured at the Fence had been previously recovered at one of the tagging sites.

Results for Sockeye Salmon

COMPARISON OF NOSE AND DORSAL TAGS

A preliminary analysis of the tag-recovery data showed that differences between the percentage recoveries of nose-tagged and dorsal-tagged sockeye were too small to warrant their separate treatment in subsequent analyses necessary for this report (Table 5). The percentage recovery of nose-tagged fish was slightly higher, but the difference was not significant on the basis of a Chi-square test using the figures for *total* numbers tagged and recovered ($\chi^2 = 2 \cdot 42$; $P = 0 \cdot 1$ approx.). For the purposes of the report, therefore, the position of the tag has been ignored.

TABLE 5

Numbers of sockeye with nose and dorsal tags, numbers and percent recovered at the Fence. (Slide figures were from a sample which included every second day's tagging, from the beginning to the end of nose tagging.)

Position of tag	Number tagged		Number recovered		Percent recovery	
	Kisgegas	Slide	Kisgegas	Slide	Kisgegas	Slide
Nose	495	606	38	70	7·7	11·6
Dorsal	1,730	1,836	112	192	6·5	10·5

SEX RATIOS

In Table 6 are listed the proportions of male, female, and jack sockeye in the tagged samples, in the 1 percent proportionate sample of the run through the Fence, and among the tagged fish that were recovered at the Fence. The figures include both injured and uninjured fish.

TABLE 6

Sockeye sex ratios at Kisgegas, the Slide and the counting Fence, 1952 (injured and uninjured combined)

Sex	Kisgegas	Slide	Fence (untagged)	Fence (tagged)
Males	41·4	46·3	54·4	59·7
Females	51·2	52·4	37·9	36·7
Jacks	7·4	1·3	7·4	3·6

The sex ratios among tagged fish from Kisgegas and the Slide differed between the injured and the uninjured, as shown in Table 7. At both sites there were relatively more females tagged than males, whether injured or uninjured.

TABLE 7

Percentages of males, females and jacks among injured and uninjured tagged sockeye, 1952

Sex	Kisgegas		Slide	
	Injured	Uninjured	Injured	Uninjured
Males	37·5	43·5	41·4	47·9
Females	59·9	46·4	58·4	50·4
Jacks	2·7	10·0	0·2	1·7

Conscious selection of fish at the tagging sites was of two sorts: (1) jacks were partly avoided, as were some of the more injured fish of all sizes; and (2) jacks usually, and the smallest of the older fish occasionally, were able to slip through the meshes of the dip nets. The net result was a fraction of jacks in the sample much too low to be representative, and also some discrimination against females among the older fish (since females are smaller than males of the same age, and since a larger percentage of females was injured). Both these tendencies were partly countered by the tendency of jacks and injured fish to be closer inshore and hence more available to the dippers.

Obviously it is difficult to use sex composition of the fish tagged to assess the differential effect of the Slide upon the two sexes. However, three other lines of evidence indicate that females and jacks were in fact more seriously affected than normal males. 1. The most direct of these evidences is the better survival of tagged males than tagged females, described in the following section. 2. Both in 1951 and 1952 the proportion of females at the Fence was smaller than in any of its 4 previous years of operation (Table 1). The percentage females among "normal" fish was 48 in 1951 and 41 in 1952, as compared with a pre-Slide average of 57 percent. The number of jack males has varied greatly, but they too were relatively scarce at the Fence in both of the Slide years (Table 1). 3. The sample of blocked fish obtained from the Skeena River near Hazelton in 1951, although it was small, had an excess of females and jacks (20 females; 14 jacks; 8 normal males) in contrast to the Fence sample of that year (Foskett, 1952). This sample from below the Slide was unselected as far as the sampler was concerned, although the different sexes and sizes of fish need not necessarily have drifted to shore equally readily.

In 1950 the mean time of arrival at the Babine Fence of male sockeye was 3 days earlier than that of female sockeye, and in all years the first male sockeye have arrived at the Fence slightly earlier than the first females. In 1952 then,

male sockeye probably encountered a longer period of stoppage than females, which would mean that the differential effect of the Slide upon females was even greater than indicated above.

Approximately 300 sockeye were captured and tagged from the ponded water immediately above the Slide, on the left bank of the river. These were fish that had made the ascent unaided, and included some that had succeeded in passing the Slide when it was still a major obstacle. Tagging was carried out during two separate periods, 193 during August 10-14 before the channel had been opened (August 27) by blasting; and 114 during September 11-14, after the major improvements had been made. Sex ratios among these fish are shown in Table 8. It is difficult to assess the various kinds of selection in effect here, but there were more large males and fewer jacks present before the major channel improvement was made.

TABLE 8

Sex ratios among sockeye captured and tagged Above the Slide; showing separation for two periods of tagging

Sex	Aug. 10-14	Sept. 11-14	Combined
Male	54·4	43·9	50·5
Female	45·1	48·2	45·6
Jack	0·5	7·9	3·9
Number of fish	193	114	307

SEXES AND RECOVERIES AT THE FENCE

UNINJURED SOCKEYE. The numbers tagged and recovered and the percentage recoveries of uninjured male, female and jack sockeye are listed in Table 9.

TABLE 9

Number of uninjured sockeye tagged, number recovered at the Fence, and percentage recoveries, by sexes

Tagged at:	Number tagged			Number recovered			Percent recovery		
	M.	F.	J.	M.	F.	J.	M.	F.	J.
Kisgegas	1,257	1,341	290	144	96	32	11·5	7·2	11·0
Slide	3,148	3,309	110	510	315	6	16·2	9·5	5·5
Above Slide	114	79	10	85	53	7	74·6	67·1	70·0

Recoveries of uninjured female sockeye were lower at each site than of uninjured male sockeye; by 37 percent for Kisgegas, by 41 percent for the Slide, and by 10 percent for tags applied Above the Slide. Recoveries of jack sockeye were fewer than for older males; only slightly so at Kisgegas and Above the Slide, but by 66 percent at the Slide.

INJURED SOCKEYE. Table 10 for injured sockeye corresponds to Table 9 for uninjured sockeye. Among the injured sockeye also, the percentage recovery of females was lower than for males; by 41 percent for Kisgegas, and by 37 percent for the Slide. Above the Slide, more females were recovered than males; but considering the small number of fish involved at this site, and the difference in the other direction among uninjured fish, it is probable that once they had passed the Slide, male and female sockeye were about equally successful in reaching the Fence.

TABLE 10

Number of injured sockeye tagged, number recovered at the Fence, and percentage recoveries, by sexes

Tagged at:	Number tagged			Number recovered			Percent recovery		
	M.	F.	J.	M.	F.	J.	M.	F.	J.
Kisgegas.....	593	948	42	32	30	2	5·4	3·2	4·8
Slide.....	888	1,251	4	87	77	1	9·8	6·2	25·0
Above Slide.....	41	61	2	22	38	2	53·7	62·3	100·0

Only at Kisgegas was an appreciable number of injured jacks tagged, and they were recovered 11 percent less often than were injured older males.

PROPORTION OF INJURED SOCKEYE

Fish were classified as injured as described on page 38. The number and proportions of injured males, females and jack sockeye in the tagged samples, and in the 1 percent proportionate sample at the Fence are listed in Table 11. Figures for the tagged sockeye recovered at the Fence have also been included.

At each location larger proportions of females were injured than either males or jacks, with the exception of the sample of jacks at the Slide.

The larger proportions of injured large males and females at Kisgegas compared to at the Slide can be explained, partially, by the following facts: *(a)* there was more selective fishing for sockeye in better condition at the Slide, and *(b)* some injured fish that had drifted back from the Slide to Kisgegas were caught and tagged there.

There were fewer injured fish among the tagged recoveries at the Fence than in the 1 percent proportionate sample of the run. Though the differences are not particulary great, they may reflect the selection of fish in better condition for tagging, and/or a heavier loss of injured than uninjured fish as a result of tagging.

The proportion of injured fish in the tagged samples changed throughout the season (Fig. 26). During the latter half of the season the taggers at the Slide rejected many more injured fish, so the proportion of injured sockeye below

TABLE 11

Numbers and percentages of injured sockeye in the tagged samples, and at the counting Fence

Location	Males			Females			Jacks			Combined percent injured
	Total sample	Number injured	Percent injured	Total sample	Number injured	Percent injured	Total sample	Number injured	Percent injured	
Kisgegas	1,850	593	32·1	2,289	948	41·4	332	42	12·7	35·7
Slide	4,036	888	22·0	4,560	1,251	27·4	114	4	35·1	24·6
Above Slide	155	41	26·5	140	61	43·6	12	2	16·7	33·9
Fence (untagged)	2,050	916	44·7	1,430	679	47·5	289	65	22·5	44·0
Fence (tagged)	915	289	31·6	565	213	37·7	56	13	23·2	33·5

the Slide must have increased more than is indicated in the graph. As a result of the major channel improvement of August 27, the number of sockeye escaping the Slide rose sharply, including many injured fish, which increased the proportion of scarred fish reaching the Fence a few days later.

Sockeye arrivals at Kisgegas and the Slide were almost over by the end of August so that the fish available for tagging consisted more and more of blocked fish which were too injured to ascend even the improved passageway, or which were no longer in physiological condition to do so. The increase in the fraction of injured fish in the Kisgegas sample during September must be attributed mainly to the presence of these blocked fish moving downstream, combined with the scarcity of new arrivals. However even the latter were more mature and may have been in poorer condition than early-run fish.

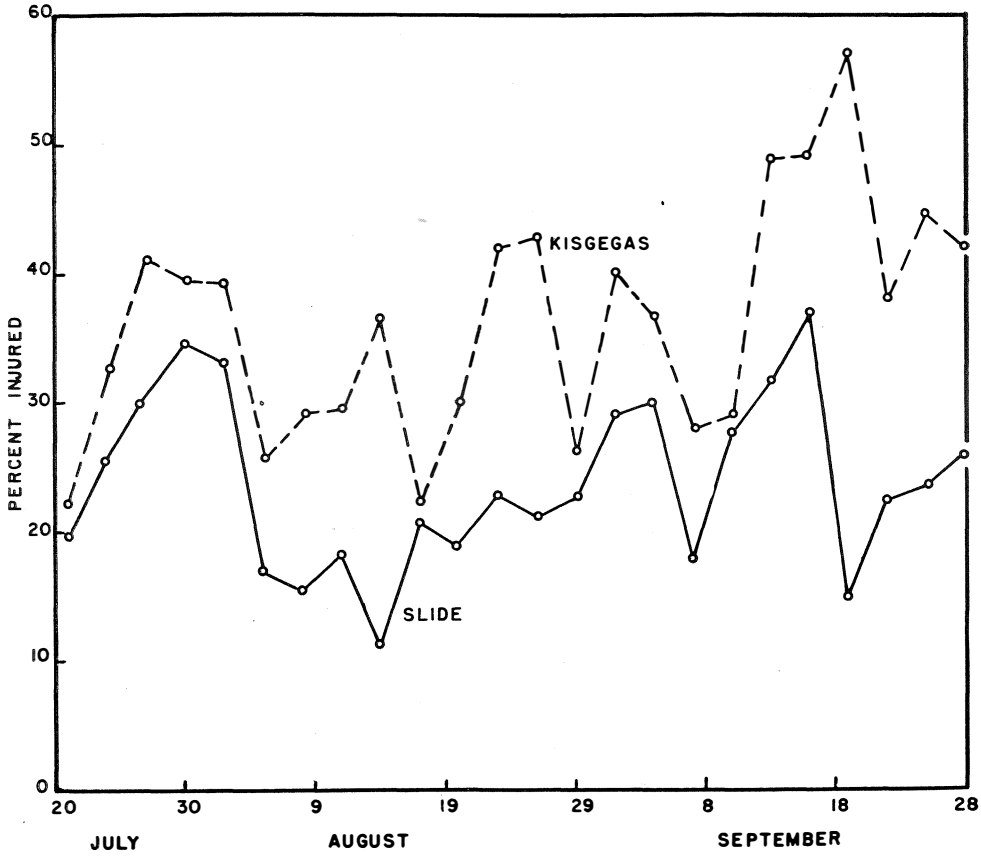

Figure 26. Proportions of injured fish among the sockeye tagged at Kisgegas and the Slide, by 3-day averages.

TYPES OF INJURIES

As they were tagged, fish were classified as having either *head*, *body*, or *head and body* injuries (Table 12). The following facts are indicated:

(a) In each tagged sample injured females had fewer *head* injuries and more *body* injuries than injured males. The proportions of injured males and females with *head and body* injuries were much the same.

(b) At Kisgegas and the Slide, and particularly at the former site, sockeye had more *body* injuries than either *head* or *head and body* injuries.

(c) The injured sockeye at Kisgegas had a lower proportion of *head* injuries (and therefore, more of *body* injuries) than at the Slide or Above the Slide.

The success of injured tagged sockeye in reaching the Fence varied with the type of injury (Table 13).

None of the sockeye tagged at Kisgegas or the Slide that had *head and body* injuries were recovered at the Fence. The recoveries of sockeye with *head and body* injuries that were tagged Above the Slide were only 33 percent of the number tagged, as compared to recoveries of 51 and 90 percent for *head* injuries and *body* injuries respectively.

For each group of tagged fish, sockeye with *body* injuries were recovered more frequently (about twice as often) than those with *head* injuries.

Recoveries of injured male sockeye were consistently greater than of injured female sockeye, for *head* injuries and *body* injuries.

The only recoveries from among injured jack sockeye were some with *body* injuries.

PROPORTIONS IN DIFFERENT STAGES OF SEXUAL MATURITY

The numbers and percentages of sockeye in different stages of sexual condition among the tagged samples (uninjured fish), the Fence recoveries of tagged fish (injured and uninjured), and the 1 percent proportionate sample of the run through the Fence (injured and uninjured) are listed in Table 14. The classification used for sexual condition has been described on page 38.

The Kisgegas sample had the largest proportion of green fish, and the lowest proportions of more mature fish. Fish that went through the Fence (both tagged and untagged) were considerably more advanced, sexually, than those at the tagging sites.

In each sample there were relatively more green females than green males. At Kisgegas and the Slide the proportions of jack sockeye that were green were higher than the proportions of large green males and green females.

Recoveries at the Fence of uninjured sockeye varied with their sexual state (Table 15). The recoveries of less mature fish were consistently higher than for fish sexually more advanced. Thus, the highest recoveries from Kisgegas and the Slide were of green fish, whilst among the fish tagged above the Slide, the recoveries of green and pink sockeye were almost equal, and both were greater than for red sockeye. (No mature sockeye were tagged there.)

TABLE 12

The numbers and percentages of sockeye with *head*, *body* and *head and body* injuries among the injured sockeye tagged at Kisgegas, the Slide and Above the Slide

Sex	Head			Body			Head and body		
	Kisgegas	Slide	Above Slide	Kisgegas	Slide	Above Slide	Kisgegas	Slide	Above Slide
Male									
Number	155	383	27	397	468	8	41	37	6
Percent	26·0	43·1	65·9	66·9	52·7	19·5	6·9	4·2	14·6
Female									
Number	204	445	38	682	766	20	62	40	3
Percent	21·5	35·6	62·3	71·9	61·2	32·8	6·5	3·2	4·9
Jack									
Number	7	0	0	33	4	2	2	0	0
Percent	16·7	0	0	78·6	100·0	100·0	4·8	0	0
Combined									
Number	366	828	65	1,112	1,238	30	105	77	9
Percent	23·1	38·6	62·5	70·2	57·8	28·8	6·6	3·6	8·6

TABLE 13

Recoveries at the Fence of tagged sockeye with different types of injuries

Sex	Head			Body			Head and body		
	Kisgegas	Slide	Above Slide	Kisgegas	Slide	Above Slide	Kisgegas	Slide	Above Slide
MALES									
Number tagged	155	383	27	397	468	8	41	37	6
Number recovered	5	25	14	27	62	6	0	0	3
Percent recovered	3·2	6·5	51·9	8·8	13·3	75·0	0	0	50·0
FEMALES									
Number tagged	204	445	38	682	766	20	62	40	3
Number recovered	3	21	19	27	56	19	0	0	0
Percent recovered	1·5	4·7	50·0	4·0	7·3	95·0	0	0	0
JACKS									
Number tagged	7	0	0	33	4	2	2	0	0
Number recovered	0	0	0	2	1	2	0	0	0
Percent recovered	0	0	0	6·1	25·0	100·0	0	0	0
COMBINED									
Percent recovered	2·2	5·6	50·8	5·0	9·6	90·0	0	0	33·3

TABLE 14

The numbers and percentages of sockeye in different stages of sexual maturity

(G=green; P=pink; R=red; M=mature)

Location	Males				Females				Jacks			
	G	P	R	M	G	P	R	M	G	P	R	M
	Numbers											
Kisgegas[1]	1,016	198	41	2	1,182	148	3	2	280	10	0	0
Slide[1]	1,798	1,097	229	23	2,109	1,132	68	3	86	21	0	0
Above Slide[1]	48	60	6	0	59	17	3	0	3	7	0	0
Fence (untagged)[2]	2	432	1,303	308	15	426	982	7	1	43	130	115
Fence (tagged)[2]	0	166	534	209	1	186	369	4	0	3	24	29
	Percent											
Kisgegas[1]	80·8	15·8	3·3	0·2	88·5	11·1	0·2	0·2	96·6	3·5	.....	.....
Slide[1]	57·1	34·9	7·3	0·7	63·7	34·2	2·1	.....	80·4	19·6	.....	.....
Above Slide[1]	42·1	52·6	5·3	.....	74·7	21·5	3·8	.....	30·0	70·0	.....	.....
Fence (untagged)[2]	0·1	21·1	63·8	15·0	1·0	29·8	68·7	0·5	0·3	14·9	45·0	39·8
Fence (tagged)[2]	.....	18·3	58·7	23·0	0·2	33·2	65·9	0·7	.....	5·4	42·8	51·8
	Sexes combined—percent											
Kisgegas[1]	86·0	12·4	1·5	0·1								
Slide[1]	60·8	34·3	4·5	0·4								
Above Slide[1]	54·2	41·4	4·4	.....								
Fence (untagged)[2]	0·5	23·9	64·2	11·4								

[1]Uninjured fish.

