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A. W. H. NEEDLER, Director

(WITH INVESTIGATORS SUMMARIES AS APPENDICES)

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The distribution of the returns from all coho salmon tagged in 1958 are shown in the accompanying figure. From a total of 2,331 fish tagged in the whole tagging area there have been 356 returns. The area of recovery is not accurately known for 18 fish. For the remaining 338 returns, more were found inside (east) of the tagging area than outside of it. Only 23 tags were recovered along the west coast of Washington and Vancouver Island, while 154 tags were caught in the tagging area, and 161 tags were recovered inside to the eastward. All of these fish were recovered by commercial or sport fisheries, except for two in the Fraser River and 12 in the streams of Puget Sound. Thus for tagged fish that were recaptured outside the whole tagging area, 23, or 12.5 percent, were from outside waters and 161, or 87.5 percent, were from inside waters. This is between the results obtained in 1957 from the early United States tagging (25 percent outside) and the late Canadian tagging (4 percent outside).

For fish tagged in each of the three tagging zones (see table), the percentages returned from along the west coast of Washington and Vancouver Island are similar, namely, 6.7 percent (13 fish) for those tagged outside the Bonilla Point-Tatoosh Island line, 6.4 percent (5 fish) for those tagged between the two lines, and 7.7 percent (5 fish) for those tagged inside of the Owen Point-Sail Rock line. Also, the percentages returned from east of the tagging area are similar, namely 47 percent (92 fish) for those tagged outside the Bonilla-Tatoosh line, 49 percent (38 fish) for those tagged between the two lines, and 48 percent (31 fish) for those tagged inside the Owen-Sail line. Therefore, neither line separates coho salmon that move either outside along the coast or inside to Puget Sound and the Strait of Georgia. From each zone most fish eventually migrate to inside areas. Within the tagging area itself the fish move in all directions and many remain for a considerable time. Thus there is considerable milling or delay period in the outer Strait region which becomes shorter as the season progresses and as the fish feed less and become more mature.

In brief, the 1958 tagging results confirm the 1957 conclusions that the coho salmon in the three tagging zones, on each side of and between the two proposed lines across the Strait of Juan de Fuca, are similar in direction of movement and that eventually most migrate eastward to spawn in inside streams.

SKEENA SALMON INVESTIGATIONS

- F.C. Withler

The purpose of Skeena salmon investigations is to provide the biological information needed to manage the salmon stocks most effectively. Since the bulk of the Skeena commercial catch is made up of sockeye and pinks, most study has been directed toward these species.

An important part of the work is the determination, for each of the major production areas, of the likely size of spawning escapements which will provide the greatest long-term yield to fishing. This work involves counting or estimating annually the numbers of spawners using each of these areas, followed by determination of the numbers of progeny (as either young seaward migrants or adults returning) which are produced.

For sockeye, the major producer is the Babine-Nilkitkwa watershed, where over 75% of the annual escapement spawns. This lake system is divided essentially into two parts. The northern part, adjacent to the outlet, has a relatively restricted lake nursery area (about 10% of the total lake surface area) populated by the young of a large run of late-running fish; the southern part, remote from the outlet, has a relatively great lake nursery area (about 90%) populated by the progeny of spawning runs of similar magnitude but earlier-running. Studies of the growth and distribution of young sockeye in the lake and observations of the numbers and sizes of seaward migrants indicate that in most years neither the spawning grounds nor the nursery area of the main lake basin has been fully used. However, in the restricted northern basin the retarded growth of young sockeye there suggests that enough fry have been produced there to approach its nursery capacity.

Since 1956, the fishery has been regulated in such a way by early season closures as to increase escapements to the main lake basin area, while maintaining the substantial runs to the restricted area. As a result of the increased early-run spawnings, production of young fish in the main basin area has been raised, with no evident taxation of nursery capacity. In 1958, as a result of closure to fishing during the passage through the fishery of relatively abundant early runs, the largest recorded escapement of spawners to streams tributary to the main basin was achieved, while large spawning runs of late fish were maintained on spawning grounds of the northern basin. With the exception of some losses caused by low water levels, spawning generally appeared to be successful, and the 1958 escapement should provide the largest output of young so far observed in either basin.

For pink salmon, three tributary streams carry the bulk of the spawners - the Kispiox, Kitwanga, and Lakelse Rivers. Since young pink salmon go directly to sea, the problem of freshwater capacity is restricted to consideration of the available spawning ground only. Intensive study of Skeena pinks began only in 1956 and hence less is known about the capacities of major streams than for sockeye. Analysis of past catch statistics has shown that spawnings in years of abundance more often resulted in large returns than did spawnings in years of scarcity. This evidence, plus the fact that direct observation of even the largest recent spawning densities does not suggest them to be excessive, strongly indicates that spawning populations need to be larger before pink production can be returned to its former high levels. On the basis of this evidence, Skeena fishery regulations since 1955 have been aimed at providing larger escapements.

After 3 years of observation, indices of fry production have been roughly proportional to the size of spawning escapement. Only two adult returns have been observed - from the 1955 spawning of 1,000,000 or so which produced the large run of 1957, and from the 1956 spawning of 275,000 which produced a moderate run. On the basis of excellent fry production indices, and given only average survival in the ocean, a large return in 1959 is expected from the 1957 spawning. Should such a large run materialize, it may be possible by regulation to provide spawning escapements in 1959 larger than those obtained in any recent years, and better use may be made of indicated spawning ground capacities.

Specific projects concerned with determination of the optimum use of spawning and nursery areas include:

(a) Estimation of spawning escapements. These data are obtained by foot, boat, and aircraft surveys by Department officers and Board personnel, and for Babine sockeye, by direct counts of fish passing a weir. Part of the work involves developing more accurate, yet economical, methods of estimating spawning numbers. For sockeye, attempts are also being made to determine the age composition of the escapement (to permit more accurate assessment of the total return of a given brood) and to identify individual runs by scale criteria (to identify production from specific spawning or nursery areas).

(b) Estimates of pink fry production. On the three major rivers, trap-netting is carried out during migration of the young to provide indices of fry output from observed spawnings. Knowledge of production from different-sized spawnings over a series of years will show the size of spawning required to provide the greatest return to fishing.

(c) Observations of growth and distribution of young sockeye in Babine Lake. Sampling young sockeye in this nursery area has given information about the effects of different-sized spawning runs to different parts of the watershed. These studies provide estimates of capacity of the nursery areas to support the young fish, and permit assessment of the size and distribution of spawning stocks required to best use the rearing areas. Fundamental studies of the relationship between growth and distribution of young sockeye and their plankton food are also being carried out.

(d) Estimation of sockeye smolt runs. Estimates of the total sockeye smolt run from the Babine-Nilkitkwa area provide measures of freshwater production from different-sized spawnings. They also give preliminary indication of the likely return of adults to Babine, aiding in interpretation of fluctuations in abundance caused by the environment in fresh water and in the ocean.

(e) Study of historical data. Available historical data are analyzed to obtain information about the escapement requirements necessary to provide the greatest sustainable yield from the stocks and to provide better understanding of the effect of changes in fishing intensity upon abundance.

The second important aspect of Skeena investigations is the study of the fishery. To regulate the fishery in such a way as to provide the desired escapements to each spawning area requires knowledge of where and how long runs are available to the fishery, and how effective the fleet is in removing portions of each run passing through the fishing area. Tagging during 1957 and 1958 has shown the routes by which the sockeye and pinks approach the river mouth and the time taken to pass through the fishing area. The time at which the major sockeye and pink runs are present in the fishery has been established both from recent tagging and from that carried out in 1944-48. By test fishing just above the upriver commercial fishing boundary, it is now possible to estimate the weekly escapement of sockeye and pinks from the fishery and hence (when these data are combined with catch statistics) demonstrate the degree of exploitation exercised by the fleet in different weekly fishing times. This knowledge permits improved precision in setting fishing regulations generally to provide desired escapements; it is also possible to modify regulations during the fishing season to take account of unexpected fluctuations in abundance. For example, in 1958 regulation of the fishery was adjusted from week to week from July 27 to August 17 to harvest the sockeye run which was unusually abundant late in the season.

Specific projects involved in the study of the fishery's effect on the stocks have included:

(a) Tagging of adult fish as they approach and pass through the fishing area. Recoveries of tags in the fishery and on the spawning grounds provide information on the timing of runs to different spawning areas.

(b) Analysis of commercial catch records. Statistics collected by the Department on the daily salmon landings from the Skeena and nearby areas are used in conjunction with escapement statistics to estimate the contribution of various runs to the fishery.

(c) <u>Sampling of the commercial catch</u>. Samples of sockeye are used to determine the age, sex, and size composition of the catch so that contributions to the catch by each brood year will be known.

(d) <u>Test fishing above the commercial fishing boundary</u>. The catches made by a standardized fishing operation are used to estimate the numbers of sockeye and pinks escaping the fishery.

(e) <u>Estimation of Indian food catches</u>. Officers of the Department collect statistics on the numbers of salmon taken by natives between the commercial fishing boundary and the spawning grounds.

1. <u>The 1958 Skeena salmon catch and escapement</u> — F.C. Withler

The main purpose of salmon fishing regulations is to permit harvesting the stocks in such a way as to provide escapements which will give, on the average, the best return to the fishery. Because present salmon fishing fleets are so effective, severe restriction of the time and place of fishing is necessary to meet escapement needs. Most major salmon runs are composed of a number of separate stocks originating from different spawning grounds. These stocks appear in the fishery at different times during the fishing season and each requires separate regulation to achieve the proper escapement. It is within this framework that catch and escapement information should be examined.

In presenting recommendations for regulation of the 1958 Skeena sockeye and pink fisheries, the Skeena Salmon Management Committee had the following considerations in mind:

(a) There was a continuing need to increase the sockeye escapement to the several under-used streams tributary to the large nursery area of the southern portion of Babine Lake. Salmon bound to spawn in these streams pass through the fishing area from mid-June until about mid-July.

(b) The total 1958 Skeena sockeye run was expected to be moderate or slightly better in numbers. The return of 5-year-olds was expected to be only average because it followed a poor return, as 4's, of the 1953 brood in the previous year, indicating a poor ocean survival of the whole brood. The return of 4's in 1958 was expected to be average or better because it would arise from a good spawning in 1954 which was followed by a good output of smolts from Babine Lake, the major sockeye producer.

(c) The 1958 Skeena pink run was expected to be small, since it would return from a spawning of only 275,000 in the parent year 1956, and indices of fry production from this small spawning stock (about 1/4 of the number of spawners in odd-numbered years) were proportionately small. The need to increase even-year pink escapements was evident.

After study of the above considerations, the Committee recommended the following regulations for the 1958 Skeena salmon fishery:

(a) That fishing for sockeye commence on July 6, by which time a good portion of early-run sockeye would have passed the fishing area.

(b) That for the 4 weeks beginning July 6 and ending August 3, three days per week fishing be permitted to harvest the middle and late season sockeye.

(c) That from August 3 to August 31, 1 1/2 days fishing per week be allowed to permit only a limited catch of pink salmon.

During the fishing season it became apparent that the sockeye run was irregular in two respects - it was more than usually abundant both early and very late in the season. The accompanying diagram pertaining to the fishery in the Skeena Gill-net Area shows the number of days fishing permitted each week, the number of gill-net boat deliveries by week, and the estimated weekly total abundance of sockeye and pinks (catch plus escapement estimates derived from test fishing above the upriver commercial fishing boundary). It will be seen from the diagram that the abundance of sockeye prior to commencement of sockeye fishing on July 6 provided a relatively large early escapement; further, during the 3 weeks ending July 13, 20, and 27, about 50% of sockeye entering the Skeena Gill-net Area were caught. During the week ending August 3, for which fishing time was extended from 3 to 4 days to harvest the abundant run, 70% were caught; during the weeks ending August 10 and 17, when fishing was again extended (from 1 1/2 to 3 days per week), about 45% were caught. Thus, as a consequence of the good run and the regulations designed to harvest it according to escapement needs, the total sockeye catch in the Skeena Gill-net Area was 600,000,[1] providing the first substantial Skeena sockeye production since prior to the first return of slide-affected sockeye in 1955.

