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MORICETOWN FALLS AS A HAZARD
TO SALMON MIGRATION

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INTRODUCTION

In any salmon conservation programme the successful escapement of the mature adults to the spawning grounds in fresh water is an important factor. The presence of any obstruction which might totally bar the fish or merely delay their ascent upriver may be of appreciable significance. With this in mind the present study of Moricetown falls, known to be one of the possible major obstructions to the upstream migration of Pacific salmon in the Skeena river system, was undertaken by the Fisheries Research Board of Canada as part of the Skeena River Salmon Investigation.

Moricetown falls is situated about thirty miles southeast of the village of Hazelton on the Bulkley river, one of the main branches of the Skeena river, British Columbia. The Bulkley river is an important spawning tributary for the commercially valuable Pacific salmon. The falls (fig. 1) present a twenty foot drop of fast cascades at the upper entrance to a deep narrow canyon which constricts the river channel for about one quarter of a mile (fig. 2).

The falls have long been noted for the thrilling spectacle of jumping salmon fighting their way to the spawning grounds in the upper tributaries of the Bulkley river as well as for the excellent sport fishing provided by the coho salmon and steelhead trout in the pool below the canyon. For many years the Indians from the surrounding reservation have taken advantage of the physical conditions at the falls to procure salmon for food. The fact that the river channel concentrates the salmon sufficiently to provide an excellent opportunity to catch them, has constantly raised the question as to how much of a hazard the falls present to the spawning migration of each species of salmon.

It is known that the species of salmon differ in their ability to surmount such an obstacle. The spring and coho salmon are usually more successful than the sockeye and pinks. From past records it is evident that the amount of water flowing in the Bulkley river varies from month to month and from year to year. The problem of determining the severity of the blockage depends, then, on both the species concerned and the amount of water passing over the falls during the period when the salmon are present. Accordingly, during the three years 1945 to 1947 the water levels were recorded, the size of the Indian catches was obtained, tagging experiments were conducted and the behaviour of each species at the falls was observed.

WATER CONDITIONS IN THE BULKLEY RIVER

The mean monthly discharge rates for the Bulkley river recorded at Quick from 1915 to 1917 and from 1930 to 1942, and at Hagwilget from 1915 to 1918 and 1928 to 1942 have been published (Dominion Water and Power Bureau,

1946). Since 1942 the readings at Hagwilget have been discontinued. Fig. 3 shows the average of the mean monthly discharge rates at Quick and Hagwilget for the years 1915 to 1942. In addition the range of the monthly means at Hagwilget is indicated and the years in which the maxima and minima occurred are noted. As the stations at Quick and Hagwilget are approximately 30 miles above and below Moricetown falls respectively, the average mean monthly discharge at the falls is interpolated halfway between the two values recorded. The peak discharges occur during June and November with the spring floods having more than twice the discharge of the fall freshets.

The salmon migrate during the period of decreasing water flow from June to October. At this period the water level in the canyon below the falls drops from 5 to 10 feet and becomes so low in the northwest channel of the falls that the salmon are forced to ascend the main falls, which present a serious obstacle to all species. Due to the variation in discharge which occurs each year the spawning runs of salmon are faced with different conditions at the falls depending on the development of the low water conditions. During the survey the lower part of the range of the discharge rates was apparently studied judging from the data recorded at Quick. For example, the August and September mean monthly dis-



FIGURE 1. Main portion of Moricetown falls from below. Note the two coho salmon jumping.