[2]Injured and uninjured fish.

TABLE 15

Recoveries at the Fence of uninjured sockeye according to degree of sexual maturity

(G = green; P = pink; R = red; M = mature)

Sex	Kisgegas				Slide				Above Slide			
	G	P	R	M	G	P	R	M	G	P	R	M
MALES												
Number tagged	1,016	198	41	2	1,798	1,097	229	23	48	60	6	0
Number recovered	142	4	1	0	372	127	9	2	38	44	3	0
Percent recovered	16·7	2·1	2·7	0	20·7	11·6	3·9	8·7	79·2	73·3	50·0	0
FEMALES												
Number tagged	1,182	148	3	2	2,109	1,132	68	3	59	17	3	0
Number recovered	95	1	0	0	239	76	2	1	40	11	2	0
Percent recovered	9·0	0·7	0	0	11·3	6·7	2·9	33·3	67·8	64·7	66·7	0
JACKS												
Number tagged	280	10	0	0	86	21	0	0	3	7	0	0
Number recovered	32	1	0	0	6	1	0	0	1	6	0	0
Percent recovered	13·3	11·1	0	0	7·0	5·0	0	0	33·3	85·7	0	0
COMBINED												
Percent recovered	10·9	1·7	2·3	0	15·5	9·1	3·7	11·5	71·8	72·6	55·6	0

The recoveries of male sockeye were higher than for female sockeye, for fish of each condition category, except in some of the cases where the total number tagged was very small.

The recovery of jack sockeye was higher than for females in the Kisgegas sample, but lower in the Slide sample.

Only 307 fish were tagged Above the Slide, and the results suggest that once fish had passed the Slide their ability to reach the Fence was little affected by their sexual condition.

SIZES TAGGED AND RECOVERED

For the purpose of this report, sockeye have been grouped into 10-centimetre classes. Since considerably fewer injured fish were recovered as compared to uninjured fish, only the latter have been considered in the size analysis. The results are summarized in Tables 16 and 17.

It has already been shown that males were recovered more frequently than females, whether injured or uninjured, or in any given stage of sexual maturity. Here it is indicated that within the same size-class, uninjured males were recovered much more frequently than uninjured females. In addition, comparing the 50+ and 60+ groups (which have adequate recoveries of both sexes), the 50+ males were in every case recaptured more often than even the 60+ females. This shows that the superior viability of the males does not depend upon the fact that they averaged somewhat larger than females.

Among the males of the Kisgegas and Slide samples, highest and almost equal recoveries were from the 50- and 60-centimetre groups. There were only small differences among the males of different size groups in the sample from Above the Slide, and in the cases of the 40- and 70-centimetre groups too few were tagged to determine whether their recovery differed significantly from that of the in-between size groups.

The situation for female sockeye was much the same as that for males, with higher recoveries among the 50- and 60-centimetre classes.

None of the 6 jack sockeye of the 20-centimetre group was recovered. Too few jacks were tagged Above the Slide to determine whether the percent recovery did actually increase with size, as occurred in the Kisgegas sample.

In general then, male sockeye were much more successful than female sockeye of the same size, while larger sockeye were recovered slightly more often than smaller sockeye of the same sex.

SEASONAL VARIATIONS IN PERCENTAGE RECOVERIES

Three-day averages of the percentages of the numbers of sockeye that were tagged during the 3-day periods, and recovered at the Fence at some later date, have been plotted in Figure 27 for Kisgegas, and Figure 28 for the Slide. In each Figure the corresponding values for "days out", from date of tagging to date of recovery, have been plotted, and will be discussed below. Only uninjured fish have been considered.

TABLE 16

The numbers and percentages of uninjured tagged sockeye in the different 10-centimetre size groups (40+ means fish 40-49 cm. long)

Location	Males				Females				Jacks		
	40+	50+	60+	70+	40+	50+	60+	70+	20+	30+	40+
NUMBERS											
Kisgegas	80	619	544	14	37	995	303	6	3	227	60
Slide	44	1,235	1,753	116	36	1,922	1,309	42	3	82	25
Above Slide	3	54	53	4	0	39	39	1	0	6	4
PROPORTIONS											
Kisgegas	6·4	49·2	43·3	1·1	2·8	74·2	22·6	0·5	1·0	78·3	20·7
Slide	1·4	39·2	55·7	3·7	1·1	58·1	39·6	1·3	2·7	74·5	22·7
Above Slide	2·6	47·4	46·5	3·5	0	49·4	49·4	1·3	0	60·0	40·0

TABLE 17

Recoveries at the Fence of uninjured sockeye of different 10-centimetre size groups (40+ means fish 40-49 cm. long)

Location	Males				Females				Jacks		
	40+	50+	60+	70+	40+	50+	60+	70+	20+	30+	40+
KISGEGAS											
Number tagged	80	619	544	14	37	995	303	6	3	227	60
Number recovered	5	70	69	0	3	64	29	0	0	23	9
Percent recovered	6·0	11·3	12·7	0	8·1	6·4	9·6	0	0	10·1	15·0
SLIDE											
Number tagged	44	1,235	1,753	116	36	1,922	1,309	42	3	82	25
Number recovered	1	203	289	17	0	151	158	6	0	5	1
Percent recovered	2·3	16·4	16·5	14·7	7·9	12·0	12·1	14·3	0	6·1	4·0
ABOVE SLIDE											
Number tagged	3	54	53	4	0	39	39	1	0	6	4
Number recovered	3	42	37	3	0	26	27	0	0	4	3
Percent recovered	100·0	77·8	69·8	75·0	0	66·7	69·2	0	0	66·7	75·0

Recoveries of Kisgegas fish increased gradually until the end of August, then experienced a sharp rise to almost 50 percent during the first 10 days in September, after which the proportion recovered fell off rapidly.

At the Slide, a small but fairly rapid rise in the proportion recovered occurred during the first three weeks of tagging. This was followed by a rate of recovery, which, although it experienced considerable daily variation, remained fairly constant throughout August and until during the first week in September. A sharp rise in recoveries took place during early to mid-September, followed by a steady and rapid decline.

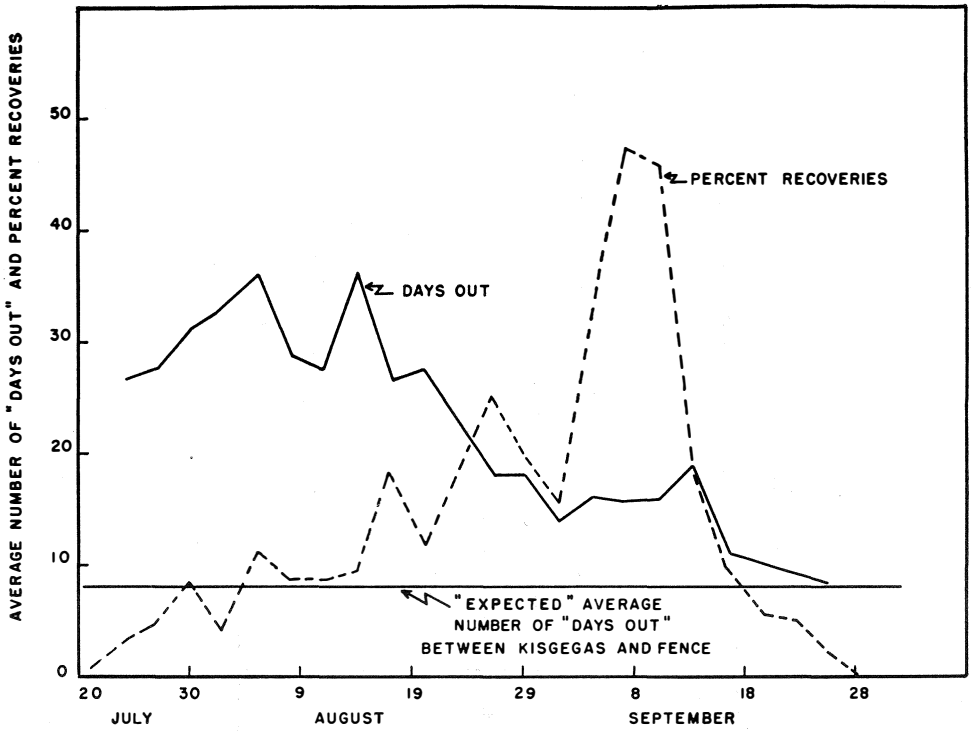

Figure 27. The seasonal change in the number of days out (from date of tagging to date of recovery at the Fence), and in percent recoveries at the Fence, for uninjured sockeye tagged at Kisgegas. Fish are grouped into 3-day periods according to date of tagging.

The sharp increase in recoveries from both sites during early to mid-September was probably due to the response of the runs to the opening of the channel on August 27 by the blasting of the large rock (referred to earlier). Differences between Kisgegas and the Slide, in the time of this rapid increase in recoveries, can be attributed to the time required for the fish to migrate from Kisgegas to the Slide.

SEASONAL CHANGES IN THE TIME FROM TAGGING TO RECOVERY

The number of days from date of tagging to date of recovery at the Fence (uninjured sockeye) have been averaged on a 3-day basis and plotted in Figures 27 and 28 for Kisgegas and the Slide respectively.

For each site a line has been drawn representing the "expected" or "normal" average number of days out from each site to the Fence. The "expected" number of days out was determined from the results of tagging above the Slide. These sockeye, more than 70 percent of which reached the Fence, took an average of 6·4 days to do so. One-and-a-half days have been added for the Kisgegas "expected" number of days out to allow for the time required for the fish to reach the Slide from Kisgegas.

The differences between the "expected" and the actual numbers of days out can be considered as the approximate delay at the Slide after tagging.

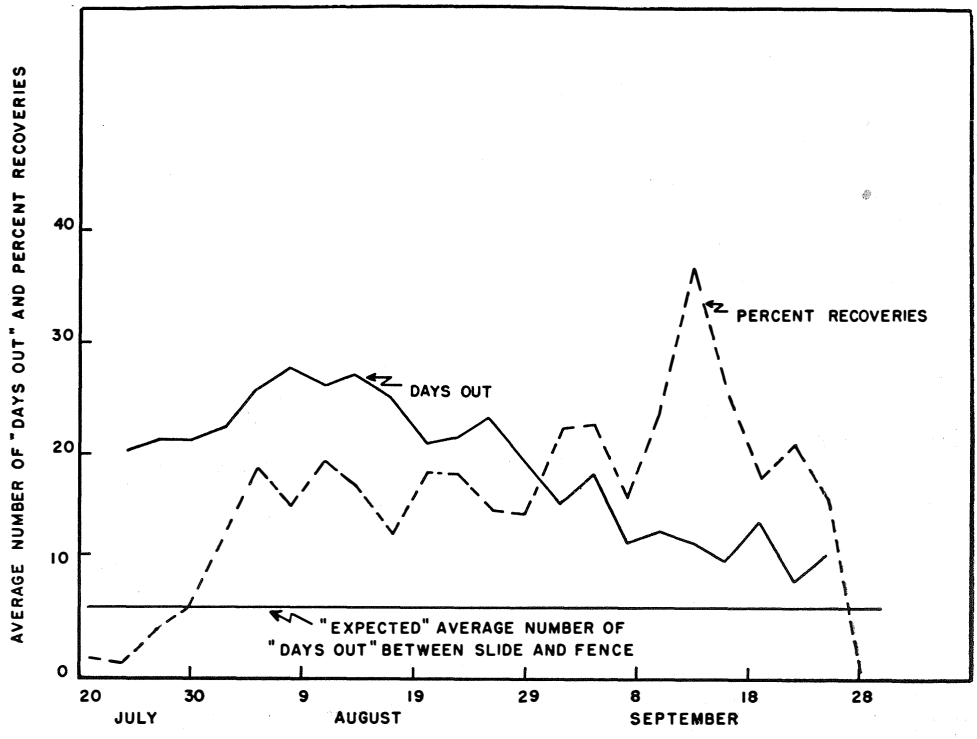

Figure 28. The seasonal change in the number of days out (from date of tagging to date of recovery at the Fence) and, in percent recoveries at the Fence, for uninjured sockeye tagged at the Slide. Fish are grouped into 3-day periods according to date of tagging.

At both sites the delay increased somewhat during late July and early August, then fell off, although irregularly, throughout the remainder of the season.

The greatest period of delay occurred during the first week in August. At that time the daily average time out exceeded the "expected", or minimum required for migration to the Fence, by as much as 20 to 30 days. Some fish were out for periods longer than this, while very few came even close to the minimum. Even after the channel was opened on August 27 the minimum was reached only by occasional fish. The remainder, including those uninjured when

88878—5½

tagged, had probably already experienced delay and weakening prior to tagging, and their average time out from tagging to recovery stayed in excess of the minimum.

The rapid decline in percentage recoveries at the end of the season was probably due to the condition of the fish that were being tagged. It has already been stated (p. 30) that by early September the sockeye run *to* the Slide was virtually over. This is again borne out by the fact that during the latter half of September it became difficult, and finally impossible, to capture the desired number of 75 sockeye per day. Furthermore, these late running sockeye at Kisgegas were much more advanced sexually than earlier fish, and were in poorer general condition. Most of the small numbers of fish being tagged in late September, then, were either late arrivals, in advanced sexual state and presumably weak, or else fish that had already been long delayed by the Slide.

RECOVERIES BELOW THE FENCE

Tagged salmon were recovered at both Kisgegas and the Slide while fishing for salmon to tag, and a few were also picked up at various points on the Lower Skeena, most of them as dead fish.

Eighty-nine of the Kisgegas tagged sockeye were recovered at the Slide. These included 66 that were uninjured and 23 that were injured at the time of tagging. They amounted to almost 2 percent of the total number tagged at Kisgegas.

The 3-day average percentage recoveries, and the 3-day average number of days out for these fish, have been plotted in Figure 29. The two curves are reasonably similar to those of Figure 27 for recoveries of Kisgegas fish at the

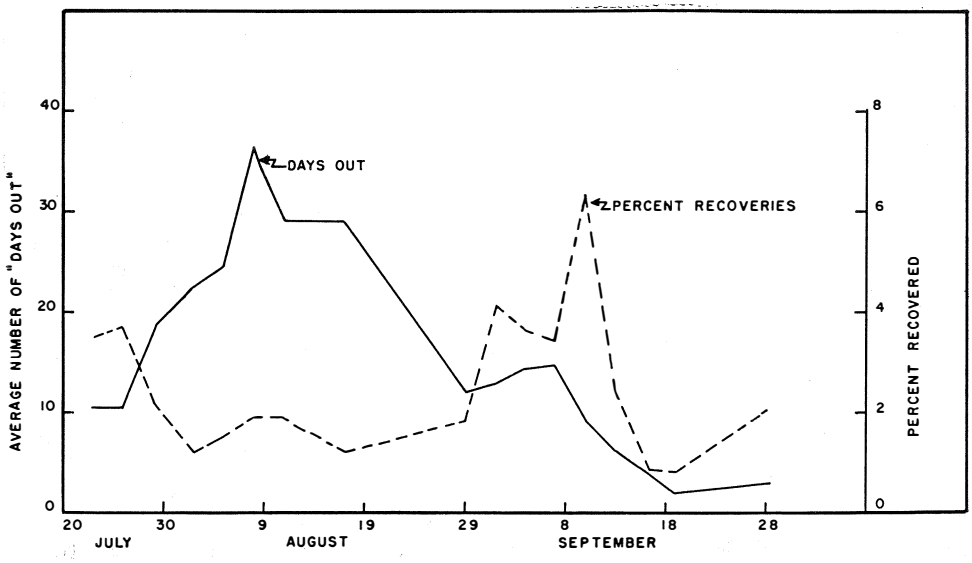

Figure 29. The seasonal change in the number of days out (from date of tagging to date of recovery), and in percent recoveries, for injured and uninjured sockeye tagged at Kisgegas and recovered at the Slide. Fish are grouped into 3-day periods according to date of tagging.

