Timing of Babine Lake Sockeye Salmon Stocks in the North-coast Commercial Fishery as Shown by Several Taggings at the Babine Counting Fence and Rates of Travel through the Skeena and Babine Rivers

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FISHERIES RESEARCH BOARD OF CANADA

TECHNICAL REPORT NO. 418

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TIMING OF BABINE LAKE SOCKEYE SALMON STOCKS IN THE NORTH-COAST COMMERCIAL FISHERY AS SHOWN BY SEVERAL TAGGINGS AT THE BABINE COUNTING FENCE AND RATES OF TRAVEL THROUGH THE SKEENA AND BABINE RIVERS

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Pacific Biological Station, Nanaimo, B.C.

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INTRODUCTION

Effective management of commercially exploited multi-stock salmon runs usually depends upon knowing their numerical strength in the fishery annually and obtaining desired escapements by regulating exploitation of major components. This calls for a reliable means of stock identification and in the past considerable research has been devoted to this goal. Unfortunately while morphological, meristic or other "stock specific" characteristics have sometimes been available, the concomitant sampling and analysis has often proven too slow for effective day-to-day application.

By contrast, knowledge of the time and order of arrival of stocks in the fishery has continuing application because timing along migration routes and on the fishing grounds tends to be similar each year (Milne 1955; Royce MS 1965). When a stock arrives early or late so generally does the entire run and so the sequence of arrival and length of time in the fishing area are apt to be little changed.

Approximate timing of Babine Lake stocks in the fishing area has been shown by tagging there and in the Skeena River estuary, and recovering tagged fish on Babine Lake spawning grounds (see Takagi and Smith MS 1973 for a summary). However, mixing with other major stocks in the tagging areas, removal of some tagged fish by recapture before they reached the river, and other causes have resulted in too few recoveries in some stocks to permit the precise management required in the intensive fishery.

Precision can be improved by utilizing data from numerous spawning ground recoveries of fish tagged at the counting fence at the outlet of Babine Lake. Seven such taggings indicate stock timing at the fence which can be back-plotted on the basis of estimated lapsed time between tagging sites and the fence to improve the picture of timing obtained by the estuarine taggings alone.

The purpose of this manuscript is to summarize the results of the "fence" taggings to estimate the most probable time and sequence of arrival of stocks there, and provide a best estimate of their time in the fishery by back-plotting according to the "outside" tagging programs. Data from several years of tagging of seaward migrants are also useful for estimating timing and we have also used this information in considering the possibility of exploiting Babine stocks at different rates on the basis of their different timing in the commercial fishery.

The Babine River counting fence was installed in 1946 (Aro MS 1961) and total counts of all species of salmon have been obtained there in most years since. There are about 15 sockeye stocks in the Babine system (Miki and Smith, unpublished MS) and more than 90% of the fish pass the fence during a 2-month period from July 20-September 5 each year (Jordan and Smith MS 1972). Figure 1 shows locations of spawning grounds of Babine sockeye stocks.

METHODS

Tag types, tagging rates and recovery effort differed among years because objectives were not always the same:

1946

Tagging was undertaken in the first year of fence operation to assess migration rates through the lakes and discover any differences in time of passage of stocks (Pritchard MS 1953a). Disc tags were applied virtually throughout the run from July 17-September 30 at a rate of 2% of each previous day's count of large (4- and 5-year-old) sockeye. Recovery was by Federal fisheries employees on streams and in the Indian food fishery, but no effort was made to recover tagged salmon from the Upper and Lower Babine rivers.

1947

Tagging and recovery were similar to 1946, but the tagging rate was 1% of each previous 24-hr fence count from noon to noon from July 15-October 7 (Pritchard MS 1953b). Very few recoveries were made on Upper and Lower Babine rivers.

1953

Sockeye were tagged with disc tags at the site of a major rock slide in the Babine River canyon (Godfrey, Hourston and Withler 1956). Some were recaptured at the fence, their tag numbers recorded and they were again released. Some were recovered again on the spawning grounds.

1957

To assess the extent of overlap in timing of middle-and late-run fish at the fence, sockeye were tagged during the second half of the 1957 run. Clip tags (commonly affixed to the ears of livestock) were applied at a rate of 100 per day from August 12-25 and 150 per day from August 26-September 13. Data were provided by Mr. J. McDonald.

1958

Sockeye were again tagged with clip tags at a rate of approximately 1% of each previous day's count of 4- and 5-year-old fish during the period July 8-September 11. (Data courtesy of J. McDonald).

1962

We used 1-inch diameter discs at a rate of 1% of each previous day's count of 4- and 5-year-old sockeye during the period July 20-September 19. Particular effort was devoted to recovery from the Upper and Lower Babine rivers.