The estimated total Skeena sockeye escapement was 885,000. Of these 812,000 entered the Babine-Nilkitkwa watershed to provide the largest spawning run there since Babine weir counts were begun in 1946. Not only was the run large, it was also well distributed over the available spawning grounds. The early season closure provided the largest number of spawners so far recorded to the under-used southern Babine streams; the moderate cropping of the relatively abundant middle and late runs by the fishery permitted substantial spawning runs to escape to the important Fulton and Upper and Lower Babine Rivers. Other Skeena sockeye spawning areas were well populated, except for Morice Lake which was once a major sockeye producer. The Nanika River, the main Morice spawning tributary, had only a few spawners in 1958 for the fifth year in a row.

Examination of the carcasses of Babine spawners indicated that spawning had been successful except on two early-run streams - Pierre and Twin Creeks. Water levels in these last became so low following prolonged hot, dry weather in July and early August that some 65,000 spawners died unspawned on the stream beds, and another 10,000 that could not enter were believed to have died unspawned after diverting to the Fulton River. Later spawners entering Pierre and Twin Creeks after rain in early September provided moderate seedings in spite of the earlier die-off.

The 1958 Skeena pink run was about twice as large as had been expected, due to an exceptionally high ocean survival of the fry from the low parent run. The accompanying diagram illustrates the weekly abundance of pinks in the Skeena Gill-net Area and the division of the stock by week into catch and remaining escapement upriver. During the 3-day fishing week ending July 27, 62% of the pinks were caught; during the week ending August 3 (for which fishing was extended from 3 to 4 days to catch sockeye), 73% of the pinks were caught. During the weeks ending August 10 and 17, when fishing was extended from 1 1/2 to 3 days per week, about 55% were caught. Thus, as a result of the unexpected

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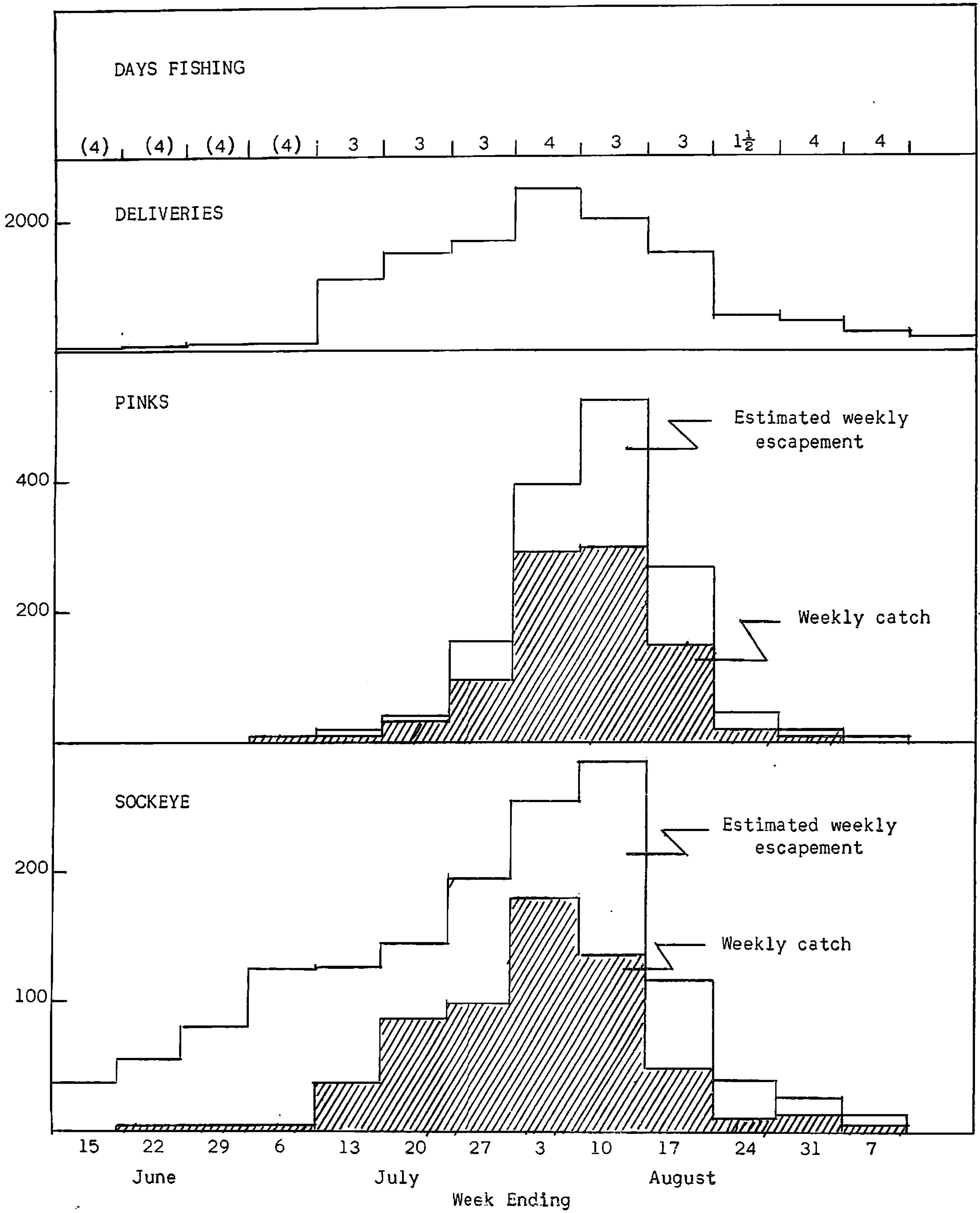
[1] An estimated 100,000 Skeena-bound sockeye also were caught in the westerly portion of the Nass Gill-net Area.



Catch, escapement (based on test fishing catches), and fishing effort (boat deliveries) by week, Skeena sockeye and pinks, 1958. Days fishing in brackets refer to days when spring salmon nets only were permitted.

large run and the extended fishing permitted to take late-run sockeye, the pink catch in the Skeena Gill-net Area was over twice as great as in the parent year, amounting to some 900,000 fish.

The estimated 1958 total pink escapement in the Skeena Gill-net Area was 672,000, of which about 116,000 spawned in coastal streams and some 556,000 spawned in tributaries of the Skeena River or in the river itself. So, in spite of heavy fishing, the escapement was also over twice as large as in the parent year (but nevertheless markedly less than in recent odd-numbered years). The heavy exploitation of the early-run pinks during the week ending August 3 was reflected in a poor escapement to the important Kispiox River - even poorer than in the parent year 1956. The two other major pink producers, the Lakelse and Kitwanga Rivers (which support later-running spawners), showed increases in spawning escapements amounting to 3 1/2 to 4 1/2 times the number of spawners in 1956.

The 1958 Skeena gill-net catch of spring salmon amounted to about 24,000, which is below average for the period since 1950. The escapement to the Lower Babine and Bulkley Rivers was reported by Departmental officers to be poor; to the Morice, Copper, Kitwanga, and Kalum Rivers to be moderate; and to the Ecstall River, good.

The 1958 gill-net catch of coho salmon in the Skeena Area was approximately 60,000, which is less than the 1950-58 average. The escapement to the Bulkley River was reported to be light; to the Babine and Morice Rivers, and the rivers entering the Skeena estuary, moderate; and to the Lakelse, Kalum, Gitnadoix, and Kispiox Rivers, very good.

The 1958 Skeena Gill-net Area catch of chums was 43,317. While slightly better than the 1957 catch, this number is below the average for the years 1950-58. The escapement to the Skeena chum spawning grounds was reported to be moderate.

2. Spawning stock size and resultant production for Skeena sockeye

M.P. Shepard and
F.C. Withler

Past information on the abundance of catches and escapements of Skeena sockeye have been examined to determine the relationship, if any, between the abundance of spawners and the size of the resulting stock.

For recent years relatively complete records of both catches and escapements are available. However, prior to 1946 the only reliable statistics for the Skeena sockeye are records of the total annual catches and of the number of boat licenses issued. By comparing these data with similar information for recent years (when catch, effort and escapement figures are all available), estimates of annual rates of exploitation from 1908 to 1945 have been derived. From these, escapement figures for the early period have been calculated. Annual determinations of the age composition of sockeye in the Skeena catch have been made since 1912. By applying this information to the catch and escapement figures described above, the total return (catch plus escapement) from each brood year since 1908 was estimated.

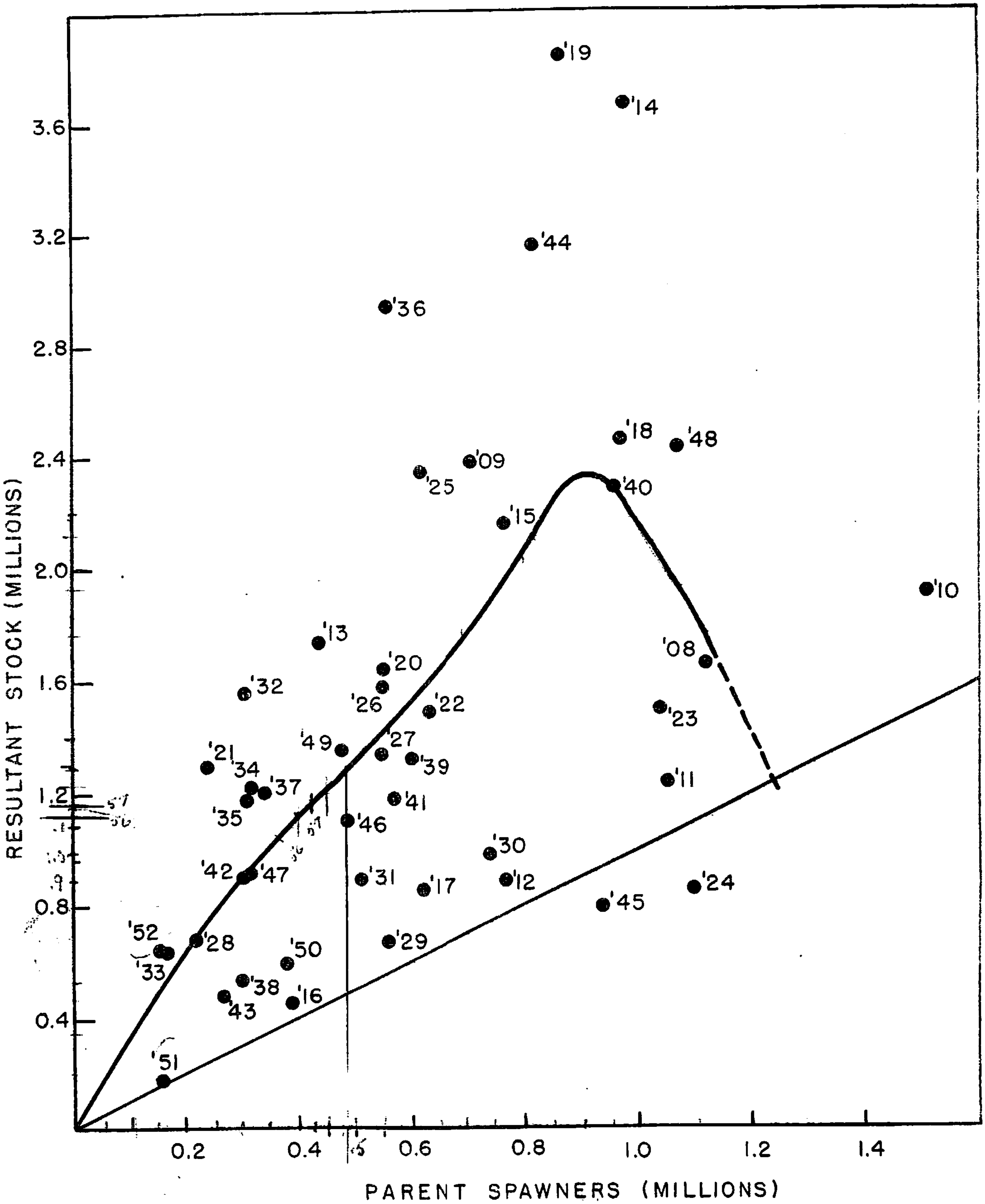
In the accompanying figure the estimated number of sockeye produced from the spawnings of individual brood years is plotted against the abundance of spawners in the parent year. Consideration has been restricted to 4_2 and 5_2 fish which are predominantly sockeye originating in a single large lake system, the Babine-Nilkitkwa. A diagonal line has been drawn to indicate the locus of points wherein the total resultant stock would just equal the number of fish spawning in the parent year. Hence, points lying above this line represent cases where the total resultant stock was greater than the number of parent spawners, and points below the line indicate brood years in which the total return was less than the number of spawners in the parent year.