Fence. The delay rose to a peak during the first week of August, then declined during the remainder of the season. The rise to a peak in the proportions recovered during early September corresponds to a similar rise for the Fence recoveries, and presumably for the same reason—the opening of the channel on August 27.

The relatively high rate of recovery early in the season had two causes. As compared with later in the season there was a small total population present, and a correspondingly large probability of recapture. In addition, the obstructiveness of the Slide was greatest early in the season, so that a larger fraction of the fish was blocked and available for recapture below the Slide.

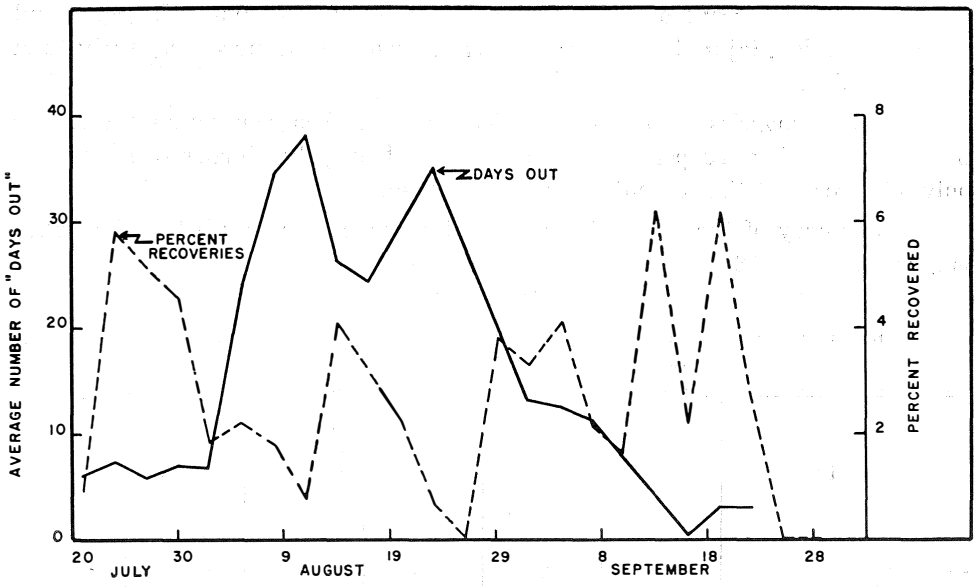

Figure 30. The seasonal change in the number of days out (from date of tagging to date of recovery), and in percent recoveries, for uninjured sockeye tagged and recovered at the Slide. Fish are grouped into 3-day periods according to date of tagging.

Nineteen sockeye tagged at Kisgegas were recovered there at a later date (0·4 percent of the total number tagged); of these 16 had been tagged in July, 2 in August and 1 in September. One fish had been recovered at the Slide prior to its second recovery at Kisgegas.

Twenty-six Kisgegas sockeye were recovered on the Lower Skeena, of which 4 had first been recaptured at Kisgegas. Sixteen of these fish had been tagged in July, 6 in August and 4 in September.

Altogether, much larger proportions of the number tagged at Kisgegas in July were recovered again, either at Kisgegas or on the Lower Skeena, than of those tagged in August or September (though the total recoveries were, of course, small).

At the Slide 6,567 *uninjured* fish were tagged, of which 195 (3·0 percent) were recovered there; and 2,143 *injured* fish, of which 81 (3·8 percent) were also recovered at the Slide.

The days out and the percent recoveries of the fish which had been tagged and were later recovered at the Slide, have been plotted in Figure 30. The curves show trends fairly similar to those described above for Kisgegas fish recovered at the Slide, and as shown in Figure 28 for Slide fish recovered at the Fence.

Recoveries at Kisgegas of fish tagged at the Slide amounted to 42. These included 0·79 percent of the injured fish tagged at the Slide, and 0·38 percent of the uninjured.

Fifty-two sockeye tagged at the Slide were later recovered on the Lower Skeena. These amounted to 0·84 percent of the injured fish tagged at the Slide, and 0·52 percent of the uninjured. In the case of both Kisgegas- and Slide-tagged fish, injured fish were recovered downstream more frequently than uninjured fish.

Of the recoveries of Slide-tagged fish made at Kisgegas or on the Lower Skeena, more than 70 percent had been tagged in July, during which month only 37 percent of the season's tagging was done.

A summary of the recoveries of tagged sockeye at points below the Fence is given in Table 18.

TABLE 18

Numbers and percentages of the total numbers of sockeye tagged at Kisgegas and the Slide which were recovered at points below the Fence

Tagged at:	Recovered at:					
	Kisgegas		Slide		Lower Skeena	
	No.	Percent	No.	Percent	No.	Percent
Kisgegas.....	19	0·4	89	2·0	26	0·6
Slide.....	42	0·5	276	3·2	52	0·6

DISPROPORTIONATE LOSSES AMONG TAGGED SOCKEYE

The number of tagged sockeye which reached the Fence was small—only about 12 percent (including an estimated number not inspected). The estimate of percentage arrival, at the Fence, of the escapement from the fishery, was 33 percent (jacks excluded in both cases).

The possible reasons for the discrepancy are various. 1. There may have been some mortality due to tagging. 2. Tagged fish were probably more seriously affected by the Slide than untagged fish. 3. Fish tagged at the Slide and Kisgegas did not represent the runs *as they reached* those places, but for the most part probably represent fish delayed for varying periods. 4. Weaker and more injured fish were more available to the taggers, although this was at least partly compensated by selection of the fresher fish.

In more detail, there were only 7·3 percent recoveries of Kisgegas sockeye actually identified at the Fence, and only 10·9 percent Slide-tagged sockeye (jacks excluded). The potential Babine escapement, as estimated from the catch-to-Fence-count relationship in former years, was 1,051,000 sockeye (p. 24); so that the 1952 Fence count of 351,500 was 33 percent of the escapement. Hence the maximum number of tag recoveries to be "expected" at the Fence is 33 percent of the number tagged, namely 1,366 for Kisgegas, and 2,837 for the Slide. Actual recoveries were 302 and 989 respectively, or 22 and 35 percent of expectation (average 31 percent). A first estimate of the disproportionate loss of tagged over fresh untagged fish is therefore $100-31=69$ percent.

However, this estimate is too high since it does not take into account the fact that tags were not applied proportionately to the run. Many more tags were put on early in the season, when conditions at the Slide were less favourable, than later when the channel was cleared. Nevertheless, even allowing for this, there was still a large disproportionate loss of the tagged fish. Table 19 shows that the *best* percentage recapture of tags at the Fence was only 20 percent, approximately, for the period August 24-September 10. Since the ratio of total Fence count to estimated escapement from the fishery is 33 percent, a *minimum* estimate of the differential loss of tagged fish is $(33-20)/33=39\%$. The true loss lies somewhere between this figure and the 69 percent mentioned above. In other words, the tagged fish reached the Fence only between $(100-69)=31$ and $(100-39)=61$ percent as frequently as did newly-arriving untagged fish.

TABLE 19

Number of sockeye tagged (excluding jacks) at Kisgegas and the Slide, and the number recaptured at the Babine Fence, arranged by 18-day periods according to time of tagging. For comparison, Fence counts are given for periods 6 days later in time, this being the average time taken from just above the Slide to the Fence.

18-day periods	Tagged	Recovered at Fence		Fence counts	
		Number	Percent	Period	Count
Jul. 18-Aug. 5	7,133	444	6·2	Jul. 25-Aug. 11	1,511
Aug. 6-23	3,186	430	13·5	Aug. 12-29	106,776
Aug. 24-Sep. 10	1,565	319	20·4	Aug. 30-Sep. 16	171,763
Sep. 11-28	1,297	139	10·7	Sep. 17-Oct. 4	93,951
	—	—	—	Oct. 5-22	2,850

Originally it was hoped that the tagged and untagged fish would be sufficiently alike in behaviour to permit making estimates of escapement and loss based upon recaptures of tagged fish by the Petersen method. Since there were actually excess losses of tagged fish, such estimates are impossibly high. Using the Fence count of 376,947, the results are as follows (jacks included):

Kisgegas: Tagged, 4,471; Fence recoveries, 336; estimate, $4,471 \times 376,947/336=5,020,000$.

Slide: Tagged, 8,710; Fence recoveries, 995; estimate, $8,710 \times 376,947/995=3,300,000$.

SUMMARY OF SOCKEYE TAGGING RESULTS

A total of 13,488 sockeye was tagged; 4,471 at Kisgegas, 8,710 at the Slide, and 307 above the Slide. Recoveries of identified tagged fish at the Babine counting Fence were 1,650, or about 12 percent.

Population estimates could not be derived from the tagging results because of the much greater loss of tagged than untagged fish.

Male sockeye were recovered more frequently than female sockeye, irrespective of injuries, sexual condition or size. Uninjured sockeye were recovered approximately twice as frequently as injured sockeye. Percentage recovery of jack sockeye tagged at Kisgegas was similar to that for larger males, but of those tagged at the Slide, rate of recovery was more similar to that for female sockeye.

There were relatively more injured females tagged than injured males.

The proportion of injured fish in the tagged samples and in the run through the Fence showed moderate fluctuations throughout the season, with perhaps a slight gradual increase, until following the opening of the channel on August 27. After this date the proportion of injured sockeye in the samples increased rapidly, then fell off again (Kisgegas and Fence) as the sockeye run ended.

Tagged fish from Kisgegas and the Slide had more *body* injuries than *head* injuries, and more *head* injuries than *head and body* injuries. Among the sockeye tagged Above the Slide there were more than twice as many with *head* injuries as with *body* injuries.

None of the 182 sockeye tagged at Kisgegas and the Slide that had *head and body* injuries were recovered at the Fence. Fish with *body* injuries only were recovered about twice as frequently as fish with *head* injuries only.

The proportions of more mature sockeye increased considerably between Kisgegas and the Fence. Thus, the ratio of green to more mature fish at Kisgegas was 86 to 14, and at the Fence was 0·5 to 99·5.

Recoveries of fish less mature when tagged were consistently higher than of more mature fish.

The proportion of fish of different length classes varied among the sexes and among the tagging sites, but more than 90 percent of males and females belonged to the 50- and 60-centimetre length groups and more than 60 percent of the jacks to the 30-centimetre length group.

The determination of the relationship between size and recovery must await an analysis more detailed than that based on a division into 10-centimetre length classes. However, within the same size-class, males were recovered more frequently than females.

The total recovery at the Fence of sockeye tagged at Kisgegas and the Slide was low, being only 10 percent approximately. The recovery of both Kisgegas and Slide fish increased as a result of the opening of the channel on August 27. However, by this date the sockeye run to the Slide was almost over, with the result that this high rate of recapture lasted for only a few days, and was followed by a rapid decline.

The delay at the Slide (as indicated by the number of days out between tagging and recovery) decreased gradually during the season. Early in August fish averaged 20 to 30 days from tagging to recovery at the Fence in excess of the minimum period required to make the migration to the Fence. After the channel was opened on August 27 the average delay was much reduced; however the minimum 6-day period from tagging to Fence was attained only by occasional fish, even though uninjured. This was probably because they had already experienced delay and weakening prior to tagging. For the same reason, probably, the rate of recovery, at the end of the season, instead of remaining high, dropped off rapidly.

Three hundred and seven sockeye which had made the ascent to immediately above the Slide were tagged there. About 70 percent of these were recovered at the Fence, including a high percentage of those with injuries. This is taken as additional evidence that it was most unlikely that any large number of sockeye spawned in the main river above the Slide, or ascended its tributaries between the Slide and the Fence.

Trends in the rates of recovery, and in the number of days out, of sockeye recaptured at either of the principal tagging sites, were for the most part similar to those for recoveries at the Fence. The exception is an early relatively high rate of recapture which resulted from the small population then present.

A small number of tags were turned in from sockeye which had drifted to the Lower Skeena, most of them from fish tagged in July, but it was not possible to conduct a campaign for recoveries in this area.

Injured fish were recovered more frequently than uninjured fish at points below the Fence.

Results for Other Species

PINK SALMON

NUMBER TAGGED AND RECOVERED. The numbers of pink salmon tagged and recovered are listed in Table 4.

From 1,988 pinks tagged at Kisgegas and the Slide, only 8 (0·5 percent) were recovered at the Fence. One pink from among 9 tagged Above the Slide was also recovered at the Fence. The total pink run through the Fence was only 2,706.

At Kisgegas and the Slide the proportions of injured fish in the samples were 24 percent and 15 percent respectively. The higher percentage of injured fish in the Kisgegas sample may have been a result of the capture there of injured fish that had drifted downstream from the Slide, though such may not be the full explanation.

SEX RATIOS. The sex ratios among tagged pinks were: Kisgegas, 57 males to 43 females; and Slide, 55 males to 45 females. The 9 tagged pinks retaken at the Fence were all males.

Of the 2,706 pinks checked through the Fence in 1952, a random sample of 674 included 82 percent males and 18 percent females.

From among the dead pinks that drifted onto the Fence in 1952, 602 were examined for sex and degree of spawning. Of these, 79 percent were males and 21 percent females. Among the latter 121 out of 126 had spawned.

In 1951, there were not less than 7 and not more than 10 females among the 50 pinks which reached the Fence. In pre-Slide years no accurate separation of male and female pinks was made at the Fence, but the general impression was of approximately equal representation of the sexes.

In summary, pink salmon were more seriously blocked than sockeye both in 1951 and 1952, and the excess of males among those which got through was much greater than for sockeye.

COHO SALMON

NUMBER TAGGED AND RECOVERED. Coho salmon were tagged and recovered, as listed in Table 4. Recoveries at the Fence of this species were the highest of any of the salmon tagged, being almost 22 percent for both Kisgegas and Slide fish. This is presumably mainly due to their late arrival at the Slide, after conditions had improved.

The percentage injured in the Kisgegas sample was again (as with sockeye and pink salmon) higher than in the Slide sample, being 32 percent as compared to 23 percent. A total of 10,554 cohoes passed through the Babine Fence in 1952.

SEX RATIOS. Sex ratios were listed as 61 percent males to 39 percent females at Kisgegas, and 50 percent males to 50 percent females at the Slide. However, sex recognition of fresh coho salmon by external examination is very uncertain.

In 1952 a random sample of 196 dead cohoes on the Babine Fence was examined for sex and degree of spawning. Sex ratios, which were 42 percent males, 5 per cent jacks and 53 percent females, suggest that coho salmon had not experienced any serious disproportionate loss of females at the Slide, such as occurred with sockeye and pink salmon. However, 50 percent of the 104 females examined had not spawned.

ESTIMATE OF ESCAPEMENT. Of the 197 cohoes that were tagged at Kisgegas, 43 were recovered at the Fence. The coho Fence count was 10,554, and the Petersen estimate of the number of cohoes at Kisgegas is therefore 48,352 or (10,554 $\times$ 197/43). The number of cohoes tagged at the Slide was 312, the Fence recoveries 68, and the estimate of the coho population at the Slide, therefore, 48,424 or (10,554 $\times$ 312/68). The two estimates are almost identical, which would imply that the two groups of fish experienced equal defections from the place they were tagged up to the Fence.

These estimates of the number of coho salmon at the tagging sites appear to be reasonable, whereas similar estimates for sockeye and pinks are not. The difference could be due to two conditions—a more equal loss among tagged and untagged coho, as a result of nearly all of them arriving after the major improvement to the Slide on August 27, and the probable tagging of a more nearly constant proportion of the run.

If the coho estimates are at least approximately right, they can indicate the number of these salmon that may have spawned below the Fence, in the main river and in its tributary streams.

The 111 coho recoveries at the Fence included 4 that were observed passing, but were not examined (that is, the tag numbers were not noted). However, others also must have passed unobserved through the Fence, since, of the 12 cohoes tagged at Kisgegas which were recovered *above the Fence*, 6 had passed through unrecorded, or else inaccurately recorded; 9 out of 14 similar recoveries of cohoes tagged at the Slide were of the same sort. The actual number of tagged cohoes which passed the Fence was therefore probably nearer 150.

If the figure of 150 Fence recoveries is used, the estimate of the coho population at Kisgegas or the Slide becomes approximately 36,000. Of these, 10,554 reached the Fence. On this basis 20,000-25,000 cohoes spawned between the Slide and the Fence and in tributaries which flow into that section.

