FISHERIES RESEARCH BOARD OF CANADA

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SUMMARY REPORTS

of the

PACIFIC BIOLOGICAL STATION

for

1938.

CONFIDENTIAL

SAIMON INVESTIGATIONS.

R.E. Foerster No. 1

The Return of Adult Sockeye Salmon to Cultus Lake, 1937

During the autumn of 1937 - Sept. 21 to Dec. 18 - there were counted over the weir into Cultus lake a total of 3,061 adult sockeye. Of these, 1,721 males and 113 females were small fish and all but 51 bore scars of clipped fins which indicated that they were three-year-old grilse. Of the remaining 1,227 adults, 411 males and 640 females had both pelvic fins and the adipose removed thus indicating that they were four-year fish, the return from the seaward migration in 1935 of 323,900 young sockeye, all of which were so marked.

The return of cycle adults to Cultus lake in 1937 thus represented only 0.32 percent of the preceding seaward migration, the lowest return on record. Since it has been found from previous experiments that marked sockeye experienced a 62 percent differential mortality from time of marking to return to Cultus lake as adults the probable return in 1937 to Cultus lake, had no marking been conducted, would approximate 0.84 percent.

For comparison, the data pertaining to extent of seaward migration and subsequent return of adults in previous years are as follows:

Year	Seaward Migration	Year	Actual Return	% of Migrants	Presumed Return	% of Migrants
1926	1,398,000	1928	15,339	1.1	15,339	1.1
1927	249,700 (91,700 marked)	1929	5,082	2.0	6,364	2.5
1928	335,700 (99,700 marked)	1930	10,395	3.1	10,910	3.2
1929	2,464,500	1931	37,473	1.5	39,151	1.6
1930	104,000 (All marked)	1932	2,511	2.4	4,808	4.6
1931	365,000 (All marked)	1933	3,471	0.95	8,242	2.3
1932	779,000	1934	19,707	2.5	19,952	2.6
1933	1,566,000 (25,000 marked)	1935	15,789	1.0	16,103	1.0
1934	183,700	1936	8,359	4.6	8,317	4.5
1935	323,900 (All marked)	1937	3,061	0.95	2,766	0.85
	Average percent return			2.01		2.42

Two columns of returns and percentage returns are given, one showing the actual return as counted at the weir and the other the presumed return which is calculated to correct for (1) a presumed differential mortality of 62 percent among marked adults and (2) the different age-classes in each year. With reference to the latter it may be pointed out that 1,678 three-year fish in the 1930 run were subtracted from that year's total and added to that of 1931. In the run of 1932 the 684 five-year-olds occurring were subtracted from that run and added to that of 1931. Similar corrections were made for 607 three-year fish in the 1933 run, 276 five-year-olds in 1934 and for 1,783 three-year-olds in the 1935 run.

The data tabulated demonstrate the variation which may occur in the return of spawners from known seaward migrations of young. This variation is due (1) to differences in survival rates in the ocean from year to year

and (2) to the change in fishing intensity from year to year and the availability of the Cultus lake fish for capture in the fishing areas.

The return in 1937 is decidedly below those shown for other seasons. That it is not all due to an increased catch in the fishing areas is suggested by the relatively small landings of marked fish at the canneries in 1937 but complete data concerning the latter are not yet available.

The occurrence of relatively large numbers of three-year-old grilse in 1930, 1933 and 1937, i.e., in years preceding a relatively large adult return lend confirmation to the general understanding that the appearance of increased numbers of grilse heralds a large run in the following year.

R.E. Foerster No. 2

The Seaward Migration of Young Sockeye Salmon from Cultus Lake in 1938 and the Increase Presumably Resulting from Predator Removal.

Commencing in the spring of 1935 (May 28) there has been carried out at Cultus lake an experiment to determine the effect upon the survival of young sockeye during their year's residence in the lake when a portion of the predator fish population is removed. The predators were caught chiefly with gill-nets.

It was anticipated that the effect upon sockeye survival would be indicated by the increased percentage migration from a known spawning. This was shown for the 1936-37 season in last year's Summary Reports, in which the migration of 1937 represented 7.73 percent of the presumed egg deposition a significant increase over previous years when the percentage migration constituted 1.13, 1.05 and 3.16 percent, an average of 1.78 percent.

