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C O N T E N T S

greatly between the two species of salmon. Hemiurus levinseni, for example, seems to indicate sockeyes of western origin, but in pinks it is common on both sides of the ocean. Some of the parasite differences are attributable to the longer freshwater period of residence of sockeye before migrating to sea whereas others seem to reflect differences in feeding habits at sea.

There are some parasites of marine origin that are very restricted in distribution and may be useful in identifying the origin of fish on the high seas. The trematode Podocotyle shawi was found only in sockeyes from the Columbia River and the cestode Diplocotyle sp. was found in pinks and sockeyes only at Attu. If fish on the high seas are found to be infected with either of these parasites, their origin could be stated with considerable certainty.

A detailed report of the results and interpretations thereof obtained from samples collected in 1955 was distributed at the Commission's meetings in Seattle in November, 1955, and has been issued in the Manuscript Report series as No. 624.

SALMON SAMPLING FOR THE INTERNATIONAL NORTH PACIFIC FISHERIES COMMISSION IN 1956

D.R. Foskett

Sampling of salmon was continued as part of the Commission's program of research to determine where salmon of North American and Asiatic origin go on the high seas. Samples were collected for meristic, parasitological, scale and other studies. Canada's share included sampling on the high seas where special fishing was done (see above) and in coastal areas.

About 1,000 salmon were taken in the high-seas fishing; about 3,000 were taken from coastal fisheries, spawning streams and seaward migrants. Scale samples collected amounted to about 9,000 of which 4,450 were from the coastal sockeye fisheries, 1,266 from coastal pink and chum fisheries, 943 from high-seas catches and the remaining 2,215 (of all species but predominantly sockeye) from special fishing in the Skeena estuary (see test fishing in next section).

The samples of whole fish have been assigned to the various investigations (principally in the United States) and are shipped as required. Impressions of all scale samples are being made on plastic slides and complete series are to be sent to both United States and Japan.

SKEENA SALMON INVESTIGATIONS

F.C. Withler

Since the inception of the Skeena Salmon Management Committee in 1954, the Fisheries Research Board has conducted investigations to provide information for improving management of the Skeena salmon stocks.

Essentially, the objective of management of any salmon stock is to achieve the maximum sustained yield. Although year-to-year variations in the marine environment exert important effects on the survival and growth of salmon, their widespread distribution in the sea suggests that the amounts of space and food available in the ocean would never be factors limiting abundance. Hence, the attainment of maximum production depends on making the fullest use of the freshwater environments, since maximum sustained yield of Pacific salmon is ultimately limited by the amount of freshwater spawning and rearing area available. Salmon management is therefore mainly concerned with providing spawning escapements which will, as nearly as possible, provide that output of young fish which will return in greatest numbers as adults.

In practice, then, studies aimed at obtaining the maximum sustained yield from a salmon stock will be concerned chiefly with two questions:

(1) What escapement is required to provide the greatest return?

(2) How may the fishery be regulated to provide such an escapement?

Determination of optimum escapement. For Skeena sockeye, since about 75% of the escapement spawns in Babine Lake watershed, provision of optimum escapement to Babine is of most concern. For the past six years, the spawning escapement to Babine has been counted and the numbers of resultant seaward-migrating smolts have been estimated. The large smolt runs of 30 million in 1955 and 20 million in 1956, which were some 5 to 6 times greater than the average smolt runs of 1951-54, arose from two of the largest escapements recorded at Babine since the installation of the counting weir in 1946. These productions indicate strongly that escapements to Babine in recent years have been too low to make full use of the lake's ability to produce young sockeye.

However, evidence, arising from tow-net collections of young sockeye first made in 1955, concerning their distribution and growth, suggested that, even though total escapements might profitably be increased, maximum utilization still might not be achieved. These collections showed that the distribution of young sockeye in the lake, and hence their ability to make full use of it, was limited by their inability, whilst in the lake, to move far from their natal streams, and that about 70% were concentrated in 12% of the total nursery area available. The result was that a large area of the lake appeared to be underutilized while the fish in the lesser area showed slower growth, presumably due to competition for food. The 1956 collections reported herein, which were more extensive, were taken from a much smaller population of young sockeye than in 1955. The concentration of fish in various parts of the lake again paralleled the intensity of spawning in the tributary streams; however, growth of the young fish appeared to be uniform throughout the various lake areas, confirming the suspicion that utilization of the lake's resources in 1955 (and probably in some other years) had been inefficient. Since the runs to different areas of Babine Lake show considerable differences in time of migration through the fishery, the possibility of making better use of Babine Lake to produce young sockeye is apparent.

Some other Skeena sockeye-producing lakes, while overshadowed by Babine in importance, nevertheless support significant spawning stocks. Since size of smolts produced gives an indication of the degree of crowding, and probably to some extent, the degree of utilization, collections of smolts at Bear and Morice Lakes have been made in 1955 and 1956. While the 1956 sampling at Morice was insufficient to provide information about growth, the results of the Bear Lake observations confirmed those of 1955: the large size of the Bear Lake smolts strongly suggests that the lake's capacity to support young fish is far from taxed by recent spawning escapements. The Lakelse enumeration data from the several years' work there has been reported below in such a manner as to provide information concerning production from different-sized stocks.

For Skeena pinks, much less information is available for past years concerning the number of spawners required to produce the greatest number of pink fry from a particular stream. Since pinks migrate directly to sea after emergence, the determination of optimum escapement involves obtaining at least gross estimates of the sizes of spawning stocks and their subsequent production of fry. Beginning with the 1955 pink spawning run, efforts have been directed toward obtaining more precise estimates of the sizes of spawning stock in all major pink streams. The results indicate that the Kispiox, Kitwanga, and Lakelse Rivers support the bulk of the escapement. In 1956, fry-trapping was begun on two of these to obtain indices, if not actual estimates, of the numbers of fry produced. Before it is possible to determine escapement sizes which will provide the best output of pink fry from these rivers, several years' observation, involving different-sized escapements, will be necessary. Preliminary attempts in 1956 to obtain an index of total Skeena fry production by tow-netting at Kwinitsa, at the head of tidal influence, show promise. Such information would be valuable in determining the likely return of adults from annual fry runs, as well as providing information about the desirable size of the total pink escapement to the Skeena.

At the present time, no specific research concerning the optimum size of spring, coho and chum salmon escapements is being carried out. Observations of size and distribution of spawning stocks of these species are being intensified, however, in conjunction with the intensified surveys of sockeye and pink salmon.

<u>Regulation to provide optimum escapement</u>. To regulate the fishery in such a way as to provide the desired escapements of salmon to each spawning area, it is necessary to know where and for how long the runs are available, to the fishery, and to estimate the fishery's ability to remove portions of the run as it passes through the fishing area.

Taggings carried out from 1944 to 1948 were successful in demonstrating the timing of runs to some spawning areas from the intense estuarial fishery. However, in 1956 a preliminary tagging in the waters outside and adjacent to the fishing area was carried out to throw light on the migration routes and timing of the runs from the first points of entry into the fishery. The results obtained, though restricted in scope, indicate that significant numbers of Skeena sockeye may be caught in outside waters of the Nass fishing area, and that numbers of Skeena pinks may be caught in both the Nass fishing area and Ogden Channel (Purse Seine Area 5). The limited 1956 tagging within the Skeena fishing area suggested, as did the 1944-48 results, that most salmon migrating through the Skeena fishing area were bound for the Skeena River and not to adjacent areas. Further information regarding the timing of particular runs has been obtained in 1955 and 1956 by tagging live fish taken in the test-fishing project in the Skeena estuary.

To derive an index of the numbers of salmon escaping the fishery immediately after they have passed through the fishery, test fishing by chartered gill-net boat was carried on immediately above the fishing boundary adjacent salmon fishing areas 3 and 5. The catch in the Skeena Gill-net Area was the lowest recorded since 1950, and amounts to slightly over one-half the average annual catch for the 6-year period 1950-55. The 1956 Skeena pink pack was further reduced by the small size of fish.

In spite of the fact that early pink salmon fishing was curtailed by the late opening for sockeye fishing, and that, from the opening of fishing until the end of the season, 72-hour weekly closed periods were in effect, the 1956 escapement amounted only to slightly over 300,000. This number must be considered a very light spawning even though reliable records of Skeena pink escapements are available for only a few years.

The 1956 gill-net catch of spring salmon in the Skeena area was 15,367, which is below the average for the 6-year period 1950-55. Fishing with spring salmon gill nets was permitted throughout the season, although restricted by 72-hour weekly closed periods and by the Mowitch-Veitch upriver boundary applicable to all salmon fishing. The resulting escapement to the spawning grounds was judged to be moderate in comparison to escapements in recent years.

The 1956 Skeena coho gill-net catch was 60,591, which is below the 1950-55 average annual catch. As with pinks, early coho fishing was curtailed by the July 31 opening date for sockeye fishing. In addition to the 72-hour weekly closed period which applied until the end of the fishing season, the lowered boundary for fall fishing, which was put into effect in 1955, provided some further curtailment of fall salmon fishing. The resultant escapement of coho was judged by Department of Fisheries officers to be moderate to good in most spawning areas.

The 1956 Skeena chum catch, which was 50,838, was also below the 1950-55 average, although almost twice the extremely low 1955 catch. The escapement was considered light. The fall fishing regulations which applied to coho and pink salmon fishing (72-hour weekly closed periods and the lower Mowitch-Veitch River boundary) also applied to chum salmon fishing.

Test fishing and tagging in the Skeena estuary — T.H. Bilton

To obtain information concerning the size and composition of the daily escapement of salmon from the Skeena commercial fishery early enough to provide a basis for changes in regulation of the salmon fishery during the run, two chartered gill-net boats were employed again in 1956 to carry out test fishing just above the fishing boundary. In addition to providing assessment of the escapement, through size of the catches, further information concerning the time of passage of salmon runs to different spawning areas was obtained by tagging the fish which were in suitable condition when the nets were lifted.

A total of 289 sets of approximately 1-hour duration was made from June 6 to September 21. Fishing was carried out on slack tides with a 200-fathom net composed of meshes ranging from 3 1/2" to 8" stretched measure, in 1/2" intervals.

The 1956 catches, the numbers tagged, and the numbers recovered are given in the following table with comparable figures for the 1955 project:

		Number caught	Number tagged	Tags recovered from fishery	from upriver
Sockeye	1955	1,173	822	113	69
	1956	2,344	1,386	39	203
Spring	1955	782	376	48	22
	1956	696	439	26	28
Pink	1955	3,590	1,488	28	34
	1956	1,408	974	24	8
Coho	1955	483	233	27	2
	1956	422	265	17	1
Chum	1955	124	45	1	0
	1956	151	79	12	1
Steelhead	1955	inadequate record			
	1956	310	199	10	5
Total	1955	6,152	2,964	217	127
	1956	5,331	3,342	128	246

Escapement indices and exploitation rates from test fishing

M.P. Shepard

Preliminary examination of the test-fishing data on sockeye suggest that catches made by the test nets do reflect the abundance of fish passing the upper fishing boundary and that the catch per hour at the test-fishing site may be used to provide a gross estimate of the escapement. Examination of the test catch patterns has also provided information on the duration of passage of the Skeena sockeye runs through the fishery and on the daily rate of exploitation of the fishery. Although these findings require further confirmation, the data have provided a basis for estimating the effects of variations in the length of weekly close times on the rate of exploitation by the fishery.