CHUM, SPRING AND STEELHEAD

The number of these fish that were tagged and recovered also appear in Table 4.

The total numbers counted through the Fence were: spring salmon, 5,915; chum salmon, 1; steelhead trout, 245.

SOCKEYE LOSSES BEYOND THE FENCE IN 1952

In 1952 a total of 376,947 sockeye were counted through the Babine Fence. The first sockeye arrived on July 27 and the last on November 5; the peak daily count of 18,133 was made on September 11. The run as a whole was from two to three weeks later than in normal years.

Throughout the season in 1952 there accumulated evidence from various sources that sockeye above the Fence were still suffering from the effects of the Slide. Most of the sockeye were considerably more sexually mature when they reached the Fence than was normal, and many were injured. Large numbers were dying before they reached the spawning streams, and among those that had succeeded some had died without spawning.

Babine Lake and its streams comprise an extensive spawning system. With a limited number of trained personnel it was not possible to follow the fate of the runs as closely as would have been desirable. A considerable volume of data and information, however, from the operations of the counting Fence and from stream surveys, has made it possible to describe the losses, and to arrive at a rough estimate of the effective spawning.

Counts of Dead Sockeye on the Babine Fence

Each year a large number of sockeye salmon spawn in the half-mile of the Lower Babine River, between the lower limit of Nilkitkwa Lake and the counting Fence.

Figure 31. Injured sockeye immediately above the Babine Fence, mid-September, 1952.

TABLE 20

Available data concerning dead sockeye taken on the Babine Fence. The count of dead is complete only in 1952.

Year	1946	1947	1949	1950	1951	1952
Period of dead counts	Aug. 12-Oct. 4	Jul. 18-Oct. 7	Jul. 29-Sep. 26	Jul. 18-Aug. 5	Sep. 7-Oct. 4	Aug. 10-Nov. 8
Number of dead sockeye	679	4,043	.....	.....	.....	36,091[1]
Unspawned (both sexes)	42 (6%)	.....	129	237	432	.....
Spawned (both sexes)	637 (94%)	.....	.....	.....	.....	.....
Unspawned males	.....	.....	.....	.....	151	.....
Unspawned females	.....	.....	.....	.....	281	7,095 (58%)
Partly-spawned females	.....	.....	.....	.....	.....	695 (6%)
Spawned-out females	.....	.....	.....	.....	.....	4,453 (36%)

[1] Includes 12,242 females, 2,313 jacks, 21,536 "normal" males.

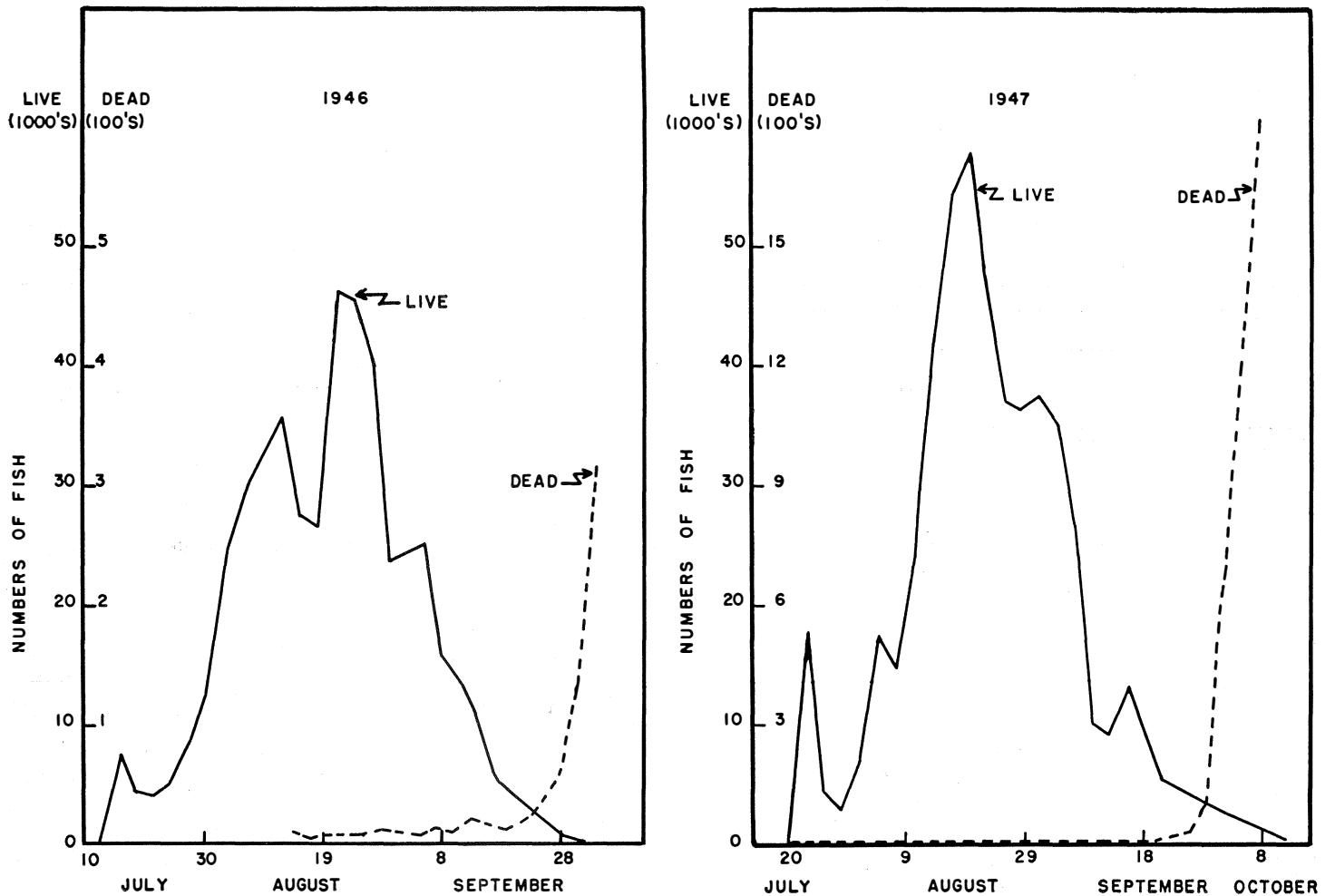

Figure 32. Three-day totals of the number of dead sockeye drifting onto the Fence, compared with the 3-day totals of live sockeye passing through the Fence, 1946 and 1947. Dead counts were not completed.

In 1952 approximately 36,000 dead sockeye drifted down onto the Fence from the river above it, and many more dead remained on the river bottom or along its banks. The dead on the Fence, as well as being counted and examined for tags, were examined for sex and degree of spawning.

In the years 1946, 1947, 1949, 1950 and 1951, counts were made (which varied in completeness depending upon their objectives) of the number of dead, or the number of unspawned dead, on the Fence. These and the 1952 data are summarized in Table 20.

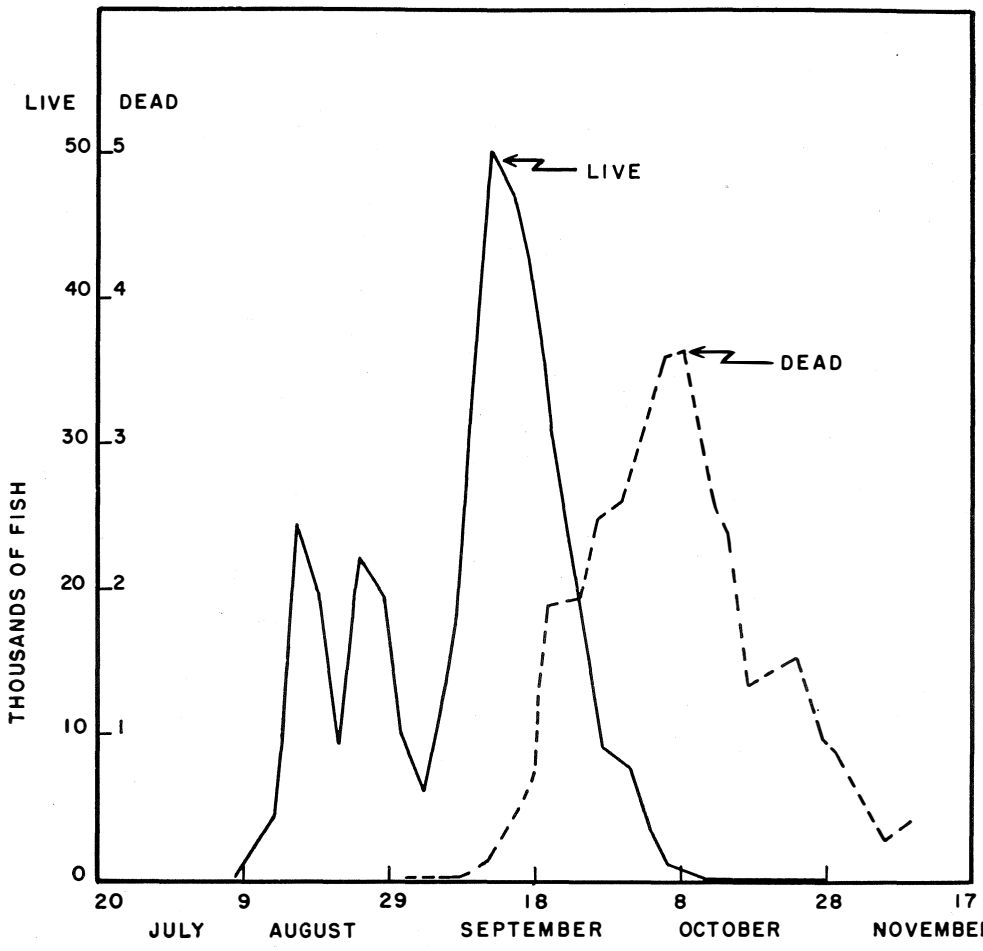

Figure 33. Three-day totals of the number of dead sockeye drifting onto the Fence, compared with the 3-day totals of live sockeye passing through the Fence, 1952.

Total counts of dead on the Fence, from the time of their first appearance until Fence operations were discontinued early in October, were made in 1946 and 1947. In Figure 32 the dead on the Fence have been compared with the live counts for the two years, by plotting the respective 3-day totals of daily counts.

In both years, apart from a small number of earlier arrivals, the dead count began to increase suddenly towards the end of September. Some of these could have been late arrivals, but most must have come from Nilkitkwa Lake, after having spent some time there, during which they matured. The movement of mature sockeye salmon downstream from Nilkitkwa Lake to the Lower Babine River is observed annually.

It is not possible to estimate the probable final counts of dead on the Fence in 1946 and 1947, had the Fence operated until after the completion of spawning there. However, Figure 32 suggests that most of the dead came from the tail end of the live run, rather than from the whole of the run. In the first place these dead did not appear until the live run was virtually over; and secondly, it is evident that, for each year, a peak in the number of dead could not have been reached until two months at least after the peaks in the live counts. Both these conditions are different from those which characterized the dead count of 1952.

In 1952, the live count through the Fence showed two small early peaks on August 16 and August 25, and a third, high peak on September 12 (Fig. 33). The distribution of the daily counts of dead in 1952 shows that their drifting onto the Fence took place over a period as long as two months. They were probably related, therefore, to the greater part of the run, rather than to the tail end of it, as in 1946 and 1947. Furthermore, among the dead tagged fish recovered, those that had died without spawning reappeared on the Fence after a much shorter time than those which had spawned. This fact also supports the suggestion that the dead in the Lower Babine River in 1952 originated from among a large segment of the run, rather than from a discrete, late-spawning population, as in normal years.

The majority of the dead on the Fence (as is described below) were unspawned fish. They may have been, for the most part, weaker individuals that were unable either to reach Nilkitkwa Lake, or to move into it very far. However, the loss in unspawned fish in 1952, in the short distance above the Fence, appears to have been rather sudden. It may have been related to some additional stress consequent to their arrival in the lake environment, and imposed upon fish already weak and considerably more sexually mature than normal.

Dead Sockeye in Nilkitkwa Lake

Babine Lake empties into the Upper Babine River, a short stream about 2 miles in length, with an average width of 200-300 feet. This river flows into Nilkitkwa Lake, which in turn narrows to become the Lower Babine River. Nilkitkwa Lake which is about 7 miles long is relatively shallow and averages one-third miles in width. It has a number of small islands in it, and several marshy points which extend towards its centre. An outline of the lake is shown in Figure 34. Nine small streams flow into Nilkitkwa Lake. According to the resident Fisheries Inspector few sockeye have spawned in these streams in years prior to the Slide.

In 1952 numerous dead sockeye were observed along the shores of Nilkitkwa Lake, and on the banks of the Upper and Lower Babine Rivers (above the counting Fence). Many live and dead sockeye were also seen by the Fisheries Inspector in several of the small streams that enter Nilkitkwa Lake.

In the first week of October in 1952, the Inspector estimated that there were "over 30,000 dead sockeye on the beaches, in rivers and on the verges of Nilkitkwa Lake". On October 20 there were many dead in the grass and weeds at the head of the lake. These formed the bulk of the 30,000 mentioned in the

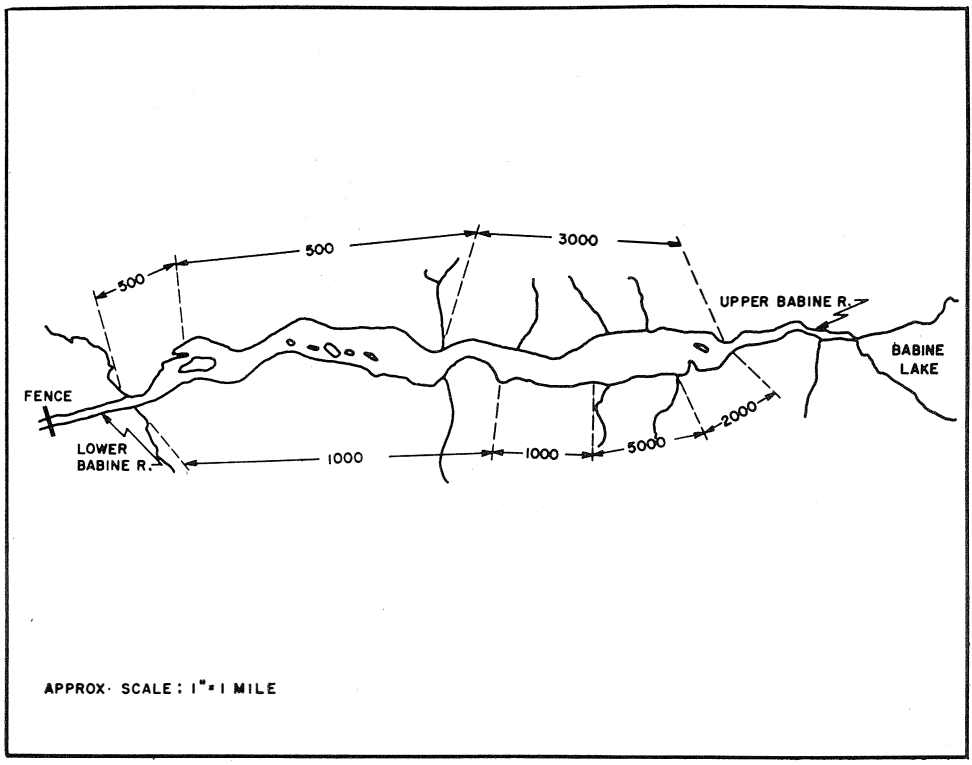

Figure 34. Outline of Nilkitkwa Lake, showing the number and distribution of dead sockeye counted during the survey of November 2-6.

earlier report, and additional dead had collected. This particular spot at the head of the lake constitutes "a natural fence for dead fish floating downstream from the Upper Babine River".

During November 2-6, the whole shoreline of Nilkitkwa Lake was surveyed by two Departmental biologists. As well as they were able they made actual counts of the dead, including disintegrated corpses. Their estimate of the number of dead along the shores was 12,779 fish, distributed as shown in Figure 34. Others could be seen in the water or among weeds, but could not be counted.

Considering the limitations of the surveys, it is felt that a *minimum* figure of the number of dead sockeye in Nilkitkwa Lake (exclusive of those that had spawned successfully in the Upper Babine River, and had then floated down into the lake) could be set at 25,000.

Prior to 1952, personnel of the Fisheries Research Board and Fisheries Inspectors have never observed such large numbers of dead sockeye in Nilkitkwa Lake, or many, if indeed any, in its small tributary streams. All agree that the number of dead in 1952, particularly in view of the small spawning run, was abnormal.

In addition to those in Nilkitkwa Lake, "a few thousand dead sockeye" were also seen along two or three miles of the shore of Babine Lake, not far from its outlet. Proportionate figures are not available, but among these dead there were unspawned fish.