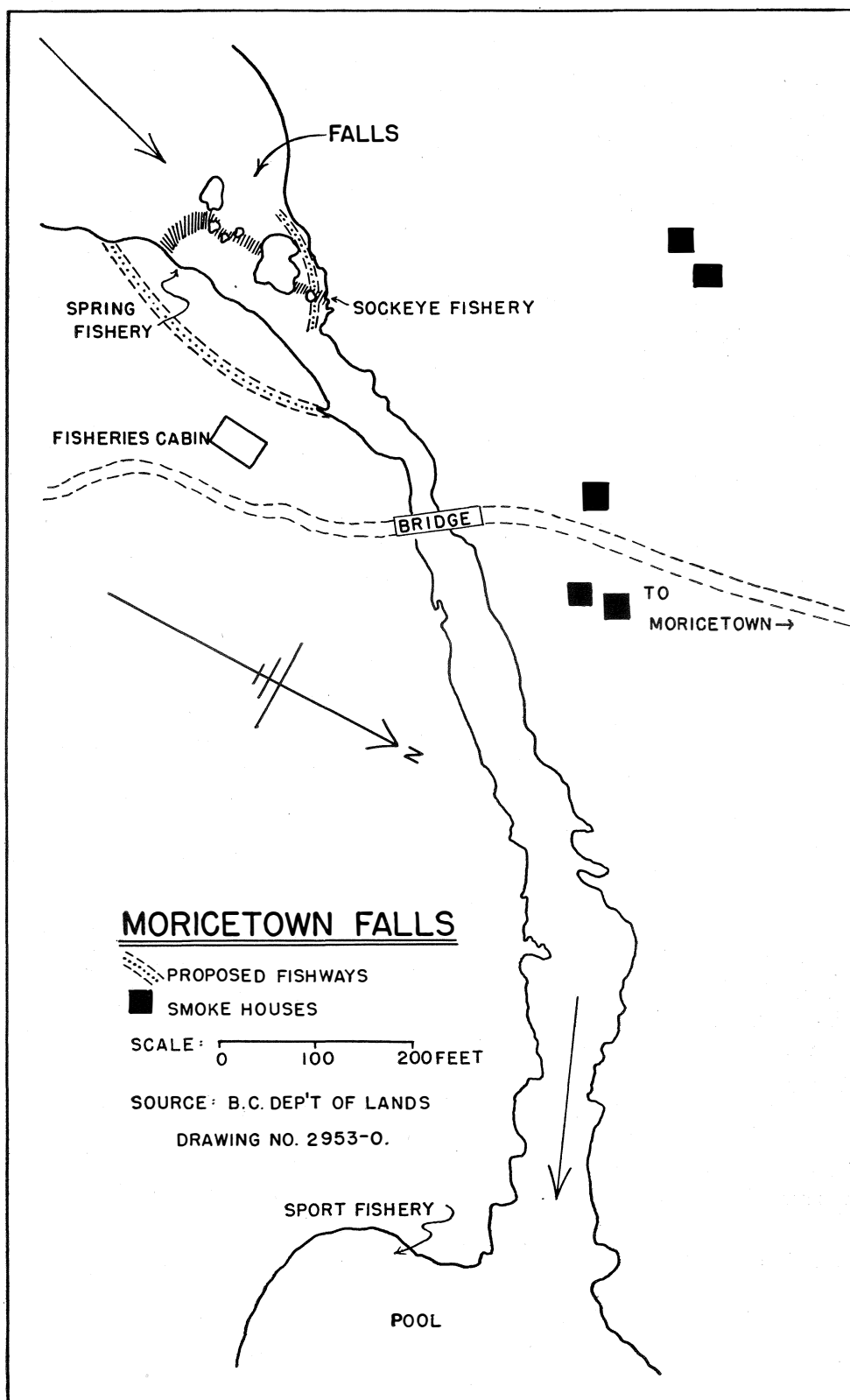


FIGURE 2. Map of Moricetown falls and canyon on the Bulkley river, B.C.

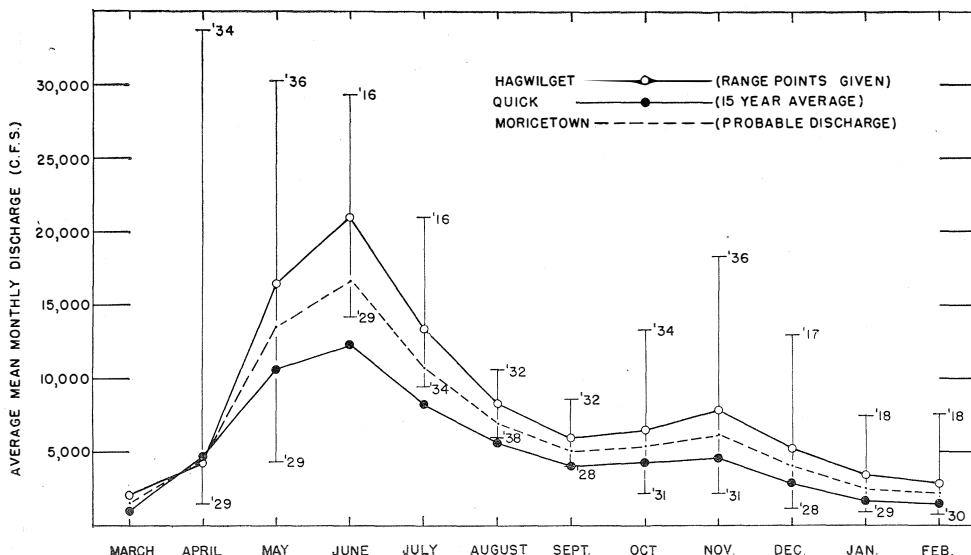


FIGURE 3. Average of the mean monthly discharge in cubic feet per second at Hagwilget and Quick on the Bulkley river. The probable discharge at Moricetown falls is also indicated,

charges in cubic feet per second (obtained by correspondence from the Dominion Water and Power Bureau) for 1945 were the lowest on record and those for 1946 and 1947 were also below the means recorded for the past fifteen years as follows:

	<i>August</i>	<i>September</i>
1930-1944	5610	4100
1945	4220	2620
1946	4770	3050
1947	4610	3550

EFFECT OF THE FALLS ON THE SALMON RUNS

In order to determine the extent to which the falls present a hazard to the salmon runs it was necessary to obtain data on the movements of the fish both by observation and tagging experiments at the different water levels encountered. The severity of the hazard depended on the volume of discharge in relation to the time of the runs of the various species.

GENERAL OBSERVATIONS

Estimates of the time and relative size of the migration runs of each species at the falls, shown in fig. 4, were based on observation and on the daily counts of fish caught by the Indians for food. The following total annual catch for each year was recorded by the Dominion fishery guardian stationed at the falls:

	<i>Sockeye</i>	<i>Spring</i>	<i>Coho</i>	<i>Pink</i>
1945	17,300	520	1,310	10
1946	8,500	810	3,470	10
1947	3,300	1,150	2,510	560

It should be borne in mind that the number of the more highly prized spring and sockeye salmon caught determines the effort devoted to catching coho and particularly pink salmon so that the size of the Indian catch alone does not indicate the size of the population. The time of the run varied both between and within each species in each of the three years.