1963

We again tagged with discs at a variable rate during the period July 22-August 18, when the objective was to differentiate timing of 10 early stocks combined, from that of the important Pinkut Creek stock which they overlap. From July 22-August 8, tagging was at a rate of 3%, from August 9-13 it was at 1%, and from August 14-18 at 0.5% of each previous day's count.

Adjustment of recoveries in 1957 and 1963

Tags were applied at different rates within each tagging period in 1957 and 1963. Recoveries from periods of higher tagging were therefore adjusted downward on the basis of a common rate throughout each year. The adjustment $R = r\ [\frac{T_1}{T_2}]$ was used wherein R is an adjusted number of recoveries, r is the actual number recovered and T_2 and T_1 are respectively the daily rate of tagging which applied to r recoveries, and the lowest rate used in the tagging.

RESULTS

Figures 2-8 show tagging and recovery results each year by day for three individual, and two groups of stocks. (These stock range from about 80,000 to 400,000 fish in combined annual catch and escapements.)

Data of 1962 (Fig. 7) probably provides the most complete and representative view of the sequence of arrival and timing and shows that there is a great deal of overlap of each group with those preceding and following. Only the early streams, and the late running Upper and Lower Babine river groups are well separated. It has become common practice to refer to three temporal groupings as follows:

early: 10 small widely scattered streams (considered here as a group)

middle: 3 larger streams all tributary to the Main Lake region: Pinkut Creek, the Morrison River system and Fulton River

late: two sections of the outlet stream known as Upper Babine River and Lower Babine River respectively

Timing of Upper and Lower Babine river stocks

These stocks spawn about 11 km apart on either end of Nilkitkwa Lake (see Fig. 1). Figure 9 shows the distribution of recovery dates in 1957, 1958 and 1962. Mean dates of passage at the fence in those years were compared by the "t" test and the calculated "t" values were respectively 1.13, 1.52 and 3.15, corresponding to p values as follows: 1962, 0.4; 1958, 0.1; and 1957, <0.01. Only the difference in 1957 appears significant. For our purposes we can consider the Upper and Lower Babine river fish to pass the counting fence almost completely mixed although there was a mild tendency for the earliest of these fish to spawn in Lower Babine River and

the latest to spawn in the Upper Babine River.

Timing of other stocks

The arrival of stocks in the fishing area is probably nearly normally distributed in time, but presumably this can be modified by alternating periods of intense fishing pressure and complete closure so that when they arrive at the counting fence their distribution may be non-normal (see for instance early stream distribution in Fig. 2, Pinkut in Fig. 7, and possibly Lower Babine River in Fig. 9). Furthermore tag recoveries are often clustered by dates of tagging because of either non-proportional tagging or recovery effort and the average timing based upon them can be biased. For these reasons we have in most cases used tagging midpoints -- dates on which 50% of recovered tags in any stock were put on -- as being most useful for comparing variation in timing among years. Other estimates of central tendency have been listed in Table 1.

Figure 10 shows midpoints of occurrence at the counting fence. There were no Upper and Lower Babine river recoveries in 1946 but those of 1957 should give an unbiased estimate of their timing that year and are included. The sparse 1963 data were not included in the figure though timing and sequence of arrival of groups appear typical (see Fig. 8).

The midpoints for most years fell within a narrow range of days and when unusual timing occurred it was common to most groups. For instance most were unusually early in 1958 and unusually late in 1946. Greatest variability occurred among the early group, likely reflecting its heterogeneous (10 stocks) composition. Timing of the Fulton stock was most consistent over the years as 4 of 5 midpoints fell on the same date.

The five groups arrive at the counting fence in the same chronological order each year.

The 3-day average interval between midpoints of arrival of Morrison and Fulton stocks and the almost complete overlap apparent most years, seems to preclude exploiting these two populations at different rates. We have, therefore, combined them to provide estimates of timing at the fence of four groups as follows:

Group or stock	Average midpoint	Interval (days)	Range
Early	July 26	10	6-17
Pinkut	Aug. 5		
Fulton-Morrison	Aug. 15	10	4-18
Upper-Lower Babine rivers	Aug. 28	13	8-15

If the 10-13 day average interval between midpoints of the four major groups prevails in the fishery it may be possible to apply different rates of exploitation on each. To assess this possibility, it is necessary to estimate timing on the fishing grounds by back-plotting on the basis of two kinds of information.

Information from marine and fishing boundary tagging

Takagi and Smith (MS 1973) estimated mean time out from the upstream fishing boundary to the Babine fence for sockeye tagged in June, July and August in coast and estuarine taggings and found differences as follows:

	June	July	August	All
Number of taggings	5	8	5	8
Total recoveries	90	1,281	270	1,641
Days out	29.0	26.2	33.1	27.3

By back-dating the entire escapement, 27 days as a first approximation (see Fig. 7), it is apparent that about half the early stream fish pass through the boundary area in June, and half in July, middle-run fish pass almost exclusively in July, and late-run fish occur about half in July and half in August. This suggests that early-, middle- and late-run groups average respectively 28, 26 and 29 days in travelling from the boundary to the fence.