1. Variations in test-net sockeye catches

Although the catches made in individual sets tended to vary widely, there was a distinct pattern in the average daily catch/hour that was apparently associated with the abundance of fish passing the test-fishing site. In 1955, when the fishery operated on a 4-day fishing week for most of the season, this pattern was characterized by a decrease in test-net catches from Sunday through Thursday (when the fishery was operating) with an increase during the weekly closed period (Thursday night through Sunday). In the table below, the average daily catch/hour of the test nets is shown for the periods when the intense fishery for sockeye was operating and when test fishing was conducted (July 1 to 24):

Day	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Fish caught/hour	48.2	20.8	9.9	7.2	6.8	17.0	52.1

The data suggest that the intensive fishery caused a marked decline in the number of fish escaping past the upstream boundary, with the weekly closure resulting in an upsurge in the numbers of fish migrating upstream. A reflection of the great intensity of the fishery is seen by the fact that the weekly low test catch/hour (occurring on Wednesday and Thursday) averaged only about 15% of the weekly high (obtained on Saturday and Sunday).

The weekly pattern of the run (with catch/hour dropping for 2 to 3 days and then tending to level off during the 3rd and 4th days) suggests that the stocks are receiving intensive exploitation for 2 to 3 days; i.e., that the duration of passage of the stock through the intensive part of the fishery is between 2 and 3 days. This finding corroborates the results of tagging experiments conducted from 1944 to 1948 which indicated a modal migration time of 3 days through the main Skeena fishing area. The 1956 data are less extensive than those obtained in 1955 due to the fact that fishing for sockeye was permitted only during the last quarter of the season. In the two weeks when significant numbers of sockeye were present and being caught, essentially the same pattern of weekly peaks and troughs was observed as in 1955.

2. <u>Relation of sockeye test catches to size of upstream escapements</u>

If there is a close relation between the test-fishing catch/hour and the size of the escaping stock, then the average daily test-fishing catch/hour would be proportional to the abundance of upstream migrants passing the test-fishing site. Although direct measures of the size of the daily escapement are not available, tagging experiments suggest that from late July on virtually all the sockeye present in the Skeena fishing area are bound for the Babine Lake system. Through operation of the Babine fence, a daily count of sockeye reaching Babine also is available. By pre-dating the Babine fence counts by the time estimated for passage from the fishing area to the fence (determined by tagging) an estimate of the number of sockeye passing the test-fishing site is obtained. The degree of correspondence between these figures and the test-fishing catch/hour can then be examined. Using the 1956 data (when the number of migrants was approximately 4 times that of 1955), the day-to-day pattern of test-fishing catches and the pre-dated daily Babine fence counts were quite similar. From the last week in July until the last week in August, there was a highly significant correlation between the average daily test-net catch/hour and the pre-dated daily Babine fence count (correlation coefficient = 0.87, $P > .0001$). A further illustration of this close parellelism is shown in the following table where the average weekly catch/hour of the test nets are compared with the weekly totals of the fish counted at the Babine fence (both expressed as a percentage of totals for the period June 23 to August 26):

Week ending Sunday	Pre-dated Babine fence count	Weekly test-catch/hour
	%	%
July 29	42.3	46.2
August 5	33.4	31.6
" 12	13.3	15.8
19	7.7	3.9
26	3.3	2.5
Total	100	100

Thus the proportions of the stock migrating during each week of the period as estimated by the test-fishing catch/hour, and by the Babine fence counts are very similar. These facts suggest that at least during the late part of the sockeye season the test-fishing daily catch/hour reflects changes in day-to-day abundance of sockeye escaping the fishery.

The 1955 results, involving only about 1/4 of the number of fish migrating in 1956, show essentially the same relationship.

Assuming that the test-fishing catch/hour is roughly proportional to the number of fish migrating upstream, it is possible to calculate an index converting catch/hour to number of migrants. In both 1955 and 1956, estimates (based on the Babine fence count and stream surveys of other areas) were made of the total spawning escapement to the Skeena system. By summing the daily catch/hour figures and dividing this number into the total estimated escapement, the estimated daily escapement indicated by a catch of one fish/hour at the test-fishing site is obtained. The data are summarized in the table below:

	Sum daily test catch/hour[a]	Total escapement[a]	Escapement per daily catch of 1 fish/hour[a]
1955	377	125,500	333
1956	750	441,000	588

[a]Excluding jacks.

The figures indicate a relatively great difference between the indices obtained in the two years. Part of the difference was undoubtedly due to a difference in fishing methods; in 1955, for the first half of the season a standard commercial net was used, whereas in the latter half of the 1955 season and during the entire 1956 season a special experimental net with a graded series of mesh panels was used. However, this difference in technique probably does not offer a full explanation and further test-fishing experiments are required to measure the variability of escapement estimates and the causes of the variability.

3. Estimates of exploitation rates

Weekly commercial catch figures and estimates of weekly escapements (using the test-fishing catch/hour index as described above) can be analysed to estimate the weekly rates of exploitation in 1955 and 1956. In the following table the weekly catches, escapements, exploitation rates and number of boat deliveries (for periods when both catch and test-fishing data are available) are listed:

1955

Week ending	Commercial catch	Est. escapement	Deliveries	Rate of exploitation
	(1,000's fish)	(1,000's fish)		%
July 3	15.8	12.4	1,244	56.0
" 10	32.4	15.3	1,487	67.8
" 17	32.7	20.4	1,628	61.6
" 24	23.5	11.0	1,359	68.1
" 31	.8	23.4	37[a]	3.1
August 7	6.0	6.0	1,213[b]	50.0
14	9.3	2.5	2,305	79.0
21	4.5	1.1	2,028	80.5
28	2.1	.6	1,444	77.8
September 4	.2	.6	607	27.2

[a]Fishery closed entries represent landings from test-fishing boats.
[b]Boundary moved seaward for 1 week.

1956

Week ending	Commercial catch	Est. escapement	Deliveries	Rate of exploitation
	(1,000's fish)	(1,000's fish)		%
August 5[a]	100.3	41.3	1,451	71.0
12	32.3	32.0	1,871	50.2
19	10.4	7.3	1,408	58.8
26	1.9	4.0	997	32.4
September 2	1.0	.6	1,095	64.0
" 9	.2	.4	511	37.5

[a]2-day fishing week, escapement estimated for 5-day period Wednesday to Sunday.

With few exceptions, when significant numbers of sockeye were present the weekly rates of exploitation greatly exceeded 50% and averaged 65.3% in 1955 and 63.52% in 1956 (excluding periods of partial and complete closures). This rate of exploitation occurred with a weekly closed time of 3 days. From 1944 to 1950, the fishery operated throughout the sockeye season on a 2-day weekly closed time. During these years there were no special closures and so the total annual rate of exploitation (based on figures for the total sockeye catch and the total estimated escapement) is comparable with the average weekly rate of exploitation outlined above. With the 2-day weekly closure, the rate of exploitation was only around 50%. Thus the present-day fishery operating with one more closed day a week (i.e., weekly close period 3 days) removes 15% more of the stock than did the fishery of earlier years. It is impossible at this time to determine the cause of such increased efficiency other than to point out that the mobility of the fleet and net operation has increased in recent years, and that nylon has largely replaced linen in the manufacture of nets.

With knowledge of the present weekly rates of exploitation and of the duration of passage of the fish through the fishery, it is possible to estimate the rates of exploitation that would exist with varying durations of weekly close times. Variations in test-fishing patterns and tagging suggest that, on the average, sockeye take between 2 to 3 days to pass through the intensive part of the fishery and that here in the past two years the rate of exploitation is about 50%/day. The data also suggest that, prior to reaching the intensive estuarial fishing area, the fish may spend 3 to 4 days migrating through the offshore fishing areas and that the rate of exploitation in the offshore area may approximate 15%. (It should be pointed out that the exploitation figures were derived in two years when the stocks were much lower than average and thus may not be applicable in years when the stock reaches higher levels.)

Using the above estimates for duration of passage and daily rates of exploitation, the weekly rates of exploitation for different weekly close times are listed in the following table:

	% Exploitation	
Weekly close time in days	Pre-1950	1955, 1956
0		87
1		81
2	50	75
3		65
4		54
5		39
6		23
7		0

The calculations indicate that to provide protection to the runs equivalent to that existing in the pre-1950 period with a 2-day weekly closed time, a 4- to 5-day closure would be required. A 2-day closure in 1955 and 1956 may only have permitted half the escapement that a similar closure would have allowed in the pre-1950 period. However, as suggested above, if larger runs appear, the relative efficiency of the fleet may be lowered, with the result that the rates of exploitation would be somewhat lower than those outlined in the table above.

Adult salmon tagging in the Skeena Gill-net Area and adjacent waters, 1956

T.H. Bilton

To determine the routes by which Skeena-bound salmon approach the river, and the speed with which they migrate, preliminary tagging of adult salmon (chiefly sockeye and pinks) was carried out in 1956 from a drum-seiner chartered by the marine salmon investigation to fish in northern British Columbia waters. Adult salmon caught in hauls made primarily to catch juvenile salmon were tagged with Petersen discs attached under the dorsal fin with nickel pins. Tagging was carried out in Ogden Channel (Purse Seine Area 5), the Skeena Gill-net Area (Area 4), and the Nass Gill-net Area (composed of Sub-areas 3X, 3Y and 3Z). The tags were recovered in the commercial and Skeena Indian fisheries and from the Babine weir.

The following table shows the place, date, and numbers of tags affixed, and the numbers and place of recovery of tags. The data are for sockeye and pinks only, because very few other salmon were tagged:

Tagging				Number recovered by area							
Species	Date	Area	No.	3X	3Y	3Z	4	5	Alaska	Skeena River	Babine Weir
Sockeye	Jul 13	3X-3Y	76	1	2		6	2		2	26
	" 18	4	25				2			2	8
Pink	" 13	3X-3Y	84	1		2	6	8	4		
	" 16	3Y	32		1	11			1		
	" 28-31	5	98			1	17	7	1	1	
	Aug 1	3Z	74		1	9	6		2		
	" 24-25	3X-3Y	215	7	3		29	2			
	" 30	5	184			1	2	2			

While the taggings were insufficient to indicate throughout the season the proportions of the stocks in adjacent areas which were bound for the Skeena, the results plainly indicate that Skeena sockeye were present in the Nass Area in mid-July, and that Skeena pink salmon were present in Ogden Channel (south of the Skeena Area) and in the Nass Area during July and August. The fact that fishing for sockeye and pinks was closed until July 31 in the Skeena Area, but not in the adjacent areas, tends to minimize the indicated proportions of Skeena salmon present in adjacent waters during July. The high return of sockeye tagged on July 13 at Arniston Point (Sub-areas 3X-3Y) at the Babine weir suggests that the stock in Sub-areas 3X-3Y at that time contained a high proportion of Skeena fish which were available to the Nass gill-net fishery.

Salmon enumeration at the Babine fence in 1956 — K.V. Aro

The run of sockeye salmon to the Babine Lake watershed was counted in 1956 at the Babine River adult counting weir as in all other years with the exception of 1948 when floods damaged the weir, making it necessary to estimate the size of that run. The weir count constitutes the best index of the sockeye escapement to the Skeena River because the runs to the Babine watershed constitute about 70% of the Skeena escapement. The data from the weir have attained further importance since 1951 in assessing the effect on the salmon runs of the partial block by the Babine River slide. The 1956 sockeye count, herein reported, was of particular importance since the two major components of the run, the 4- and 5-year-old sockeye, were the progeny of those sockeye which surmounted the rock slide in 1951 and 1952, the years of block.

The counts of the five species which passed the Babine fence during the 1956 season are compared in the following table with counts obtained in previous years:

Year	Sockeye		Spring	Pink	Coho	Chum
	Large	Jack				
1946	417,841	57,864	10,528	28,161	12,489	18
1947	261,460	261,101	15,614	55,421	10,252	7
1948[a]	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

[a]Total sockeye estimated from comparison with stream surveys and fence counts of other years.

The sockeye salmon count in 1956 was somewhat larger than anticipated but smaller than in most of the years not affected by the rock slide. The run followed the pattern typical of most years, commencing in early July, climbing to an early peak in late July, then, following a decline, climbing again to the main peak of 21,261 sockeye on August 20, and finally declining to 50 fish on September 30 at which time counting was discontinued.