In general, the return and the number of spawners have tended to vary together; small spawnings have tended to provide small returns and, although the resultant stocks vary widely at high spawning levels, the largest returns have been obtained from larger - though not the largest - seedings. In only two brood years of the 45 examined were the returns smaller than the number of parent spawners. In other words, in only two years did the spawning stock fail to replace itself.

Spawnings below 0.5 million have never produced better than moderate resultant stocks. Escapements between 0.5 and 0.9 million have produced larger returns on the average and have resulted in all of the really big returns. With spawnings of over 0.9 million the average magnitude of the return diminishes.

This relationship suggests that the abundance of spawners is one of the most important factors determining the return of sockeye. It would appear that for spawning populations up to 0.9 million the capacity of the environment to produce sockeye is not limiting; the decrease in size of the average return for spawning populations over 0.9 million suggests that the capacity of the environment to produce sockeye is exceeded at these escapement levels.

In examining the spawner-return relationship it is evident that the individual points scatter widely about the trend line. At spawning levels in the region of the ascending limb of the curve (see accompanying figure), the deviations of the observed returns from the trend line are smallest near the origin and tend to increase with increasing spawners. However, the proportional variation is the same throughout the range of spawnings. This pattern of variation probably results from the influence of randomly fluctuating environmental conditions which affect the survival of the sockeye independently of their abundance, e.g. adverse temperatures or scouring of spawning grounds.



Total returns from spawning stocks of different sizes - Skeena sockeye, 1908-1952. Figures associated with individual points indicate parent brood years.

3. Salmon tagging in and around Chatham Sound in 1958 K.V. Aro

Adult salmon were tagged in 1958 as in the preceding two years in and around the Skeena gill-net area to determine the time, speed, and route of migration of Skeena salmon and to determine the ultimate destination of salmon present in Ogden Channel, in the Skeena gill-net area, and in the outer portions of the Nass area.

The 1958 tagging, in which conventional Peterson-type disc tags and some plastic dart tags were used, was carried out from the chartered drum-seiner "Cape Blanco" during the period July 12 to August 12 in the following areas:

(1) in Area 3 at several locations at the northern end of Dundas Island;

(2) in Area 4 off Grace Island at the northern tip of Porcher Island, off Smith Island, and near Green Island;

(3) in Area 5 at several locations in Ogden Channel.

The numbers of salmon tagged in the three areas are shown by the species in the following table:

Species	Area 3	Area 4	Area 5	Totals
Pink	2794	1318	2516	6628
Sockeye	388	253	120	761
Spring	3	8	5	16
Coho	125	21	90	236
Chum	96	11	78	185
Steelhead	1	2	--	3
Totals	3407	1613	2809	7829

Tags were recovered from the commercial, sport and Native food fisheries, at the Babine River counting weir, and from spawning streams. By March, 1959, 2,890 tags had been returned from the commercial fishery and 393 from freshwater areas, a total of 3,283, representing a return of 42%. The distribution of the tag returns by area of recovery is indicated in the accompanying tables.

The tables indicate that of the pinks tagged at the northern end of Dundas Island one-quarter of the recoveries were made in Area 4, one-quarter elsewhere in B.C., and the remaining one-half in Alaska. Of the recoveries of pinks tagged in Area 4, about 73% came from Area 4, 6% from Area 3, 11% from elsewhere in B.C., and 9% from Alaska. From pinks tagged in Ogden Channel about 33% of the recoveries were made in Area 5, about 62% in Area 4, 3% elsewhere in B.C., and 2% in Alaska. The large proportion of recoveries in Alaska of pinks tagged off the northern end of Dundas Island in 1958 contrasts sharply with the situation in 1957 when the Alaskan returns constituted less than 4% of the recoveries of pink tags placed there. The movement of tagged pinks from the northern end of Dundas Island to Alaska was more or less constant throughout the season whereas the few pink tags which were recovered in Alaska from the taggings in Areas 4 and 5 were from the early part of the season. The 1958 tagging

Pink Salmon

	Area of Tagging			
	Area 3	Area 4	Area 5	Total
No. Tagged	2794	1318	2516	6628
Recoveries				
Area 3				
Fishery	188	35	19	242
Area 4				
Fishery	230	324	610	1164
Streams	27	66	62	155
Totals	257	390	672	1319
Area 5				
Fishery	42	40	380	462
Streams	-	-	14	14
Totals	42	40	394	476
Other B.C.				
Fishery	50	19	36	105
Streams	1	-	-	1
Totals	51	19	36	106
Total B.C.				
Fishery	510	418	1045	1973
Streams	28	66	76	170
Totals	538	484	1121	2143
Alaska				
Fishery	478	46	26	550
Streams	13	1	1	15
Totals	491	47	27	565
Grand Total				
Fishery	988	464	1071	2523
Streams	41	67	77	185
Totals	1029	531	1148	2708

Other Species

	Spring	Coho	Chum	Steelhead
No. Tagged	16	236	185	3
Recoveries				
Area 3				
Fishery	-	6	6	1
Area 4				
Fishery	3	21	20	1
Streams	1	4	3	-
Totals	4	25	23	1
Area 5				
Fishery	-	4	9	-
Other B.C.				
Fishery	-	7	3	-
Streams	-	1	-	-
Totals	-	8	3	-
Total B.C.				
Fishery	3	38	38	2
Streams	1	5	3	-
Totals	4	43	41	2
Alaska				
Fishery	-	3	10	-
Grand Total				
Fishery	3	41	48	2
Streams	1	5	3	-
Totals	4	46	51	2

Sockeye Salmon

	Area of Tagging Area 3	Area 4	Area 5	Total
No. Tagged	388	253	120	761
<u>Recoveries</u>				
Area 3				
Fishery	26	4	2	32
Area 4				
Fishery	82	71	48	201
Streams	100	79	19	198
Totals	182	150	67	399
Area 5				
Fishery	7	2	9	18
Other B.C.				
Fishery	6	1	1	8
Total B.C.				
Fishery	121	78	60	259
Streams	100	79	19	198
Totals	221	157	79	457
Alaska				
Fishery	14	-	-	14
Streams	1	-	-	1
Totals	15	-	-	15
Grand Total				
Fishery	135	78	60	273
Streams	101	79	19	199
Totals	236	157	79	472

suggests that a large proportion of the Skeena pinks entered the Skeena gill-net area from a southerly and southwesterly direction whereas in 1957 the majority entered the area from a northerly direction.

The table showing the recoveries of tagged sockeye indicates that the majority of the sockeye tagged in 1958 were destined for the Skeena River, (particularly to Babine Lake, a large number of tags being recovered at the Babine River counting weir). The data also suggest that most of the sockeye entered the area from a northerly direction in 1958, as in 1957. This suggestion is further confirmed by the recovery at the Babine River counting weir of 95 tags which had been placed on sockeye by the Fisheries Research Institute of the University of Washington at various locations along the west coast of Prince of Wales Island in Southeastern Alaska.

Most of the tags placed on spring, coho, chum and steelhead were recovered in the Skeena gill-net area.

4. Test fishing catches as indices of escapement F.C. Withler

Catches of salmon in standardized test drifting of gill-nets above the upriver commercial fishing boundary have been used since 1955 to provide information on the weekly escapement of sockeye and pinks from the commercial fishery. These estimates, when used with catch statistics, have permitted assessment of the seasonal changes in rate of exploitation.

Comparisons of the seasonal patterns of test fishing catches with those of escapements reaching the spawning grounds have indicated that the test fishing catches were, within each season, roughly proportional to the daily escapements. This being so, it is possible to derive indices converting catch/hour to escapement for each year by summing the daily catch/hour figures and dividing this number into the total estimated escapement to areas upstream from the test fishing site. The indices derived for the years from 1955 to 1958 are shown below:

Year	Sum daily catch/hour		Total escapement (1,000's fish)		Escapement per daily catch of 1 fish/hour	
	Sockeye	Pink	Sockeye	Pink	Sockeye	Pink
1955	377	1,672	125	987**	333	584
1956	834*	522	441	202**	530	387
1957	769*	1,929	485	868**	632	451
1958	1,203*	1,149	884	556	735	484

*Adjusted to correct for differences in efficiency of boat skippers.

**Estimates of escapement to areas above the test fishing sites have been revised since last year's report.

There was a relatively large difference between escapement indices derived from the 1955 and 1956 data, and this discrepancy has been attributed largely to differences between nets used in the two years. When fishing procedure and nets were essentially identical, as in 1956 and 1957, the differences between the indices were much less.

In 1958, the indices, particularly for sockeye, differed from those derived in 1956 and 1957. Tentatively, the difference is attributed to the use in 1958 of new nets which showed signs of being of poorer quality than those used in 1956 and 1957. Tests under actual fishing conditions of the 1958 netting compared with netting equivalent to that used in 1956 and 1957 will be necessary to determine whether the differences in the indices are caused by differences in net quality alone.

5. Babine fence counts in 1958 F.P. Jordan

Since the sockeye escapement to Babine Lake constitutes about 75% of the total sockeye escapement to the Skeena River, the Babine River weir count, which was carried out in 1958 as in all years since 1946 (except in 1948 when floods damaged the weir) provides the best single measure of sockeye escapement. The weir data have been of especial importance since 1951 in assessing the effect on the salmon runs of the partial block by the Babine River rock-slide.

