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J.L. HART DIRECTOR

(WITH INVESTIGATOR'S SUMMARIES AS APPENDICES)

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FISHERIES RESEARCH BOARD OF CANADA.

Report of the
Pacific Biological Station
Nanaimo, B. C.

At the Pacific Biological Station much research emphasis is given to studying factors affecting the natural supply of fish for the fishery. The salmons are by far the most important fish resource in British Columbia and all of them spawn in fresh water. During their spawning migrations through the inlets and in the fresh water they are very vulnerable to all kinds of fishing - so much so that it is evident that the fishery could readily reduce the breeding population below the numbers required to maintain the runs. At present, enforcement officers of the Department of Fisheries are very effective in generally assuring that enough fish for propagation escape the fishery. They work, however, with incomplete knowledge of the relationship between the number of spawners and the number of resulting offspring, or the other factors controlling success in reproduction. Better information could assist in avoiding over- or under-restriction and consequent economic loss. As the resource is limited, knowledge of the factors restricting natural production has other advantages since it can point the way to remedial measures. The critical spawning and early life-history stages of salmon take place in areas which are not only very vulnerable to the inroads of civilization but are also areas where it is possible to adjust conditions when such seems advisable.

The increasing demand for fresh water for power, irrigation, domestic and industrial use, etc. is a growing threat to salmon, and, especially, to the most valuable species which spawn near the headwaters of the large rivers. Tests and observations are being made to indicate suitable methods of guiding fish around hazards in their migration routes.

Some aspects of the attitude in herring research are similar to those for salmon. The habit of herring in British Columbia of entering confined waters some months before spawning on the vegetation in the intertidal zone makes them easily caught in large numbers. This has led to the reasonable fear of over-exploitation. Some of the research projects study the relation of catch size to whole population size and of the abundance of the spawning population to the amount of young. Other parts of the work define the populations and assess the various causes of mortality.

Other biological programs are designed to survey and study the resources, largely in international waters, in groundfish, whales, and crustacean shellfish, or to study the organisms causing diseases of fish or the loss of quality in fish products.

Most fish live in the sea, and an understanding of water movements and water character is necessary for good understanding of their distribution and changing abundance. A program in oceanography is supplying valuable data and analyses.

SOCKEYE SALMON

The work on sockeye salmon is carried out in four situations. They are: Babine Lake, which accommodates over half of the spawning run in the Skeena River system; Lakelse Lake where effort is concentrated on fundamental studies in the freshwater life history; Port John where incidental observations on sockeye in a small lake are made to supplement other information; and at coastwise canneries where the commercial landings are sampled.

Babine Lake. The main program at Babine Lake centres round a counting weir across the Babine River just below the outlet of Nilkitkwa Lake, an expansion of the river. Through this weir is enumerated the sockeye run to the main spawning grounds in the Skeena River drainage.

Other species of salmon besides sockeye are enumerated, and records are maintained on the size, sex distribution and incidence of injuries on the sockeye.

In 1951 a rock-slide in the Babine canyon, some 40 miles below the source of the Babine River, partially blocked the channel so that only about one-third of the sockeye run succeeded in reaching the lake. An abnormally high proportion of the fish which succeeded in reaching the counting weir were injured. In 1952 engineers of the Fish Culture Development Service of the Department of Fisheries pushed an access road through to the site of the slide. Access made feasible some marginal improvements along the edge of the slide and a substantial improvement in the run was observed. During the winter of 1952-53 the slide was shovelled and trucked out of the river bed, restoring it to as good a condition as formerly, and possibly producing an improvement. The history of the effect of the slide on the sockeye run is illustrated briefly in the following tabulation:

Year	Sockeye	Percentage *"jack" sockeye	Spring	Pink	Coho	Chum
1946	475,705	12.2	11,528	28,161	12,489	18
1947	522,561	47.7	15,614	55,421	10,252	7
1948	560,000**					
1949	509,132	9.4	7,433	13,663	11,938	5
1950	543,658	33.0	6,838	38,728	11,654	7
1951	152,457	7.2	2,778	50	2,122	0
1952	376,947	c. 7.3	5,915	2,706	10,554	1
1953	714,536	c. 4.2	8,353	1,018	7,611	17

* Jack sockeye are precocious fish which mature a year early.
** Estimated from comparison with stream survey counts and weir counts of previous years.

The percentage of injuries recorded was 2.7% - much lower than the 29.8% recorded in 1952 or 29.5% in 1951, and generally comparable to the 3.0% in 1950, 6.6% in 1949, and 3.5% in 1947.

The evidence of these records is that the obstruction has been very effectively removed.

In order to obtain additional information on the effects of the slide on the salmon run the Fish Culture Development Branch of the Department of Fisheries tagged fish in the neighbourhood of the slide both in 1952 and in 1953. The Board's employees recorded the tags as the fish passed the counting weir. The data so obtained are being used in joint reports on the effects of the slide. The reports will appear in 1954.

Satisfaction over the increased escapement in 1952 was dimmed by the observation that large numbers of fish which passed through the weir at the head of the Babine River died unspawned. Representative samples of the fish which drifted down against the weir were examined. The results, given below, show (1) that there was genuine cause for concern in 1952, and (2) the situation is largely relieved in 1953.

Year	Females examined	Completely spawned	Partly spawned	Unspawned
		%	%	%
1952	9,600	25	6	69
1953	26,000	89	9	2

Spawning escapement figures such as those obtained at the Babine weir are indispensible in learning the spawning potential. The number of year-old smolts as they commence their migration to the sea is, however, a better measure of the effectiveness of reproduction. Preliminary steps to estimate this number were taken in the spring of 1951 and more refined estimates were made in the two subsequent years. They are:

1951	4,200,000
1952	4,500,000
1953	3,000,000

The smolt run of 1953 is the first one to be affected by the slide. It is some 30% lower than its predecessor. As the spawning escapement was about 70% lower it appears that the natural resilience of the species has already begun to compensate for the damage which the slide did to the run.

The dependable spawning grounds in the Babine watershed are in the larger tributary rivers and in the Babine River itself. The small streams are less dependable producers and may be a source of variation in smolt output. One of these, Six-Mile Creek, has been studied since 1950. A weir to allow counts of spawning adults and their offspring fry was installed. In its first year of operation the stream accommodated 545 female spawners and a calculated 1,580,000 eggs from which developed 188,000 fry for an efficiency of 12%. In the two following years the stream was dry and there was no production. In 1953 there was again a good run of sockeye to the stream and 2,671 male and female fish deposited an estimated 4,200,000 eggs. The subsequent fate of these eggs and the resulting fry will be closely followed.

<u>Lakelse Lake</u>. Lakelse Lake has an area of five and one-half square miles. It is, accordingly, large enough to support a significant population of sockeye but small enough to allow thorough study of factors influencing the size of the sockeye population. These were the principal reasons for selecting the lake as the site for basic research. Lakelse is a relatively low-lying lake near the coast. It drains into the Skeena River through the Lakelse River. A short distance below the source of the river a weir facilitates counting both adult salmon as they enter the lake on their spawning migration and the yearling smolts as they start out on their migration to the sea.

Fry production in Tally Creek is rather erratic. In 1952-53, 19,078 fry were produced from 380,000 eggs - 5.0%. Percentages in former years have been 25.2, 1.75, 5.1, 8.9 and 5.0.

If the 1953 smolts are all regarded as being two-year-old fish, the 14,075 smolts counted as they migrated out of Hooknose Creek represent approximately 3% of the egg deposition in 1950 and 60% of the fry production. Port John Lake supports relatively few predators but also produces relatively little food for fish.

In 1949 all the seaward migrating smolts from Port John Lake were marked by removing both pelvic fins and the adipose fin from each fish. During the succeeding three years marked fish returned as adults: 194 in 1950, 388 in 1951, and 33 in 1952. These came from 19,486 smolt. The percent ocean survival is 3.1% for the marked fish. The marking of all the smolts in the run of 1949 provided a measure of wandering from the home streams. The 194 precociously-maturing male "jacks" were 90.3% of the 215 "jacks" counted in 1950. The remaining 21 fish were apparently wanderers.

Catch Sampling. The systematic examination of the commercial sockeye catches in the Nass, Skeena, Rivers Inlet, and Smith Inlet area has been continued. The collections for 1952 are now examined and the results reported. There was a high proportion of 4_2-fish in the Skeena fishery (66%). The males averaged 5.6 pounds in weight and the females 5.0 pounds. These are exceptionally high values for recent years. Female fish were better represented than usual in Rivers Inlet among the 4_2's with 42%. At Smith Inlet 91% of the catch was 5_2-fish. The value is high but was exceeded in 1947 (95%). The sampling is being extended to include a comparison of the fish in the catch with those on the spawning grounds for the Rivers Inlet area.

PINK AND CHUM SALMON

The spawning grounds of the pink and chum salmon are near the sea in the smaller rivers and streams. When they are in the larger rivers they are in the lower reaches and tributaries. The newly hatched fry reach the salt water at a very early age. The production of these species is, accordingly, subject to quite different limitations than those affecting the sockeye which frequent the larger river systems. The factors controlling production in pink and chum salmon are studied at two sites, Nile Creek, about 40 miles north of the Pacific Biological Station on the east coast of Vancouver Island, and Port John on King Island in central British Columbia. A technique for assessing the permeability of spawning beds is being developed in the model laboratory at the Pacific Biological Station, and in the field.

Two special projects have been undertakem. A survey was carried out on the Queen Charlotte Islands to assess the hatch from the specially large spawning run in the autumn of 1952. An extensive tagging program on pink and chum salmon was undertaken in Johnstone Strait. The fishery there has developed rapidly, raising serious problems in management. The work is planned to determine the destination of the fish supporting the fishery there and to estimate the intensity of the fishery.

Port John. The research facilities at Port John have been described above. They permit enumeration and, when desired, examination of adult fish entering the stream to spawn and of young on their seaward migrations.

Part of the work is to follow the fate of each generation of spawning fish. The pink spawning run of 1952 was the largest on record (8,685), representing a return of mature fish of 3.73% of the fry output of the 1950 brood year. This is close to the three-year average of 3.85%. The large spawning escapement of 1952 produced a very large fry migration in 1953 (1,227,025) for 14.4% efficiency in hatching. The good yield was anticipated from the favourable water conditions which prevailed during the spawning period.

The chum salmon run of 871 fish was below average. It produced 182,200 fry for 19.4% efficiency in hatching. In general, efficiencies for chum and pink salmon have followed each other closely at Port John. The comparative reduction of efficiency for pinks may be due to the large size of the spawning run which increased competition for desirable redd sites and may have resulted in more interference with pink salmon eggs by the later-spawning chums.

Within limits, low stream levels at spawning time are associated with high survival by eggs and fry (correlating r = 0.90). When water is low spawners are confined to the main channels where they are less subject to desiccation, freezing, etc.

The returns from a marking experiment carried out on chum salmon fry in 1948 are now complete and provide the first estimate of ocean survival for this species. The calculated return to fresh water is 2.6% of the fish going to sea.

It is frequently desirable to estimate the fry production in a stream without placing elaborate fixed equipment. To provide basic information for quantitative sampling various types of portable traps have been tried and the behaviour of the fry in their downstream migration has been examined. Sampling both pink and chum fry runs by traps and comparison with the total numbers of migrants as determined at the weir shows that individual trap catches accurately reflect variations in the abundance of the fry run but that the fraction of the run caught varies widely according to the position of the trap. Pink and chum fry migrate almost entirely at night. At Port John 50% of the nightly run occurred during the first two hours of darkness. The largest numbers of fry were caught in the fastest water.

Predation is a significant factor in reducing pink and chum fry runs. The sculpin is an important predator and the only important predator which is not of use. Its activities have been observed to see what control measures might prove feasible. At Port John many sculpins migrate downstream in spring and spawn in the intertidal area from late May to early July. An upstream migration begins soon after spawning. Apparently not all individuals take part in the spawning migration.

Nile Creek. In addition to the main fence at Nile Creek where both adults and fry may be enumerated there is a subsidiary fence to provide data on a special experimental area of the stream. The experimental area is a natural oxbow fitted with a water gate at its upper end. By its use water flow on the experimental areas may be controlled. The first experiments involved only holding water flows steady, eliminating winter floods. Latterly both the predator population and the gravel composition have been modified. Most of the work is carried out on chum salmon.

In 1952-53 the output of chum salmon fry was 6.4% of the eggs deposited in the unmodified part of the river and 21.5% in the controlled section. The difference was largely due to the suppression of predators in the controlled section since water flows were favourable in both spawning areas during the incubation period.

SOCKEYE SALMON - R.E. Foerster

A. Lakelse Lake. — M.P. Shepard and J.G. McDonald

I. Sockeye fry studies, Lakelse Lake. — J.G. McDonald

1. Production of sockeye fry at Scully Creek.
2. Predation on sockeye fry at Scully Creek.
3. Design and operation of a trap for estimating fry migrant populations.

II. Smolt studies. — R.E. Foerster

1. The natural propagation of sockeye salmon - to the seaward migrant stage - at Lakelse Lake, 1950-1952. — R.E. Foerster
2. Length and weight studies on sockeye smolts, 1952. — R.E. Foerster
3. Enumeration of seaward-migrating sockeye and coho smolts at the Lakelse River counting weir, 1953. — R.E. Foerster and M.P. Shepard
4. Sockeye fry marking, 1953. — J.G. McDonald and T.H. Bilton

III. Adult studies. — M.P. Shepard

1. An analysis of the age, size, and sex composition of the adult sockeye run to Lakelse Lake in 1952. — R.E. Foerster and D.R. Foskett
2. Adult escapement to Lakelse Lake in 1953. — M.P. Shepard
   (a) Composition of the run.
   (b) Injuries.
3. Distribution and survival of adult sockeye in Lakelse Lake. — M.P. Shepard
   (a) Lake mortality.
   (b) Injuries.
4. Adult studies at Williams Creek. — Dixon MacKinnon and M.P. Shepard
5. Williams Creek spawning ground surveys. — M.P. Shepard
   (a) Distribution.
   (b) Tagging studies.
6. Observations on spawning activity. — Dixon MacKinnon

IV. Limnology. — H. Godfrey

1. Lake levels and ice cover.
2. Lake temperatures.
3. Lake chemistry.
4. Plankton collections.
5. Attempts to capture lacustrine sockeye.
6. Plankton collections at Lakelse Lake, 1949-1952. — V.H. McMahon

V. Fish studies. M.P. Shepard and T.H. Bilton

1. Lakelse River fence lake fish count. M.P. Shepard
2. Gill-netting. T.H. Bilton
3. Trap-netting. M.P. Shepard
4. Distribution of lake fishes. M.P. Shepard and T.H. Bilton
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8. Creel census, 1953. T.H. Bilton
   (a) The catch.
   (b) Factors affecting the catch per hour.
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10. Comparison of length samples from three sampling methods. T.H. Bilton

B. Babine Lake. F.C. Withler

I. Adult studies. F.C. Withler and K.V. Aro

1. Enumeration of salmon at the Babine fence. K.V. Aro
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III. Fry production studies. F.C. Withler and E. Dombroski

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5. Weather and water conditions. E. Dombroski

C. Port John — J.G. Hunter

I. Adult sockeye salmon escapements, Port John, 1952.

II. Production of sockeye salmon fry at Port John in 1953.

III. Sockeye smolt production at Port John - 1953.

IV. Return of adult sockeye from a release of marked smolts in 1949.

D. Coastal Sampling Studies. — D.R. Foskett

I. Sockeye salmon catch sampling.

II. The Rivers Inlet sockeye run.

III. Changes in sockeye sampling technique.

SOCKEYE SALMON - R.E. Foerster

For the effective establishment of a sound management policy for the valuable sockeye salmon fisheries of the Pacific Coast of Canada there must be a clear understanding of the life-history of the fish, particularly of the early freshwater phases, and of the many factors causing mortality during the several stages of the life cycle, i.e., the egg, the fry, and the fingerling up to smolt stage. Whether the objective of management be (a) to maintain the stocks of sockeye salmon at their present level of abundance, (b) to increase them by improving natural conditions of survival, (c) to reduce, if possible, the prevailing fluctuations in abundance from year to year and thus tend to stabilize more effectively each season's catch or, finally, (d) to meet and guard against any effect of man-made interference to young sockeye salmon production resulting from the "march of progress", such as logging off of the forest cover, clearing of land for agriculture, building high dams for development of hydroelectric power, installation of irrigation projects, etc., these same basic facts of the early life-history must be known in order to determine what action must be taken.

Most of the factors potentially limiting freshwater survival of sockeye are known; the magnitudes of their effects are not. By carrying out the assessments of survival in different geographical locations where the limiting factors express themselves to varying degrees the effects may be more readily separated and their significance evaluated. Furthermore it is important that many of the studies be long range in scope. The variable pattern of salmon survival demands that work be well collaborated by repetition before the fundamental principles underlying freshwater management can be described with confidence.

The sockeye salmon investigation has, therefore, for a number of years been collecting life history information at three field stations, (1) at Port John, a small sockeye area in the central region of the B. C. coast, (2) at Lakelse Lake, a tributary of the lower Skeena River approximately 100 miles from Prince Rupert, and (3) at Babine Lake, the major sockeye-producing area of the Skeena system lying in the central plateau district of northern B. C. These three areas, located in quite different geographical and climatic regions, present a variety of conditions which it might take many years to encounter at a single station. Consequently a comparison of sockeye production in them from year to year should fairly quickly present the required broad picture of the production of young sockeye according to environmental conditions and at varying spawning population levels and reveal the importance of these varying factors.

As will be evident from the reports which follow, percentage production of young sockeye is determined by the number of seaward-migrating smolts produced from a known or estimated egg deposition at each of the three field stations. This figure represents the overall success of propagation under the environmental and climatic conditions prevailing and at the spawning intensity level represented by the spawning escapement of adults. It takes account of all the losses occurring between the time of the ascent of adults to the spawning grounds and the time of seaward migration of the one or two-year-old young. As far as possible these losses are broken down, at each field station, into narrower stages so that the mortalities within the various phases of the life-history can be segregated, the causative factors revealed, and the possibility of remedial measures assessed. The studies therefore include observations of adult spawning activity, survival during incubation of the egg and at the time of fry emergence and survival during migration of fry down the streams to the lake.

Survival of the young sockeye during their one or two years' residence in a lake is very important. Losses during lake residence are believed to be high and any means that can be devised to reduce this mortality will have a more or less direct effect on the abundance of adults. Therefore, at Lakelse Lake, basic research is being conducted to describe as accurately as possible the dynamic relation of the young sockeye to its environment for one lake. The study involves especially the relation of lake conditions, food supply, and populations of other fish in the lake, whether predators or competitors, to young sockeye well-being. The general principles elucidated at Lakelse Lake will no doubt be applicable to other areas.

Very little information is available pertaining to the mortality occurring during the up-river migration of sockeye and the sojourn in a lake (a matter of from one to three months) prior to movement on to the spawning grounds. Some mortality no doubt occurs. The extent of production of sockeye depends primarily upon the number of adult fish reaching the spawning grounds. If the actual spawning population represents a fraction only of the escapement past the commercial fishing areas it is desirable that the amount of this fraction be known. If the mortality during up-river migration be appreciable and an important drain on the spawning potential it should be recognized. Corrective measures may be feasible. Observations are being made at all three field stations to determine the actual condition of the arriving adults, assess the seriousness of injuries, etc., and ascertain what losses may occur between the counting weirs and the spawning grounds, i.e., to evaluate the lake mortality.

Associated with the sockeye salmon propagation studies has been, for a number of years, the sampling of the sockeye catches each season for the Nass River, Skeena River, Rivers Inlet and Smith Inlet fishing areas. An analysis of the samples provides information on the age, size and sex compositions of the runs from which the variations from year to year can be revealed. Where possible these are being correlated with Departmental spawning escapement records to reveal the causes of variation in abundance of year groups. At Rivers Inlet a special study has been made of the spawning escapements to determine the selective action of the gill-net fishery and its possible effect on seeding and on maintenance of principal age groups.