In 1956 a proportionately greater number of sockeye spawned in the streams tributary to the southern and central areas of the lake than usual. Among these streams, Grizzly, 15 Mile, and Pierre Creeks were more heavily seeded than in most years while Twin Creek and the Fulton and Morrison Rivers had moderately good runs. About 56% of the fish spawned in the southern and central areas, the remaining 44% in the Upper and Lower Babine Rivers.

The run of spring salmon was one of the poorest on record in number of eggs deposited, because most of the fish were jacks. Since spring salmon spawn below the fence as well as above it, the count provides an index of the run to the Babine River.

The pink salmon run was almost half of that in the cycle year 1954 but almost equal to that in the 1952 cycle year which was affected by the slide. As with springs, some pinks spawn below the fence.

The run of coho salmon was larger than in the cycle year 1953.

A few chum salmon again reached the Babine River.

Sockeye sampling at the Babine fence

To obtain details on the composition of the 1956 Babine sockeye run, 2% of the previous half-day's count were measured and sexed twice daily, and a "jack count" was carried out for an hour daily.

The jack count, which accounted for 20% of the run, indicated that 4.9% of the sockeye were jacks and 95.1% were larger fish. The percentage and number of jacks was lower than in most years. The jack count also showed that 4.3% of the larger sockeye had net marks, 1.5% showed other injuries, and 94.2% had no injuries. The percentages of fish with injuries and net marks was lower than in most years.

The data from the 2% sample indicated that among the larger sockeye 48.6% were males and 51.4% were females. This predominance of females over large males is typical of all previous runs other than the two slide-blocked runs of 1951 and 1952. A length-frequency plot suggests that the larger fish were about 10% 5-year-olds and 90% 4-year-olds. The low return of 5_2 fish follows a low return of 4_2 fish in 1955, indicating a very low survival from the small seeding in 1951.

Egg counts were made in 1956 for comparison with egg counts obtained in all years prior to 1953 and were not found to be significantly different. The average egg content in 1956 was calculated to be 3,071 eggs per female. Since the number of female sockeye surviving the Indian fishery on the lake was estimated to be 170,300, the potential egg deposition was roughly 523 million. This potential egg deposition is higher than those in the slide-affected parent years and is slightly larger than in one of the pre-slide years (1947).

Size of Babine sockeye smolt runs, 1951-1956

Estimates have been made of the size of the sockeye smolt emigration from the Babine watershed since 1951 by a marking and recovery technique employing smolt traps at the outlets of Babine and Nilkitkwa Lakes. It has been possible to calculate survival to smolt stage from eggs carried into the system each year by using estimates of potential egg depositions from 1949 to 1954. The egg depositions have varied considerably from the low depositions of 1951 and 1952 caused by the Babine River rock slide to the large depositions of 1953 and 1954. The smolt runs which have resulted from these variable egg depositions have provided information on the relationship between spawning broods of varying size and subsequent smolt production.

Employing the technique used since 1951 the 1956 smolt run was estimated to be 20 million, two-thirds the size of the 1955 run but several times larger than in the other 4 years. The method employed involves the capture and marking of portions of the run as it passes the outlet of Babine Lake, and the subsequent recovery of some of the marked fish in catches made at the outlet of Nilkitkwa Lake, some eight miles downstream from the Fort Babine trap site. Ratios of marked to unmarked smolts in the samples are used to estimate the size of the run passing the upstream trap.

The total numbers of smolts marked and released, the total numbers of marked fish recovered, and the total samples recovered in each year are given in the following table. Final estimates of the run for each year have been adjusted to conform with known changes in the mark/catch ratio at Fort Babine and to allow for the late installation of trapping structures in years when portions of the run had passed before trapping began.

Year	No. of smolts marked	No. of marked smolts recovered	Size of sample examined	Estimated size of run	95% limits
1951	34,689	200	21,855	4.2×10^6	3.7 to 4.8×10^6
1952	33,880	646	86,391	4.5×10^6	4.2 to 4.9×10^6
1953	61,950	2,498	124,396	3.1×10^6	3.0 to 3.2×10^6
1954	42,631	1,156	81,082	2.8×10^6	2.7 to 3.0×10^6
1955	113,931	1,287	270,546	30.9×10^6	28.6 to 32.6×10^6
1956	72,707	1,802	649,588	21.1×10^6	18.5 to 22.9×10^6

Certain errors associated with the possibility of increased mortality due to marking by fin-clipping and the likelihood of disproportionate intensities of marking with relation to the run passing Fort Babine each day cannot be assessed and have been assumed to be constant each year.

Assuming that all smolts are 1-year-olds, survival from eggs potentially available in the spawning to resulting smolts have been calculated and are shown in the table below for the brood years from 1949 to 1954

	1949	1950	1951	1952[a]	1953	1954
Eggs potentially available	853×10^6	591×10^6	194×10^6	409×10^6	$1,241 \times 10^6$	$1,020 \times 10^6$
Year smolts appear	1951	1952	1953	1954	1955	1956
Estimated number of smolts	4.2×10^6	4.5×10^6	3.1×10^6	2.8×10^6	30.9×10^6	21.1×10^6
Survival egg to smolt	0.49%	0.76%	1.60%	0.68%	2.49%	2.07%

[a]Only about one-third of this run spawned successfully, thereby reducing the potential egg deposition and raising the estimate of smolt survival to about 2%.

A tendency for greater numbers of smolts to result from greater depositions has prevailed from 1951-56; an increase in the survival to smolts from smaller egg depositions was indicated for the adult runs from 1949 to 1952. However, the egg to smolt survivals from the 1953 and 1954 spawning runs, which were the largest recorded in the years of Babine fence operation, were higher than those of any other runs. The survival rate obtained for Babine Lake as a whole is a composite of the survival rates within the various lake nursery areas. They may vary considerably from one area to another, depending upon a number of factors, including the concentration of young sockeye in each and the amount of food available for them. Recent work by Johnson (elsewhere in these reports) shows that when the 1954 brood were present in the lake the concentrations and sizes of the underyearlings in various parts of the lake were quite different.

The 1957 smolt run will be the product of the 1955 brood which produced a potential deposition of 105 million eggs.

Age, sex, growth and parasite studies of Babine sockeye smolts

Since 1950, samples of Babine sockeye smolts have been collected for special studies. The sampling site has been variously the Babine fence, the Nilkitkwa Lake smolt trap, and the Fort Babine smolt trap. In 1955, because of water-level conditions, the sample was taken at the Nilkitkwa Lake trap and later at the Fort Babine trap. In 1956, samples were taken throughout the season at both locations.

Scale examination has shown, as indicated in the following table, that the smolts leaving Babine Lake are predominantly 1-year-old fish. The table also shows that the sex ratio does not depart significantly from a 50:50 assumption and that there was no real deviation from a 50:50 ratio in the Fort Babine and Nilkitkwa samples taken in 1956.

Year	1-year-old		2-year-old	
	Male	Female	Male	Female
1950	1,296	1,320	5	9
1951	1,428	1,367	6	4
1952	826	828	6	5
1953	629	605	8	14
1954	467	505	0	0
1955	966	978	1	1
1956 N	1,166	1,042	3	4
1956 FB	1,038	1,003	4	0

N = Nilkitkwa Lake FB = Fort Babine

Comparison of the average lengths and weights of smolts in the table below indicates differences in the average size between years and between samples taken at different traps in the same year:

Year	Sampling site	No. in sample	Fork length (mm.)		Weight (gm.)	
			Range	Average	Range	Average
1950	Babine Fence	2,616	54-104	83.0	1.3-10.6	5.5
1951	Babine Fence	2,795	58-111	82.4	1.6-12.8	5.6
1952	Nilkitkwa	1,654	55-109	80.4	1.3-12.7	4.9
1953	Fort Babine	1,234	70-111	86.0	2.4-13.5	6.2
1954	Fort Babine	972	62-110	86.4	2.8-12.6	6.3
1955	Nilkitkwa	431	56- 93	72.7	1.6- 8.2	3.8
	Fort Babine	1,513	60-105	83.9	2.1-11.0	5.8
1956	Nilkitkwa	2,208	50- 99	77.8	1.1-10.1	4.7
	Fort Babine	2,041	55-100	83.1	1.3- 9.7	5.4

When the average sizes of smolts sampled at the two smolt traps are compared for 1955 and 1956, it is evident that those sampled at the Nilkitkwa Lake trap were smaller than those sampled at Fort Babine. This difference is due to the inclusion in the Nilkitkwa sample of very small smolts taken early in the season, which emanated either from Nilkitkwa Lake or from the North Arm of Babine Lake (passing Fort Babine before the trap was operating). Johnson has demonstrated that sockeye smolts can vary considerably in size from one nursery area to another within Babine Lake. It is likely that the 1953 and 1954 samples which were taken at Fort Babine did not include the seemingly earlier-running smolts from the North Arm of the lake.

Notations have been made since 1952 during the examination of smolt samples regarding the presence or absence of infection by the cestode Eubothrium salvelini (Schrank, 1790) and the nematode Philonema oncorhynchi Kuitunen-Ekbaum, 1933. The percentage of infection by these parasites has varied considerably from year to year. The 1955 and 1956 data suggest that the degree of infection may vary between the nursery areas. Smolts from the southern and central areas appear to be more heavily infected with nematodes than those from the northern areas. Generally, smolts infected by cestodes were smaller than uninfected fish or those with nematodes. Smolts infected by nematodes were larger than uninfected individuals.

Migration times of Babine sockeye runs through the commercial fishing area

From the first taggings of sockeye in the Skeena estuary in 1944 until 1956, a total of 1,375 "ocean" sockeye tags have been recovered at Babine Lake. Since the Babine fence was put into operation in 1946, most of the tagged fish were stopped, recorded, and then allowed to proceed to the spawning grounds. During spawning-ground surveys, 188 of these tags were recovered from the spawning grounds. In addition to these "ocean" taggings, several thousand tags were placed on sockeye as they passed the Babine fence in 1946 and 1947. Of these tags, 1,250 were recovered subsequently from spawning streams.

The recoveries of ocean-tagged sockeye at the Babine fence demonstrated that Babine Lake sockeye are present in the commercial fishing area throughout the period of the sockeye fishery. The information also demonstrated the number of days which the tagged fish took to reach the Babine fence. The modal time of travel varied from year to year, from a low of 21 days in 1947 to a high of 35 days in 1955. The data also indicated that fish tagged during the middle of the run reached the Babine fence in less time than those which were tagged earlier or later in the season. By using these times of travel it is possible to calculate the time at which fish tagged at the Babine fence and recovered subsequently in spawning streams were likely to have been present in the commercial fishing area.

From these estuary and fence taggings it is possible to describe fairly accurately the times at which the sockeye runs to various parts of Babine Lake were present in the fishery. Sockeye which spawn in the smaller streams, including 6 Mile, 4 Mile, Donald's Landing, Pendleton, Twin, Sockeye, and Tachek Creeks, tributary to the southern and central areas, and to 9 Mile Creek in the North Arm of the lake, are present in the fishing area during June and early July. The greatest proportion are present between June 15 and July 1 with a peak around June 22. This peak appears to form the "early peak" which is evident in late July in the Babine fence count of most years. These early runs have formed about 4% of the Babine sockeye escapement.

Sockeye destined for Pierre Creek are present in the fishery at the same time but with a somewhat greater concentration in July than the early runs. These fish, which have accounted for about 3% of the Babine escapement, pass the fishery in waves with no definite peak.

The runs to 15 Mile and Grizzly Creeks represent around 5% of the escapement and, though present in the fishery from mid-June to early August, pass the area in greatest numbers from about July 5 to July 26, with a peak around July 15.