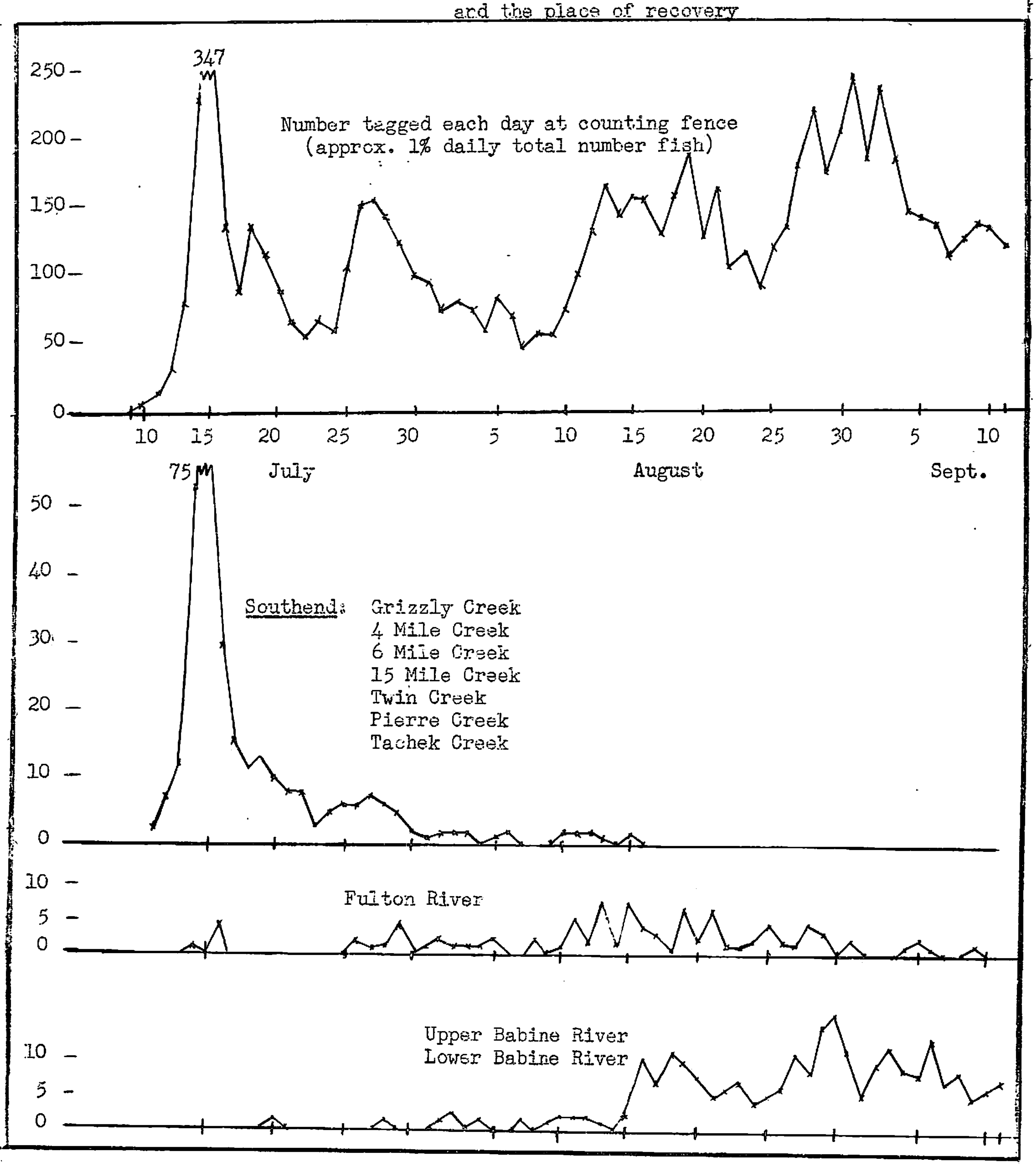
The numbers of the five species of Pacific salmon which were counted in 1958 are compared in the table with counts made in the other years of operation.

Year	Sockeye		Spring	Pink	Coho	Chum
	Large	Jack				
1946	419,637	56,068	10,528	28,161	12,489	18
1947	261,460	261,101	15,614	55,421	10,252	7
1948*	650,000					
1949	461,139	47,993	7,433	13,663	11,938	5
1950	364,356	179,302	6,838	38,728	11,654	7
1951	141,415	11,042	2,778	50	2,122	0
1952	349,011	27,936	5,915	2,706	10,554	1
1953	686,586	28,028	8,353	1,108	7,648	17
1954	493,677	9,745	5,925	4,604	3,094	66
1955	71,352	30,624	3,528	2,151	8,947	3
1956	355,345	18,164	4,345	2,691	9,250	3
1957	433,149	50,162	7,509	25,865	4,421	15
1958	812,043	30,769	8,274	6,600	7,606	8

*Total sockeye estimated from comparison with stream surveys and fence counts of other years.

The sockeye run in 1958 was the largest recorded to Babine Lake since weir operations began in 1946. From commencement of counting on July 8, the daily count rose rapidly to a peak of 28,114 large sockeye on July 14. This early peak, which has been characteristic of most years and which is composed of early running fish to the smaller streams of the south end of the lake, was over one week earlier than usual and was almost twice as large as the highest early peak in previous years. Following the early peak the run declined with considerable fluctuation and rose again to a second peak of 23,189 large sockeye on August 30. This later peak was several days later than usual and was larger than in most years. Following August 30 the count declined until only 202 large sockeye were counted on October 1, the day when fence operations were discontinued.

Number of sockeye tagged each day at the Babine Fence in 1958 and the place of recovery



Stream surveys were made during August, September, and October to recover tags. The number of fish examined, the number of tagged individuals among them, and their tag numbers were recorded. A total of 129,495 fish was examined from which 610 tags were recovered.

The accompanying figure shows the number tagged daily at the weir and the number and place of the recoveries in relation to the date of tagging. The spawning streams have been grouped into three, corresponding to the three major spawning areas of the Babine system. These are the outlet Upper and Lower Babine Rivers at the extreme north end of the lake, the Fulton River which is a large spawning area located centrally in the system, and "south-end" streams all of which have runs which are small relative to the other areas described.

The graph shows that the 1958 Babine escapement can be divided roughly into two parts. The early run, which passed through the weir from early July to early August, proceeded mainly to streams located at the south end of the lake. These sockeye made up almost the entire early peak recorded at the fence about July 15 and which, together with early runs to other Skeena lakes, would have made up the stock present in the fishing area during June.

The second part of the Babine escapement, which comprised the greatest part of the total, proceeded to the large spawning areas of the Fulton and Upper and Lower Babine Rivers. These runs passed through the weir beginning in early August and would have made up the bulk of the sockeye in the commercial fishery during July and August.

The tag recoveries indicate that the run to the Fulton River was somewhat earlier than those to the Babine Rivers and could be considered intermediate, falling somewhat between the early run to the south-end streams and the late runs to the Upper and Lower Babine.

8. Tagging and recovery to estimate the 1958 Babine sockeye escapement

J. McDonald

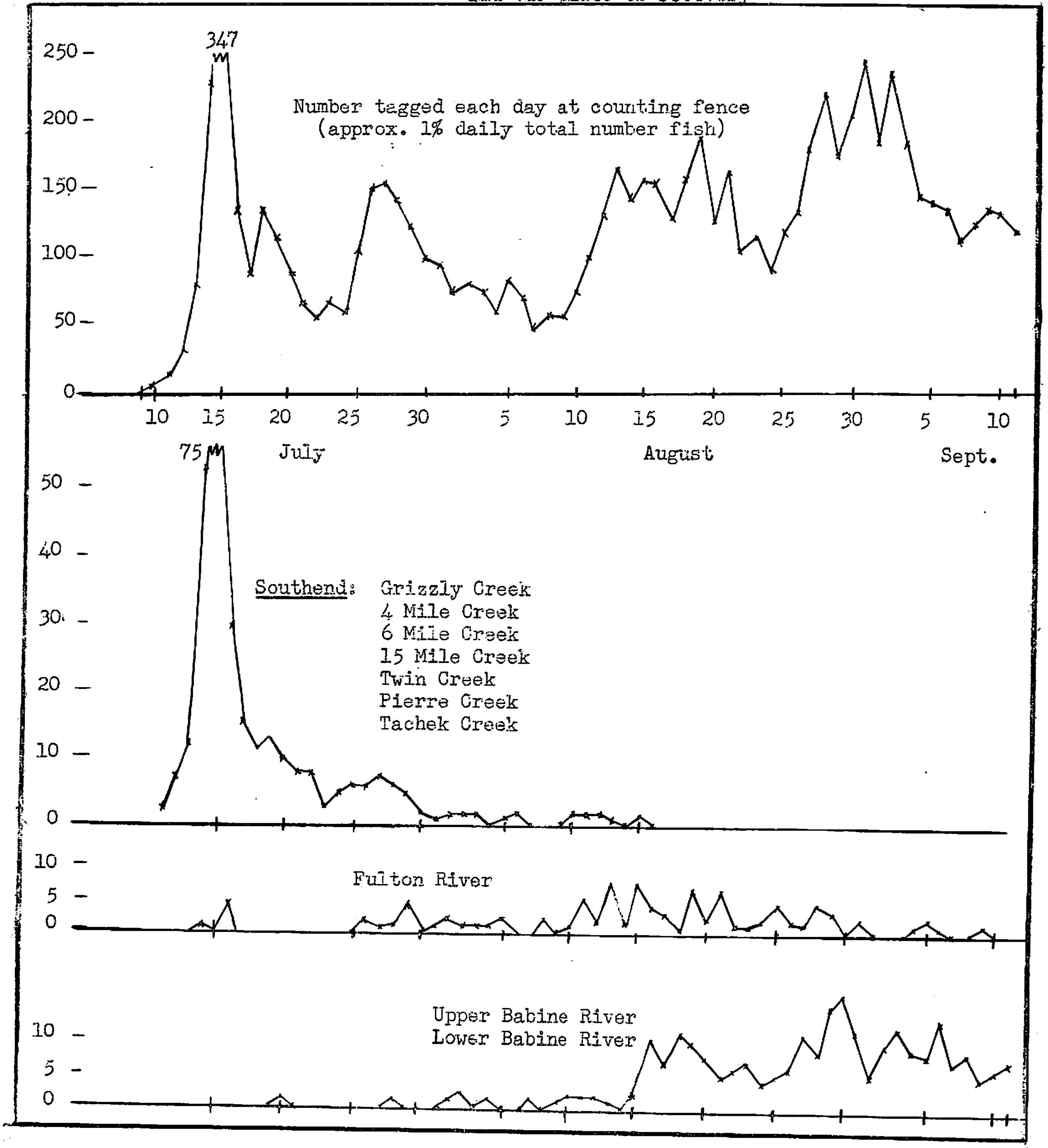
The tagging program described in the preceding appendix provided an opportunity to test the tag and recovery method as a means of estimating the 1958 sockeye population at Babine Lake.

Except for a short period at the end of the run, 1% of the sockeye passing through the weir each day was tagged. The proportion of the total run tagged was 0.93%.

The accompanying table gives the number and place of recoveries and the proportion of the fish examined found to be tagged.

Area	No. fish examined	No. tags recovered	% tags recovered
Grissly Creek	2,772	14	0.51
4 Mile Creek	4,345	9	0.21
6 Mile Creek	1,886	8	0.42
15 Mile Creek	3,877	15	0.39
Twin Creek	14,515	64	0.44
Pierre Creek	32,402	165	0.51
Fulton River	20,190	90	0.46
Upper Babine	24,897	117	0.47
Lower Babine	24,611	128	0.52
Total	129,495	610	0.47

Number of sockeye tagged each day at the Babine Fence in 1958 and the place of recovery



The proportion found tagged on the various streams ranged from 0.21% to 0.52% and averaged 0.47% over the whole system. This proportion is almost exactly one-half the proportion tagged at the weir. A population estimate calculated on the basis of the recoveries would therefore be twice the true number.

Experiments almost identical to this were carried out by Pritchard at Babine in 1946 and 1947. Petersen-disc tags were used at that time and 2.0% and 1.0% respectively of the 1946 and 1947 sockeye runs were tagged. The estimates resulting from these programs were also much higher than the actual. The degree of error is indicated below for all three trials:

Year	Proportion tagged	Proportion recovered	Degree of error in population estimate
1946	2.00	1.05	+90%
1947	1.00	0.71	+41%
1958	0.93	0.47	+98%

Pritchard's data indicated that the selection of tagged fish in the Indian gill-net fishery at Babine was the main source of error. Operculum tags, believed to make the fish less vulnerable to gill-nets than the Petersen-type tags, were used in 1958 to reduce this source of error. In addition, no reward was offered for tags to discourage fishing for tagged sockeye on the spawning grounds.

Despite these attempts to avoid the more obvious sources of error in the method the estimate derived from the 1958 tag and recovery program was still twice the weir count. These trials show very clearly that the method described above, at least without extensive revision, will not provide an accurate or even very useful estimate of the Babine escapement.