The increased percentage survival shown for 1936-37 was based, however, on the total presumed egg deposition. Since the effect of predation is largely felt after the fry have hatched and during their subsequent year in the lake, it was decided to test out the effect shown from the fry stage on, by liberating a known number of fry into the lake in the spring of 1937. Twelve million sockeye fry were thus released.

In the spring of 1938 a total of 1,627,000 yearling migrants were counted migrating from the lake, constituting a percentage survival of 13.6 percent of the original fry liberation. Previous tests of the survival from fry liberations, conducted in 1926, 1929 and 1932, showed percentages of 5.83, 3.85 and 2.81 respectively, the average being 4.16 percent. The increase, thus presumably resulting from the removal of predators amounts to 3.3 times or 330 percent of that prevailing, on the average, in other years when no predator removal was practised. Instead of an average seaward migration of 499,200 individuals, there were provided 1,627,000, plus whatever two-year-old migrants may occur next spring.

R.E. Foerster and W.E. Ricker No. 3

The Destruction of Fish Predatory upon Young Sockeye Salmon in Cultus Lake.

The predatory fish removal campaign at Cultus lake, originally commenced on May 28, 1935, to test the effect of such removal upon the survival rate of young sockeye in the lake, was continued to March 31, 1938, when the International Pacific Salmon Fisheries Commission took over the operations.

During November and December, while adult sockeye were spawning in the lake, baited wire cages were used to trap coarse fish but from December 24 gill-nets were set out as in former years. The catches obtained are as follows:

Date	Squaw-fish	Char	Trout	Sucker	Sculpin	Coho	Sock-eye	White-fish	Total
Wire cages: Nov. 4/37 to Jan. 5/38	34	29	4	71	238	1	0	0	377
Gill-nets: Dec. 24/37 to Jan. 31/38	195	28	65	29	3	32	0	1	353
Feb. 1 - 28	232	16	137	50	17	40	1	1	494
March 1-31	206	14	126	71	26	29	2	5	479
	667	87	332	221	284	102	3	7	1703
Previously caught,	9605	668	1502	3020	519	495	1045	-	16854
Totals	10272	755	1834	3241	803	597	1048	7	18557

Squawfish, char, trout and coho are the species of particular importance as predators of young sockeye in Cultus lake. The effects of the predator removal brought about as above are discussed in accompanying summary reports. In general, notable decreases in populations of predators have occurred, with the possible exception of the coho whose abundance is determined by the extent of the natural propagation of the incoming spawners each year. In 1935 there occurred a fair run of coho to the lake, 1161 males and 266 females, which may explain the increase in the coho population of 1937-38 and of the gill-net catches.

R.E. Foerster & W.E. Ricker No. 4

Changes in Abundance of Predatory Fish in Cultus Lake following Intensive Netting.

In evaluating the efficiency of efforts to control predatory fish in Cultus lake, estimates of the percentage decline in numbers of various species have been made from the catch data, as outlined in previous Summary Reports. All of these estimates have however been complicated by the fact that the kind and amount of gear in use has been changed from year to year, so that it was impossible to use catch data as an exact measure of abundance. In 1938 it was

decided to overcome this difficulty by duplicating the conditions which obtained at the beginning of predator control in 1935, as regards kinds and numbers of nets in use, their position, and the frequency with which they were attended.

The period during which sets were duplicated lasted from May 25 to June 22, 1938, and the nets ranged in mesh from 2 1/4 to 4 1/2 inches stretched. A comparison of the catches in 1935 and 1938, segregated by mesh, is as follows:

Mesh	2¼		2½		2¾		3		3½		4		4½	
Year	1935	1938	1935	1938	1935	1938	1935	1938	1935	1938	1935	1938	1935	1938
Squawfish	264	55	174	8	324	12	7	0	11	10	8	7	5	3
Ratio	0.21		0.05		0.04		-		0.91		0.88		0.60	
Trout	12	3	7	1	17	11	1	3	1	0	0	3	0	1
Ratio	0.25		0.14		0.65		3.0		-		-		-	
Char	1	2	0	2	10	0	0	1	0	0	2	0	0	1
Suckers	22	31	1	8	50	14	1	0	7	2	58	42	43	11
Ratio	1.41		8.0		0.28		-		0.3		0.72		0.26	