These are followed through the fishery by the large Fulton River run, which is present from early July to mid-August with about 75% of it passing the fishery between July 17 and 29. The Fulton River run has in recent years been larger than the other runs to the southern and central areas of Babine Lake combined.

The runs to the Morrison Lake drainage, which form about 3% of the escapement, coincide in timing very closely with the Fulton River run.

The last runs to pass the commercial fishery are those to 5 Mile Creek, and the very important Upper and Lower Babine River spawning grounds. Tag-recovery data from these streams are rather limited. However, all the information available indicates that the Babine River runs have a similar time of passage to that of the Fulton River run but up to a week later.

Distribution of age-0 sockeye in Babine-Nilkitkwa Lake nursery area

W.E. Johnson

Based on catch per unit of fishing effort, tow-net collections in August and October, 1955, indicated that at least 67%, and possibly as much as 88%, of the total age-0 sockeye population of these lakes (estimated as 45 to 65 million) was concentrated in Nilkitkwa Lake and the North Arm of Babine Lake; i.e., in about 11% of the total lake area. Mean size of young sockeye in these areas of concentration was much smaller than in the sparsely populated remainder of Babine Lake (south of Halifax Narrows).

This unequal distribution of young sockeye, and resulting inefficient utilization of the lake-nursery facilities, was apparently a result of the distribution of the spawning parent population and a limited dispersal of young sockeye from their points of entrance into the lake as fry.

During the period August to October, 1956, the total estimated number of young sockeye in the Babine-Nilkitkwa nursery area, based on catch per unit of effort with tow-net gear, was 4 to 6 million as compared to an estimated 45 to 65 million during the same period of 1955. These fish resulted from total potential egg depositions of 104 million in 1955, and 1,020 million in 1954. Assuming comparable survival rates, this tenfold difference in numbers of eggs deposited is in good agreement with the tenfold difference in estimated numbers of young sockeye. In addition, in 1956 there were present in the area south of Bear Island an estimated 7 to 9 million young sockeye-type fish believed to be kokanee. Evidence for this belief is as follows:

(1) the presence of what appear to be two overlapping size groups in samples taken south of Bear Island;

(2) the good agreement in mean size of the smaller group when they first entered the lake with the size of fry known to be progeny of kokanee from an experiment carried out at 6 Mile Creek (Babine Lake) in 1952; and

(3) the spawning of an unusually large number of kokanee in streams tributary to Babine Lake south of Bear Island in 1955. (Fisheries Inspector Gelley states that the numbers of kokanee on the spawning grounds in 1955 was phenomenally greater than any he had ever observed at Babine Lake; he estimated 100,000 to 200,000

in Tachek Creek alone.) Assuming a total kokanee spawning of 1/2 to 1 million with 50% females and survival rates from egg deposition comparable to that ordinarily found for sockeye, the 7 to 9 million estimated is most reasonable.

Comparison of the 1955 and 1956 distributions of young sockeye in Babine-Nilkitkwa Lakes is made in the following table:

Distribution of age-0 sockeye salmon in the Babine-Nilkitkwa Lakes nursery area during the period August-October, 1955 and 1956. (Estimates based on catch per unit of effort with tow-net gear.)

	Area (acres)	Estimated number of age-0 sockeye salmon present	
		1955	1956
Nilkitkwa Lake	1,200	5 to 6 million	1.5 to 2 million
North Arm of Babine Lake	11,500	32 to 47 million	0.5 to 1 million
Babine Lake south of Halifax Narrows	98,500	7 to 19 million	2 to 3 million (plus 7 to 9 million of what are believed to be age-0 kokanee
Totals		45 to 65 million	4 to 6 million

In 1956 approximately equal numbers of young sockeye were found north and south of Halifax Narrows as compared to 67% or more north of Halifax in 1955. This is in agreement with differences in distribution of the spawning parent populations for the two years. In 1954, 56% of the spawners spawned north of Halifax Narrows, while only 51% spawned north of that point in 1955 (actually, the potential egg deposition north of Halifax was even less than this 51% in 1955 owing to a higher percentage of "jacks" there than on spawning grounds south of Halifax Narrows).

Further evidence of limited dispersal of young sockeye from their point of entering the lake as fry comes from the fact that in constant sampling throughout the 1956 season not one young sockeye (or kokanee) was taken in that part of Babine Lake from 9 Mile Creek south to Bear Island; this is the region of the lake which has no tributary spawning areas other than the Morrison (Hatchery) River which had only 600 spawners in 1955.

It is interesting to compare the relative numbers of young sockeye in Nilkitkwa Lake and the North Arm of Babine for the two years. Young sockeye in both these areas are almost exclusively progeny of adults spawning in the Babine River spawning areas above and below Nilkitkwa Lake. In 1955 most of the young sockeye were found in the North Arm of Babine, with, however, the greatest density in Nilkitkwa Lake and the part of the North Arm nearest the spawning grounds. In 1956 the majority of young sockeye from these spawning grounds remained in Nilkitkwa Lake. It appears that the proportionately greater dispersal from these spawning grounds in 1955 may have been aided by population pressures as a result of extreme crowding in that year.

All in all, the results of the 1956 investigations strongly support the views expressed earlier that the unequal distribution of young sockeye and resulting inefficient utilization of this nursery area is the result of the unequal distribution of the spawning parent population and a subsequent limited dispersal of young sockeye from their points of entrance into the lake as fry.

Growth rates of age-0 sockeye

A comparison of the mean size (weight in grams) of age-0 sockeye salmon in late September, from the three general areas of the Babine-Nilkitkwa Lakes nursery area for 1955 and 1956.

	Mean weight in grams in late September (those weights for 1956 being only approximate)	
	1955	1956
Nilkitkwa Lake	1.0	3.0
North Arm of Babine Lake	1.4	3.0
Babine Lake south of Halifax Narrows	3.0	3.0

The mean weight of age-0 sockeye in late September of 1956 in Nilkitkwa Lake and all areas of Babine Lake was approximately 3.0 grams. This is comparable to the rate of growth shown by young sockeye in the sparsely populated regions of Babine Lake south of Halifax Narrows in 1955 and by young sockeye at Lakelse Lake in recent years. This supports the view that slow growth in Nilkitkwa Lake and the North Arm of Babine in 1955 was the result of competition resulting from high density of young sockeye there.

It appears that the rates of growth shown by all age-0 sockeye in 1956 and over recent years at Lakelse Lake, can be considered "normal" for populations of low density in these lakes. At some level between these relatively low densities (less than 1,000 to 1,500 young sockeye per acre) and the higher densities of Nilkitkwa Lake and the North Arm of Babine Lake during 1955 (4,000 to 5,000 young sockeye per acre), competition becomes strong enough to effect a depression of growth rate. Observations on growth at different levels of population density expected to be made in the future should answer the question of the numbers of young sockeye such lakes will support at given rates of growth. Adult returns from the large runs of comparatively small smolts in 1955 and 1956 will give evidence of the importance of smolt size in ocean survival.

In all regions other than Nilkitkwa Lake, young sockeye were so sparse during 1956 that it was impossible to follow the seasonal trend of growth with accuracy. Young sockeye in Nilkitkwa Lake, however, showed the following pattern: they grew extremely rapidly from the time they entered the lake in June until early August, at which time growth declined and apparently remained constantly lower until late September. This is similar to the general pattern of growth shown by the young sockeye of Lakelse Lake during 1955. The relation of this to the zooplankton food is shown below.

Studies of the zooplankton in Babine and Nilkitkwa Lakes

The primary objective of these studies of zooplankton is to measure their availability as food for young sockeye. In order to do this in the Babine-Nilkitkwa nursery area, samples from various depth intervals at 55 different locations have been taken at regular time intervals.

Quantitatively the zooplankton of all regions of Babine and Nilkitkwa have shown the same general seasonal trend, i.e., great increases from the small quantity present after ice break-up to a high in late June to early July followed by a sharp decline throughout the month of July and then a more gradual decline through the remainder of the summer and fall. This general seasonal pattern was expressed at different levels of zooplankton abundance in the different general areas of the Babine-Nilkitkwa nursery area, i.e., at the highest levels in regions south of Halifax Narrows, intermediate in the North Arm, and lowest in Nilkitkwa Lake.

At Lakelse Lake during 1955, the same general seasonal trend in zooplankton abundance prevailed (except at a slightly earlier time - no doubt as a result of the earlier spring in that region) and at levels comparable to those of Nilkitkwa Lake during 1956. During these periods at Lakelse Lake and Nilkitkwa Lake the same pattern of rapid growth of the young sockeye prevailed, with the decline in growth rate occurring when the quantity of zooplankton declined from a dry weight of 20 to 30 mg./cu.m. to less than 5 mg./cu.m. These observations were at comparable levels of water temperature which remained relatively constant throughout the periods of high growth rate and of decline in both cases. Future observations should further define the levels of zooplankton abundance required for good growth at various levels of sockeye density.

At Babine-Nilkitkwa, as at Lakelse Lake and other Skeena lakes, the zooplankton has been found to be most concentrated at near-surface depths, and all evidence to date indicates a similar near-surface concentration of the young sockeye.

Quantitative and qualitative differences in the zooplankton, as well as evidence from temperature studies, show a discreteness of water masses within the Babine-Nilkitkwa nursery area.

<u>Size and distribution of Skeena pink salmon escapements</u> J.G. McDonald

Greater emphasis has been placed in recent years upon more complete accounts of the size and distribution of the pink salmon escapement to the Skeena to provide information necessary for improved management of this fishery.

Stream surveys and estimates of the escapement to most spawning areas are made annually by officers of the Fisheries Department. In 1956, additional observations were made by Fisheries Research Board personnel. Fuller use was made of aircraft to permit better and more frequent coverage of known and likely spawning grounds. The use of a helicopter during the spawning period provided an excellent means of observation in areas which were more or less inaccessible by other means and also in large rivers such as the Skeena and the Bulkley where ground surveys are inadequate.

The estimated escapement to the larger tributaries since 1950 is shown in the accompanying table. Estimates of the number of spawners were not obtained in the Kispiox River, and other major producing areas, until 1954, and hence the total escapement to the Skeena system can only be estimated for the last three years. During this period the total annual escapement has been between 300,000 and 1,200,000 fish.