9. Babine sockeye smolt runs, 1951-1958

J. McDonald

The magnitude of annual Babine smolt runs has been estimated since 1951. The estimates together with the adult fence counts provide a measure of the production of smolts from spawning runs of known and varying sizes.

The same marking and recovery technique has been used each year to estimate the smolt run. A number of migrants are captured, marked and released at a trap at the outlet of Babine Lake. The proportion of marked fish in the run is determined from samples taken about 10 miles downstream in a similar trap located at the outlet of Nilkitkwa Lake.

Pertinent data are given in the following table. In some years it has been necessary to make adjustments to the estimate to account for migrants proceeding downstream prior to the time the mark and recovery program was started. "Fyke" net catches and school counts indicate that the "early" migration amounted to 6.3 million smolts in 1958.

Year	Number of smolts marked	Number of marked smolts recovered	Size of sample examined	Estimated size of run (millions)	95% limits (millions)
1951	34,689	200	21,855	4.2	3.7 to 4.8
1952	33,880	646	86,391	4.5	4.2 to 4.9
1953	61,950	2,498	124,396	3.1	3.0 to 3.2
1954	42,631	1,156	81,082	2.8	2.7 to 3.0
1955	113,931	1,287	270,546	30.9	28.6 to 32.6
1956	72,707	1,802	649,588	21.1	18.5 to 22.9
1957	68,666	1,496	170,772	6.4	6.0 to 6.8
1958	37,469	161	68,777	15.9	13.8 to 18.9
				+ 6.3	
			1958 total	22.2	

Since almost all Babine smolts migrate after only one year in the lake, estimates of survival from egg to emigrating smolt for each brood year from 1949 to 1956 can be shown as follows:

Brood year	Eggs potentially available (millions)	Year smolts emigrate	Estimated number of smolts (millions)	Survival egg to smolt (%)
1949	853	1951	4.2	0.49
1950	591	1952	4.5	0.76
1951	194	1953	3.1	1.60
1952*	409	1954	2.8	0.68
1953	1,241	1955	30.9	2.49
1954	1,020	1956	21.1	2.07
1955	105	1957	6.4	6.10
1956	523	1958	22.2	4.24
1957	653		38.5	5.90
1958	1524			
1959	≙ 1565			

*Only about one-third of this run spawned successfully due to adverse effects of the Babine slide. An adjusted account of the estimate of smolt survival would be about 2%.

Seasonal changes of the length, sex, and age composition of emigrant Babine smolts is observed each year from daily samples.

10. Studies of young sockeye salmon in Babine Lake — W.E. Johnson

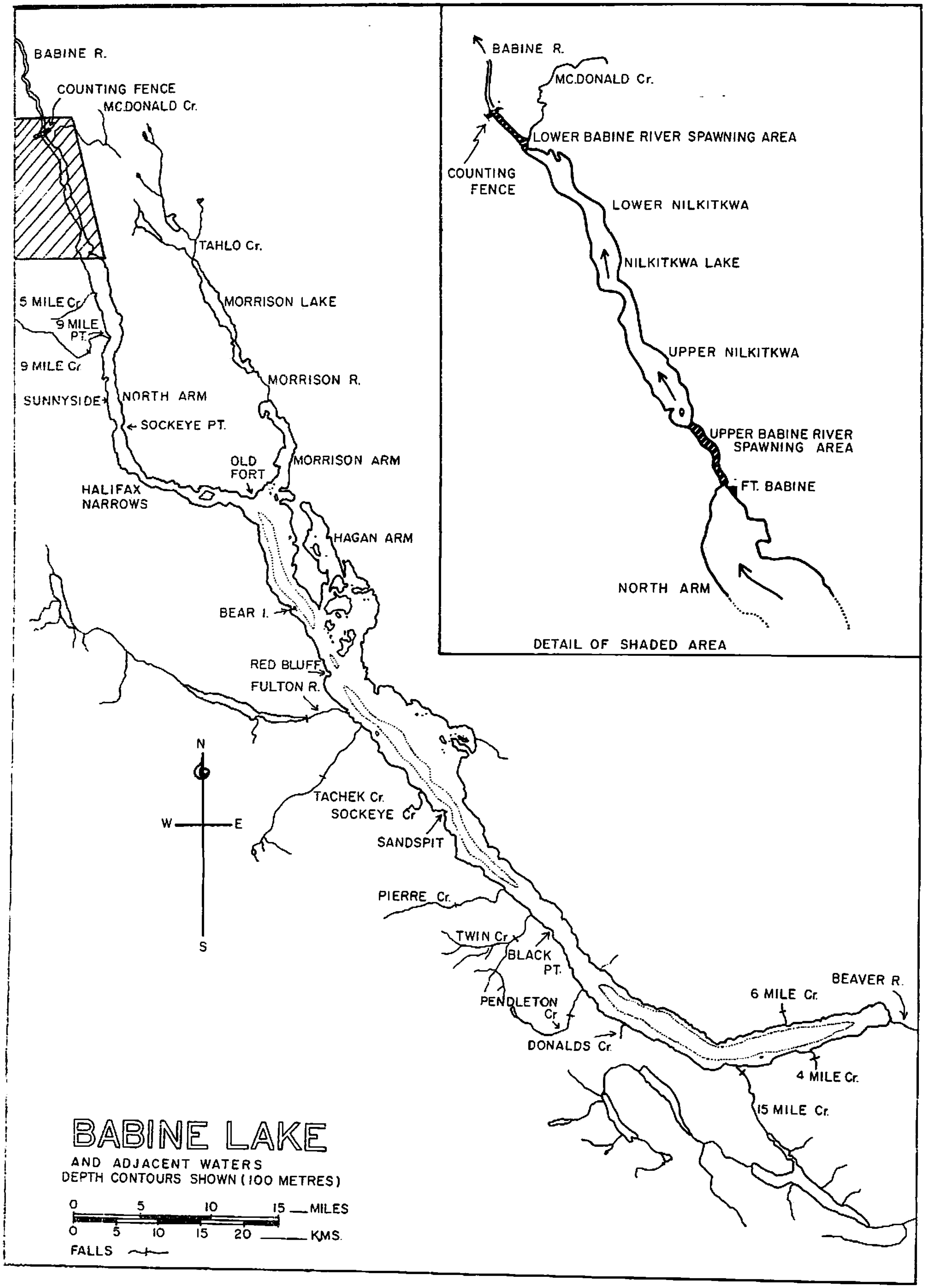
Since 1955, the distribution, density, and growth of young sockeye salmon in Babine Lake have been studied intensively with simultaneous observation of their zooplankton food supply and of the lake water conditions. The results have provided new concepts of what conditions affect young sockeye production, and have provided the basis for changes in management procedure. Some of the results have been reported previously; background and new information are provided below.

<u>Distribution throughout the lake system</u>. Study of the distribution of young sockeye following their entry into the lake in May and June has shown that they travel limited distances from their natal streams during the summer and fall of that year. In a long lake such as Babine, this limited travel means that the overall distribution of underyearlings is controlled largely by the distribution of the parent spawners in the tributary spawning streams. Thus, prior to 1955, when about 50% or more of the Babine sockeye escapement spawned in the outlet Upper and Lower Babine Rivers, the majority of young sockeye produced were contained within the basin north of Halifax Narrows (see map). Since this basin constitutes only about 10% of the total lake area, the majority of young sockeye were using only a restricted part of the total nursery area. With restriction of the fishery since 1956 to protect the early-running fish which spawn in streams tributary to the relatively unused southern portion of Babine Lake, the distribution of young sockeye within the nursery area has been changed.

The following table compares estimates of abundance of the 1955-58 underyearling populations in the two regions of the lake system, with the numbers of parent spawners in the adjacent streams.

Lake region	Number of adult sockeye spawning, excluding "jacks" (thousands)	Number of age-0 (underyearling) sockeye in lake (millions)
	1954	1955
North of Halifax Narrows	256.3	38.2 to 52.9
South of Halifax Narrows	185.6	7.1 to 19.3
Total	441.9	45.3 to 72.2
	1955	1956
North of Halifax Narrows	19.2	2.0
South of Halifax Narrows	27.8	3.1 + (7.4)*
Total	47.0	5.1 + (7.4)*
	1956	1957
North of Halifax Narrows	119.5	26.5
South of Halifax Narrows	148.9	34.8 + (22.3)*
Total	268.4	61.3 + (22.3)*
	1957	1958
North of Halifax Narrows	188.2	46.2
South of Halifax Narrows	202.8	52.5 + (16.0)*
Total	391.0	98.7 + (16.0)*

*Additional millions of underyearlings believed to be progeny of "kokanee".


BABINE R.
COUNTING FENCE
MC.DONALD Cr.
TAHLO Cr.
5 MILE Cr.
9 MILE PT.
9 MILE Cr.
MORRISON LAKE
MORRISON R.
SUNNYSIDE
NORTH ARM
SOCKEYE PT.
OLD FORT
MORRISON ARM
HALIFAX NARROWS
HAGAN ARM
BEAR I.
RED BLUFF
FULTON R.
N
W
E
S
TACHEK Cr.
SOCKEYE Cr.
SANDSPIT
PIERRE Cr.
TWIN Cr.
BLACK PT.
PENDLETON Cr.
DONALDS Cr.
6 MILE Cr.
BEAVER R.
4 MILE Cr.
15 MILE Cr.
BABINE LAKE
AND ADJACENT WATERS
DEPTH CONTOURS SHOWN (100 METRES)
0 5 10 15 MILES
0 5 10 15 20 KMS.
FALLS
BABINE R.
MC.DONALD Cr.
LOWER BABINE RIVER SPAWNING AREA
COUNTING FENCE
LOWER NILKITKWA
NILKITKWA LAKE
UPPER NILKITKWA
UPPER BABINE RIVER SPAWNING AREA
FT. BABINE
NORTH ARM
DETAIL OF SHADED AREA

The table shows that with a change in the proportion of spawners using the two regions, there has been a corresponding change in the overall distribution of underyearlings toward greater numbers in the large southern basin.

Distribution and population density. The local distribution of young sockeye in the limited and (in most years) densely populated region north of Halifax Narrows has been intensively observed. It is possible to examine the extent of dispersal from the parent spawning grounds in relation to different-sized underyearling populations originating there. The following table shows the estimated numbers of underyearlings (in millions) in late August in four sections of the basin north of Halifax Narrows for the years 1956, 1957 and 1958.