The 1946 and 1947 water level records shown in fig. 4, were taken each day by reading a sounding line lowered from the bridge below the falls to the surface of the water. The water levels for 1945 were translated from readings taken each day from stakes set in the river above the falls in 1945 and 1946. By observation the water passing through the northwest channel became critical to the passage of fish on August 20 in 1945, September 7 in 1946 and not at all in 1947. Fortunately by this time in each year the runs of both spring and sockeye were almost over. In the three years under observation the water level varied about five feet during September although in the lowest year, 1945, only two observations were made on September 4 and 27 respectively. At the latter date there were many spring, sockeye, coho and pink salmon still present in the pool so that it now seems likely that 1945 was the most severe year in that all species were held up to some extent by the falls.

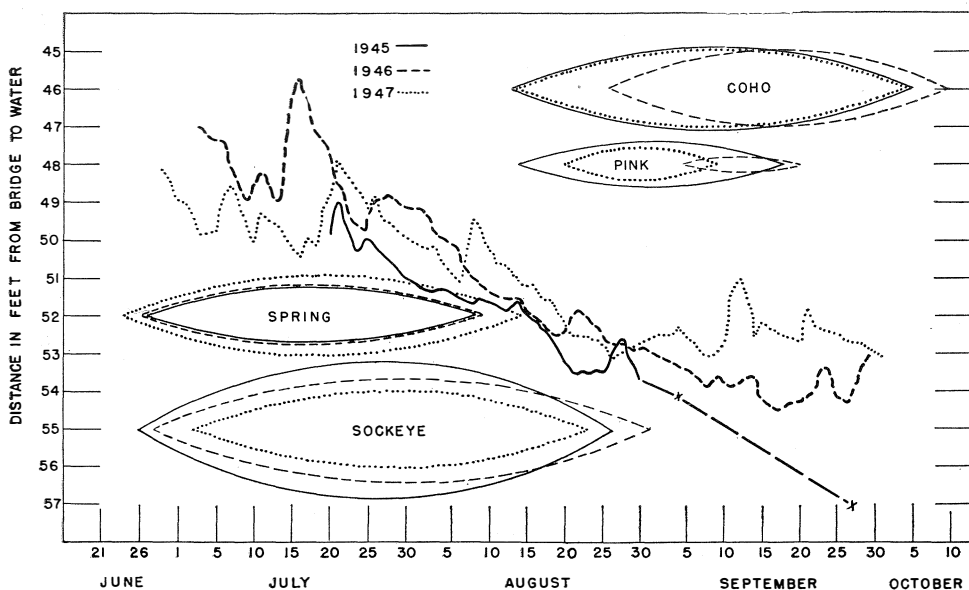


FIGURE 4. The relative size and duration of the salmon runs of each species and the daily water level readings at Moricetown falls in 1945, 1946 and 1947. Note that only two readings were made in September, 1945.

In 1945 and 1946 observations on the temperature and turbidity of the water were recorded and a few attempts were made to count the fish surmounting the

falls by way of the northwest channel. The daily water temperature varied as much as 2°C. with the warmest water occurring in the evening. The temperatures during August ranged from 11° to 17°C. The turbidity of the water prevented observation of the fish in more than four feet of water until August 3 in 1945, August 8 in 1946 and August 22 in 1947. From these preliminary observations on the variation of water temperature and turbidity no effect on the migration of the salmon could be ascertained.

In 1945 a few spot counts of three minutes' duration taken at intervals throughout the day indicated that near the peak of the run on August 3 approximately 4,000 sockeye were passing through the northwest channel of the falls each day. By August 19 only about 300 fish were estimated to be passing each day, most of which were coho salmon. In 1946 the few spot counts made when the water was clear indicated that the daily variation in the intensity of the run was diurnal, with peaks in the morning and afternoon. This would be comparable to the more accurately described migration found at Skutz falls (Neave, 1943).

As it was not feasible to count the numbers of fish involved it was difficult to determine the degree of success or failure of the fish in ascending the falls. However in 1945, the year in which the delay was most evident, the number of sockeye in the pool appeared to remain in proportion to the size of the run as the season progressed. Thus, despite the delay, most of the sockeye must have been able to surmount the falls. By the end of September many salmon were still in the pool, very few were jumping below the falls and none were observed ascending the falls. At this time approximately 5% of the salmon in the pool were large springs bearing numerous scars around the region of the head. These scars, badly infected with fungus, were presumably the result of many futile attempts at the falls. In some cases the fish had become so blind that they could not be disturbed by dropping stones near them. Among the 10% which were sockeye, three pairs of the more mature specimens were observed attempting to spawn in the coarse gravel. In a year of more normal water conditions the last specimens of both these species would probably have migrated past the falls a month previously. Unfortunately nothing is known as to the final fate of these fish. The pink salmon, comprising 30%, appeared to be spawning successfully both in the pool and in the river below the falls. Few fish of this species had previously been observed to ascend the falls in order to utilize the suitable spawning areas in the upper Bulkley river. The remaining 50% was composed of coho salmon fresh from the ocean. As these are notably better jumpers than either sockeye or pink salmon most of them no doubt were able to surmount the falls during the freshets occasioned by the fall rains.

TAGGING EXPERIMENTS

In order to obtain more accurate information on the length of time the salmon were delayed by the falls, the number of fish present and if possible the proportion which successfully surmounted the falls, a tagging programme was carried out each year during July and August. Particular care was taken to handle the sockeye salmon but some data were obtained incidentally on the other species.