Estimated pink escapement, Skeena system 1950-56

River	1950	1951	1952	1953	1954	1955	1956
Kispiox	..	..	..	..	100,000	750,000	100,000
Kitwanga	75,000	75,000	150,000	70,000	100,000	150,000	50,000
Lakelse	100,000	100,000	1,000,000	150,000	100,000	171,000	75,000
Bulkley	..	750	1,500	5,000	750	3,000	a few
Morice	..	..	..	..	1,000	4,000	a few
Babine	39,000	50	3,000	1,000	5,000	3,000	3,000
Bear	..	2,500	7,500	1,500	1,500	6,000	nil
Others	< 75,000	< 50,000	< 150,000	<50,000	<50,000	<125,000	<75,000
Totals	..	..	..	..	358,000	1,211,000	303,000

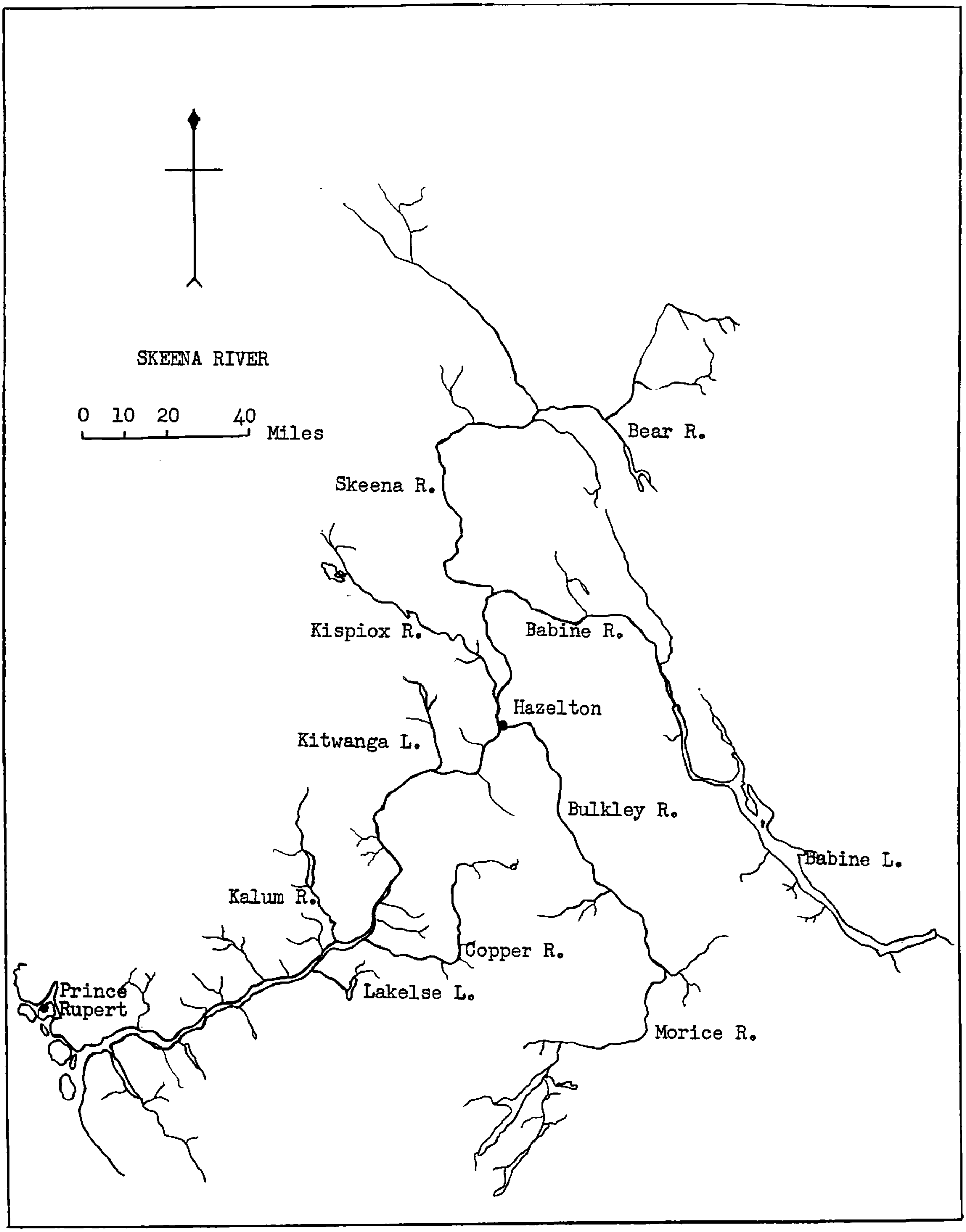
The map shows the larger rivers and streams in which pink salmon spawn. The main producing areas have been found to be the Kispiox, Kitwanga and Lakelse Rivers. Since 1950 the number of spawners estimated to have spawned in the Lakelse River has varied from 75,000 to one million; in the Kitwanga from 50,000 to 150,000. Escapements to the Kispiox have fluctuated from 100,000 to 750,000 in the past three years.

The remainder of the other large tributaries of the Skeena and the Skeena itself do not appear to be contributing to the production of pink salmon to any large degree at present. The surveys made in 1956 revealed extensive areas in these rivers apparently suitable for spawning but which were for the most part barren. In the Skeena, many miles of the main stem and side channels from above the estuary to as far upstream as Hazelton appeared suitable. The only evidence of spawning here in 1956 consisted of a few redds and spawned-out fish which were observed near the outlets of the Shames and Esker Rivers.

The Babine River has produced large numbers of pinks in the past. Large runs were reported in spawning reports made during the 1920's and later. In recent years as many as 130,000 pinks have been estimated to have spawned in the upper part of the river. However, since the slide in 1951, this run has been as low as less than 100 and never greater than 5,000.

The Bulkley system potentially offers one of the largest spawning areas for pink salmon in the Skeena drainage. The major tributaries to the Bulkley are the Morice, Suskwa and Telkwa Rivers (see map). A small number of spawners have been observed in the Bulkley since the construction of a fishway at Moricetown. However, a possible obstruction still exists further downstream near Hazelton. The annual escapement to the Bulkley and its tributary streams was estimated to have been from a few hundred to a few thousand fish since 1951.

Spawning occurs in many other tributaries of the Skeena but the number of fish involved is not large. No pink salmon were observed in the Bear River in 1956. In past years, runs of up to 10,000 fish have been reported. An assessment of the escapements to the Copper and Kalum Rivers is difficult due to the extreme turbidity of the water. However, the small number of spawned-out fish observed on the banks and adjacent to the mouths of these rivers in 1956 indicates that they do not contribute importantly to pink production.


SKEENA RIVER
0 10 20 40 Miles
Bear R.
Skeena R.
Kispiox R.
Babine R.
Hazelton
Kitwanga L.
Bulkley R.
Babine L.
Kalum R.
Copper R.
Prince Rupert
Lakelse L.
Morice R.

The spawning surveys have shown that although extensive and apparently suitable spawning areas exist throughout the Skeena drainage, the greater part of the escapement has utilized only three of the tributaries, at least in recent years. Since 1954, the total estimated escapement to the Skeena has varied from about 300,000 to 1,200,000 fish. Not less than three-quarters of these have spawned each year in the Kispiox, Lakelse and Kitwanga Rivers. The present pink salmon fishery is therefore now primarily dependent on the success or failure of production in these streams.

Pink fry output from major Skeena spawning areas, 1956

A program designed to provide an annual index of the pink fry output from major-producing areas of the Skeena was initiated in 1956. The immediate objective of this work was to determine the relation between escapement size and fry production for each major tributary and also to obtain some indication of the total Skeena pink fry output producing the adult stocks of 1957.

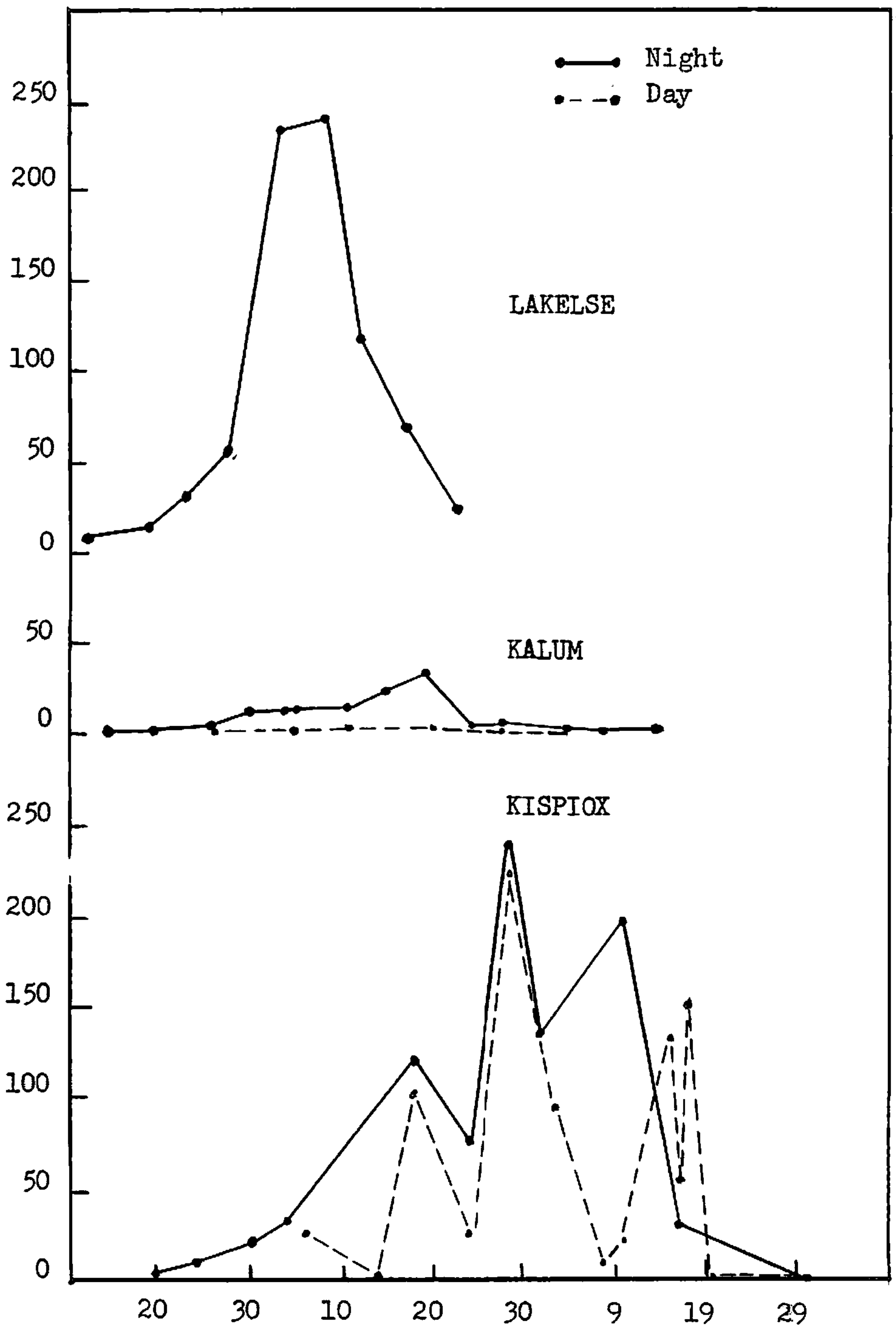
The migrations from the Lakelse, Kalum and Kispiox Rivers were examined. On the basis of the spawning distribution observed in the fall of 1955 the fry produced from the Lakelse and Kispiox Rivers would be expected to be over 80% of the total produced in the Skeena area.

The method used on the three rivers was an adaptation of methods developed for estimating fry runs at Lakelse Lake and Port John, B.C. The experience of Fisheries Research Board personnel there had shown that: (1) the run was generally described by a "normal curve", i.e., the daily number of migrants increased until a peak was reached and then decreased steadily until migration was completed, (2) movement occurred mostly at night, (3) the fry, during migration, were distributed in relation to the current.

The method employed was designed to obtain a representative sample of the run in view of the behaviour of the fry noted above. A small mesh trap net, with an opening 2 ft. x 1 ft., was operated usually every fourth to sixth day near the mouth of each river. The trap was suspended from a cable which spanned the river, thus permitting operation at a number of different stations. The net was fished at each station once each hour throughout the total netting period of up to 24 hours.

Timing of the runs. Trap-netting began on the Lakelse River on April 12 and on the Kalum and Kispiox Rivers on April 15 and 17 respectively. The migrations were completed by the end of June. The average catch of pink fry per hour during the day (5:00 a.m. to 9:00 p.m.) and night (9:00 p.m. to 5:00 a.m.) on each river is shown in the accompanying figure. The timing of the migration was found to vary from river to river in respect to both season and daylight. On the Lakelse River the migration had begun by April 12, when trapping started. The largest catches were recorded on May 8. By May 23 the migration was almost completed. Movement of the fry took place almost entirely at night on this river. The first fry were captured just before dark and the peak movement usually occurred between 11:30 p.m. and midnight.

The run on the Kalum River occurred later than at the Lakelse. Small numbers of fry were captured on April 15. The run increased steadily up to May 19 and then decreased to almost zero by June 14 when operations ceased. The major part of movement took place at night in a pattern similar to that recorded at the Lakelse River. Throughout the run, however, a small



Average catch per hour each day and night of trap-netting on the Lakelse, Kalum and Kispiox Rivers.

proportion of the migrants were found to move during the day.