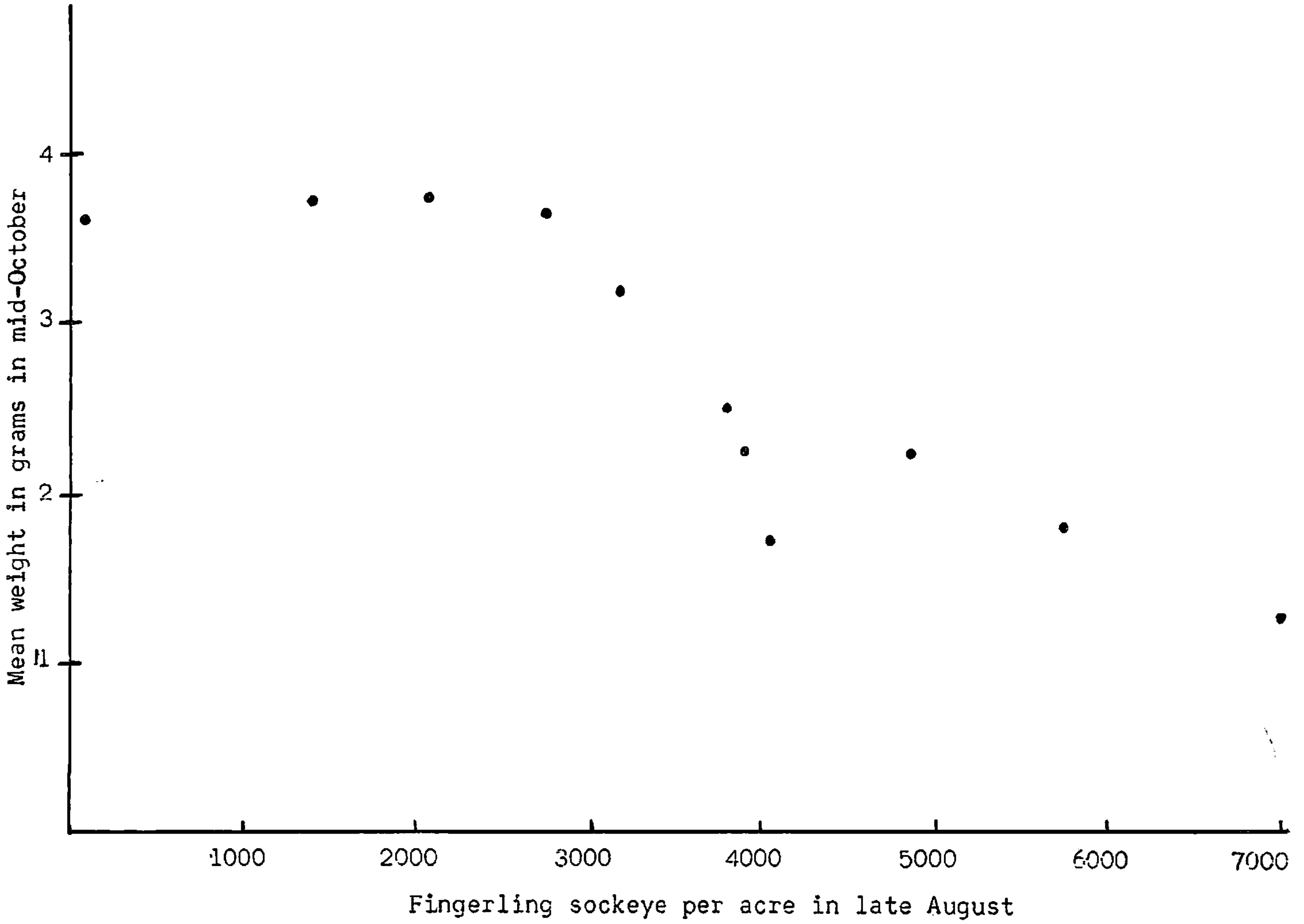
	1956	1957	1958
Nilkitkwa Lake	1.7	6.4	6.0
North Arm: outlet to 9-Mile Pt.	0.3	13.6	19.5
North Arm: 9-Mile Pt. to Sockeye Pt.	very few	5.7	10.6
North Arm: Sockeye Pt. to Halifax Narrows	very few	0.8	10.1
Total:	2.0+	26.5	46.2

The data strongly suggest that dispersal from the spawning ground area is positively related to the abundance of underyearlings: with greater total numbers, the young fish occupy to a greater extent the more distant sections of the basin. However, with spawning densities so far observed, it does not appear that significant numbers of underyearlings of the outlet region disperse further southward than Halifax Narrows.

For regions south of Halifax Narrows, the effect of density may not affect dispersal to such an extent. The wider distribution of tributary spawning grounds and freer circulation between adjacent lake basins likely permit wider distribution over the lake area.

Growth of young sockeye. Barring genetic differences between different underyearling populations (for which there is no evidence), and with the comparable temperature conditions observed over the period of study, the growth rate of young sockeye appears to have been determined largely by food abundance and underyearling population density. Although these two factors are not entirely independent (for example, high density underyearling populations tend to lower food abundance by cropping) certain relationships can be shown. It has been possible to examine underyearling growth rate in a wide range of underyearling population densities in the regions north of Halifax Narrows. The accompanying figure compares the mid-October mean weight of underyearlings with the numbers of sockeye per acre. As shown, underyearling sockeye in the region north of Halifax Narrows attain a mean size of 3.5 to 4 grams by mid-October when the population density does not exceed about 3,000 per acre. With increase of population density beyond 3,000 per acre, there is a depression of the growth rate.

Because of the marked relationship between population density and growth rate, it is more difficult to observe independently the effect of food



Relationship between population density and growth rate of fingerling sockeye salmon abundance on growth rate. However, some data which imply a direct relationship between growth rate and food abundance are available. At low population densities (below 3,000 per acre), underyearlings in Nilkitkwa Lake and the North Arm achieve a weight of 3.5 to 4 grams by mid-October with zooplankton abundance ranging between 10 and 40 milligrams dry weight per cubic metre of water; in regions south of Halifax Narrows, where population densities are low and zooplankton abundance ranges between 70 and 100 milligrams dry weight per cubic metre, underyearlings achieve a mean weight of 4.5 to 5 grams by mid-October.

Zooplankton studies. Intensive zooplankton sampling was carried out in all major regions of the system during 1958. As in former years, zooplankton abundance increased greatly in all regions soon after ice breakup. Highest levels were reached in regions south of Halifax Narrows and in the southern portion of the North Arm. Whereas all regions south of Halifax Narrows maintained high abundance until fall, all regions north of Halifax Narrows showed a marked decline in abundance beginning in late June or July. The most important factor causing the marked decline in the northern basin appears to be the greater densities there of underyearling sockeye which crop the zooplankton to low levels.

Capacity of Babine Lake as a sockeye producer. The above findings permit an evaluation of Babine Lake as a nursery area for young sockeye salmon. If it is assumed that it is desirable to use the food resources of the lake only up to the point just below that which would cause depression of the growth rate, best use would arise when a uniform density of about 3,000 underyearlings per acre in late August was achieved. Since the total lake area amounts to approximately 128,000 acres, such an ideal uniform distribution would require a total underyearling population of 384,000,000 in late August. Under survival conditions comparable to those observed in the past two years, such a population would require a total fry input of about 900,000,000, and should provide a smolt output of about 130,000,000.

In practice, it would be very difficult to achieve the ideal distribution described above. The two main lake regions may be considered separately.

The region north of Halifax Narrows, whose lake surface area amounts to 12,000 acres, is characterized by having large capacity spawning grounds (the Upper and Lower Babine Rivers) in relation to the nursery area available to the young sockeye. In this region it appears that the factor limiting production is the small lake surface area available, and best practical use would require only that number of spawners which would provide sufficient underyearlings to fully use the lake area.

The region south of Halifax Narrows is characterized by the opposite situation: an extremely large lake nursery area is available in proportion to the capacity of the tributary spawning grounds. To achieve the best production of young sockeye from this nursery area requires the fullest possible use of the available spawning grounds, which have in most recent years been populated below capacity.

Freshwater-maturing sockeye in Babine Lake. Preliminary investigation of freshwater-maturing sockeye, whose numbers on the spawning grounds in some years are large, was begun in 1958. Of the two types described previously by Ricker - "residuals" and "kokanee" - the specimens at Babine appear to be more typically "kokanee", for the following reasons:

(a) The sex ratio appears close to 50-50 ("residuals" are almost exclusively males).

(b) Colour at maturity is typical of the anadromous sockeye - green head and red body ("residuals" are dull olive-gray).

(c) Absorption of scale margins at maturity appears advanced (scale absorption in "residuals" is limited or non-existent).

Because other means of identifying the kokanee component of underyearling samples have not yet been devised, separation of kokanee from anadromous specimens has been tentative and based on the difference in size of the young fish in samples.

Observations of young sockeye and other fish with "Sea Scanar" echo-sounding gear. Information concerning the vertical, and to some extent, the horizontal movement of young sockeye and other species is becoming available with high sensitivity sounding gear. In Babine, during daylight, in summer, groups of fish are associated with the following depth intervals:

(a) surface to 15 feet
(b) 30 to 50 feet
(c) 70 to 100 feet
(d) 140 to 180 feet
(e) 200 to 370 feet (scattered schools)

Except for those groups at 200 to 370 feet, which appear to remain at great depth throughout 24 hours, the fish all show marked movement upward in evening twilight - to the surface if above the region of sharp temperature change during the day, or to the region of sharp temperature change if below it during the day. During morning twilight all groups quickly resume the levels maintained during daylight hours.

Sampling by tow-nets has demonstrated that underyearling sockeye mostly compose the groups nearest the surface, but positive identification of fish at greater depths has not yet been possible. Some information concerning horizontal displacement and concentration of young sockeye, apparently related to wind circulation of lake water, has been obtained.

11. Migration time and abundance of major Skeena pink runs, 1957 and 1958

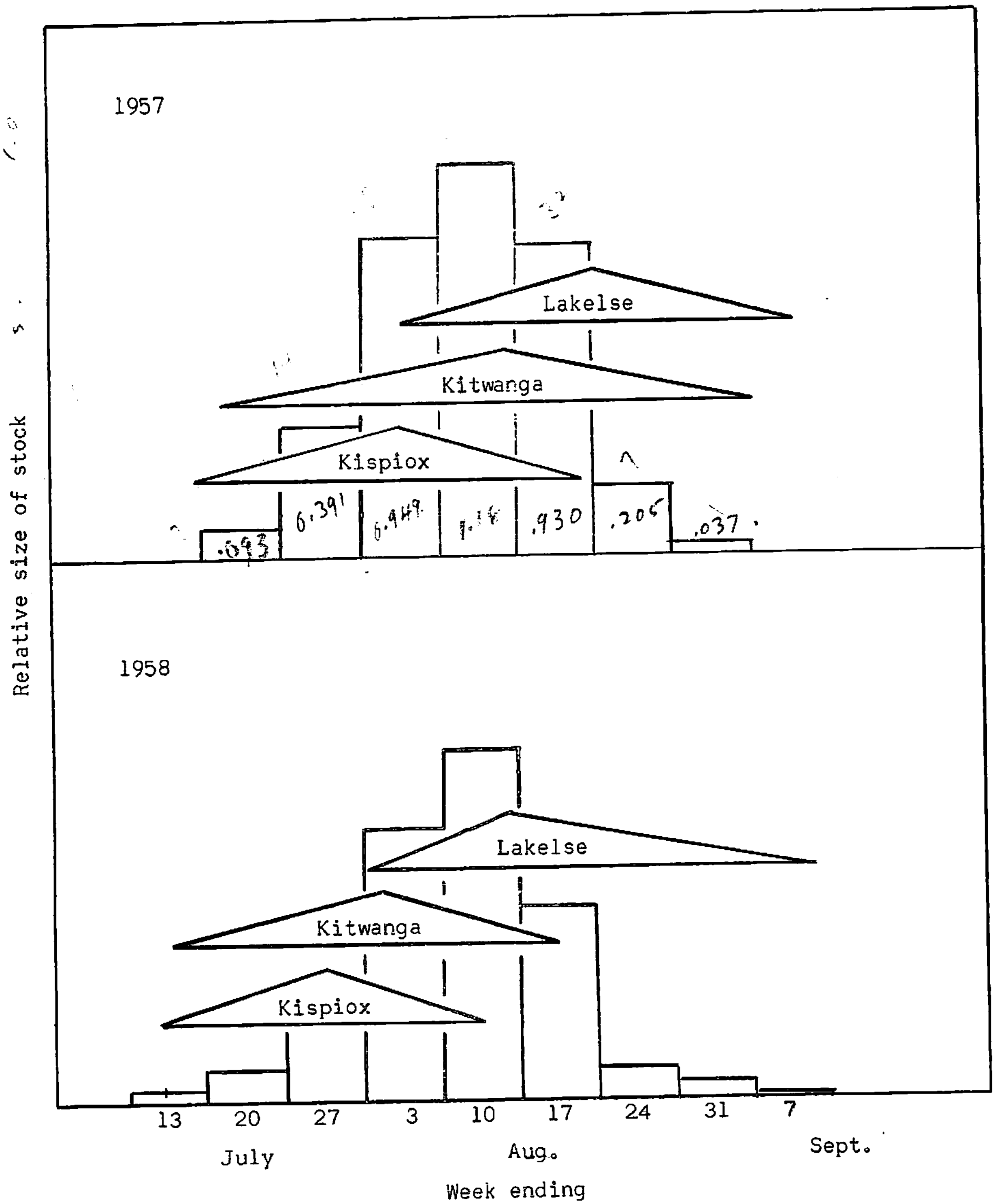
J. McDonald

Precise management requires that the best number of spawners be permitted to escape the fishery to each spawning ground. To accomplish this objective requires that the timing of each major run be known.