Aro and McDonald (MS 1968) estimated mean time out from the fishing grounds to the boundary in a number of years to range from 2-5 days and we consider 4 days as a best point estimate.

We have used these data to correct the first approximation to time out from the fishery and estimate the midpoint of occurrence of stocks as follows:

Stocks	Estimated days out, fishing grounds-fence	Estimated mid-date in the fishery	Difference (days)
Early	32	June 24	
Pinkut	30	July 6	12
Fulton-Morrison	30	July 16	10
Upper-Lower Babine rivers	33	July 26	10

There may be a rather longer interval between Early and Pinkut groups than between Fulton-Morrison and Upper-Lower groups in the fishery rather than the reverse suggested by the uncorrected data above.

Information from smolt tagging

Smolts marked with magnetic tags (see method of Bergman et al. 1968) throughout the period of emigration from Babine Lake 1967-1968 and recovered as 4- and 5-year-old adults in the commercial fishery over a 3-year period also permit a separate estimate of timing of two groups (from unpublished data of Smith and McDonald).

Smolts emigrate in two modes of abundance corresponding to separate rearing areas in the North Arm-Nilkitkwa and Main Lake regions. Tag codes permitted identification of recaptured tagged fish by day of tagging so timing of the large Upper and Lower stocks in the fishery (early mode) was readily determined. By contrast Main Lake smolts are a mixture of many stocks of varying sizes so complete separation of early- from middle-timed groups is not possible from the sequence of recoveries. However, when the Fulton timing shown in Fig. 2-8 is back-dated 26 days it becomes apparent that very few Fulton fish could be in the fishery prior to July 10, but they constitute the bulk of Main Lake fish thereafter. Thus Main Lake recoveries after July 10 can be used to estimate the means and midpoints of occurrence of Fulton fish in the commercial fishery; the estimated interval between them and Upper and Lower fish can be usefully compared with that obtained from the adult tagging.

Two adjustments of the raw recovery data were required: first, variable fishing periods and exploitation rates within and among seasons had to be adjusted to yield a common recovery rate; second, tags were generally recovered in the canneries 1-2 days after capture of the fish so means and midpoints were back-dated 2 days. The resulting estimates are as follows:

	1969		1970		1971		Mean	
	$\bar{x}$	MP	$\bar{x}$	MP	$\bar{x}$	MP	$\bar{x}$	MP
Fulton River	J 24	J 21	J 20	J 17	J 20	J 20	J 21	J 19
Upper-Lower Babine rivers	J 31	J 29	J 30	A 2[1]	J 26	J 26	J 29	J 30
Difference (days)	7	8	10	16[1]	6	6	8	11

J = July; A = August

[1] These values misleading. See text for explanation.

There was no commercial fishery in the Skeena area (Area 4) during the week ending August 2, 1970. Since this coincided with the peak occurrence of Upper and Lower Babine river fish no recoveries were made then and the estimates of mean and midpoint are heavily weighted by recoveries at other times.

Nevertheless, smolt tagging data does indicate a small between-year variation in timing and about the same interval (11 days) between Fulton and combined Upper and Lower river fish as estimated from fence tagging (10 days). There is, however, a small discrepancy in estimated calendar dates by the two methods as follows:

Source of data	Midpoints of runs in the commercial fishery	
	Fulton River	Upper and Lower Babine rivers
Adult tagging	July 16	July 26
Smolt tagging	July 19	July 30
Difference (days)	3	4
Difference as % of estimated time out	10%	12%

Recoveries from fish tagged as smolts suggest that Fulton and Upper and Lower river stocks were present in the fishery 3-4 days earlier than was indicated by fence tagging data back-plotted according to estimated rates of travel through the coastal waters and estuary.

DISCUSSION

Seven tagging experiments from 1946-1963 confirm that Babine Lake stocks pass the Babine River counting fence in the same order, and at very nearly the same time each year. In particular midpoints of passage of the Fulton River stock fell on the same day in 5 of 6 years when recoveries of that stock were numerous. Such precise timing seems remarkable in view of variable year-to-year influences of the commercial fishery.

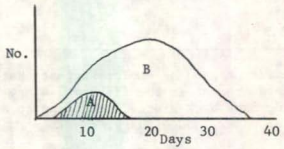
When recapitulating this timing in the fishing area it appears profitable to back-plot each of early-, middle- and late-timed stocks a different number of days according to small seasonal differences in migration rate indicated by coastal and estuarine tagging programs.