The migration began as early as April 17 and ended as late as June 30 on the Kispiox River. The peak of the run occurred about the end of May. A large part of the migration was found to take place during the day, particularly during periods of high and turbid water. At lower levels and with relatively clear water, the fry followed much the same diurnal pattern as was recorded on the other rivers.

Fry production and relative abundance. Relative indices of the fry output from the three rivers examined were calculated on the basis of the average catch per hour and the calculated efficiency of the trap at each site. These indices are shown below together with the estimated escapement which produced each fry run.

River	Estimated escapement 1955	Index of fry output 1956
Kispiox	750,000	133
Lakelse	171,000	21
Kalum	Not recorded	7

The Kispiox and Lakelse Rivers were found to have produced approximately the same proportion of fry in relation to the size of the escapement to each river, i.e., escapement to the Kispiox River was over four times that to the Lakelse and produced about five times as many fry.

The escapement to the Kispiox River in 1955 was considered heavy while that to the Lakelse was medium. In terms of the density of spawners, however, the runs were nearly equal. The portion of the Kispiox River accessible to pink salmon is about four times the length of the Lakelse. The number of spawners per square yard of usable gravel was estimated to be 0.24 for both rivers in 1955. In view of this density and the relative fry output recorded above it is apparent that the large escapement to the Kispiox River in 1955 did not result in overseeding, but evidently produced fry somewhat more effectively than the much smaller run to the Lakelse River.

Lakelse Lake sockeye production

R.M. Humphreys

Beginning in 1944, enumerations of the Lakelse Lake salmon runs have been carried out to provide a detailed measure of mortality during various stages of the freshwater history. This enumeration program was terminated in 1956 and in the following sections the results of the 1956 program and a summary of data collected since 1944 are presented. The 1956 program involved enumerations of the fry migrating from the main tributary stream, Williams Creek (which supports over 90% of the Lakelse run), of the smolts migrating seaward down the Lakelse River and of the mature sockeye as they ascended the various spawning streams.

1956 Enumerations

Williams Creek fry enumeration. An estimate of the fry production of Williams Creek was made during April, May and June of 1956. A system of sampling a known percentage of the escaping fry was established in 1954, and this was modified to obtain the 1956 estimates.

Nine fry traps were set up in the same positions as in previous years, and a partial count was made by operating the traps every third night from April 11 until June 16. During this period 32,797 sockeye fry were trapped. Allowing for the fact that sampling ended before the run had ended, and for the loss of one night's count due to freshet, the estimated total number of fry which would have been trapped without these shortcomings would be 35,197. On the basis of 1954 and 1955 experiments, had the traps been operated every night instead of every third, the counts would have totalled between 93,976 and 120,374. Since in the other years the same number of traps set in the identical positions and operated every night were found to take 11.3% of the run, the 1956 fry run was estimated to be about 998,400 with a range of 931,600 to 1,065,200.

On the basis of the 1955 egg deposition in Williams Creek, which was estimated to be 6,300,000, the survival of fry during the winter of 1955-56 would be about 16.5%.

By extending the 1955-56 estimate of survival from egg to fry to the depositions in the other, but much smaller, streams tributary to Lakelse Lake, the total fry output into Lakelse Lake must have been approximately 1,042,800 in the spring of 1956.

<u>Lakelse River smolt migration, 1956</u>. During May and June, the smolt weir on the Lakelse River, one mile below the lake, was operated. During a six-week period, a total of 300,693 sockeye yearlings, 2,495 2-year-old sockeye and 91,825 coho were counted during migration.

The weir was removed on June 14, before the actual migration was completed, because the presence of the stop-logs necessary for smolt weir operation was delaying the upstream migration of large numbers of adult sockeye. However, the majority of the smolts had passed downstream by this time. The sockeye migration was virtually complete and approximately 85% of the coho had migrated. The estimated total coho run was 106,000. The total of 300,693 migrating sockeye yearlings is the smallest migration in recent years. The survival from egg to smolt (1.81%) is slightly higher than the 1953-55 mean of 1.50%.

<u>Adult sockeye escapement to Lakelse Lake, 1956</u>. The Williams Creek weir count and spawning ground surveys of other creeks were used to provide an estimate of the numbers of sockeye reaching the spawning grounds.

At Williams Creek, the sockeye spawning escapement followed a similar pattern to previous years, large schools of sockeye appearing off the creek mouth in late July and moving upstream in early August, with a small "late run" in mid-September. The 1956 Williams Creek escapement amounted to 1,955 males and 2,111 females.

Spawning-ground surveys of other creeks in the Lakelse system were carried out in the two-week period following the peak of the Williams Creek escapement. These surveys showed that Scully Creek contained a total of 280 sockeye, 145 males and 135 females; Clearwater Creek contained 6 sockeye, and 8 sockeye were spawning in the shallows near the mouth of Salmon Creek. All other creeks were barren.

Lengths of dead sockeye which drifted back on the Williams Creek weir show that the average length of the females was 52.8 cm. From previous data on the relationship of length to egg content, it was calculated that the average egg content per female was 3,112.6. The ovaries of 142 spent females examined at Williams Creek showed an average retention of 68.5 eggs per female, leaving a net deposition of 3,044.1 eggs per female.

The calculated deposition of eggs in various creeks at Lakelse in 1956 is given below:

	No. of spawners	Deposition
Williams Creek	4,066	6,426,095
Scully Creek	280	410,953
Others	14	21,308
Total		6,858,356

<u>Age composition of Lakelse adults, 1956</u>. Since the adult sockeye were not enumerated as they entered the lake in 1956, it was not possible to obtain scale samples for age determinations. However, examination of past length-age relationships of Lakelse sockeye and of the length-age relationship of Babine sockeye in 1956 provide a gross method for estimating the age composition of the 1956 Lakelse stock.

In the following table the estimated age-composition of 1956 adult sockeye is compared to the four previous years in which scale samples were taken:

Year	Age-class				No. sampled
	3_2	4_2	5_2	6_2	
1952	0.4	11.9	87.1	0.6	927
1953	..	38.5	61.1	0.4	288
1954	0.3	21.3	78.4	..	344
1955	..	27.2	72.8	..	77
1956	2.0	80.9	17.1	..	..

The table below shows the returns of adults in various age-classes from each brood-year. The offspring of the 1951 brood-year failed to return in appreciable numbers in any age-group:

Brood year	Age of return				Total
	3_2	4_2	5_2	6_2	
1946	..	..	..	106	..
1947	..	..	15,440	47	..
1948		2,109	7,219	0	9,328+
1949	71	4,549	6,643	0	11,263
1950	0	1,805	2,912	0	4,717
1951	25	1,088	746	..	1,859+
1952	0	3,529	..	..	..
1953	85	..	..	..	..

To summarize the survivals observed at different stages of the life history of Lakelse sockeye for the years in which the observations have been made, all counts and estimates are presented in the following table, with corresponding percentage survivals:

Brood year	Count or estimate (X1000)					Survival (per cent)					Smolt length (cm.)
	Spawners	Potential deposition	Fry	Smolts	Returning adults	Egg-fry	Fry-smolt	Egg-smolt	Smolt-ret. adult	Spawners-ret. adult	
1944	16.5	31,350[a]	..	557	..	..	..	1.78	..	..	7.59
1945	33.0	62,700[a]	..	373	..	..	..	0.60	..	..	..
1946	29.0	55,100[a]	..	600[b]	..	..	..	1.09	..	..	7.63
1947	13.5	25,650[a]	..	..	..	..	..	..	..	..	..
1948	13.0	24,700[a]	..	..	9.3	..	..	..	..	71.5	..
1949	7.5	14,250[a]	..	..	11.3	..	..	..	..	150.7	..
1950	6.2	11,800[a]	..	596	4.7	..	..	5.05	0.79	75.8	8.18
1951	19.0	36,100[a]	..	394	1.8	..	..	1.09	0.45	9.5	8.39
1952	12.0	21,600	..	379	..	..	..	1.75	..	..	8.18
1953	9.3	19,000	1,510	315	..	7.9	20.9	1.66	..	..	8.61
1954	7.7	16,500	2,780	300	..	16.5	9.3	1.81	..	..	..
1955	3.7	6,600	1,042	..	..	15.8	..	..	..	..	..
1956	4.6	6,800	..	..	..	..	..	..	..	..	..

[a]Potential deposition estimated, assuming a 50:50 sex ratio and an average egg content of 3,800 per female.

[b]Estimate based on partial count.

Behaviour of pink salmon fry during extended seaward migrations

J.G. McDonald

Field observations of the behaviour of pink fry migrants were made in the Skeena River and some of its major tributaries in 1956. From April through to the end of June the migrations from the Lakelse, Kalum and Kispiox Rivers were examined. In addition, observations were made along the main stem of the Skeena and at Kwinitsa, on the Skeena near the upper limit of the tidal zone. The fry runs were sampled periodically during the migration period. The fry were captured in a small net which was operated for short periods of time throughout the night and day. This procedure was followed on all three tributaries usually every fourth to sixth day and night.

Movement in relation to light. The movement of the fry with respect to light intensity was found to vary from one river to another. Migration from the Lakelse River, as recorded approximately 3 1/2 miles below the top of the spawning area, occurred almost entirely at night. The number captured each hour throughout the night of May 17 is shown below to describe the general movement pattern. The migration began at dark, built up to a peak in a few hours and then steadily decreased with the coming of dawn.

Time	No. fry captured
9:00 - 10:00 p.m.	1
10:00 - 11:00 p.m.	54
11:00 - 12:00 p.m.	135
12:00 - 1:00 a.m.	135
1:00 - 2:00 a.m.	62
2:00 - 3:00 a.m.	32
3:00 - 4:00 a.m.	26
4:00 - 5:00 a.m.	11

Migrants were captured in numbers both day and night on the Kalum and Kispiox Rivers. The spawning area above the trapping site was considerably longer in both these rivers than that on the Lakelse. The Kalum River has approximately 22 miles of spawning area while spawning in the Kispiox River occurs up to 55 miles upstream. A large proportion of the migration from the Kispiox River took place during the day. Day catches went as high as 225.6 per hour compared to 240.2 for night catches. Only a small proportion migrated from the Kalum River during daylight. The average catch per hour during daylight did not exceed 4.8 fry while night catches were as high as 33.0.

Movement in daylight was found to occur under all stream conditions. However, on the Kispiox River, the largest numbers were recorded during periods of relatively high and turbid water. This was not apparent on the Kalum River where the water is normally turbid presumably due to large clay deposits in the upper drainage. These observations suggest that increased turbidity and therefore reduced light rather than a rise in water level enhanced daytime migration in the Kispiox River.

Frequent observations to indicate whether or not schooling occurred were made during the migratory period at vantage points on both the tributary rivers and on the Skeena as far downstream as tide water. Although numerous individual fry were seen along the banks and in slow eddies, no schools were observed except under certain conditions in the tidal zone near Kwinitsa. This point is approximately 60 to 160 miles downstream from the major pink-producing areas. It is within the upper limit of tidal influence but it is not known whether an actual influx of salt water occurs at this point.

Pink fry were observed here only during the period of the high slack-tide. At this time thousands of individual fry were seen to rise to the surface and swim more or less randomly in respect to the direction of the current. The fry, upon encountering other individuals, formed small schools which continued moving at random. This situation was seen to exist from a period of a few minutes up to one hour. With the ebb of the tide the fry disappeared rapidly and could no longer be observed.

