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SKEENA SALMON MANAGEMENT COMMITTEE

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Committee Members

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Terms of Reference

On October 7, 1954, the Minister of Fisheries appointed Dr. A. W. H. Needler, Director of Fisheries Research Board Station at Nanaimo, and Mr. A. J. Whitmore, Chief Supervisor of Fisheries for the Pacific Area, as a Committee on Management for the Skeena River Salmon Fisheries. The Committee was directed to investigate thoroughly the condition of salmon stocks in the Skeena River to improve the management of the runs and to increase the yields. The Minister particularly noted that the Babine River rock slide of 1951 had destroyed two-thirds of the 1951 and 1952 sockeye spawning runs to Babine Lake, the major producer, and hence special measures would be necessary to rebuild these runs.

To achieve its aims the Committee would make full use of the research and administrative staffs of the Federal Department of Fisheries, both of which had carried out considerable work on Skeena salmon stocks in the past. The Committee would bring about full coordination and extension of these activities.

The Minister subsequently appointed an Advisory Board whose members for 1956 are shown on page 1 of this report. Since the formation of the Committee, it has met several times each year with its Advisory Board to discuss new developments arising from investigations, and to discuss thoroughly the basis for recommendations for regulation of the Skeena fishery.

This report reviews the meetings concerning the 1956 fishery, the results of the 1956 regulations, and the progress of investigations.

Record of Meetings

The Committee met in Vancouver on November 26, 1955, to review the evidence concerning the likely size of the 1956 Skeena sockeye run. It was noted that the 1956 Babine sockeye run would be composed of 4- and 5-year-olds, both age groups being the progeny of the slide-blocked Babine runs of 1951 and 1952. The best estimate, based largely on the known sizes of the Babine smolt runs which would give rise to the 1956 adults and the low ocean survival which had applied to the 1955 4's, indicated a total 1956 Babine sockeye return of about 150,000 4's and 50,000 5's, or a total of 200,000. The total Skeena sockeye run would be expected not to exceed that of 1955 (about 300,000).

It was agreed that the anticipated run would not provide an adequate spawning for Babine Lake, and that closure of the 1956 sockeye fishery would be necessary to protect the small run.

In a statement issued immediately after the meeting, the Committee reviewed the evidence bearing on the likely size of the 1956 sockeye run and proposed tentative regulations in accordance with the expected small size of the run. It was proposed:

(1) that fishing for sockeye salmon should not be permitted until 6 p.m. Sunday, July 29, 1956,

(2) that fishing for spring salmon, using gillnets having a mesh not less than 8" linen, or 8 1/2" nylon, should be permitted before this date, and

(3) that the 72-hour weekly closed period and the upriver boundary from Mowitch Point to Veitch Point should continue to apply in 1956.

Subsequently, the evidence bearing on the size of the 1956 sockeye run was reviewed with the Committee's Advisory Board at a meeting held in Vancouver on December 8, 1955. Members of the Advisory Board present were Messrs. R. E. Walker, R. T. Hager, R. Nelson, A. E. MacMillan and R. Bell-Irving. After consideration of the evidence, the Advisory Board members discussed the proposed regulations with the Committee. It was agreed that special protection for the sockeye was required in 1956: most members agreed with the proposed opening date for sockeye, others suggested that it might be even later. The proposed program of investigation for 1956 was briefly outlined.

At Prince Rupert on December 16, 1955, the evidence bearing on the size of the 1956 sockeye runs was reviewed with the Prince Rupert members of the Advisory Board: Messrs. K. F. Harding, O. Olafson, and S. Oddsun. Further advice and opinion concerning the opening date for sockeye and pink fishing was obtained by the Committee, and the tentative program of investigations for 1956 briefly outlined.

The regulations proposed in the statement of November 26, 1955, were reviewed in the light of representations made at the above Advisory Board meetings at a meeting of the Committee held on January 30 in Vancouver. On February 9, 1956, the Committee issued a statement in which the following regulations for salmon fishing in 1956 in the Skeena were recommended to the Department of Fisheries:

(1) that sockeye fishing be not permitted until 6 p.m. Tuesday, July 31, 1956,

(2) that up to this date only gillnets having mesh not less than 8" linen, or 8 1/2" nylon, stretched measure, be permitted, to allow normal fishing operations for spring salmon (fishing for spring salmon to be terminated earlier if such is found to be necessary for conservation purposes),

(3) that the 72-hour weekly closed period and the upriver boundary from Mowitch Point to Veitch Point continue to apply to all salmon net fishing in 1956, except

(4) that the 72-hour weekly closed time be extended in the event that for any week or series of weeks the 72-hour weekly closure is deemed insufficient to provide for the escapement of an adequate number of spawners.