The Catch of the Indian Fishery

The losses of sockeye beyond the Fence include those that were taken by Indians for food. Estimates of the Indians' catches are made each year by Fisheries Inspectors through visits to the fishing camps. The sockeye catches of the past several years were estimated as follows:

1946	20,052
1947	26,109
1948	26,276
1949	28,525
1950	27,449
1951	19,036
1952	34,153, plus 8,000 discarded

Each year there have been some sockeye which were in such poor condition, mostly because of their advanced sexual state, that the Indians discarded them. The number rejected in 1952, however, was abnormally high.

Spawning Condition of Dead Sockeye on the Fence

In 1952 proportionate samples of the 36,000 dead sockeye on the Fence were examined to determine the proportions which had spawned, or had died without spawning. The results are summarized in Table 21. Although both males and females were examined the data on the latter are more complete, and are more reliable, since the degree of spawning in females can be better estimated. Losses in unspawned fish will therefore be considered in terms of females only.

Figure 35 gives the 3-day totals, expressed as percentages of the combined total, of the number of spawned, partially spawned and unspawned females found dead on the Fence. Here it can be seen that from August 10 to September 22 virtually all the female sockeye were unspawned fish. Fluctuations in the 3-day percentages during the period can be ascribed to the varying occurrence of partially spawned fish, which constituted only 5·5 percent of the total dead. (Partially spawned fish were classed as being 25, 50 or 75 percent spawned-out).

TABLE 21

Three-day totals of number and spawning condition of dead sockeye on the Babine Fence in 1952

Date	Females—degree of spawning						Females		Large males	Jacks	Sexes Combined
	None		Partial		Complete		No.	Percentage	No.	No.	Totals
	No.	%	No.	%	No.	%					
Aug. 12	1	100	.....	.....	.....	.....	1	25	3	.....	4
15	2	66	1	33	.....	.....	3	38	5	.....	8
18	3	100	.....	.....	.....	.....	3	33	6	.....	9
21	9	100	.....	.....	.....	.....	9	43	12	.....	21
24	7	90	.....	.....	1	10	8	47	6	3	17
27	7	100	.....	.....	.....	.....	7	21	24	3	34
30	22	92	2	8	.....	.....	24	40	36	.....	60
Sep. 2	19	86	2	9	1	5	22	40	33	.....	55
5	21	91	2	9	.....	.....	23	33	33	13	69
8	29	85	5	15	.....	.....	34	46	36	4	74
11	69	99	1	1	.....	.....	70	34	120	15	205
14	161	100	.....	.....	.....	.....	161	37	243	30	434
17	287	100	.....	.....	.....	.....	287	40	380	47	714
22	725	100	.....	.....	.....	.....	725	37	1,088	136	1,949
25	819	97	10	1	13	2	842	42	985	162	1,989
28	856	93	25	3	39	4	920	37	1,311	275	2,506
Oct. 1	814	81	67	7	125	12	1,006	38	1,376	265	2,647
4	804	74	63	6	223	20	1,090	35	1,796	262	3,148
7	644	56	115	10	397	34	1,156	32	2,253	246	3,655
10	608	52	75	6	489	42	1,172	32	2,262	232	3,666
13	338	42	67	8	398	50	803	30	1,667	174	2,644
16	273	33	84	10	477	57	834	34	1,454	137	2,425
18	137	31	32	7	271	62	440	31	925	57	1,422
21	313	27	70	6	784	67	1,167	34	2,154	142	3,463
24	55	11	29	6	410	83	494	31	1,059	34	1,587
27	35	11	23	7	257	82	315	30	716	23	1,054
30	14	5	10	4	246	91	270	31	586	23	879
Nov. 1	15	9	7	5	130	86	152	27	374	28	554
5	4	5	3	3	83	93	90	27	236	0	325
8	4	3	2	2	109	95	115	24	357	2	474
Total	7,095	.....	695	.....	4,453	.....	12,243	33·9	21,536	2,313	36,091
Average	.....	64·6	.....	5·5	.....	29·8	.....	.....	.....	.....	.....

During the period September 22 to November 8 the proportions of unspawned females decreased, with a corresponding increase in the proportions of spawned-out fish. The rate of increase in the proportion of spawned females was approximately 2 percent per day. A 50:50 ratio of spawned to unspawned females did not obtain until about October 13, and not until about November 8 were virtually all the females spawned-out fish.

Although meagre, there is some information on the spawning condition of dead on the Fence in former years (Table 20). Thus, in 1946 only 42 (6·2 percent) males and females of a total of 679 were unspawned fish. In 1949, 1950 and 1951 when incomplete totals of unspawned fish only were recorded, these numbered 129, 237 and 432 (males and females) respectively.

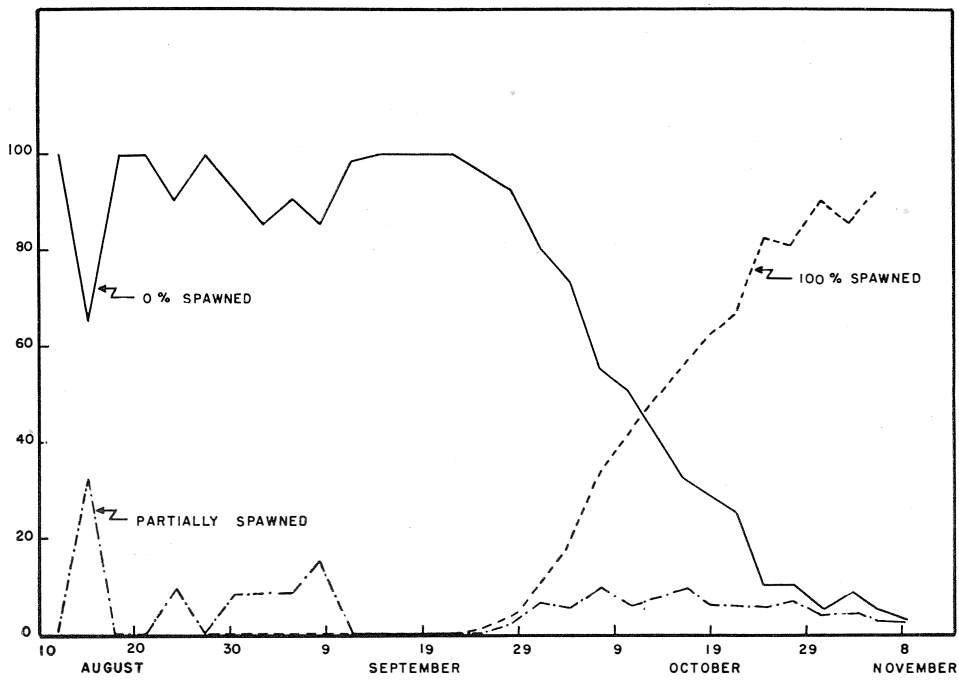

Figure 35. The seasonal change in the percentages of the numbers of spawned, partially-spawned and unspawned dead female sockeye drifting onto the Fence in 1952.

Tag Recoveries from Dead Sockeye on the Fence

Among the 439 sockeye tag recoveries above the Fence, 87 were from among the dead on the Fence. These amounted to 19·3 percent of the total recoveries, and 4·3 percent of the estimated 1,800 tagged sockeye which passed through the Fence. Eight of the tagged fish were not examined at the time of their passing through the Fence, so that the following analysis has been based on the remaining 79.

In Figure 36 are shown the 3-day totals of 72 Kisgegas and Slide tags recovered from the dead on the Fence, plotted against the dates upon which they passed as live fish through the Fence. A small proportion of these fish had

come with the earlier part of the sockeye run (July 27 to September 1), but the bulk of them came with the later run (September 2 to November 5), which was characterized by the peak of September 12.

From among 24 tagged female sockeye found dead on the Fence, 7 (29 percent) had spawned completely, 5 (21 percent) had spawned partially, and 12 (50 percent) had died without spawning. There were also 8 other female sockeye whose spawning condition was not determined.

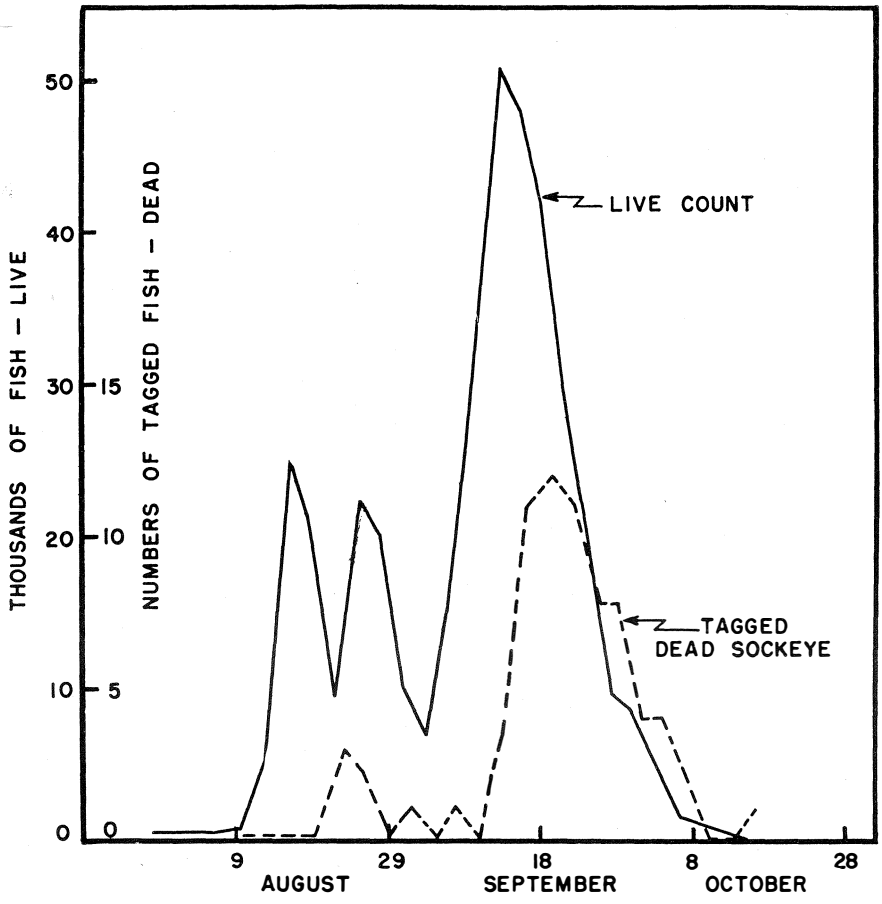

Figure 36. Three-day totals of tagged sockeye passing through the Fence, which at various later dates were found dead on the Fence, compared with the live sockeye counts.

In Table 22 are shown the number of days out from date of tagging to date of arrival at Fence, and from date of arrival at Fence to date of drifting down onto the Fence as dead fish, for the 79 sockeye upon which there is adequate data.

In the case of the Slide-tagged fish (which made up most of the recoveries) the average number of days out from Fence to dead on Fence was approximately 17 days less for fish which had died without spawning, than for those which were spawned-out.

TABLE 22

Spawning condition, and number of days out for dead tagged sockeye found on the Babine Fence

——	Degree of spawning								
	Complete			None			Partial		
	Kisgegas	Slide	Above Slide	Kisgegas	Slide	Above Slide	Kisgegas	Slide	Above Slide
Number recovered	3	28	4	8	31	3	1	1	0
Average number days out—tagging to fence	36·3	24·3	15·8	18·2	21·2	8·0	4·6	17·0	.....
Average number days out—fence to dead on fence	32·7	27·9	22·5	4·3	10·7	9·7	9·0	18·0	.....
Average number days out—tagging to dead on fence	69·0	52·1	37·3	22·5	31·9	18·0	55·0	35·0	.....

Spawning Condition of Dead Sockeye in Streams and in Nilkitkwa Lake

Between mid-September and early November, stream surveys were made for the purpose of estimating the spawning populations and to sample the dead fish to determine their degree of spawning. Similar examinations were also made from among the dead in Nilkitkwa Lake. The results are summarized in Table 23.

In Nilkitkwa Lake, among a non-random sample of 379 fish, 321 were females, of which 73 percent had spawned, and 27 percent had not. In seven spawning streams, a total of 338 dead sockeye were examined, of which 173 were females. The ratio of spawned to unspawned females was 64 to 36 in the spawning streams. Thus, the ratios of spawned to unspawned were similar in Nilkitkwa Lake and in the spawning streams.

The sampling of dead, however, was not carried out until relatively late in the season. Thus, the date of the first sample from Nilkitkwa Lake was October 10, and from the streams, September 16.

In Nilkitkwa Lake only 11·9 percent of the females of the first sample (October 10) were spawned-out fish. Earlier in the month the Fisheries Inspector had examined 100 dead sockeye on the lake-shore (they were males and females) and had found 70 of them unspawned. The last sample (of November 6) showed a smaller proportion of spawned-out fish, but as the investigators noted, it contained a number of "older" dead fish. These investigators had also observed that the newer dead, which lay nearer to the water's edge, were mostly spawned-out fish, whilst among the older dead, which lay farther inshore, the proportions of unspawned fish were higher.

Of the stream samples, only those for the Fulton River approached a number that might be considered as adequate for the purpose of determining a trend in the proportions of spawned and unspawned females. If a trend did occur there, it was towards an increasing proportion of spawned-out females later in the run (Table 23).

The Inspector has also recorded (although no specific figures are available) that the condition of fish on the streams improved, and the proportions of spawned-out fish increased, toward the end of the season.

The spawning condition of fish in the streams seems to have followed a trend similar to that demonstrated by the dead on the Fence—a larger proportion of unspawned fish earlier in the season. The actual final proportions of unspawned dead in the streams were considerably lower than was the final Fence proportion, but, as has been explained, the stream data probably represent later conditions. Furthermore, if factors were causing fish to die before spawning, the expected result, as far as fish migrating to the more distant streams is concerned, might be the elimination of weaker fish before they reached the streams. In such an event, the situation on the streams should have resulted in a higher proportion of spawned-out fish, but a *smaller total number of spawners* on the streams. The stream estimates were decidedly lower than in "normal" years, but the total Fence run in 1952 was smaller. Because the stream estimates have varied considerably in the several years, it is not possible to use the evidence directly towards measuring the losses in unspawned fish.

TABLE 23

Spawning condition of dead sockeye in streams, 1952

Place	Date	Number of males examined	Number of females examined	Spawning of females					
				None		Partial		Complete	
				No.	%	No.	%	No.	%
Nilkitkwa Lake	Oct. 10	58	42	35	83·3	2	4·8	5	11·9
	27		10	3	30·0	—	—	7	70·0
	Nov. 2		50	6	6·0	4	8·0	43	86·0
	3		42	3	7·1	—	—	39	92·9
	4		96	7	7·3	4	4·2	85	88·5
	6[1]		81	25	30·8	1	1·2	55	67·9
15-Mile Creek	Sep. 18	20	7	0		0		7	
	Oct. 5	11	10	2		0		8	
	14	2	8	3		0		5	
	22	4	6	2		0		4	
	29	—	1	0		0		1	
Pierre Creek	Oct. 6	1	2	1		0		1	
	13	4	5	3		1		1	
	16	1	3	0		0		3	
	25	0	1	0		0		1	
Grizzly Creek	Sep. 19	3	7	1		0		6	85·7
4-Mile Creek	Sep. 18	1	1	0		0		1	100·0
Twin Creek	Sep. 20	1	—	—		—		—	—
Hatchery Creek	Oct. 9	2	1	0		0		1	
	18	3	11	5		1		5	

Babine Lake[2]	Oct.	20	7	0	0		0		0	
		27	21	3	2		1		0	
Fulton River	Sep.	21	6	5	1	20·0	0		4	80·0
	Oct.	7	40	28	3		3		22	78·6
		11	9	11	7		0		4	
		11	14	9	9	55·3	0	7·9	0	36·8
		12	11	18	5		3		10	
		16	2	2	0		1		1	
		17	16	16	3	16·7	5	33·3	8	50·0
		25	6	9	0		1		8	
		28	0	1	0		0		1	
		29	3	8	1	4·8	1	14·3	6	80·9
		30	5	3	0		1		2	
		31	—	—	—		—		—	

Summaries

Nilkitkwa Lake	58	321	76	23·7	11	3·4	234	72·9
15-Mile Creek	37	32	7	21·9	0	0	25	78·1
Pierre Creek	6	11	4	36·4	1	9·1	6	54·5
Grizzly Creek	3	7	1	14·4	0	0	6	85·7
4-Mile Creek	1	1	0		0	0	1	100·0
Twin Creek	1	0	0		0	0	0	0
Fulton River	112	110	29	26·4	15	13·6	66	60·0
Hatchery Creek	5	12	5		1	0	6	0
Babine Lake	28	3	2		1	0	0	0
	251	497	124	24·9	29	5·8	344	69·3
Streams and rivers	165	173	46	26·6	17	9·8	110	63·6
Nilkitkwa Lake	58	321	76	23·7	11	3·4	234	72·9

[1]These counts are noted in records as including "older" dead fish.
[2]9-Mile Post and Sweetheart Bay.