In 1957 and 1958, pink salmon were tagged at the outer fringe of the Skeena fishing area. Of the 16,000 tagged in the two years, about 300 were recovered on Skeena spawning grounds. Sufficient information is available to show the progress of the three major pink runs through the fishing area. The accompanying figure demonstrates the seasonal abundance of each run in the fishery. The bars on the figure represent the total stock of pinks (catch plus escapement) estimated to have been in the fishing area each week of the season.

The relative timing of the runs to the Lakelse, Kispiox, and Kitwanga Rivers was similar in both years: the Kispiox run appeared first and was closely followed by the Kitwanga run. The Lakelse run was the last major run to enter the fishery.

The timing of three major pink runs to the Skeena in 1957 and 1958



Although the relative timing of the runs in 1957 and 1958 was the same, all three runs appeared in the fishery over one week earlier in 1958 than in 1957. Since the proportion of the total stock present in any week was about the same in both years (in spite of the earlier appearance in 1958), individual runs contributed differently to the total stock in the two years. Differences in the sizes of escapements confirm this observation; in 1957 the Kispiox escapement was 5 times that of 1958, while the Kitwanga and Lakelse runs were smaller in 1957 than in 1958. It appears that the 1957 pink stock was composed largely of Kispiox fish; the 1958 stock was composed largely of Kitwanga and Lakelse fish.

J. McDonald

12. <u>The 1958 Skeena pink escapement</u>

Annual spawning ground surveys by officers of the Department of Fisheries provide the basis for Skeena pink escapement estimates. In 1957 and 1958, Fisheries Research Board personnel have supplemented these data by tagging and recovery on the major spawning grounds - the Kispiox, Kitwanga, and Lakelse Rivers - in attempts to obtain more precise estimates. Special surveys of possible spawning grounds on the main stem of the Skeena River also were initiated.

The 1958 Skeena pink escapement was estimated to be more than twice that of the parent year 1956. The relatively large escapement was made possible by a better than average return from the 1956 spawning in spite of intensive fishing. The following table compares the 1958 estimates of escapement with those of the parent year 1956.

	1956	1958
Kispiox River	75,000	66,000
Kitwanga River	35,000	158,000
Lakelse River	75,000	262,000
Babine River	3,000	10,000
Bear River	nil	nil
Coastal streams	75,000	116,000
Others	15,000	60,000
Total	278,000	672,000

The greatest increase in number of spawners occurred in the Lakelse and Kitwanga Rivers - the combined total accounted to about two-thirds of the total escapement. The Kispiox River escapement was less than in 1956, despite the overall increase. Greater numbers of spawners were observed in 1958 in the coastal streams of the Skeena Gill-net Area than in the parent year.

Evidence for spawning in the main stem of the Skeena River itself was as follows:

(a) Pink salmon were observed finning over numerous riffles.

(b) Pinks caught in gill-nets in the river were often mature, partially, or completely spawned.

(c) Dead spawned out pinks were found on many river bars.

Direct observation of spawning was impossible due to the turbitity of the water. Apparent spawning occurred in the 60 miles of river between Terrace and Kwinitsa; the largest concentration appeared to be between a point some 20-30 miles downstream of Terrace and the junction of the Kasiks and Skeena Rivers.

A tentative estimate of the number of main stem spawners in 1958, based on the number of dead pinks observed in surveys, would be 50,000 more or less.

13. Skeena pink fry production in 1958 J. McDonald

Standardized trap-netting for pink fry migrants has been carried out at the mouths of the large spawning tributaries of the Skeena since 1956. The catch per unit of effort is used as a relative measure of fry outputs, and is compared with the size of the spawning runs which produced them.

The indices which have been calculated for the Lakelse, Kispiox and Kitwanga Rivers are compared with the estimates of spawning stock size which produced each fry run:

Area	Parent year	Escapement	Index of fry output
Lakelse River	1955	175,000	3.2
	1956	75,000	1.9
	1957	140,000	13.5
Kispiox River	1955	540,000	8.6
	1956	75,000	1.4
	1957	360,000	13.2
Kitwanga River	1955	125,000	--*
	1956	35,000	3.7
	1957	160,000	7.6

*Not observed.

The indices indicate a fry output from the 1957 spawning proportionately greater than those from the 1955 and 1956 spawnings. The Lakelse output was 6 to 7 times greater than that of 1956 and 4 times greater than that from the 1955 spawning. Increased output was also evident from the Kispiox and Kitwanga Rivers.

To date, fry outputs from the small 1956 brood stock (estimated at 278,000) and the relatively large broods of 1955 and 1957 (about 1,000,000 spawners each) have been assessed. The data indicate that the number of fry produced from the 1957 spawning in the Lakelse, Kitwanga, and Kispiox Rivers was about twice that produced in these rivers from the 1955 spawning. These fry productions, while different in themselves, are nevertheless both far greater than that resulting from the small 1956 escapement.

CONDITIONS FOR ASSISTING THE NATURAL PROPAGATION OF SALMON

- W.P. Wickett

Progress has continued to be made in the study of the conditions affecting the propagation of salmon.

Until recently, only general relations between the environment and salmon stocks could be recognized and they have been overshadowed by the study of the relation between parent and offspring stocks. It is now clear that stocks will produce nearer their optima if both the spawning escapements and the environment are under some control. A recent paper by W. E. Ricker makes it clear that regulation for maximum long-term yield of stocks which are subject to variable survival rates leads to great fluctuations in yearly catches. During some years and in certain cases, no fishing can be permitted if the long-term maximum production is to be obtained from stocks which use a variable natural environment. Stocks with low survival rates may be eliminated when fished in conjunction with stocks having higher freshwater survival rates at intensities giving the maximum combined yield.

An action program to improve salmon propagation requires particular values of the dependent and independent variables. Survival from the egg to fry stage has been the dependent variable studied because it is the most important factor for species with a short freshwater life-history. It is also an important factor for the other species when their stocks are at such low densities that recruitment of underyearlings is less than the freshwater environment can support. Previous reports have shown low particular values of oxygen, velocity of water, permeability of gravel etc. can be related to survival of pink and chum salmon. Work in 1958 has clarified and broadened these relationships, and has indicated that sockeye survival is governed by the same factors.

In past years, it was proposed that a laboratory be obtained in which the optimum combination of several of the more important factors would be worked out. Particular values of survival associated with particular values of spawning density, water flow and gravel composition would be investigated. Applied studies will be less than fully efficient until the project is carried out.

General relations are of little use in an action program except when extreme values are obviously detrimental. The negative approach of guarding against disasters from floods or droughts falls in the latter class. Very useful applied work can be done but the value of the resulting improvement is not easily assessed until experimental work is completed. A study of the Qualicum River before and after a flood gave some useful information, indicating a 6% loss of spawning ground. Conditions in the gravel where there is a heavy deposition of chum eggs are being monitored this winter so as to provide a guide to precise studies on effects of density.

Productive capacity of the Qualicum River. A survey of the biological potential of the Qualicum River was commenced in 1957 and finished in October, 1958. Exploratory gravel surveys made earlier were useful in assessing the effects of a flood that occurred on January 23 and 24, 1958.

The survey of course, distance, width and length of that part of the river available for spawning of salmon involved 186 stations. The area of gravel unsuitable for spawning was recorded during the initial survey. The length of the stream below the falls is 37,000 feet. There are 164,000 square yards of spawning gravel. Permeability readings were taken every 50 feet, a total 646 readings in useable areas. Permeabilities were assigned to the 50-foot sections according to the readings obtained. Total areas of gravel in permeability brackets of 0-2,000, 2,000-4,000, 4,000-6,000, 6,000-8,000, 8,000-10,000, over 10,000 cm/hr were calculated. These areas were multiplied by factors obtained from the writer's paper in volume 15 of the Journal, to estimate the number of pink or chum spawners per square yard that would give the maximum fry output; the estimate for the whole stream is 240,000 fish.

Floods and droughts occur at least every 10 years and prevent such a potential being maintained. Chum spawning stocks have varied between 20,000-50,000 and 50,000-100,000 categories in the last few years. The chum salmon survival from egg to migrating fry was estimated by using 7 nets. From March 26 to May 22, 549,969 fry were counted with the peak on May 4. Allowance for fry moving below the nets and between them gave a maximum estimate of 2,750,000 migrants and a minimum of 2,050,000. On the basis of a reported 20,000 to 50,000 escapement, 3% to 10% of the eggs produced migrants. During the winter, the surveys indicated that 6% of the spawning area or 11,000 square yards had its permeability reduced to zero - i.e. was scoured to consolidated material. Sections 166 to 169 had their average permeability reduced from 3,000 cm/hr to 2,000 cm/hr. During and after the flood, live eyed coho and chum eggs were found along the banks and bushes of the lower stream. Birds were feeding in large numbers at this and nearby stream mouths after the flood.

The fry survival is reasonably good considering the flood destruction - at least not a complete failure as was considered possible at the time. The loss of part of a particular year-class of salmon and part of the spawning gravel is not all of the flood damage. The rate at which the stream bottom becomes looser, either by removal of fine materials, deposition of moderate-sized gravel or by the action of spawning fish will determine how lasting the damage is to future runs of salmon.

The figures for the potential of the stream have been given above for the state of the stream after the flood. Data from Nile, Jones and McClinton Creeks indicate that with loose gravel and steady flow a survival rate of 10% is feasible at high spawning density. The catch off McClinton Creek in 1936 was over 280,000 fish. This came from an escapement of 155,000 fish at a density of 1.4 fish per square yard. These fish produced 12.6 million fry or 9% of the egg deposition. The Qualicum in its present condition should produce a catch of a quarter of a million fish from a similar size of escapement, in the absence of adverse water conditions. A sustained yield much higher than this is possible if predators, water flow and gravel are controlled. These matters are being investigated by the Department for their feasibility.

It may be desirable to build up stocks of chinook, coho, pink and chum salmon and accept a lesser increment of individual species rather than concentrate on the build-up of one species. Fundamental data on such a situation are desirable because effects cannot be assessed beforehand at present.

The study has served to show that the techniques and skills developed by the investigation can provide fundamental data for an action program in management and fish culture.

<u>Sockeye spawning at Lakelse Lake</u>. A short study of spawning gravel in relation to sockeye production was made at Lakelse Lake. Average permeabilities of the river bottoms of Scully and Williams Creeks were obtained and compared with fry survivals of sockeye in these creeks.

Twenty-three permeability readings in Williams Creek gave an average of 8,708 cm/hr. This stream in two unsilted years had a mean survival of 17%. Thirty-six readings at Scully Creek gave a mean permeability of 5,863 cm/hr. The mean survival was 12%. These two points lie on a line passing through the origin when plotted. The relationship is similar to that of pink and chum salmon.

Taking Williams Creek as the only supplier of fry, we can calculate the number of spawners required to produce the desired recruitment to the lake. If 4,000 per acre are needed at the start of summer, then a total of 14 million fry or about 200 fry per square yard of spawning ground must be produced.