METHODS

The salmon were caught by means of a dip net at the various fishing sites used by the Indians directly below the falls. In 1945 the tagging was done throughout the week at various locations as the opportunity presented itself. In 1946 and 1947 all the fish were tagged at the most suitable fishing site in the lower portion of the northwest channel and only during the periods when fishing was closed to the Indians, namely on Wednesday afternoons and on Sundays. This resulted in a more uniform tagging, although the fish tagged are selected as to size since the dip nets tend to catch more small fish.

The tags were of the celluloid-button type and were attached through the body of the fish below the dorsal fin by means of a non-corrosive nickel pin. In both 1945 and 1946 white opaque discs were employed. The tagging in 1947 was similar to that in 1946 except that alternate fish were tagged with clear transparent discs in an attempt to determine the amount of selective fishing for tagged fish by the Indians.

The fish tagged were all in good condition except for a few which bore evidence of previous attempts at capture by either the commercial gill nets at the coast, the Indian set-nets in the lower Skeena or the Indian gaff-hooks at Hagwilget or Moricetown canyons. In 1945, 1946 and 1947 the percentages bearing gill net marks were 5.8, 6.1 and 3.0, and those bearing gaff marks 2.1, 6.3 and 6.0 respectively. Towards the end of the run a few mature fish were tagged which were less active.

A reward of fifty cents was offered for each recovery accompanied by complete data of time and place of capture. Because the northwest channel was the most favoured site for the Indian fishing the majority of the tags were recovered there. Since the gaffs tend to catch large fish the tag recoveries are selected as to size of fish. Inasmuch as both the fish tagged and recovered are selective samples, particularly in 1947, the results cannot be used for absolute estimates of population size but relative estimates have a comparative value from year to year. Unfortunately few fish or tags were taken above the falls for the Indians fish little in the upper Bulkley and the recovery of tagged fish on the spawning grounds is rendered most difficult by their inaccessibility and the siltiness of the water.

The probable behaviour of the fish after tagging appears to be that they drop down the canyon to rest in the pool before attempting to ascend the falls again. This is borne out by the fact that few tags (nine by Indians and one while tagging) were retaken in 1945 on the same day as tagged although the Indians made every attempt to catch tagged fish while the tagging operations were in progress. This was avoided in 1946 and 1947 when the fish were tagged only during the closed fishing periods. No doubt untagged fish which have failed to surmount the main falls similarly retire to the pool to rest before trying again. In returning up the canyon they appear to try either side, for the fish which were tagged on both sides in 1945 were recaptured at the northwest passage in about equal numbers. Thus it appears that most sockeye eventually locate the northwest passage and if not disturbed by tagging or recapture would probably be able to surmount the falls.

Because both the tagging and return of the majority of the tags took place directly below the falls at the foot of the most suitable passage, the number of days out indicates only the total period of delay due to tagging and locating this most favoured channel again. The delay caused by tagging is probably small (part of a day) compared to the latter. Since the absolute periods of delay of the fish by the falls were not obtained the relative periods of delay after tagging both within and between seasons for each species must be used. The relative periods are from two to ten times longer than in similar tagging experiments conducted below the fish-counting fence on Babine river.

TAGGING EXPERIMENT IN 1945

From July 19 to August 26 a total of 811 salmon were tagged at the falls. The numbers of each species tagged and later recovered are as follows:

	No. tagged at falls	Number returned				Total	%
		At falls	Above falls	Below falls			
Sockeye.....	675	165	—	9		174	25.7
Coho.....	81	12	—	—		12	14.8
Spring.....	22	1	1	—		2	9.1
Pink.....	33	1	—	—		1	3.0

Of the 811 fish tagged the majority were released directly below the falls where they were tagged. However, from July 22 to 24 twenty-five sockeye were caught below the falls, tagged, and then released above. Only two were recaptured below the falls, 6 and 57 days later. None of these fish was recovered above the falls. In fact of all the fish tagged only one jack spring was recaptured above the falls, 21 days later in a gill net set in Morice lake. Thus it was impossible to ascertain the percentages which successfully surmounted the falls and the periods of delay below the falls give the best indication of the blockage.

Nine (5%) of the tagged sockeye were recovered from distances below the falls varying from 2 to 70 miles and with times out of from 6 to 38 days: four in the lower Bulkley river between Moricetown and Hazelton, a distance of 30 miles, three in the upper Skeena within 15 miles of Hazelton and two in the lower Skeena within 40 miles of Hazelton. Two of these fish were in poor condition as a result of the gaffing practised by the Indians but the remainder were reported to be normal.

Of the 165 sockeye captured at the falls twelve have already been dealt with, two in connection with releases above the falls and ten recaptured the same day as tagged. The period of delay below the falls for the remaining 153 is presented in fig. 5 which indicates both the date of tagging and the date of return. It should be noted in these sockeye returns that the delay period increased markedly after August 20 when the water in the northwest channel reached a critically low level. The average number of days out was 6.7.