Feeding activity in fresh water. The stomachs of a small number of fry taken at the mouth of the Kispiox River and on the Skeena at Kwinitsa were examined to indicate whether or not feeding commenced during the period spent in fresh water. Results are tabulated below:

Place captured	No. empty	No. with sand grains	No. with food organisms	Total no. no. examined
Kispiox	39	21	20	80
Skeena	13	..	27	40

One-quarter of the fry examined from the Kispiox River were found to have food in their stomachs. The proportion was increased to over two-thirds for those fry taken further downstream. Although the sample is small and cannot be considered representative of the situation throughout the whole of the run, the results show clearly that feeding commences at a fairly early stage of migration and further they suggest that the number of fry feeding increases during the journey.

Discussion. Field observations reveal that a change in the behaviour of pink fry occurs during extensive migrations to the sea. Initially the fry respond negatively to light and as a result remain inactive during the day and migrate at night. This behaviour was observed by other investigators and by the author on streams where the migration route did not exceed 10 miles in length. Migration from the Kalum and Kispiox Rivers, however, included journeys of up to 22 and 55 miles respectively to the mouths of the rivers and another 60 to 160 miles to the salt water. Under these circumstances the migrants, in part at least, did not avoid light, migration continued during the day, and feeding began.

Although a change in the response to light occurred, this did not appear to be related to the formation of schools. Schooling was not observed to occur until the fry entered the tidal zone and long after their response to light had changed.

The results suggest that where the migration must of necessity extend over a period of one night the fry became adapted to light and continue movement during the day. This change in the response to light sets the stage for feeding and schooling, both of which are primarily dependent upon the visual processes. It is probable that conditions favourable for schooling are not encountered until the fry reach the tidal zone.

Age, sex, and growth of Bear and Morice Lake sockeye smolts K.V. Aro

To gain information on the sockeye smolts emigrating from Bear and Morice Lakes, visits were made to those lakes in the spring of 1955 and 1956 to obtain samples. The samples were collected at both lakes by means of small-meshed gill nets placed at the lake outlets. At Bear Lake, 694 sockeye smolts were caught in 1955 and 62 in 1956; at Morice Lake one sockeye was caught in each year. Many small fish of other species were caught at both lakes.

Examination of the scales of the Bear Lake smolts indicated that in both years the fish were all 1-year-olds but that considerable growth had been added in the few weeks prior to migration. The sex ratio was close to 1:1. Lengths and weights of Bear Lake smolts in 1955 and 1956 are shown in the following table:

Year	Fork length (mm.)		Weight (gm.)	
	Range	Average	Range	Average
1955	81-105	91.0	5.6-12.4	7.8
1956	77-98	91.4	7.5-11.5	9.6

Comparison with Babine Lake smolts shows that in both 1955 and 1956 the average size of the smolts sampled from Bear Lake was greater than that of smolts sampled in any year at Babine Lake.

The one sockeye caught at Morice Lake in 1955 was a male in its fourth year, 132 mm. in length, and 20.9 gm. in weight. The smolt caught there in 1956 was a 2-year-old female 106 mm. in length and 9.0 gm. in weight.

AGE COMPOSITION OF SOCKEYE CATCHES AND ESCAPEMENTS

D.R. Foskett

The regular program of sampling the sockeye catch to determine the age-composition was continued in 1956. A total of 4,450 sockeye was measured and weighed and a scale sample was taken from each fish for age determination. The sample was distributed amongst the four major northern sockeye areas as follows: Nass River, 1,075; Skeena River, 1,150; Rivers Inlet, 1,200; and Smith Inlet, 1,025. In addition, a total of 2,215 sockeye scale samples were taken in the Skeena Salmon Management Committee's test-fishing program, which is carried on above the commercial fishing boundary and is thus, predominantly, a sample of the escapement. The distribution of age-groups in the samples by percentages was as follows:

	Age-classes						
	4_1	3_2	4_2	5_2	4_3	5_3	6_3
Nass River	1.3	..	26.8	8.8	0.2	49.6	13.2
Skeena River							
Catch	..	..	84.0	13.8	..	0.8	1.3
Test fishing	0.1	0.6	69.2	24.1	0.2	2.6	3.2
Rivers Inlet	..	..	10.2	89.8	..	+[a]	..
Smith Inlet	..	..	12.2	87.7	..	0.1	..

[a]Age-class represented but less than 0.05%

The age-distribution in the Nass River catch sample was normal with the 5_3 age-group being dominant in the sample, followed by the 4_2 group. The 5_2 age-group was not quite as numerous as in some years and the 6_3 group was present in slightly above normal numbers.

The Skeena River catch showed the highest recorded percentage of 4_2 sockeye - 84%. The 5_2 percentage represents a very poor return for this age-group which can only be partially accounted for by the Babine slide in 1951; nor was it, in this case, due to a high proportion of the brood returning as 4-year-old fish. The percentage of 5_3 and 6_3 sockeye was also low. In the test fishing, however, the percentage of 4_2 fish was 15% lower than in the catch and the percentage of 5_2 sockeye 10% higher, which indicates that the commercial nets captured the 4-year fish more successfully than the five's.

Both Rivers Inlet and Smith Inlet were characterised by having almost 90% of the catch 5-year-olds, with the remainder almost wholly 4-year-olds,

<u>Salmon collections at Owikeno Lake</u>. In order to obtain sockeye-smolt samples of the Rivers Inlet population in connection with the investigations for the International North Pacific Fisheries Commission, a trip was made to Owikeno Lake during the latter part of May, 1956. Considerable difficulty was experienced in obtaining boats and motors for the trip up the river and the work on the lake. The equipment which was finally obtained was in such extremely poor condition that work had to be confined to the end of the lake near the outlet. Nevertheless, a total of over 800 yearling sockeye was obtained in four days with smaller numbers of coho yearlings and coho and sockeye fry. Since this satisfied the requests for smolts for the meristic and parasitological work for the International North Pacific Fisheries Commission, as well as the needs of the Biological Station, the stay at the lake was terminated.

A further opportunity to collect young salmon at the lake occurred during the October survey of the spawning streams, by accompanying Inspector P.J. Sims. At this time young sockeye, coho and spring salmon were collected, along with a number of resident fish likely to be either predators or competitors of the salmon.

SOCKEYE SALMON STUDIES AT THE PORT JOHN FIELD STATION

F. Neave and R.C. Wilson

Adult sockeye salmon escapement, Port John, 1956

Although the total number (1,515) of adult sockeye entering Hooknose Creek in 1956 was very close to the long-term average for this small watershed, the proportion of jacks in the run was relatively small and the seeding was the second largest recorded in 9 years of operation.

The migrants were divided as follows: females, 890; large males, 442; jacks, 183. Of the jacks, 151 (82.5%) were found to be marked by removal of the adipose and left ventral fins - the result of the marking of the outgoing smolts in the spring of 1955.

About 27% of the adults entering Hooknose Creek failed to appear in the spawning streams tributary to the lake. This percentage of loss is quite similar to that which has occurred in previous years.

At the weir on Tally Creek (the chief spawning stream), 515 females were counted and the estimated potential egg deposition was 1,316,127. Fish spawning below the weir and in other streams contributed an estimated additional 299,500 eggs.

Production and disposal of sockeye fry in 1956

The potential deposition of sockeye eggs above the weir on Tally Creek in 1955 was estimated at 899,373. The downstream migration of fry began on May 14, 1956 - a month later than usual - and lasted until July 1. In spite of the unusually prolonged incubation period, 81,690 fry were trapped at the weir, the percentage survival from eggs being 9.08, which is close to the average for the last 8 years. Assuming a similar survival for the small populations spawning below the Tally Creek weir and in other tributaries, the total fry production of the lake area was 121,000.

All the sockeye fry from the Tally Creek weir except 959 (1.17%) which died in the trap and an estimated 700 which escaped during a freshet, were transported to the mouth of Hooknose Creek and released. This was in continuance of experiments to test the possible advantages of early entrance to the sea.

On the basis of the above figures, the number of sockeye fry which entered the lake (i.e., were not transported) was 41,100.

Sockeye smolt production in 1956

Seaward-migrating smolts trapped at the weir on Hooknose Creek in 1956 numbered 22,607 - the largest run recorded in 9 years of operation. The age-composition of the run, determined from scale samples read by D.R. Foskett, was: I, 2.01%; II, 97.54%; III, 0.22%; IV, 0.22%. The size of the run was therefore due to the large number of 2-year-old fish. These were the survivors of the exceptionally large crop of fry (estimated 115,000) which entered the lake in the spring of 1954, from the spawning of 1953.

In considering the age at which the members of a given brood-year go to sea, it has been noted that the proportion of 1-year-old smolts was fairly constant for the brood-years of 1950, 1951 and 1953, varying only from about 17% to 25%. The smolts attributed to the 1952 brood-year, however, showed a much higher proportion of 1-year-old fish (44%). The population of young sockeyes in the lake in 1953 was very small and this may have favoured the early attainment of a size and condition associated with migration.

All outgoing sockeye smolts released from the Hooknose Creek weir in 1956 were marked by removal of adipose and right ventral fins. This is to assist in the definite segregation (in returning adults) of lake-reared fish from fish which were transported to tidal water as fry.

SPRING AND COHO SALMON

D.J. Milne

For the last five years the total catch of spring and coho salmon has amounted to about one-quarter of the total landings and value of salmon in British Columbia. In 1956, they accounted for higher proportions and, because of high prices, the trollers experienced a good season, particularly on spring salmon. The outside gill-net catch of coho salmon was exceptionally large in 1956 but this will probably be prohibited in 1957. In addition, the expanding ocean sport fishery in inside waters catches spring and coho salmon almost exclusively. During the year a summary of past catches was prepared and it appears that the highest catches of both spring and coho salmon have been made in the last decade. This is associated with the rapid growth of the trolling fleet after World War II. In recent years the commercial and sport fishermen have expressed concern about the conservation of both species.

Because spring and coho salmon stocks are fished internationally, a close liaison has been maintained with United States biologists through their coordination agency, the Pacific Marine Fisheries Commission. Coastwide tagging, marking and sampling programs have been carried out in friendly cooperation. A bulletin on tagging experiments conducted in outside waters of British Columbia will be out shortly. The results of the other programs are reviewed in this report. More uniform coastwide troll regulations have been considered for many years, but it was not until the "Conference on Coordination of Fishing Regulations" in February, 1957, that coordination between Canada and the United States was achieved. Resulting from this meeting, spring salmon in British Columbia will be regulated by a closed season from October 31 to April 15 and a minimum size limit of 26 inches in total length. The adoption of the minimum size regulation is discussed in this report since it will necessitate further sampling of the troll catch in 1957 to compare with the size data obtained in previous years. The coho salmon regulations are uniform along the Pacific coast and will not be changed at the present time.

The results of our small experiments on the mortalities involved in catching and releasing small salmon from troll gear, were given in Pacific Progress Reports No. 106. The 1956 tagging experiments of small spring and coho salmon in the Strait of Georgia are presented in this report.

Recent tagging and marking experiments have suggested that the rate of exploitation for spring salmon is higher than that for coho salmon. Because the recent decline in the important Columbia River fall chinook stocks has affected our outside troll fishery, a history of the spring salmon fisheries in British Columbia was started in 1955 and reviewed in last year's report. This in turn focussed attention on the unknown condition of the red and white spring salmon stocks of the Fraser River system. Preliminary observations on these important stocks are presented in this report.

Catch of spring and coho salmon in 1956

For the past five years the average catch of spring salmon has been approximately 14 million pounds and that of coho salmon has been 25 million pounds. This is about one-quarter of the total landings and value of salmon in British Columbia. In 1956 the catches of spring salmon (13,700,000 lbs.) and coho salmon (25,150,000 lbs.) were about average but together they accounted for 33% by weight and 44% by value of the total British Columbia salmon catch. This was because of higher prices and poorer catches of other species of salmon in 1956. The trollers have been catching about two-thirds of both spring and coho salmon but in 1956 the proportion caught by troll was the highest (72%) for spring salmon and the lowest (51%) for coho salmon in the last six years.