TABLE 24

Numbers of injured and uninjured sockeye in 1% proportionate sample, Babine Fence, 1952, by sex and week

(N = normal; I = injured; NM = net marks; G = gaffed)

Week	Males				Jacks				Females			
	N	I	NM	G	N	I	NM	G	N	I	NM	G
J29-A4	2	1										
A5-A11	3	2										
A12-A18	154	100	11	3	1	2			108	34	8	4
A19-A25	135	62	2	2	12	1			90	48	3	1
A26-S1	137	56	3	1	20				81	39	2	
S2-S8	133	66	2		24	2			107	36	3	
S9-S15	295	228	15		98	32	2		193	186	11	
S16-S22	166	253	2		51	21	1		94	201	5	1
S23-S29	66	79	1		16	4			52	76	1	
S30-O6	32	21			2				22	16		
O7-O13	7	4							3	2		
O14-O20	4	1										
O21-O24		1								1		
Total	1,134	874	36	6	224	62	3	0	751	640	33	6
Percentage	55·3	42·6	1·8	0·3	77·5	21·8	1·0	0	52·5	44·8	3·3	0·4

TABLE 25

Numbers of injured and uninjured sockeye among the tagged fish recovered and measured at the Babine Fence, 1952, by sex and week

(N = normal; I = injured; NM = net marks; G = gaffed)

Week	Males				Jacks				Females			
	N	I	NM	G	N	I	NM	G	N	I	NM	G
J29-A4	4	1										
A5-A11	2	5										
A12-A18	129	56	3	1	1	1			90	38	2	3
A19-A25	100	23							53	20		
A26-S1	61	12			2				19	4		
S2-S8	30	7			1				14	2		
S9-S15	97	49			7	1			40	36		
S16-S22	125	74			27	9			70	49	5	
S23-S29	48	38			5	2			51	40		
S30-O6	23	16							12	10		
O7-O13	6	2							1	1		
O14-O20	1	1							2	2		
O21-O24		1										
Total	626	285	3	1	43	13	0	0	352	203	7	3
Percentage	68·4	31·2	0·4	0	76·8	23·2	0	0	62·3	35·9	1·2	0·6

Condition of the Sockeye Run at the Fence

Tables 24 and 25 list the weekly totals of injured and uninjured sockeye in the 1 percent proportionate sample of the run at the Fence in 1952, and among the tagged fish reaching the Fence. By combining the categories "injured", "net marks" and "gaffed", the percentages for the sexes combined become:

Untagged sockeye: 44·0 percent injured; 56·0 percent uninjured;

Tagged sockeye: 33·5 percent injured; 66·5 percent uninjured.

The numbers of injured sockeye at the time of tagging amounted to 35·7 percent at Kisgegas, and 24·6 percent at the Slide. These proportions at first appear similar to that among the tagged sockeye when they were re-examined at the Fence. However, samples taken for tagging were not representative of the run as it arrived at a tagging site, because of the inclusion of a disproportionate number of injured fish (p. 00). In actual fact the proportion of injured fish increased greatly between time of arrival at a tagging site, and time of arrival at the Fence.

The degree of maturity of the run at the Fence is indicated in Table 26 for the 1 percent proportionate sample, and in Table 27 for the tagged sockeye recovered at the Fence.

TABLE 26

Numbers of sockeye in the "1 percent" sample at the Babine Fence, 1952, in four stages of maturity, by sex and week

(G=green; P=pink; R=red; M=mature)

Week	Males				Jacks				Females			
	G	P	R	M	G	P	R	M	G	P	R	M
A5-A11			3							2		
A12-A18	1	139	95	33		2		1	12	115	27	
A19-A25		94	93	14		10	3		2	89	50	1
A26-S1	1	96	81	19	1	10	4	5		80	40	2
S2-S8		56	126	19		16	5	5	1	68	77	
S9-S15		41	435	62		2	75	55		57	329	4
S16-S22		5	333	83		3	38	32		13	288	
S23-S29		1	108	37			5	15		2	127	
S30-O6			25	28				2			38	
O7-O13			4	7							5	
O14-O20				5								
O21-O24				1							1	
Totals	2	432	1,303	308	1	43	130	115	15	426	982	7
Percentage	0·1	21·1	63·8	15·0	0·3	14·9	45·0	39·8	1·0	29·8	68·7	0·5

88878—7½

TABLE 27

Numbers of sockeye of four stages of maturity in the tagged sample examined for degree of maturity; Babine Fence, 1952

(G = green; P = pink; R = red; M = mature)

Week	Males				Jacks				Females			
	G	P	R	M	G	P	R	M	G	P	R	M
J29-A4				5								
A5-A11			3	4								
A12-A18		86	76	26		1		1	1	103	26	
A19-A25		48	60	15						44	27	2
A26-S1		14	44	13				2		7	16	
S2-S8		6	28	2			1			5	11	
S9-S15		3	119	23			3	5		6	68	1
S16-S22		5	132	61		1	19			8	114	1
S23-S29		3	51	32		1	1	16		9	82	
S30-O6		1	20	18				5		4	18	
O7-O13			1	7							2	
O14-O20				2							4	
O21-O24				1								
Total	0	166	534	209	0	3	24	29	1	186	369	4
Percentage	0	18·3	58·7	23·0	0	5·4	42·8	51·8	0·2	33·2	65·9	0·7

The change in sexual condition, from mostly green fish at the tagging sites to mostly more mature fish at the Fence is indicated in Table 14. The percentages of green and more mature fish at the several sites were:

Kisgegas	Green	86·0;	more mature	14·0
Slide	"	60·8;	" "	39·2
Above Slide	"	54·2;	" "	45·8
Fence (untagged)	"	0·5;	" "	99·5

Recoveries of Tagged Sockeye Above the Fence

Tags recovered at points above the Fence, from sockeye that had been tagged at Kisgegas, the Slide, and Above the Slide, amounted to 439. The total number of tagged sockeye which were passed through the Fence was 1,650, including 112 (7 percent) which were seen but were not examined (for tag number or condition). However, there was probably also a small number of tags which passed through the Fence unobserved, since of the 439 recoveries above the Fence 81 (18·5 percent) had not been recorded at the Fence. Because some of the difference between the two percentages may have resulted from recording tag numbers wrongly, the actual number of Fence recoveries is arbitrarily set at 1,800 instead of the fully corrected figure 1,887 [$=(1{,}650-112)/(1-0{\cdot}185)$]. The recoveries at points above the Fence therefore amounted to 24 percent of the 1,800. The distribution of these recoveries is shown in Table 28.

TABLE 28

Numbers of tagged sockeye recovered at points above the Babine Fence in 1952

Recovered at:	Kisgegas	Slide	Above Slide	Total
Grizzly Creek	1	6	1	8
4-Mile Creek	0	1	0	1
15-Mile Creek	0	7	5	12
Twin Creek	0	2	1	3
Pierre Creek	1	11	1	13
Fulton River	6	28	9	43
Morrison River	1	0	0	1
Upper Babine River	3	3	0	6
Lower Babine River (exclusive of dead on Fence)	0	12	1	13
Total for spawning streams	12	70	18	100
Indian fishery				
Nilkitkwa Lake	33	100	24	157
Babine Lake	17	56	10	83
Dead on Fence	14	65	8	87
Nilkitkwa and Babine Lakes	8	4	0	12
Grand total	84	295	60	439

ESTIMATION OF THE EFFECTIVE ESCAPEMENT IN 1952

Number of Sockeye on the Spawning Grounds

The basis for a possible estimate of the effective escapement in 1952 is a comparison of the tag recoveries from spawning streams in that year with those obtained in 1946 and 1947.

In the two earlier years sockeye were tagged daily at the Fence, in proportion to the numbers arriving—2 percent in 1946, and 1 percent in 1947. In addition, in both years numbers of sockeye had been tagged in the ocean as they approached the fishing grounds, and some of these also passed through the Fence. In 1952 sockeye were tagged at Kisgegas and the Slide, and they passed through the Fence as a varying proportion of the run.

The returns for 1946 and 1947 have been taken from reports of Pritchard (1953a-d) and original records. They are not necessarily definitive figures, but contain no errors of importance for the present purpose.

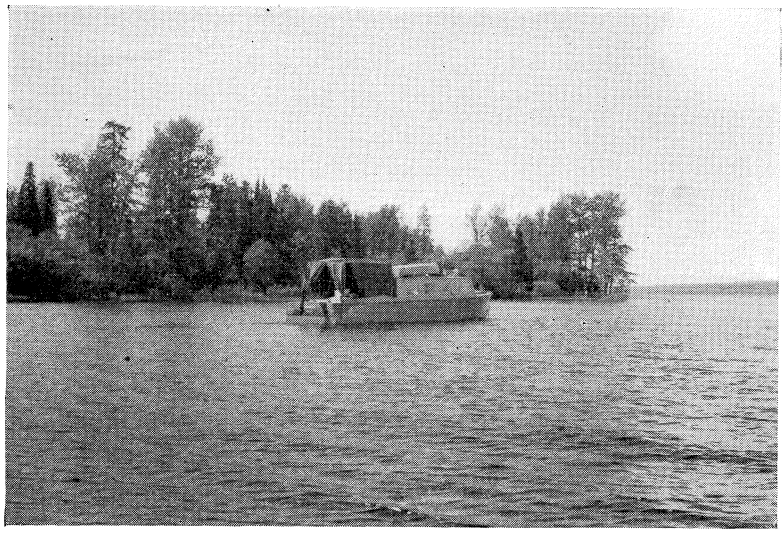

Figure 37. Fisheries Patrol Launch *Branta* off Pierre Creek, Babine Lake, in the course of spawning ground inspection.

EXAMINATION OF SPAWNING GROUNDS

The chief difficulty in comparing the percentage recoveries from streams in the three years is the probable variation in the intensity of search at different places and times, and it is not possible to attach numerical estimates to this. In each year the greatest percentage recoveries were made from fish which passed the Fence early in the season, with most of the recoveries coming from the smaller streams. In 1946 and 1947 stream surveys during the early part of the

TABLE 29

Number of live tagged and untagged sockeye seen on streams at time of last inspections, and total number of live and dead tagged sockeye seen on streams in 1946

Stream	Total dead tagged seen	Total live tagged seen	Live tagged last visit	Live tagged and untagged last visit
Trail Creek	0	1	1	33
5-Mile Creek	0	0	0	13
9-Mile Creek	12	13	0	105
Fulton River	223	294	77	8,077
Tachek Creek	16	37	1	69
Sockeye Creek	2	5	1	47
Pierre Creek	119	184	10	691
Twin Creek	52	71	4	324
Pendleton Creek	9	18	1	41
Donalds Landing Creek	5	4	0	5
4-Mile Creek	27	139	2	67
6-Mile Creek	5	0	0	0
15-Mile Creek	17	9	76	6,798
Grizzly Creek	11	43	8	260
Morrison Creek	19	232	77	4,437
Salmon Creek	0	14	14	1,314
Totals	517	1,074	272	22,281

Total number of live counted during season..... 121,884
Total number of dead counted during season..... 49,804
Proportion tagged.....2 percent of run

TABLE 30

Numbers of live tagged and untagged sockeye seen on streams at time of last inspections, and total number of live and dead tagged sockeye seen on streams in 1947

Stream	Total dead tagged seen	Total live tagged seen	Live tagged last visit	Live tagged and untagged last visit
Trail Creek	0	0	0	6
5-Mile Creek	0	0	0	0
9-Mile Creek	1	3	0	2
Fulton River	105	53	3	12,073
Tachek Creek	10	26	4	2,534
Sockeye Creek	1	3	1	226
Pierre Creek	49	149	44	5,569
Twin Creek	43	88	1	263
Pendleton Creek	5	10	0	32
4-Mile Creek	3	13	0	107
6-Mile Creek	5	8	0	10
15-Mile Creek	1	26	12	9,608
Grizzly Creek	9	36	4	1,060
Morrison Creek	16	31	1	1,137
Salmon Creek	0	4	4	1,504
Totals	248	450	74	34,131

Total number of live counted during season..... 104,322
Total number of dead counted during season..... 35,126
Proportion tagged.....1 percent of run

run were possibly more frequent than in 1952. The search late in the spawning season, particularly on larger streams such as the Fulton River, was more effective in 1952. Though the run of 1952 was late in arriving at the spawning streams, compared to the earlier years, searches on most streams were continued nearer to the completion of spawning than were those of 1946 and 1947.

Tables 29 and 30 have been arranged to list the numbers of live sockeye, and the numbers of live tagged sockeye counted or estimated on the streams at the time of the last inspections in 1946 and 1947 (Pritchard, 1953a, c).

In 1946 the live sockeye still in the streams at the last inspections were approximately one-fifth of the estimated number seen during the whole season. The live tagged sockeye counted during final surveys amounted to over half the total recoveries of dead tagged fish in the streams. Thus there was still available in the streams a large number of tags, some of which would have been recovered from dead fish had there been later inspections. The result would have been a higher final percentage recovery of tags from streams than was actually achieved.

In 1947, one-third of the season's estimate of live sockeye in the streams was present at the time of the last surveys; and live tagged sockeye then numbered 30 percent of the total dead recoveries. Again, therefore, an important number of tags was still available for recovery on the streams, had there been later inspections.

Unfortunately the data of 1952 are not altogether comparable to those of the two earlier years. Estimates of the number of spawners in the streams were carried out by the resident Fisheries Inspector in the same manner as he has made them in former years; but no counts of live sockeye, either tagged or untagged, were kept by the stream survey parties who examined the dead and looked for tags later in the season. However, the records of these parties and the reports of the Fisheries Inspector do indicate that sockeye spawning was complete in some of the streams, while very few live sockeye were left in the others at the time of the last inspections. In contrast to 1946 and 1947, therefore, it is felt that in 1952 inspections were carried out until virtually all the tags that could have been recovered in the routine manner were actually recovered.

SEASONAL CHANGE IN TAG RECOVERIES FROM SPAWNING GROUNDS

In each of the three years the trend in tag recoveries from streams showed a marked decrease as the season advanced (Fig. 38). Although there were probably other causes also, this is associated with a shift of principal recovery sites from the smaller and more easily inspected streams to the larger rivers (Pierre Creek, 15-Mile Creek, Morrison River, and particularly the Fulton River).

The year 1952 differs from the other two years in that the earliest percentage recovery was lower than that of the next period instead of being higher. This may have been the result of low water in 1952 making access to some creeks difficult or impossible, or it might also have been associated with the effects of the Slide. A third possibility might have been a less intensive search for tags during the earliest spawning; however there were few, and on some streams no, dead sockeye at the time of the first and second inspections at least.