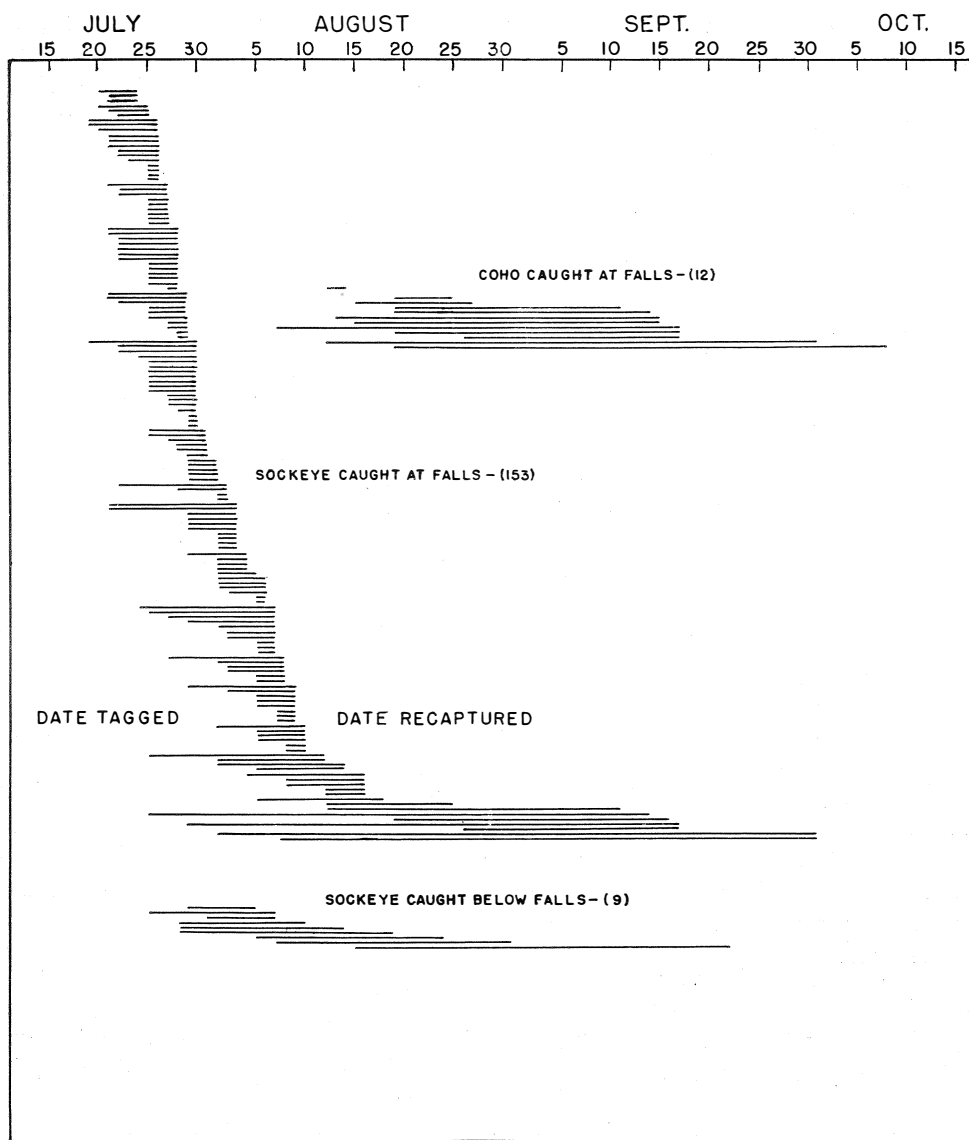


FIGURE 5. Number of days out for sockeye and coho salmon tagged at Moricetown falls in 1945. The returns are listed in order of recapture.

In an attempt to estimate the size of the sockeye population passing Moricetown falls it should be noted that from July 19 to August 25 the Indians caught 10,577 sockeye which bore 162 tags. If the 650 tags are considered to be randomly distributed then approximately 42,000 sockeye were present. As 6,707 sockeye had been caught prior to July 19 the total for the season might approximate

70,000. However, an adjustment for extra tags should be made as a few of the Indians, particularly during the latter part of the season, were observed to fish selectively for tagged fish (one young lad admitted catching 5 tags in 20 fish). This correction might raise the estimated total population to 85,000 sockeye.

Of the 81 coho salmon tagged between August 5 and August 26 only 12 were recovered and the days out are shown in fig. 5. The percentage recovery was low (14.8%) because, as the Indians had taken a larger number of sockeye than usual, the Fisheries guardian curtailed the number of fish per man per day to 10 after August 20. Prior to this date only one tagged fish had been recovered. However, it is clear that the tagged coho were delayed much longer than the tagged sockeye as the average days out was 27.4 with a variation of from 2 to 50 days. Thus the low water conditions in late August and September provided a serious obstacle even to these splendid jumpers. Although detailed observations were not made in October and November, undoubtedly many coho were able to surmount the falls during this period when the water rose as a result of the fall rains. Due to the paucity of data it is impossible to estimate the size of the coho run.

Concerning the 22 springs tagged little can be noted except that one was recovered at the falls two days after tagging and one, already mentioned, was taken above the falls at Morice lake. It should be mentioned that for this species most of the tags were placed on the small males or "jacks" while the Indians caught mainly much larger specimens. Judging from the Indian catch the migration lasted from July 1 to August 10 during which time the falls were reasonably passable so that the majority of the springs probably surmounted them without too much delay.

Few pinks were tagged and only one was recaptured on the same day as tagged. The Indians seldom attempt to capture this species for food. As the water was low during the period when the pink salmon were migrating from August 15 to September 15 and as the mature specimens are noticeably handicapped in fast water the majority must have spawned below the falls. Thus only a few of the earliest arrivals were able to surmount the falls.