The 3-4 day difference in indicated time of occurrence in the fishery of major stocks, depending upon whether adult or smolt tagging data are used, may indicate that the former yield a false estimate of travel rate. This may be due to the fact that many adults were gillnetted for tagging and may have been injured while being extricated. Injured fish, particularly those tagged at the mouth of the river, sometimes drifted seaward for some time before recovering sufficiently to commence the upstream journey (K. V. Aro, personal communication). Those tagged as smolts on the other hand would presumably not be affected in any way after one or more years bearing a minute tag in the cartilage of their snout. In view of the results of smolt tagging we suggest 24 days as the best point estimate of travel time from the river mouth (test fishing site) to the fence, and 28 days from the centre of the Area 4 commercial fishing area to the fence.

The combined adult and smolt tagging data suggest that the midpoints (and the means for that matter) of three groups plus one individual stock (Pinkut) can be expected to occur in the commercial fishery at 10-12 day intervals in most years. There is no evidence that among-years rates of travel through the rivers is significantly affected by mean date of arrival

in the fishery, but this possibility should not be overlooked when estimating arrival times at the coast on the basis of timing at the counting fence.

While timing of major Babine groups appears reasonably predictable there may often be major practical problems in applying this knowledge to obtain optimum catch. First, the relative abundance of the groups will often be imprecisely known. In the drawing below group A has a midpoint 10 days earlier than group B but in view of their relative numerical strengths the early "B" fish and the "A" fish will likely have to be fished together and at the same rate (assuming equal susceptibility to capture).



If effective management of A requires a lower rate of exploitation than for B fish, appropriate fishing constraints may result in excessive numbers of early B fish escaping to the spawning grounds and perhaps adversely affecting the spawning composition of that group. However, that may be the unavoidable price in protecting A from over-exploitation and possible annihilation.

In the example given the manager will wish to shift fishing pressure at a time best calculated to optimize exploitation on each group. This calls for good forecasting of relative abundance for, if the magnitude of A and B should be reversed, the appropriate change in regulations might need to be scheduled for 3-5 days later.

A second consideration is the shape of the curve relating numbers to time of occurrence. Non-normal distributions, whether appearing naturally or perhaps resulting from non-random fishing outside the Skeena fishing area, could cause further complication.

Relative abundance and temporal distribution of Babine stocks in the fishing area is currently of vital concern. The Babine Sockeye Development Project is expected to increase numbers of Fulton River fish from a pre-development level of perhaps 200,000 fish per year (average escapements from 1949-1966 were 80,000) to about 800,000 or 10 times the earlier level. Meanwhile Morrison River spawners can be expected to produce about 30-50,000 returning adults and the combined Upper and Lower Babine river fish about 200-400,000 annually. While it is rather difficult to determine the return per spawner of these stocks their performance in brood years 1961-1965 wherein time in the fishery, weekly exploitation rates and numbers and age composition of progeny are reasonably well established, suggest that the Fulton River stock clearly outproduced the others. Fulton returns per spawner averaged better than 3.4 from those brood years as compared with about 2.5:1 for the combined Upper and Lower rivers. The addition of spawning channels and controlled flow on the Fulton River should make that stock even more productive and the gap between these two groups can be expected to widen even more. This will necessitate very careful management to avoid over-exploitation of the Upper

and Lower Babine river group. It may be impossible to preserve the Morrison River stock under these circumstances.

Clearly, management problems associated with different natural productivities of stocks can be further accentuated by artificial enhancement of single stocks. It is suggested that there is need to plan enhancement projects with the entire system (all stocks and perhaps all local salmon species which might be affected by simultaneous harvesting) clearly in mind.

ACKNOWLEDGMENTS

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Table 1. Tagging and recovery rates and timing of Babine Lake sockeye stocks from tagging at the counting fence: J = July; A = August; S = September.