The above regulations, as recommended to the Department of Fisheries, were accepted and applied to the 1956 Skeena salmon fishery. No further meetings were held until December 7, 1956, when the Committee met in Vancouver to review the results of 1956 investigations and regulations and to discuss proposals for regulation of the Skeena salmon for 1957. It was noted that the total 1956 Skeena sockeye stock had amounted to some 575,000, somewhat greater than had been anticipated. Of this total, the fishery caught 157,000, and of the remainder 355,000 entered the Babine Lake spawning area. This seeding, while low, approached in size some of the smaller pre-slide Babine runs. The total 1956 catch of Skeena pinks had amounted to approximately 600,000 altogether and the escapement was estimated to be some 3-400,000, which amounted to less than one-third the 1955 escapement.

The Committee also reviewed the information pertaining to the likely size of the 1957 Skeena salmon runs. It was agreed that proposals for 1957 regulations would be studied, and that a statement should be prepared for release early in January for consideration by the Committee's Advisory Board at meetings in Prince Rupert and in Vancouver.

The 1956 Skeena Salmon Runs

The 1956 Skeena salmon fishery produced one of the lowest total Skeena salmon packs recorded, chiefly for two reasons:

(1) the special closure of sockeye fishing until 6 p.m. July 31 to protect the expected small return of 4's and 5's from the 1951 and 1952 slide-blocked Babine spawning run allowed 75% of the Skeena sockeye stock to escape the commercial fishery, as compared to an average of 50% escapement in previous years.

(2) the pink catch was the lowest recorded for the period 1950-56, taken from a small total Skeena pink stock of less than 1 million fish.

Gillnet catches of springs, cohos, and chums were all below the 1950-55 average. Of the catches of the five species, only that of the chums exceeded the 1955 catch.

The 1956 regulations for the Skeena Gillnet Area especially provided increased protection for all early sockeye, and to a lesser extent for early pink runs, through the very late opening of sockeye fishing on July 31. The additional protection of a lowered upriver commercial fishing boundary for spring and fall fishing, and a 72-hour weekly closed period (both measures implemented for the 1955 season) applied to spring, pink, coho and chum fishing in 1956.

The following table summarizes the weekly catches for all species in the 1956 season (as reported in the B. C. Catch Statistics of the Department of Fisheries) for Statistical Area 4.

WEEK ENDING		SOCKEYE	PINK	SPRING	COHO	CHUM
April				3		
May	12			2		
	19			6		
	26			39		
June	2			269		
	9	3		389		
	16	18		1,119		2
	23	126		1,482		3
	30	292		2,308	3	13
July	7	329		2,490		38
	14	292	24	2,579	5	49
	21	294	31	1,525	26	222
	28	259	149	1,758	128	1,066
Aug.	4	100,204	49,115	315	3,058	2,620
	11	32,316	102,390	368	17,364	5,475
	18	10,440	116,667	160	6,949	7,015
	25	1,935	68,441	164	12,359	14,300
Sept.	1	995	56,880	258	10,269	11,164
	8	206	8,517	76	5,041	6,523
	15	40	1,454	33	2,621	1,712
	22	10	154	24	2,768	636
TOTAL		147,759	403,822	15,367	60,591	50,838
Average 1950-55		650,852	779,263	24,994	73,141	64,999

The Sockeye Run. From the estimated total 1956 Skeena sockeye stock of 575,000 (not including "jacks"), the commercial fishery removed 147,759 in the Skeena Gillnet Area, leaving an escapement above the commercial fishing boundary of some 425,000. Of these the Indian fishery removed an estimated further 40,000, leaving an effective escapement of some 385,000. The Babine weir sockeye count was 355,000. The larger than expected return of sockeye arose from a 15% marine survival of the 2.8 million smolts of the 1952 Babine brood year, which contributed some 440,000 4's to the Babine stock returning in 1956.

While the 1956 sockeye catch was the lowest on record, it was made in a short fishing season: sockeye fishing began in 1956 at 6 p.m. on July 31, as compared to the usual late June opening. Slightly over 100,000 sockeye were taken in the first two days of fishing and most of the remainder in the four fishing days of the following week. Thus, as a result of the special total closure, which had been proposed by the Skeena Salmon Management Committee to protect the anticipated low return of Babine sockeye whose parent runs had been seriously depleted by the Babine River slide, the proportion removed by the commercial fishery amounted to only 25%, as compared to an average of about 50% in previous years. The 1956 sockeye escapement to Babine Lake was five times that of 1955, and approached in size some of the smaller pre-slide Babine Lake

sockeye spawning escapements. Further, the sockeye catch was composed almost entirely of sockeye which would have spawned in the Upper and Lower Babine Rivers, which appear to be less depleted than most other Babine spawning grounds.

The Pink Run. The 1956 pink salmon catch in the Skeena Gillnet Area amounted to 403,822. In addition, it is estimated that some 200,000 were caught in the adjacent salmon fishing areas 3 and 5. The catch in the Skeena Gillnet 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 Spring Run. The 1956 gillnet 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 Coho Run. The 1956 Skeena coho gillnet 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 Chum Run. 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.