TAGGING EXPERIMENT IN 1946

From July 8 to September 8 a total of 1,280 salmon were tagged and released below the falls. The number tagged and returned for each species are as follows:

	No. tagged at falls	Number returned				
		At falls	Below falls	Above falls	Total	%
Sockeye.....	942	175	18	—	193	20.4
Coho.....	260	8	6	2	16	6.2
Spring.....	76	3	—	—	3	3.9
Pink.....	2	—	—	—	—	—

Included in the 175 sockeye tags returned at the falls are ten which were recaptured while tagging and one which was caught by a sportsman. The remainder were caught by the Indians at Moricetown. Of the 18 tagged sockeye recovered some distance below the falls four were caught in the lower Bulkley, six in the

Skeena above Hazelton and eight below Hazelton at locations similar to those in 1945. The percentage so caught (9.3) is almost twice as great as that in 1945.

The periods of delay at the falls for the 164 sockeye recaptured are shown in fig. 6. The times out were less than in 1945 particularly during the later part of the run in late August. As a result the average number of days out, namely 5.1, was lower by 1.6 days. Less difficulty of ascent was also observed at the falls

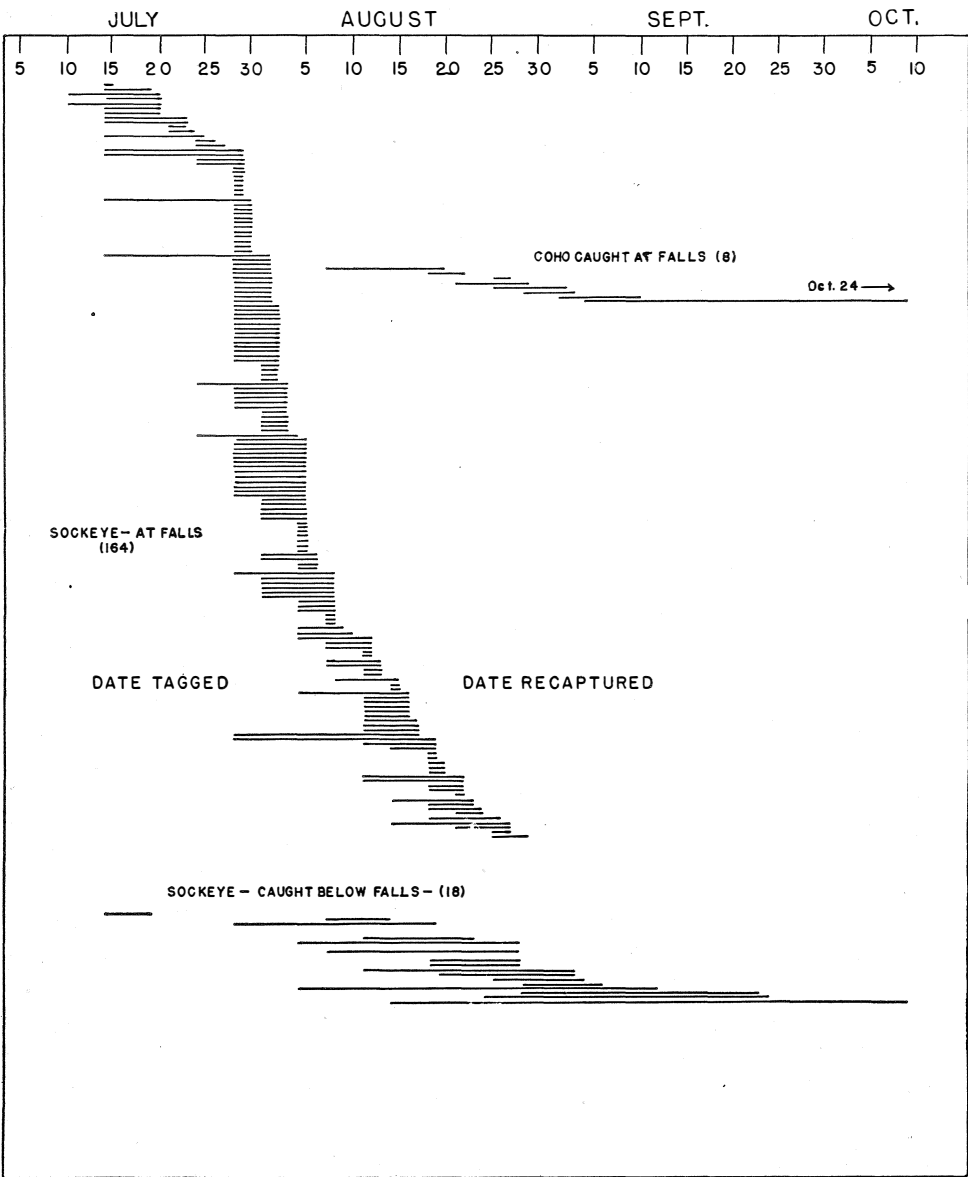


FIGURE 6. Number of days out for sockeye and coho salmon tagged at Moricetown falls in 1946.

throughout the summer and fewer sockeye were seen holding over in the pool in September. An estimate of the size of the sockeye population indicated that the run may have approximated 50,000, compared to 70,000 in 1945.