Year	1946	1947	1953	1957	1958	1962	1963
				Number tagged			
	9417	5225	2238	4200	7970	6200	5000
				(Number recovered) and timing			
Early streams	(275)	(246)	(117)	"	(308)	(167)	(611)
range	J 17 - A 24	J 15 - S 14	J 18 - A 18	"	J 8 - A 15	J 20 - S 1	
mean	J 30	J 29	J 25		J 17	A 3	
s.d.	9.23	10.18	7.79		6.24	6.69	
midpoint	J 30	J 28	J 20		J 15	A 1	
median	A 5	A 14	A 2	"	J 27	A 10	
Pinkut Cr.	(43)	(4)	(19)	"	(15)	(172)	(343)
range	J 17 - S 6	J 30 - A 18	J 24 - A 17	"	J 15 - A 12	J 30 - S 3	
mean	A 12	A 7	A 5		J 28	A 7	
s.d.	9.58	6.94	6.19		8.91	5.36	
midpoint	A 11	A 5	A 6		J 28	A 7	
median	A 11	A 8	A 5		J 28	A 16	
Morrison system	(71)	(27)	(15)	"	(2)	(75)	(58)
range	A 3 - S 10	A 4 - S 13	J 28 - A 12	"	A 6 - A 24	J 31 - A 29	
mean	A 17	A 18	A 6		A 15	A 13	
s.d.	9.70	10.16	4.06		9.00	6.80	
midpoint	A 15	A 15	A 5		A 15	A 14	
median	A 22	A 23	A 4		A 15	A 14	
Fulton R.	(274)	(285)	(59)	(19)	(93)	(333)	(48)
range	J 29 - S 21	J 30 - S 20	J 30 - S 12	"	J 14 - S 9	A 1 - S 18	
mean	A 20	A 17	A 15		A 15	A 16	
s.d.	10.12	8.71	8.15		12.53	6.88	
midpoint	A 19	A 15	A 15	"	A 15	A 15	
median	A 25	A 25	A 21		A 11	A 25	
Upper-Lower B.R.	(0)	(25)	(116)	(420)	(247)	(791)	(93)
range	-	A 3 - S 18	A 4 - S 27	A 12 - S 13	J 20 - S 11	A 2 - S 19	
mean		A 25	A 26	S 2	A 27	A 27	
s.d.		10.37	11.16	7.09	9.32	9.16	
midpoint		A 23	A 26	S 2	A 29	A 25	
median		A 25	A 26	A 28	A 15	A 26	
Total recov.	663	587	326	439	665	1538	1153
%	7.0	11.2	14.6	10.5	8.3	24.8	23.1

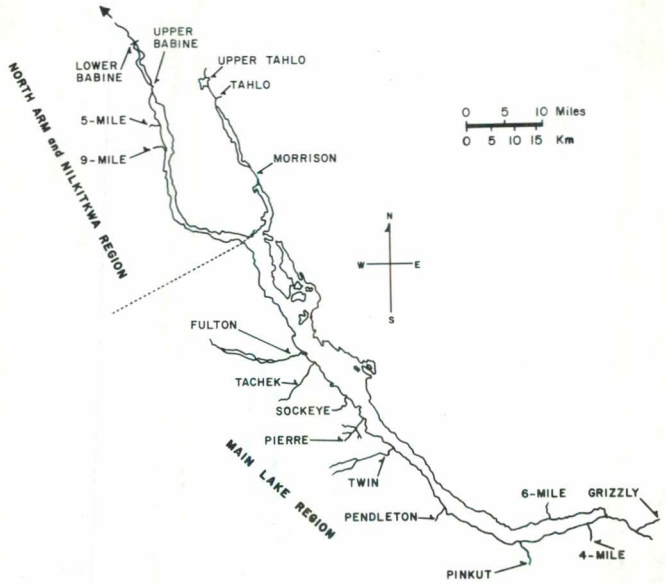

Fig. 1. Locations of spawning grounds of sockeye salmon stocks in North Arm-Nilkitkwa and Main Lake regions of the Babine drainage.

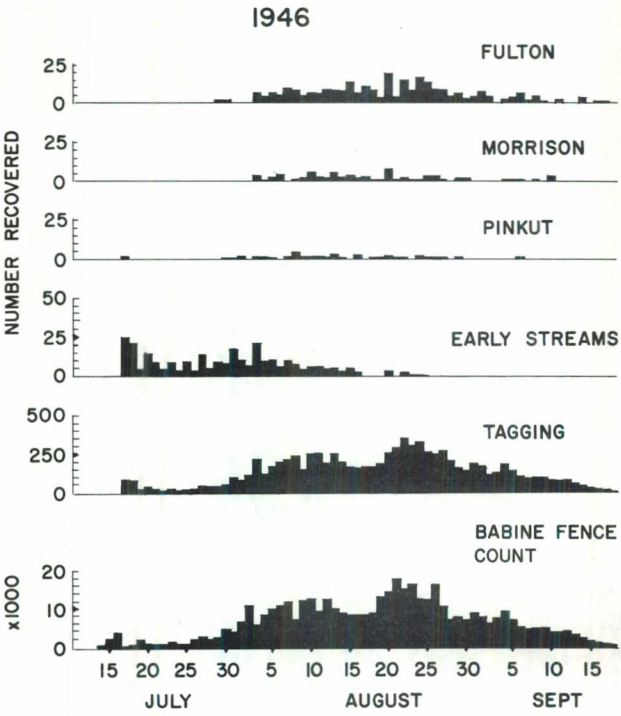

Fig. 2. Babine fence count and tag and recovery data from the 1946 tagging (after data of Pritchard MS 1953a).