The recorded fry productions at Williams Creek have been: 38 fry/sq yd at a spawning density of 0.10 sockeye/sq yd and 15 fry/sq yd at a spawning density of 0.05 sockeye/sq yd. McClinton Creek produced 18 pinks/sq yd at 0.10 fish/sq yd and 114 fry/sq yd at 1.4 pinks/sq yd. The average permeabilities of the two streams are about the same. The fry production per unit area in Williams is about double that of McClinton Creek, probably due to the species difference in eggs per female.

Extrapolating from the above, Williams Creek would need about 70,000 spawners, or half the McClinton Creek 1934 escapement, to produce a suggested 4,000 fry per acre of lake area.

Proposed transfer of pink salmon to Newfoundland. Exploratory studies were made on the feasibility of transplanting Pacific salmon to Atlantic streams. Some of the background is given in Number 16 of the Canadian Fish Culturist which contains papers presented at the Canadian Committee on Freshwater Fisheries Research in January, 1954.

Early in 1958 the general requirements for a transplant were considered and it was agreed that Dr. Blair of the Newfoundland Station and the author should familiarize themselves with each coast and assess the problems involved.

Dr. Blair and the author visited fourteen streams in Newfoundland from June 26 to July 24. Streams were rated for gravel, water-flow, presence of side-channels for planting and incubation, public relations, presence of predators, and ease of transportation. Specific values of temperatures in fresh and salt water, gravel characteristics, etc. were collected for Pacific coast streams and submitted for study.

Four streams in St. Mary's Bay on the Avalon Peninsula were well ahead of the other streams examined. North Harbour River at the head of St. Mary's Bay was recommended for the first transplant and experimental studies.

Ocean temperatures and salinities do not appear to be a limitation. Further data are being gathered. Freshwater temperatures appear suitable and data are being gathered this winter to make sure.

Because the timing of the fry migration is important as well as the degree of survival to emergence, it was decided to test the reaction of pink salmon eggs and fry to typical Newfoundland incubation temperatures. This information is necessary before making even an initial experimental scale transplant. Facilites at the Nanaimo station were overcrowded pending new construction, so 6,000 pink salmon eggs were shipped in early November to Newfoundland for incubation in cages in the stream bed. Fry counts in the spring will give data on which to plan future work. Already it is apparent that large egg shipments will have to be accompanied by an attendant to cope with shipping delays.

It appears that eggs for an experimental transplant in 1959 might be taken from the Tsolum River. This would have the advantage of matching latitudes as closely as possible in case this is important to return from the sea. However, at this stage, sizable returns from the sea of the small numbers contemplated this year are not to be counted on.

Pink eggs are recommended for the first three years of study. Efforts should be concentrated on one species in one stream to get as large numbers of migrants as possible. Pinks will give answers on returns most quickly.

The next two phases are (1) the experimental transplantation in 1959-60 of up to 1,000,000 eggs to check on freshwater survival more fully and familiarize personnel with shipping, planting and incubation problems; (2) a pilot-plant phase in a subsequent year to make the first real test of sea-survival, if the experimental studies are satisfactory. For (2) a transplant of 10-25 million eggs to one stream is believed to be needed and the gathering of such large numbers of eggs would involve large effort and cost.

STUDIES ON SALMON PRODUCTION AT PORT JOHN

R.C. Wilson and F. Neave

Sockeye

Adult sockeye salmon escapement, Port John, 1958. The number of adult sockeye entering Hooknose Creek in 1958 was 1,284, divided as follows: females 621; large males 288; jacks 375. Although the total number of fish was slightly smaller than in 1957, the number of females was about twice as great and the estimated egg deposition (see below) was more than twice as great.

Of the returning jacks, 330 (88%) were found to be marked by removal of both ventral fins, the result of the marking of the outgoing smolts in the spring of 1957. Of the large fish, 887 (90%) had been marked by removal of the adipose and right ventral fins. To the latter can be added 759 marked jacks which returned in 1957, giving a return to date of 1,646 marked fish from 21,570 smolts which reached the sea in 1956, i.e. a survival after marking of 7.63%.

In the spring of 1955, 43,000 sockeye fry resulting from the spawning of 1954 were transferred to the sea at the mouth of Hooknose Creek. The low percentage of unmarked fish returning in 1958 showed that few if any of these transplanted fry returned as 4th year fish.

The 1958 spawning of sockeye in Tally Creek yielded the following figures:

Females reaching weir	Average egg content	Females released above weir	Potential deposition
374	2,998	356	1,067,288

The number of fish spawning below Tally Creek weir and in other streams was very small, the estimated additional number of eggs deposited in these places being only 66,000.

Production and disposal of sockeye fry in 1958. The estimated potential deposition of sockeye eggs above Tally Creek weir in 1957 was 429,348. The downstream migration of fry took place between April 12 and June 3, 1958, and produced a count of 11,725 at the weir. The survival at this point was 2.73%, which is low for this stream. These fry (minus 109 which died in the trap and holding pen) were transported from Tally Creek to the mouth of Hooknose Creek. At the latter place they were released along with other fry taken at the Hooknose Creek weir. The unusually large number (10,605) of sockeye fry counted at the Hooknose weir was the result of low water in the fall of 1957. At that time a considerable number of sockeye adults which had failed to get through to Port John Lake spawned in Hooknose Creek.

No sockeye fry from above Tally Creek weir were permitted to enter the lake in 1958 and it is thought likely that the lake did not receive more than 200 or 300 fry hatched below the Tally Creek weir or in other tributaries.

Sockeye smolt production in 1958. The run of seaward-migrating smolts (5,936) trapped at the weir on Hooknose Creek in 1958 was small, since most of the fry which would otherwise have contributed to it had been transferred to the sea. Scale readings made on a two-percent sample of these migrants showed the following age composition:

1 year residence in lake - 1%
2 year residence in lake - 88%
3 year residence in lake - 11%

The dominant 2-year-old fish were survivors of the fry which entered the lake in the spring of 1956. These were estimated to number 41,000. On this basis the survival of these smolts from fry was 12.7%.

All outgoing smolts released from Hooknose Creek weir in 1958 were marked by the removal of the adipose and left ventral fins.

Pink and Chum

Adult pink and chum migration in 1958. As had been expected on the basis of fry output, relatively large escapements of both species were recorded, although the ocean survival was lower than the long-term average. The combined deposition of nearly 12,000,000 eggs is thought to be near the optimum seeding for this stream.

Species	Number of adults	Percent females	Average egg content	Potential deposition	Percent loss of eggs by retention
Pink	6,109	55.33	1,773	5,896,998	1.23
Chum	3,760	52.37	2,977	5,748,973	0.72

The average egg content and the loss due to retention were based on 33 and 352 samples respectively for pink salmon, and 33 and 189 for chum.

<u>Ocean survival of pink salmon</u>. The adult pink salmon escapement of 6,109 in 1958 can be regarded as the survivors of 454,148 fry which went to sea in the spring of 1957. The survival from outgoing fry to returning adult was therefore 1.34%. This is about half the long-term average for this stream.

<u>Output of pink and chum fry in 1958</u>. The mid-point of the downstream migration of pink fry resulting from the spawning of 1957 was reached on March 31 and that of chum fry on April 20. The pinks were three weeks earlier than the average time and the chums two weeks earlier.

Species	Potential deposition	Number of fry	Percent survival
Pink	2,142,550	60,001	2.80
Chum	4,838,616	136,444	2.82

Coho

Coho smolts migrating to sea in the spring of 1958 numbered 4,452. These resulted from an estimated deposition of 354,688 eggs in the Hooknose Creek watershed in 1956. The survival was therefore 1.26% to this stage. The previously established range was from 0.6% to 4.0%.

The ocean survival of cohoes from the brood year of 1955 is represented by the jacks which returned in 1957 <u>plus</u> the large males and females in 1958. These were: jacks 417; large males 163; females 165; a total of 745. This is a return of 12.27% from the 6,074 smolts which left the stream in 1957. This is quite similar to the return from the 1956 smolts (11.9%). The ocean survival recorded from previous years has varied from about 4% to 20%.

In addition to the large males and females reported above, the 1958 coho escapement included 347 jacks.

The estimated potential deposition in 1958 was 425,104 eggs.

EXPERIMENTAL HATCHERY INVESTIGATION

- M.P. Shepard

The experimental hatchery project is concerned with devising means of increasing the survival of salmon fry released from hatcheries. In the past, standard hatchery procedures have provided hatches of 90% and greater compared to an average of less than 20% nature. However, after release hatchery-reared fry have not survived to the returning adult stage as well as naturally produced fry; in most cases adult returns per egg in the hatcheries have been no greater than would occur with natural spawning.

Failure of many hatcheries to release fry at the same stage of development and at the same time as in nature may account for the poor survival of hatchery fry in some cases. Another reason for low survival might be that unnatural environmental conditions (e.g. exposure of developing larvae to light) in hatcheries may seriously affect the behaviour patterns of fry so that on release they fail to carry out normal seaward migration or other behaviour sequences (e.g. initiation of feeding) necessary for survival.

Experiments conducted at the experimental hatchery at Kleanza Creek (a small pink salmon stream tributary to the Skeena River) involve releasing hatchery-reared fry at the natural stage of development and at the normal time of seaward migration, providing as nearly natural environmental conditions at the time of release as practicable. The experiment began in 1957; in that year the eggs from about one-half the natural run of females to the creek were reared in the hatchery. Eggs from the remaining females were deposited naturally in the lower reaches of the creek but severe floods later scoured most of the spawning area probably resulting in an almost total loss of the naturally deposited eggs. In 1958 the eggs from most of the females arriving at Kleanza were taken for the hatchery. In both years, the Kleanza egg take was supplemented by eggs taken from pinks entering the nearby Lakelse River. As described below, the hatchery-reared fish were placed in special release troughs near the end of larval development and permitted to escape to the creek as they reached the active free-swimming stage. The success or failure of the rearing and release techniques will be assessed by counting the adults returning to Kleanza in future years.

The 1958 release

M.P. Shepard,
R.M. Humphreys
and A.S. Coburn

From a natural run to Kleanza Creek in 1957 of approximately 2,100 pink adults (including about 1,000 females), approximately 570,000 eggs were taken and incubated in the hatchery. These were supplemented by some 1,360,000 eggs obtained from later running pinks from the Lakelse River to give a total take of 1,930,000 eggs. The developing eggs were incubated in darkness in vertical bank incubators supplied with water pumped directly from Kleanza Creek. Using this procedure light and temperature conditions were similar to those that would be encountered by eggs deposited naturally in Kleanza Creek. On reaching the late alevin stage (yolk sac approaching absorption), the fish were transferred from the incubator trays to a special release trough consisting of a 4' x 4' x 4' light-proof box provided with a water flow welling up through a false bottom and overflowing at the top into a 4" pipe which carried escaping fry to the creek.

Breakdowns in the new pumping system and failure of the transported Lakelse eggs to develop rapidly enough in the relatively cold Kleanza water resulted in severe losses. From the 570,000 Kleanza eggs, 345,000 (roughly 62%) survived to the fry stage; of the 1,360,000 Lakelse eggs only 325,000 (roughly 24%) reached the fry stage.

Despite these losses, the Kleanza fish that survived released themselves from the experimental trough at apparently the same stage of development and at the same time as naturally propagated fry would be expected to begin their seaward migration. When placed in the release trough the alevins remained quiescent on the bottom of the box until they developed to the migrant stage when they began to swim actively and to escape through the overflow to the creek. At the end of the release the only fish left in the trough were several hundred "freaks" including Siamese twins, fish with twisted spines, etc.

During the fry release, trap-nets (similar to those used by Skeena salmon investigators to obtain indices of fry production) were operated near the outlet of Kleanza Creek to the Skeena (about 1/2 mile downstream from the hatchery). The traps were cleared each morning. In the accompanying figure, the numbers of fish removed from the trap-nets each morning are compared with the numbers of fish released from the hatchery during the preceding 24 hours. The trap-net catches are seen to parallel the releases of the previous day closely.