The coho tags were also returned within a much shorter period with an average time out of 13.0 days or about one half of that in 1945. However, the fact that six tags were recovered up to a distance of 60 miles below the falls indicates that the falls probably interrupts the spawning migration to some extent.

The small return from the spring salmon tagging and the scarcity of pinks to tag add little new information. Since there were only about one quarter as many fish in the pool in late September the delay in 1946 must be rated as less than that of 1945.

TAGGING EXPERIMENT IN 1947

From July 9 to August 27 a total of 1204 salmon were tagged at the falls in the same manner as in previous years except that alternate fish were tagged throughout the season with *white* opaque tags which were visible and with *clear* transparent tags which were not visible. This was done in an attempt to determine how selective the Indians were in fishing for tags. The number of each type tagged and returned is given in table I.

TABLE I. Number of salmon of each species tagged with each type of tag at Moricetown falls and the recoveries in 1947.

Species	Type of tag	Number tagged	Number returned						
			At falls		Below falls	Above falls	Total		
			By Indians No.	%					
Sockeye.....	Clear	356	40	11.2	12	5	2	59	16.6
	White	385	61	15.8	6	3	3	73	19.0
Coho.....	Clear	111	9	8.1	1	-	-	10	9.0
	White	117	18	15.4	1	2	1	22	18.8
Spring.....	Clear	83	6	7.2	4	-	2	12	14.5
	White	77	9	11.6	-	-	1	10	13.0
Pink.....	Clear	35	2	5.7	-	1	-	3	8.6
	White	40	4	10.0	-	1	-	5	12.5
Totals.....	Clear	585	57	9.7	17	6	4	84	14.4
	White	619	92	14.8	7	6	5	110	17.8

The white visible tags (14.8%) were in the aggregate returned by the Indians more often than the clear non-visible tags (9.7%). However, it varies for each species, with the sockeye showing a difference of 4.6% and the coho 7.3%. The higher selection in the case of coho is probably due to the fact that later in the season the water is low and clear and as the Indians have caught most of their

winter's food supply they look more diligently for tagged fish. Why such a high proportion of clear tags were recaught while tagging spring and sockeye early in the season is difficult to understand for no attempt was made to capture tagged fish of either type and in other years few tags were recaught. Considering the total of all the tags returned, wherein 17.8% of the visible tags and 14.4% of the non-visible tags were caught, the selection of tagged fish is not so excessive that it renders the returns meaningless. The swift, deep and murky water tends to prevent much selection of tags except in the case of coho salmon.

Some of the eight sockeye tags returned from below the falls were found at greater distances than in previous years. Two were taken in the upper Skeena within ten miles above Hazelton while two were observed at the counting fence operated on Babine lake, a distance of at least 150 miles. The remaining four were taken in the lower Skeena river, three within 20 miles of Hazelton and one was caught a distance of about 100 miles below. This is contrary to the results of the

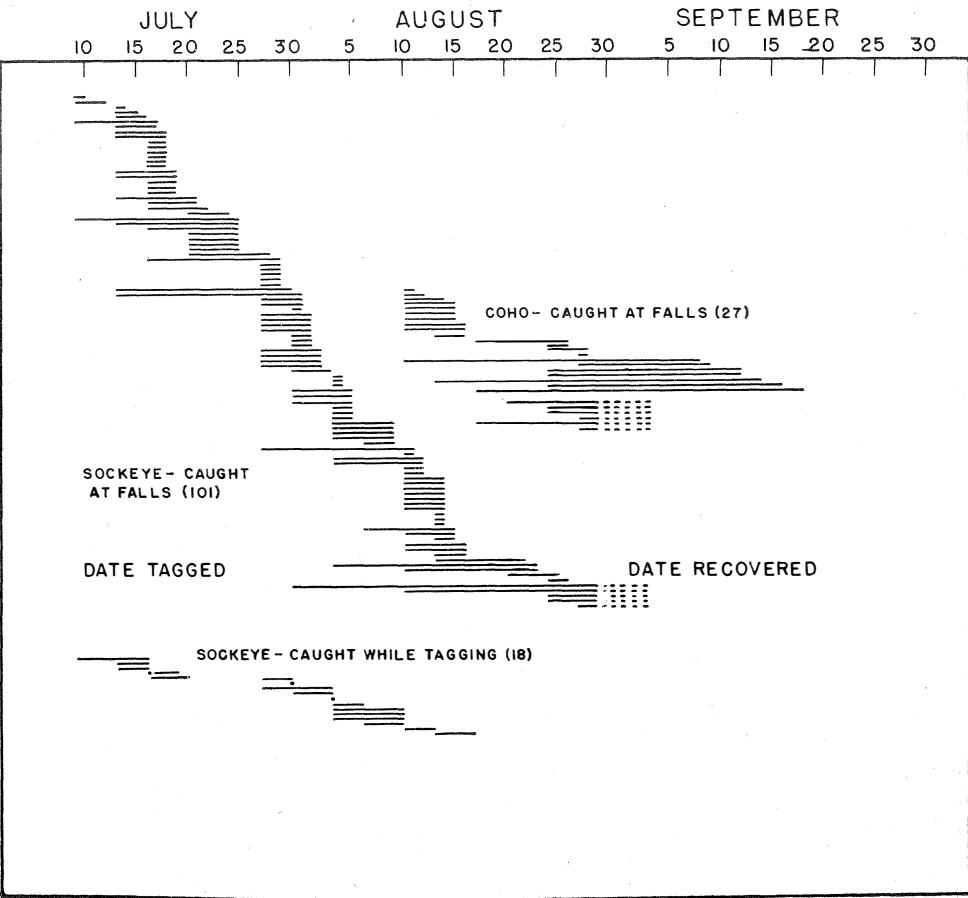


FIGURE 7. Number of days out for sockeye and coho salmon tagged at Moricetown falls in 1947.