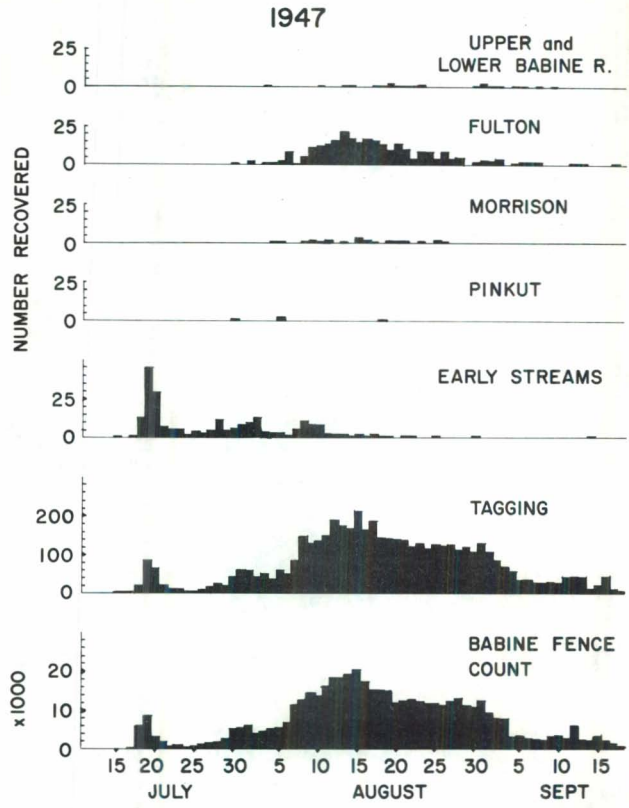

Fig. 3. Babine fence count and tag and recovery data from the 1947 tagging (after data of Pritchard MS 1953b).

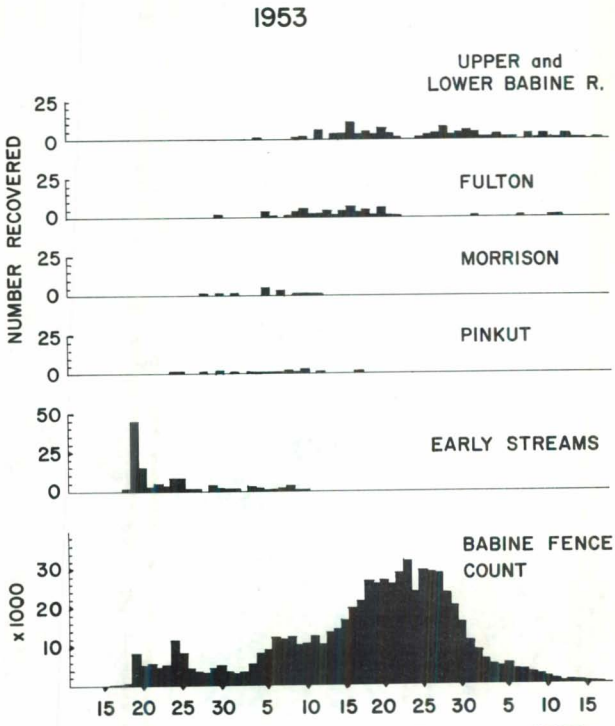

Fig. 4. Babine fence count and tag and recovery data from the 1953 tagging initiated at the site of the Babine River slide (after data of Godfrey et al. 1956).

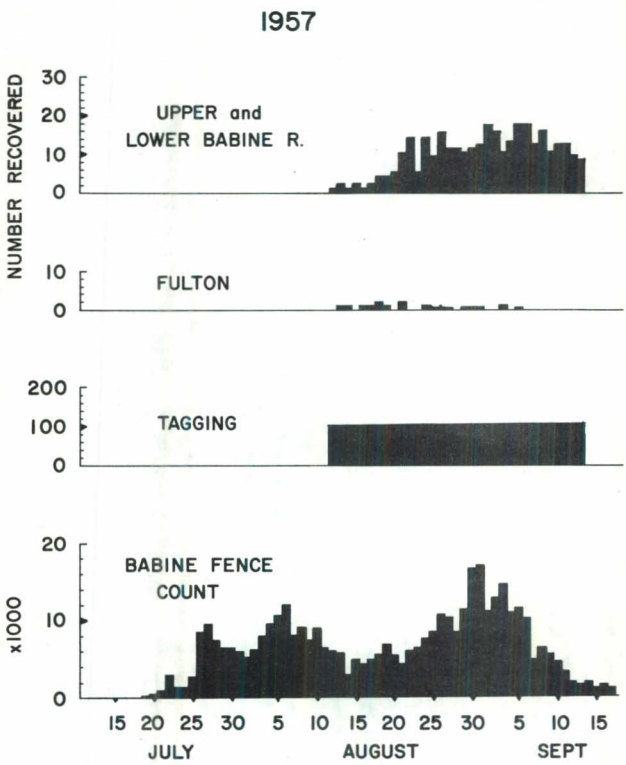

Fig. 5. Babine fence count and tag and recovery data from the 1957 tagging (from unpublished data, courtesy of J. McDonald).