Record of Investigations

Since the inception of the Skeena Salmon Management Committee, several projects have been carried out by the Fisheries Research Board to provide information for improving management of Skeena salmon stocks. The results of the major investigations are reported after the general summary immediately following.

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 had 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 under-utilized 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 by adjustment of fishing regulations 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.

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.

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.

Regulation to provide optimum escapement. 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 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 projects in the Skeena estuary.

To derive an index of the numbers of salmon escaping immediately after they have passed through the fishery, test fishing by chartered gillnet boats was carried on immediately above the fishing boundary throughout the 1955 and 1956 seasons. The successful development of such a method would aid greatly in making an immediate assessment of the effectiveness of existing regulations in providing desired escapements, and would provide a basis for changing regulations during the season if the existing regulations were not providing escapement of required size. Analyses of test-fishing data for sockeye indicate that the test catches do reflect the abundance of sockeye escaping the fishery and can be used to provide gross estimates of the daily escapement. However, further experiments with runs of different sizes are required before the degree of variation and thus the relative precision of the estimates are well enough understood to make the fullest use of the techniques.

Rough as they are, the measures of daily escapements obtained in 1955 and 1956 have permitted a study of the effectiveness of the Skeena sockeye fishery. In conjunction with data on tagging, commercial catch and spawning-ground enumerations, estimates of the daily rate of exploitation of the 1955 and 1956 fisheries were obtained and hypothetical curves derived, indicating the rate of exploitation that might be expected with various durations of weekly close times. The analysis emphasizes the marked increase in efficiency of the Skeena fleet in recent years: whereas a 2-day weekly close time prior to 1950 provided an escapement of 50% of the stock, a 4- to 5-day close time (if the fleet fished every week throughout the season) would have been necessary to have provided a similar rate of escapement in 1955 and 1956.

Details of Investigations

Adult salmon tagging in the Skeena Gillnet Area and adjacent waters, 1956. 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. Adult 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 Gillnet Area (Area 4), and the Nass Gillnet Area (composed of Sub-areas 3X, 3Y and 3Z). The tags were recovered in the commercial and 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 gillnet fishery.

Test fishing and tagging in the Skeena estuary. 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. Test-fishing data were analysed to determine whether or not catches at the test-fishing site reflect the abundance of fish moving upstream past the fishing boundary. Preliminary examination of the data indicate that the catches do reflect changes in abundance. Although at least one more year's data will be required to complete assessment of the methods, information to date suggests that the catch per hour at the test-fishing site may be used to provide a gross estimate of the escapement.

In addition to providing escapement estimates, the test-fishing data have also given information on the duration of passage of the Skeena sockeye runs through the fishery and on the daily rate of exploitation by the fishery. The data have also been used to estimate the rates of exploitation that would probably occur if the length of the weekly close times were varied.

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 close 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. Relation of sockeye test catches to size of upstream escapements

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, $P > .001$). A further illustration of this close parallelism 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
Aug. 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, 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 analyzed 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
Sept. 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
Sept. 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 close time of 3 days. From 1944 to 1950, the fishery operated throughout the sockeye season on a 2-day weekly close 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.

Using tagging data to estimate the duration of passage of sockeye through the Skeena fishing area (including both estuarial and "outside" waters), and estimates of the daily rates of exploitation in 1955 and 1956 for the whole fishing area, it has been possible to estimate what the rate of exploitation would be with weekly close times of varying duration. In the following table, the weekly rate of exploitation for different weekly close times are listed. It should be pointed out that the data used to provide the estimates were obtained in 1955 and 1956 when the Skeena sockeye runs were considerably below average. It is quite possible that these figures would not be applicable in years when the stock reaches higher levels.

Weekly close time in days	% Exploitation 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 have been required in 1955 and 1956. 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, 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 out-lined in the table above.

Salmon enumeration at the Babine fence in 1956. The run of sockeye salmon to the Babine Lake watershed was recorded in 1956 at the Babine River adult counting fence as in all other years with the exception of 1948 when floods damaged the fence making it necessary to estimate the size of that run. The fence 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 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.

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.

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, and growth 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.

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. Recently 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 sockeye runs to pass the commercial fishery are those to the very important Upper and Lower Babine River spawning grounds. These Babine River runs have a similar time of passage to that of the Fulton, but peak up to a week later.

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

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 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 runs of smolts of different sizes will indicate the relationship between smolt size and ocean survival and, consequently, how much crowding and resulting stunting pays.

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 (milligrams per cubic metre) to less than 5 (milligrams per cubic metre). 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.

Size and distribution of Skeena pink salmon escapements. 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 table 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. A small number of spawners have been observed in the Bulkley since the construction of a fishway at Moricetown. 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 at the present time.

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 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 adapatation 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 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 of 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 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 the 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 River produced a somewhat higher proportion of fry in relation to the size of the escapement to each river, i.e. the escapement to the Kispiox River was over four times that to the Lakelse and produced about six 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.

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