Reports indicate that good runs of sockeye salmon returned to British Columbia streams during 1953. Commercial catches were excellent. In the early part of the season the runs to the Skeena were light but subsequently improved appreciably. Due to a 10 day fishing closure in mid-season, when the outlook for a good spawning escapement was of some concern, an excellent run of sockeye to the Babine Lake area took place. No evidence of difficulty in ascending the Babine area through the cleared-out rock-slide area was found. An excellent seeding is therefore anticipated.

One perplexing problem associated with the sockeye salmon fishery has been the difficulty to predict the likely size of the populations coming in from the sea each season. Rough estimates have, in the past, been made on the basis of the spawning escapement in the preceding cycle year but are not too reliable because of the great range of mortality that can occur during the freshwater stages of the life-history. If a good estimate of the size of the seaward-migrating smolt population from a river system could be obtained a much more reliable indication of the likely return of adults would be possible. The Babine Lake smolt estimates may be particularly useful in this regard.

In association with the present investigations the feasibility of developing sampling techniques to obtain reliable estimates of fry and smolt migrations rather than have to rely on expensive and difficult-to-maintain counting weirs is being investigated. If successful results are obtained they may be applicable in a wider field and be of use in estimating the smolt migrations from major sockeye producing river systems, hence, of much value in forecasting the ocean returns in subsequent years.

In the reports which follow accounts are given of the progress made during 1953 in the various phases of the investigation. In some instances results obtained during 1952 are reported, either because the material collected in 1952 could not be analyzed until 1953 or because of the close association of the autumn, 1952, research with that of the spring operations of 1953. It should be pointed out that the Division of Experimental Biology, reporting elsewhere below, is expected to contribute valuable information in course of time on the limits of tolerance, etc. of various environmental factors - oxygen, temperature, etc. - for young sockeye. These findings will be directly applicable to field studies undertaken by the Sockeye Salmon Investigation.

A. Lakelse Lake.

M.P. Shepard and J.G McDonald

Research at Lakelse Lake has been directed primarily toward evaluating factors limiting the natural production of sockeye during the early life history phases. The emphasis of the 1953-54 program has been on the development, improvement and assessment of standard techniques for cataloguing the environment of the sockeye and enumerating the sockeye runs. In all phases critical studies were instigated or continued to assess the accuracy of sampling methods or to develop new descriptive techniques. Special studies were made on the effects of the fences on the timing and condition of the various runs.

Using the routine description of the dynamic ecology of the sockeye as a base line, the initiation of an active research program involving the manipulation of certain phases of the sockeye's environment is being planned for the 1954-55 season.

I. Sockeye fry studies, Lakelse Lake.

J.G. McDonald

The output of sockeye salmon fry from the spawning areas of Lakelse Lake is being measured as part of the general investigation into the freshwater life history of this salmon.

An assessment of this output is essential in order to (1) determine the loss in sockeye production occurring during the period spent in the spawning stream as adults, eggs and fry, and (2) provide knowledge of the number of young sockeye which each year utilize Lakelse Lake as a nursery area.

Since 1949 the operation of a suitable weir on Scully Creek, a small natural spawning creek flowing into Lakelse, has made possible a yearly enumeration of the ascending adult sockeye and their progeny descending to the lake as fry. The yearly or seasonal production of fry has been calculated from this information. Experiments were conducted to determine the factors affecting the survival of the young fish.

During the spring of this year a trap was designed and tested which should make possible an estimation of the fry output of Williams Creek, the main spawning stream of the area. This information together with that now available at Scully Creek will provide an assessment of over 90% of the total fry production of the Lakelse watershed.

1. Production of sockeye fry at Scully Creek.

As in past years, the percent of fry production has been calculated from a count of the number of fry resulting from a known potential egg deposition.

Both values were obtained by the operation of a weir through which all migrants, both adults and fry, were counted.

During August and September of 1952, 596 male and 507 female sockeye passed through the weir to spawn above. A representative number of females was sampled for egg content and a potential deposition of 2,053,000 was calculated (average egg content X number of females).

By the end of September, spawning was completed, and examination of over 10% of the females which had spawned showed an egg retention of 1.1%. Two females died without spawning and two had been killed by bear prior to depositing their eggs. The probable deposition was 2,014,000 eggs.

Of the potential deposition, 249,882 fry, or 12.2%, survived as fry to be counted at the weir.

Given below are pertinent data from which the production was calculated for 1952-53 and also for past years.

Year	Escapement			Potential deposition (eggs)	No. fry surviving	Per cent production
	Males	Females	Jacks			
1949-50	565	485	28	1,766,370	242,346	13.7
1950-51	195	146	121	377,775	35,129	9.3
1951-52	809	384	21	1,221,696	165,782	13.6
1952-53	556	507	40	2,053,350	249,882	12.2

Should the sockeye fry production measured at Scully Creek be fairly representative of the remainder of the Lakelse spawning area a severe loss in annual sockeye output occurs during the stream phase.

It has been found, during four consecutive years, that in this creek 9 to 14 of every 100 eggs carried into the spawning area by adult sockeye survive to enter the lake as fry. It is evident also that during this period production has been relatively stable. The higher production of 1950, 1952 and 1953 is associated with spawning escapement of 1000 or more, while the low production year of 1951 (9.3%) was the result of 341 four and five year old adults. This suggests that a minimum escapement of approximately 1000 is essential for optimum production.

2. Predation on sockeye fry at Scully Creek.

During their downstream migration sockeye fry are subject to predation by coho salmon smolts, cutthroat trout juveniles, dolly varden juveniles and sculpins.

Numbers of these predators are captured at the fry fence each year and the data collected have made possible an approximation of the degree of predation occurring upon sockeye by these fish.

Two methods, independent of each other, have been used to arrive at the percentage predation occurring each year. The first involves an estimate of the number of fry eaten as determined by the number of active predators, their average stomach contents and their digestive rate. The second method relies on the return of marked sockeye fry to indicate the survival of all fry migrants.

The number of coho, cutthroat and dolly varden recorded yearly is indicated by fence data and by the results of a marking program carried out in 1953 to represent almost completely the total number of these fish actively preying on fry. Sculpins are less definite in their movements and the return of marked individuals suggests that one third of the population is represented by the fence count.

Table I. No. of fish preying on sockeye migrants.

Year	Coho smolts	Cutthroat and dolly varden	Sculpins*
1950	1445	612	1197
1951	2179	423	705
1952	4146	292	1197
1953	9771	404	609

* Estimated.

The average stomach content of a representative number of all predator species has been determined for periods within the time of fry migration since 1951. Tests made on coho smolts indicated that approximately two days are required for digestion of sockeye fry. This information has been used to determine the total number of sockeye fry eaten by predators each year. The results are approximations only as sampling carried out at the counting fence may not be completely representative of actual stream conditions and also the digestion rates found for coho smolts may not apply to all species. However, the figures obtained will indicate the magnitude of the loss sustained by sockeye fry at this stage and when applied to data available on egg deposition and fry survivors may be used to evaluate the loss of eggs during incubation (Table II).

The marking, release and recapture of sockeye fry has been carried out each year during periods throughout the fry migrations. From the per cent returns of these marked fish minimum and maximum values of loss due to predation have been determined. The method used to calculate these per cent losses was outlined last year. These values are summarized in Table II.

Table II. Losses in production of sockeye fry.

Year	Percent loss by predation: From fry marking Min.	Max.	From predator data	Per cent loss in redds
1949-50	43	86	63	63
1950-51	68	91	84	40
1951-52	32	79	76	43
1952-53	71	81	85	64

The values obtained through the use of the two methods are in agreement. In all four years the percent predation as determined from predator population data and stomach analysis falls within the range of values resulting from the return of marked sockeye fry.

Accepting the figures on percent loss from predator data, the percent loss between egg deposition and emergence of fry can be calculated directly. This additional loss probably occurred while the eggs were in the redds. In Table II the estimated percent losses of eggs in the redds during the four year period are listed.

Considering all the available data, loss of fry to predators is an important factor in the mortality of sockeye in the creeks.

3. Design and operation of a trap for estimating fry migrant populations.

As Williams Creek is the major spawning stream at Lakelse it is most desirable to measure the production of fry in this creek. To make this possible both the escapement and the number of fry resulting must be known. The former (adult count) is being carried out at present, the latter has not been possible by use of conventional methods.

During the spring of this year a fry trap was designed to fill these requirements:

(a) No decrease in the rate of flow of water through the trap, to help insure representative sampling of migrants.

(b) Straining efficiency constant.

(c) No deleterious effect on fry captured.

(d) Operation to require a minimum of attention.

(e) Simple and economical construction; portability.

The trap designed consisted of a 14 foot long straining funnel attached at the downstream end. The funnel or lead had a 1' x 3' opening, tapering down to 2" x 4" at the end of its length and consisted of a 2" x 2" wood frame covered with galvanized hardware cloth. The pen in which the fry collected was made of 1/4" plywood with a galvanized screen bottom. Cedar blocks provided the necessary buoyancy. Approximate weight of the trap was 75 pounds. Total straining area was 55 square feet.

Three such traps were operated in the main channel of Williams Creek which discharges normally 400 cu. ft./se. at a mean velocity of approximately 1.7 ft./sec. Spring freshets may cause great fluctuations in discharge.

Unfortunately the period of trial did not coincide with the main fry migration but took place at a slightly later date. However, enough fry were captured to indicate the effect of the trap on their well being.

In only two tests did any mortality or injury to fry occur. In these instances debris blocked the funnel of one trap and caused almost 100% mortality. The addition of a wire rack at the mouth of the traps prevented recurrence of this event.

No noticeable decrease in flow of the water in the trap was evident.

Attention was required only once a day. Cleaning of the pen was necessary at daily intervals when freshet conditions prevailed. The lead where roughly 95% of the water entering the trap is strained out required no cleaning throughout the test period.

The tests suggest that through the use of this trap an estimate of the fry output of Williams Creek is feasible.

R.E. Foerster

II. Smolt studies.

The enumeration of sockeye smolts as they migrate downstream from Lakelse Lake makes possible a calculation of the percentage production of sockeye from the known or calculated egg deposition in the brood year. A complete count is made at the Lakelse River counting weir each season. Since more than one age group may be included in any season's migration an age analysis of an appropriate sample of the run must be made. Furthermore, in order to assess the influence of lake-population density on the young sockeye as well as the effect of abundance of food and other environmental factors on growth and development, length and weight data are collected, also, from the sample.

1. The natural propagation of sockeye salmon - to the seaward migrant stage - at Lakelse Lake, 1950-1952.

R.E. Foerster

In 1952 a seaward migration of 595.741 sockeye smolts passed through the counting weir in the Lakelse River. Before any calculation could be made of the efficiency of smolt production it was necessary to learn, by ascertaining the age composition of the smolt run, the egg deposition from which they were produced.

During 1953 an age analysis of a sample of 1671 smolts was made. The occurrence on the scales of a rather unusual and not too definite narrowing of some of the circuli, which could or could not be considered a winter band depending upon one's interpretation, led to some disagreement as to the exact age but tentatively and until other contradictory evidence becomes available, this questionable winter band or check has been ignored. Length and weight frequency plots of the data indicated only two modes, for one and two year fish, respectively. On such basis the vast majority of the sample smolts (1649 out of 1671) were one-year-old fish. Most of the 22 two-year-smolts were encountered during the early part of the run.

Dividing the smolt run up into the two age classes in conformity with the age composition of the sample at different periods of the migration, the 600,000 migrant population (595,700 counted and 4300 in sample) is made up of 594,300 yearlings and 5700 two-year-olds. The yearlings are the product of the 1950 spawning in the Lakelse Lake area.

In 1950 the count of females through the Williams Creek weir was reported as 480. On the basis of an average egg content of 3800 per female, the presumed egg deposition in the spawning area amounted to 1,824,000. In the same year the egg deposition in Scully Creek was reported by Mr. McDonald to have been 375,000. For the Lakelse area therefore the total egg deposition in 1950 amounted to 2,199,000 of which the 1952 yearling smolt run would represent a production of 27.0%. However, as indicated below, the accuracy of the 1950 adult count appears to be questionable.

During the 1950 operations at Lakelse Lake, counting weirs were operated in the three outlets of Williams Creek into Lakelse Lake. The count of 480 females and 1026 males was the total for all three weirs. In 1952 the same three weirs were operated but when observations were made up Williams Creek to check on spawning activities, etc., it was immediately evident that there were many more sockeye present than had gone through the weirs. Investigation disclosed that a new channel had broken through some distance up-river and was diverting off Williams Creek water into Lakelse Lake through Blackwater Creek, heretofore a small stream draining marsh area adjacent to the lake.

Since there is no record of observations being made in Williams Creek in 1950 whereby the presence of more sockeye than accounted for by the weir tallies would be noticed, it cannot with confidence be said that some escapement of sockeye up the Blackwater diversion and into the Williams Creek spawning areas could not have taken place in 1950. It is the opinion of the resident Fisheries Officer that the Blackwater break-through probably occurred during a late-autumn freshet period in 1951 but it is possible that an extra flow of water through Blackwater Creek, up which sockeye could ascend to Williams Creek, as in 1952, would not have been observed.

Therefore, to make due allowance for the possible escape of spawners to the Williams Creek area via the Blackwater diversion, the weir count, 480 females, has been multiplied by a factor, 3.66, which represents the increase in the estimated spawning population of 1952 (10,200) over the weir count (2791) and gives what might be considered a maximum number of 1750 females, and a presumed natural deposition of approximately 6,597,000 eggs. This, together with the presumed deposition of 375,000 eggs in Scully Creek, indicates a total of around 7,000,000 eggs deposited in the Lakelse area. From this deposition the run of 594,300 yearling smolts would represent a production of 8.5%.

Tentatively, then, and on the assumption that the bulk of the migrants were yearlings, the 1952 smolt run represents a production of from 8.5 to 27.0% of the egg deposition in 1950 in Williams and Scully Creeks. Even the lower figure, 8.5%, is very high, having regard to past recorded smolt production estimates at Lakelse (1 to 2%). Future years' data will be examined with particular interest. It may be pointed out that in 1950 the Lakelse River adult sockeye counting weir was not in operation, hence could not serve as a check on other escapement counts.

2. <u>Length and weight studies on sockeye smolts, 1952.</u> R.E. Foerster

During 1953 an analysis was made of the length and weight features of the yearling sockeye migrating seaward from Lakelse Lake in the spring of 1952. The following data were obtained:

	Number of smolts	Average length in cm.	Average weight in. gr.
Both sexes	1644	8.18	5.53
Males	866	8.17	5.46
Females	778	8.20	5.60

In order to demonstrate any size trend during the period of migration, average lengths were computed for specific samples taken during the runs. The results, both sexes combined, were:

Period	May 13-17	18-21	22-25	26-30	May 31-June 3	June 3-July 14
No. in sample	338	228	330	319	327	106
Average length, cm.	8.34	8.23	8.02	8.05	8.20	8.42
Average weight, gr.	5.67	5.58	5.09	5.33	5.96	6.6

A decrease in size as the migration progressed and as the peak period approached is apparent. Thereafter an increase again in size is indicated.

The few (17) two-year-old migrants for which data are available showed a length range of from 9.6 cm. to 12.5 cm., with a mean of 11.3 cm. and a weight range of from 8.7 to 20.0 gr., with a mean of 13.56 gr.

3. Enumeration of seaward-migrating sockeye and coho smolts at the Lakelse River counting weir, 1953.

R.E. Foerster and M.P. Shepard

During the spring of 1953 the second counting of sockeye smolts produced in Lakelse Lake and migrating seaward was undertaken. The weir was put into operation March 19 and on April 19, nine days after the ice-cover left the lake, the first smolt appeared. The migration rather quickly built up to a peak of 45,634 on May 8, declined to 5,118 on May 16, then rose to a second peak of 25,732 on May 28, and thereafter gradually fell off daily. The last sockeye was taken July 11. The total run amounted to 394,208 smolts plus a 1% sample, preserved for age, sex and size analysis, or approximately 398,000 smolts.

A comparison of the migrations of 1952 and 1953 is of interest:

	1952	1953
Break-up of ice cover	May 1	Apr 10
First migrant appeared	May 11	Apr 19
First and main peak daily run	May 21	May 8
Number of smolts involved	88,891	45,634
Secondary peak daily run	Jun 1	May 28
Number of smolts involved	28,966	25,732
Last migrant	Aug	Jul 11
Total migration	600,000	398,000

Detailed studies were made on the effects of fence operation on the migrating smolts. The immediate mortality caused by the fence was considerably less in 1953 than in 1952 (1.6% in 1953 compared to a rough estimate of from 4-6% in 1952). Very few fish were caught on the screens in 1953 (only 0.45% of the run). Examination of migrating fish revealed that passage of fish into the pens occasioned the loss of a small number of scales on some of the fish (about 20% of the run) and a serious loss of scales in some 5% of the fish. When representative samples of fish that had passed through the fence were placed in live pens very little mortality occurred (6% as a maximum), even after two months of retention. Thus the slight damage to the fish inflicted by the fence did not appear to cause any immediate mortality. On the basis of information obtained remedial modifications have been incorporated into the fence in preparation for the 1954 smolt run. Delay, splitting of schools and disruption of migratory pattern associated with fence operation are probably deleterious to the smolts (e.g., they are probably more vulnerable to predators immediately after passing through the fence). In designing the fence operation for 1954 attempts will be made to minimize this disruption of migration.

In order to confirm the interpretation of scale markings - annual winter bands in particular - in age reading, 5,418 sockeye fry were marked at Scully Creek in 1952 and released into Lakelse Lake. In 1953 approximately 110,500 smolts were examined for missing fins (both pelvic fins off). Only two were taken that bore genuine marks but five others were observed with one or both fins abnormally developed, perhaps the result of marking.

Determination of the percentage production of seaward-migrating smolts in 1953 from the brood year egg deposition must await analysis of the 1% sample for age composition.

A seaward migration of young coho salmon, chiefly one-year-old fish, takes place at the same time as the downstream movement of young sockeye. In 1953 the first coho was observed on April 25, the bulk of the run occurred during the last week of May and the first week of June and the last cohos were recorded on July 11. The total count was 128,113. Mortality consisted of 312 fish or 0.24% of total coho smolts.

4. <u>Sockeye fry marking, 1953.</u> J.G. McDonald and T.H. Bilton

During April and May of this year 11,253 sockeye fry captured at the Scully weir were marked by the removal of the left pelvic fin and released to the lake.

A check will be made of the 1954 seaward migrants for the fish marked. Those recaptured should provide a firm basis for the determination of the age classes of these migrants through a comparison of scale patterns between marked and unmarked fish.

M.P. Shepard

III. <u>Adult studies</u>

Enumerations of the size and composition of adult sockeye runs at Lakelse have been carried out annually. In the past, determination of the number of eggs deposited by the adults has been the primary aim of this program. Additional studies are now being carried out or are projected to determine what factors limit the deposition of eggs. The mortality of adults in fresh water prior to spawning has become a major part of the work. Studies on the spawning behaviour of the salmon have been instituted to determine, among other things, the minimum proportion of spawning males required to fertilize effectively the eggs of the females present.

An intensive study of the effects of the fences on the condition and pattern of the sockeye runs have been carried out. Such projects are necessary to separate artificial effects from natural trends.

The estimation of the size of spawning populations received considerable attention. It is hoped that when data from streams of various sizes are collected a workable method of visually estimating the size of spawning populations may be formulated. Such a method would be of considerable use to the Department of Fisheries officers in their annual surveys of salmon spawning grounds.

As more information is collected it is becoming increasingly apparent that a large segment of the adult salmon population entering fresh water does not contribute to the deposition and fertilization of eggs. Jack males, injured fish, late-run fish and possibly surplus males on the spawning grounds, appear to contribute few participants in the actual spawning. These observations suggest that a considerable segment of the sockeye escapement to fresh water could be utilized by the fishing industry without seriously affecting seeding.

1. <u>An analysis of the age, size and sex composition of the adult sockeye run to Lakelse Lake in 1952.</u> R.E. Foerster and D.R. Foskett

During the upstream migration of adult salmon to Lakelse Lake in 1952 approximately 10% of the fish were examined for sex and length and scale samples were taken for age determinations. Mr. Foskett made the age analysis. The results, the first available for the Lakelse Lake population of adult sockeye, are as follows.

Table I.

Age group	Sex	Nos. in samples	Length range	Mean length (inches)
3_2	Male	4	13.00-15.00	14.00
4_2	Male	39	17.75-25.25	20.75
	Female	67	18.50-26.50	21.50
5_2	Male	394	22.50-29.00	27.00
	Female	365	21.00-28.00	24.75
6_2	Female	2	24.75-25.25	25.00
6_3	Male	29	23.75-28.50	26.25
	Female	24	23.00-27.75	25.00

The high proportion of five-year fish (82%) was somewhat unexpected. The absence of 5_3 adults in the sample was also of special interest. The trends in the age classes in this discrete population will be followed with much interest, particularly when, in 1954 and thereafter, it will be possible to associate the adult return with known smolt migrations.

2. <u>Adult escapement to Lakelse Lake in 1953.</u> M.P. Shepard

(a) Composition of the run. The run of adult sockeye passing upstream through the Lakelse River fence tended to be divided in two parts. First, a concentration of fish, comprising the majority of the run, 95% of which passed through the fence between June 14 and July 10, and secondly, a smaller, more protracted run beginning near the end of July and continuing in small numbers through September. As the figures for the late run are not complete at the time of writing, this report is restricted to data collected during the early part of the run. The weekly totals of fish moving through the fence are listed in Table II.

Table II. Weekly totals of adult sockeye at the Lakelse River adult fence.

Week ending	No. fish	Percent males in run	Percent slight inj.	Percent ser. inj.	All inj.
Jun 12	106				
19	2643	67	24	4	28
26	3970	62	21	8	29
Jul 3	3754	43	12	7	19
10	548	32	11	7	18
17	232	-	15	6	21
24	75	-	-	-	-

Male fish predominated in the early part of the run whereas females were more frequently observed in the latter part. The proportions of males for each week during the run are listed in Table II. Recapture of fish tagged at the Lakelse River fence on the spawning grounds showed that workers at the River fence erred in the determination of the sex of the migrants in 17% of the cases. The most common error was in mistaking males for females. The immature condition of the fish made identification of the sex of the fish difficult. Correcting for the error the estimated percent of males for the entire early run was 59%.

Scale reading showed that the 1952 adult run consisted mainly of fish in their fifth year (5_2's). Preliminary analysis of length frequency data indicates the fifth year fish again predominated in 1953.

There was some indication that fish captured in the sampling pens were not truly representative of the fish in the run. The number of injured fish moving into these pens was significantly higher than the number of injured fish passed through the panels. There was also a tendency for more smaller fish to enter the pens than passed through the fence as a whole.

(b) Injuries. The presence of injured fish in the run was the subject of close observation during the run. The number of fish bearing some injury varied throughout the run. There was a tendency for the proportion of injuries to drop as the run progressed. The average weekly counts of injuries divided into slight injuries (i.e., slight laceration of snout, evident scale loss, slightly frayed fins) and serious injuries (open lesions, fungused wounds, and badly frayed fins) are listed in Table II.

The proportion of injured fish in the run also varied with trends in the daily count. An increase in the daily run was usually accompanied by a decrease in the proportion of injuries, while a decrease in the daily run was associated with an increase in the relative number of injuries. In Table III the trends in daily run and in the proportion of injuries are compared for the most intensive part of the run (June 18 to July 10). The pattern of the run suggests that the salmon moved up the river in groups. On reaching the fence fish bearing injuries or fish injured at the fence tended to be delayed more than uninjured fish. This suggestion is strengthened by the observation that groups of fish lying below the fence contained significantly more injured fish than groups of fish comprising the run through the fence.

Table III. Relation of injuries to trends in daily runs.

Trend of run	Trend of injuries Increase (no. cases)	Decrease (no. cases)
Increase	1	6
Decrease	11	3

The cause of many injuries could not be ascertained with certainty. Abrasion to the snouts of fish (occurring in approximately 8% of the run and amounting to about 33% of the injured fish) was often caused by fish "burrowing" against the metal screens. Detailed observations on the behaviour of the fish and experiments involving holding of fish behind the fence were conducted to establish this point. The cause of such injuries as open lesions, damage to the head, fraying and fungusing of fins could not be determined.

Experiments wherein fish trapped at the fence were tagged and returned downstream indicated that fish were delayed longer before and after the peak of the run than during the peak. The delay imposed on tagged fish varied from 1 to 4 days during the major portion of the run to 1 to 30 days before and after the peak. In most experiments between 80 and 90% of the tagged fish returned to the fence. The data also showed that the longer the fish delayed their return to the fence, the more frequently the returning fish bore injuries. In some cases fish released in good condition had serious body lesions and similar injuries when they were observed returning to the fence.

In general the data suggest that the fence causes little delay in the up-stream movement of adult sockeye during the major part of the run. At the beginning and toward the end of the run the up-stream movement may be retarded. Injured fish tended to be delayed longer than uninjured fish. In turn, delay seemed to increase the occurrence of injuries among the fish.

Throughout the run conscientious attempts were made to pass the fish through the fence as rapidly as possible. During the major part of the run a 24-hour watch was maintained, fish being released hourly.

3. Distribution and survival of adult sockeye in Lakelse Lake.

M.P. Shepard

(a) Lake mortality. Following passage through the Lakelse River fence, the adults spend, on the average, about 54 days in the lake before ascending the spawning stream. During this period a number of fish die; in 1952 it was estimated that some 33% of the run (about 6,000 fish) died after entering the lake. In 1953 fence counts at Williams and Scully Creek and estimates of the numbers of fish present in other spawning areas indicate that almost 80% of the adult migrants survived to reach the spawning streams. After the majority of the run had reached the lake, floating dead fish were observed in the lake. During July a total of 78 dead fish were found in the course of daily surveys of the lake. In 1952 it was estimated that for every dead fish seen approximately 37 dead were present. On this basis it might be expected that roughly 3,000 fish had died in 1953. This figure is similar in magnitude to the estimated number of fish missing between the Lakelse River and the spawning stream (about 2,500 fish). Thus it is likely that about 20% of the run to Lakelse in 1953 died before reaching the spawning grounds. The data on survival are summarized in Table IV.

Table IV. Distribution of adult run in Lakelse Lake.

	No. fish	No. red tags	No. white tags
Lakelse River*	11,815	285	42
Spawning grounds			
Williams Creek	8,068	151	30
Scully Creek	627	10	1
Other**	600	11	2
Total	9,295	172	33
Missing	2,520	113	9

* Count to Aug. 1, (approx. 50 days before termination of Williams Creek count).
** Estimates of spawners in other creeks and in Williams and Scully Creek mouths.

The results of tagging experiments indicate that the handling involved in measuring the length, weight and taking a scale sample inflicted an added mortality on the tagged fish. While almost 80% of the total run could be accounted for by spawning stream counts, only 60% of the tags reached the spawning grounds. To provide a control 42 fish were tagged (called white tags in table IV) as innocuously as possible; scale sampling and weighing were not carried out. Returns from this tagging showed that almost 80% (the same percentage return observed in the total run) of the tags were accounted for. Thus handling involved in obtaining weights and scale samples are deleterious to the survival of the fish.

(b) Injuries. Examination of fish in various stages of migration was made to assess the effect of injury on survival. There was no clear cut pattern to the survival of various types of injured fish. Many of the slight abrasions to the snout observed at the Lakelse River fence appeared to have healed before the fish reached the spawning grounds. Many of the other slight injuries apparently had healed while others had become infected and developed into serious injuries. The large percentage of injuries observed on fish found dead in the lake indicates that many of the injured fish had died. The injury data are summarized in Table V. Next year a number of injured fish will be tagged at the Lakelse River fence to give more exact information on the fate of this segment of the population.

Table V. Comparison of injured fish at three locations.

	Percentage of fish examined						
	Slight nose injury	Other slight injury	Total slight injury	Serious injury	Total injury	Uninjured	Total examined
Lakelse River	7.9	8.1	16.0	7.2	23.2	76.7	10,634
Dead on lake	-	-	30.4	63.1	93.1	6.5	46
Williams Creek	1.8	5.6	7.4	5.1	12.5	87.4	7,763

4. Adult studies at Williams Creek. Dixon MacKinnon and M.P. Shepard

The Williams Creek fence is a major tool in the study of adult sockeye in Lakelse Lake. Between 80 and 95% of the sockeye spawning population of Lakelse Lake are passed through this fence. By enumeration and observation information is gained on the size of the seeding population, sex ratio, lake mortality and incidence of injured fish. Inspecting the gonads of samples of live fish passing upstream through the fence and of dead fish drifting downstream on to the fence provides an appraisal of the size and success of deposition. Length samples of both live unspawned fish and dead "spawned out" fish provide clues to the age composition of the run. These length frequencies when compared to length frequencies obtained by sampling the run at an earlier stage in their spawning migration should point out whether one size of fish successfully reaches the spawning stream and another size does not. Trends in lengths are also revealed by comparing lengths from year to year. Recapture of fish which have been tagged while entering the lake through the river fence allows appraisal of the length of time the sockeye spend in the lake. These data also provide information on the fate of individual fish whose characteristics (injuries, size, etc.) were recorded at an earlier stage. Tagging fish at the Williams Creek fence followed by stream surveys gives a method of checking the dynamic distribution of the run in spawning areas of the creek. Recovery of these tags on dead fish tells how long these fish have spent in the spawning stream.

Conditions for carrying out the above studies were very favourable this year. Only during a small part of the run was the water sufficiently high in glacial silt to suspend observations. Consequently nearly 100% of the run was examined for sex ratio, injuries, and tags. The Blackwater diversion that detracted from last year's program was successfully blocked and all sockeye spawning in Williams Creek went by way of the main channels.

Early in the run it was discovered that fish would move up to the fence and after making several unsuccessful attempts to get through would on some occasions return to the lake for as long as a full day. This was especially evident at night when fish that were at the fence and even in the pens at midnight would not be there on the following morning. It was also found that handling a fish or the web of a dip-net then returning it to the water would introduce sufficient repellent odour to the water to "scare" the fish back into the lake. With this knowledge it was possible to modify techniques in such a manner that whenever possible fish were rapidly passed through the fence at whatever time they reached the fence. Rubber gloves were worn when inspecting tagged fish. Tagging and sampling utilized fish that had accumulated in the pen and was carried out after the main body of the daily run had been passed through. In this way it is felt that the fish moved upstream at their own intrinsically dictated time with no appreciable delay from the fence. It is felt that this would in turn allow normal distribution on the spawning stream.

Two sources of error arose as a result of failures in the fence. In one case a small panel of pickets was raised for an unknown period during one morning. Observations indicated that from 50 to 200 fish passed through this opening. The other source of error arose as a result of a few too-widely spaced pickets. It is believed that a fraction of the fish under 56 cm. passed through unobserved. By knowing the size composition of the fish on the spawning stream and being familiar with the operation of the fence it is possible to estimate 200 to 400 small fish passed through unaccounted for. The sex ratio of the fish moving upstream on the day of the first source of error would weight the estimate in favour of males while the size of fish in the second source of error would weight it in favour of females. Thus for the present it will be assumed that 200 sockeye of each sex passed through the fence unrecorded.

The total number of fish spawning in Williams Creek then was 8,508 (8,058 counted, 400 estimated unobserved and 50 estimated in the stream below the fence). The sex ratio of the total run was almost exactly 1:1. The first fish went through the fence August 3 and for a week the sex ratio was predominately male. The sex ratio changed to a female predominance in the second week and continued this way until August 29 when the main body of the run was through.

The average egg content of these sockeye was 4,183 giving a maximum deposition of 17,765,201 eggs. Examination of the ovaries of "spent" fish shows that the egg retention was nearly negligible. Examination of the testes of dead males revealed that approximately 20% of the sample retained approximately 25% of their milt or more. Incidence of fish of either sex dying unspawned was rare.

Length frequency distributions of dead fish washed down on the fence suggest the presence of three age groups. This evidence is present chiefly in the length frequencies of the male fish and shows the three groups dispersed about modes of 52 cm., 61 cm. and 71 cm. If these fish were considered to be 3, 4 and 5 years old the age composition would be approximately 10, 25, and 65% respectively.

Comparison of length frequency of live fish trapped in the pen and dead fish washed down on the fence shows that a larger percentage of small fish (under 56 cm.) were present on the spawning ground than were recorded through the fence pen (14.2%:9%). This discrepancy may have been caused by small fish getting through the pickets or by the pen capturing an unrepresentative sample. Both possibilities have evidence to support them. In the first case it was found possible to push a 53 cm. fish through one of the gaps in the pickets; in the second case sex ratio data show that the pen does not capture a representative sample.

Tag recoveries of live fish at the fence showed that the fish spent an average of 54 days in the lake (range 42-69). The data also pointed out a 17% inaccuracy of sexing at the river fence. The minor injuries of tagged fish recorded at the river fence when compared with the minor injuries observed at the Williams Creek fence show a large discrepancy. Two possible explanations exist - the injuries may have healed during the lake residence or the criterion for a minor injury may have been different at the two locations. Interpretation becomes more difficult in the light of bad injuries. One bad injury recorded at the river apparently healed by the time the fish reached Williams Creek while another fish uninjured at the river fence had a bad injury recorded at Williams Creek. A third fish showed that a slight injury at the river had increased to a bad injury at Williams Creek.

Tag recoveries of fish spawned out and dead on the fence show that both male and female live approximately 15 days in the spawning stream.

The above report is a result of preliminary analysis. The complete report and original data will be available in our files.

5. <u>Williams Creek spawning ground surveys</u>.   M.P. Shepard

Spawning ground surveys and tagging were conducted to gain information on the distribution of the spawning sockeye in Williams Creek and to develop methods of estimating the size of spawning populations. A complete map of the Williams Creek area is being prepared. An engineering survey was conducted to give accurate information on stream dimensions.

(a) Distribution. In 1952 an estimated two thirds of the adult sockeye run to Williams Creek moved to the spawning grounds through an unfenced and previously unknown channel (the Blackwater diversion) of Williams Creek. As part of a stream improvement program the Department of Fisheries cut off this by-pass, increasing the flow of water down the main channels of Williams Creek. A marked change in the distribution of spawners resulted from this change in topography. In 1952, it was estimated that 67% of the spawners were present in the area upstream from the Blackwater diversion. In 1953 this percentage dropped by a third to 43%. It would appear that the majority of those fish passing through the diversion in 1952 moved to the area of the creek upstream from the diversion. The lower spawning stretches were sparsely populated in 1952, while the upper area, having a much lower gravel area was densely packed. Movement of the entire run through the main channel in 1953 resulted in more uniform distribution of fish throughout the spawning reaches of the creek.

The distribution of adults varied throughout the season. At the beginning of the run the fish tended to be most concentrated in the lower reaches of the stream, whereas during the peak of the run the maximum concentration of fish was in the up-stream regions. Near the end of the run, when spawned out fish tended to drift downstream, an increase in the downstream concentration was noted. The relative changes in distribution are not great, indicating that the tendency for fish arriving during any period of the run to spawn in any particular location is not great. The relative distribution of adults as determined by creek surveys is summarized in Table VI.

Table VI.

Date	Run to date	Percent of run	
		Downstream region	Upstream region
Aug 10	2934	46.5	52.5
17	6640	41.0	59.0
26	7711	42.0	58.0
Sep 3	7828	52.4	47.6

Knowledge of distribution of spawners is being utilized by Mr. McDonald in connection with stream survival studies.

(b) Tagging studies. Tagging experiments were conducted in an attempt to estimate the size of the spawning population of Williams Creek independently from the fence count. A critical analysis of methods disclosed a number of sources of error.

Changes in the turbidity of the water influenced the number of fish seen by observers. It was estimated that on the clearest day very careful counts accounted for about 95% of the run, whereas on other days when the water was only slightly more turbid as few as 65% of the fish present were counted.

Tagged fish are not easily separated from untagged individuals. Comparisons between the percentage of tags known to be present in the run and the percentage noted in stream surveys indicated that even at best only about 60% of the expected number of tags were observed. No doubt loss of tags could account for some of this discrepancy. However, the main reason for the discrepancy was the inability of observers to spot tagged fish in turbulent water and pools. Five different types of tags were used, differing in colour and location. White tags located on the caudal peduncle or immediately posterior to the head were most apparent. The ability of observers to see coloured tags was poor. An estimate of the total run of sockeye to Williams was made, correcting for differential visibility of tags and variations in general visibility. The computed number of fish was 8,100, very close in magnitude to the actual run of about 8,500 fish. This result suggests that the method used for estimating the spawning population is sound and that the 1952 estimate computed in a similar manner (see earlier section on lake survival of sockeye) was probably quite accurate.

6. Observations on spawning activity. Dixon MacKinnon

A 360 square yard section of Williams Creek was chosen for preliminary observations of sockeye spawning. The activities of the fish in this section were followed intermittently during the main period of spawning in Williams Creek. At the peak of the spawning 103 females and 109 males occupied this territory. At this time vigorous defence of territory prevented new spawners from digging redds. These fish were chased in all directions; some passed through to an upstream pool while others were forced back downstream. It seemed then that in this case the maximum utilization of spawning ground was 1 pair to approximately 3.5 sq. yards of gravel. This was further evident after completion of spawning when the females stationed over their completed redds were most vigorous in their defence of territory. New unspawned fish attempting to start a redd were attacked by at least 2 and often 4 females. Males at this time took no active role in territory defence but gathered in groups of from 3 to 10 fish generally downstream from the females. Although none was seen to leave the area a count at one stage showed 79 females and 41 males suggesting that after spawning the males either died more rapidly than the females or moved out of the area.

Observations during spawning activity showed that a typical spawning unit consisted of one female and two males. One male was permanent and attended the female in the redd at most times while the other remained downstream from the redd and would dart into the redd with the spawning pair following a digging or quivering motion in the centre of the redd. This "substitute" male would also move into the redd with the female when the "permanent" was absent on a "chase" and would leave without being chased when the permanent male returned. Competition between males was still vigorous yet this substitute male was accepted by both male and female in this role. It must be pointed out that this activity occurred despite the 1:1 sex ratio in the area. The fact that all females were not in the same stage of spawning activity meant that some males were free to act as substitute males. In many cases where no free males were present the male in the adjacent redd would leave its female and act as a substitute. In these cases it seemed necessary for the stimulus from a digging or quivering motion to bring the substitute out of its own redd.

Occasional observations at night showed that a different behaviour pattern existed. The extreme activity associated with territory defence was absent and the male and female were close together and generally touching each other in the bottom of the redd. Digging seemed confined to the anterior portion of the redd. Two nights out of three the substitute male was present downstream from the redd. Although no deposition of sex products was observed it is suspected that most spawning occurs at night.

A full scale study of spawning activity is planned for next year. special emphasis will be placed on the role of the male. The same section of spawning ground will be followed from the time the first fish begins spawning until the last fish dies. To supplement this, experiments are planned in which fish will be allowed to spawn in captivity. By variation of the sex ratio it is felt that some information on the optimum sex ratio for efficient spawning will result. To this end a small scale experiment was carried out in which three pink salmon of each sex were confined in a 9' x 9' area on the floor of the river fence. This area was supplied with an 8 inch thickness of gravel and water flowed over it to a depth of from 5 to 11 inches. The main results were:

(a) One male was aggressive and was apparently attending all three females (one of the 3 males died shortly after being placed in the pen).

(b) Each female dug several small redds.

(c) These excavations were covered during the night.

(d) The three females spawned completely and died, while one of the two males died unspawned and the other died half spawned.

(e) The fish were in the pen three days before territorial behaviour was evident, 5 days before digging commenced and 13 days before the first fish died. The average length of life after territorial behaviour began was 15 days.

At this time no information of the extent of fertilization is available. Redd samples will be taken by J.G. McDonald when the eggs have reached the eyed stage.

H. Godfrey

IV. Limnology.

Since young sockeye spend at least a year in lakes before they migrate to the sea as smolts, it is pertinent to know the trophic status of a sockeye-producing lake, and its capacity to support a population of these fish; and to determine how the properties of the lake govern or affect their growth and survival. These are the broad objectives of the program; and as such they call for the cataloguing of certain characteristics of the lake (by season and from year to year), and for a knowledge of the activities of the young sockeye within the lake.

The program involves recording of meteorological data, lake levels, air and water temperatures, chemical contents of lake and stream waters (oxygen, phosphate and nitrate-nitrogen), and the abundance of plankton in the lake. In addition attempts have been made to capture young sockeye in the lake.

During the past several years the limnological program at Lakelse Lake has been conducted by Mr. V.H. McMahon, who resigned from the Station this spring. The work was continued during the past summer, through the routine collection of limnological data, by Mr. T. Mitchell, a medical student who has been one of the Lakelse field party for the past three seasons. The writer spent six weeks at Lakelse, during August and September of this year, to become familiar with the present objectives and methods, with a view to designing an effective limnological program for 1954.

1. Lake levels and ice cover.

The times of the break-up of the ice cover in 1952 and 1953, and of the first appearance at the Lakelse River fence of migrating smolts in those years, have been compared in a preceding report.

In 1952 extreme fluctuations in lake and river levels were coincident with marked differences in the daily number of migrating smolts. In 1953, on

Other notations made during each survey concerned water conditions, number of predators, and the number of dead unspawned sockeye.

A detailed analysis of the data collected during stream surveys is to be made this winter. However, a cursory review shows that:

(a) the majority of the sockeye travelled up the stream until stopped by an impassible barrier,

(b) the majority of the early arrivals spawned at the upper end of the stream, while succeeding spawners took up positions successively closer to the weir,

(c) approximately 92% of the dead females were recovered and examined for egg retention. An estimated 1.5% of the females examined had died unspawned,

(d) approximately 85% of the tagged sockeye were recovered,

(e) adequate water conditions prevailed while spawners were in the stream.

E. Dombroski

4. Egg and fry survival studies.

The first sockeye spawned within 5 days from the time of the run's entry into the stream. The peak of spawning occurred within a period of 18 days, while the total spawning duration was 43 days.

Sockeye egg deposition was approximately 4,200,000. A number of redds will be sampled this fall to determine egg survival to the pre-eyed stage of development. It is proposed that other redds will be sampled sometime during the winter and early spring in order to estimate the egg survival to the eyed and alevin stage.

A spring fry count is contemplated in 1954 to establish the survival figure from the egg to fry stage.

Sockeye spawned successfully in wire-meshed pens installed in the stream. Observations were made whenever possible. The spawn within the pens is to be examined at a later date.

Kokanee were also retained in a pen in which they successfully spawned. It is hoped that some information may be obtained upon the relative sizes of kokanee and sockeye fry.

E. Dombroski

5. Weather and water conditions.

Daily weather conditions were recorded throughout the sockeye run. Constant water levels and water temperatures were taken by a recording thermograph during the fence operation, and will be continued throughout the coming winter.

J.G. Hunter

C. Port John

While in the Port John experimental area the determinations of egg deposition, fry survival and smolt production are made, as at Lakelse and Babine lakes, there is the added advantage that, since the bulk of the spawning and egg deposition occurs in one tributary stream, Tally Creek, there can be obtained a reasonably accurate record of the smolt production from a known fry survival. There can thus be obtained a good determination of the mortality in Port John Lake from the fry to the smolt stages. Results already obtained and reported of studies made on Port John Lake have indicated that the lake may be, on the one hand, poor in plankton food for young sockeye, yet, on the other hand, contains only a small population of predator fishes. These factors have an important influence on the well-being and the survival of the sockeye during their lake-resident period.

Furthermore the marking of young migratory sockeye has provided valuable data on the percentage return of adult sockeye from the sea to Hooknose Creek, the outlet stream of Port John Lake. As yet the extent to which Port John sockeye are taken by commercial fishing gear has not been ascertained so that the number of marked fish that might have been taken by the fishery is not known. Only one cannery recovery was reported.

I. Adult sockeye salmon escapements, Port John, 1952.

At Port John the adult sockeye escapements pass from Port John Bay into Hooknose Creek and ascend approximately three miles to Port John Lake. Most of the fish subsequently arrive at and spawn in Tally Creek, a small tributary flowing into the lake almost half a mile from the lake outlet. Counting weirs are operated on both Hooknose Creek and on Tally Creek. It is possible thus to ascertain the extent of the escapement into Hooknose Creek and the proportion that finally reach the main spawning ground in Tally Creek.

Sockeye first appeared at the Hooknose Creek weir on June 20 and continued to move into the stream in periods of high water until September 18. Only 15 fish or 1.4% of the run appeared after that date. The peak of the run occurred during the third week of August.

It is not possible to determine accurately the sex of sockeye entering Hooknose Creek, except for late-season fish, since no real sexual dimorphism, other than general roundness of female fish, is evident for those sockeye appearing before September. "Jack" sockeye are, however, easily distinguished by their size. Checks by marking and tagging have shown that errors in sex determination do occur at the Hooknose weir. It is felt, therefore, that the sex ratio as shown by the Tally Creek census would be more representative of the whole population and since the Tally Creek sex ratio was 44.3% male to 55.7% female, the actual Hooknose Creek weir counts have been corrected in Table I.

The distribution of the sockeye ascending Hooknose Creek was determined from the Tally Creek weir counts and observations elsewhere. Weekly examinations of the entire lake and the tributaries were made and accounted for only 69 sockeye. No lake spawning was observed nor were any areas on the lake shore judged suitable for lake spawning. A few sockeye may have spawned in Hooknose Creek below the lake as revealed by the few sockeye fry encountered at the Hooknose Creek fry weir the following spring. From a tagging experiment at Hooknose Creek weir in 1949 it was found that sockeye spend from 90 to 5 days in the lake before spawning. In this extended period of time it is quite probable that there may be appreciable natural mortality.

The complete data for the Port John sockeye run are shown in Table I.

Table I. The distribution, by sex, of sockeye salmon passing through the Hooknose Creek weir into the Port John system in 1952.

	Jacks	Males	Total males	Females	Total
Hooknose weir count	562	181	743	346	1089
Adjusted Hooknose count	562	233	795	294	1089
Accounted for above Hooknose weir					
Through Tally Creek weir	430	136	566	171	737
Estimated spawned below Tally Creek	9	5	14	8	22
Estimated spawned in other streams	15	11	26	21	47
Dead at Hooknose weir	0	2	2	3	5
No. accounted for	454	154	608	203	811
No. unaccounted for	108	79	187	91	278
% loss	19.2	33.9	23.5	31.0	25.5

Egg deposition. Seven female sockeye were examined for egg content and 38 spent sockeye were examined for egg retention. Fourteen female sockeye entered Tally Creek but failed to spawn. Deposition and egg loss are shown in Table II.

Table II. Potential deposition of eggs in Tally Creek and Port John Lake in 1952.

Location	No. of females spawned	Av. egg content	Potential deposition	Av. egg retention	% loss by retention
Tally Creek	156	2436	380,016	92	3.77
Remainder of lake	32	2436	77,952	92	3.77
Total	188	2436	457,968	92	3.77

II. Production of sockeye salmon fry at Port John in 1953.

The egress of sockeye fry from Tally Creek began the middle of April, reached a peak near the end of April and terminated, but for a straggling 5% of the run, on May 10. From a potential deposition of 380,016 eggs in 1952, 19,078 sockeye fry emerged to pass through Tally Creek weir into the lake. This production of fry from Tally Creek consitituted, therefore, a 5.023% survival.

The total production of fry for the whole lake area (see Table II above) based on this percentage survival was 23,004. Experiments involving the release of fry to sea reduced the lake population by 5,794. Further salinity experiments removed 2,744 fry and fence mortality accounted for 444 fry. These extractions and mortalities leave an estimated total of 14,022 fry in Port John lake.

Stream temperature and water level readings were not obtainable from Tally Creek during the incubation period of the sockeye eggs. The caretaker-observer hired for the winter months was unable to attend the lake because of its distance and difficult terrain.

Some sockeye fry, though usually very few, pass through Hooknose fence into the sea. This spring a total of 23 fry passed through Hooknose fence, indicating that some sockeye spawning is likely in Hooknose Creek below the lake.

III. Sockeye smolt production at Port John - 1953.

Sockeye smolts began seaward migration from the lake and through the Hooknose Creek weir the middle of April, reached a peak near the end of April and had completed their downstream movement by the end of May. A count of 14,075 was obtained.

A determination of the percentage survival of smolts produced from a known egg deposition requires that the age of the smolts be known in order that they may be credited to the proper egg deposition and fry release. Age determination for smolts in the runs of 1950 and 1952, as made by Mr. D.R. Foskett, gave the following age representation:

Year	Age group I	II	III
1950	0.94%	97.81%	1.25%
1952	17.55%	76.33%	6.11%

In both of these years the two-year-old fish were most abundant. Therefore before the 1953 smolt run can be used to calculate percentage survival from either egg deposition or fry production it will be necessary to make an age analysis of the 1% sample of the migration which has been preserved. Completion of age analysis of the smolts of 1951 and 1953 will make possible an understanding of sockeye production in a small coastal area such as Port John over several years. If, for example, the 1953 smolts are principally two-year-old fish, the count, 14,075, would represent approximately 3% of the egg deposition of 1950 and 60% of the fry release in 1951.

It may be mentioned that in order to confirm the age readings 5,075 sockeye fry were marked last spring, 1952, and released into Port John Lake. This spring 21 marked smolts were recovered. This indicates that a percentage, at least, of the young sockeye from Port John Lake migrate seaward at the end of the first year; it suggests that the bulk of the fish, however, remain in the lake for a second year and go to sea at the end of their second year, as revealed by Mr. Foskett's age analysis, tabulated above, for the 1950 and 1952 smolt runs. Length frequency curves also bear this out.

IV. Return of adult sockeye from a release of marked smolts in 1949.

In order to determine the percentage return from the sea to the Port John river system of adult sockeye from a known marked smolt population, all the smolts of the 1949 seaward migration (19,486) were marked by removal of the adipose and two pelvic fins and released to the sea.

Recoveries at the Hooknose Creek counting weir were made in 1950, 1951 and 1952 as follows:

Year of return	Years in sea	"jacks"	Large males	Total males	Females	Total sockeye
1950	1	194	0	194	0	194
1951	2	0	174	174	214	388
1952	3	0	15	15	18	33
Totals		194	189	383	232	615

The total return to the weir of 615 marked adults represents an ocean survival of 3.1% of the marked smolts released. Almost one-third of the returns were "jacks" or precociously-maturing male fish. No real attempt was made to obtain recoveries of marked sockeye in the commercial fishery because of the difficulties involved.

The marking of all smolts in the run of 1949 provided some information on the extent of wandering from the parent stream. In 1950 a total of 215 "jack" males were counted at the weir. Of these, only 194 were marked. The remainder, 21 unmarked, thus demonstrate a wandering to Hooknose Creek from some other stream, amounting to 9.7% of the Port John "jack" sockeye population.

D. Coastal Sampling Studies.

This study continues the analysis of samples taken each year from the Nass River, Skeena River, Rivers Inlet and Smith Inlet sockeye salmon catches which was begun by the Provincial Fisheries Department in 1916. The age and size composition are determined each season and also the sex ratios, to build up a very valuable series of data on the changes in the composition of the runs from year to year. For the Rivers Inlet area a special study is being made of the composition of the spawning escapement to determine in what respects the gill-net fishery may be selective and influence the perpetuation of the populations. The Rivers Inlet area represents a sockeye-producing region but yet little affected by logging, etc., and in that respect represents an opportunity to follow the effect on salmon streams and on salmon production of removal of the forest cover, whenever that may commence.

D.R. Foskett

I. Sockeye salmon catch sampling

The samples of the 1952 sockeye catch in the Nass River, Skeena River, Rivers Inlet and Smith Inlet areas have been examined in order to determine the age and size composition of the runs and the sex ratios. The data were subsequently analysed and Paper No. 38 in the series "Contributions to the Life History of the Sockeye Salmon" was prepared and submitted to the British Columbia Fisheries Department for inclusion in their 1952 report.

A total of 6,745 samples was taken of which 1,927 were from the Nass River catch, 2,363 from the Skeena River catch, 1,568 from Rivers Inlet and 887 from the Smith Inlet catch. In addition 838 samples were taken on the Rivers Inlet spawning grounds, giving an overall total of 7,583 samples.

The Nass River sockeye pack in 1952 was 29,492 cases composed, chiefly, of 46% 5_3 fish, 28% 4_2 fish and 19% 5_2 fish. That is 65% was the return from the 1947 spawning. The 5_2 fish were slightly larger than those of the same group in 1951 while the 4_2 and 5_3 age class sockeye were approximately the same size as the fish of the same groups in 1951. The overall sex ratio in 1952 was

50:50 with the 5_2 and 6_3 groups showing the greatest deviation from this, having 56 and 59% males respectively.

The Skeena River sockeye pack was 114,775 cases composed of, chiefly, 66% 4_2 fish and 26% 5_2 fish. Though the 4_2 males exceeded in size those of 1951 the females of that age class averaged the same as the sample of 1951. The 5_2 sockeye in both sexes averaged slightly less than the same age class in 1951. The sex ratio was 48 males to 52 females in the sample with the 4_2 age class having a ratio of 52 males and 48 females and the 5_2 group having only 34 males to 66 females.

The Rivers Inlet sockeye pack in 1952 was 84,298 cases and the sample was composed, mainly, of 41% 4_2 fish and 58% 5_2 fish. These fish were slightly under the 1951 averages of length and weight for the 4_2 group and slightly larger in the male 5_2 fish though the female 5_2 fish exceeded the 1951 average in length only. The sex ratio in the whole sample was 44 males to 56 females, with the 4_2 sockeye having a ratio of 58 males to 42 females and the 5_2 sockeye 34 males to 66 females. The spawning ground samples differed from the catch samples both in percentage of age class representation and in the sex ratio. As mentioned in the next section this is believed due to gear selectivity in the commercial fishery.

The Smith Inlet sockeye pack was 34,834 cases. The catch sample was composed chiefly of 4_2 and 5_2 age groups, the former being only 8% of the sample and the latter 91%. The 4_2 males were smaller than those of the 1951 sample in both length and weight though the females of that age group exceeded those of the 1951 sample in length but had the same average weight. The 5_2 age group sample exceeded in average length the fish of the 1951 sample but did not equal them in average weight. As is normal in the catch samples for this area there were more males than females amongst the 4_2 age sockeye and less males in the 5_2 age group. The ratios were 57 males to 43 females in the 4_2 group and 38 males to 62 females in the 5_2 age group with an overall ratio of 40 males to 60 females.

II. <u>The Rivers Inlet sockeye run</u>.

A preliminary study has been carried out on the effect of the fishery on the Rivers Inlet sockeye run. The regular sockeye catch samples have been compared with samples of fish on the spawning grounds. Unfortunately, due to the absorption of the scales age determinations have not been possible for spawned out fish recovered. However separation of age classes by means of length frequencies is feasible and histograms were prepared which show the differences between the catch and escapement samples. It is clear from this preliminary work that gear selectivity occurs in the Rivers Inlet sockeye fishery though the exact nature of the selectivity and its effect on the population could not be determined by this preliminary program. In any case its final effect on the population cannot be determined until it is known to what extent such factors as age and size at maturity are inheritable. For instance, present gear allows the majority of jack sockeye to proceed to the spawning grounds and yet we do not know whether this practice will tend to increase the proportion of jacks produced by future generations.

In the course of the above study much additional information on this run and on the Rivers Inlet area was obtained. Conditions on the spawning grounds and in the nursery area (Owikeno Lake) are those which are normally associated with low production and yet for size of the area it ranks among the highest producers of sockeye salmon. For this reason a general report of conditions in the area is being prepared.

III. Changes in sockeye sampling technique.

For some years changes in the technique of handling samples have been made with a view to reducing the time spent in their preparation for reading. This has resulted in the change from the glycerine jelly mount to the plastic impression method of scale preparation. This latter method as at first practised involved taking the scales from scale books and placing them on the plastic slides and running them through steel rollers in the laboratory. Static electricity, at times, slowed down the operation to a very great extent so that it was found necessary to stick the scales on tape to ensure their correct alignment on the slide and to prevent the scales being reversed with the consequent loss of the impression.

This required additional time in the laboratory and necessitated the training of a technician. To eliminate this additional time waste, tests were made at Rivers Inlet to see if it was practical to place the samples directly on the tapes in the field. The results were encouraging and in 1952 Skeena and Nass River samplers were asked to give the new method a trial. Though the results from these trials were not all that had been hoped new instructions were prepared and the method was used in all the catch sampling in 1953.

The results of this new method of handling the scales are that the impressing of all the commercial catch samples was completed this year in less than two weeks and the necessity of having a technician for the work was eliminated. The new technique, which involves plucking the scales from the scale pocket with tweezers, reduces the occurrence in the samples of loose scales from other salmon thus increasing the accuracy of the readings.

Though it requires more care on the part of the samplers the method is preferred by those who have tried both techniques. One advantage of the new technique is that the sample books do not become wet with slime and thus they are not offensive due to bacterial decomposition as was almost invariably the case during wet weather when the old method was used.

PINK AND CHUM SALMON - F. Neave

A. Nile Creek. — W. P. Wickett

I. Adult studies, 1952.

II. Fry studies, 1953. — J. G. Hunter

B. Port John.

I. Adult studies.

1. Adult pink and chum salmon migration at Port John, 1952.
2. Estimation of numbers of adult pink salmon present in Hooknose Creek, 1952.

II. Fry and smolt studies.

1. Output of pink and chum salmon fry from Hooknose Creek, 1953.
2. Horizontal distribution of pink and chum fry migrating in Hooknose Creek.
3. Life history of the sculpin, Cottus asper. — J. I. Manzer
4. Use of sampling nets for estimating numbers of sea-going salmon migrants. — J. G. Hunter
5. Coho studies. — W. P. Wickett

C. Spawning Ground Studies.

I. Criteria for salmon spawning beds.

D. Applied studies.

I. The 1952-54 pink salmon cycle in the Queen Charlotte Islands. — F. Neave, J.G. Hunter, W.P. Wickett, J. I. Manzer

II. Pink and chum salmon tagging operations, 1953.

PINK AND CHUM SALMON - F. Neave

The work of the Pink and Chum Salmon Investigation is mainly directed to establishing facts, principles and procedures which can be used (a) in diagnosing the biological condition of the fishery when and where such action is desired; (b) in determining the effectiveness and feasibility of remedial or improvement measures; and (c) in prediction of abundance from year to year or over longer periods.

These studies are for the most part carried out at the field stations located at Nile Creek on Vancouver Island and Port John, near Ocean Falls. At these places the mortalities occurring at various stages in the life history are recorded and the causes of mortality are elucidated and assessed. While detailed findings on these streams are made possible by rather elaborate installations which cannot be widely employed elsewhere, tests are also made of methods and equipment which can be used to give helpful information in a short time and at low cost on salmon streams in general. Problems of this kind in which progress has been made during the present year include the estimation of fry runs by sampling methods and the evaluation of spawning beds in terms of their physical composition and porosity. The latter study has involved laboratory as well as field work.

The pink salmon fishery in 1953 has been marked by relatively low catches in the northern and central areas and by large catches, accompanied by high fishing intensity, in the southern districts. The chum salmon fishery, much of which takes place in the autumn months, cannot yet be assessed adequately.

Both these species of salmon are exploited in nearly all parts of the British Columbia coast and their spawning grounds are similarly widespread. While the Investigation keeps in touch with the main features of the fishery, limitations of personnel dictate that special attention be given each year to only a very few selected features or areas. (The Investigation is not charged with responsibility for the long-term study or management of a particular area or portion of the fishery.) The proposed closing of the Nile Creek field station in 1954 will to some extent permit closer application of existing knowledge to local or regional needs.

In contribution to the solution of current problems of the fishery, the Investigation during the present year has carried out: (1) a study of the reproductive efficiency of pink salmon in the Queen Charlotte Islands, to provide information on the probable magnitude of the 1954 run; (2) a tagging program on the pink and chum salmon migrating through the Johnstone Strait area, to determine the destination of these fish and the extent to which they contribute to the fishery in various coastal areas.

W. P. Wickett

A. Nile Creek

This field station, located on the southeast coast of Vancouver Island, has been recording data on the natural freshwater survival primarily of chum salmon but also of pink and coho salmon. The watershed has been heavily logged and burned over in the last 30 years. Water levels tend to fluctuate widely with rainfall, the operations since 1945 being characterized by the frequency of winter floods. The upper end of an ox-bow of the stream has been fitted with a water gate so that the surface flow can be controlled. In this area eggs have been planted each year. At first only the water flow was held steady, eliminating winter floods. Latterly both the predator population and the gravel composition have been modified.

Percentage survivals recorded at the fence at the stream mouth for naturally deposited eggs have acted as a basis for comparison with the higher survivals of planted eggs recorded in the "controlled-section".

Carrying on the program of assessment of natural freshwater survival and of testing the feasibility of improving incubation conditions for pink and chum salmon, the past season's program was repeated, but only chum salmon eggs were planted in the section over which the surface flow is controlled. In 1951-52 the natural output of fry had been 7% (which is high for Nile Creek) while the planted pink eggs produced 17% fry and the chum eggs 5%. The discrepancy between planted pink and chum eggs was believed due to unsuitable gravel conditions in the area where the chum eggs were planted.

A repetition of similar natural conditions enabled this thesis to be demonstrated, as shown below (part II).

I. Adult studies, 1952.

Total fence counts were 142 pink (plus 42 below the fence), 1,507 chum, and 537 coho (plus 129 jack). Although some streams in the area were dry, Nile Creek had enough water for the fish to ascend. The pink run, though insignificant commercially, is the largest since the start of operations. Fry counts were not made of the brood-year migrants due to loss of the fence. The chum run was the largest since 1946 and is in line with the larger fry output of 1949. The coho run was the largest to date but in this instance again, brood migrant counts are not available. The number of two-year-old jacks was very high.

	Brood year migrants		Adult return			Percent return	Egg count per female	Estimated egg deposition
	Total	Natural	Male	Female	Total			
Pink	-	-	82	60	142	-	2,000	120,000
Chum	82,930	22,231	778	729	1,507	1.8	2,429	1,717,600
Coho	-	-	264	273	537	-	3,420	933,660

II. Fry studies, 1953.

Winter conditions were favourable this year as they were last year. However, the natural pink fry output was very low. Possible causes were the digging up of pink eggs by chum salmon and heavy predation on the pink fry. Neither were numerically assessed but observations suggest that they contributed to the failure of reproduction above the fence. Survival of eggs below the fence is unknown. The chum salmon output of 6.4% is comparable with the 7% output of 1952 although the deposition was eight times greater than that of the previous year, giving rise to the largest fry output since the start of operations. Three hundred and eighty thousand chum eggs were planted in the same portion of the controlled-water section that the pink eggs had been placed in the year previously. The gravel of this area was re-screened and washed before planting. The fry output was 21.5%, a very marked improvement over the natural output. As in other years when natural production was high, this improvement was mainly due to the removal of predators. The efficiency attained was comparable with that recorded for pink eggs in 1952.

Data for 1953 migrants is summarized below.

	Eggs available in 1952	Migrants					
		Live	Dead	Total	Percent emergence	Percent survival during migration	Percent output of fry
Pink							
Natural	120,000	445	3	448			0.37
Chum							
Natural	1,718,000	107,903	1,536	109,439			6.4
Planted	379,000	81,361	230	81,591	23.7	91	21.5
Total for stream		189,264					
Coho		Fry		Total	Yearlings		
Natural	934,000	8,844	505	9,349	3,946		

B. Port John

J. G. Hunter

Since the establishment of this field station in 1947, the annual output of sea-going migrants of four species of salmon (pink, chum, sockeye and coho) has been recorded and has been compared with the number of spawning adults from which it originated. With respect to pink and chum salmon, the accumulated data have indicated that in general the number of migrants going to sea is reflected in the size of the returning adult run and that the efficiency of reproduction is determined to a considerable extent by the water levels prevailing at the time of spawning. Ability to diagnose favourable and unfavourable circumstances in the freshwater phases of these species becomes more precise as the record is extended to cover a wider variety of weather conditions and population levels.

In 1952 and 1953 special attention has also been given to two problems of widespread importance, namely, (1) the estimation of spawning stocks by observation, and (2) the evaluation of fry-migrant runs by sampling with simple, portable equipment. The high losses which have been shown to be suffered by migrating fry have led to a study of an important predator, the sculpin.

I. Adult studies

1. Adult pink and chum salmon migration at Port John, 1952.

Adult pink and chum salmon commenced their upstream movement in Hooknose Creek in early September. Their continued movement into the stream varied with the volume of water discharge throughout the period of their migration.

Stream discharge levels permitting, the mid-point of the pink and chum runs occur at approximately the same date from year to year. The 50% point for the years 1947 to 1952 is September 23 ± 4 days for pinks and October 3 ± 8 days for chums.

Eighty one pink and 8 chum salmon were taken for egg counts. Forty six dead pink and 31 dead chum salmon were examined for egg retention. The average egg count is used to determine the potential deposition of eggs in the stream. Egg retention is considered as a loss and is one of the factors determining the survival of young the following spring. Table I shows the number of incoming adult pink and chum salmon and their estimated egg content.

Table I. Number of adults, percent females, average egg content, potential deposition, average egg retention and percent loss of eggs by retention for pink and chum salmon.

Species	Total	Percent female	Average egg content	Potential deposition	Average egg retention	Percent loss of eggs by retention
Pinks	8,685	57.06	1,757	8,510,908	16.9	0.96
Chums	871	43.74	2,516	938,463	12.8	0.51

Hooknose Creek fence is located just above tidal water, leaving approximately 150 yards for intertidal spawning to occur. In 1952 an estimated 1,500 pink salmon (14.72% of the entire run) spawned in this area.

Pink salmon. From a liberation of 232,636 fry in 1950, 8,685 adults returned in 1952, representing an ocean survival of 3.733%.

Chum salmon. Two variables prevent ready calculation of return of adults from known liberations of fry. Returns from the release of 54,831 marked chum fry in 1948 were completed in 1952. In 1950, 51 returned as three-year-olds, in 1951, 186 returned as four-year-olds and in 1952, 22 returned as five-year-olds. This represents a ratio of 2.31:8.45:1.00.

The total return of 259 chums from a marked release of 54,831 fry shows a 0.472% ocean survival. Release of marked and unmarked pink salmon fry in 1948 and a comparison of the numbers returning in 1950, indicated that marking might result in a mortality of as much as 82%. Assuming a similar effect for chum salmon, then a total calculated return from the 1948 liberations would have been 2,613 adults; representing an ocean survival of 2.621%.

Meteorological stream discharge and water temperature readings were made twice daily.

2. Estimation of numbers of adult pink salmon present in Hooknose Creek, 1952.

Stream estimates of pink salmon were made at intervals throughout the spawning season. Tagging and observation of tagged pinks until death showed a mean survival time, after entering Hooknose Creek, spawning and dying, of 17 days. The stream counts and the calculated numbers present on the same dates (based on fence counts and a 17 day life expectancy) are compared in Table I.

Table I. Stream counts and calculated numbers of live pink salmon in Hooknose Creek, 1952.

Date	Stream count	Calculated number
Sep 13	565	1,101
Oct 5	1,657	3,470
Oct 21	103	251
Total	2,325	4,822

The numbers recorded by stream counting are only 48.22% of the actual numbers which should have been present. Counts multiplied by the factor 2.078 give the actual number.

The sum of the estimates for the given dates, 4,822, does not represent the complete run of pink salmon in Hooknose Creek. If, however, it had been possible to make a stream count every 17 days with the same observational efficiency of 48.22%, then the estimated number of pinks would have been, as is shown in Table II, 8,494 fish.

Table II. Calculated number of live pink salmon in Hooknose Creek, 1952.

Date	Calculated number
Sep 13	1,101
Sep 30	6,992
Oct 17	401
Total	8,494

The actual population was 8,685, or a difference from the estimated population of only 192 fish (2.2%). Estimates made at intervals of the mean life expectancy (17 days), but commencing on different dates, would have given fair estimates of the true population, as shown in Table III.

Table III. Theoretical sets of stream counts and percent discrepancy from the true population.

Date	Calculated number	Date	Calculated number	Date	Calculated number
Sep 5	3	Sep 9	210	Sep 17	2,983
Sep 22	5,696	Sep 26	6,427	Oct 4	4,338
Oct 9	2,751	Oct 13	1,164	Oct 21	251
Oct 26	125				
Total	8,575		7,801		7,571
Percent error	1.3		11.8		12.8

These findings differed from those obtained from observations on the 1951 run. In that year, the average survival period was considered to be about 10 days and stream counts indicated that observational efficiency was close to 100%. The substitution of a 17-day survival period would bring the 1951 results into substantial agreement with the 1952 findings.

It is quite probable that the mean survival time changes during the season. It is probably also affected by the length of time the fish are prevented from entering the stream by low water conditions. Observational efficiency will vary according to density of the fish, water level, water colour, type and size of stream. Assessment of these factors is continuing.

II. Fry and smolt studies.

1. Output of pink and chum salmon fry from Hooknose Creek, 1953.

The downstream weir on Hooknose Creek was installed March 23 at which time pink salmon fry were beginning their migration. The runs of pink and chum fry reached a peak about April 18 for both species. The output of fry in relation to the egg deposition is shown in Table I.

Table I. Average egg content, potential deposition, numbers of fry, and percentage survival of pink and chum fry.

Species	Average egg content	Potential deposition	Numbers of fry	Percent survival
Pinks	1,757	8,510,908	1,227,025	14.417
Chums	2,516	938,463	182,200	19.414

The percent survival recorded for both species is relatively high and is in accordance with expectations based on water levels prevailing in October, 1952. A negative correlation (r = .9024) has been found between stream discharge in this month and pink fry survival in the following spring. On this basis a survival of 16.072% with 95% confidence limits of 12.303 to 19.841 had been calculated for 1953.

The percentage survival from egg to migrating fry has been remarkably similar for pinks and chums during the five-years' operation of the fence prior to 1953 (r = .9976). While both species showed high survival in 1953, a somewhat lower efficiency for pinks than for chums was apparent. This is thought to be related to the large size of the parent pink salmon escapement which would increase competition for desirable redd sites and might also result in increased interference with pink eggs by the later-spawning chums.

Tables II and III permit comparison between this year's findings and the results obtained in previous years during the period of operation of the Port John field station.

Table II. The spawning stock, percent females, average egg content, potential deposition, numbers of fry produced, percentage freshwater survival, ocean return and percent ocean survival for pink salmon in Hooknose Creek from 1947 to 1953.

Year of spawning	1947	1948	1949	1950	1951	1952
Spawning stock	5,576	1,160	1,173	1,857	1,670	8,685
Percent females	52.47	51.46	44.58	55.30	52.63	57.06
Average egg content	1,316	1,341	1,650	1,543	1,708	1,757
Potential deposition	3,788,764	787,167	838,200	1,550,715	1,475,712	8,510,908
Numbers of fry produced	33,349	64,312	54,061	234,396	242,993	1,227,025
Percent freshwater survival	0.882	8.170	6.449	15.115	16.466	14.417
Number returning from ocean	1,632*	1,857	1,670	8,685	-	-
Percent ocean survival	5.215	3.052	3.187	3.733	-	-

* Total if marking mortality had not occurred.

Table III. The spawning stock, percent females, average egg content, potential deposition, numbers of fry produced, percentage freshwater survival, ocean return and percent ocean survival for chum salmon in Hooknose Creek from 1947 to 1953.

Year of spawning	1947	1948	1949	1950	1951	1952
Spawning stock	10,191	1,022	718	2,382	1,329	871
Percent females	51.55	49.90	49.58	50.46	55.38	43.74
Average egg content	2,107	2,101	2,083	2,416	2,201	2,516
Potential deposition	10,977,470	1,054,702	714,469	2,858,128	1,593,524	938,463
Numbers of fry produced	108,746	77,539	44,463	431,399	269,701	182,200
Percent freshwater survival	0.990	7.351	6.223	15.093	16.924	19.414
Number returning from ocean	2,613*	-	-	-	-	-
Percent ocean survival	2.621**	-	-	-	-	-

* Calculated return if there had been no marking mortality

** Assumes same marking mortality as for pinks

A comparison of the percent survival in the stream and in the sea emphasizes the greater variability of survival in the freshwater stages. This has led to the conclusion that the large fluctuations of abundance found in escapements of adult pink salmon are caused especially by freshwater factors.

Ocean survival for pink salmon is readily ascertained since the fish adheres closely to a two-year cycle but the picture becomes more complicated in chum salmon. Chum salmon adults return at ages of three, four and five years old. It is not known to what extent the ratio between these may change for different brood years.

The successful handling and recording of the exceptionally large fry run of 1953 was especially due to the work and direction of R. C. Wilson.

2. Horizontal distribution of pink and chum fry migrating in Hooknose Creek.

Because of their bearing on current attempts to estimate fry runs by sampling, observations were made in 1952 and 1953 on the horizontal distribution of fry migrating past the Hooknose Creek weir. This weir is divided into 14 equal sections, thus permitting comparison between the numbers of fry passing through different portions (Table I).

Table I. Location of pink and chum fry captured at Hooknose Creek weir.

Species	Year	Ratio of number of fry/unit width of stream Right hand 24 feet	Centre 48 feet	Left hand 24 feet
Pinks	1952	1.00	2.13	1.58
	1953	1.00	1.85	1.52
	2 year mean	1.00	1.89	1.52
Chums	1952	1.00	1.56	1.27
	1953	1.00	1.79	1.53
	2 year mean	1.00	1.65	1.37

Although equal volumes of water are passing through the weir at all points the fry are found concentrated in the centre of the creek. This analysis would suggest distribution is not a function of volume of water as much as a combination of volume, current, and topography. Depth is a factor not lending itself to observation on a Wolf-type fry fence.

3. Life history of the sculpin, *Cottus asper*.

During the spring migration of pink and chum salmon fry the sculpin (*Cottus asper*) becomes a serious predator. Estimates of the amount of predation, made at various times, indicate sculpins are capable of taking up to 80% of the salmon fry runs.

Spawning of the sculpins occurs from late May to early July in Hooknose Creek. It has been found that many of these fish move downstream through the weir into the intertidal zone to spawn. Observations have shown that although large numbers make this short migration sculpins continue to be distributed throughout the entire creek. Marking and recovery observations indicate upstream migration commences shortly after spawning.

Data on population size, fecundity, growth, age, natural mortality, migration, distribution and food habits are being accumulated but have not yet been sufficiently analyzed to be reported.

4. Use of sampling nets for estimating numbers of sea-going salmon migrants.

J. I. Manzer

The number of young salmon migrating from fresh water is evidently a measure of the reproductive success of a spawning population and frequently represents the latest stage at which the progress of a new "crop" can be assessed. The use of counting weirs, which have proved invaluable in establishing standards of reproductive efficiency, is necessarily limited to a few streams. In Hooknose Creek the catches of sampling nets could be checked against the complete daily counts available at the weir. While data were collected on the seaward migrants of other species of salmon, analysis at present is confined to pink and chum salmon fry.

The nets used were fyke-like in design with the opening measuring 2 feet in width and one foot in depth. Fry were directed by a smaller inner net into a detachable bucket which for sampling efficiency could be removed, emptied and replaced without much loss of time. Operations were conducted at night. When light was required for counting or sampling the source was contained within a shelter or behind a screen, thus minimizing any effect that it might have upon migration pattern.

Netting was carried out a short distance above the counting weir in two sections of the stream which differed topographically. To obtain data on fluctuations in migration under different conditions, in each section various combinations of netting stations and intervals were used. Horizontal distribution of fry throughout the run was determined by sampling in a shallow, reasonably flat section of the stream. Here two nets were used nightly in fixed positions - one near shore, the other in mid-stream. Periodically three additional similar nets were used, the five being spaced equidistantly across the stream. For data on vertical distribution of fry, three nets, one above the other, were used in a deeper section of the stream.

An extremely good positive correlation was found to exist between daily net samples and total fry counts for both shore and mid-stream nets, with the relationship being slightly better for the latter. Relationships between net samples and total fry for the other three nets used across the stream could not be reliably established since they were used on only five nights during the season. The mid-stream net, therefore, on this basis was regarded as the standard net. Expressing the catch of each of the four other nets as a proportion of the standard net's catch, and knowing the number of fry caught by it, the number of fry caught by each of the other four nets was estimated. The sum of these estimates were then trebled, since the nets covered only one-third of the stream's width. The estimates of pink and chum salmon fry obtained in this way equalled 89.4% and 76.5%, respectively, of the absolute total number of fry of each species counted at the weir. The difference between the absolute and estimated numbers can be accounted for somewhat by the fact that some fry passed through the netting areas during times when buckets were being removed and hence were not captured; also some fry emerged below the netting sites and had no opportunity to be included in sample counts.

It was again found that 50% of the fry migrated during the first two hours after dark, with the peak for pink salmon fry occurring shortly before that for chum salmon fry. As regards distribution in proximity to the shore, fry of both species were most abundant in fastest flowing water, suggesting a positive relationship between the number of fry and volume of water. Numbers of fry were found to increase with depth under the relatively slack water conditions in which vertical tests were made. The number of migrants increased when stream level rose.

In summary, net sampling appears as a useful method by which total numbers of fry can be estimated. The accuracy of estimates, however, will depend upon knowing the migratory habits of the species in question and how its migration is affected by the conditions under which sample data are collected.

J. G. Hunter

5. Coho studies.

A small run of coho salmon enters Hooknose Creek each year. The fish are counted and sampled for egg content in the same manner as the other species. Fry production is not readily assessable, since most of the young fish remain in fresh water for a year and the numbers which are recorded at the weir do not necessarily represent fish which are leaving the stream to enter on the ocean phase of life. The smolt migration on the other hand provides an opportunity for quantitative comparisons from year to year. The exodus of coho smolts from Hooknose Creek reaches a peak about the middle of May and is complete by the middle of June.

Certain quantitative data on the coho populations of Hooknose Creek have now been compiled and are summarized in Table I.

Table I. Coho statistics, Hooknose Creek.

Year of spawning	1944	1945	1946	1947	1948	1949	1950	1951	1952
Total escapement				733	558	693	203	360	655
No. of jack males				314	109	93	42	289	106
Percent jack males				42.8	19.5	13.4	20.7	80.3	16.2
No. of III-year-old adults				489	449	600	161	71	549
Percent male III-year-olds				45.6	54.6	51.0	55.9	59.2	55.2
Percent female III-year-olds				54.4	45.4	49.0	44.1	40.8	44.8
No. of smolts produced			10,157	3551	2982	4389	3620	4037	-
No. of returning jacks		314	109	93	42	289	106	-	-
Total no. of returning adults	419*	763	709	254	113	838	-	-	-
Percent return of jacks	-	41.2	15.4	36.6	37.2	34.5	-	-	-
Percent ocean survival**	-	-	7.0	7.2	3.8	19.1	-	-	-

* Jacks not included
** Slight difference from true survival because of fence mortality

Considerable variation in the percentage of jack males of the total runs for the different years is evident whereas the adult returns (two- and three-year-old coho) from the smolt releases to sea show considerably less variation in the percentage of precocious males. The five-year average for percent jack male return from smolt releases is 31.6%. Applying this average percentage to any given escapement of coho provides a rough index of the numbers of three-year-old fish to be expected in the following year.

Conditions in the sea may be adverse or favourable as is reflected by the percentage ocean survival. Fishing effort could modify ocean survival but the jack males enter into the fishery very slightly and they too reflect ocean survival. The 41.2% return of jacks from the 1945 spawning is greater than the average 31.6% of jacks and would therefore indicate a poor ocean survival for the three-year-old returning adults from the same spawning stock. This poor ocean survival could be a result of either fishing or natural mortality. However, the smolts which went to sea in 1948 and returned the same year as jacks show by their very low percent composition of the 1946 returns that conditions were poor in the sea and that natural rather than fishing mortality was high in that year.

The fact that the commercial fishery does not take jack coho would show a greater or less percentage of jacks depending upon the intensity of the fishery. Part of the low percent return of jacks from the 1946 spawning may be accounted for by a low intensity fishery for three-year-old coho in 1949. The 1946 ocean survival of 7%, as yet from our present knowledge, bears this out.

The assumptions that the migrating smolts have a 1:1 sex ratio and that natural mortality for the greater part of the ocean phase of the life of a coho is equal for both sexes would suggest, since many of the males have been removed as jacks, a predominance of females returning as three-year-old fish. As is shown such is not the case. This suggests that either the natural mortality is less in three-year-old males because of larger size, which is not known, or that the fishery is selective for female coho.

The data thus far treated has assumed a strict one-year freshwater phase and a one- and two-year marine phase for the life history of the coho. This probably accounts for a very high percentage of the coho but it is known that a few will remain in fresh water for two years and that some go to sea as fry. The percent of the total run of these divergent individuals has not been assessed but it is felt they are small to insignificant as compared to the numbers of orthodox behaviour.

W. P. Wickett

C. Spawning Ground Studies.

I. Criteria for salmon spawning beds.

Two main sets of factors have to be considered: (1) those affecting the adult fish and thus the successful deposition of eggs in gravel, and (2) those affecting the eggs after deposition. In the study of the first set of factors it is assumed that the adult fish are largely influenced by the hydraulics of the surface flow.

The second set of factors has been under study for some time, from the general standpoint of correlation between population size and ecological factors as well as by specific studies of individual portions of egg bearing gravel. The thesis for the study of portions of gravel is that eggs require mainly an adequate supply of oxygen-bearing water for survival and are thus dependent on the hydraulics of the sub-surface flow.

The 1951 report gave a formula from which adequacy of the oxygen supply can be calculated when certain factors are known. By use of a standpipe which was developed for the study, the required factors from the gravel - apparent velocity, oxygen content and temperature - can be recorded. However, the standpipe must be calibrated in various types of gravel and this important step is now being done by Mr. R. A. Pollard whose interest together with the active support of Dr. Tully is gratefully acknowledged. Mr. Pollard's work (reported elsewhere in these summaries) has shown that the standpipe can give a satisfactory measure of the velocity of sub-surface flow in a spawning bed.

Data already obtained by the writer show that losses of eggs in the pre-eyed stage can be ascribed to lack of oxygen and indicate the oxygen requirements of salmon eggs. A report is being prepared for publication.

Findings permit a verdict as to whether a given portion of gravel does or does not provide sufficient oxygen for the survival of salmon eggs.

This is a step towards the objective of stating clearly the requirements for an artificial spawning bed or a reconstructed natural spawning bed - a problem which is assuming urgent proportions in connection with human interference with salmon habitats.

D. Applied Studies.

Investigations reported in this section were undertaken in response to specific requests by the Industry or the Department of Fisheries for information on matters affecting production or regulation of fisheries. With the considerable body of knowledge which has now been accumulated from field station studies, it is felt that investigations of this type can be undertaken with increasing hope of reaching useful conclusions within relatively short time periods.

I. The 1952-54 pink salmon cycle in the Queen Charlotte Islands. — F. Neave, J. G. Hunter, W. P. Wickett

The advent in 1952 of the largest pink salmon run since 1930 raised the question of the ability of the stock to maintain the new level of abundance in the next generation. In other words, what will be the size of the 1954 run?

Since field station studies have shown that changes in abundance of adult fish are due in large measure to freshwater factors, efforts were made to assess the magnitude of the 1952 seeding and the degree of success attending its development into ocean-dwelling fish.

Departmental reports and subsequent egg-sampling operations left no doubt that seeding was generally heavy. The progress of development was investigated at two stages:

(1) A number of streams on Graham Island and on the northern part of Moresby Island were visited in February, 1953 and samples of eggs and alevins were obtained by digging. Counts of living and dead material showed an average survival of 58% - a reasonably satisfactory proportion in the light of experience gained elsewhere. Some destruction by flood was noted but general meteorological conditions during the incubation period were not considered to be severe.

(2) In April and May, 1953 much effort was given to the examination of the fry migration in selected streams of the Masset Inlet and Skidegate Channel districts. The numbers of fry captured in portable traps of standard dimensions were recorded during the main season of migration. Habits of the fry necessitated that this work be done at night. Conclusions as to total volume of migrants were based on observations of stream width, stream depth, relative numbers caught by traps set in different positions; and on the performance of similar traps in relation to the known numbers of migrating fish at Port John.

It was thought likely that the outgoing fry in these streams represented a survival of from 4% to 10% of the eggs deposited. This is not a high rate of efficiency but in other localities has been found to be sufficient to replace the parent population. Given normal conditions of ocean survival, the adult run of 1954 is expected to be of the same order of magnitude as that of 1952.

J. I. Manzer

II. <u>Pink and chum salmon tagging operations, 1953.</u>

At the desire and with the co-operation of the Department of Fisheries, pink and chum salmon are being tagged in Johnstone Strait and Discovery Passage to determine: (a) their destinations once they have passed through these waters, (b) the extent to which the same runs are being exploited at other points during their migration, and (c) to assess and compare this year's fishing intensity with that in former years when tagging experiments were conducted.

As in previous tagging experiments in this general area two vessels are being employed in this program, one at the upper end of Johnstone Strait, the other mainly in Discovery Passage. Tagging operations for both vessels began during the week of July 20, when pink salmon first appeared in any number, and will continue until the main chum salmon fishery terminates. Insofar as possible each vessel is tagging 75 fish of the prevalent species per fishing day or 300 per week. In general, the pink fishery precedes the chum fishery. Except on two occasions involving short periods this schedule has been maintained. To date (October 1) a total of 3,436 pink salmon and 669 chum salmon have been tagged.

As of October 1 the number of tags received at the Pacific Biological Station amounted to 30% for pink salmon and 4% for chum salmon. These are interim figures and in the case of chum salmon represent only an early stage in the program. Return of tags is being stimulated by the offering of a reward, accompanied by wide publicity.

Preliminary analysis of the geographic distribution of the pink salmon recoveries shows that more than half of the tags have been taken in the Johnstone Strait-Discovery Passage area, that is, not far from the tagging localities. Tags recovered elsewhere show that movement of the fish has been predominantly southward; only 5% of the tags found outside the tagging areas being recovered to the north of the latter. Tags have been recovered in all the main inlets and sounds of the southern mainland coast according to the following percentages:

Loughborough, Phillips Arm and Bute Inlet	8.4%
Toba Inlet	3.5%
Jervis Inlet, Pender Harbour	19.1%
Georgia Strait	3.0%
Howe Sound, Burrard Inlet	12.7%
Fraser River	36.4%
South of 49th Parallel	11.9%

Since fishing intensity has not been considered in these preliminary figures they do not necessarily represent the true relative distribution of pink salmon migrating through Johnstone Strait-Discovery Passage waters and bound for other areas.

Chum salmon recoveries as yet are insufficient in number to indicate any good distribution pattern. The concluding phases of the field work will be devoted especially to the tagging of this species and to the recovery of both pink and chum tags from the spawning grounds.

the other hand, lake and river levels increased gradually to peaks that remained relatively constant throughout May to mid-June, while the smolt run this year similarly rose gradually to a peak, and showed only moderate fluctuations in the daily counts at the fence.

2. Lake temperatures.

Temperatures were taken twice each week throughout the spring and summer, at four stations set along the north-south axis of the lake, and at 2-metre depth intervals. A reversing thermometer was used. A "shallow-water" bathythermograph will be used to complete the picture of the thermal stratification of the lake during the fall and winter.

As in former years no thermocline developed in the lake during the summer. This was the result of the action of fairly frequent winds stirring up the relatively shallow waters.

The peak summer surface temperature in the lake, of approximately 20° C. was reached during the first week in August. Due to wind action the temperature of the upper 10-15 metres was fairly uniform during much of the summer, varying in the extreme by less than 5 degrees within those depths, on each occasion of measurement. In the deep hole which lies at about the centre of the northern half of the lake, the bottom temperature at 30 metres reached a peak of approximately 10° C. in August. The cold water of Williams Creek enters the lake in this region, and contributes to the maintaining of the cold bottom temperature.

3. Lake chemistry.

In the past, determinations of the content of dissolved oxygen, phosphate, and nitrate-nitrogen of the lake water and of three streams were made each fortnight. Oxygen determinations were discontinued this past summer, as the earlier records had shown that dissolved oxygen concentrations remained relatively high at all seasons of the year throughout the lake. The value of the other chemical determinations will receive critical appraisal this winter.

4. Plankton collections.

Plankton collections were made each fortnight at four stations set along the north-south axis of the lake, using a Wisconsin type net of No. 10 bolting silk.

The collections were examined in the field, total counts of the important species of entomostracans being made.

Besides these routine collections, several tests were made to determine the efficiency of gear and procedure. In one test, two apparently identical nets of No. 10 bolting silk, hauled simultaneously and in the same manner from an equal depth, but at about 10 feet apart, had catches that showed important differences either between successive hauls or between nets.

Haul no.	Cyclops	Epischura	Daphnia	Bosmina	Other Entomo-stracans	Total	Cyclops as percent of total
Net A.							
1	604	10	4	40	6	664	91
2	872	14	6	59	4	955	91
3	1403	9	5	86	10	1513	93
4	1147	21	11	115	21	1315	87
Net B.							
1	517	17	9	74	5	622	83
2	538	18	8	81	9	654	82
3	506	17	13	57	6	599	84
4	566	12	10	84	8	680	83

As shown in the above table _Cyclops_ sp. formed not only the bulk of the organisms in each catch, but also made up a relatively constant fraction of each total catch. The catch per haul of Net B. was relatively very constant for all organisms taken, while that for Net A. increased for the first three hauls, and dropped in the fourth haul in the take of _Cyclops_.

In another experiment ten total verticals were made from a depth of 10 metres, one haul immediately following the other, at the same station and with the standard net. The catches were centrifuged, and the volumes per haul compared:

Haul no.	1	2	3	4	5	6	7	8	9	10
Volume in cc.	0.25	0.16	0.24	0.22	0.26	0.25	0.20	0.20	0.25	0.27

The samples contained varying numbers of the cladoceran _Holopedium gibberum_ (Zaddach). These organisms have a large gelatinous mass, with the result that they were precipitated with difficulty. They formed the top layer of the precipitate. Even after 30 minutes centrifuging there remained spaces between individual _Holopedium_.

The objectives of a third experiment were to determine variations in the catch of a standard net (by taking replicate hauls), to compare the additive catches of stage hauls with corresponding total verticals, and to test for variations in the horizontal distribution of the plankters (by comparing total verticals of equal depth from the four stations). The catches have not yet been examined.

The writer is of the opinion that adequate sampling of the lake's plankton crop to determine changes in its seasonal and annual abundance, by the use of the Wisconsin type net, is definitely impractical at Lakelse. Other gear and procedures will be sought for during the winter.

5. _Attempts to capture lacustrine sockeye_.

Methods that will permit adequate sampling of the young sockeye in the lake must be devised before their distribution, growth and survival can be related to the properties of their environment. A simple trawl was constructed and tested during the writer's stay at Lakelse, with results that are considered quite promising, provided certain obvious improvements are made, and a sufficiently powerful boat is available. These problems will be given attention during the winter in preparation for next year's operations. Small-mesh nylon gill nets will also be tried out next year.

6. Plankton collections at Lakelse Lake, 1949-1952. V.H McMahon

The following is the summary of a paper titled "Plankton collections at Lakelse Lake 1949-1952", submitted for publication by V.H. McMahon earlier this year.

"Analysis of plankton samples taken at Lakelse Lake in 1949 revealed that the greatest concentrations of entomostracans were in the upper half of a 30 metre column. The copepods were quite uniform in horizontal distribution over the deeper part of the lake while the cladocerans tended to concentrate at the north end. A high production of entomostracans occurred between mid-July and mid-October. Sampling at the deepest station only may be sufficient to give an indication of total production of *Cyclops* sp. in the lake, but a true representation of total production of the other entomostracans cannot be obtained by this restricted method of sampling. An apparent decline in the production of entomostracans following 1949 can probably be attributed, in part at least, to a differential efficiency of the collecting nets used."

V. Fish studies. M.P. Shepard and T.H. Bilton

Studies on the fishes of Lakelse Lake have centred on the description of the life histories of the piscivorous species present in the lake. The chief aim has been to determine to what extent the annual loss of young lacustrine sockeye is due to the activities of predator fishes. Information on the habits of competitor and forage species is being gathered as a subsidiary part of the program. It is felt that the present program is providing sufficient background information to begin a well-controlled predator removal program in the near future.

In the reports that follow data collected in 1952 and analysed in 1953 are included along with a preliminary account of the 1953 program. Mr. M.P. Shepard supervised the work during the 1952-53 season while Mr. T.H. Bilton assumed responsibility for conduct of the program during the 1953-54 season.

1. Lakelse River fence lake fish count. M.P. Shepard

Movements of fish to and from Lakelse Lake were followed at the Lakelse River fence. From the end of March to mid-November counts were made of the numbers of fishes moving up and downstream through the fence. In addition to routine enumeration, length samples were taken, and a marking program was carried out to provide information on the movements and abundance of the various species.

The downstream runs of cutthroat and dolly varden were much larger and tended to be earlier in 1953 than in 1952. The provision of expanded facilities for passing fish through the weir was undoubtedly a reason for the increased runs; general observation and creel census results indicated that the 1952 smolt fence presented a block to the passage of these fish. The whitefish run was about the same in both years. In addition to the runs of trout, char, and whitefish, a small number of suckers, squawfish, peamouth, lamprey, sculpin, and juvenile trout were counted. Data on the runs of the three major species are summarized in Table I.

Table I. Downstream migration of adult cutthroat, dolly varden, and whitefish in 1952 and 1953.

Week ending	Cutthroat 1952	Cutthroat 1953	Dolly varden 1952	Dolly varden 1953	Whitefish 1952	Whitefish 1953
Apr 2	28	31	1	3	0	1
9	1	347	0	10	0	10
16	6	668	0	52	5	85
23	16	1,136	0	313	0	490
30	31	680	5	489	0	2,520
May 7	206	693	58	1,165	3,183	1,276
14	223	207	213	996	897	319
21	62	118	111	2,097	0	366
28	60	27	195	850	0	373
Jun 4	64	15	15	133	295	581
11	69	24	4	51	184	278
18	11	24	12	14	87	180
Remainder to Sep 9	151	0	7	2	411	17
Total	928	3,970	621	6,175	5,057	6,496

In the springs of 1952 and 1953, cutthroat, dolly varden, and whitefish were marked during their downstream migration. A small number of marked dolly varden and cutthroat were transported upstream from the fence and released to obtain information on the usually intensive angling fishery taking place above the fence. All other marked fish were released below the fence. In addition to fish trapped in the fence, a few dolly varden and cutthroat caught upstream from the fence by angling were also marked. Populations containing marked fish moved upstream through the fence during the autumns of 1952 and 1953. Samples of these populations were examined for marks. Table II summarizes the details of the marking programs of 1952 and 1953.

Table II. Marks applied to downstream migrant fish at the Lakelse River fence during the springs of 1952 and 1953.

Species	Marked upstream 1952*	Marked upstream 1953**	Marked downstream 1952	Marked downstream 1953	Total
Cutthroat	262***	75	169	39	545
Dolly varden	154	235	78	923	1,390
Whitefish	0	0	1,140	0	1,140
Total	416	310	1,387	962	3,075

* 1952 mark - right pelvic fin.

** 1953 mark - right pectoral fin.

*** Including 68 angled fish marked by removal of ½ right pelvic fin.

Fence data are utilized in establishing the numbers of fish present in the lake and in describing their distribution (see Sections 4 and 5).

T.H. Bilton

2. Gill-netting.

To obtain information on seasonal and annual variations in the composition, magnitude and diet of the various fish populations in Lakelse Lake a standard gill-netting program was begun in October, 1952. The program was designed so that all parts of the lake were sampled with approximately equal intensity three times a year. The program requires sixteen sets using gangs of 10 nets (two each of nets having meshes of 1.5, 2.0, 2.5, 3.0, and 3.5") to be made in the late fall, under ice cover and in the late spring. The sets cover inshore and offshore areas with bottom sets and, for pelagic regions, suspended sets. By repeating the same procedure each time, it is hoped that changes in the characteristics of the lake populations can be followed with considerable accuracy. The fall program of 1953 will complete the first year of operation. Due to an unusually mild winter only one set was made during the period of ice cover. The results are discussed in the sections dealing with abundance and distribution.

Experimental netting was continued during 1953. Experiments were conducted to determine the time of entry of fish into gill-nets. Two gangs of nets were set; one in inshore waters, the other at the bottom in an offshore position. The nets were lifted at two-hour intervals and their catches removed.

Most of the fish entered both gangs at the darkest periods of the night. The maximum rate of capture of peamouth occurred at midnight inshore and offshore. The peak of squawfish capture occurred at 2:00 A.M. at both positions. This confirms the findings obtained at Lakelse in 1947, that during the spring, fish enter gill-nets between midnight and 3:00 A.M. Also notable was a secondary peak of entry of peamouth and squawfish at the offshore position at 11:00 A.M. The numbers of whitefish entering the nets at both positions were sporadic throughout the 24 hours. Varying numbers of cutthroat were caught at the inshore position between midnight and 6:00 A.M. with very little evidence to suggest a peak in the rate of entry. No cutthroat were captured following this period. Of the sculpins captured at the inshore position, the greatest number of them entered the nets at midnight, with small numbers entering the nets during the remaining time. The data are summarized in Table III.

Table III.

Species	Times of maximum entry*		Secchi disc reading
	Inshore	Offshore	
Peamouth	Midnight	Midnight	6 feet
Squawfish	2 A.M.	2 A.M.	4 feet
Cutthroat	6 A.M.	--	11 feet
Whitefish	Sporadic entry throughout the 24-hour period		--
Sculpins	Midnight	--	6 feet

* Pacific Daylight Time.

The information obtained from the experiment suggests the following conclusion: nets must be set for a specific time without variation, if comparable catch per net night values are to be obtained from year to year.

3. Trap-netting. M.P. Shepard

Peamouth and squawfish (and to a lesser extent all other indigenous species) are readily trapped in fyke nets placed in stream mouths or along the shoreline of the lake. During the spring and summer of 1952, fish trapped at 4 locations were marked. Two trap nets at the north and south ends of the lake were operated during the fall of 1952 to sample the populations containing marked fish. In 1953, two trap nets were operated, one at Hotsprings Creek (which supports a run of about 1,000 peamouth), the other at Mailbox Point (where a spawning run of squawfish occurs in the late spring). The purpose of the project was to determine whether peamouth and squawfish tend to return to the same location every year during the spawning season. No new marking was carried out in 1953 except on some 1952 marked peamouth, which were remarked. The marking data for 1952 were summarized in the 1952 Annual Report. The results are discussed in Sections 4 and 5.

4. Distribution of lake fishes. M.P. Shepard and T.H. Bilton

Seasonal changes in the distribution of lake dwelling fishes have been followed closely during the last three years. Concentrations of various species associated with spawning and feeding have been noted at various times. In general the spring is a time of movement shoreward and downstream from the lake, while the fall and winter period is characterized by an upstream movement of fish into the lake and a tendency for fish to disperse throughout the lake. The vertical and horizontal distribution of adult lake fish is summarized in Table IV, while the movements of concentrations of fish are briefly outlined in Table V.

Table IV. Spatial distribution of fish during different seasons.

Distrib. / Species	Vertical distribution offshore			Horizontal distribution		
	Spring	Fall	Winter	Spring	Fall	Winter
Peamouth	Deep	Deep	Few present	Inshore	Dispersed	Inshore
Squawfish	Deep	Deep	Few present	Inshore	Offshore dispersed	Inshore
Cutthroat	Shallow	Dispersed shallow	Shallow	Inshore dispersed	Inshore	Dispersed
Whitefish	Few present	Few present	Few present	Inshore	Inshore	Inshore ?
Sucker	Few present	Few present	Absent	Inshore	Inshore	?
Dolly varden	Few present	Dispersed deep	Deep	Inshore	Inshore	Dispersed

Table V. Movements of fish in Lakelse Lake.

Species	Spawning period	Spawning location	Downriver spring migration	Peak downriver migration	Upstream fall migration	Peak of upriver migration
Peamouth	Jun	Inshore reeds, Tributary streams.	Very few	Jun	Very few	Sep
Squawfish	Jun-Jul	Rocky beaches, Inshore reeds, Tributary streams.	Very few	Jun	Very few	Sep
Cutthroat	Feb-Apr	Tributary streams Lakelse River.	Major spawning run.	Apr	Major feeding (?) migration.	Oct-Nov
Whitefish	Nov ?	Inshore areas.	Major feeding (?) run.	Apr-May	Major run preceeding spawning.	Oct
Sucker	May-Jul	Lakelse River.	Major spawning run.	May	?	Oct
Dolly varden	?	?	?	May	Major feeding (?) migration.	Oct

Data on the distribution of juvenile fishes, sculpin, lake shiners and stickleback is not sufficiently extensive to permit a thorough analysis at this time.

Cutthroat appear to be more or less divided into two discrete groups; lake resident fish and fish inhabiting the Lakelse River. Netting and creel data indicated that marks applied in the river and in the lake failed to mix to any extent (only one dubious case of an interchange was noted). However the dolly varden migrating upstream in the early fall were taken in the lake in the late fall indicating that the full lake population was recruited to some extent from the upstream migrant population. Whitefish migrating downstream in the spring probably represent a segment of a larger population resident in the Lakelse drainage area throughout the year; fish marked in the spring were followed as they re-entered the lake in the fall and again as they moved downstream in the spring. Following the spring migration marked fish were still present in the lake population, indicating an exchange of fish between the lake resident and the emigrating population.

Trap-netting experiments indicated that peamouth and squawfish have a tendency to return to the same spawning area each year. At Hotsprings Creek about 45% of the spawning run of peamouth had spawned in the creek in 1952. At the Mailbox Point spawning area almost 21% of the squawfish bore 1952 marks, while approximately 30% of the squawfish captured at Hotsprings Creek were marked.

M.P. Shepard

5. Abundance of lake fishes.

Estimates of the size of some of the lake populations have been made by following the dispersion of fish marked in 1952 and from information on the movements of the fish gained from gill-net catches and fence counts. The 1952 marking program was preliminary in nature. Thus the results outlined below must be considered tentative. A more extensive marking program has been designed for 1953-54.

Estimates of the size of the adult fish populations are summarized in Table VI.

Table VI. Approximate abundance of adult fish populations during the lake fall and winter in Lakelse Lake.

Species	Fall-winter population (X1000)	App. fiducial limits (95%) (X1000)	No. spring emigrants (X1000)
Peamouth	40	26-57	<1
Squawfish	50	28-91	<1
Cutthroat*	20	14-34	5
Whitefish	9	3-17	3
Sucker**	10	-	5
Dolly varden***	8	-	7

* Cutthroat include 5000 upper river residents.

** Suckers represent only population contributing to spawning in upper Lakelse River, and therefore is minimal. Based on 1947 estimate.

*** Estimate equals no. spring emigrants plus a few stream resident fish not migrating.

These estimates of abundance are discussed in relation to sockeye survival and predation in later sections.

M.P. Shepard

6. Diet of lake fishes.

Examination of the contents of predator stomachs collected during the fall of 1952 and the spring of 1953 corroborate findings summarized in last year's report. The most important general trend is the increase in fish feeding by predators from spring to fall. The incidence of prey fish in cutthroat and squawfish stomachs doubles from May to November, while the occurrence of sockeye shows an even greater increase (about five fold). The diet of the predator fishes will be the subject of a manuscript report to be circulated in 1954.

M.P. Shepard and T.H. Bilton

7. Predators and young sockeye.

The number of young sockeye removed by predators depends for the most part on the feeding habits, distribution and abundance of the predators. At this time only a preliminary assessment of the effects of predators can be presented. The following relations are apparent.

The amount of predation occurring during the spring is probably lower than in other seasons. Examination of stomach contents indicate that only a small proportion of the resident predator populations are feeding on sockeye. Changes in the habits and distribution of the fish confirm this evidence of a springtime low. During the spring both cutthroat and squawfish tend to move inshore where the emergence of insects provides a ready source of alternate food. Although these species are netted inshore most frequently, they do not appear to concentrate at the mouths of creeks from which sockeye fry are emigrating. Many of the dolly varden, vigorous predators during the winter, emigrate from the lake shortly after break-up.

A gradual movement of predators to the offshore waters occurs during the summer. This offshore movement is probably accompanied by an increase in sockeye feeding. Netting is necessarily restricted during the summer months by the presence of readily catchable adult sockeye in the lake. For this reason data collected during this period are scanty.

In the fall dispersion of fish to the offshore waters is evident. The incidence of sockeye feeding is increased five fold over that of the spring (according to 1952-53 figures). The gradual decline of insect fauna during the fall no doubt contributes to the diet shift. In the late fall a large population of dolly varden re-appear in the lake. Extensive sampling of this population during the month after its arrival indicated that the fish are present mainly in the inshore waters and exhibit a low rate of sockeye consumption.

When the winter ice cover forms, a dispersal of cutthroat and dolly varden occurs. A very high occurrence of sockeye in dolly varden stomachs is noted at this time.

A preliminary estimate of the removal of sockeye by predators may be made by combining data on representation of sockeye in predator stomachs, abundance of predators and a rough measure at predator digestive rates (as afforded by experiments conducted on the digestive rate of sockeye fry by a stream predator, the coho salmon). These estimates are very tenuous, but are valuable as a guide to further work. Correction and refinement will be made as further analysis is conducted and new studies are carried out.

The following rough figures have been computed. Cutthroat, exhibiting most active predation during the fall could remove about 800,000 sockeye annually. Squawfish approximately three times as numerous in the lake as cutthroat probably exert their most damaging effect on the sockeye in the late summer and fall and could have removed some 900,000 sockeye in the 1952-53 season. The predation of dolly varden on lacustrine salmon appears to be concentrated in the late fall and winter months and could account for a sockeye loss of about 400,000. The total removal by these three species according to these estimates lies in the vicinity of 2,000,000 sockeye.

The loss of sockeye between the time of emigration of fry from the creeks and the emigration of smolts from the lake a year later may be estimated from sockeye production figures. A run of approximately 16,000 adult sockeye deposited approximately 25,000,000 eggs in the spawning streams of Lakelse in 1951. Figures from Scully Creek suggest that 13.6% or about 3,400,000 eggs survived to the fry stage. The run of smolts from the lake in the spring of 1953 totalled approximately 400,000 indicating a loss of some 3,000,000 sockeye during their year's inhabitation of the lake. As outlined earlier, predation could readily account for about 2/3 of this loss (i.e., 2,000,000 sockeye eaten).

In view of the foregoing the possible effect of predation on the young sockeye population is apparent. The figures quoted are tentative and must be supported by a more complete analysis of the stomach sampling data and experiments on digestive rate before they can be accepted with assurance. A manuscript report detailing the present state of knowledge will be prepared during 1954.

It is felt that the present program is providing sufficient background information to enable the investigators to follow changes in the characteristics and habits of the fish population of Lakelse that might attend a predator control program. With detailed knowledge of the habits of the predator species a control program is being designed. It is felt that selective removal of squawfish might be the first step in such a program. An energetic sport fishery for cutthroat trout makes a program of general predator control undesirable. If a squawfish removal program was instituted, the effects would be interpreted in terms of changes in abundance and size of the emigrating sockeye smolt population and in the general abundance, growth and feeding habits of the other fishes of Lakelse.

8. Creel census, 1953. T.H. Bilton

The creel census began its fourth year of operation on May 1 and continued to September 5. As in past years as many fishermen as possible were contacted and the following information recorded; the number of hours fished, the numbers of each species of fish caught, time of catch, type of bait or lure used, area in which the fish were caught, the weather and number of marked fish recaptured. When time permitted, all the fish in each angler's catch were sampled for length, sex, state of sexual maturity and scales. Stomach samples were taken from approximately 30% of the cutthroat and dolly varden sampled.

(a) The catch. The catch per hour of cutthroat on the Lakelse River throughout the angling season of 1953 was lower than in previous years (see Table VII). Two reasons for the decline may be suggested; first, there was a greater proportion of unskilled anglers among the anglers this year and secondly, the major fishing effort was concentrated on the less productive areas of the river. There were twice as many anglers fishing on the Lakelse River in 1953 than in 1950, and one and one half times the number of anglers that fished on the river in 1952. A major proportion of the anglers in 1953 were new to the area, and had very little knowledge of the local fishing conditions. There is little doubt that these anglers would not fish as efficiently as the more experienced local anglers. Compared to 1952, the number of fish available to anglers fishing upstream from the Lakelse River fence was probably low in 1953. In the spring of 1952 a total of 777 cutthroat and 615 dolly varden migrated downstream through the fence. In 1953, 3,970 cutthroat and 6,159 dolly varden emigrated from the up-stream region. Improvement in fence design, facilitating the passage of fish was no doubt responsible for the increase in the runs. In both 1952 and 1953 the majority of the fishing effort was conducted upstream from the fence. It is felt that the unusually high catch/hour in 1952 (see table VII) was due to the concentration of fish upstream from the fence caused by the fence. The catch/hour of both cutthroat and dolly varden in 1953 was lower than in former years. This was felt to be due to the failure of fishermen to fish the areas downstream from the fence after the fish from the up-stream areas had migrated.

The catches of cutthroat in the lake were above the 1950-51 level but below the level observed in 1952. Recovery of marks in the population suggested that this drop in catch/hour was probably due more to changes in the skill of the anglers as a group rather than to a radical change in population size.

Table VII. Average yearly catch per hour of cutthroat and dolly varden.

	Year	No. hours fished	No. cutthroat	Catch per hour	No. dolly varden	Catch per hour
River						
	1950	409.5	576	1.406	20	.048
	1951	382.0	423	1.107	88	.230
	1952	441.5	915	2.072	397	.899
	1953	883.0	627	.710	242	.274
Lake						
	1950	647.0	671	1.037	13	.020
	1951	442.5	384	.867	8	.018
	1952	303.5	671	2.210		
	1953	415.0	589	1.419		

(b) Factors affecting the catch per hour. A preliminary analysis of the data was carried out to determine some of the factors affecting catch per hour.

The data suggest that the catch per hour decreased when the number of fishermen fishing on the lake on weekends or holidays increased. This might have been due to either a fishing out of an area due to heavy fishing pressure, followed up by recruitment when the fishing pressure decreased, or to the increased proportion of unskilled fishermen on holidays or weekends. The latter possibility is the most likely.

The catch per hour of cutthroat was higher in the evening than at any other period of the day.

Cloud coverage and winds may have an effect upon the catch per hour. Cloud coverage probably has no effect upon the catch of cutthroat on the lake, but it does affect the catch of trout on the Lakelse River. The catch per hour increases with the cloud coverage. The force of the winds effect the catch per hour on the lake and the river. The catch per hour of cutthroat on the lake decreased with increased winds. The catch per unit of effort was highest when the lake was calm. Winds had no effects upon the catches of cutthroat on the river till the force of the winds were sufficiently strong enough to create a good ripple on the water. Then the catch per hour increased.

In general it appears that the relationship between catch per hour and amount of effort is not a straight line relationship but is probably a curvelinear function. This fact is important when attempting to compare the results of fishing under different conditions when varying amounts of effort are expended.

9. Age and growth studies. T.H. Bilton

The age and growth studies of the lake fish populations were continued this year. Changes in the age composition and the growth rates of the piscivorous fish may be related to changes in the population density, or to the general abundance of food with particular emphasis placed upon the relation of growth and the yearly occurrence of young sockeye in the diets of these fish. The data may be used to compare the efficiencies of the methods used to sample the lake fish populations, e.g., trap-netting, gill-netting and angling.

The age determinations of the cutthroat sampled from the anglers' catches on the lake and on the Lakelse River in the creel census for 1952 were completed, as were age determinations of cutthroat captured in the fall gill-netting. The age determinations of the other lake fish species will be begun next year.

For the past three years the largest percentage of cutthroat in the anglers' catches were age III and age IV fish. The following table shows the number, the percentage of each age class in the samples, the mean size in inches of each age class and the samples of cutthroat caught on the lake and the Lakelse River in the creel census for 1950, 1951 and 1952.

Table VIII.

	II	III	IV	V	VI
1950					
No. fish	90	322	206	31	
% no.	13.86	49.30	31.74	4.77	
Mean length	8.38	10.79	12.17	14.45	
1951					
No. fish	20	216	189	39	
% no.	4.31	46.55	40.73	8.41	
Mean length	8.02	10.20	11.48	12.91	
1952					
No. fish	22	206	191	98	27
% no.	3.97	37.18	34.47	17.68	4.87
Mean length	7.90	9.86	11.16	12.29	13.58

The mean lengths of the cutthroat in all the age groups have decreased slightly each year.

The data suggest that the brood years of 1947 and 1948 were dominant year classes in the population. These year classes entered the fishery in 1950 as age III and age II fish and have moved through the fishery to age V and age IV cutthroat in 1952. The higher survival of the brood years of 1947 and 1948 may have placed a greater pressure upon the available food in the lake and resulted in an increase in intraspecific competition. This is suggested by the declining growth rates of the fish for the past three years and also the large variation in the sizes of cutthroat of the same ages.

Further evidence suggesting the presence of the dominant year classes in 1947 and 1948 is indicated by the higher percentages of age III cutthroat in the anglers' catches of 1950 and 1951. Three year olds made up approximately 50% of the anglers' catches. The catch of age III fish in 1952 was lower than in the preceding years. This suggests that the abundance of the 1949 year class is smaller than that of the preceding two brood years. Also competition between the dominant year classes and the 1949 year class is suggested by a further decline in the growth rates. By the end of 1954 it is probable that both the dominant year classes will have moved through the fishery. When this has occurred the catch per hour of cutthroat may decline significantly and the mean growth rates may increase.

In 1952 age VI cutthroat appeared in the anglers' catches for the first time. This suggests that there may have been either a higher survival of age V fish to age VI than is usual, or that the installation of the river fence in 1952 partially prevented the normal pre-fishing season downstream migration of cutthroat of this age class.

The cutthroat trout appear to become sexually mature at age IV and age V, with a small number attaining maturity at age III.

10. Comparison of length samples from three sampling methods. — T.H. Bilton

Gill-netting, angling and trap-netting are methods used to sample the lake fish populations. A study to determine the efficiency of two of the methods was begun this year.

Scale samples removed from cutthroat captured in the creel census and the fall gill-netting of 1952 were read and the age compositions of the catches of both the methods were determined.

Angling and gill-netting sampled the cutthroat population equally well with the exception of the age II fish. The gill-netting sampled a significantly higher percentage of age II fish than did the angling. Both methods sampled the remaining age groups with approximately equal efficiency. The slightly lower percentage of age IV and age V fish in the netting catch may have been due to a depletion of some of these older fish by the angling fishery during the summer months or by emigration of the larger fish down the river.

Table IX compares the age composition of the cutthroat captured by the creel census and the fall gill-netting. The mean length of adult fish taken in trap-nets is included.

Table IX

Age	II	III	IV	V	VI
Creel census, 1952					
No. fish	22	206	191	98	27
%	3.97	37.18	34.47	17.68	4.87
Mean length	7.90	9.86	11.16	12.29	13.58
Mean length of all fish captured - 10.76".					
Gill-netting, 1952.					
No. fish	50	132	108	39	20
%	14.32	37.82	30.94	11.18	5.73
Mean length	7.86	9.88	11.47	12.91	14.4
Mean length of all fish captured - 10.68".					
Trap-nets					
Mean length of all fish captured - 9.58".					

The average lengths of adult cutthroat captured by the angling and gill-netting were longer than those sampled in the trap-nets. There was a difference of one inch between the mean lengths of cutthroat captured by the trap-nets in 1952 and the other methods.

The individual gill-net meshes sampled several of the age groups, with one age group predominating in the catches of each of the meshes. The 1½ inch mesh captured chiefly age II fish, the 2 inch mesh age III, the 2½ inch mesh age IV, the 3 inch mesh age V and the 3½ inch mesh age VI fish. The data are summarized in Table X.

Table X. The percentage age composition of cutthroat captured by gill-nets of various sized meshes.

Mesh size		Age II	III	IV	V	VI
1½	No. fish	28	24	2	-	-
	% no.	51.8	44.4	3.8	-	-
2	No. fish	7	87	39	3	-
	% no.	5.1	63.9	28.6	2.4	
2½	No. fish	-	8	42	11	-
	% no.	-	13.1	68.8	18.1	-
3	No. fish	-	1	14	25	12
	% no.	-	1.9	26.9	48.0	23.2
3½	No. fish	-	-	-	3	6
	% no.	-	-	-	33.3	66.6

The age II cutthroat were probably not sampled by the gill-netting in proportion to their abundance. If a smaller mesh was used in addition to the present meshes in use a more complete picture of the total percentage representation of age II cutthroat in the population would be obtained.

Age determination of cutthroat and other lake fish captured by angling, gill-netting and trap-netting will be completed in the future and the age composition of the catches obtained by the various sampling methods will be compared.

B. Babine Lake.

F.C. Withler

Since the Babine River and Lake system has been found to be the major sockeye spawning area of the Skeena, representing perhaps as high as 70% of the total Skeena spawning, it is of importance to trace the correlation between the commercial catch for the Skeena with the Babine escapement, as revealed by the counts at the counting weir each season. Since estimates of the numbers of young sockeye migrating seaward from Babine Lake can be obtained it is of value to correlate also the extent of the migration of smolts with (a) the size of the commercial fishery and (b) the return of spawners to Babine. This may be of special value for prediction purposes.

The smolt estimates, when related to the presumed egg deposition in the brood year, indicate the percentage production of sockeye for a large sockeye spawning area. Studies of the spawning success, and of the seeding generally under the prevailing weather and stream conditions provide information on the probable fry hatch and the likely abundance of smolts a year later. Pertinent information on the factors causing wide fluctuations in runs from year to year may be obtained.

The manner in which and the extent to which smolt production varies with the size of the spawning population and the amount of seeding is of special interest. To what extent does the "resilience of the species" counteract the effect of a low or poor seeding? Valuable information on this point is being provided by the two relatively poor runs to Babine which resulted when the Babine River was partially blocked by a rock slide. The smolt production records of 1953 and 1954 will be particularly pertinent.

Special studies of fry production in one creek, Six Mile Creek, which is subject to wide fluctuations in water level - much greater than either Tally Creek at Port John or Scully Creek at Lakelse - provide information on the effect of water level and related conditions upon the production of sockeye fry. The data may also be used when related to observations on the Babine streams, to assess the success of fry production for the Babine area generally.

F.C. Withler and K.V. Aro

I. Adult studies.

Annual runs of sockeye salmon to the Babine Lake watershed have been enumerated at a counting weir in the Lower Babine River since 1946, except in 1948 when floods damaged the Babine River fence. The 1948 run was estimated by observations on the spawning grounds.

The earliest result of the weir operation was the discovery that runs to the Babine watershed constituted about 70% of the Skeena sockeye escapement. Since then the Babine weir figures have been regarded as the best single measure of the Skeena River sockeye escapement.

In 1951 the weir counts took on further importance. They confirmed the suspicion that a blockage had occurred in the almost inaccessible section of the Babine River between the counting weir and the Skeena River. The effects of the Babine slide, which impeded the runs of 1951 and 1952, were indicated by the counts and by observation of the condition of adults, and, in 1952, by recovery of salmon tagged in the slide area by the Department of Fisheries. The weir also in 1952 collected a large sample of dead adult salmon thus providing information of success of spawning in the Lower Babine River which is one of the major salmon spawning areas of the watershed.

The 1953 adult run, herein reported, is the first to pass the slide area after removal of the obstruction, and has been closely watched. Comparable samples of dead spawners from the Lower Babine River are being collected at the time of writing (October 19); an added refinement is a spawning ground tagging program to provide data on the normal length of life on the spawning grounds and on the total number of spawners. Tagged salmon from the slide area have again been recovered to compare an unblocked sockeye run with the runs of 1951 and 1952.

Because mere enumeration of the sockeye run to the Babine area may give a false picture of the run's spawning potential, extensive sampling is carried out on fish passing the weir. It is possible now to estimate within narrow limits the number of sockeye eggs potentially available for deposition in the Babine area. This spawning potential has been shown to vary more widely than the size of annual runs.

Although spring, coho, pink, and chum salmon do not spawn exclusively above the weir in the Babine system, these species are counted each year to provide indices of the sizes of those runs to the river.

1. Enumeration of salmon at the Babine fence.

K.V. Aro

Operations in 1953 began on July 4, when the panels were installed, and are expected to continue until November 1. The counts of the five species of salmon which passed through the weir in 1953 up to the time of writing

(October 19) are compared in the following table with counts obtained in other years.

Year	Sockeye	Percentage "jack" sockeye	Spring	Pink	Coho	Chum
1946	475,705	12.2	11,528	28,161	12,489	18
1947	522,561	47.7	15,614	55,421	10,252	7
1948	560,000*					
1949	509,132	9.4	7,433	13,663	11,938	5
1950	543,658	33.0	6,838	38,728	11,654	7
1951	152,457	7.2	2,778	50	2,122	0
1952	376,947	approx. 7.3	5,915	2,706	10,554	1
1953	714,536	approx. 4.2	8,353	1,018	7,611	17

* Estimated from comparison with stream survey counts and weir counts of previous years.

The counts in 1953 show considerable variation from both the slide and pre-slide counts.

Sockeye salmon occurred in greater numbers than in any previous year of operation. The first sockeye arrived on July 5. Thereafter the run increased gradually to an early peak of 12,102 sockeye on July 24. This early peak is characteristic of three of the four pre-slide runs. After the decline which followed the early peak the count again increased until August 23 when the maximum count (32,650 sockeye) was obtained. This peak falls midway between the earliest and latest peak days recorded in the pre-slide years. The daily count was over 20,000 for 14 days, August 16 to 29 inclusive, and was over 30,000 on 3 of these days. This peak period accounted for well over one-half of the total run. The large size of the peak run suggests that a very large portion of the Babine run passed through the estuary of the Skeena River during the 9-day closure (July 25 to August 2 inclusive) which was imposed on the commercial fishery by the Department of Fisheries. Following the peak period the daily counts fell off rapidly until September 14 when less than a thousand sockeye were counted. Thereafter the counts declined less rapidly until on October 19 only 15 sockeye passed through the fence.

The count of spring salmon was considerably higher than in the two slide years but below average by pre-slide standards. However, the escapement was probably good in terms of the potential egg deposition in that the run appeared to have a large proportion of females. The peak of the spring run occurred on the day previous to the sockeye peak. Since some spring salmon spawn below the Babine fence the count is not absolute but is a good annual index of the magnitude of the run.

The size of the pink salmon run in 1953 was of considerable interest in that the returning pinks were the progeny of those fish which were affected by the Babine slide in 1951. The 1953 count was one-thirteenth the size of the count in the cycle year 1949 but was twenty times that of the cycle year 1951. It is apparent that though the 1951 pink run was severely affected by the slide, some individuals managed to spawn successfully. The count of pink salmon is only an indication of the size of the run since the pinks, like the springs, spawn both above and below the Babine fence.

Coho salmon appeared in lower numbers than in pre-slide years and in lower numbers than in 1952, the second slide year. The largest number of coho was counted on September 10. Coho spawn in the Babine River both above and below the Babine fence, as well as in the streams tributary to Babine Lake and to the Babine River.

A few chum salmon again reached the Babine weir. The small number which enter the area are only of academic interest since chum salmon usually spawn closer to the sea.

2. Sampling at the Babine fence. K.V. Aro

Sampling is carried out throughout the period of the sockeye run to obtain details on the size of the fish, the sex ratio, the average number of eggs per female, the condition, and the sexual maturity. In addition the sockeye count is broken into definite periods for what is termed the "jack" count, i.e., to determine the proportion of "jacks" (precocious three-year-old males) occurring in the run. The proportion of large sockeye bearing injuries, net marks, and gaff marks is also noted.

The proportion of "jacks" in the 1953 run was approximately 4.2%. The percentage of large injured fish, other than ones with net marks and gaff marks, was 3% which is slightly less than average for 1947, 1949, and 1950, and considerably less than the 29.5% and the 31% recorded in 1951 and 1952 respectively. Fish with net marks formed approximately 4% of the large sockeye in the "jack" count. This figure is less than in all years with the exception of 1952.

As in previous years, one percent samples based on the previous half day's count were measured and sexed. In addition the fish sampled were examined for condition and sexual maturity to provide comparison with the slide-blocked fish of 1952. Scales were taken from these fish on every fifth day to obtain information on freshwater age and growth. From this one percent sample the sex ratio of the larger sockeye was found to be 44% males and 56% females. The average lengths were found to be 39.9, 62.4, and 60.3 centimeters for "jacks", larger males, and females, respectively.

For every 10,000 sockeye which passed the fence, one female was taken for an egg sample. The 71 females sampled carried an average of 3,498 eggs each. Since the number of females to pass the fence to the time of writing would be close to 382,000, the potential egg deposition would be in the vicinity of 1.3 billion eggs. This figure is approximately 400 million more than in the highest previous year (1949), and approximately one billion in excess of the low potential egg deposition of 1951. The large potential egg deposition is due to the large proportion of females in the large run and to the slightly larger than usual average egg content.

Remaining sampling data will be further analyzed and refined during the coming winter.

3. Babine slide area tagged fish recovered at the Babine fence. K.V. Aro

Sockeye, spring, pink, and coho salmon were tagged by the Department of Fisheries in the Babine slide area during the summer of 1953. The object was to provide information on the passage of salmon through the slide area when no blockage existed in the river, for comparison with information obtained from the 1952 tagging when the blockage was present.

Tagged fish which reached the Babine weir were stopped and examined in 1953, as in 1952. The number of the tag, and information concerning the species, length, condition, and sexual maturity were recorded for 2,111 fish.

Comparable information, plus the degree of spawning, have been recorded for tagged fish which died and drifted back on the weir. Up to the time of writing, data have been collected on 115 tagged individuals.

4. Success of spawning and estimation of size of the run on the Lower Babine River.

F.C. Withler, K.V. Aro and E. Dombroski

To date (October 19) over 53,000 dead sockeye spawners drifting against the Babine weir have been examined for the degree of spawning. In the sample over 99% of the males showed signs of having spawned successfully. The records for females are given below with comparable figures for 1952, one of the years in which the sockeye adult run was impeded by the Babine River slide:

Year	Number of females examined	Completely spawned	Partially spawned	Unspawned
1952	9,600	25%	6%	69%
1953	26,000	89%	9%	2%

The unblocked female spawners of 1953 appear to have been far more successful than those of 1952.

Examination of spring and pink salmon spawners among the samples indicates that these species also spawned successfully in the region above the weir. Coho as yet have not spawned in large numbers.

During spawning on the Lower Babine River, 360 tags were affixed to sockeye to facilitate estimating the size of the Lower Babine River run and to illustrate the length of time spawners spend on the spawning grounds. To date 114 tagged sockeye have been recovered.

5. The Babine slide report.

H. Godfrey

A report on the effects of the slide of rock in the Babine River on the salmon runs of 1951 and 1952 has been compiled by the writer, with co-authors W.R. Hourston and J.W. Stokes of the Fish Culture and Development Branch in Vancouver, and F.C. Withler of this Station. The report is to be published shortly as a Bulletin of the Fisheries Research Board of Canada.

The writer was employed by the Department of Fisheries in Vancouver, in the analysis of data on which the report is based, from January to June of this year. On July 1 he was appointed to the staff of the Pacific Biological Station to develop future limnological studies at Lakelse, and to complete the above report and to prepare a second report on the slide. This second report will describe the condition and fate of the Babine salmon runs of 1953 subsequent to the removal of the slide during the foregoing winter.

The investigations into the effects of the slide called for the cooperative efforts of personnel of the Fisheries Research Board, the Fish Culture and Development Branch, and Fisheries Inspectors. Acknowledgments to individuals will be made in the above reports.

In 1952 and 1953, crews from the Fish Culture and Development Branch tagged fish at and below the slide. At the Fisheries Research Board counting weir the salmon runs into Babine Lake were counted and sampled, tagged fish were recovered, and the dead fish which drifted back onto the fence were counted and examined for degree of spawning. The Fisheries Inspector at Babine

Lake, assisted by personnel of the Fish Culture and Development Branch, surveyed the Babine spawning streams to estimate the spawning populations, to recover tags, and to examine dead salmon for their spawning condition.

Estimates of sockeye losses at the slide in 1951 and 1952 were made by recourse to a relationship between Babine fence counts in earlier years, and the commercial catch of Skeena sockeye. Losses beyond the fence, and estimates of the effective spawning in 1952, were determined on the basis of comparisons of tag returns from streams in that year with those of 1946 and 1947 (when the Board tagged sockeye at the Babine fence), and the spawning condition of dead fish examined at the fence and on the streams.

II. Smolt studies.

F.C. Withler, K.V. Aro, and E. Dombroski

With the accurate picture of each year's potential egg deposition by the adult run provided by the Babine weir counts, a valuable addition to the Babine population assessment program is the estimation of the number of smolts emanating from different sizes and constitutions of spawning stocks. Because fencing the Babine River in such a way as to collect all smolts would be a costly and effort-consuming task, techniques involving the release of marked smolts and their subsequent recapture in large samples have been employed to determine the sizes of annual smolt emigrations.

As well as demonstrating the spawning stock to production relationship, estimates of sizes of smolt runs may provide a method of predicting the sizes of future Babine sockeye runs. An immediate practical significance of Babine smolt estimations results from manipulation of those runs which arise from the slide-blocked adult runs of 1951 and 1952. (The smolt run of this year arose from the adult run of 1951 which was seriously reduced by the slide.) The size of the smolt runs of 1953 and 1954 will give a final measure of the effects of the Babine slide.

Concurrent with estimation of numbers is an auxiliary program designed to clarify the pattern of migration of Babine smolts and to demonstrate the sources of error which may be present in the estimation procedure. These are partly demonstrated by marking smolts with distinctive threads for subsequent recapture, and by numerous observations of behaviour.

This year a preliminary study of food habits of waterfowl in the Fort Babine area, where all Babine smolts are funnelled into the river from the lake and where the fry emerging from the major spawning grounds of the Upper and Lower Babine Rivers must pass into Babine Lake, was begun.

1. Estimation of size of runs in 1951, 1952, and 1953.

F.C. Withler

The method employed to estimate the size of the annual smolt run from Babine Lake involves the capture of a portion of the daily run at the outlet of the lake, the marking (by fin clipping) of known proportions of each day's catch, and the subsequent recovery of some of the marked fish at a site some eight miles downstream, in large daily samples. The seasonal ratio of marked to unmarked smolts in the recovered samples is used to calculate the size of the total run of smolts passing out of Babine Lake into the Babine River.

The capture site at Fort Babine has remained unchanged, and the methods and times of capture have been kept nearly uniform for the three years of operation. The recovery site and the method of recovery have been altered somewhat in every year until the means of recovering the largest daily samples has been found. The site employed in 1953 proved most efficient for recovery and this site will be maintained for future operation.

The total annual numbers of smolts marked and released, the total numbers of marked fish recovered and the total samples recovered are given below with the estimates of size of runs:

	No. of smolts marked	No. of marked smolts recovered	Size of sample examined	Estimated size of run
1951	34,689	200	21,855	4,200,000?*
1952	33,880**	646**	86,391	4,500,000
1953	61,950	2,498	124,396	3,100,000

* Observations made in 1952 and 1953 suggest that approximately 10% of the run had passed before marking began in 1951. As a result the estimate has been corrected to include the portion of the run missed.

** In 1952, the number of marked fish released and recaptured was adjusted to give them values corresponding to 10% of daily catches at the capture site. When the proportion of fish marked in daily catches changed, distinctive marks were employed to allow identification upon recapture.

Certain errors in estimation of the smolt run cannot yet be accurately measured. They are currently being given careful study. In due course correction factors may be applied to the data here reported.

Below are given the depositions for the years 1949, 1950 and 1951, and the estimated numbers of smolts resulting in the runs of 1951, 1952 and 1953. The percentage calculations are based on the assumption that the bulk of the smolts are I-year fish.

	1949	1950	1951
Eggs potentially available	875,500,000	582,700,000	196,900,000
Estimated number of smolts resulting	4,200,000?	4,500,000	3,000,000
Survival from egg to smolt	0.48%	0.77%	1.52%

The data so far indicate that heavier spawning potentials may produce greater absolute numbers of smolts, but that the efficiency is reduced as the number of spawners increases. Only when further estimations have been made will it be possible to demonstrate whether or not the suggested effect is real and not related to such coincidental factors as stream water levels or temperatures, or lake conditions, etc.

Of practical significance is the suggestion that, though the 1951 adult run was reduced to about one third the usual (or to about 150,000) by the Babine River slide, the resultant smolt run was about two thirds that of previous unblocked adult runs. The smolt run of 1954 will be the product of another affected adult run (that of 1952 of 377,000 sockeye), while the smolt run of 1955 will consist of the progeny of the large unblocked 1953 run of 715,000 sockeye.

2. Time and speed of migration. F.C. Withler and K.V. Aro

Smolt capture and recovery extend over almost all of the run in such a way that fishing begins and ends when catches are very low. A few smolts have been observed passing before May 20 and after July 1 in most years but the vast majority are observed during the usual fishing season. The following table shows the fishing seasons and the times of peak run:

	Fishing started	Fishing ended	Peak run
1951	May 23	Jul 1	Jun 1 and 6
1952	May 27	Jul 3	Jun 5
1953	May 21	Jun 30	Jun 8

By marking some of the smolts with different coloured threads, it has been possible to demonstrate the length of time required for smolts to migrate from Fort Babine down the Upper Babine River and through Nilkitkwa Lake to the recovery site (a distance of approximately 8 miles).

	No. of thread marks recovered	Range of time out	Average time out
1951	11	2-6 days	3.4 days
1952	100	1-11 days	3.4 days
1953	62	1-8 days	2.9 days

Throughout the smolt run records of water level, water temperature and weather conditions are kept in addition to the regular spring, summer, and fall readings which are kept daily at the Babine fence. Copious notes on the number, size, distribution and behaviour of smolt schools are kept, with any other pertinent observations which may affect the pattern of the migration.

As a preliminary step toward plotting the movement of smolts out of Babine Lake and through Nilkitkwa Lake, a detailed sounding survey of the whole of Nilkitkwa Lake was carried out in June. Some preliminary use of submerged current indicators suggests that the water movements associated with the smolt migration could be described.

3. Age, sex, growth, and parasite studies of sockeye smolts. E. Dombroski

Smolt samples taken in 1951 and 1952 have been analyzed for age composition, sex distribution, and average size of smolts in the run. Measurements and circuli counts have been made on scales from all smolts taken in 1952 to demonstrate the amount of growth in the first and second years of life in fresh water. The incidence of cestode infestation in the samples has been recorded.

The 1953 sample involving 1% of the daily catch at Fort Babine, will be studied in a manner similar to that of 1952. This sample should demonstrate whether or not the relatively large run of smolts in 1953 was the progeny of the 1951 slide-blocked run, or if the run consisted of significant numbers of smolts originating from the unblocked 1950 run.

4. Wildfowl food studies in the Fort Babine area. F.C. Withler and I.V.F. Allen

During the months from May to September, 1953, representatives of several species of wild fowl including gulls, mergansers, grebes, and loons were collected from the Upper Babine River, Nilkitkwa Lake, and the Lower Babine River. Censuses of wild fowl in the area were also made. Contents of the digestive tracts have been preserved for analysis this winter.

Moderate concentrations of wild fowl are seen in the Fort Babine area at some seasons of the year including May and June when fry from the Upper and Lower Babine Rivers are numerous and smolts are emigrating in large numbers from Babine Lake. Study of wildfowl food habits and numbers should demonstrate whether or not they are serious predators on the young sockeye populations.

III. Fry production studies. F.C. Withler and E. Dombroski

To illustrate the degree of spawning success of sockeye and to describe the factors limiting the survival from egg to fry, an adult-fry counting weir was constructed in a small tributary to Babine Lake in 1950. Six Mile Creek typifies the smaller unstable Babine streams which in some years carry moderate numbers of spawners. These streams provide more variable environments for spawners and their progeny than the stable lake-controlled rivers such as the Fulton, Fifteen Mile and Babine.

The effect of summer stream conditions on spawners is assessed by numerous stream surveys and by tagging. These provide data on dispersal of spawners on the grounds, their response to the conditions which prevail, and their success in depositing the eggs in the gravel. Progressive losses during development to fry emergence are followed by examination of eggs in the redds; and the final survival from egg to fry is determined from the fry fence count in the spring following deposition. Constant records of water level and temperature provide a picture of stream conditions during the winter when the stream is not under close observation.

In an attempt to relate survival figures in Six Mile Creek to other streams on Babine Lake, spawning pens, in which spawners deposit eggs which later can be recovered, have been devised. If successful, these pens may be installed in neighbouring streams next year.

1. Enumeration of spawners. E. Dombroski

The Six Mile adult counting weir was operated from July 15 to September 10 of this year. Sockeye were observed off the creek mouth on July 24, with the first passing through the weir two days later. The peak of the run was reached on August 3, when 378 sockeye were counted. The run terminated on September 6, with a total count of 2,671. Fish other than sockeye were also enumerated: 91 kokanee and 40 rainbow trout. The 1953 run to Six Mile arrived 10 days earlier than the 1950 run, and was approximately twice as large.

2. Sampling of spawners. E. Dombroski

As in 1950, every sockeye was measured and sexed prior to its release into the stream. The sex distribution among the sockeye was 1,337 (50.2%) large males, 57 (2.1%) small males or "jacks", and 1,269 (47.7%) females. The proportion of females to males was greater in the 1953 run than in the run of 1950.

Kokanee released above the fence were measured and an attempt was made to sex each one by expressing a small amount of reproductive material. The early arrivals lacked secondary sexual characteristics and could not be sexed. The male kokanee numbered 56, females 20, while 15 were recorded as "sex unknown".

All rainbow trout were measured to determine their average size. The majority of this species stayed within the vicinity of the weir, and died within a short time of their arrival. Although a few stomach samples yielded dead and live sockeye eggs, most stomachs were found to be empty.

The condition (head and body injuries) of all sockeye was noted for purposes of comparison with those taken at the Babine River counting weir; also for comparison of the frequency of normal unspawned sockeye with that of injured unspawned sockeye. The data compiled will be analyzed later.

The eggs in every twenty-fifth female sockeye were counted to determine the average number of eggs carried into the stream by each female. After 500 females had passed through the fence the frequency of the egg sampling was changed to one in fifty in the anticipation that the run would be unusually large. The average number of eggs per female sockeye (35 samples) was 3,452. This figure compares closely with the average egg count per female sockeye passing through the Babine River fence, which was found to be 3,498. This fact indicates that females entering Six Mile carried their full complement of eggs.

Female kokanee entering Six Mile were also sampled for egg content. Five random samples were taken, and the average number of eggs per female was found to be 380.

A tagging program was undertaken this year to demonstrate the distribution of sockeye on the spawning beds. At the same time this procedure afforded an excellent opportunity to check the results of the Petersen method of estimating population size by tagging. Every tenth sockeye entering the stream was tagged; the tag number was recorded to establish the time of entry; and various coloured baffles were used to facilitate observation on the movements and/or distribution of live tagged sockeye during stream surveys. For similar reasons every tenth kokanee released above the fence was tagged.

Data were collected on sockeye passing through the fence which had been tagged previously at the Babine River slide area. In all, 24 Babine River tagged sockeye were examined. The majority arrived in the first week of the Six Mile run.

3. <u>Stream surveys.</u> E. Dombroski

Stream surveys were undertaken every four days to establish the following:

(a) the ratio of tagged to untagged sockeye (and their sexes) dying since the previous survey,

(b) the distribution of live and dead tagged sockeye relative to the previous survey,

(c) the number of eggs retained by the females.