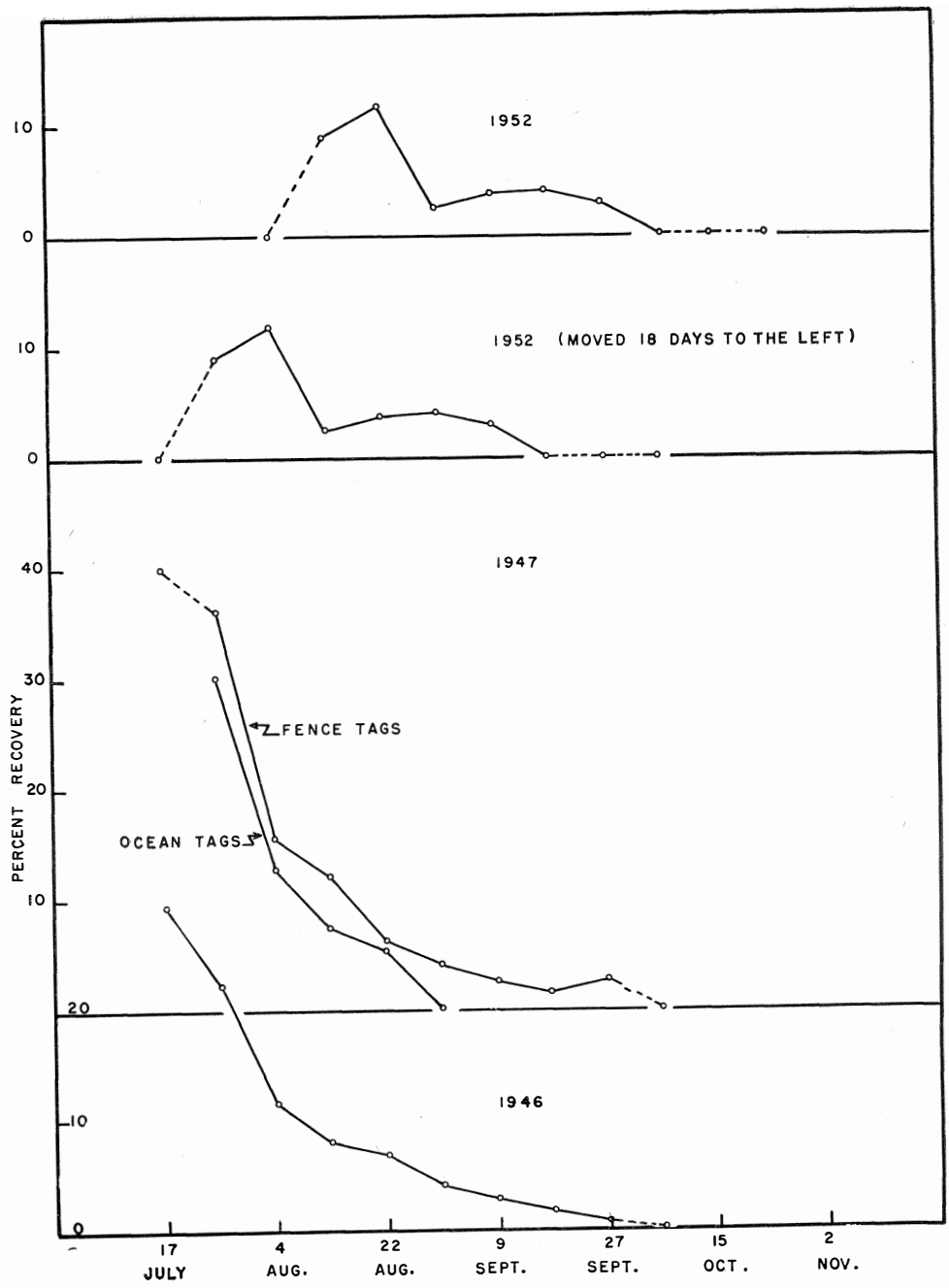

Figure 38. Seasonal distribution of percentage recoveries of sockeye tags in streams, for 1946, 1947 and 1952. Nine-day periods.

The general seasonal decrease in percentage recovery is the most serious obstacle to an accurate overall comparison of 1946-47 with 1952, because it makes the average percentage recovery depend upon the relative numbers of fish present in different segments of the run, in the different years.

The seasonal changes in the percentage recoveries for the three years are compared in Figure 38. The 1952 seasonal distribution is shifted later in the year as a result of the lateness of the run at the Fence, including its arrival, peak and completion. Since the delay at all stages seems to have been two to three weeks, the 1952 points, for the purposes of comparison with the other years, have been set 18 days ahead in Figure 38. For each year, because of the small total number of usable recoveries from streams, percentage recoveries here have been grouped by 9-day periods. Returns for 1947 ocean tags have also been plotted.

RELATIVE RECOVERY OF TAGS IN 1946-47 AND IN 1952

The 9-day period percentage recoveries which are used in Figure 38 have been listed in Table 31. These show that, when comparing only those points which have a reasonable number of tagged fish leaving the Fence (that is, excluding those periods in 1952 with less than 20 tags), 4 out of 7 percentages were higher in 1946 than the corresponding values in 1952; 5 out of 7 in 1947 for Fence tags, and 4 out of 4 for ocean tags in 1947. However, these simple majorities do not describe the situation adequately, for when 1952 was higher it was by no great amount, whereas differences in the other direction were sometimes large. The 1952 recoveries were particularly low, relatively, during the first two periods, and again in the period ending August 31, (and corresponding to August 13 of the two normal years).

An overall comparison can be made by using the weighted mean percentage recoveries for 1952 (Table 31), and by increasing the percentage recovery of the other two years to take care of a few tags reported without complete data. The revised percentages are:

1946	7·0
1947	8·4
1952	4·6

The 1952 average is low partly because the early tags were retaken less often than in 1946 and 1947. This is a legitimate indication of poor recovery in 1952. A second reason for the low overall 1952 percentage is "artificial": the early fish were less numerous than usual, and hence the early period of (relatively) high recovery contributes less to the weighted mean for 1952.

The 1946 and 1947 figures can also be considered as somewhat too low, relatively, firstly because of the less effective search for tags late in the spawning season in those years, described earlier, and secondly because there was some competition for tags by Indians fishing at the mouths of streams in 1946 and 1947, but not to the same extent in 1952.

TABLE 31

Seasonal distribution of percentage recoveries of tagged sockeye in streams, by 9-day periods, for 1946, 1947 and 1952. The weighted mean for 1952 is weighted as the total number going through the Fence in each period (last column). In other years Fence tags were applied proportionately to the daily run; 2 percent in 1946; 1 percent in 1947.

Period ending	1946			1947			1952			
	Tags put on	Recaptures	Percent recaptured	Tags put on	Recaptures	Percent recaptured	Tags put on	Recaptures	Percent recaptured	Total sockeye
										(1000's)
July 17	91	27	29·7	5	2	40·0	0	.....	.....	.....
26	305	68	22·3	238	86	36·1	0	.....	.....	.....
Aug. 4	1,003	114	11·4	333	52	15·6	5	0	0	0·4
13	1,938	153	7·9	971	116	12·0	34	3	8·8	5·8
22	1,986	136	6·8	1,426	86	6·0	389	46	11·8	54·0
31	2,165	87	4·0	1,091	41	3·8	248	6	2·4	52·4
Sep. 9	1,279	34	2·7	470	11	2·3	89	3	3·4	54·8
18	595	9	1·5	269	4	1·5	409	17	4·2	138·6
27	150	1	0·7	79	2	2·5	327	10	3·1	55·3
Oct. 6	5	0	0·0	39	0	0·0	107	0	0·0	13·6
15	0	.....	.....	0	.....	.....	17	0	0·0	1·6
24	0	.....	.....	0	.....	.....	5	0	0·0	0·4
Total	9,517	629	6·61	4,921	400	8·13	1,630	85	5·21	376·9
Weighted Mean	.....	.....	6·61	.....	.....	8·13	.....	.....	4·63	.....
				Ocean tags put through Fence in 1947						
July 26				56	16	30·2				
Aug. 4				79	10	12·7				
13				212	16	7·5				
22				206	11	5·3				
31				22	0	0·0				

Since only the order of magnitude of the spawning success can be indicated in any event, this has been done, without further adjustment, through a direct comparison of the weighted mean percentage recoveries for the three years. Thus the mean percentage recovery of 1952 was 4·6, or approximately 66 percent of that of 1946, and 55 percent of that of 1947.

If an average of 60 percent is used, this is intended to indicate that sockeye which passed through the Fence reached the spawning streams only 60 percent as frequently as in the previous years. However, for the reasons given, particularly the important numbers of tags still available on the streams in 1946 and 1947 at the time of the last inspections, it is felt that the fraction may have been as low as 50 percent, and this value will therefore be set as a lower limit of the proportion of the run at the Fence in 1952 which reached the spawning streams.

The 40-50 percent of the run which did not reach its normal spawning grounds would presumably consist to a large extent of some of the dead in Nilkitkwa and Babine Lakes, and most of the unspawned dead on the Fence. These would amount to 150,000-188,000 (40 and 50 percent respectively of 377,000) less some of the Indian catch.

PERCENTAGE OF UNSPAWNED FEMALES

Of the sockeye that did reach the streams, not all spawned. The results of examining samples of dead in the streams are listed in Table 23. The mean percentage spawned out was 63·6. It was suggested that this value may have been high because it was derived mostly from examinations of fish that had died later in the season, after the proportion spawning successfully had probably increased. However, the *partially* spawned fish in the stream dead samples is not included in the 63·6 percent. For these reasons the proportion spawned out is set at between 60 to 70 percent, as against a normal figure of probably about 90 percent.

ESTIMATES OF EGG DEPOSITION IN 1952

COMPARISON WITH 1952 ESCAPEMENT TO THE FENCE

Of the sockeye that reached the Fence in 1952, it was estimated above that only 50-60 percent reached their customary spawning streams; and only 60-70 percent of the females spawned successfully, giving the following limits for the effective 1952 spawning population:

(a) Upper limit: $0 \cdot 6 \times 0 \cdot 7 = 42 \cdot 0$ percent of the 1952 run of females at the Fence.

(b) Lower limit: $0 \cdot 5 \times 0 \cdot 6 = 30 \cdot 0$ percent of the 1952 run of females at the Fence.

COMPARISON WITH 1946-50 AVERAGE FENCE ESCAPEMENT

From Table 1, the number of females in the run through the Fence in 1952 was 0·66 of the average for the pre-Slide years (143,000 as compared with

215,000). Spawning by females in pre-Slide years was never 100 percent successful, and if 90 percent success is considered as normal, the estimate of effective spawning for 1952, relative to that of the 4 pre-Slide years, becomes:

(a) Upper limit: $0{\cdot}66 \times 0{\cdot}6 \times 0{\cdot}7/0{\cdot}90 = 31$ percent of "normal".

(b) Lower limit: $0{\cdot}66 \times 0{\cdot}5 \times 0{\cdot}6/0{\cdot}90 = 22$ percent of "normal".

COMPARISON WITH 1952 ESCAPEMENT FROM THE FISHERY

The Babine escapement from the fishery in 1952, exclusive of jacks, was estimated at 1,051,000. If the pre-Slide average sex ratio of 43·2 "normal" males to 56·8 females is used as an estimate of the 1952 sex ratio, the number of female sockeye in the 1952 escapement from the fishery becomes 56·8 percent of 1,051,000 = 597,000. The number of females in the run at the Fence in 1952 was 143,000 approximately, and the loss of females at the Slide in 1952 is therefore calculated as 597,000 − 143,000 = 454,000.

The effective 1952 spawning, relative to the Babine escapement from the fishery of female sockeye is estimated as:

(a) Upper limit: $143/597 \times 0{\cdot}6 \times 0{\cdot}7 = 10{\cdot}1$ percent of the 1952 Babine escapement of females from the fishery.

(b) Lower limit: $143/597 \times 0{\cdot}5 \times 0{\cdot}6 = 7{\cdot}2$ percent of the 1952 Babine escapement of females from the fishery.

The above estimates of the effective spawning in 1952, in comparison with the different norms, have been summarized in Table 32.

TABLE 32

Estimates of effective sockeye spawning in 1952

Effective spawning population	
A. As a percentage of the 1952 run of females at the Fence	Upper Limit: 42% Lower Limit: 30%
B. As a percentage of the "normal" run of females at the Fence	Upper Limit: 31% Lower Limit: 22%
C. As a percentage of the 1952 Babine escapement of females from the fishery	Upper Limit: 10% Lower Limit: 7%

OTHER FACTORS INFLUENCING PRODUCTION FROM THE 1952 SPAWNING

Two other factors will influence the final output of smolts from the 1952 spawning. Firstly, the lateness of the run, and the condition of fish which did spawn, may contribute further to the poor production of young fish. No information exists by which these effects might be assessed. On the other hand, it has been observed that smaller spawnings may produce more young *per spawner* than larger spawnings (Pritchard, 1948b). This "resilience" of the population should partially offset the various effects described above.

THE SPAWNING OF 1951

Although in 1951 data were not obtained, comparable to those of 1952, on the condition and distribution of the sockeye beyond the Fence, some measure of the 1951 effective spawning can be given.

The sockeye sex ratios at the Babine Fence are given in Table 1. The 1951 fraction of females among normal-sized fish was 48·1 percent. The average for years before the Slide was 56·8 percent. The sockeye females in the 1951 run at the Fence therefore amounted to only 48·1/56·8 = 0·85 of the average pre-Slide proportion of females. This compares with 0·72 for 1952, and again indicates a loss of female sockeye in excess of males, although less severe than in 1952.

In 1951, the number of female sockeye at the Fence was 70,573, or 32 percent of the pre-Slide average of 221,500. The corresponding value for 1952 was 66 percent.

In 1951 a sample which amounted to 6 percent of the sockeye run at the Fence was examined to record the number of fish, leaving a counting pen, that bore injuries visible to an observer from above. (Injuries on the under parts of fish could not be observed by this method.) Of these, and exclusive of jacks, 30·1 percent were injured, and in addition 18·3 percent had net marks. Corresponding figures for the 1952 sample (when 20 percent of the run was similarly examined) were 29·9 percent injured and 1·0 percent with net marks.

As in 1952, some sockeye in 1951 died without spawning. Dead unspawned sockeye were found on the shores of Babine and Nilkitkwa Lakes, and in the spawning streams. According to observers, however, the condition of spawning sockeye in 1951 was better than in 1952.

Withler (1953) has reported on the Babine sockeye smolt run of 1953, which was produced from the 1951 seeding. More smolts *per spawner* were produced from the 1951 seeding than from the considerably heavier seedings of the years 1949 and 1950 (Table 33). The resiliency of the reduced 1951 spawning stock is clearly indicated. It is the more striking because the spawners of 1951 were in poorer condition than those of the earlier years, although, unlike those of 1952, they did arrive at about the normal times.

TABLE 33

Estimates of sockeye smolts leaving Babine Lake from three spawnings, related to potential egg deposition (eggs in females passing the Fence, less Indian catch). After Withler, 1953.

——	1949	1950	1951
Potential female spawners	260,342	192,563	60,982
Eggs potentially available (millions)	876	583	197
Smolts produced, as percentage of eggs	0·48%	0·77%	1·52%
Number of smolts (millions)	4·2	4·5	3·0

FUTURE BABINE SALMON PRODUCTION

Although the Babine Slide has destroyed many salmon, timely effort has prevented a major catastrophe. Most important is the prompt action which made possible the removal of the Slide during the winter of 1952-53, so that its effects were restricted to only two spawnings, 1951 and 1952.

In 1951, when no remedial action of any sort was possible, it was fortunate that water levels in the river were moderate, so that about a third of the sockeye run was able to pass unaided. In 1952, when very high water would have made the Slide almost a complete barrier, improvements along the margin of the river were possible which again permitted about a third of the sockeye to pass.

The successful 1952 fish had been delayed longer and were in worse condition than those of 1951, with the result that many failed to spawn successfully. However, the escapement from the fishery was large to start with, so that despite the losses, the effective spawning in 1952 was probably at least as much as 20-30 percent of the pre-Slide 4-year average. This should be sufficient to restore the usual abundance of Skeena sockeye in the second generation at latest, by reason of compensatory increase in survival rate when stocks are small. It is already known that the small 1951 seeding produced more than twice as many smolts *per spawner* as the heavier seedings of 1949 and 1950, and the actual number of smolts was only a third less than in those years. Whether 1952 will do as well remains to be seen.

Another fortunate circumstance is that the Babine adult sockeye include substantial numbers of both 4-year-old and 5-year-old fish, so that only one year (1956) will have practically its whole escapement (other than jacks) come from the Slide years. Some extra restriction of fishing may seem desirable in 1956, and possibly also in 1955 and 1957. It will be possible to make a much better decision on this point by the summer of 1954, when estimates of the smolt production from both the 1952 and the 1951 spawnings will be known.

No great concern need be felt for the other kinds of salmon, in spite of the fact that the Fence count showed that pink salmon were much worse blocked by the Slide in 1951 than were sockeye. However, the pinks spawn in rivers, and many of the pinks which normally would have passed the Slide may have spawned successfully below it. Furthermore, unless "homing" of this species to the point of hatching is much more accurate than seems likely, recolonization of the river from the Slide upward should proceed rapidly now that the Slide is gone. Escapement of spring salmon and coho in 1951 and 1952 was ample to quickly rebuild their runs; indeed the 1952 Fence count of coho was about normal.

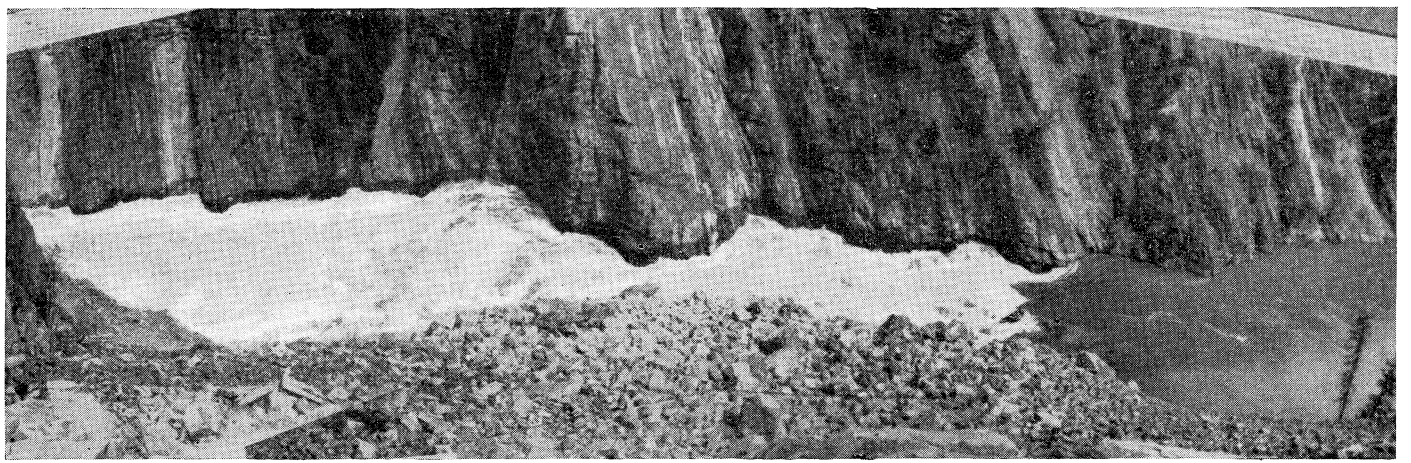

Figure 39. View down the Slide from a point about 300 feet above the river, May 29, 1952. The water level is high but not yet near its maximum.

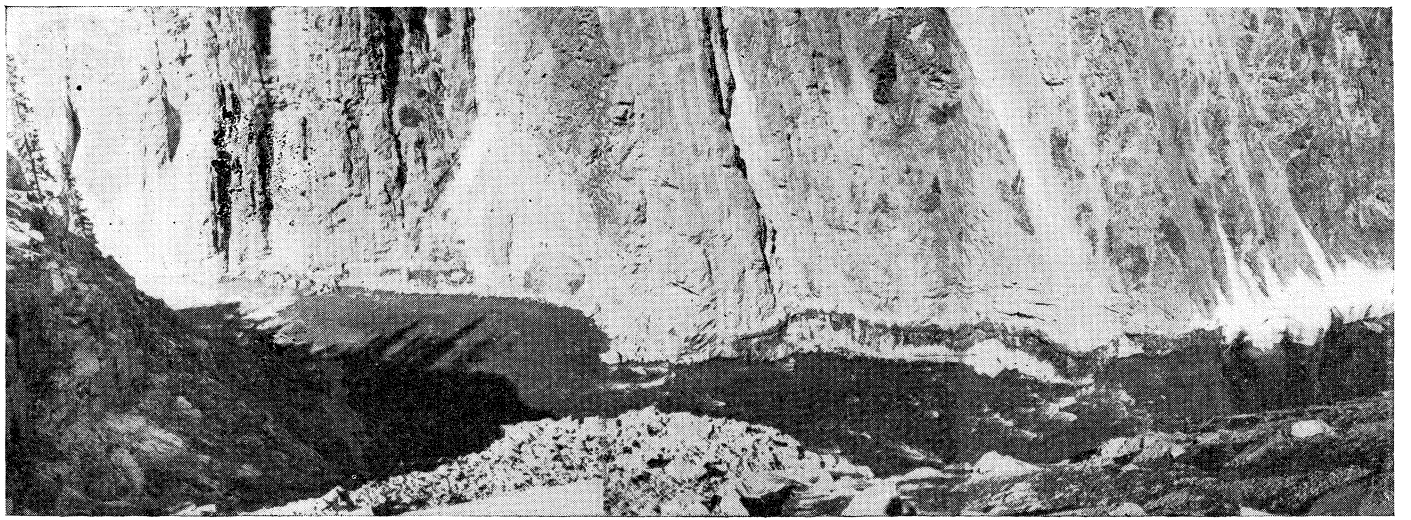

Figure 40. View of the site of the Slide after removal of the fallen material, April 16, 1953. Compare with Figure 39.

SUMMARY

The Skeena River in British Columbia supports one of the largest salmon fisheries of the Province. Its main tributary is the Babine River, which joins the Skeena some 200 miles inland from the Pacific Coast. Each year between 50 and 70 percent of the sockeye salmon, and large numbers of other species of Pacific salmon, that escape the fishery and enter the Skeena River, proceed to the Babine spawning grounds.

In the spring or early summer of 1951 a large slide of rock fell into the Babine River at a point approximately 16 miles above its junction with the Skeena and about 40 miles below Babine Lake. It blocked the Babine salmon runs of 1951 and 1952, and in both years caused the destruction of many thousands of fish.

The Slide occurred in remote and isolated country. The first indications that the Babine salmon were experiencing difficulty in the river were the late arrival and damaged condition of fish entering Babine Lake, and observations of many dead and injured salmon in the Lower Skeena River.

The Slide was located from the air during August of 1951, and a few days later was reached by land. After subsequent inspection by fisheries biologists and engineers it was decided to remove the fallen material, and return the channel to its former natural state. A 60-mile long access road to the Slide was built from the nearest community to transport the needed materials and equipment. This was begun during the autumn of 1951, and was completed by midsummer of the following year.

By the time the Slide was discovered it was too late for action that year to aid the salmon then migrating to pass the obstacle. Remedial measures were carried out during the summer of the following year, and were effective in permitting a large number of fish to escape that otherwise would have perished. They were particularly beneficial because the obstructiveness of the Slide was very much more serious in 1952 as a result of persistent high water levels.

Since 1946 the Fisheries Research Board has operated a counting weir, or "fence", on the Babine River, about 10 miles below Babine Lake. Here complete counts have been made each year of the fish entering the Babine spawning grounds, and the runs have been sampled. In 1951 and 1952 the operations of the Fence, and extensive stream surveys combined with the sampling of dead fish on the spawning streams, provided information by which estimates were made of the effective spawning and egg deposition in both years.

In 1952 an extensive tagging and sampling program was conducted below the obstruction, with recoveries of tags being made at the Babine Fence and on the spawning grounds.

These investigations were carried out through the combined efforts of personnel of the Protection and Fish Culture Development Branches of the Department of Fisheries, and of the Fisheries Research Board.

To estimate the sockeye losses at the Slide in 1951 and 1952 recourse was made to the very constant relationship between the annual Skeena sockeye catch and the annual count of sockeye passed through the Fence in the four pre-Slide years of Fence operation. Each year the count of sockeye at the weir has amounted to approximately two-thirds of the Skeena sockeye catch, and the variation from this fraction has been only slight ($67 \cdot 5 \pm 0 \cdot 6$ percent). Thus the estimated Babine sockeye escapement from the fishery in 1951 and 1952 was two-thirds of the year's sockeye catch. The losses at the Slide were calculated by subtracting the Fence totals (which were the actual escapements beyond the block) from the estimated escapements from the fishery to the Babine River.

The relationship between Fence count and catch could be demonstrated for only the four years of Fence operation. It was given further corroboration, however, when it could be shown that the Fence counts were approximately two-thirds of the catch throughout the period of migration each year.

From the results of tagging in earlier years and in 1952, it was calculated that sockeye take 20 days on the average to migrate from the fishing grounds to the Slide, and 5 days from immediately above the Slide to the Babine Fence. Thus, by employing the relationship between Fence count and catch, and knowing the time spent in migrating, it was possible to describe the progression of sockeye up the Babine River to the Slide in 1951 and 1952, the accumulation of dead and live fish below the obstacle, and the escapement beyond it throughout the season.

In 1951 the estimated escapement of sockeye salmon from the fishery to the Babine River was 461,000. The count of sockeye at the Fence was 142,000, so that the estimated loss at the Slide was 319,000, or approximately two-thirds of the Babine escapement from the fishery. In that year, too, the escapement beyond the Slide was a fairly constant fraction (one-third) of the numbers arriving below it. This was presumed due to the moderate water conditions at the Slide, and the relatively constant obstructiveness of the obstacle during the summer.

The water discharge from Babine Lake in 1952 was the heaviest in the 10 years of recording, and water levels at the Slide were much higher than in 1951. The sockeye escapement from the fishery to the Babine River, however, was very large in 1952, and remedial action had important effects. The estimated escapement of Babine sockeye from the fishery was 1,051,000, of which 351,000 reached Babine Lake. The calculated loss was therefore 700,000, or again approximately two-thirds of the escapement. For both years the estimates of escapement and loss are exclusive of jack sockeye, for reasons given in the report.

In contrast to 1951 the number of sockeye escaping the obstacle in 1952 did not constitute a constant fraction of the number arriving below the Slide. An estimated 300,000-400,000 sockeye had accumulated below the obstacle before an appreciable number had passed it. Many of the former subsequently perished below the Slide. There was a peak accumulation of about 900,000 dead and live sockeye below the Slide until a surge in the escapement above it occurred following the partial opening of the channel late in August.

Approximately 13,000 sockeye and 3,000 of other kinds of Pacific salmon were tagged in the Babine River in 1952. Tagging was done immediately below the Slide, and at a second site 10 miles further downstream. Most of the recoveries were made at the Babine Fence, while second recoveries were made from the Babine Lake Indian fishery and from dead fish on the spawning streams.

Recoveries of tagged sockeye at the Fence amounted to only 12 percent approximately. Estimates of the number of fish at either of the two tagging sites could not be derived from these returns because of a heavy disproportionate loss of tagged fish. At the tagging site immediately below the Slide, weakened and injured fish crowded into pools close to the bank where they were available for capture. Stronger and fresher fish tended to remain in the swifter, mid-stream, water where they could not be dipped. Even at the site 10 miles below the obstruction weak and damaged fish, which had drifted downstream from the Slide, were unavoidably included in the tagging samples. Tagged samples were thus not representative of the fish migrating to the Slide, but contained large proportions of damaged or weakened fish. This situation, combined with the fact that more tags were applied early in the season when conditions at the Slide were worse than they were later, resulted in the excess loss of tagged fish.

Among the tagged fish male sockeye were more successful in ascending the block than were female sockeye; and this was irrespective of size, injuries or degree of sexual maturity. The more serious effect of the Slide on female sockeye was also borne out by the change in sex ratios in the runs at the Fence in 1951 and 1952 as compared with pre-Slide years. In the four years before the Slide the runs at the Fence invariably had more females than males (excluding jacks), whereas in 1951 and 1952 the reverse was true.

Tagged uninjured sockeye were recovered about twice as often as injured sockeye; and green (i.e. fresh) fish more often than more mature fish. Recoveries were higher among fish with *body* injuries than among those with *head* injuries. No fish with both *head and body* injuries that had been tagged below the obstruction were recovered at the Fence.

Fish were delayed for long periods below the Slide in 1952. The greatest delay was experienced early in August, after which it decreased gradually throughout the season.

Pink salmon probably suffered even worse than sockeye at the Slide, and very few reached the Fence in either year. Sex ratios among the tagged and untagged pinks that reached the Fence in 1952 indicated a greater loss of female pinks than of males. However, pink salmon spawn in rivers, and important numbers may have done so in the Babine River in 1951 and 1952, both above and below the Slide.

Most of the coho run of 1952 reached the Slide after conditions there had improved, with the result that they probably suffered relatively small losses. The ratio of males to females among tagged coho at the Fence, and also among untagged dead coho that drifted back onto the Fence from the river above it, were approximately equal. This was taken as an indication that neither sex had suffered a disproportionate loss at the Slide in 1952.

In both years there were heavy losses among fish that had succeeded in passing the Slide and entering the Babine Lake spawning grounds. Less information on this situation was available for 1951 than for 1952, but reports did indicate that such losses in 1951 were not as serious as in the following year.

In 1952, 40,000 dead sockeye drifted onto the Babine Fence from the river above it. Almost 70 percent of the females in this group had not spawned. A large number of dead sockeye, among which was a substantial proportion of unspawned fish, was observed along the shores of Nilkitkwa Lake (which extends for about 7 of the 10 miles between the Fence and Babine Lake). Although some of these had doubtless spawned in the 2-mile long Upper Babine River between Nilkitkwa and Babine Lakes, this number of dead in Nilkitkwa Lake was considered abnormal, particularly in view of the very small escapement from the Slide in 1952. Unspawned sockeye were also found among the dead examined on the spawning grounds.

On the basis of the proportions of unspawned females in the samples of dead examined, it was estimated that of the female sockeye that reached the spawning streams in 1952, only between 60 and 70 percent had spawned.

The proportion of the 1952 sockeye run at the Fence which reached spawning streams was estimated by comparison of tag recoveries from streams that year with corresponding recoveries in two earlier years. In 1946 and 1947 the Fisheries Research Board had tagged proportionate numbers of the sockeye run as it passed through the Fence, and had conducted stream surveys to recover tags. Recoveries of tags from spawning streams in 1952 amounted to only 50-60 percent of the proportions recovered in 1946 and 1947. Thus it was estimated that in 1952 only between 50 to 60 percent of the sockeye run at the Fence reached their customary spawning streams.

From the estimates of the proportion of the 1952 sockeye run which reached customary spawning streams, and of the proportion of the females among these that had spawned, it was calculated that:

(a) 30-42 percent of the 1952 female sockeye that passed through the Fence spawned effectively.

(b) the number of female sockeye that spawned in 1952 was 22-31 percent of the average for Babine Lake female sockeye.

(c) 7-10 percent of the Babine escapement of female sockeye from the fishery spawned in their customary streams.

Resiliency of salmon populations—the production of more young salmon per spawner from reduced spawning populations—has been demonstrated, for example, for pink salmon (Pritchard, 1948b). Withler (1953) has estimated the production of sockeye smolts in Babine Lake in 1953 from the spawning of 1951. Although the potential spawning population of female sockeye in 1951 was reduced by two-thirds compared to the potential spawning populations of females in 1949 and 1950, the production of smolts from the 1951 seeding was only a third less than that of the two earlier years.

Babine sockeye runs usually have substantial numbers of age III, IV and age V fish only, so that only the year 1956 should have nearly all of its adults (exclusive of jacks) come from the two Slide years.

Because of the compensatory increase in survival rates when stocks are low, and in view of the usual age composition of Babine sockeye, it is anticipated that the effects of the Slide upon the Babine sockeye should not extend seriously beyond the second generation. Fishery restrictions may be necessary to protect the Babine sockeye runs of 1956, and perhaps of 1955 and 1957 also. However, the decision should await knowledge of the production of smolts in 1954 from the 1952 seeding.

Although pink salmon were affected by the Slide even more seriously than were sockeye salmon, adequate numbers may have spawned successfully in the Babine River above or below the Slide. From these a rapid recolonization upward may proceed, now that the Slide has been removed.

ACKNOWLEDGMENTS

The discovery of the Babine River slide, the survey of its physical and biological significance, the planning to overcome it and the final removal involved many individuals whose participation affected the biological projects profoundly.

In a large undertaking one of the most onerous tasks is the coordination and administration, for which much credit is due to Mr. A. J. Whitmore, Chief Supervisor of Fisheries, and to Dr. J. L. Hart, Director of the Pacific Biological Station, both of whom maintained close and active interest. Division Engineer C. H. Clay, a man of wide experience with both physical and biological problems of obstacles to salmon migration, was in charge of engineering aspects of the work. Regional Supervisor G. S. Reade, responsible for the area, brought his extensive personal experience to the administration of the project, and Dr. R. E. Foerster, in charge of the Pacific Biological Station sockeye salmon investigation, immediately swung the Babine area program toward solving the problem.

The Babine River Committee, composed of Mr. Clay, Consulting Engineer M. C. Bell, Dr. Foerster, Biologist W. R. Hourston and Fishery Officer W. K. Elliott encouraged the biological program on the Babine River through their knowledge of methods and organization. Engineer J. Dyson, in organizing the local assault on the Slide, constantly supported the tagging crews by providing equipment, and when necessary men, for the tagging and sampling project on the Babine River.

To Fishery Officer H. Giraud and Dr. Ferris Neave of the Pacific Biological Station goes the credit for first sighting the Slide from an aircraft in August, 1951, following observations of Officers Giraud and W. K. Elliott upon damaged fish in the Hazelton area.

At the Babine River Fence, Biologists K. V. Aro and E. Dombroski did much of the work of recovering tags and examining dead sockeye. They also assisted in the compilation of Fence and tag recovery data. Information concerning salmon above the counting Fence, upon which one large section of the Report mainly depends, comes from surveys conducted by Fishery Officer L. J. Gelley, Mr. R. Crouter and assistants on the Babine Lake spawning grounds.

The International Pacific Salmon Fisheries Commission kindly loaned certain equipment items to the project, and also the services of Mr. H. S. Dunlop. Similarly the fishing industry operating at the mouth of the Skeena River generously donated nets for use in catching salmon for tagging.

Seasonal assistants employed at both the Babine River and the counting Fence carried out much hard work involved in tagging and recovery. The river tagging, an exacting task under the best conditions, often was made more difficult by unpleasant weather conditions and by the precipitous and unstable nature of the Slide area. At the Fence, which is geared to handle adequately normal runs to Babine Lake, the recovery of tags and additional sampling of the runs taxed the efforts of men who worked there.

Finally Dr. W. E. Ricker, Editor for the Fisheries Research Board of Canada, took a prominent part both in planning the program and in analysing the results.

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