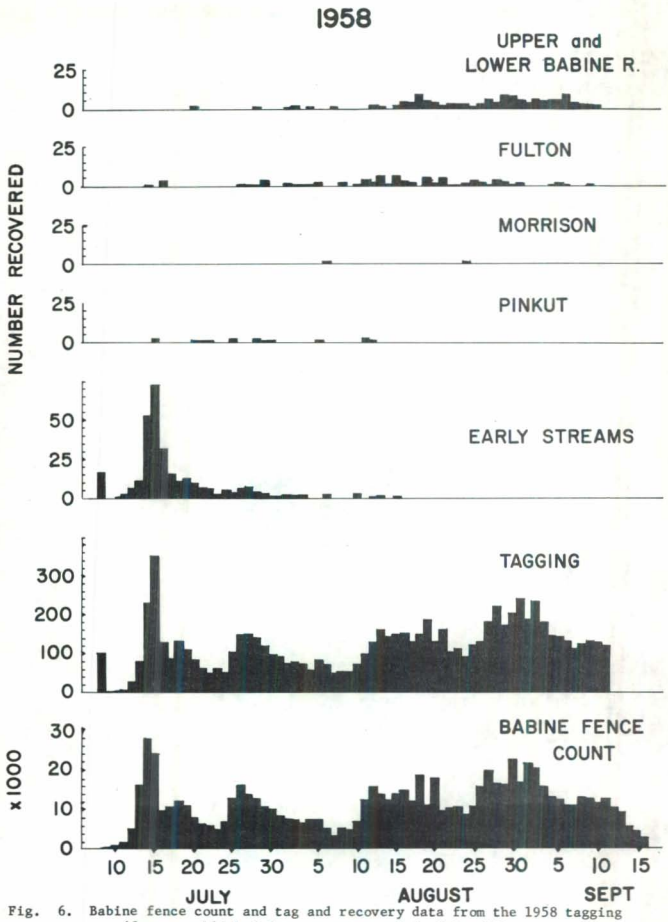

Fig. 6. Babine fence count and tag and recovery data from the 1958 tagging (from unpublished data, courtesy of J. McDonald).

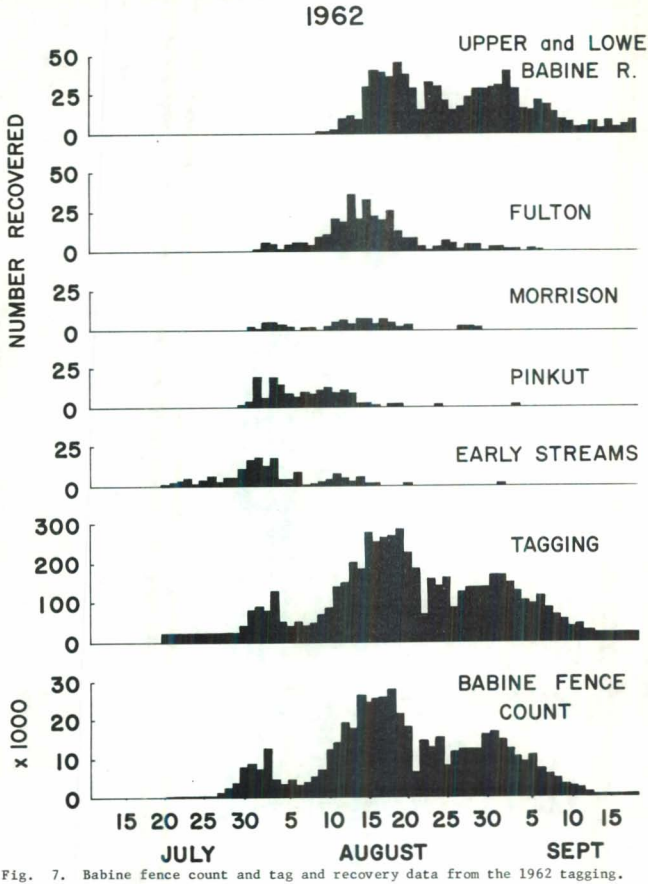

Fig. 7. Babine fence count and tag and recovery data from the 1962 tagging.