delay experiments conducted below various counting fences on the Skeena in which all fish eventually passed through the obstruction rather than seeking other areas in which to spawn. Five sockeye were also returned from 30 miles above the falls, an average of 17.2 days after tagging. These fish must have been delayed by the falls for some time after tagging for the sockeye which were tagged in the ocean 230 miles distant require an average of 19.7 days to reach Moricetown falls and thus should probably reach a point 30 miles above the falls in an average of 3.5 days after tagging.

The days out for the 101 sockeye and the 27 coho recaptured at the falls are shown in fig. 7. The average days out of 5.5 for sockeye and 10.0 for coho indicate that the delay was more comparable to 1946 than to 1945. Again few fish were observed held up below the falls in late September.

In 1947 the sockeye run to the Skeena river contained an unusually large proportion of small precocious males or "jacks", particularly toward the end of the migration. Of the 741 sockeye caught at Moricetown for tagging purposes, 214 (29.0%) were jacks less than 19 inches in length. The few scales which have been read indicate that these fish were all four years old and had spent two years in fresh water. The dip net used for tagging was no doubt selective to these small fish. On the other hand the Indian gaffs were probably selective to large fish as the Indians caught only 8% of the tagged jacks and 16% of the larger fish tagged. Thus neither the fish tagged nor returned were probably as representative of the whole population as in the previous two years.

On the basis of the return of 101 tags out of 741 fish tagged while catching 3,250 fish, the sockeye population is estimated at 24,000 compared to 50,000 in 1946 and 70,000 in 1945. If corrections are made, (1) for tag selection, then 84 tags or 11.2% of the 741 tagged fish should be considered recaptured instead of 101 and (2) for jack selection, then the catchable number of fish tagged should be considered as 634 or 741 less one-half of the 214 jacks tagged. As these corrections cancel each other in 1947 the population estimate remains at approximately 24,000.

The few returns from the coho, spring and pink salmon depict a situation similar to that which obtained in the previous two years. The effect of the falls in 1947 must be rated more similar to 1946 than to 1945.

DISCUSSION

Both observations and tagging experiments carried out from 1945 to 1947 have indicated that all species of salmon were delayed at Moricetown falls for various periods. Also that the severity of the block increases with the low water levels which occur in August and September. This situation differs from that described for Hell's Gate on the Fraser river wherein the maximum blockage occurs at intermediate water levels (Thompson, 1945). Since the August and September discharges in recent years, particularly in 1945, have been lower than the average of the past fifteen years, the effect of the falls should be more serious at the present time.

Although a complete blockage has not been demonstrated for any species, as a few pink salmon were able to surmount the falls each year, nevertheless the period of delay below the falls does enable the Indians to catch salmon with extreme ease. This is particularly noticeable for sockeye in a year such as 1945 when the water was low. Over the three years under discussion the Indians returned from 15% to 25% of the tagged sockeye. From counts taken each year approximately 35% of the fish which were gaffed struggled off the hooks in a damaged condition. Thus in some years it appears possible that as much as one third of the total run may be caught and damaged by the Indians. To this must be added the unknown number which either fail to surmount the falls and return downstream or are delayed so long that they attempt to spawn elsewhere than on the suitable grounds of the numerous tributaries far above the falls.

In order to alleviate any unnecessary delay of salmon below the falls and to make the passage more readily surmountable it appears highly desirable that consideration be given to the providing of suitable fishways over or around Moricetown falls. The two locations which seem practicable for fishways are indicated in fig. 2. The passage on the west bank now operates as a natural fish ladder except at low water in late August and September. The site on the east bank is dry except at high water in May and June before the main salmon runs have arrived. Of the two locations the former should present the better and more economical site for the construction of an efficient fishway. The gaffing of salmon as practised by the Indians below the falls might be either replaced by the type of dip net now in use on the Fraser river or by some other method of capture in order to eliminate the wanton destruction of the remaining salmon runs.

SUMMARY

From a study of the returns from 3,329 tagged fish, the behaviour of each species at the falls, the incidence of low water conditions and the size of the Indian catches during the three years from 1945 to 1947, Moricetown falls has been shown to delay the migration of all species of Pacific salmon. The degree of blockage varied with each of the four species of salmon present and was found to increase in severity during low water periods. These occur in August and September which coincides with the latter part of the spring and sockeye salmon migrations, and with almost the full duration of the migrations of the coho and pink salmon.

The average days of delay for tagged fish in the three years was 5.8 for sockeye and 16.8 for coho. Each year most of the springs but only a few of the pinks were able to surmount the falls. The majority of the pinks were forced to spawn below the falls. The most severe hazard was presented in 1945 when the water was the lowest recorded since 1915.

It is recommended that consideration be given to the construction of an efficient fishway in order to facilitate the passage of salmon during the low water period and that the wastage occasioned by the Indians gaffing for salmon below the falls be eliminated.

ACKNOWLEDGEMENTS

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