The troll catch in 1956 of <u>red spring salmon</u> off the west coast of Vancouver Island was earlier and larger than the low catches in 1954 and 1955. Fishing was greatly encouraged by the exceptionally fine weather early in the season and the high prices which prevailed. Of special note was the small size of the fish caught. For example, in the important area (23) off Barkley Sound, the percentage of reds which were graded as small was 31% for March, 37% for April, 56% for May, 48% for June, 36% for July, 38% for August, and 44% for September. The total number of small reds in Area 23 (125,000 fish) was about twice the average number caught in the last 5 years. The peak period was May and June with only 5% of the small red spring salmon caught prior to the United States opening date of April 15. In 1957-58, a closed season of October 31 to April 15 will apply in British Columbia. The outside catch during this period amounts to less than 5% of recent total troll catches.

The troll catch of white spring salmon off the west coast of Vancouver Island was about average in 1956 but more small fish were taken than in recent years.

The troll catch of both red and white spring salmon was poor off the Queen Charlotte Islands. The total troll catch of spring salmon in 1956 was 9,830,000 pounds or above average but the net catch was below average (see under Fraser River gill-net fishery).

The coho salmon troll catch in 1956 was good, early in the season, with the peak catch in July. Poor catches were made in September and October. The outside fishery (off Vancouver and Queen Charlotte Islands) was good but the fish were small in average size. In the Strait of Georgia the catch of "bluebacks" was poor but the fish were large in average size. The total troll catch of coho salmon in 1956 of 12,890,000 pounds is the second lowest since 1951 and is below that made in the brood-year, 1953. However, good gill-net catches of coho salmon were made in August and September off both ends of Vancouver Island. Of particular significance is the great increase in the size of the gill-net catch off the southwestern part of the Island (an increase of over 1,000,000 lbs. in Area 21). The Fraser River gill-net catch of coho salmon was about 1,000,000 pounds or twice as large as in 1953. Because of the larger net fishery in 1956, the total coho catch is the largest since 1951 and is above that taken in the brood-year.

The total troll catch of 22,720,000 pounds was taken in 107,000 boat-days (lowest in the last 6 years) and the average catch per boat-day of 212 pounds is the highest in the last 6 years. Hence, with fewer fishermen (only 3,183 troll licenses were issued in 1956) and higher prices, the trollers experienced a good season in 1956.

Sampling of the troll catch for marks and size of fish

1. 1956 mark returns in spring and coho salmon

Each year since 1952 the troll catches have been sampled for fish marked in United States hatcheries. In 1956 this sampling was greatly reduced. A total of 10,630 coho salmon were examined in the south and only 1 fish was found with a single fin missing. A total of 23,611 spring salmon were examined in the south and only one double-fin and 11 single-fin marks were found off the west coast of Vancouver Island where most of the marked fish have been recovered in the past. In the north, 8,027 spring salmon were examined and 5 double-fin and one single-fin records were reported. Since this is at variance with our previous experience and since only 2 single-fin records were found in 20,666 fish examined in south-eastern Alaska, the 5 double-fin records are considered to be doubtful marks.

The records of the few marks obtained have been forwarded to the marking agencies as in previous years. It is hoped that the analysis of the results of these large marking experiments will be completed as soon as possible. A preliminary summary of 6 experiments in each species was presented in last year's report.

2. Age and length studies with special reference to recent changes in troll regulations

(a) Coho salmon. Most coho salmon mature and are caught in their third year. The average lengths of fish sampled from inside and outside waters in 1956 are compared with the averages of the last four years in the following table:

	Average fork length (cm.) of coho salmon			No. of fish
	June	July	August	
Caught inside Vancouver Island				
1952-55 (Av.)	51.8	53.3	53.9	7,656
1956	55.2	58.0	58.1	3,400
Caught outside Vancouver Island				
1952-55 (Av.)	57.4	61.8	64.5	5,888
1956	57.6	60.5	63.2	4,115

In 1956 the inside (blueback) fishery opened on June 16 for the first time (formerly June 1) and it was the second season in which the minimum size limit (2 1/2 lb. dressed weight) has been removed. These changes may have contributed to the smaller catch in 1956 but they do not account for the larger size of fish caught during July and August. The fish were the largest in average size for the last 5 years. In contrast, the outside fish were smaller than average during July and August. The fish caught outside are always larger than those taken inside but this is the first year that the growth rate has differed in each area. This suggests that poor conditions for growth were encountered in outside ocean waters while good conditions prevailed in inside waters.

(b) Spring salmon. A summary of the ages of spring salmon sampled from 1952 to 1955 was presented last year. In 1956 only the troll catches in the southern part of the coast were sampled. The percentages in each age-group for red- and white-fleshed fish are as follows:

Area	Flesh color	No. of fish	Age in years								
			Ocean-type					Stream-type			
			2	3	4	5	Total	3	4	5	Total
West coast of Vancouver Island	Red	277	3	61	26	1	91	3	5	1	9
	White	34	3	56	32	..	91	3	6	..	9
Strait of Georgia	Red	120	12	75	7	..	94	1	3	2	6
	White	28	18	57	25	..	100	..	..	..	..

As in past years, younger and more fish of the ocean-type (young go to sea in their first year) were found in the Strait of Georgia than off the west coast of Vancouver Island. The white-fleshed fish appear to be older than the red-fleshed fish. However, this is more apparent in the ages of mature fish caught in the Fraser River gill-nets as will be shown later.

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(4) In the case of chum salmon (Table II) it will be seen that smaller streams in the aggregate were of relatively greater importance in salmon production than they were for pink salmon. Thus, for all the areas combined, almost 40% of the total number of fish is credited to approximately 92% of the streams (those given A to H estimates). Nevertheless, the very small proportion of streams with large escapements accounted for an important fraction of the total escapements, viz., 23.5% of the escapement in 1.0% of the streams (categories M plus N), and as much as 60.8% of the escapement in only 17.3% of the streams (categories K to M).

(5) If escapement data is to be truly useful in salmon population studies, some revision of the present method of estimation will be necessary. In particular the N category should be replaced by the best possible numerical estimate. The great difficulty of estimating numbers of fish in streams is well recognized, and the solution to the problem will no doubt vary with such things as local conditions, the experience of Inspector or Guardian, and the availability of time, monies, and new aids for the performance of the job.

Freshwater production of coho salmon

W.P. Wickett

The diversion of streams for industrial or civic use of water has brought out the need for protection of coho salmon which spend their first year in the streams.

The numbers of fish that can grow from fry to yearlings in a stream, the numbers of yearlings to produce a known spawning run, and the numbers of hatchery-raised yearlings needed to maintain a run, are required.

The following data gathered by various investigations may be of use:

	Natural yearlings per 100 sq. yd.	Returning adults per 100 natural yearlings	Returning adults per 100 hatchery yearlings
Nile Creek	11-20	3.2-11	..
Cowichan (Beadnell Cr.)	89-172)		
Cowichan (Oliver Cr.)	21-108)	4+	0.9-1.55
Hooknose (Port John)	19-47	4-20	..
Scully Creek (Lakelse)	25		..
Cultus	..	8+	..
Minter Creek (Puget Sd.)	17-26 (approx.)	2-4	0.2-2.1(av. 1.1)

In addition, the yearling production at Oliver Creek follows the minimum monthly run-off for the previous year. The pattern of fluctuation is the same recorded for the availability of the returning adults a year later.

NATURAL PRODUCTION OF PINK, CHUM AND COHO SALMON AT PORT JOHN

F. Neave and
R.C. Wilson

Adult pink and chum salmon migration in 1956. The pink salmon escapement of 1956 was the second-largest recorded during the 10-year operation of the Port John field station, having been exceeded only by its immediate ancestral generation, the escapement of 1954. The chum salmon escapement was of moderate size.

Statistics relating to the spawning of the two species in 1956 are as follows:

Species	Number of adults	Percent female	Average egg content	Potential deposition	Per cent loss of eggs by retention
Pink	21,650	52.19	1,425	15,811,800	1.10
Chum	3,131	51.52	2,627	4,074,477	1.50

The average egg content and the loss due to retention were based on 112 and 924 samples respectively for pink salmon, and 32 and 196 for chums.

On the basis of past experience at Port John, it seems possible that the total deposition of pink and chum eggs in 1956 was somewhat above the optimum number for Hooknose Creek. However, since only two previous spawnings have seemed to be in this category, the present opportunity to obtain further data on the effect of density is very welcome. The number of fry-migrants in the spring of 1957 will provide important information.

Ocean survival of pink salmon. The adult pink salmon escapement of 21,650 in 1956 can be regarded as the survivors (after natural ocean mortality and fishery) of 907,458 fry which went to sea in the spring of 1955. The survival of 2.4% is almost exactly the 8-year average for this stream.

Output of pink and chum salmon fry in 1956. The mid-point of the downstream migration of pink salmon fry was reached on May 7 and of chum salmon fry on May 26, these dates being respectively about two and three weeks later than the average for the preceding 8 years. The output of fry in relation to the egg deposition is shown in the following tabulation:

Species	Potential deposition	Number of fry	Per cent survival
Pink	1,275,768	86,256	6.8
Chum	1,275,960	49,443	3.9

The per cent survival of both species was relatively low (recorded percentages at Hooknose Creek range from 0.88 to 16.47 for pinks and from 0.99 to 19.41 for chums). The result, however, was in conformity with previous findings that small seedings produce a low percentage output of fry.

Coho studies, 1956. Coho smolts migrating to sea in the spring of 1956 numbered 4,513. They were the survivors from an estimated deposition of 373,600 eggs in the Hooknose Creek watershed in 1954. The survival was therefore 1.2% to this stage. This is within the previously established range of 0.6% to 4.0%.

The ocean survival of cohoes from the brood-year of 1953 is represented by the jacks which returned in 1955, plus the large males and females in 1956. These were: jacks, 464; large males, 201; females, 141; a total of 806. This is a return of 11.9% from the 6,756 smolts which left the stream in 1955. Previously recorded ocean survival has varied from 4.0% to 20.0%.

In addition to the large males and females reported above, the 1956 coho escapement included 225 jacks. The estimated potential deposition of 354,700 eggs is less than the seedings of 1954 and 1955 but still much larger than the 1953 deposition.

BEHAVIOUR OF MIGRATING JUVENILE PACIFIC SALMON

W.S. Hoar

Two additional behaviour patterns of Pacific salmon fry were noted in 1955. Pink salmon fry which had never schooled were found to prefer a cover of stones and did not emerge into bright light. Brief schooling experience changed this response and schooled fish were found regularly in bright light swimming above the stones. Chum salmon fry were found to establish constant directions of swimming in circular channels. These established directions were not disturbed by changing light or location, by water currents, or by startling the animals in a variety of ways.

These two activities were analyzed in more detail and compared in the different species during the period of downstream salmon migration in May, 1956.

In 1956 a different technique was used to study reactions of schooled and unschooled salmon fry. Fry were collected, as before, during the night from the screens of the counting weir. They were placed individually in separate paper drinking cups (450-ml. capacity) or in small groups in paper milk cartons. During the following day their reactions to cover were tested by placing them in aquaria where they could hide among stones or swim above them. As before, unschooled pink fry prefer to hide under stones while schooled fry tend to swim above the stones. Chum fry, collected in the same way, prefer to swim above the stones whether schooled or unschooled (?). Sockeye fry which have recently emerged and are migrating, hide under the stones during the day even though they may have had schooling experience. In further studies, cover reactions of the four species of fry were compared and shown to form a graded series with the pinks at one extreme (no hiding when startled) and the sockeye at the other (continuous hiding). The stability of the behaviour change of the recently schooled pinks was studied further by isolating them for varying periods from schools.

The results of further studies of the constant course of movement shown by young salmon in circular channels are summarized as follows: