CONFIDENTIAL

…ERIES RESEARCH BOARD OF CANADA
ANNUAL REPORT

…FIC BIOLOGICAL STATION

…B.C.

INDEX TO SUMMARY REPORTS FOR 1952

R. E. Foerster

SOCKEYE SALMON INVESTIGATIONS

The principal objective of sockeye salmon research has been stated to be to achieve (a) an understanding of the natural production of sockeye through all phases of the life-cycle under prevailing climatic and environmental conditions, (b) an appreciation of the extent of the losses occurring at each stage and their causes thereof, and (c) an assessment of what remedial measures may be feasible. With this information available some effective effort may be undertaken to increase the present rate of production and thus maintain and perhaps increase the commercial utilization of the resource; some means may be invoked of continuing this resource in the face of present and future conflicting and jeopardizing influences caused by development of other natural resources, e.g., lumber, hydro-electric power, agriculture, and the gradual spreading of land settlement.

Such research embraces all phases of the life-history but particularly the early freshwater phases. It must reveal the relationship of the fish to the environmental conditions and to predator and competitor species under those ranges of variations in climate and environment which are likely to be encountered normally. It must be planned, therefore, to be comprehensive and to be continued over a sufficiently long-enough period to include all reasonable conditions of climate and environment.

Since sockeye salmon occur in coastal areas and in climatically-different portions of the interior of British Columbia a study of sockeye production in a number of these regions can provide a greater range of conditions, climatic and environmental, than would be possible at one location. Therefore, three centres of research have been set up, at Port John, in the central area of the B. C. coast (near Ocean Falls), at Lakelse Lake, some 100 miles up the Skeena, and at Babine Lake, an important inland tributary of the Skeena River system. In each of these areas investigations are being made of spawning escapements, egg incubation and fry survivals, lake residence, and seaward smolt survivals, under the climatic and environmental conditions which occur and concerning which records are kept.

For convenience the studies are divided up into life-history periods for each of which mortalities, the causes thereof, and other pertinent data can be determined. The summary reports of results of work done during 1952 - in some cases late 1951 findings are also reported - are grouped together in this way, rather than by geographical location.

Spawning escapement and egg deposition, 1951

The numbers of sockeye contained in the spawning runs to each area, the ratio of the sexes, and the average egg content of the female fish - varying with size - are all factors in the calculation of the presumed egg deposition. The latter is, of course, the base for calculations of subsequent survival of eggs, fry, smolts, and adults and of percentage efficiency of natural propagation.

In last year's Annual Report an account was given of the numbers of sockeye in the spawning run to the Babine Lake area. An analysis of this run has since been made and is dealt with in Appendix 2. Consideration is also given to the analysis of samples taken in 1951 from the commercial sockeye packs of the Skeena, Nass, Rivers Inlet, and Smith Inlet areas (Appendix 3) and special attention was given to a comparison of the fish on the spawning grounds at Rivers Inlet with those sampled from the gill-net fishery (Appendix 4).

R. E. Foerster

In the Port John experimental area, the sockeye pass up Hooknose Creek and proceed through Port John Lake to the spawning grounds in Tally Creek. The return of marked fish to Hooknose in 1951 indicated a return from the sea of 3% of the smolts marked in 1949 (Appendix 5). The returns to Tally Creek represented only 85% of the Hooknose Creek counts (Appendix 6) and an explanation of the loss is given.

Fry studies and per cent survival from egg deposition

From the egg deposition in Tally Creek in 1951, a survival of 9.8% to the fry stage was revealed (Appendix 7). A portion of the fry run - from Tally Creek to Port John Lake - was marked in an effort to determine, on recovery as smolts as they leave the lake, their age at that time. Some fry, perhaps from seedings in Hooknose Creek itself, migrated directly to sea. Survival will depend to a great extent on their tolerance to sea-water. Experiments on the salinity tolerance have been made (Appendix 8). At Scully Creek, Lakelse Lake, a fry survival of 13.6% of eggs deposited was obtained (Appendix 9). Here, too, fry were marked for smolt age-determination (Appendix 10). Studies were made (Appendices 11, 13) of the fry losses in the creek and the extent to which predator fish were responsible. At Six-Mile Creek, Babine Lake, no fry counts were made (Appendix 14). Because of drought conditions in the fall of 1951, no sockeye spawning occurred.

Smolt migrations and per cent survival

At Port John (Hooknose Creek) smolt counts indicated a migration of 11,038 fish (Appendix 15). Over 800 fry were also taken. At Lakelse River a new smolt-counting weir was operated for the first season. Both sockeye (Appendix 16) and coho seaward migrants (Appendix 17) were taken and samples collected for later analysis as to age, etc. During the seaward migration period, losses due to predator fishes occur. A study of this problem was commenced this spring on the Lakelse River (Appendix 18). At Babine, only estimations of the number of smolts could be made and the technique and results for 1952 are given in Appendix 19. During the winter of 1951-52 an analysis was made of the sockeye smolt samples from the 1951 migration for age-classes, size-frequencies, and sex-ratios. These are reported in Appendix 20.

Lake studies

Heavy mortality among young sockeye takes place during the one- or two-year residence in a lake. Limnological conditions (physio-chemical) and plankton food availability and/or abundance during this period are no doubt influential factors; activity and abundance of predator and competitor species are undoubtedly also intimately involved.

A. Limnology. For Port John Lake a report of a two-year limnological study is in preparation. Some late autumn records for 1951 are given (Appendix 21). For Lakelse Lake, a long-term intensive programme of research is being developed. The survival of the young sockeye in the lake is dependent on the food materials available (plankton) and the physical conditions within the lake. The food supply is in turn dependent on the chemical composition of the water and on sunlight. The chemistry of the water is governed by the types of mineral formation of the areas draining into the lake and the meteorology of the region, chiefly the annual precipitation.

It has been with this general relationship in mind that the Lakelse limnological programme has been designed. Analyses of the lake waters and of the influent and effluent streams for nitrate and nitrite nitrogen, phosphates and silicates have been carried out (Appendix 22) to correlate the chemical composition of the waters and its fluctuations with the geological formation of the drainage area, with meteorological conditions (Appendices 23, 24) and with plankton abundance within the lake (Appendix 25). Eventually, through the plankton populations, the chemistry can be related to the survival and growth of young sockeye during their period of lake residence. The contribution of inorganic and organic nutritive substances provided annually by decomposing salmon carcasses is also being investigated (Appendix 26).

B. Lake-fish studies. The effects of predation and interspecific competition on the survival of lacustrine sockeye are dependent on a sound knowledge of (1) the size of the predator and competitor populations, (2) the degree to which the distribution of fish overlap, (3) the representation of sockeye in the diet of predators, (4) the extent to which competitors compete for the same food as the sockeye, and (5) the rate at which sockeye are digested by the predators. To obtain this basic information a population estimation programme involving the marking of predators captured in traps and by angling was undertaken (Appendices 18,27). Gill-netting was carried on, on the one hand to make a comparison of catches in 1952 with those of an earlier year, 1947 (Appendix 28) and, on the other, to examine critically the techniques (Appendix 29). Creel census studies, giving a measure of the abundance of trout and char in the lake, were continued (Appendix 30); stomach-content analyses were made to gain information on trout and squawfish diets (Appendix 31) and additional stomachs were collected (Appendix 32). From samples of the fish examined in the creel census, material for age- and growth-studies of trout and char is obtained (Appendix 33) and yields valuable information on population changes. These may have a direct bearing on young sockeye survival in the lake. Since sockeye are resident in the lake throughout one winter at least it is important that the lake conditions during that period also be examined. The results of net-sets made during the winter of 1951-52 are reported in Appendix 34.

For comparison with the Lakelse Lake data and to contribute further to the knowledge of predator populations and their relation to sockeye survival, some studies were made at Port John in late 1951 (Appendix 35) and a "follow-up" analysis of data for Cultus Lake was undertaken (Appendix 36).

The problem of parasitism and disease among lake fish, including sockeye, is one which has received little attention. It could be a matter of much significance in certain years and under certain limnological conditions. Some observations were made at Lakelse Lake in 1952 (Appendix 37) and will be followed henceforth.

The capture of young sockeye during their period of lake residence would make it possible to collect valuable information on growth-rates, diets, regions of the lake usually occupied, etc. Such capture has been found extremely difficult. Further attempts were made in 1952 (Appendix 38) and will be carried further, it is expected, in 1953.

Spawning escapements, 1952, and losses among adults prior to spawning

With the initial operation of the new Lakelse River smolt-adult salmon counting weir it was possible this season to study (Appendix 39) the adult sockeye run, which arrives relatively early in the season (June to August, chiefly), check the subsequent distribution of the fish to the spawning streams (Appendices 40, 41) and determine the loss occurring in the lake during the maturing period (Appendix 42). Findings from the latter study may have an important bearing on assessment of lake losses among adult sockeye in other areas.

R. E. Foerster

For the Babine area where a rock-slide in the lower section of the river blocked a large portion of the spawning escapement in 1951 and where some efforts to alleviate the difficulty had been undertaken during 1952, counts of salmon arriving at the counting weir were made (Appendix 43) and sampling done (Appendix 44) to ascertain the condition of the fish and obtain particulars as to sex proportions, size ranges and egg-content. Observations on the success of the 1952 spawning and the likely egg deposition are outlined in Appendix 45.

Sampling of the commercial sockeye catches on the Skeena and Nass rivers and at Rivers and Smith inlets was again undertaken. For Rivers Inlet a comparison of the fish on the spawning grounds and those taken by commercial gear was again made (Appendix 46) to identify any selective effect of the gill-net fishery on the sizes and age-groups of sockeye.

During the year the following members of staff, full-time and seasonal, participated in the sockeye salmon research studies:

<u>Lakelse Lake</u>

Scientific:

T. H. Bilton - creel census; lake-fish age and growth
R. E. Foerster - seaward migration of sockeye
J. G. McDonald - Scully Creek sockeye fry production
V. H. McMahon - limnology, plankton
M. P. Shepard - lake fish; Williams Creek sockeye observations

Seasonal:- A. W. Beach, G. G. Futcher, E. D. Lane, R. J. LeBrasseur, C. G. McDiarmid, T. M. Mitchell, I. L. Withler

Technical:

J. C. Chatwin, E. L. Hollett (seasonal), J. A. Paul, J. Martell

<u>Babine Lake</u>

Scientific:

K. V. Aro - smolt estimation; weir operation
E. Dombroski - smolt estimation; Six-Mile Creek sockeye production
F. C. Withler - in charge; counting weir operation, spawning observations

Seasonal:- H. J. Heilbron, R. P. Hogan, G. R. Robertson, A. B. Stephenson, V. R. Taylor, J. A. Thomson

Technical:

R. H. Eaton, D. W. Murray, L. Quickenden

<u>Coastal Area Sampling</u> (part season only)

D. R. Foskett (Rivers Inlet)
G. G. Futcher (Skeena)
C. G. McDiarmid (Nass)

Scale reading, spawning surveys - D. R. Foskett

Administration and direction - R. E. Foerster
Mrs. R. Taylor, Secretary

The Port John experimental area observations were made by the staff there, who are listed under "Pink and Chum Salmon". Their co-operation and interest are gratefully acknowledged.

K. V. Aro

Appendix No. 2

ANALYSIS OF THE 1951 BABINE SOCKEYE RUN

The Babine counting weir is operated primarily to obtain an accurate numerical count of the adult sockeye returning to spawn at Babine Lake. The weir is valuable, secondarily, in that it provides the means for sampling these runs. Both the numerical count and the sampling carried out in 1951 were of particular value in view of the rock-slide in the Babine River which obstructed the salmon runs. The numerical counts of the salmon which passed the counting weir were reported in Appendix 19 of the Annual Report for 1951 of the Pacific Biological Station. The present report will deal briefly with results of the sockeye sampling.

Sex ratio

In the 1951 sockeye run 46.3% of the fish were females, 3.8% "jacks" (precocious three-year-old males), and 49.9% large males (four-year-old and older fish). The proportion of females was close to the average for past years, the proportion of "jacks" was low, and the proportion of large males was higher than usual. The 1951 Babine sockeye run thus consisted of 70,573 females and 81,884 males, of which 5,806 were "jacks".

Length

The average lengths of the females, "jacks", and large males were 58.4 cm. (23"), 38.9 cm. (15¼") and 60.1 cm. (23¾") respectively. Comparison of these figures with those obtained in other years revealed that the females and large males were larger with the exception of 1949 while the "jacks" were larger than in 1949 and 1950 but smaller than in 1946 and 1947.

Age

To determine the age composition of the 1951 sockeye run, length frequency distributions were plotted of the fish sampled for length and sex. The percentage age composition of the males and females is shown in the following table:

Age	Males	Females	Total run
3_2	8	0	4
4_2	50	60	55
5_2	42	40	41

The predominance of four-year-old fish over the five-year-olds is the converse of the situation in the commercial catches taken in the Skeena gill-net area where five-year-olds were predominant. This difference may be attributed either to a greater selectivity of five-year-olds by the gill-nets or to the presence in the fishing area of large numbers of five-year-old fish from other spawning areas of the Skeena River.

"Jack" count

An additional check on the proportion of "jacks" in the 1951 run placed the proportion of "jacks" at 7.2%, as determined from an observed sample of 5.2% of the run. The discrepancy between this figure and that obtained from the length-sex sample is probably due to sampling errors and is of negligible proportions. Both figures are well below those obtained in other years when "jacks" have formed from 9.4% to 47.7% of the runs.

K. V. Aro

Injured sockeye

The "jack count" sampling also showed that 29.5% of the large sockeye ("jacks" excluded) were injured. In other years injured fish formed from 3.0% to 6.5% of the runs. The greater proportion of injured sockeye in 1951 can undoubtedly be attributed to the rock-slide in the Babine River.

Potential egg deposition

The average egg content of the female sockeye was found to be 3525, somewhat higher than usual. As the average size of the females in the egg sample was larger than the general average for females in the run, as sampled for length and sex, the figure was adjusted to give a most probable egg content of 3229 eggs per female. The potential egg deposition for 1951 is, therefore, 227,880,000 eggs. Comparison with potential egg depositions in other years shows that the 1951 seeding was approximately one-third, one-half, one-quarter and one-third of the size of the potential egg depositions in 1946, 1947, 1949, and 1950 respectively.

The sampling carried out at the Babine counting weir showed that, with the exception of the low proportion of "jacks" and the high proportion of injured individuals, the composition of the 1951 sockeye run to Babine Lake was generally similar to that of other years. The potential egg deposition was comparatively small because of the reduced size of the 1951 run.

D. R. Foskett

Appendix No. 3

SOCKEYE SALMON AGE DETERMINATIONS

Sampling of the commercial catches of sockeye on the Nass and Skeena rivers and in Rivers and Smith inlets was continued. Paper No. 37 in the series "Contributions to the Life History of the Sockeye Salmon", covering the 1951 run, has been submitted to the Provincial Fisheries Department for publication.

In all, 7972 samples were obtained as follows: Nass River, 2901; Skeena River, 2978; Rivers Inlet, 1420; and Smith Inlet, 673. In addition, data on individual catches and net mesh used were obtained in the Rivers Inlet area but these await analysis.

The Nass River pack of 24,405 cases was very good for that river. The catch consisted chiefly of 4_2 and 5_3 age-class fish with 5_2 and 6_3 groups constituting the bulk of the remainder.

The Skeena pack of 61,694 cases about equalled the 10-year average of 61,720 cases. The fish were chiefly in the 4_2 and 5_2 age-groups, the latter comprising over 61% of the sample.

The Rivers Inlet pack of 102,565 cases was well above the average of 78,004 cases for the past ten years. The fish were mostly in the 5_2 age-class (60%) with most of the remainder being in the 4_2 group (38%). Sampling on the spawning grounds indicated that the bulk of the escapement came from the ends of size range of the fish.

The Smith Inlet pack of 49,473 cases was the highest recorded in statistics going back 26 years. This was due not only to the numbers of fish but also to the high average weight of the fish, 7.24 pounds. The 5_2 age-class constituted 77.6% of the catch sample and the 4_2 age-class 21.9%.

D. R. Foskett

Appendix No. 4

SPAWNING GROUND SAMPLES AT RIVERS INLET, 1951

During October 1951 a trip was made to the sockeye spawning streams tributary to Owikeno Lake at the head of Rivers Inlet. Samples were taken of the spawned-out sockeye for comparison with the samples taken from the commercial catch. The samples were taken only in October and thus do not represent the early runs nor the latest runs. Due to the advanced stage of absorption the scale samples taken could not be used for age determinations. However length frequencies were used in the analysis and it is felt that the results from this method were fairly accurate.

It was found that the length distribution on the spawning grounds was complementary to that of the commercial catch, the bulk of the escapement coming from the extreme ends of the size range. The precocious three-year-old males, the "jacks", though negligible in the commercial catch, constituted a large part of the spawning population in some of the streams. These "jack" sockeye are of almost no value to the commercial fishery and if this precociousness is inheritable it could be a serious factor in a spawning population. Certainly there seems to be some linkage between sex and age at maturity in the Rivers and Smith Inlet sockeye.

The analysis of the samples and the comparison between them and the commercial catch samples are dealt with in No. 37 of the series "Contributions to the Life History of the Sockeye Salmon" which will appear in the 1951 Annual Report of the British Columbia Department of Fisheries.

M. P. Shepard and J. G. Hunter

Appendix No. 5

ADULT SOCKEYE SPAWNING ESCAPEMENT, PORT JOHN, 1951

The run of sockeye to the Port John spawning areas (chiefly Tally Creek), as indicated by the numbers of fish passing through the Hooknose Creek counting weir, amounted to 1182 fish. Of these, 773 were precociously-maturing males in their third year - "jacks". The remainder were 174 marked and 7 unmarked males and 214 marked and 14 unmarked females.

The marked individuals represent a return from the marking of 19,486 sockeye in the spring of 1949 as they passed to sea from Hooknose Creek. These 388 recaptures, together with 194 marked "jacks" taken in 1950, indicate a total return, to date, of close to 3%. Very few marked sockeye recoveries were reported from the commercial fishery. The possible differential mortality due to handling and marking has not yet been assessed.

In 1951 a phenomenal run of "jacks" occurred. The following table shows the comparison with previous years' "jack" representation:

Year	Total sockeye run	Total "jack" run	Per cent "jacks" in run
1948	231	1	.4
1949	2,245	325	14.5
1950	658*	196*	29.8*
1951	1,182	773	65.4

* Tally Creek counts

Appendix No. 6

M. P. Shepard

ADULT SALMON MIGRATION AT TALLY CREEK, PORT JOHN, 1951

The adult counting fence on Tally Creek was installed on June 19, immediately after the removal of the fry fence. The total counts of salmon, trout and char passing through the fence are listed in Table I.

Table I. Total counts of adult salmon and trout passing through Tally Creek counting fence, 1951.

	Sockeye	Coho	Dolly varden	Cut-throat
Unmarked males	2	2		
Marked males	120	-		
"Jack" males	504	13		
Total males	626	15		
Unmarked females	3	3		
Marked females	124	-		
Total females	127	3		
Total fish	753	18	120	2

<u>Sockeye</u>

Five female sockeye were sampled and egg counts made. To estimate the average number of eggs retained, 15 females found dead above the fence were taken and the number of eggs in each counted. Table II summarizes the production data.

Table II. Calculation of the potential deposition of sockeye at Tally Creek, 1951.

No. of females	Average egg content	Average egg retention	Average egg output	Potential deposition
127	2,632	164	2,468	313,436

Table III. The distribution of sockeye adults throughout the system after passage through the Hooknose Creek fence.

Location	Large males	"Jacks"	Total males	Females	Total
Counted through Hooknose Creek	181	773	954	228	1,182
Accounted for above Hooknose fence					
Through Tally Creek	122	504	626	127	753
Est. below Tally fence	7	35	42	7	49
Est. spawn. No. 2 Cr.	24	62	86	25	111
Gill-net catches	19	52	71	11	82
Dead at Hooknose fence	0	5	5	2	7
No. accounted for	172	658	830	172	1,002
No. unaccounted for	9	115	124	56	180
Per cent loss	5.0	14.9	13.0	24.6	15.2

Table III summarizes information on the fate of the 1182 sockeye that passed through the Hooknose Creek fence. It is likely that the fish that could not be accounted for had remained in the lake and had not spawned. Weekly examinations of the entire spawning area of Hooknose Creek during October failed to reveal any spawning sockeye. No sockeye were seen in any of the lake creeks other than in Tally and No. 2, nor was any shore spawning evident. Periodic surveys of all potential spawning areas were made from September to mid-November. On October 29th a school of approximately thirty sockeye were observed milling in the mouth of Tally Creek. After this date only 6 sockeye passed through the fence and no fish were observed spawning below the fence. Thus, it is likely that the majority of the individuals in this school failed to spawn. From October 27th to November 4th, 24 sockeye were taken in gill-net sets at the south end of the lake. During the same period only 24 sockeye passed through the Tally Creek fence. The fish caught in the gill-nets were unspawned and appeared to be much riper than the fish passing through the fence; the eggs of the one female taken alive in these gill-net samples appeared to be disintegrating. The flesh of these fish was very "soft", similar in texture to that of spawned-out fish. It is not likely that the few gill-net sets made after October 27th (9 net-nights) could have taken all the sockeye present in the lake at that time. The gill-netted fish must be considered as only a fraction of the population. Thus after October 27th, when 98% of the run in Tally and No. 2 creeks was over, gill-net catches indicated that a population of unspawned sockeye was still in the lake. It seems likely that these unspawned fish represented the majority of those unaccounted for in Table III. It is of note that the proportion of females reaching the spawning grounds was lower than in the case of either large males or "jacks".

Stream diversion

In early September, it was estimated that approximately two-thirds of the water flowing down the south branch of Tally Creek (approx. 200 yd. above the mouth) was passing through temporary diversions which would become dry in the winter. In 1950 it was observed that many sockeye were spawning

M. P. Shepard

in these sections and that the return of fry from here would be very small. To return most of the water to the permanent channel, on September 10, 1951, a dam was built at the head of the diversion. As far as could be determined this operation was successful and the flow reduced sufficiently to prevent sockeye from entering the temporary stretches.

J. G. Hunter

Appendix No. 7

PRODUCTION OF SALMON FRY AND SMOLTS FROM TALLY CREEK, PORT JOHN, 1952

The absolute production of sockeye fry from Tally Creek was 39.21% greater than in 1951. The course of the run is indicated in the following table.

Number of salmon fry and smolts produced by Tally Creek; the absolute and percentage mortality caused by operation of the fence and the numbers released downstream naturally.

Week ending	Sockeye fry	Coho fry	Coho smolts
Apr 28	2	0	0
May 5	14	0	4
12	3	0	5
19	906	0	6
26	10,652	0	19
Jun 2	7,843	0	15
9	4,446	7	6
16	4,322	142	15
23	1,733	59	13
30	11	113	13
Total	29,932	323	96
Mortality	1,051	2	1
Percentage mortality	3.5	0.61	1.04
Numbers released (unmarked)	23,806	321	95

Five thousand and seventy five (5,075) sockeye fry were marked by the removal of the two pelvic fins. These fry were released into the lake making a total of 28,881 fry from Tally Creek.

Appendix No. 8

J. G. Hunter

SOCKEYE FRY SALINITY TOLERANCE

Experiments to determine the salinity concentrations which can be tolerated by sockeye fry at different sizes were carried on partly at the University of Washington and partly at Port John field station.

Aquaria of salinities varying by 3°/oo in a series from 0°/oo were set up. Thirty sockeye fry were placed (sudden change) in each aquarium and the time of their deaths was carefully noted for a period of 8 days, after which time all mortality had ceased.

Analysis of the results obtained has not been completed but it is readily apparent that sockeye fry are able to tolerate 18°/oo salinity with no mortality and that after two months' growth the tolerance had increased to 24°/oo salinity with a zero mortality.

Appendix No. 9

J. G. McDonald

ESCAPEMENT AND FRY PRODUCTION, SCULLY CREEK, 1952

For the third consecutive season a count of sockeye salmon spawners and their resulting fry was made.

Scully Creek, a relatively small part of the Lakelse Lake watershed, has lent itself well to the collection of data of this sort. It also provides reasonable conditions for a more complete understanding of factors contributing towards the efficiency of the natural production of sockeye.

This creek, flowing into the southeast corner of Lakelse Lake, originates from mountains slightly higher than timberline. A low, heavily wooded area extending approximately 2 miles from the lake to the foothills provides a check on the turbulence of flow and results in a stream-bed suitable for salmon production. Numerous side channels, beaver dams, and swamps in the drainage area alleviate extremes in water levels and remove, to some extent, debris which would otherwise be swept downstream.

To date, at Scully, the main effort has been directed towards construction and operation of the adult-fry counting fence. Some information pertinent to salmon production has been gathered. In addition, studies of spawning distribution, redd sampling, predation on fry, and numbers and distribution of other species in the creek have been carried out. Creek levels and temperatures have been recorded whenever possible.

J. G. McDonald

Given below is a table showing the adult and fry counts of 1951-52, followed by a general summary of escapement and fry production, 1949-52.

Week ending	Adults, 1951 Males	Females	Week ending	Fry, 1952
Aug 16	108	50	Apr 14	1
23	279	127	21	335
30	269	111	28	237
Sep 6	156	85	May 5	1,901
13	11	6	12	14,240
20	3	5	19	27,839
27	4	0	26	37,445
			Jun 2	46,007
			9	26,269
			16	9,325
			23	1,985
			30	196
			Jul 4	2
Totals	830	384		165,782

Escapement and Production, 1949-52

Year-class	Escapement Males	Females	No. eggs female	Potential egg deposition	No. fry	Per cent fry production
1949-50	593	485	3665	1,777,767	242,346	13.7
1950-51	341	121	3285	377,775*	35,129	9.3*
1951-52	830	384	3181	1,221,696	165,782	13.6

* Corrected figures from 1951 report

J. G. McDonald

Appendix No. 10

MARKING OF SOCKEYE FRY FOR SMOLT AGE DETERMINATIONS, 1952

At the request of Mr. D. R. Foskett a number of sockeye fry were marked at the Scully Creek fence. These fry, upon recovery as one- and two-year-old individuals at the Lakelse River, will make possible a check on the age determination by scale readings of the sockeye smolts.

Throughout the migration, fry were chosen randomly and marked by removal of both pelvic fins. Prior to marking, the fry were anaesthetized with chloretone.

In all, 5148 fry were marked and released.

To indicate the degree of an initial mortality due to marking, 119 marked fry were retained in a trough. A similar number of "normal" fry were kept as controls.

J. G. McDonald

Five days after holding, 9% of the marked fry had died. No mortality had occurred in the control trough. After this period no mortality occurred in either the marked fish or the controls until a period of 19 days had elapsed. From this time on mortality occurred similarly in both groups.

At the end of 71 days when the trial was discontinued, 57% and 49% of the marked and unmarked fish respectively were dead.

It would appear that the initial mortality due to marking occurred during the first five days and was in the order of 9%. After this period the mortality in both groups was nearly equal (53% and 49%) and could be said to be due to conditions of holding (e.g., inadequate diet).

J. G. McDonald

Appendix No. 11

MARKING, RELEASE AND RECAPTURE OF SOCKEYE FRY AT SCULLY CREEK, 1952

This program has been carried out since 1950 in order to make available an assessment of the loss in fry production occurring during the downstream migration of sockeye fry.

The fry were marked by means of a light, double silk thread inserted immediately in front of the dorsal fin. Prior to marking, the fish were anaesthetized by a dilute solution of chloretone.

Only those fry showing no obvious signs of distress, due to the anaesthetic, marking or handling, were used. In all fish released, the same technique in marking was used. The places of release were chosen and maintained. Time of release varied only slightly and took place immediately before dark. Threads of different colors were used to designate the date and place of liberation.

In 1950 and 1951, marked fish were liberated at 2000 and 4000 feet above the fence. In 1952, additional marks were released at 500 feet.

The majority of returns were recaptured the night of release, a small number the following night, and occasionally marked fry returned to the fence three nights after release.

Below is given the per cent return of marks, distance released upstream, and the fry run the night of release.

Date	Per cent mark return 500 ft.	2000 ft.	4000 ft.	Unmarked fry count night of release
1950				
May 2		8.2	6.9	412
12		29.5		18,333
15			16.5	14,917
18		17.5	10.4	10,620
20		10.0	8.8	4,694
27		8.0	5.9	7,522
30		3.0		654
1951				
May 21		32.3	10.0	675
25		28.7	24.4	944
30		6.8	1.7	1,664
Jun 5		13.6	5.3	1,343
7		16.0	9.9	1,134
1952				
May 1		4.0	2.6	205
6	10.0	8.1	0.7	508
10		9.3	29.9	4,378
12	31.1	31.6	30.0	3,913
23	28.8	31.8	33.3	8,661
28	20.8	14.9	32.4	6,350
Jun 2	14.3	9.8	21.1	3,255
10	26.1	10.2	22.4	1,816

Evaluation of returns

To what extent the returns of these marked fry represent the survival occurring under natural stream conditions can only be assessed if the following factors are determined, namely, (a) the marking mortality and any greater susceptibility to predation due to marking; (b) loss of threads, and (c) ability of the fence operators to pick out marked individuals.

Mortality among marked fry, as shown by retention in troughs, has been found to be negligible for the first 24 hours but increases rapidly after that time.

Greater susceptibility to predation and loss of threads has been tested only in comparison with fin-clipped fry (both pelvics removed). In this test release of both groups of marked fry occurred at the same time and place. All fry captured at the fence in the 3 days following the release were examined individually for marks. All predators captured in the same period were examined for stomach contents. Returns (56% and 65% for thread marked and fin-clipped fish, respectively) suggest a slightly greater susceptibility to predation on the part of the thread marked fry. Marks recovered from the predators examined raised the overall returns of both groups to 64% and 68%. This similarity would not be reflected if loss of threads occurred to any great extent.

The ability of the fence operators to pick out the threaded fish has been checked and error does occur, but, infrequently. The number of marks not seen by the operators is low in comparison to the number recovered and can affect only in a minor way the per cent returns of the marked fish released.

J. G. McDonald

Results to date

The variability of returns from the three years' trials is evident from the table presented above. As could be expected, assuming a fairly random distribution of predators in the creek, returns in 1950 and 1951 show a greater loss of those fry released at the furthest distance upstream. The 1952 returns, however, reveal on the average, a greater loss of individuals released at 2000 feet than at 4000 feet and only a slightly higher return from 500 feet.

Per cent returns and the number of fry migrating the night of release show a close positive relationship in 1950 and 1952. Returns of 1951 are just the opposite. This difference may be attributed to the very small and scattered numbers of fry migrating in 1951.

By statistical treatment of the available data the survival of fry from hatch to arrival at the counting weir may be determined if the number of fry hatching, and the number of fry surviving to the fence, is known. Below are given the tentative values obtained for the three years studied. These values represent survival only of that portion of the migration which descended with marked individuals. This never amounted to less than one-seventh of the total fry run and was drawn from daily counts dispersed throughout the migration.

Year	Total no. of fry on days of mark-returns	Total minimum hatch	Total maximum hatch	Per cent survival hatch to fence	
				Min.	Max.
1950	57,152	122,000	413,000	14	47
1951	5,760	18,000	67,000	9	32
1952	29,086	43,000	136,000	21	68

The calculated minimum survival for fry from the time they hatch out of the gravel to the time that they are counted at the fence is low. For 1951 this survival proves to be less than the survival recorded for sockeye from the time of potential egg deposition to fence count. It is evident, then, that the assumption under which the calculation of the minimum survival was made was invalid, i.e., per cent return of marked fry is not identical to per cent survival, from hatch of unmarked individuals.

The values given for maximum survival indicate that a substantial loss in fry production occurs during the downstream migration.

The actual value of survival will lie between the minimum and maximum values presented. As loss during migration may be attributed largely to predation, then the relationship between the number of migrants and the number of fry eaten, together with an estimate of the predator population, should provide means of determining more exactly the loss occurring on the migrants.

Appendix No. 12

A. W. Beach

PREDATION ON PACIFIC SALMON FRY AT SCULLY CREEK, 1951-52

The aim of the stomach sampling of predators has been to determine the degree and nature of predation by coho yearling, cut-throat trout, and sculpins at Scully Creek. Although this information applies locally, similar predation on fry likely exists in other spawning areas.

A. W. Beach

Predators captured at the fence were sampled randomly for stomach contents during the sockeye fry run. The following table shows the results obtained.

Predators	- 1951 - Coho yearlings	Cut-throat	Sculpin	- 1952 - Coho yearlings	Cut-throat	Sculpin
No. predators sampled	123	17	36	172	15	46
No. sockeye fry eaten	386	80	167	758	161	249
No. coho fry eaten	16	3	9	67	10	12
No. pink fry eaten	103	5	25	-	-	-
Av. no. sockeye fry eaten per predator	3.14	4.71	4.63	4.41	10.74	5.41
Av. no. coho fry eaten per predator	0.13	0.18	0.25	0.39	0.67	0.26
Av. no. pink fry eaten per predator	0.84	0.47	0.69	-	-	-
Av. no. fry (all species) eaten per predator	4.11	5.36	5.57	4.80	11.41	5.67
Per cent predators sampled	9.2%	8.6%	32.7%	6.2%	7.7%	19.5%

Since predators digest their stomach contents almost completely between 40 and 50 hours at creek temperatures prevalent during migration, and if predators captured with the fry are representative of all predators in the creek, it is apparent that they destroy a fair portion of the sockeye fry population. The table indicates that the predation was greater in 1952 than in 1951, assuming that the number of predators remained constant.

As the sockeye fry run in 1952 was several times that of 1951 the volume of the predators' stomach contents might very well be expected to be greater in 1952. This increase in stomach content, however, is not proportionate to the increase in numbers of fry present in the creek. Perhaps it may be concluded, then, that a small fry run as in 1951 affords sufficient food for the captured predators, and that a much larger fry run, as in 1952, does not increase the amount of fry consumed by predators to a great extent.

Calculations have been made to correlate the daily sockeye fry run with the average stomach contents of the coho yearlings. A positive correlation exists for both years. For 1951, the correlation coefficient (r) has the value of +0.36 and a probability (P) of 0.075. In 1952, "r" is +0.43 with a "P" of 0.02. These (r) values are on the border line of significance and suggest that further investigation might be of value.

Appendix No. 13

J. G. McDonald

DIGESTION RATES OF COHO SALMON YEARLINGS AT SCULLY CREEK, LAKELSE LAKE

In 1951 a preliminary study of the rate at which coho yearlings digested sockeye fry was carried out. This year facilities were at hand for a more detailed study.

J. G. McDonald

Coho yearlings captured at the fence were placed in troughs until all food eaten previously was completely digested as indicated by sampling. Fry were introduced with a group of predators. After one or two hours all fry remaining were removed. Each group of coho was sampled for stomach contents at various intervals after feeding.

Temperature range of the water in the troughs was 3°C-9.5°C or that temperature range prevailing in the week during the fry migration.

No exact time for a determined "end point" of digestion could be obtained because of differences in individuals, sizes of yearlings and volume of fry eaten. However, in practically all instances digestion appeared complete between 40-50 hours after feeding.

Under natural stream conditions a greater rate is possible due to increased activity of the predator.

It is assumed, and has been noted many times, that additional fry may be eaten before those fry previously eaten are fully digested.

Appendix No. 14

E. Dombroski

SIX-MILE CREEK FENCE IN 1952

Generally, sockeye enter Six-Mile Creek to spawn sometime during the first week of August. However, sockeye failed to enter Six-Mile Creek in 1952, owing to (a) the small number of spawners present in the lake when sufficient water was available (last week of July and early August) at Six-Mile Creek to attract and admit fish, (b) insufficient flow of water to attract or admit spawners at the time when they ordinarily are entering the stream.

It is indicated by aerial survey photographs that Six-Mile Creek is a lake-fed stream. This indication was supplemented by a stream survey conducted in August of this year when it was found that the stream may flow from a small lake which is approximately 12 miles, in a northerly direction, from the fence. Approximately 4 miles from the fence a dry stream-bed was found to join Six-Mile Creek. From the appearance of the bed, it is believed that this is a flood channel which supplements the flood waters of Six-Mile Creek during the time of the spring freshets, and that the source of water for this channel arises from a smaller lake which is approximately 8 miles, in a north-easterly direction, from the fence.

Assuming Six-Mile Creek is a stream fed by only a small lake, the supply of water during the sockeye spawning season may become dangerously low and the admittance of spawners, during seasons of low water, may largely depend upon rain which swells the stream sufficiently to attract and carry fish to the spawning beds. In 1952, the flow of the stream at the fence stopped abruptly by mid-August. Approximately one-quarter of a mile above the fence the water seeped through numerous gravel-bars interspersed with pools. These gravel-bars were laid down in the main channel by the spring freshets of 1951 and 1952, and consist, in general, of coarse gravel to small boulders. By 1953 the gravel-beds may tighten up sufficiently to prevent water from disappearing entirely into them. Thus a flow may be present at the time sockeye arrive in August of 1953.

A shed was constructed at Six-Mile Creek this year to house a recording thermograph. Anticipating that sockeye may enter the stream to spawn in 1953, records of water levels and water temperatures will be obtained

E. Dombroski

throughout the entire spawning cycle. The information obtained during the October-March period when the eggs are being incubated will be of particular value, since in the past these records were unobtainable.

Appendix No. 15

J. G. Hunter

SEAWARD MIGRATING SOCKEYE SMOLTS, HOOKNOSE CREEK, PORT JOHN, 1952

During the 1952 season the following migrating sockeye were taken at the Hooknose Creek fry counting weir:

Week ending	Sockeye fry	Sockeye smolts
Apr 21	1	0
28	1	20
May 5	0	284
12	5	5,058
19	262	3,962
26	68	1,457
Jun 2	492	238
9	10	34
16	3	5
Totals	842	11,058

During the weir operations, 8 fry and 94 smolts were found to have died. A sample of 242 smolts was taken for age, size and sex analysis. The releases to salt water were, therefore, 834 sockeye fry and 10,703 smolts.

Low water in the fall of 1951 was an important factor in inducing the spawning of sockeye in Hooknose Creek itself.

Appendix No. 16

R. E. Foerster

ENUMERATION OF SEAWARD-MIGRATING SOCKEYE SMOLTS AT THE LAKELSE RIVER COUNTING WEIR, 1952

During the spring of 1952 the newly-constructed counting weir in the Lakelse River, situated approximately one mile below Lakelse Lake, was operated for the first time. The 112 fine-mesh (1/4") wire screens were put in place on March 25, prior to the disappearance of the ice-cover from the lake, and kept in operation throughout the season except for the period April 16-20 when high water required that they be lifted.

The ice-cover on the lake broke up on May 1 and the first sockeye appeared May 11, when 10 individuals were trapped. The daily counts for May and early June are tabulated below to show the speedy onset of the migration and the more gradual tapering off:

May 11	10	May 25	12,912	Jun 8	3,176
12	286	26	9,804	9	2,544
13	2,499	27	7,554	10	1,356
14	7,034	28	20,006	11	2,804
15	34,494	29	20,811	12	3,400
16	19,776	30	11,763	13	1,041
17	36,612	31	27,183	14	1,458
18	30,334	Jun 1	28,966	15	1,777
19	27,625	2	13,801	16	1,821
20	16,469	3	5,819	17	521
21	88,891	4	10,262	18	862
22	86,599	5	14,149	19	332
23	18,188	6	4,743	20	199
24	5,567	7	4,625		

Toward the end of June the migration dwindled to but a few smolts per day but carried in this manner through July and into August. The records show a total for the season of 595,741 sockeye smolts handled, of which approximately 30% appeared in the course of two days, May 21 and 22 and almost overwhelmed the facilities and personnel.

Early in the operation it was realized that under prevailing high water conditions the collecting traps provided (similar to those used at Cultus Lake) would be of little value. Consequently inclined-plane screen collecting devices of the "Wolf" weir type were hastily constructed, one at either end of the fence, and these functioned particularly well. In consequence several are being installed for future use. During the course of the 1952 operations it was found that many smolts were forced up against the screening of the fence and had to be removed. This required a constant 24-hour patrol of the fence and in many cases injured the smolts. It is anticipated that the provision of additional traps, spaced at regular intervals along the length of the fence, will prevent the stranding of smolts on the screens and reduce the potential loss and extra labour of speedy removal.

For the season a loss of around 2% of smolts occurred on the screens and in the course of trapping and counting. As a suitable sample of the run for analysis of age-groups, length, weight and sex, one individual per 100 smolts counted was preserved when the daily runs were small and one per every 200 smolts when the daily counts were large.

During the course of the migration, records of river water temperature and water level were kept, for possible correlation with smolt downstream movement. Observations revealed that the smolts arrived at the weir chiefly just before or at dawn, although schools appeared throughout the day in varying numbers.

Considerable variation in size of migrants during the season was observed. This suggests that probably two age-groups were present, yearlings and two-year-old individuals. The former are the product of the 1950 sockeye spawning in the streams tributary to Lakelse Lake; the latter, of the 1949 spawning. A break-down into age-classes, as revealed by a study of the sample collections, will be required before assessment of percentage survival of smolts based on the presumed egg deposition will be possible.

Technical operation of the weir with adjustments, refinements, etc. was in the very capable hands of Mr. J. Martell. Counting and handling of fish was supervised by the writer, ably assisted by Messrs. I. L. Withler, G. G. Futcher, C. G. McDiarmid and, during the peak of migration, by Messrs. M. P. Shepard, V. H. McMahon, J. G. McDonald, T. H. Bilton and R. J. LeBrasseur.

Appendix No. 17

R. E. Foerster

ENUMERATION OF COHO SMOLTS AND OTHER SPECIES OF FISH AT THE LAKELSE RIVER COUNTING WEIR, 1952

During the period May 1 to August 30 when the sockeye smolt count was in progress, other species of fish were handled as they entered upon their seaward migration (coho in particular) or moved downstream for spawning or feeding purposes. An appreciable coho migration was anticipated, although not to the extent of some 95,000, and pink salmon fry were also expected though it was realized that they would pass readily through the relatively large mesh of the screening. What other fish would be encountered remained to be ascertained.

The tabulation below gives a record of the species handled with the exception of sculpins, of which an appreciable number gathered in the traps but probably were not in migration, and a few large steelheads, probably a dozen or so which were spawning just above the weir and drifted down in "spent" condition. The opportunity was taken (by Mr. Shepard) to mark some of the trout, dolly varden, whitefish, squawfish and suckers to get information on movements within the river and some trout (not recorded in the tabulation) were used for tagging experiments in the lake and upper river area. During the peak of the sockeye smolt migration, May 17 to 24, circumstances did not permit a too accurate record of other species of fish handled. The totals are therefore not complete but present a good picture of the activities of the river fish in general. Mr. Ira Withler was in charge of the counting and recording during most of the season and the tabulation is made up from his records.

Week ending	Coho	Trout	Dolly varden	Suckers	Whitefish	Lamprey	Squawfish	Peamouth
May 10	0	321	57	0	3,102			
17	7,379	76	113	0	879	1		
24	17,450	3	3	0	-	2		
31	27,638	35	23	26	73	4		
Jun 7	21,466	83	13	81	371			
14	9,112	38	1	22	101			
21	8,093	31	3	84	51			
28	2,090	17	1	73	16	5		
Jul 5	541	3	2	65	31	30	3	1
12	445	0	0	68	5	5	4	1
19	48	0	0	29	1	13	1	9
26	143	7	1	88	39	47	17	13
Aug 2	130	29	1	121	105	90	33	31
9	37	38	0	57	155	8	16	124
16	187	16	0	40	91	17	6	30
23	60	7	1	16	45	11	7	20
30	21	4	1	8	25	9	1	54
Total	94,840	708	220	778	5,090	242	88	283

M. P. Shepard, T. H. Bilton, and R. J. LeBrasseur Appendix No. 18

PRELIMINARY STUDY OF THE PREDATORS OF THE UPPER LAKELSE RIVER

When sockeye and coho smolts migrate from Lakelse Lake to the upper Lakelse River on their way to sea, they present a vulnerable target for the predators concentrated in the region. Concurrently with the downstream movement of the smolts, pink salmon fry are emerging from the river gravel and migrating seaward. All three species contribute to the spring diet of the river predators. The number of fish of any one of these prey species consumed by predators is dependent on the abundance of the predator populations and on the availability of the two alternative prey species. A knowledge of the interrelationships between the predator and prey species would permit an accurate assessment on the possible losses suffered by sockeye during their movement from the nursery area to the sea.

To gain an understanding of the predator-prey relationships, the following information is being gathered:

(1) the abundance of migrating sockeye and coho smolts, as indicated by the weir counts;
(2) the abundance of pink fry, as roughly determined by the extent of the adult spawning population;
(3) the abundance of predators, as determined by recovery of marked individuals in the angling fishery and at the weir;
(4) diet of predators, as indicated by stomach analyses of approximately 20% of the fish examined in the Creel census.

When several years' information has been collected, a synthesis of the data should provide an accurate evaluation of the predator-prey relationships existing in the upper Lakelse River when the seaward migration of salmon takes place.

F. C. Withler, E. Dombroski, and K. V. Aro Appendix No. 19

ESTIMATION OF NUMBERS OF MIGRANT SOCKEYE SMOLTS AT BABINE LAKE, 1952

Furthering the attempt begun in 1951 to estimate the size of the sockeye smolt run leaving Babine Lake each year, the project was carried out again in the spring of 1952 with several refinements of technique. The experiment involves (1) the capture of migrating smolts at Fort Babine at the outlet into the Babine River, (2) the marking and release of a portion of these, and (3) the subsequent capture of samples eight miles downstream to determine the ratio of marked to unmarked fish in the run. Using the ratio so obtained an estimate of the total size of the smolt run can be made.

Technique

The trapping device at Fort Babine to capture smolts for marking consists of an 8 feet x 5 feet x 5 feet trap with a hinged door and with "leads" angled upstream from the trap. The offshore "lead", 200 feet in length, consists of minnow seine backed with chicken wire and fastened to hand-driven piling; the inshore "lead" is approximately 100 feet in length. A similar trapping device to recapture samples of the smolt run below Fort Babine was installed in 1952 at the outlet of Nilkitkwa Lake, 8 miles downstream from Fort Babine. This recapture method was a considerable improvement over

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

the dip-nets used at the Babine Fence in 1951. Improvements also were made in the marking procedure: an attempt was made to mark definite proportions of the daily catch at Fort Babine, the fin mark being changed when the proportion of smolts marked in daily catches was changed. More smolts were fin-clipped in 1952 than in 1951, and marking with distinctive threads to elucidate the pattern of smolt migration was extended. By going over the ice to Fort Babine in early April two investigators were able to install all the necessary structures before the smolt run was under way. In this way it was possible in 1952 to mark and recover smolts throughout the whole of the smolt run, as was not the case in 1951, when the numbers which had migrated before marking began had to be estimated.

Estimate of total migration

Fin clipping of portions of the daily catches at Fort Babine took place from May 27 to July 1. During this time 62,848 smolts were marked. Of these, 1043 were recovered at the outlet of Nilkitkwa Lake from a catch totalling 86,411. The population, when estimated on the basis of the "Peterson" method would be approximately 5,200,000 with 95% confidence limits of 4,900,000 and 5,550,000. The calculation does not allow for a marking mortality which, if large, would tend to make the estimate too great. Careful marking, the release of healthy fish only, and the short time between release and recovery should tend to minimize this error. On the basis of these estimates, the size of the smolt run in 1952 was approximately 2,000,000 less than the estimated 7,000,000 of 1951.

Although a few two-year-old smolts have been caught, the vast majority of smolts taken are yearlings and therefore were produced from the eggs deposited by the 1950 adult sockeye run to Babine Lake. The potential egg deposition in 1950 amounted to 672,000,000 eggs. The survival from egg to migrating smolt of the progeny of the 1950 adult run was then 0.8%, the same as that calculated for the progeny of the 1949 adult run, although the potential egg deposition in 1949 was 1.4 times greater than that in 1950.

Preparation for 1953

The smolt migration in the spring of 1953 will consist of the progeny of those adults which managed to pass the slide in the Babine River in 1951. The potential sockeye egg deposition in 1951 was the lowest yet recorded during the Babine fence operation, suggesting that the 1953 smolt run might be very low. In any case an estimate of the smolt run will give the best measure of the real effect of the reduction of the spawning population in 1951 to approximately one-third of its usual size. The survival data (from egg to smolt) will show whether or not the slide was, in fact, more deleterious to the run than the numbers in the spawning escapement indicated.

To help insure the successful operation of the smolt estimation program in 1953, the piling at the recovery site was driven this summer and other preparations made in anticipation of next spring's needs. The piling for the capture site at Fort Babine should be serviceable for use in 1953.

Appendix No. 20

E. Dombroski

SUMMARY OF AN EXAMINATION OF SMOLT SAMPLES FROM BABINE LAKE IN 1951

In addition to the marking of sockeye smolts at Babine Lake in 1951 to estimate the number of migrants, samples were obtained at the Babine fence. The smolts were examined at the Pacific Biological Station in 1952 to determine the length, age, and sex distributions; a Progress Report was prepared (Issue No. 91, pp. 21-26).

Scale readings from the 2815 specimens examined indicated that 2805 were one-year-olds, and 10 two-year-olds. The sex distribution among the yearlings was found to be 51% (1428) males and 49% (1367) females. The average fork length and weight of the male yearlings was 81.9 ± 6.9 mm. and 5.5 ± 1.5 grams, respectively; the average fork length of the females was 82.3 ± 6.9 mm. and 5.6 ± 1.5 grams. The number of two-year-olds obtained was very small but examination showed that, on the average, they were larger than the yearlings; a comparison of the range in length and weight showed that it is possible for some two-year-olds to be smaller in size than some yearlings.

In general, the size of the yearlings (length and weight) increased as the season of migration progressed. This increase was probably brought about by new second-season growth, which does not take place to any great extent until the latter part of June. The percentage of yearlings with new second-season growth increased as the season progressed, the greatest increase taking place in the latter part of the migratory season (June 18-July 1). This parallels the observation that the weekly average length and weights of the yearlings did not change appreciably until the latter part of June.

A comparison was made with smolt samples obtained in 1950 and examined by L. A. Wilson at the University of British Columbia. A small but significant difference was found between the length of male and female yearlings obtained in 1950 and 1951, respectively. However, the difference in the general average length of yearlings of each year was only 1 mm. A comparison of the sex distribution in the samples obtained in each year showed no significant departure from a 50:50 ratio.

Smolt samples were obtained by M. A. Keenleyside and R. H. Eaton under the direction of F. C. Withler.

Appendix No. 21

M. P. Shepard

LIMNOLOGICAL RECORDINGS AT PORT JOHN LAKE, AUTUMN, 1951

Limnological recordings were made at Port John Lake from September 11 to November 7, 1951, to supplement summer limnological studies carried out in 1949 and 1950. The purpose of this work has been to compare the characteristics of Port John Lake with other lakes supporting salmon, in an attempt to describe some of the environmental factors influencing salmon production.

Water temperature

In the first half of September, a definite thermocline existed between 20 feet and 30 feet. After September 20, the surface water cooled, and by November 7, isothermal conditions, marking the beginning of the fall overturn, were noted.

M. P. Shepard

Oxygen

Some vertical stratification of the lake with respect to the oxygen content of the water was observed. The surface oxygen concentration varied between 85 and 100% saturation while the bottom concentration fluctuated from 58 to 68% saturation. The most uniform conditions were noted in November, indicating that the vertical interchange of water associated with the fall overturn was beginning.

Transparency

Accompanying a continuous rise in lake level (brought about by the fall rains) there was a steady decrease in the transparency of the lake throughout the autumn months.

Appendix No. 22

T. Mitchell and V. H. McMahon

CHEMICAL ANALYSIS OF LAKELSE LAKE WATERS

Analyses of the inflowing, outflowing and lake water for phosphate, nitrate-nitrogen and silicate content were continued through the fall of 1951 until ice-coverage and weather conditions prevented further sampling for that year. This work was not resumed till late spring of 1952 at which time the assessment of nitrite-nitrogen was added to the program.

The average summer concentrations for the past three years are listed below, followed by some of the more obvious conclusions which may be drawn from the data at this time. Nitrite-nitrogen is not included in the table since almost all samples had insufficient quantity of this substance to be detectable.

Average summer concentrations of phosphates, nitrates and silicates found at three depths in the lake and at Scully and Williams creeks (inflowing) and Lakelse River (outflowing) for the years 1950, 1951, and 1952.

	PO_4 (mg./l)			NO_3 (mg./l)			Si. mg. atoms /l	
	1950	1951	1952	1950	1951	1952	1951	1952
Lakelse Lake								
- 0 m.	.0970	.5540	.1865	.0346	.0228	.0288	$.049 \times 10^{-3}$	$.0548 \times 10^{-3}$
- 15 m.	.1031	.5797	.3328	.0493	.0321	.0324	$.0548 \times 10^{-3}$	$.0564 \times 10^{-3}$
- 30 m.	.0904	.4710	.2357	.1633	.0566	.0461	$.0590 \times 10^{-3}$	$.0632 \times 10^{-3}$
Scully Creek		.4153	.5535		.0362	.0329	$.0703 \times 10^{-3}$	$.0715 \times 10^{-3}$
Williams Creek	.1038	.6540	.3835	.0592	.0269	.0278	$.0575 \times 10^{-3}$	$.0572 \times 10^{-3}$
Lakelse River	.0743	.4083	.3593	.0484	.0301	.0294	$.0483 \times 10^{-3}$	$.0567 \times 10^{-3}$

Conclusions

1. This year's results confirm past findings that the nitrates are in greatest concentration at the bottom of the lake, least concentrated at the surface and of intermediate concentration in the central waters. The inflowing Scully Creek appears to contain nitrates in higher concentration than either

T. Mitchell and V. H. McMahon

Williams Creek or the outflowing Lakelse River, and is similar to the central waters of the lake in nitrate content.

2. Silicates display a graduation of concentration with depth similar to the nitrates. Scully Creek water has a higher concentration of this substance than either the other inflowing stream or Lakelse River. This may be explained by the fact that Scully Creek flows through swamp and wooded countryside while Williams Creek water is primarily glacial.

3. Little uniformity of concentration with depth occurs in the case of the phosphates in the lake. The concentrations are greater in the two inflowing streams than in the Lakelse River and that of Scully Creek was highest for one of the two years analyzed.

4. The values for phosphates are highest for 1951 and next highest for 1952. On the other hand nitrates were found to be of greatest concentration in 1950 and of similar concentrations in the following two years.

The last two years' data indicate a strong mid-summer peak of phosphate concentrations at the bottom of the lake, with a much smaller one at this time in 1950. On the other hand strong peaks of nitrate concentrations occurred in bottom water in mid-summer of 1950 and 1951 whereas the concentrations this year showed no great fluctuations during this period. The higher concentration of the salts at the bottom are undoubtedly a result of the greater amount of organic decomposition at this depth as well as perhaps the influence of ground water.

There is little similarity in the seasonal fluctuations of nitrates in the different depths of water but the concentrations of phosphates and silicates fluctuate fairly uniformly from bottom to surface throughout the season.

With respect to the analyses last fall, it was found that following September 12 the nitrate content of the intermediate and surface waters of the lake rose to a maximum peak for the season by the end of October while the concentrations at the bottom increased slightly during the fall season. The concentration of phosphates fell off drastically prior to September 12 and then increased gradually to a moderate value by November 21 at which date analyses were discontinued.

Appendix No. 23

V. H. McMahon

METEOROLOGY AND LAKE LEVELS, LAKELSE LAKE

Heavy rains in the fall of 1951 were accompanied by wide fluctuations in the level of the lake. The first high water came October 10 when the level rose to 28 inches, the result of 3.25 inches of precipitation in the preceding five days. The lake level then dropped quickly. This was followed by a very sudden rise caused by a rainfall of 3.62 inches in two days as well as the melting of early snow on the hills. At this time, late October, the level rose from 5.25 to 54.5 inches in two days. A sudden decline followed and then a more gradual one till November 22 when the lake first froze over.

The winter of 1951-52 was a relatively mild one, there never being more than 4 feet of snow on the level at any one time. The temperatures were relatively high. A low temperature of 16°C. below zero was recorded for January 22 but the weather did not remain cold for long. High temperatures and heavy rainfalls during the middle of April brought the lake level up to an unusually high peak for that time of year. On April 17 the level was at 43 inches and the ice was still intact on the lake. The ice broke up on May 1.

V. H. McMahon

Another water level peak came shortly after the middle of May and the lake then stayed high for an unusually long period till the beginning of July. From this point on the level dropped very gradually to a reading of 9 inches on August 31.

The annual and seasonal hours of sunshine, which were recorded for the purpose of determining the heat budgets, have not been analyzed as yet.

The meteorological data, while of little use in themselves, can be useful in most biological correlations. Thus a high survival of fry in the streams may be partially attributed to water conditions the previous fall, winter and spring and the severity of the previous winter. Abundant plankton growth and thus perhaps increased sockeye salmon survival may have resulted from warmer weather, more sunshine or heavier run-off during the year.

Appendix No. 24

R. J. LeBrasseur

TEMPERATURE STUDIES IN LAKELSE LAKE

A series of B. T. stations was maintained throughout the summer with the object of observing the thermal changes in the lake as the summer progressed, and the circulation of the lake water.

This programme was interrupted in July when it became evident that the bathythermograph gave inconsistent readings. It was continued again in August when an accurate instrument was obtained.

A total of 6 series of temperature readings was made. The first 3 series were designed to demonstrate if there was any upwelling near the Lakelse River mouth associated with the prevailing south wind. It had been noted at the Lakelse River fence that the sockeye smolts appeared in the greatest numbers after a south wind had been blowing for several days. It was thought that the action of the wind might change the temperature gradient in the lake, affecting perhaps, the movements of the migrating sockeye. There might also be an increased flow of water down the river due to the action of the wind.

Had upwelling occurred at the river mouth one might have expected to find a column of water of constant temperature which would be lower than the surface temperature of water in adjacent areas. However, the results were not conclusive. The data did not describe such a situation nor did it indicate any increased flow of water into the river due to wind action. A number of factors are responsible for the nature of the data, namely (a) the stations were too localized to demonstrate upwelling, (b) the region studied was too shallow to permit efficient use of the bathythermograph, and (c) the bathythermograph was not accurate enough to provide readings in which confidence could be placed.

The other 3 series of B.T's indicated that the influent streams contribute very little to the general circulation in the lake during the summer months. The main tributary, Williams Creek, is largely glacial in origin and consequently its waters are very cold. When the creek water reaches the lake it mixes slightly with the lake water and sinks to the bottom where it contributes to a region of cold bottom water. The other influent streams which are also quite cold, also contribute to the bottom water and help maintain a current which moves southward along the bottom of the lake and into the Lakelse River.

As yet there is little evidence of any circulation in the intermediate or surface waters of the lake. The one reliable series of B.T. readings

R. J. LeBrasseur

and the surface temperatures indicate that there is an accumulation of warm water at the north end of the lake, particularly after a south wind has been blowing for several days. This suggests that warm water has been blown from the south to the north end. To compensate for the accumulation of water at the north, there must be a movement of water southward, either along the shore or beneath the surface.

In June and July there was a thermocline which was broken down by wind and wave action at the surface, and a gradual temperature gradient downwards. By August a well defined thermocline had formed in the deep water, producing 3 distinct layers, the cold bottom water, warm intermediate and surface waters and a narrow intermediate zone where mixing takes place.

This summer's temperature work suggests that a future programme could well be designed to study the thermal changes of the lake as they might affect the behaviour of migrating fish and to study the circulation of the water in the intermediate and shallow areas of the lake where the production of plankton is perhaps at its greatest point. Also the effects of meteorological changes could be assessed and from this perhaps predictions could be made regarding the distribution of the plankton and the fish which eat plankton.

Appendix No. 25

V. H. McMahon

PLANKTON IN LAKELSE LAKE

Samples of plankton were collected in the fall of 1951 until ice-coverage of the lake. One sample was taken during ice cover and sampling was then discontinued till the spring of 1952. Water temperatures were usually recorded concurrently with plankton sampling.

Collections were made to test the efficiency of a new type of gear consisting of a long canvas sleeve with a large straining bucket at the bottom end. After several trials it became evident that the sleeve section would not operate efficiently and the use of this part of the apparatus was discontinued. In subsequent sampling a screen top was attached to the bucket and the gear was operated as an upside-down version of the conventional type of net sampler. The important difference between the two methods of sampling is that the old method sampled from the bottom up whereas the new gear samples on the way down and thus gives a minimum of warning to the organisms as it encompasses them. The new gear (McMahon plankton trap) consists of a rectangular box with 4 side screens measuring 6" x 12" and a top screen of 6" x 6". The opening at the bottom has a diameter of about 5 inches, the same as the diameter of the opening on the plankton net in use. The trap is fixed with a door which can be closed at any desired depth by releasing a messenger. The new gear has more than double the straining area of the conventional plankton net for the same size opening.

No definite statements can be made at present as to the relative efficiencies of the old and new samplers, but from observation alone it would appear that the new apparatus collects more organisms through the same column of water. The wire screen also samples more consistently, since there is no fraying of the threads with wear.

Up until this year no specimens of the genus Daphnia had been seen in plankton samples collected at Lakelse Lake. This year they were discovered in fair abundance. The explanation for this probably comes from a combination

V. H. McMahon

of factors. In the process of testing the new sampling gear every organism in the whole sample was enumerated from trap and net instead of only one seventh of the sample as had been done previously. This is probably one reason for the Daphnia showing up in numbers. It appears also that the trap samples a higher percentage of the larger forms and since Daphnia longispina (identified by G. C. Carl) is one of the larger Cladocerans, more of these forms showed up in the trap samples. Then, since even in the net samples the odd Daphnia was observed, it would seem that there are more of these organisms present in the lake than there were in past years.

During 1952 plankton samples were taken, mostly from a station in the deepest part of the lake where it is felt that the best representative distribution prevails. These samples are being analyzed, along with those collected in 1951. Analysis is expected to be completed this winter.

Appendix No. 26

T. M. Mitchell and V. H. McMahon

PHOSPHATE AND NITRATE RELEASE FROM DECOMPOSING FISH CARCASSES

As a follow-up of last year's preliminary experiment, a series of analyses was carried out this year on decomposing adult sockeye salmon to determine the rates at which phosphates and nitrates are returned to the water from the decomposing fish. This was accomplished by placing one dead sockeye in each of two 5-gallon cans and sampling the water periodically as the fish rotted. For this year's experiment the temperature of the water was kept constant.

Probably as a result of there being a different species of fish used this year (squawfish were used in 1951), the results of the two years are quite different. Tabled below are the approximate concentration values for nitrates and phosphates, taken weekly from the graph of the actual values for 1951 and 1952.

	PO_4 1952 mg./1	PO_4 1951 mg./1	NO_3 1952 mg./1	NO_3 1951 mg./1
Control	.0369	.1439	.0208	.0095
End of first week	10.250	2.2000	.0685	.0870
End of second week	11.300	3.230	.1035	.1330
End of third week	11.750	2.730	.1500	.1083
End of fourth week	11.100	8.930	.2500	.0700
End of fifth week	10.300	2.470	.3525	.0633
End of sixth week	6.95	3.330	.3300	.0900
End of seventh week	3.55		.3100	
	sockeye	Squawfish	Sockeye	squawfish

Apart from the fact that two different species of fish were used, other factors such as weather, condition and weight of the fish when first immersed and temperature of the surrounding water may be responsible for the different results in the two years. However, one indication which is common to both years is that a peak in the concentration of phosphates occurs around the third or fourth week after death. The nitrates reached a maximum early in the 1951 experiment, whereas in 1952 the greatest concentration came in the fifth week of experiment.

Appendix No. 27

M. P. Shepard and R. J. LeBrasseur

PRELIMINARY REPORT ON THE LAKELSE LAKE POPULATION ESTIMATION PROGRAMME

This year a small-scale marking experiment was carried out at Lakelse Lake to provide the basis for an extensive population estimation programme to be carried out next year. The main purpose of this year's project was to determine methods of capturing a large enough number of live lake fish to insure the success of a population estimation study. Other reasons for carrying out this "pilot plant" experiment were to provide tentative estimates of the sizes of the lake fish populations and to follow the movements of the fish in the lake. The design of next year's experiment will depend largely on the information gathered this year.

The experiment involved the marking of adult lake fish (all fish captured that were 15 cm. or over were marked) in the spring of the year, and subsequently, in the fall the sampling of the populations containing marked fish. This year only one type of mark (removal of both pelvic fins) was applied and marking was restricted to the south end of the lake. By distributing the fall fishing efforts throughout the entire lake the dispersion of marks will be followed. At the time of writing the fall recovery programme had not yet begun, and thus the results reported are restricted to those obtained during the spring marking period.

Results

Fyke nets, made of 1/2 inch (stretched mesh) tarred web, 18 feet long and with a front funnel opening 5 feet in diameter, were used to capture lake fish. These nets were provided with leads and wings to channel fish toward the funnel opening. The nets were operated during June and early July in four locations at the south end of the lake; two of the locations were in creek mouths (Andalas and Hotsprings) while the other two were in shallow water with the leads directed perpendicularly to the shore-line. The nets were successful in capturing fish in good condition and, with some changes of design, should be an effective tool in next year's experiment. As the catches of cut-throat were low, supplementary efforts were made to obtain live fish by angling. The lengths of all fish marked were recorded. The numbers of fish marked at each of the stations are recorded in the table below.

	Species						
Trap locations	Peamouth	Squawfish	Suckers	Cut-throat	Whitefish	Dolly varden	Totals
Andalas	260	144	257	67	13	8	749
Hotsprings	823	55	22	11	0	2	913
Lake	90	188	107	54	10	2	451
Mailbox	20	380	-	-	-	-	400
Catts Bay (angling)	-	-	-	205	-	-	205
Totals	1,193	767	286	337	23	12	2,718

In addition to the fish marked, approximately 5000 other fish were trapped (sculpins, lake shiners, young coho, and juvenile fish of the species listed in the table above). The total number of fish marked in the one-month marking period (2718) is of the same order as the number of fish handled in a full scale summer gill-netting programme (e.g., in 1947, 1944 fish were caught as the result of 404 net-nights of effort).

During the course of marking, a number of the marked fish were recaptured. This was especially evident at the creek mouth netting stations where spawning migrations were occurring at the time of trapping. In addition to these recaptures, a number of fish marked in 1946 and 1947 were recaptured. The data concerning the recaptures of marks during the marking period are listed below.

	Species						
Trap locations	Peamouth 1947[1]	Peamouth 1952[2]	Squawfish 1952	Suckers 1947	Suckers 1952	Cut-throat 1952	Totals
Andalas	2	10	32	6	5	9	64
Hotsprings	32	203	33	3	3	2	276
Lake	0	2	9	2	2	6	21
Mailbox	0	0	63	-	-	-	63
Catts Bay (angling)	-	-	-	-	-	4	4
Totals	34	215	137	11	10	21	428

1 marked in 1946 and 1947
2 marked in 1952

These early mark returns will give information on the sizes and movements of the populations in the vicinities of the marking locations.

The completed results of the programme will be fully analyzed at the end of the two-year experiment. It is hoped that by that time the abundance of adult fish of the various species in the lake may be determined with some accuracy.

Appendix No. 28

M. P. Shepard and R. J. LeBrasseur

COMPARISON OF THE GILL-NET CATCHES OF 1947 AND 1952 AT LAKELSE LAKE

To follow changes in the abundance, age composition and diet of the various species of fish at Lakelse Lake, gill-netting studies have been conducted since 1944. A knowledge of these changes is essential in determining the interrelation between the young sockeye and the other inhabitants of the lake. In addition, the effectiveness of predator or competitor control measures will be reflected by changes in the characteristics of the affected populations. For these reasons, adequate and accurate sampling of the lake populations is an essential part of the lake fish studies.

Each year, from 1944 to 1949, a series of sets was made to sample the lake populations randomly. The catch per net-night for each year was used as an index of the relative abundance of the various species sampled. Although similar stations were used each year, the number of sets made at each station, the mesh sizes of the nets used and the dates on which the stations were sampled, varied considerably. This fact made direct comparison of the data from year to year difficult, for the samples were chosen from the populations in slightly different ways. This would not be a serious drawback if the number of stations was large and represented a truly random sample of the ecological zones of the lake but in this case the relatively small number of stations, and the year to year differences in mesh sizes and set distribution, introduced a considerable amount of variability; only the grossest changes in population size would produce significant differences in the mean yearly catches per unit effort. In an attempt to increase the precision of such experiments, the majority of the sets made in 1947 are being duplicated this year. Thus, by making the sampling procedure uniform from year to year, one source of variability is removed. However, with the relatively few sets that can be made during the sampling season (to date approximately 40 gang sets, each consisting of 5 nets), this precision may not be sufficient to detect moderate changes in abundance.

Results

From May 17 to July 5, 13 sets were made, similar in detail to those set in 1947. Gangs consisting of five 50-yard gill-nets were set in eight locations scattered throughout the lake. The nets were made of the same thread and had the same mesh sizes ($1\frac{1}{2}$" to 6") as those used in 1947. All sets were made within eight days of the set dates in 1947. The table below compares the total catches made in the two years. A statistical comparison of the paired sets was made by computing 't' values for the catches of each species.

Species	Total catch 1947	Total catch 1952	Catch 1952 / Catch 1947	't'	P
Peamouth	199	682	3.42	3.03	.01
Cut-throat	50	141	2.84	3.91	.01
Squawfish	41	110	2.70	2.37	.05
Whitefish	24	56	2.37	1.76	.10
Others[1]	15	50	-	-	-
Totals	329	1,039	3.16	-	-

[1]Comprising sculpins, suckers, dolly varden and rainbow trout - numbers too few to permit individual comparisons.

The catches of all the more abundant species were greater in 1952 than in 1947. The results of the 't' test indicate that the peamouth and cut-throat catches were significantly higher in 1952 than in 1947, while the difference between the two squawfish catches was on the border-line of significance. Statistically, there was no significant difference in the whitefish catches of the two years. It is felt that in the last two cases, a significant difference will be demonstrated when more sets are made in the fall of 1952. In general there was about a threefold increase in the size of the catches from 1947 to 1952. This may have been due either to a difference in the efficiency of the nets used or to an increase in the abundance of the nettable species. Although the first alternative is possible, it is probably not the major factor in bringing about the increase; the nets used in 1952 had the same specifications as those set in the earlier experiments. As evidence of the similarity of the sampling properties of the 1947 and 1952 nets, meshes of the same size seemed to be sampling fish of the same length in both years. A full analysis of the size distribution in the two series of sets will be presented

M. P. Shepard and R. J. LeBrasseur

next year. There are other data that suggest that the second possibility, an increase in the abundance of the fish, is probably the major contributing factor for the increased catches: Creel census returns suggest that there has been a marked increase in the abundance of cut-throat within the last three years. Also, a very preliminary analysis of the data from the lake population estimation programme (see Appendix 27) suggests that the lake population size is somewhat larger than estimates made by workers studying the lake from 1944 to 1948 indicated. In general, it is felt that there has been an increase in the numbers of adult lake fish within the last five years, especially in the cut-throat population. The size of this increase cannot be determined until the results of the creel census, population marking programme and netting programme have been analyzed.

M. P. Shepard, R. J. LeBrasseur, and T. H. Bilton

Appendix No. 29

PRELIMINARY STUDIES OF GILL-NET SAMPLING TECHNIQUES

Gill-netting is a ready means of sampling fish populations. To obtain quantitative information on the abundance, distribution and diet of the various species of lake fish, some knowledge of the variability associated with net sampling is necessary.

This year experimental studies are being conducted to determine methods of gill-net sampling that will give dependable data on the abundance, age and size composition and diet of the fish populations of Lakelse Lake. This involves a consideration of the sources of error associated with gill-net sampling and a comparison of fish taken in gill-net samples with the true populations. The various approaches being employed to study the general problem are outlined below.

Relation of catch size to abundance

This year's marking experiments and those to be carried out in 1953 are being conducted to estimate the population sizes of the more abundant species of fish in the lake. In addition, a gill-net programme, to be repeated annually, has been designed to sample the lake in a representative manner. By comparing the representation of the different species in gill-net catches with the estimated abundance of these species, differences in "catchability" of the more abundant species may be detected. A knowledge of these relations will be valuable in future years for interpreting catch figures in terms of absolute population sizes.

Representativeness of the size-classes sampled by gill-nets

To obtain size and age data that accurately reflect the size and age composition of the true lake population of any species, all size-classes should be sampled with the same efficiency. In previous years the range of mesh sizes catching the most fish was from $1\frac{1}{2}$ to $3\frac{1}{2}$ inches. Five net gangs were used, each containing 3 nets in the above size range. In experimental sets this year, 5 net gangs were used with $1\frac{1}{2}$-, 2-, $2\frac{1}{2}$-, 3-, $3\frac{1}{2}$-inch meshes represented in each gang. In future all standard sets will be made with gangs of this composition. It is hoped that an increase in the number and variety of mesh sizes in the high catch range will result in an improved representation of the size-classes sampled. Comparison of samples taken by different fishing methods (i.e., trap netting, gill-netting, and angling) should offer information on this subject.

M. P. Shepard, R. J. LeBrasseur, and T. H. Bilton

Effects of physical factors on netting efficiency

Factors such as turbidity (affecting the fishes' ability to see and possibly avoid gill-nets), wave action (affecting the tautness of the net), may be important sources of variability in gill-net sampling. Now that eight years of gill-netting data (comprising some 300 gang sets) have been collected at Lakelse, it is hoped that a comparison of the physical data and the catch records will demonstrate the effects of some physical factors on catch size. In connection with this study, observations on the time of entry of fish into gill-nets (initiated in 1947) are being carried out this year.

Variability of gang sets

If it is assumed that a gill-net samples in proportion to the abundance of the fish present in the area of the set, then the number of fish caught in that net is subject to the random errors associated with any type of biological sampling. As an illustration of the range of variability that may be associated with gill-net sampling, a series of experiments were performed in which duplicate gill-net gangs were set in the same locations at the same time. Altogether 14 duplicate sets, each involving two 5-net gangs, have been made (6 in 1947 and 8 in 1952). The differences between the catches of the identical gangs will be due to sampling errors and to any differences in the manner in which the two nets were set. The difference between the catches of the two members of each gang was determined for each of the more abundant species. The data on the catch differences are summarized in the table below. The differences associated with small catches (under 10 fish per gang) and moderate catches (over 10 fish per gang) are treated separately.

Catch range (no. fish)	Mean catch (no. fish)	No. pairs obsns.	Mean diff.[1] between 2 sets no. fish)	Sd[2]	SEd[3]
.5 - 10	3.8	36	-.11	2.71	.45
above 10.5	18.8	20	-.40	9.35	2.09

1 To eliminate possible systematic errors due to the manner of setting, the sign of individual differences was determined by using a table of random numbers.

2 Standard deviation of the differences.

3 Standard error of the mean differences.

The results indicate that in less than 5 cases out of a hundred would the difference between catches of members of duplicate gangs exceed 5.5 by chance (mean difference ±2 Sd), where catches average under 10 fish. For catches of more than 10 fish, a difference of 19.7 fish or more would be expected by chance in less than 5 cases out of 100. These wide limits of error make the use of data from single gill-net sets very unreliable for quantitative studies; for example, if a catch of 19 peamouth was obtained in a single gill-net set, then 95 times out of 100, if an identical set had been made in the same area at the same time, the catch of the duplicate net would be expected to lie between 0 and 39 fish. From this statement we must assume that the limits of error on this specific catch amounts to 100% of the actual value of the catch. However, when the means of a series of sets are compared, a more precise comparison of the duplicate catches can be made. If the mean catch

M. P. Shepard, R. J. LeBrasseur, and T. H. Bilton

difference of a series of sets comprising about 36 duplicate sets was 19, then less than 5 cases out of 100 would we expect to obtain, by chance, a mean difference of over 4.6 fish (mean difference -2SEd). Thus we might infer that in 95 cases out of 100, the catch we obtained would lie between 14 and 24 fish. These figures, indicative of the general range of variability that is encountered in gill-net sampling, emphasize the need of a sound quantitative approach to the problem. Suitable techniques for dealing with this variability are being developed.

Day to day variations in catches in one area

When duplicate gangs are set over a period of several days in one region, a variation in the total daily catch occurs. Some of this variation is due to sampling error (see above). However, other possible sources of variability are the changes in the population in the sampling region from day to day due to migrations and to the depleting effect of the fishing effort. This year a number of repetitive gang sets are being made to investigate the catch variations that occur in such cases. From an analysis of the catches it is hoped that information on the following points will be gathered.

(1) Relative sizes of local populations.
(2) Rates of immigration and emigration.
(3) Feasibility of predator removal by gill-netting.

Much of the ground work for these experimental studies was laid by Dr. J. R. Brett and F. C. Withler in the course of netting studies conducted at Lakelse Lake and Babine Lake from 1944 to 1948. The use of data collected during this period is acknowledged.

T. H. Bilton

Appendix No. 30

CREEL CENSUS 1952, AT LAKELSE LAKE

The creel census, one phase of the general fish study at Lakelse Lake, began its third year on May 1 and continued to September 7.

Cut-throat

In May the availability of cut-throat on the Lakelse River was approximately double that of May in 1951. This higher catch per hour may have been due to the cut-throat concentrating above the Lakelse River fence at the time of the sockeye yearling migration. Very little fishing was done below the river fence, only 7.5 hours with a catch of 3 cut-throat, giving a catch per hour of .400. There was no fishing on the lake during May. In June the fishing effort continued on the river and started up on the lake. The catch per unit of effort on both the lake and river was about double the value obtained in June of the year previous. In July the catch per hour on the lake was approximately three times that of July, the year before, with a decrease of availability on the river. The availability of cut-throat on the lake in August was nearly the same as in July. However, there was a large increase in the catch per hour on the Lakelse River. In September there was no fishing on the lake, while the catch per hour on the river decreased. In general the catches per unit of effort throughout the entire fishing season on the lake and on the river was significantly higher than in previous years. This higher availability may have been due to the entrance of a large age four year-class into the fishery. (See Appendix 33).

T. H. Bilton

The following table shows the total number of cut-throat and dolly varden caught and the total number of hours expended by the anglers contacted at Lakelse Lake and Lakelse River for the months of May to September, 1950, 1951, and 1952, together with the average per fisherman-hour.

		Cut-throat			Dolly varden	
Year	Month	Total hours fished	Number caught	Catch per hour	Number caught	Catch per hour
Lake						
1950	May	47.0	67	1.425	12	.255
1951		25.5	33	1.294	-	-
1952		-	-	-		
1950	June	278.5	292	1.048	-	-
1951		161.5	138	.777	-	-
1952		56	92	1.642	-	-
1950	July	277.0	261	.942	-	-
1951		179.5	154	.863	-	-
1952		183.0	437	2.387	-	-
1950	August	43.5	49	1.126	-	-
1951		76.0	59	.776	1	.013
1952		64.5	142	2.201	8	.124
1950	September	1.0	2	-	-	-
1951		-	-	-	-	-
1952		-	-	-	-	-
River						
1950	May	105	179	1.704	14	.123
1951		88	115	1.306	78	.886
1952		245.5	583	2.374	364	1.482
1950	June	113.5	154	1.365	2	.017
1951		119	115	.866	9	.075
1952		152.5	272	1.763	22	.144
1950	July	123.0	176	1.430	3	.024
1951		121.0	154	1.272	1	.008
1952		30.0	24	.8000	2	.066
1950	August	68.0	67	.978	1	.014
1951		52.0	36	.692	-	-
1952		8	27	3.375	25	3.125
1950	September	-	-	-	-	-
1951		2.0	3	1.5000	-	-
1952		5.5	9	1.631	6	1.090

T. H. Bilton

Dolly varden

Dolly varden appear to be most abundant in the spring and fall of the year on both the lake and the river. Catch per hour on the Lakelse River has been increasing since the census began. The catch per unit of effort for dolly varden in May of this year was ten times higher than the value obtained in May, 1950. The higher availability may have been due to their concentrating above the river fence where the food (sockeye and coho yearlings) was more concentrated. However, the possibility that the population of catchable fish has increased must not be overlooked. Future gill-netting data may shed some light on this alternative. The catch per hour on the river decreased in June and July, but was still higher than in previous years. No dolly varden were caught on the lake in those two months. In August the catch per unit of effort on the lake and the river was higher than in the previous years. The catch per hour of dolly varden increased on the river in August and decreased considerably in September.

From May to September, 481 fishermen were contacted on the lake and on the Lakelse River. Their total catch throughout this period was 2086 fish, of which 1586 were cut-throat, 427 dolly varden, 35 squawfish, and 73 rainbow. The numbers sampled were: 757 cut-throat, 100 dolly varden, 41 rainbow, and 35 squawfish. It is estimated that this catch represents about 80% of the fish caught on the river and 50% on the lake.

Appendix No. 31

T. H. Bilton and V. H. McMahon

SUMMARY OF STOMACH ANALYSES OF CUT-THROAT AND SQUAWFISH, LAKELSE LAKE, 1945-51

From 1945 to 1951 the contents of approximately 2000 stomachs of fish of all species have been analysed for Lakelse Lake. The majority were of fish considered to be predaceous on young sockeye salmon, e.g., cut-throat trout, squawfish, and dolly varden char. They were collected mostly during the summer but a small number were taken during the fall and winter months. The numbers and volumes of the organisms found in the stomachs of each fish were recorded.

During the past winter the stomach analyses for each species of fish were catalogued and summarized with respect to whether the fish were caught inshore or offshore, the month of capture, and the lengths of the captured fish. The types of food in the diet were grouped into: insects, sticklebacks, sockeye, fish remains, and miscellaneous, e.g., vegetable material, molluscs, etc. The report comprises preliminary analyses of the cut-throat and the squawfish diets.

The summer diets of cut-throat trout caught from May to September inshore and offshore at Lakelse from 1945-1951 are summarized as follows:

T. H. Bilton and V. H. McMahon

Organism	Captured inshore Total no.	No. of stomachs	Av. no. per stomach	Captured offshore Total no.	No. of stomachs	Av. no. per stomach
Insects	9025	598	15.091	1162	146	7.273
Sockeye	127	598	.212	101	146	.691
Stickleback	838	598	1.401	110	146	.753
Unidentified fish remains	1057	598	1.766	211	146	1.445

Tentative conclusions are: (1) that from May to September cut-throat caught inshore have a higher average number of insects per stomach than cut-throat captured offshore, probably the result of the large hatches of insects along the shallow reedy shores of the lake; (2) that the average number of sockeye per stomach is significantly higher (three times) in cut-throat captured offshore, probably due to higher availability of young sockeye in offshore waters; and (3) that the average number of sticklebacks per stomach of cut-throat inshore is approximately twice the average number found in cut-throat caught offshore.

The summer diets of squawfish from June to September, caught inshore and offshore at Lakelse Lake, 1945-1951, were found to be:

Organisms	Captured inshore Total no.	No. of stomachs	Av. no. per stomach	Captured offshore Total no.	No. of stomachs	Av. no. per stomach
Insects	164	610	.268	6	210	.028
Sockeye	57	610	.093	15	210	.071
Stickleback	90	610	.147	54	210	.256
Unidentified fish remains	231	610	.378	111	210	.528

They show that: (1) the number of insects per stomach is higher in the stomachs of squawfish caught inshore; (2) squawfish caught inshore and offshore have approximately the same average number of sockeye per stomach; (3) squawfish caught offshore have on the average double the number of sticklebacks per stomach compared with those caught inshore; (4) the average representation of sockeye in the stomachs of squawfish caught offshore is around one-tenth the average number found in the stomachs of cut-throat trout captured offshore.

The cut-throat captured inshore have a higher number of unidentified fish per stomach than cut-throat caught offshore. The opposite condition prevails for the squawfish.

In general, the most important conclusion that may be drawn from the preliminary analysis of the data, is that a well designed netting programme be set up to sample for diet, lengths, age, etc., such a netting programme to sample seasonally the fish populations in the lake in proportion to their abundance each year.

Appendix No. 32

M. P. Shepard and R. J. LeBrasseur

STOMACH CONTENT ANALYSES, LAKELSE LAKE, 1952

This year, in conjunction with studies on fish populations in Lakelse Lake, almost 1000 stomach samples will be taken. The purpose of this work is to relate the representation of the various prey organisms in predator stomachs with the survival and abundance of prey fish, especially the sockeye salmon. To date, of the 600 stomachs collected, over 400 have been analyzed.

Appendix No. 33

T. H. Bilton

AGE AND GROWTH STUDIES OF LAKE-RESIDENT FISH AT LAKELSE LAKE

This year an age and growth study was initiated at Lakelse Lake to obtain information on (a) changes in growth rate which might indicate a change in population size, and (b) variation in age-class representation which might have a bearing on survival rates. It was felt that the data might also be useful for comparing the efficiency of sampling methods, e.g., trap-nets, gill-nets, angling.

Age determinations of cut-throat trout sampled on the lake and the Lakelse River in the creel census in 1950 and 1951 were completed this season. Approximately 100 yearling and underyearling cut-throat were collected at the Lakelse River fence in May and their ages determined. Age determinations of cut-throat sampled in the creel census this year were begun, and will be completed in the near future. A total of 1440 cut-throat scales were read this year.

The following table shows the number, the per cent and the mean size in inches of the individuals in each age-class in the sample of cut-throat caught on Lakelse Lake and Lakelse River in the creel census, 1950 and 1951.

		II	III	IV	V
1950 -	Mean fork lengths (inches)	8.38	10.79	12.17	14.45
	Number of fish	90	322	206	36
	Per cent of catch	13.86	49.30	31.74	4.77
1951 -	Mean fork lengths (inches)	8.02	10.20	11.48	12.91
	Number of fish	20	216	189	39
	Per cent of catch	4.31	46.55	40.73	8.41

Originally the river and lake samples were analyzed separately but no significant differences in the age compositions and the mean size were obtained, therefore, the two were combined as in the above table. This continuity in the age compositions and mean sizes of the lake and river fish suggests that they are members of the one population. In both years the age-III and age-IV fish make up the greatest percentage of fish in the anglers' catches.

The following table shows the brood year of the cut-throat in each age-class and the year in which each entered into the sport fishery at Lakelse Lake. The per cent and the mean size of each age-class were obtained from the creel census records of 1950 and 1951, and a preliminary analysis of 200 scales sampled in the 1952 creel census.

Brood year	1952 Per cent	1952 Age	1952 Mean length (inches)	1951 Per cent	1951 Age	1951 Mean length (inches)	1950 Per cent	1950 Age	1950 Mean length (inches)
							4.77	5	14.45
1945				8.41	5	12.91	31.74	4	12.17
1946	3.33	6	13.45	40.73	4	11.48	49.30	3	10.79
1947	16.66	5	12.32	46.55	3	10.20	13.86	2	8.38
1948	49.33	4	11.02	4.31	2	8.02	-	1	-
1949	30.66	3	10.02						

Note: Per cent = per cent representation in the catch

Assuming firstly, that the creel census samples the population with the same efficiency from year to year, secondly, that all the age-classes over II are equally vulnerable to the fishery and, thirdly, that the percentage age composition in the sample represents the age composition of the population, the year-classes may be followed through the fishery and predictions may be made on their size and abundance.

The higher percentage of age-IV in 1952 is probably due to the biased nature of the preliminary sample for age determinations used to represent the 1952 age composition. In past years it was found that the age-IV and age-V fish make up most of the catches at the beginning of the season. The scales used in the preliminary analyses of the age composition of cut-throat sampled by the 1952 creel census were all taken from fish caught at the beginning of the season. The low percentage of age-III is probably due to inadequate samples by angling, because of the eight-inch legal limit. The percentage of age-IV and age-V fish have been increasing in the samples of the catches from 1950 to 1952. Also the growth rates have been decreasing. The mean size of age-V fish have decreased from 14.45 inches in 1950 to 12.32 inches in 1952. The mean lengths of age-IV cut-throat have decreased from 12.17 inches in 1950 to 11.02 inches in 1952. The mean lengths of age-III have also decreased, e.g., 10.79 inches in 1950 to 10.016 in 1952. The data suggest that the population of cut-throat in the lake and the river is increasing in density. Further evidence suggesting this increase, is demonstrated in the increased catch per hour by the anglers (Appendix 30), and the gill-netting which shows an increase in the catch per net-night of cut-throat in the last 5 years (Appendix 28).

A catch curve was plotted for the age composition of the creel census fish of 1950 and 1951. The curve suggests that the age-II fish are inadequately sampled. A large decrease in the percentage of age-V as compared with the age-IV has been noted and may be due to (a) high mortality rate, (b) seaward migration of the older fish, (c) a decreased vulnerability to the fishery, or a combination of all factors. Per cent age composition has also been plotted on a monthly basis. The catch per unit of effort of age-II cut-throat increased throughout the season suggesting that there are some faster growing fish which reach legal size in the spring, with a gradual increase in the availability as more of the slower growing fish reach the eight-inch size limit later on in the season. The catch per unit of effort of age-IV and age-V fish decreased from May to September, suggesting either a decrease in vulnerability to the fishery, or a decrease in abundance. The per cent age compositions

T. H. Bilton

of male and female cut-throat were plotted. No significant differences in the per cent composition of male and female in each age-group were observed.

An estimation of the total survival rates and conversely the mortality rates from year to year will be calculated when this and next year's age analyses are completed. The fishing mortality will be calculated when the rates of exploitation from mark return are calculated. From the total mortality and the fishing mortality the natural mortality will be obtained.

Appendix No. 34

V. H. McMahon and T. H. Bilton

WINTER NETTING, LAKELSE LAKE

Uniformity of water temperatures and light penetration in the lake as well as a probable scarcity of forms of food other than small fish led investigators to believe that the consumption of young sockeye salmon by predator fish may be higher during winter ice-cover than in the open-water seasons. In early 1948, 1950, and 1951, some nets were set under the ice in various positions on the lake. However, little information on predation was gained during these years. Most of the sets had been made inshore or in the shallow areas of the lake. Last winter, however, it was decided to test the deeper regions since experience suggested that the young sockeye inhabit the deeper waters, at least during the summer months. Consequently in the winter of 1952 gill-net sets were made in offshore areas.

As in other years weather conditions during the winter of 1951-52 limited gill-netting operations under the ice to a period of six weeks commencing the middle of February. A total of 33 sets were made during the period in 3 regions of the lake and for the most part a single net of $2\frac{1}{2}$-inch mesh was employed in each set. A few sets were made using 3- and $3\frac{1}{2}$-inch meshes.

Most of the sets (27 out of 33) were made in the centre of the lake in water of approximately 20-foot depth, and 23 of the sets were made using $2\frac{1}{2}$-inch mesh. Of these 23 sets, 12 were made at the surface, one at 10-foot depth and 10 at the bottom (20 ft.). A total of 37 fish were caught, 34 of which were either cut-throat trout or dolly varden. One rainbow trout and 2 squawfish were also taken.

The following table shows the numbers of cut-throat and dolly varden caught at the surface and bottom, their relative catch per net-day and their stomach contents. The single catch from the 10-foot level has not been included because of the inadequacy of the sampling at that depth.

Depth of water No. of net-days ($2\frac{1}{2}$-inch mesh)	0 ft. (surface) 22 Cut-throat	 Dolly varden	20 ft. (bottom) 25 Cut-throat	 Dolly varden
No. caught	19	2	1	9
Catch per net-day	0.864	.091	.040	.360
No. of stomachs containing:				
Sockeye	3	2	-	7
Stickleback	11	-	1	-
Coho	-	-	-	1
Fish remains	1	-	-	-
Mysids	-	-	-	1
Insect remains	-	-	-	-
No. stomachs empty:	5	-	-	1
Per cent stomachs containing food:	73.2	100.0	100.0	88.8
No. of fish in all stomachs:				
Sockeye	3	16	-	31
Stickleback	132	-	10	-
No. sockeye per stomach:	.157	8.00	-	3.44
No. stickleback per stomach:	6.947	-	10.0	-

It is evident from the results above that the dolly varden char is an important predator on the young sockeye salmon during this period of sampling. To a much lesser extent the cut-throat trout is also a predator on sockeye. The cut-throat, however, appears to depend to a greater extent on the 3-spined stickleback for its food supply in the pelagic regions. The limited amount of data makes it difficult to draw definite conclusions as to the distribution of fish under the ice. However, the results suggest that there is a greater abundance of cut-throat trout in the surface waters whereas the dolly varden char appear to be more abundant near the bottom of the lake.

Although it would appear, from the table, that the number of sockeye ingested by dolly varden is greater at the bottom than at the surface this deviation would probably have been less obvious had more samples of dolly varden been caught in the surface sets. The reverse holds true for the cut-throat since only one fish was caught in the bottom sets and this fish happened to have ingested 10 sticklebacks.

More abundant sampling may decide (a) whether there are more cut-throat and sticklebacks at the surface and more dolly varden and sockeye near the bottom, with fewer dolly varden and sockeye at the surface and fewer cut-throat and stickleback at the bottom; or (b) whether all sticklebacks are at the surface and all sockeye at the bottom with occasional upward and downward migrations of dolly varden and cut-throat, respectively, from their normal feeding grounds.

Appendix No. 35

M. P. Shepard

DOLLY VARDEN AND CUT-THROAT POPULATIONS OF PORT JOHN LAKE, 1951

During the fall of 1951, a population estimation programme was conducted on the dolly varden char and cut-throat trout of Port John Lake. In the course of this investigation information on the movements and diets of the two species was obtained.

Population estimates

To estimate population sizes, two experiments were conducted on each species. The first involved marking prior to the main sampling period, while in the second marking was coincident with the recapture programme. In the recapture period, fish marked in the first series of markings were found to be more widely dispersed throughout the lake than fish marked in the second marking period. As a result population estimates based on the recovery of fish marked during the first period tended to be higher than similar estimates based on the results of the second marking experiment. As the second experiment was coincident with the sockeye run to Tally Creek and marking was confined to the areas surrounding the spawning streams, the later population estimates represent the sizes of the populations present in the area surrounding the spawning streams (the extreme south end of the lake).

The methods used to estimate the populations were the Petersen and Schnabel methods. The applicability of these methods to the experiments was thoroughly tested. In the dolly varden experiments, the use of these methods seemed justified, the underlying assumptions of the calculations being supported by the data. In the cut-throat experiments, however, differences in the vulnerability of fish of different lengths, the observation that marked fish tend to remain close to the point of marking and an unequal vulnerability of fish to the two sampling tools used (gill-nets and angling) prohibited the use of the unmodified Petersen and Schnabel methods. Attempts were made to adjust for these sources of error. The results of the two series of experiments are summarized in the table below.

	Estimate of population confined to extreme south end of lake		Estimate of entire lake population	
	Estimate	95% Confidence interval	Estimate	95% Confidence interval
Dolly varden	232	394-623	1,058	635-2,540
Cut-throat	213*	129-516	1,650	408-2,600

* Estimate for Tally Creek mouth only.

Distribution

Angling and gill-netting (involving 14 gang sets) were conducted throughout the lake. The results indicated that dolly varden were largely restricted to the south end of the lake. Cut-throat were more widely distributed, but tended to be more concentrated at the south end of the lake. Dolly varden were caught in gill-nets set between 6 and 40 feet, while some cut-throat were caught at all depths down to 100 feet. The highest concentration of dolly varden was between 20 and 40 feet, while cut-throat were most abundantly represented in sets made between 6 and 20 feet. The majority of these sets were made on the lake bottom and hence results are not applicable to the pelagic regions of the lake. The concentration of fish at the south end of the lake during the fall coincides with the adult sockeye salmon run to the two spawning creeks situated at the south end of the lake.

Diet

Sockeye eggs appeared to form the major portion of the dolly varden's food at this time of the year. Sticklebacks formed the most frequent item in the cut-throats' diet. No sockeye young were found in the char stomachs, while only 2 of the 46 cut-throat stomachs examined contained sockeye (smolts in this case).

During the period of sampling the average number of eggs observed in the stomachs of dolly varden was 3.5. Assuming that eggs become completely digested in 48 hours (as suggested by digestive rate experiments carried out at Lakelse), the average egg consumption of the char might be set at about 1.75 eggs per day. The population of dolly varden in the south end of the lake was estimated to be about 500 (see above). The dolly varden appeared to concentrate off the creek mouths for a period of about 35 days. From these data, a rough estimate of the number of sockeye eggs consumed by char may be made:

No. eggs consumed =
(no. char) X (av. cons. of eggs/day) x (duration of predation)

Here no. eggs consumed =
(500) X (1.75) X (35) = 30,625

In 1951, the potential deposition of the Port John Lake sockeye was 392,412. Thus predation by dolly varden of sockeye eggs could conceivably account for approximately 8% of the total deposition. However, all the dolly varden were captured in the creek mouths or in the lake and hence the majority of this predation must have occurred before the sockeye had reached the spawning grounds. Hence the majority of the eggs in the char stomachs may have been eggs dropped by the sockeye before active spawning began. In this case, predation of eggs by char would not be an important factor in limiting the size of the sockeye seeding.

R. E. Foerster and W. E. Ricker — Appendix No. 36

FURTHER ASSESSMENT OF AN EXPERIMENT IN CONTROL OF PREDACEOUS FISHES TO INCREASE SOCKEYE SURVIVAL IN A LAKE

Control of predaceous fishes in Cultus Lake was begun by the Fisheries Research Board in 1935 and was continued on a somewhat reduced scale by the International Pacific Salmon Fisheries Commission from 1938 to 1942. The data through 1938 were summarized some years ago; subsequent data have been made available recently by the Director of the Salmon Commission.

Following an initial rapid reduction in 1935-36, the squawfish population of the lake remained low through 1939, but increased noticeably in 1940 and reached a high in 1941, decreasing in 1942. The 1941 maximum consisted mostly of fish which had just grown into the vulnerable size range; since these did not appear in the next size-class in 1942 in any numbers, continued effective control of medium-sized fish by the nets is indicated.

R. E. Foerster and W. E. Ricker

The increase of smaller squawfish in 1940 and 1941 may possibly reflect increased survival of fry in 1936 and 1937, resulting from removal of large squawfish. The trout population has not fluctuated in response to gill-netting, and trout are probably the most important predators in the lake. Char were early reduced and remained at a low level. Lake coho populations have fluctuated sharply with variations in spawning stock; the extent to which the nets may have affected them is unknown.

An index of abundance of squawfish shows considerable parallelism with changes in mortality rate of sockeye in the lake, but there is considerable residual variability. Some of this has been tentatively associated with (a) poor survival of very large spawning stocks, and (b) the unfavorable effect of a large carry-over of yearlings upon the fingerlings of the following brood.

The limit of the capacity of Cultus Lake to raise sockeye can be estimated as an annual production of about 45 metric tons, which yields 2,300,000 smolts of 6 grams each without predator control, or 3,500,000 of the same size with control. Larger numbers of yearlings have been produced, but only at the expense of smaller individual size and unfavourably large carry-over.

At the time gill-netting was stopped, the squawfish population was still in process of adjustment to the new conditions of mortality. Hence the long-term practicability of control cannot be assessed without further trial. However, it remains probable that sustained control would yield benefits of the order of 15-20 times its cost, which is the order of magnitude of the return for what was spent in 1935-42.

T. H. Bilton, T. M. Mitchell, R. J. LeBrasseur, and
M. P. Shepard

Appendix No. 37

PARASITES AND DISEASE, 1952, LAKELSE LAKE

In July, the presence of increasing numbers of dead unspawned sockeye floating on the lake, suggested that some mortality had occurred in the population. At the same time most of the sockeye that had moved up through Williams Creek counting fence into the spawning grounds, were recovered on the fence dead and unspawned.

In an attempt to determine the cause of the mortality, a parasite and disease study was initiated. Each day a dead sockeye from the fence was brought in for autopsy. The following body parts and internal organs were examined: skin, fins, external genitalia, eyes, mouth cavity, gills, stomach, pyloric caeca, intestine, rectum, peritoneum, liver, gall-bladder, heart, kidneys, testes, and ovaries. The gills in 58% of the 20 dead sockeye examined had what appeared to be a primary bacterial infection with a secondary fungus infestation. Fungused and injured fins were found on 37% of the fish examined; 26.3% of these injuries occurred on the caudal fin. The internal organs of all the fish examined appeared to be normal. The above data suggest that the gill infection was the major contributing factor for the early mortality in the adult sockeye salmon.

Records were also kept on the general condition of the dead sockeye recovered on the lake and at the Williams Creek fence. Sixty of the dead fish recovered on the lake were examined for lesions and fungus. Thirty-five per cent of these were in good condition, 28% had lesions and fungus on the head,

T. H. Bilton, T. M. Mitchell, R. J. LeBrasseur, and M. P. Shepard

13.2% had body lesions and fungus, and 6.6% had head and body lesions and fungus. Of the 57 dead fish recovered on the fence, 10.5% were in good condition, 24.5% had head lesions and fungus, 29.8% had head and body lesions, 12.2% had head and tail lesions, and 5.2% had body lesions. The higher percentage of head injuries suggests the possibility that at least some of these may have been due to rubbing against the frameworks of the Lakelse River fence, when they were migrating upstream into the lake.

During the same period dead lake-resident fish were observed, suggesting that the mortality was not confined just to the sockeye. Diseased fish were caught in the trap nets. A description of each diseased fish was recorded. A total of 7 diseased squawfish were examined, 4 with small blood spots scattered over the body, 2 with small lesions and lumps on the body dorsal to the base of the pelvic fins, and one with a lesion on the caudal peduncle. One peamouth chub was caught with a gill infection and one sucker with red blood spots on the body. The lesions and blood spots are probably a result of bacterial infection. Others were brought in for autopsy. The fish were examined in the same way as stated previously. Lesions, fungus, and ulcers (probably caused by bacteria) were found on the head, gills, skin, and fins. Smears from the ulcers were made and stained. The parasites from the external body parts and the internal organs were preserved for future analyses.

Past studies have shown that quite often when animal populations reach a peak in density, factors such as disease, parasites, decrease in available food, may reduce the population. In future, in order to assess the relative infestation from year to year, sampling of the fish for parasites and disease will be included in the continuous netting programme.

V. H. McMahon

Appendix No. 38

YOUNG SOCKEYE STUDIES

A preliminary attempt was made this summer to capture young sockeye salmon in the lake but without success. A large fyke-net, of the type used to capture larger fish in the lake was suspended in the centre of the lake at the point where the sockeye-feeding trout and char were caught last winter. The fyke net was fitted with two 50-foot wings which formed a wide funnel into the net. A few 3-spined stickleback and sculpins were caught by this method but no sockeye.

A preliminary test was made of the use of rotenone for the collection of fish. A cloth bag containing 25 pounds of rotenone was towed behind the boat in a circle of about 40-50 feet in diameter for several times and what remained of the contents was then poured and mixed into the centre of the circle. The area was then patrolled for 2 to 3 hours but no fish were seen.

R. E. Foerster

Appendix No. 39

THE SOCKEYE SPAWNING ESCAPEMENT TO LAKELSE LAKE, 1952

In order to compute the general efficiency of the natural propagation of sockeye salmon to the seaward smolt stage, under local prevailing conditions, it is necessary to have an accurate count of the individuals comprising the

R. E. Foerster

spawning population, the sex ratio and the mean egg content per female. The egg deposition can then be determined.

The first count of sockeye proceeding to the spawning grounds in the Lakelse Lake area through the new counting weir was undertaken this summer and during the period June 4 to September 8 a total of 18,329 sockeye were released through the weir. The Lakelse Lake sockeye run is extremely early, the fish playing about in the lake for several weeks prior to ascent to the spawning grounds, and therefore the sex of the fish could not readily be determined as the fish were released periodically under the raised screens. It was necessary, therefore, to take a sample of the run for sex representation, at first 10% of each day's count and later on (as the daily numbers increased) 5%. This sample was also used to obtain length frequency data and scales were taken to determine the age-group representation.

Prior to release the sample fish (955 in all) were tagged in order to study spawning ground distribution and also to determine the value of tagging as a means of estimating spawning populations.

During the early part of the run a large number of sockeye were observed with snout and head injuries and body wounds. Subsequently most of these injured fish died in the lake (Appendix 42). Further investigation will be made next summer.

Mr. Ira Withler was in charge of the scientific observations, counting, sampling, etc., while Mr. Martell was responsible for the weir operation and maintenance.

M. P. Shepard, R. J. LeBrasseur, and G. G. Futcher Appendix No. 40

PRELIMINARY ACCOUNT OF THE SOCKEYE RUN TO WILLIAMS CREEK, 1952.

Williams Creek, the principal tributary to Lakelse Lake, carries approximately 80% of the sockeye population spawning in the Lakelse Lake area. In 1939 and from 1944 to the present, counting weirs have been operated on the three channels of the creek to enumerate the sockeye entering the spawning area. In addition to the three main channels, a fourth channel drains from Williams Creek into an adjacent non-sockeye stream - Blackwater Creek. Previous to this year it was not believed that sockeye ascended this branch. This summer, however, it became evident that this branch permits the passage of an appreciable number of sockeye from the lake to the upper spawning stretches of Williams Creek. Early in the run a barrier, made of chicken-wire frames, was established across the branch. This did not form a complete block, however, to the passage of sockeye, but did retard the fish sufficiently to permit rough observations on the relative magnitude of the Blackwater branch run.

This year, as part of the Williams Creek programme, weekly counts were made of the number of fish on the spawning grounds. The counts showed that many more fish had reached the grounds than could be accounted for by the counts made on the three main fences. These excess fish must have reached the spawning ground by migrating up the Blackwater branch of Williams. There is evidence that this Blackwater branch run may have occurred in at least the last two years but, since previous operators of the Williams Creek fence did not make surveys of the spawning grounds, the accuracy of the fence counts cannot be readily assessed.

M. P. Shepard, R. J. LeBrasseur, and G. G. Futcher

Fence counts

The first sockeye were counted through the fences on July 8. Until August 5 the run consisted mainly of injured and diseased fish in unripe condition. None of these fish appeared to spawn, the majority dying within a few days of their arrival at the creek. A run of healthy, ripening fish began early in August, reached its peak on August 13 and continued until the first week in September. The early run of unspawned fish constituted approximately 5.5% of the total run. A total of 2791 fish were counted through the fence. The sex composition of the run is listed in the table below.

The lengths and weights of approximately 10% of the run were recorded. The average egg content of unspawned females was determined by examining the ovaries of 26 females. The testis volumes of 31 males were recorded. Egg counts and testis measurements were made on 165 fish found dead on the fence to compare with the gonads of spawned and unspawned fish. Another 525 dead fish were examined to determine what proportion of the fish had spawned.

A preliminary analysis of the measurement data has been carried out; the complete results will be reported at a later date.

Spawning ground surveys

Five surveys were made to enumerate the sockeye present on spawning grounds and to inspect the condition of the spawners. From these observations and from tagging experiments set up to estimate the spawning populations in the creek, it was determined that approximately 10,200 sockeye ± were present.

Thus, although only 2791 live fish passed through the Williams fences, at least three times as many fish were present on the grounds. In all probability these fish passed up through the Blackwater channel. As evidence of such a large run occurring, during one 2-hour observation period at the peak of the run, over 200 fish passed through the Blackwater branch fence, whereas the maximum daily count through any of the main Williams fences was 178 fish. As mentioned previously, it is likely that this Blackwater branch run has occurred in other years. In the following table the runs of previous years are listed, and assuming that approximately the same proportion of the run ascended the Blackwater branch in the last two years as in this year, the estimated total runs to Williams have been calculated.

Year	Males	Numbers of Females	Numbers of "Jacks"	Ratio Males:females	Total fence count	Estimated run
1939	12,350	11,735	-	1.05:1	24,085	24,085[1]
1944	-	-	-	-	-	20,000[2]
1945	-	-	-	-	-	50,000[2]
1946	-	-	-	-	-	34,000[2]
1947	-	-	-	-	-	15,000[2]
1948	-	-	-	-	-	13,000[2]
1949	2,685	3,000	22	.90:1	5,707	?
1950	1,026	480	-	2.14:1	1,507	5,300
1951	2,259	1,898	-	1.19:1	4,157	14,900
1952	1,461	1,252	78	1.22:1	2,791	10,200

[1] Blackwater channel probably not open.
[2] From spawning ground surveys made by J. R. Brett *et al.*

J. G. McDonald

Appendix No. 41

SOME OBSERVATIONS FROM TAGGING DONE AT SCULLY CREEK, 1952

As a result of tagging sockeye adults in 1951 some information on the distribution and life span of these fish on the Scully spawning ground has been obtained.

Twenty per cent of the daily run was tagged at the fence throughout the migration. Of the 1214 sockeye put over the fence, 237 were tagged. Of those tagged 84 were recovered from spent and dead fish during periodic stream surveys.

For purposes of determining the distribution of spawners in relation to time of entry into the creek, that part of the stream in which the tags were recovered was taken as being in close proximity to their spawning site. The nature of the creek is such that there occurs only a slight displacement of spent and dead fish from the redds over which they spawned.

When the location recovered is plotted against the date tagged, no trend is evident. Fish entering the creek during the early stages of the run showed no different preference for spawning area, as far as distance upstream was concerned, from intermediate and later running sockeye.

It was noted, however, that differences occurred in the distribution of the sexes over the length of the spawning ground.

Below is given the sex ratio of the spawners for different areas of the creek, as obtained from tag returns.

Area	Male	Female	Ratio Male	:	Female
Fence - 1200 ft.	14	18	1	:	1.3
12 - 2400 ft.	7	3	2.3	:	1
24 - 3600 ft.	18	4	4.5	:	1
36 - end of spawning	20	3	6.6	:	1

The ratio obtained for tagged individuals varied from 1:1.3 on the area immediately above the fence to 6.6:1 on the furthest reaches of the spawning area. The ratio obtained from the count at the fence as the fish were ascending the creek was 2.2:1.

Such a distribution of males and females as observed could possibly be reflected in the fry production if the efficiency of egg deposition and fertilization is related, within certain limits, to the number of males present. For example the ratio from the fence to 1200 feet shows a predominance of females. A lesser number of males may result in incomplete service to females whereas a surplus of males as in areas above 1200 feet would be expected to produce optimum service per female.

Date of tag recovery when compared to date of tagging reveals, on the average, that male and female sockeye lived 14 and 16 days, respectively, after entering the stream. These figures compare almost exactly with the interval existing between the peaks of live and dead fish seen during creek surveys. The values, although not of great importance in themselves, prove useful in determining the spawning population in streams where actual counts cannot be obtained.

Appendix No. 42

M. P. Shepard and J. G. McDonald

THE DISTRIBUTION AND SURVIVAL OF ADULT SOCKEYE AT LAKELSE LAKE

After passing upstream through the Lakelse River counting fence, adult sockeye spend a month or more in Lakelse Lake before ascending the spawning streams. Petersen disc tags were applied to about 1000 of the 18,000 fish that passed through the Lakelse River fence. Recoveries of these tags on dead fish in the lake, and on live fish on the spawning grounds provided information on the distribution and duration of stay of the fish in the lake. This year the appearance of dead fish floating in the lake suggested that a considerable mortality had occurred before the actual spawning run began.

Distribution

Sockeye ascend almost all the 12 creeks draining into Lakelse Lake. Most of the creeks were visited at least once, usually near the peak of the run, to determine the number of spawning fish each creek supported. As all of the streams examined are of small size (with the exception of Williams Creek), it is felt that most of the sockeye present during each survey were observed and counted. As the run lasts approximately four weeks and the average life span of the fish is about two weeks, at the peak of the run approximately two-thirds of the total run will be present on the spawning grounds (assuming that the course of the run follows a roughly normal pattern and that 95% of the run is completed in four weeks). Thus by multiplying the stream estimates by 1.5 an approximation of the total run may be made. The results of the stream surveys and counts are listed in the table below.

Creek	No. spawners seen at peak of run	Estimated spawning population (to nearest 100 fish)
Williams	(Estimated by tagging)	10,200
Scully	(Weir count)	1,300
Others	396	600
Total		12,100

Tag returns indicated that on the average, fish spawning in Williams Creek had remained in the lake 52 days before moving to the spawning grounds while Scully spawners had remained about 8 days longer. As the Scully run tends to be later than the Williams run (e.g., this year the peak counts at the two creeks were separated by 10 days), there did not seem to be any segregation of the two runs with respect to time of arrival at the Lakelse River fence.

Survival

Although no records were kept in the past, it is believed that the number of floating dead in 1952 was greater than in previous years. To assess the extent and possible causes of this mortality daily searches of the lake were made to collect dead fish for examination. Altogether 159 dead fish were recovered; 69% of these had noticeable injuries or were diseased (Appendix 37). Concurrently with this mortality, an early run of injured and diseased fish occurred at Williams Creek (Appendix 40) and at Scully Creek. This run of injured fish was estimated to contain 550 fish, compared to the run of approximately 10,200 healthy fish that ascended Williams Creek later in the summer.

In an attempt to determine the magnitude of the lake mortality, 75 dead sockeye were marked and distributed throughout the lake. Six of these marked fish were recovered in the course of the daily reconaissances of the lake. As the number of fish involved in the experiment was small, an accurate quantitative interpretation of the data is not possible. However, it is evident that fish observed floating in the lake represented only a fraction of the total number of fish that had died. From inspection of the data, a rough estimate of 2000 dead fish might be forwarded. This number added to the estimate of the number of fish dying in the spawning creeks before the spawning run commenced would place the known mortality at about 2500 fish. Thus, of the 18,000 adult sockeye that passed through the Lakelse River fence, 12,100 live fish and roughly 2500 dead fish could be accounted for. This left an estimated 3400 fish missing. Whether unobserved lake spawning or an undetected mortality among lake fish had occurred to account for the missing fish could not be determined from the available data.

Compared to the proportion of the population tagged at the fence, the proportion of tags in the dead fish found floating on the lake was high. This suggested that a differential tagging mortality had occurred. This premise received further proof when it was found that the proportion of tags in the fish spawning in Williams and Scully creeks was lower than in both the other groups of fish. From the data concerning this differential mortality a method of estimating the abundance of the spawning run and of the number of fish dying before the run began was devised. These estimations were made independently of spawning stream fence counts or surveys.

In the following table, figures obtained by this method are compared with figures computed from fence counts and spawning ground surveys.

	Number of fish	
	Calculated from tagging ratios	Estimated from counts and surveys
1. Live fish spawning		
Untagged	12,480	11,797
Tagged	312	303
Total	12,792	12,100
2. Died before spawning		
Untagged	4,520	-
Tagged[a]	266	-
Tagged[b]	422	-
Total	5,208	2,500
3. Missing	0	3,400
4. Dead and missing	5,208	5,900
5. Total 1 and 4	18,000	18,000

[a] Where death was not due to the tagging operation.
[b] Where death was due to the tagging operation.

M. P. Shepard and J. G. McDonald

The values for the total number of live fish (1) and the total number of dead or missing fish (4), computed by the two independent methods, agree quite closely. As both sets of estimates are subject to considerable sampling error, there is probably no significant difference between the two. The estimate of the number of live spawners calculated from the tag-ratio data includes all fish spawning in the Lakelse Lake area (i.e., includes both lake and stream spawning runs). The estimate of live spawners based on creek surveys and counts includes only those fish moving into the spawning streams. As the two estimates are almost equal, it must be concluded that there was no appreciable amount of lake spawning in Lakelse Lake this year. Thus, the majority of the fish that could not be accounted for in the estimate based on counts and surveys, probably died in the lake before the spawning run commenced.

From the figures presented in the table above, the mortality occurring in tagged fish was approximately 3 times that occurring amongst untagged fish. On the basis of this finding, changes in tagging technique are recommended. Analyses of other tagging experiments conducted on migrating salmon at Lakelse and elsewhere will be made to determine whether similar tagging mortalities have occurred in the past.

There is no doubt that the operation of the Lakelse River fence was the cause of some of the mortality occurring amongst the unmarked fish. However, the appearance of a bacterial gill disease on many of the dead fish (Appendix 37) suggests that an epidemic may have broken out in the population causing a large natural mortality. It is hoped that further studies on the diseases of salmon will shed some light on the subject.

F. C. Withler, K. V. Aro, and E. Dombroski — Appendix No. 43

ENUMERATION OF THE RUN AT THE BABINE FENCE, 1952

The Babine fence was operated first in 1946 to discover the size of the run of adult sockeye to the Babine Lake system. After the first year's counts it became apparent that Babine Lake accounted for over 50% of Skeena River sockeye escapement and that the fence counts were a measure of the escapement to the major sockeye spawning area of the Skeena system. In addition, the fence counts provided indices of the sizes of the spring, pink, and coho salmon escapements. The fence operated every year except in 1948 when exceptional spring floods washed out part of the weir.

In 1951 the counts at the Babine fence took on further significance after a slide in the Babine River provided a serious obstacle for the migrating salmon. The difficult passage caused by the slide reduced the run of sockeye salmon to approximately one-third of the usual size and appeared to have even more serious effects on the pink, spring, and coho populations.

During the winter of 1951-52 the Department of Fisheries constructed a road from Hazelton to the slide, where the biologists and engineers were able to assist the passage of salmon by marginal improvement of the river channel. Some of the effects of the slide on the 1951 and 1952 runs may be seen in the following table which summarizes the counts of the five species for the six years of fence operation. The counts shown for 1952 are those up to October 6, about which time fence operation normally ceases as all runs except coho are nearly past.

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

Year	Sockeye	Percentage "Jack" sockeye	Spring	Pink	Coho	Chum
1946	475,705		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	374,867	(approx. 7.3)	5,904	2,706	9,601	1

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

The sizes of the runs of the four major species in 1952 show considerable improvement over those in 1951 but they are still well below those of the years previous to the slide.

Sockeye passing the Babine fence more than doubled the 1951 run. They appeared later than ever before (July 27) and thereafter the run came in three waves which roughly divide the 1952 run into three parts with increasing numbers in each wave:

Jul 27 - Aug 19	51,037
Aug 20 - Aug 31	61,548
Sep 1 - Oct 6	262,282

The peak run of 18,000 sockeye arrived on September 11, eighteen days after the mean peak day for the four years of operation prior to 1951. (It may be noted that the commercial fishery on the Skeena River was later in 1952 than in previous years.) By October 6 the sockeye run had dwindled to 200-300 daily at the counting weir. As yet the waves demonstrated by the run have not been related to water levels, marginal improvements at the slide or other factors affecting the timing of the run.

The spring salmon run doubled that of 1951 and approached the size of the runs of 1949 and 1950. The run consisted largely of "jack" springs as in 1951, so that the large females would be a relatively small proportion of the total. The escapement records are, therefore, not a good indication of probable egg deposition. Spring salmon spawn below the fence and most probably between the slide and the fence, making the count only an index of the run to the Babine River. The peak of the spring run coincided with that of the sockeye. Indian fishermen were again successful in taking large spring salmon above and below the fence.

Pink salmon passing the fence exceeded the 1951 run considerably but were still far from their previous levels - in fact the run was approximately 8% of the 1946-50 average. If the potential size of the run to the Babine River was equivalent to pre-slide years, the pinks appear to have suffered most severely from the slide. As with springs, pinks spawn below the fence and the count is only an indication of the run to the Babine River. More males than females passed through the fence.

Coho salmon up to October 6 came closest to the pre-slide counts. These fish are still moving upstream after fence operation normally ceases. By October 6 the count daily was 100-300 and many were still in fresh condition. The peak count occurred on September 27. Coho spawn below and above the Babine fence and in the tributaries of Babine Lake.

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

In order to help the Department of Fisheries assess the effect of the slide on the salmon runs, extra observations were made on the runs passing the Babine fence. Over 1400 of the 14,000 sockeye, coho, and pink salmon tagged at the slide were taken from the fence pens, measured, sexed, examined for injuries and degree of maturity. The "jack" count procedure, which also records the proportion of injured fish, was stepped up to include about 20% of the run. Weather conditions permitting, the counts of salmon, the percentage of fish injured and the number of tags recovered were reported daily by radio-telephone to the Department of Fisheries workers at the slide. Daily reports of the counts were sent by telegraph to the District Supervisor and Chief Supervisor of Fisheries from Fort Babine.

F. C. Withler and K. V. Aro

Appendix No. 44

SAMPLING AT THE BABINE FENCE IN 1952

Throughout the period that counts of sockeye passing the Babine fence are made, sampling is carried on to give details on size of fish, sex proportions, etc., in the annual spawning runs. There is also taken what is termed a "jack" count whereby for definite periods the proportion of "jack" sockeye (precociously-maturing three-year-old males) occurring in the run is determined. At the same time the number of injured fish is noted. Normally the "jack" count represents 10% of the run but this year it was stepped up to include approximately 20% of the sockeye passing the fence.

The percentage of "jack" sockeye in the run was approximately 7.3, nearly the same as that recorded in the "jack" count of 1951, but lower than those of any year of operation prior to 1951. Injured fish, other than those which showed net or gaff marks, made up 31% of the large sockeye in 1952, which approximates the 30% obtained in 1951 counts. These figures are six times greater than those obtained prior to the slide. The percentage of injured sockeye, as shown by the "jack" count, is a relative figure because only the upper part of each fish can be observed as it passes out of the pens. On the other hand, all injuries seen, however small, are recorded, thus making the "jack" count record of injuries a valuable relative index. Netted and gaffed fish formed approximately 1% of the large sockeye in the count.

One per cent samples based on the previous half day's counts were measured, sexed, examined for injuries and degree of maturity; scales of these fish were taken every 5 days. From this sampling the sex ratio of the large sockeye is available: 41% females, 59% males. Calculations of the average lengths have not been made to date.

Twenty-seven females so far examined in the 1952 sockeye run carried an average of 3216 eggs apiece. The number of females to pass the fence by October 6, based on the sex ratio obtained in the 1% sample, would be approximately 141,700, thus the total number of eggs potentially available for deposition would be 456 million. These would be twice those available in 1951, and 20 million short of the number available in 1947, the lowest figure previous to the slide. The 1952 figure is approximately one-half the largest yearly figure yet recorded: 917 million eggs potentially available in 1949. Although the 1952 run was 2.5 times that of 1951, the number of eggs potentially available was only twice as great.

Analysis of the remainder of the length-sex, injury, degree of maturity data and refinement of the "jack" count data will be done this winter.

Appendix No. 45

F. C. Withler

SPAWNING OF THE 1952 SALMON RUN TO BABINE LAKE

Information about the success of spawning in Babine streams has been collected throughout the 1952 season by the writer and also by Inspector L. J. Gelley who has kindly passed some of his general observations on to the Board's workers at Babine. Particularly careful studies have been carried out because of the possible deleterious effects of the Babine River slide in causing injury to many of the salmon and delaying the upstream ascent of adult fish to the spawning grounds.

Sockeye runs to the small streams - Grizzly, Four-Mile, Twin, Pierre, and Tachek creeks - were finished at date of writing (October 18). In most of these streams the water level this year was low, but adequate to accommodate the small number of spawners entering them. Estimates so far made indicates that spawning was less successful in the smaller streams in 1952 than in 1951 in spite of the fact that the Babine Lake run, as shown by weir counts (Appendix 43), was over twice as great.

In the larger streams, spawning appeared to be more successful. Fulton and Fifteen-Mile rivers still had fair numbers of sockeye in them, although the Fulton River had passed the peak. By the time spawning has been completed, the Fulton River sockeye run will have exceeded that of 1951. At the present time coho are spawning well in the Fulton River. The run to another larger stream, Morrison Creek, was almost over. It is estimated that the sockeye run to Morrison had so far been approximately 25% of the 1951 run to that stream. Here again large numbers of coho are spawning with apparent success.

Because the lower Babine River above the Babine fence is a major sockeye spawning area and the only area above the fence where spring and pink salmon spawn, particular attention has been paid to spawning success there. Examination of a large number of dead spawners is made easier because they drift against the fence where they are readily available. Samples of these dead salmon have been examined since August 10, when they first appeared, to the present time (October 18).

Random samples, amounting to 27% of an estimated 30,000 dead sockeye, showed that the dead drifting onto the fence consisted of 58% large males, 35% females and 7% male "jacks". Among the 9600 females examined, the overall percentage of spawned fish was 25%, with 69% wholly unspawned and 6% partially spawned. "Spent" females began to appear in samples about September 23 and since that date the proportion has steadily increased until at date of writing the daily percentage of completely spawned females has increased to 62% with only 31% unspawned. Observations of floating dead fish indicated that many of the unspawned sockeye drifted out of Nilkitkwa Lake, which flows directly into the lower Babine River.

From examinations similar to those made on the sockeye, the spring salmon spawning above the fence appears to have been moderately successful, while examination of dead female pinks showed that they had spawned exceedingly well. A few well-spawned coho females are beginning to drift onto the fence at the present time.

Appendix No. 46

D. R. Foskett

RIVERS INLET SOCKEYE SAMPLING, 1952

Sockeye sampling at Rivers Inlet was again carried on at Goose Bay and 1625 samples were obtained. This is part of the regular yearly sampling of commercial sockeye catches. In addition it is also planned to sample on the spawning grounds as was done in 1951. However this year an attempt will be made to sample throughout the run on all the spawning beds in the same proportion, 1%, as was done with the commercial catch. This should give a better comparison between the sockeye in the catch and in the escapement than was possible last year when sampling on the redds was confined to one short period.

Appendix No. 47

F. Neave

PINK AND CHUM SALMON INVESTIGATION: INTRODUCTION

The aim of the investigation has been to acquire the information necessary to deal with the conservation problems which may attend the fisheries of these species. This is essentially a matter of understanding and measuring the factors which cause mortality and investigating methods for increasing the available supplies of fish.

The programme, as at present constituted, can be regarded as consisting of two parts:

Detailed studies (Appendices 48-56), in which the effects of various conditions, natural and artificial, on stocks of known size are recorded and measurement techniques are tested. These investigations are carried on mainly at two field stations, Nile Creek on Vancouver Island and Port John, near Ocean Falls. During the past year they have included: measurement of the reproductive efficiency of natural salmon escapements under recorded environmental conditions; comparison between reproductive efficiency obtained under natural conditions and that obtained under certain artificial controls; estimation of mortality taking place during the downstream migration of fry; the testing of techniques for measuring fry output and adult escapements where trapping and counting of the fish is not practicable; the investigation of the sex ratios of young salmon; investigation of the behaviour of young and adult salmon; the inauguration of a small run of pink salmon from eggs introduced into a stream from elsewhere.

General studies (Appendices 57-59), in which information relating to the stocks of large areas is compiled and analyzed. Such information is derived from catch statistics, reports of fishery officers, meteorological data, surveys made by personnel of the investigation and inferences based on the findings of field stations. Many of these data cannot readily be expressed in the form of separate summary reports.

No major crises affected the adult stocks of pink and chum salmon during the year. In certain areas marked increases of pink salmon were noted. The east coast of Vancouver Island has shown definite signs of recovery in regard to the populations of this species in the last few years. This increase is ascribed, at least in part, to the beneficial effect of new growth on the deforested areas of certain watersheds. The long-term relatively depressed condition of the chum salmon stocks of the west coast of Vancouver Island is not considered to be due to deterioration of spawning grounds but rather to a reduction in the spawning populations which the Department is endeavouring to correct by fishing restrictions.

The excellent output of pink and chum fry recorded at Hooknose Creek in the spring of 1952 augurs well for the future supply of adults returning to the smaller streams of the Central region,--that is, the pinks in 1953 and the chums in 1955. Judging from Nile Creek results the chum fry output from east Vancouver Island streams was also above the average for recent years.

Personnel associated with the investigation during the year are as follows:

Scientific Staff

W.S. Hoar (seasonal)	Studies on the behaviour of young salmon.
J.G. Hunter (part-season)	Port John field station studies.
Ferris Neave	In charge, pink and chum salmon investigations; general studies.
J.G. Robertson (part-season)	Limnological and sex ratio studies.
M.P. Shepard (part-season)	Port John field station studies.
W.P. Wickett	Nile Creek field station studies; key stream studies.

F. Neave

Technical Staff	
J.D. Carswell	Field operations, Port John.
W. Caulfield	Field and maintenance operations, Nile Creek.
A.S. Coburn (part-season)	Field operations, Port John.
E.L. Hollett (part-season)	Field operations, Port John.
H. Neate	Field operations, Nile Creek.
R.C. Wilson	Field, maintenance, and boat operations, Port John.
Stenographic Staff	
Margaret K. Philp	Clerical and stenographic duties.

J. Curtis acted as caretaker and recorder at Port John during the winter of 1951-52.

Appendix No. 48

W.P. Wickett

ADULT SALMON MIGRATION TO NILE CREEK 1951

Total fence counts were 113 pink, 225 chum, and 362 coho salmon. The pink run was the largest odd-year run since fence counts were started and is the result of planting eggs in the controlled water section in 1949. The chum run was the lowest recorded with the possible exception of that of the previous year when an incomplete count was made. The coho run was a little above average.

	Brood year migrants		Adult return			Per cent return	Egg count per female	Estimated egg deposition
	Total	Natural	Male	Female	Total			
Pink	13,553	104	50	63	113	0.84	1,993	122,000
Chum	62,650	7,103	143	82	225	0.36	2,602	206,000
Coho	3,577	3,577	181	172	353	9.9	3,191	527,000

Appendix No. 49

W.P. Wickett

PRODUCTION OF SEAWARD MIGRANTS AT NILE CREEK, 1952

Absence of floods, frost, or crowding and the presence of a good flow of water during the fall and winter seem to have led to the best percentage natural emergence and output of pink and chum fry recorded at Nile Creek. The coho yearling count was the second highest recorded. Stream improvements made last year, particularly the provision of pools by means of stoplogs placed at intervals across the stream, may have contributed to a higher survival of yearlings.

W.P. Wickett

As in previous recent years, a comparison was made between the fry output resulting from natural spawning and the output obtained from eggs planted in a controlled section of stream and thereby immune to the destructive effects of large changes in water volume. The advantages of the latter treatment are chiefly evident in years when natural production is reduced by floods. Although the controlled section showed a much higher efficiency of pink salmon output than the natural spawning grounds in 1952, this must be ascribed mainly to the elimination of predation rather than to water control alone. The chum fry output from the controlled section was disappointingly low and subsequent investigation indicated that unsuitable gravel conditions prevailed at some points where eggs of this species had been planted. It is hoped that this condition has now been rectified by a thorough cleaning and screening of the stream bottom.

The following table summarizes this year's results.

		1952 Migrants					
	Eggs available in 1951	Live	Dead	Total	Per cent emergence	Per cent survival during migration	Per cent output of fry
Pink							
Natural	122,000	8,495	332	8,827	18.2	39(?)	7.2
Planted	255,000	42,543	354	42,897	21	83	16.8
Total for stream		51,038	686	51,700			
Chum							
Natural	206,000	13,937	431	14,368	18.0	39	7.0
Planted	165,000	8,692	30	8,722	5.6	95	5.3
Total for stream		22,629	461	23,100			
Coho		Fry		Total	Yearlings		
Natural	527,000	9,639	188	9,800	5,950		

Appendix No. 50

M.P. Shepard and J.G. Hunter

ADULT SALMON MIGRATION AT PORT JOHN, 1951.

The adult counting fence on Hooknose Creek was installed June 14, 1951, immediately after the removal of the fry fence, and was operated until November 12. The final counts of adult salmon moving upstream through the fence are listed in Table I.

M.P. Shepard and J.G. Hunter

Table I. Final counts of adult salmon passing through the Hooknose Creek counting fence, 1951

	Pinks	Chums	Sockeye	Coho	Dolly varden
Unmarked males	791	528	7	42	
Marked "	--	65	174	--	
"Jack" "	--	--	773	289	
Total "	791	593	954	331	
Unmarked females	894	626	14	29	
Marked "	--	121	214	--	
Total "	894	747	228	29	
Total fish	1685	1340	1182	360	14

Samples of 11 chum and 15 pink females were taken and egg counts made. Samples of dead females were taken to estimate the number of eggs retained per female (42 chum and 18 pink). These data are utilized in table II to calculate the potential deposition of this year's runs. Due to the small number of coho migrating, no live females were sampled.

Table II. Calculation of the potential deposition of pink, chum and coho salmon

Species	Female (total)	Female (unsp.)	Effective no. of females	Average egg content	Average egg retention	Average egg output	Potential deposition
Pink	879	4	875	1,708	46	1,662	1,454,250
Chum	736	1	735	2,201	104	2,097	1,541,295
Coho	29	5	24	2,369[x]	--	2,369	56,856

x Average of 1947, 1948, and 1949 counts.

<u>Pinks</u>

From an output of 51,037 fry in 1949, 1685 adults returned in 1951. Thus the ocean survival was 3.301%. The survival from eggs to adults was 0.1952%.

<u>Chums</u>

Chum salmon fry marked in 1948 appeared as IV-year olds in 1951. Of the 54,831 marked fry released in 1948, 51 returned as III-year-olds in 1950 and 186 as IV-year-olds in 1951. As some marked fry will probably return in 1952 as V-year-olds, no calculation of the ocean survival can be made as yet. The returns indicate that the ratio between marked fish returning as III-year-olds and as IV-year-olds is 1:3.65. A differential mortality between the sexes due to marking or an uneven sampling of fish in the original marking seems to have occurred. Of the 186 marked adults counted in

1951, 121 or 65% were females. As the normal sex ratio for unmarked chums at Port John has always been close to 1:1, the excess of females over males seems significant.

Many of the pelvic fins of the marked fish had regenerated to some extent. Of the 175 marked fish examined, only 30 completely lacked both pelvic fins, 54 lacked one with regeneration occurring in the other, while in the remaining 91, some regeneration had occurred in both fins. Twenty-eight (16%) of the marked fish showed no evidence of having more than one fin removed. This knowledge might be of some importance in planning fry-marking experiments where different combinations of marks are used. This fact also suggests that there might be a few fish that underwent marking as fry, but showed no evidence of the operation when they returned as adults.

Coho

The run of adult coho (excluding "jacks") at Port John in 1951, was the smallest recorded in the five years of the station's existence. One contributing reason for this low escapement may have been the heavy coho fishing that took place in the vicinity of Port John. The precipitation during the run was the lowest recorded during the five-year period. With the resultant low water levels prevailing in the creek, many fish that might have been expected to enter the creek earlier were milling in the bay for long periods of time. These fish were vulnerable to concentrated fishing immediately outside the Port John fishing boundary and it is likely that the fishermen were taking an unusually large proportion of the Hooknose Creek adults.

The adult coho entering Hooknose Creek after October 1, appeared to be in good condition, but of four coho found dead above the fence, three were completely unspawned.

As in the case of the sockeye, a high proportion of "jacks" was evident (Table IV). As the fishery does not take "jacks", it is possible that this proportion is due to the intensive fishing of the larger fish.

Table IV. Proportion of "jacks" in the coho run at Hooknose Creek

Year	Total coho run	Total "jack" run	Per cent "jacks" in run
1947	734	314	42.8
1948	449	109	24.3
1949	694	93	13.4
1950	172	38	22.1
1951	360	289	80.3

In general the production from the 1951 adult coho run will probably be meager.

Routine observations

Standard meteorological and creek level observations were carried out daily. A recording thermograph was operated throughout the season.

Appendix No. 51

M.P. Shepard

ESTIMATION OF NUMBERS OF SPAWNING SALMON, HOOKNOSE CREEK, 1951

Stream counts are widely used to estimate the size of salmon spawning runs. To assess the accuracy of counts made on small streams (e.g., Hooknose Creek) an experiment was conducted during the pink and chum run at Port John in 1951.

Four counts of the numbers of spawning fish were made. During the same period the average duration of life of spawning fish was determined by tagging 52 fish at the fence and noting the time of death of as many of these fish as could be recovered (23 fish). From these data on the life span, the number of live fish present on the spawning ground upstream from the fence at any time was estimated. Table I compares the estimated number of live fish on the spawning grounds with the actual counts.

Table I. Estimated and counted numbers of live pink and chum adults above the Hooknose Creek fence, October 1951

Date	Pinks		Chums	
	Estimate	Count	Estimate	Count
Oct 4[x]	629	602	214	203
11	366	444	169	115
22	99	96	85	42
26	41	36	52	20

x Counts of Oct 4 are an average of three separate counts by different observers, while other counts are averages of two separate counts.

The results indicate that in the pinks the number of fish counted compares closely with the estimated number of live fish. The chum count, however, tends to be somewhat lower than the estimate. The most probable reason for the discrepancy is that chums are found more frequently in deep pools (where visibility is poor) than are pinks. Thus in the pinks at least, it is suggested that most of the fish present in a small spawning stream at the time of the survey are observed by the surveyor.

A comparison of simultaneous counts made by two observers is made in Table II.

Table II. Comparison of simultaneous counts made by two observers of pink and chum adults in Hooknose Creek, 1951

Date	Pinks		Chums	
	Observer A's count	Observer B's count	Observer A's count	Observer B's count
Oct 4	679	594	183	225
11	433	454	120	110
22	100	82	52	32
26	36	36	18	21

M.P. Shepard

Although differences of up to 20% may occur between simultaneous counts by two observers, over a series of surveys fairly good agreement is obtained.

Appendix No. 52

M.P. Shepard

OBSERVATIONS ON SPAWNING SALMON AT PORT JOHN, 1951

In conjunction with the operation of the Hooknose Creek counting fence, a study was made of the spawning behaviour of pink and chum salmon. The purpose of this study was to determine what factors affect the efficiency of egg deposition and the deposition of milt during the spawning period.

General observations were made on pinks and chums spawning in a 600-yard section immediately upstream from the counting fence. These observations were supplemented by more detailed observations on tagged fish. Observations were made on the following:

1. Selection of redd sites by females - stream locations and types of bottom selected.

2. Mating behaviour - courtship activity and social patterns in groups of spawning fish.

3. Time relations of the various phases of the spawning activity - times of arrival of fish in fresh water and beginning of active spawning, duration of active spawning and time of death.

4. The effects of tidal changes on the behaviour of fish spawning in the inter-tidal zone.

Some of the conclusions drawn from this study are listed below:

1. While both pinks and chums spawned in medium to coarse gravel, at depths up to 18 inches, chums could also be found spawning in stretches of the stream containing small boulders and at depths up to 30 inches. The chum, being a larger fish than the pink, can probably cope with more difficult excavation problems than the latter and this may permit chums to exercise a broader discrimination in the selection of redd sites. In this connection, chums were observed to be more widely distributed throughout the length of the creek than the pinks; a higher proportion of chums than pinks were present in the more rocky upstream waters of Hooknose Creek.

2. Males attend females from the time the males arrive on the spawning grounds until they are too weak to maintain their position in the stream. However, females are attended only during the relatively short period while they are actively spawning (about 1/5th of the active spawning period of the males). Thus only a segment of the living female population is attended by almost the entire population of live males. As a result of this pattern each female tends to be provided with several spawning partners. If, as in other salmonids, egg deposition occurs intermittently, (no instances of egg deposition were actually observed at Port John) then it is likely that the eggs of one female may be fertilized by the sperm of several males. This may be an important factor in bringing about efficient fertilization of the eggs. The attendance of each female by several males suggests the possibility that a somewhat smaller proportion of males in the spawning population might not induce the efficiency of reproduction to any extent. Thus if the males could be selectively fished by the fishery a somewhat higher rate of exploitation of males than of females would not cause a serious drop in the efficiency of

M.P. Shepard

natural propagation. Preliminary indications suggest that in a spawning population of pinks, a male to female ratio of 1:2 would not adversely affect the reproduction of the species.

3. The time relations of the various phases during the spawning period, as determined by tag returns, are listed in the table below.

Phase	Pinks		Chums	
	Males	Females	Males	Females
1. Tagging to start of spawning -				
Range (hours)	31-168	4-72	½-24	½-24
Mean "	93	27	12	7
No. of observations	6	5	2	4
2. Active spawning -				
Range (hours)	135[x]	9-24	101[x]	4-42
Mean "		20		17
No. of observations		4		4
3. Tagging to disappearance from redd -				
Range (hours)	--	168-240	--	60-144
Mean "		210		104
No. of observations		4		4
4. Tagging to death -				
Range (hours)	168-288	192-336	96-168	72-240
Mean "	228	235	113	166
No. of observations	4	5	4	10

[x] Active spawning occurs throughout period extending from the first appearance on spawning grounds until death - estimate obtained by subtracting (1) from (4).

J.G. Hunter

Appendix No. 53

PRODUCTION OF SEAWARD MIGRANTS FROM HOOKNOSE CREEK, 1952

The downstream weir on Hooknose Creek was installed March 19 at which time pink and chum fry were beginning their migration.

The course of the spring migration is indicated in Table I.

Table I. Number of salmon fry, smolts and sculpins moving downstream each week

Week ending	Pinks	Chums	Coho fry	Coho smolts	Sculpins
Mar 24	717	662	0	0	331
31	1,823	2,405	0	0	586
Apr 7	3,165	3,069	0	0	166
14	11,751	12,449	0	0	200
21	40,377	32,893	4	11	248
28	84,401	60,838	0	11	375
May 5	44,669	52,822	0	10	65
12	40,558	43,533	4	494	137
19	5,183	30,303	1,004	1,861	230
26	1,552	21,967	2,537	905	328
Jun 2	140	4,659	1,023	222	284
9	9	2,284	462	86	572
16	0	95	32	19	182
23	0	0	0	0	0
Totals	234,345	267,979	5,066	3,619	3,704

The percentage efficiency of fry migrant production, on the basis of the number of eggs carried into the stream by the parent fish, was for pinks 15.69%, for chums 16.57%. These percentages are approximately the same as those obtained in 1951 and greatly exceed the efficiencies recorded in 1948, 1949, and 1950. Losses of fry during migration (prior to arrival at the counting weir) varied from 25% to 73%, as measured by the survival of marked fry. An average mortality of about 50% for the whole run of 1952 is considered to be probable. The output of coho smolts was about equal to the average of the preceding three years, but since the 1952 migrants were the offspring of only about one-third the number of females recorded in those years, the reproductive efficiency was much higher (2.15%, as compared with a previous average of 0.70%).

Some mortality of the migrating fish is inevitable at the weir, particularly under flood conditions. Table II gives the actual and percentage mortality for all species at the weir.

Table II. Actual and percentage mortality caused by fence operation

Species	Pinks	Chums	Coho fry	Coho smolts	Sculpins
Numbers killed	4,536	2,846	37	15	31
Percentage mortality	1.93	1.06	0.73	0.41	0.83

J.G. Hunter

The actual numbers of fish released downstream are shown in Table III.

Table III. Numbers of fish released downstream through fence

Pinks	Chums	Coho fry	Coho smolts	Sculpins
229,315	264,508	4,929	3,504	3,673

A return of 87 marked sculpins (Cottus asper) from a 1951 marking experiment were counted through the fence.

J.G. Robertson

Appendix No. 54

SEX RATIOS OF SALMON MIGRANTS AT PORT JOHN

There is considerable experimental evidence to show that under adverse environmental conditions, the offspring from a spawning population are not equally divided as to sex. In some cases all-male broods have been produced. Because of the importance of the sex ratio to the success of salmon production, and since the sex ratios of young fish have been little examined in the field, sex data is being compiled at Port John.

The analysis from the 1952 migrants is as follows:

	Pink fry	Chum fry	Coho fry	Coho smolt	Sockeye fry	Sockeye smolt
Number	288	271	104	45	60	196
Average length	33.9	39.1	--	--	48.3	--
Per cent males	50.4	53.1	51.0	42.2	61.7	50.5
Chi square	.01	1.06	.03	1.09	3.26	.02
Sampling level (%)	.12	.10	2.05	1.24	--	1.77

For chum, coho, and sockeye fry, it was necessary to retain samples until the sexes differentiated. The results show that no sex disproportion occurred except for sockeye fry and coho smolt. Here the unbalanced ratio probably reflects the few fish sampled rather than a characteristic of the entire migrant population.

Appendix No. 55

J.G. Robertson

ESTIMATION OF SALMON MIGRANTS AT PORT JOHN BY NET SAMPLING

For effective fisheries management it is most desirable to have some knowledge of the output of young salmon resulting from given spawning populations. Since actual counting of the migrants demands expensive installations and therefore cannot be widely applied, attention has been given at Hooknose Creek, Port John, to the practicability of estimating fry and smolt runs by sampling during the course of migrations. Advantage was taken of the fact, established by numerous previous observations, that the great majority of pink and chum salmon fry move downstream during a quite limited period of the night. At Port John, the results of sampling could readily be checked against the actual numbers recorded from day to day at the fence.

A metal hoop, diameter 16¼ inches, was fitted with a ¼-inch cotton mesh lead, 4 feet long. The lead was tapered to 5 inches where a no. 10 bolting silk cone was sewn in place. The net was tested in a water current by releasing known numbers of fry into its mouth. All fry were collected unharmed.

The net was anchored in about 15 inches of water above the counting weir on Hooknose Creek. Here the water was 15 feet across and not excessively variable in depth. Collections were made at intervals of one hour from 9 P.M. to 1 A.M. (P.S.T.), after which time the net was occasionally left intact until morning.

Catches obtained when the net was operated all night are shown in Table I. The corrected return is based on the assumption that the net covered about 9% of the width of the stream and caught a similar proportion of the migrants. The fence return are those migrants counted through the weir for the night in question. By comparing totals of pink, chum, coho, and sockeye fry, with the absolute counts obtained at the weir, it is clear that the estimates represent good approximations. The small discrepancy between the pink fry sampled, and their fence return, is probably due to the few migrants at this time. The estimates for coho and sockeye smolts, however, differed widely from the fence counts. This may reflect ability of the larger fish to avoid or swim out of the net.

The hourly data from which Table I was compiled showed that approximately 50% of the migration of chum fry occurred between 10 and 11 P.M. Since 16 samples gave information for this period, the migrant count from May 13 to May 28 was estimated by doubling the net return and compensating for stream width. The necessity for adjusting such a sampling procedure to the habits of the fish is shown by the poorer estimate obtained for pink salmon fry in Table II. Repeated observations showed that this species tended to migrate in maximum numbers about one hour earlier than the peak period for chum salmon fry.

Summing up, the catches of fry migrants by net sampling appear to give a useful estimate of their total numbers. The present technique can be improved by using more nets suitably placed and spaced.

J.G. Robertson

Table I.

	May 14	May 15	May 22	May 25	May 28	Totals
Pink fry						
Net return	59	43	7	1	0	110
Corrected return	655	477	78	11	0	1,221
Fence return	944	517	136	19	42	1,658
Chum fry						
Net return	409	410	236	75	69	1,199
Corrected return	4,539	4,551	2,619	833	766	13,308
Fence return	3,699	3,608	3,056	951	1,244	12,558
Coho fry						
Net return	24	21	37	59	27	168
Corrected return	266	233	410	655	300	1,864
Fence return	277	210	535	471	198	1,691
Coho smolt						
Net return	2	0	0	0	0	2
Corrected return	22	0	0	0	0	22
Fence return	298	283	147	104	41	873
Sockeye fry						
Net return	13	8	0	1	11	33
Corrected return	144	89	0	11	122	366
Fence return	100	51	5	5	204	365
Sockeye smolt						
Net return	8	1	1	0	0	10
Corrected return	89	11	11	0	0	111
Fence return	538	410	103	225	50	1,326
Sculpins						
Net return	2	2	0	2	10	16
Corrected return	22	22	0	22	111	177
Fence return	35	39	59	62	53	248

Table II.

Total for 16 days (May 13 to May 28)	Pink fry	Chum fry	Coho fry	Coho smolt	Sockeye fry	Sockeye smolt	Sculpins
Net return	204	3,762	250	10	60	42	8
Corrected return	2,261	41,759	2,773	111	664	463	88
Fence return	5,046	46,427	4,062	2,677	749	4,544	660

Appendix No. 56

W.S. Hoar

BEHAVIOUR OF JUVENILE SALMON

Two phases of the life-history were studied at the Port John field station between May 27 and August 18. Downstream migrants were examined during the early part of the season. Later, a preliminary investigation of the inate behaviour of somewhat older sea-dwelling juveniles was undertaken.

Juvenile sockeye were the main targets of the first study. The comparative methods used, however, have yielded considerable additional data concerning the activities of chum and coho. In particular, a study of distribution in a 6-foot water column showed that sockeye fry remain inactive in the lower 12 inches of the column while chum and coho fry are active in the upper layers. Coho are nearer the surface than the chums. Smolts in the column were conspicuously active. This activity is more marked in sockeye than coho. Responses of sockeye and coho smolt to current were re-examined using two different types of apparatus. Sockeye smolt consistently show a strong positive response while coho remain indifferent to current or respond feebly. Coho smolt, in fresh water, are not, however, carried by the current during the day. Although aggressive behaviour is a normal activity of coho juveniles it is evidently a displacement reaction when seen in juvenile sockeye, pink, and chum salmon. Additional experiments on cover responses and general activity confirm the findings of 1951.

For the second phase of the investigation, four species of salmon were retained in cylindrical pens (6 feet in diameter) anchored in Port John Bay for 2½ months. The fish fed well, appeared in excellent condition and were vigorous in every way. Mean fork-lengths of samples preserved at the end of the study were as follows: chum fry 82.6 mm. (increase 42.3 mm.); pink fry 82.3 mm. (increase 46.0 mm.); sockeye fry 49.7 mm. (increase 21.6 mm.); coho smolt 136.6 mm. (increase 30 mm.); and sockeye smolt 125.2 mm. (increase 24 mm.).

Salmon were observed in sea water under experimental conditions similar to those used for the freshwater studies. Several contrasts were evident. The most marked change in behaviour is a lessening in the response to current. Whereas, during the day, positive rheotaxis is general in fresh water all the species in salt water <u>move with the current</u>. Pink underyearlings and sockeye smolt seemed to show the most marked reaction, swimming rapidly and almost continuously with the current. Chum underyearlings show the least change. At one moment they may be carried tail first with the flow, at another they hold position and swim into the current, again they will turn and swim head first some distance with the current. Thus, the response is variable but over a period of time the movement is definitely with the flow. Coho smolt and sockeye fry in sea water show a response which is intermediate in intensity between that of chum fry and pink fry or sockeye smolt. The results were consistent in three types of apparatus previously used with young salmon in fresh water and the conclusion is that the response of juvenile salmon during the day in sea water is different from that of the same species during their downstream migration.

Additional observations on young salmon in sea water were that:

a. Swimming speeds of underyearling sockeye, chum and pink salmon in quiet water are the same in salt as in fresh water.
b. Pink, chum, and sockeye fry school together readily but in swimming about pinks travel faster and tend to leave the others behind.
c. Chums go relatively deeper in salt water and show a cover reaction which is not evident in the streams.
d. Pink salmon remain in the upper layers and do not develop a marked cover reaction.

W.S. Hoar

e. Sockeye fry are in the surface layers of salt water in marked contrast to their deep location in fresh water. They show a lessening in cover reaction.
f. Aggressive behaviour is less marked in coho smolts in salt water but is still apparent and is occasionally seen in all species examined in sea water.

W.P. Wickett — Appendix No. 57

KEY STREAM SURVEYS BY DEPARTMENTAL OFFICERS

Out of thirty-two areas, data on the natural survival of salmon eggs and on related meteorological and stream-flow conditions were gathered in five areas for the 1950-51 season and in sixteen areas for the 1951-52 season. In the first season, 299 reports on 53 streams were made and 93 redds sampled. In the 1951-52 season, 325 reports on 47 streams were made and 145 sampled.

A few examples illustrate the importance of the information being gathered if it is realized that the proportion of eggs surviving is one of the factors (and in some cases the governing factor) controlling the future size of the salmon populations. In the Babine area, with floods and freezing conditions in 1950-51, the sockeye egg survival was 61% and the coho survival was 79%. In 1951-52, with the absence of these factors the survivals rose to 86% and 92%. Low water and freezing caused very low survival of sockeye and chum eggs in the Mission area in 1951-52 but on Vancouver Island the survival of chum eggs was good where floods were absent.

The value of the program is evidently great but certain minor changes could be made to advantage. For example, if there were only one key stream in each area, with neighbouring areas selecting different kinds of streams (glacial, non-glacial, coastal, inland, etc.), more intensive coverage of the key streams would be possible and the reports on streams could be considered by ecological areas to give a balanced view of the winter survivals.

F. Neave — Appendix No. 58

"EVEN-YEAR" AND "ODD-YEAR" PINK SALMON RUNS

Data concerning the changes in abundance of pink salmon and the causes of differences between even-year and odd-year stocks have been assembled and reviewed. In most parts of British Columbia and also in other North American and Asiatic regions of the Pacific, neither stock possesses any extreme or permanent superiority in numbers over the other. Changes in abundance take place independently in the two stocks and a high level of both, or a change in the leading position from one to the other, are matters of frequent occurrence. Increases or decreases in abundance usually affect large districts rather than purely local streams or areas and are ascribed in large part to natural environment variations in such factors as rainfall or temperature. The extreme and persistent differences in abundance between even- and odd-year fish characteristic of the Lower Mainland, the Queen Charlotte Islands and one Asiatic area are exceptional cases. Each of these cases embraces the streams of a large district and has probably arisen through operation in an exceptionally severe manner of the natural conditions which cause regional fluctuations elsewhere.

F. Neave

Available evidence indicates that the small stock is not "held down" in any way by the presence of a large population in alternate years. In spite of lack of success in certain previous experiments, it is believed that under certain conditions the establishment of runs in "off years" should be possible.

Appendix No. 59

F. Neave and W.P. Wickett

STREAM SURVEY, WEST COAST OF VANCOUVER ISLAND

As an outgrowth of Nile Creek studies which have indicated that increased output of pink and chum salmon fry can be attained by control of water flow during the incubation period, the feasibility of setting up a larger-scale experiment was explored in a short survey of west coast streams. Nineteen streams were examined in the Barkley Sound, Clayoquot Sound, and Quatsino Sound areas.

It was concluded that much excellent spawning ground is available for fish in these areas and is not being fully utilized by existing populations. At the present time, particularly in the Barkley and Clayoquot streams, the immediate requirement for improvement of the fishery is thought to be an increase in the size of spawning stocks, rather than the improvement of existing grounds. As a practical conservation measure, it is felt that installation of an expensive water control project should be deferred pending the outcome of fishing restrictions designed to increase the adult escapements.

D.J. Milne

Appendix No. 60

SPRING AND COHO SALMON INVESTIGATION: GENERAL INTRODUCTION

Since the start of the spring and coho salmon investigation in 1950, much information has been accumulated for the commercial and sport fisheries, the age and size of the fish stocks and the fresh water and ocean environments of these two important species, which in 1951 had a landed value of over $9,000,000 plus an incalculable tourist and recreational value provided by an expanding sport fishery. An attempt is being made to obtain the data required for an understanding of these populations on which to base sound regulations and to plan improvements to the spawning streams. Up to the present the emphasis has been placed on defining the ocean migration patterns in relation to those in adjacent American waters. This involved cooperation in a coastwise tagging and mark recovery program and sampling the catches for size throughout the season to provide a basis for framing possible regulations for the protection of immature salmon.

Catch statistics (Appendices 61, 62)

Since accurate commercial catches are available for each species only back to 1945 these are compared with the sales slip returns for 1951 and with similar data from the State of Washington which, in part, exploits the same stocks of salmon. Preliminary information on the current season is also discussed.

An estimated catch of the total sport fishing in 1951 is presented together with detailed catches for the fisheries at Cowichan Bay, Rivers Inlet, and Phillips Arm.

Spawning escapements and ocean studies (Appendices 63, 64)

A general summary of the spawning escapements of spring and coho salmon in British Columbia is presented and it is suggested that predictions of the relative sizes of the annual coho salmon populations may eventually arise out of the "key stream" program. The relationship of ocean summer salinities to the availability of coho salmon may also prove useful in prediction of the troll catch.

Tagging experiments (Appendix 65)

The results of the offshore co-operative tagging experiments are now almost complete. The total percentages recovered from both Canadian and American waters are compared to similar experiments carried out 20 years ago. This year the only tagging program conducted was at Sooke traps on spring salmon. Because the low returns (ca. 10%) are at variance with the expected exploitation (ca. 50%), the possible loss of tags by pin corrosion was checked and found to be less serious than in the California experiments.

Sampling for marks and size of fish (Appendices 66, 67)

A preliminary sampling was made for the size of fish landed at Vancouver in 1951. This was intensified and expanded in 1952 to include landings at both Prince Rupert and Victoria. The methods employed, the numbers sampled in each area and a few details on comparative sizes of fish are shown. The ages of spring salmon are presented for part of the 1951 collections. The returns from marked fish supply added information on the distribution and abundance of fish from American streams but there is an indication that the natural occurrence of fish with abnormal fins will make the findings difficult to interpret.

D.J. Milne

Regulations (Appendix 68)

The new proposals for regulations designed to protect immature salmon are discussed. For coho salmon they involve the recently adopted opening date of June 15 and the proposed adoption of July 1 and for spring salmon a consideration of the possible adoption of a minimum total length of 26 or 28 inches.

Scientific Staff

D.J. Milne	In charge, spring and coho salmon investigation.

Technical Staff

E.A.R. Ball	Field and laboratory assistant.
K.K. Jerome (seasonal)	Sampling at Prince Rupert.
J. Trotter (seasonal)	Sampling at Vancouver.
D. Denbigh (part-season)	Sampling at Victoria.

Appendix No. 61

D.J. Milne

COMMERCIAL FISHERY FOR SPRING AND COHO SALMON

Prior to 1945, catch statistics of salmon landed in British Columbia were not recorded by species. Consequently the only average catch of spring and coho salmon available is for the period 1945 to 1950. In the following table averages for the period are compared to the 1951 catches obtained from the new sales slip system. Since part of the catch of the State of Washington is from the same stocks of salmon, similar data for Washington are presented with an approximation of the amount caught by American trollers off the British Columbian coast, mostly off the west coast of Vancouver Island.

	Catch in thousands of pounds (round weight)				
	British Columbia		Washington		
	Troll	All gear	Troll	All gear	Troll off B.C.
Spring salmon					
1945-50 average	--	13,500	4,830	10,900	2,700
1951	8,340	12,910	5,430	10,910	1,880
Coho salmon					
1945-50 average	--	22,800	4,180	10,500	1,400
1951	19,510	35,120	5,430	11,920	2,370

In British Columbia the 1951 spring salmon catch was 5% below the average of the last six years and 65% was taken by trolling. The remainder was taken by the net fisheries, chiefly gill nets. The majority (77%) of the catch was red spring of which 73% was taken by trolling whereas in the case of the white spring salmon 58% was caught by the net fisheries.

D.J. Milne

The average Washington catch of spring salmon is smaller than that of British Columbia but more than half of the troll catch has been caught off the British Columbia coast. In 1951 this offshore American fishery was lower than average although it amounted to 35% as much as the troll catch made by Canadian boats operating off the west coast of Vancouver Island.

The 1951 coho salmon catch in British Columbia was 54% above the average of the last six years with a record value of $6,600,000. The trollers accounted for 55% with the gillnetters catching 25% and the purse seiners 20%. A discussion of the large troll catch of coho salmon off the northwestern part of Vancouver Island has been given in Progress Reports No. 91.

The average Washington catch of coho salmon is about half the size of the catch in British Columbia with approximately one-third of the troll catch taken off the west coast of Vancouver Island. In 1951 the total Washington catch was above average but was not a record catch as in British Columbia. However the American fishery off the west coast of Vancouver Island was above average and was one-third as large as the troll catch made by Canadian boats operating in this area.

For the current season the sales slip returns up to October 1 indicate that the spring salmon catch was similar to that of 1951 and that the coho salmon catch was good in June and September, poor in July and August and in total not as large as in 1951. Strikes and lower prices have resulted in a smaller total fishing effort particularly for the net fisheries. While in 1951 the weather was poor in June, affecting the spring salmon catch, in 1952 it was poor during August and affected the coho salmon catch.

The trends in the troll catch per effort for the last 4 years are shown below based on trip reports collected from the large trollers landing at Vancouver.

	Average pounds (dressed) per boat day	
	Spring salmon	Coho salmon
1949	150	250
1950	165	270
1951	71	384
1952	62	342

D.J. Milne

Appendix No. 62

SPORT FISHERY FOR SPRING AND COHO SALMON

The records obtained by the fishery inspectors for 1951 indicate that 4000 boats caught 40,000 spring salmon, 60,000 coho salmon and 100,000 grilse for a total catch of 1,500,000 pounds. These figures are rough estimates but the sport fishery catch is probably less than 5% as much as the commercial catch. New sport catch forms were initiated in 1952 which will eventually result in more accurate catch data for this fishery.

D.J. Milne

Judging from the experience in California the problem of catching many small salmon on sport gear is best solved by rigidly enforcing a bag limit rather than by gradually raising a minimum size limit. A bag limit per boat in addition to the 10 fish per man-day would help to eliminate the large catches of small salmon made now. In order to discourage the sports fishermen from selling large fish, the commercial licence fee should be raised from one dollar per person or the boat and gear should be licensed specifically for commercial and sport fishing.

At Rivers Inlet all fishermen are registered and limited to 3 fish per day. In 1951 a total of 328 red spring were caught by 245 fishermen. These fish are exceptionally large, and averaged 41 pounds with a range from 7 to 82 pounds. At Phillips Arm 150 fishermen registered a catch of 106 spring salmon in 1951. These fish averaged 32 pounds and ranged from 7 to 59 pounds. Scale samples have been taken from these two fisheries as well as from fish at several derbies held at Vancouver, Victoria, Cowichan, and Port Alberni. The age determinations for Rivers Inlet are given elsewhere in these reports and the others will be reported on later.

Catch and effort data have been recorded since 1939 for the sport fishery at Cowichan Bay (see previous summary reports). Since new catch forms have been initiated by the Fisheries Department in 1952 the above series of data is terminated with the following summary for the 1951 season.

	Boats	Line-hours	Spring		Coho		Line-hours per	
			Large	"Jacks"	Large	Grilse	Spring	Coho (large)
Entire season Aug 1-Nov 4	6593	56,078	1469	223	1433	945	--	--
Spring sample period Aug 13-Sep 9	2614	21,911	1005	133	--	--	19.2	--
Coho sample period Sep 19-Oct 29	2748	19,041	--	--	1321	554	--	14.4

The spring salmon catch was above average due to the large effort but the number of hours required per capture was the highest recorded. Few "Jacks" were taken. The coho salmon catch was the second lowest recorded and the line-hours per large coho was the second highest. Many grilse were taken. It appears that the increase in fishing effort in recent years is resulting in a lower return per effort in both species of salmon. The relationship of the minimum summer water flows and the availability of the returning adult coho salmon (Neave, 1949) has not held since the 1947 catch.

Appendix No. 63

D.J. Milne and E.A.R. Ball

SPAWNING ESCAPEMENT OF SPRING AND COHO SALMON

The following general picture of the spawning escapement of spring and coho salmon was obtained from a detailed examination of the fishery inspectors' spawning reports, Form B.C.16, for the period 1945 to 1949. There are a total of at least 1500 salmon streams in British Columbia. In 15% of the streams approximately 500,000 spring salmon spawn annually and in 85% of the streams approximately 3,000,000 coho salmon spawn.

Of the 200 or more spring salmon streams 30% are in District I with headquarters New Westminster, 20% in District II (Prince Rupert) and 50% are in District III (Nanaimo). Based on the fishery inspectors' estimates of the size of the spawning runs, less than one-quarter of the spring salmon spawn in the Fraser River system, chiefly the Harrison, Thompson, and Shuswap Rivers. The Squamish River is also an important stream in District I. More than one-quarter of the spring salmon spawn in District II where the Bear, Babine, Morice, and Bella Coola Rivers support the largest populations. The remaining half of the fish spawn in numerous streams in District III of which the Cowichan, Somass, Southgate, Homatho, Nahmint, Puntledge, and Campbell Rivers are the most noteworthy. It is apparent that the spring salmon spawn mainly in a few large streams since the five best streams in each district account for 75% of the total estimated escapement. Because of this fact it is difficult to observe and estimate the size of the spring salmon escapement with much accuracy.

Of the 1300 or more coho salmon streams 10% are in District I, 40% in District II, and 50% in District III. Less than one-tenth of the coho salmon spawn in the Fraser River system chiefly in the Chilliwack, Capilano, and Lillooet Rivers. Also important in District I is the Squamish River. In District II where more than one half of the coho salmon spawn the Kitlop, Bella Coola, and Tlell Rivers are the most important. The remainder spawn in the many streams of District III of which the Cowichan, Puntledge, Somass, Quatsie, Oyster, Tsolum are the important producers. In contrast to the spring salmon, the coho salmon spawn in many small streams and the best five streams in each district account for only 40% of the total escapement. Since it is impossible to assess the size of the escapement and the subsequent survival of eggs in so many streams, detailed examinations of a few streams in each area must suffice. It is hoped that the present program on "key streams", conducted by the fishery inspectors will yield data which will be useful in predicting the relative sizes of the coho salmon populations which result from the annual spawning escapement.

Appendix No. 64

D.J. Milne

OCEAN STUDIES

Mr. V.R. Taylor, who carried out the tagging experiments off the northwest coast of Vancouver Island in 1951, has analysed the surface temperature and salinity readings taken at the Kain's Island Lighthouse in relation to the coho salmon landings in this area. The catch and effort data were from approximately 30 "day fishing" trollers and covered the period from 1943 to 1951. He found that a significantly high positive correlation exists between the average summer salinity and the annual catch per unit effort of coho salmon. No relationship was found between the temperatures and the coho catches.

D.J. Milne

The correlation of salinity with catch of coho salmon has been expanded to include salinities recorded at Amphitrite Lighthouse off the southwestern coast of Vancouver Island and coho salmon catches made along the entire west coast of Vancouver Island. A good positive relationship was apparent with the Canadian "day boat" catches but a negative relationship was evident with the American "ice boat" catches. Neither relationship held when the data were extended back to 1938 in order to include the large catch in 1941.

Further studies are required to elucidate the underlying cause of this apparent correlation to make it useful in predicting the availability of coho salmon. It appears that the high inshore salinities during the summer are associated with low precipitation and predominant westerly winds which cause upwelling of more saline water. These conditions apparently provide good coho fishing for the inshore boats but poor catches for the offshore boats. In 1951 the summer ocean conditions off the northwestern part of Vancouver Island were apparently ideal for the coho salmon to feed and for the Canadian fishermen to take a record catch. In 1952 the catch has been better off the southern part of Vancouver Island, particularly in June and September.

Since so little data are available on the ocean environment of salmon a detailed study of such factors as the depth, salinity, temperature, and feeding habits should be made during the ocean migration period.

Appendix No. 65

D.J. Milne

SUMMARY OF RECENT TAGGING EXPERIMENTS

The recoveries from the ocean tagging experiments conducted on spring and coho salmon since 1949 are now almost complete. The returns are summarized in the following table, together with the percentages of the returns which were made from American waters. In the case of spring salmon the percentages of the returns from the Fraser and Columbia Rivers are given.

	Ucluelet		Quatsino		Kyuquot	North Is.	Sooke		Totals
	1949	1950	1949	1951	1950	1951	1951	1952	
<u>Coho salmon</u>									
Number tagged	40	262	470	544	110	614	150		2590
Number returned	5	41	41	40	5	46	31		209
Per cent returned	12	16	9	7	5	7	21		8
Per cent of returns from U.S. waters	60	41	10	47	20	25	48		
<u>Spring salmon</u>									
Number tagged	772	140	45	54	22	64		125	1222
Number returned	72	37	12	6	4	7		21	159
Per cent returned	9	25	27	11	18	11		17	13
Per cent of returns from U.S. waters	26	38	25	17	0	42		24	
Columbia River	12	16	25	0	0	0		0	
Fraser River	8	14	25	17	25	14		57	