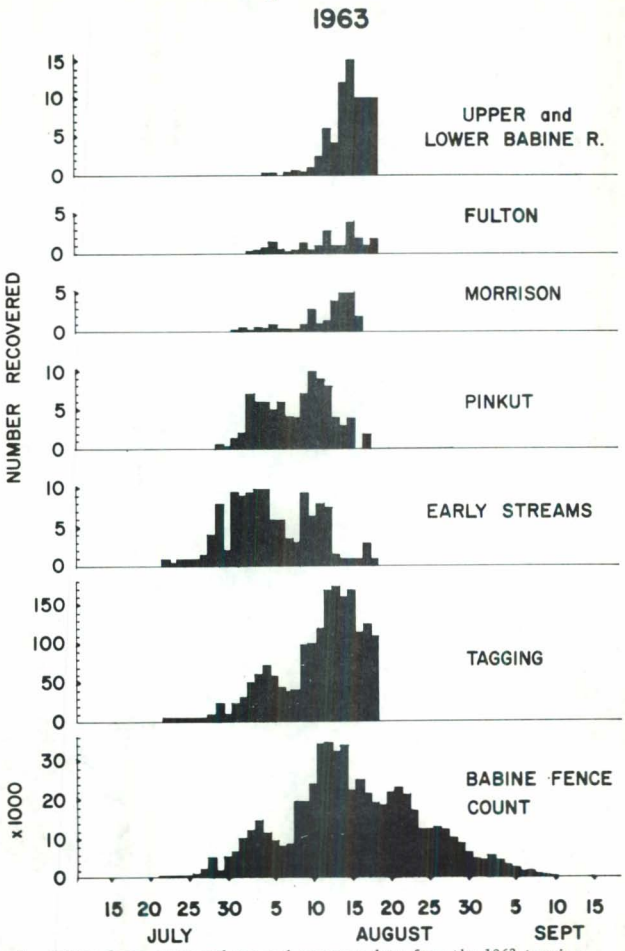

Fig. 8. Babine fence count and tag and recovery data from the 1963 tagging.

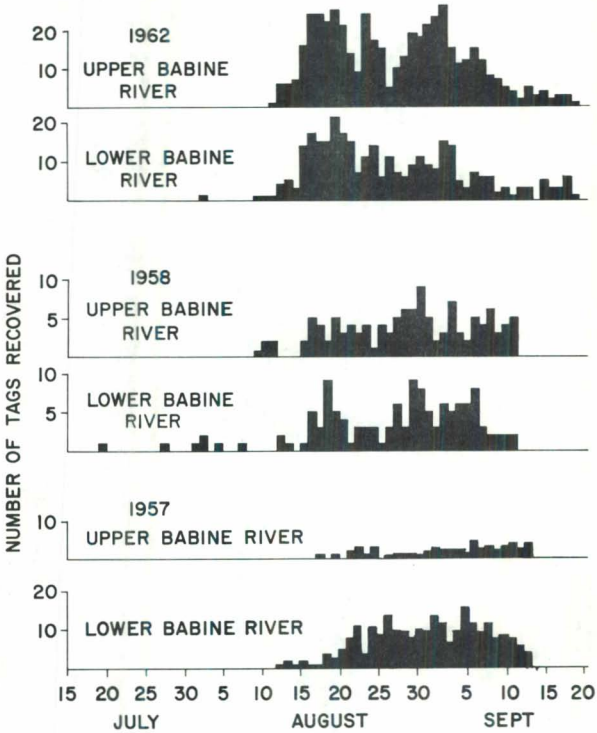

Fig. 9. Tag recoveries on Upper and Lower Babine River from 1957, 1958 and 1962 taggings.

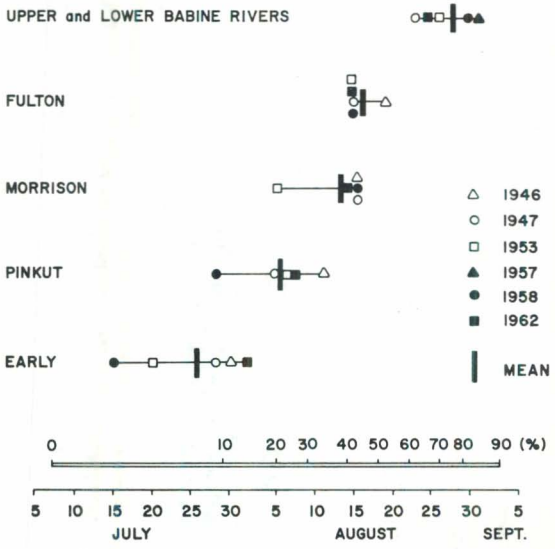

Fig. 10. Mean, and range of dates when 50% of tagged fish in several individual and grouped stocks passed the counting fence. Scale shows average dates of occurrence of each escapement decile.