Total for all meshes	Squawfish		Trout		Char		Suckers	
	1935	1938	1935	1938	1935	1938	1935	1938
Number	793	95	38	22	19	7	182	108
Ratio	0.12		0.58		0.37		0.59	

The greatest reduction in numbers appears to have been accomplished among the squawfish, of which the 1938 catch was only 12 percent of the 1935. Among these, the intermediate size range caught by meshes 2 1/2 and 2 3/4 inches has been most reduced; the smaller incoming group suffered less, and the few very large specimens are about as common as formerly. The trout have apparently decreased by about 40 percent, and the char by 60 percent, though the smaller numbers caught make the comparisons less exact. With char the larger specimens have been most reduced, while with trout the reverse is the case. Although not known predators upon sockeye, suckers are included in the schedule. They too appear to have been much less reduced than the squawfish, averaging 59 percent of their former numbers.

The above estimates of changes in abundance correspond in a general way with those which it was possible to make in 1937. No direct comparison with that year has been made, but it would seem that there has been little change between the two years. In other words, the populations in the lake are approaching a new reduced level of abundance, temporarily in balance with the increased hazards of existence. Except possibly in the case of the trout, it is too soon to expect any possible result of a decreased amount of reproduction to show up in the catches of net-sized fish. For the time at least, netting should be pursued vigorously if it is desired to keep predatory populations at their present level of abundance.

The test netting was conducted under the auspices of the International Pacific Salmon Fisheries Commission, as a continuation of the previous work done by the Fisheries Research Board, and permission has been given to report upon the results obtained.

R.E. Foerster & W.E. Ricker No. 5

Estimation of Fishing Mortality Among Squawfish in Cultus Lake by Means of Tagging.

Additional returns have been obtained from the squawfish tagged and released in 1936-37. Excluding 9 which died immediately, or were caught on the day after tagging, the number tagged was 220 in November and December of 1936, and 271 from March to May, 1937. The distribution of recaptures is as follows, segregated by length at time of tagging:

Length Group	173 -197	198 -222	223 -247	248 -272	273 -297	298 -322	323 -347	348 -372	Total
Number tagged	9	55	107	162	120	27	7	4	491
Retaken to Jan. 4/37	0	0	0	2	1	1	0	0	4
" Jan. 5 to July 31	0	3	5	21	26	5	0	0	60
" Aug. 1 to Dec. 31	0	0	3	3	1	0	0	0	7
" Jan. 1 to June 30/38	0	1	3	5	6	2	0	0	17
Total recaptures	0	4	11	31	34	8	0	0	88
Percentage	0	7	10	19	28	30	0	0	17.9

The 28 percent return for the 285 mm. group is of course a minimal estimate of the fishing mortality rate for fish of that size, as any natural mortality, loss of tags, or death due to tagging, decreases the number of recaptures that can be made. Some of the fish do not survive the tagging operation, as the recovery of dead fish immediately afterwards shows; moreover a few of those recaptured much later had fungus growths about the gill cover, and would probably soon have died. Other fish lost their tags without apparent harm, as 12 were taken with holes in the opercle, mostly in 1938. For these reasons there can be no doubt that the true rate of fishing mortality is considerably greater than the percentages shown.

The significant increase in percent of recaptures as length increases, up to the 275 and 320 mm. groups, can be attributed to either (1) a progressively lower fishing mortality among smaller fish, (2) a greater tagging mortality or loss of tags from same, or (3) a greater natural mortality rate among the smaller fish. It is difficult to distinguish between these, but the condition of the recaptured fish suggests that (2) plays some part, so that mortality rates for the smaller sizes is somewhat greater, relative to the 285 mm. group, than is indicated by the figures above.

R.E. Foerster & W.E. Ricker No. 6

Rate of Growth of Tagged Squawfish in Cultus Lake.

The experiments in tagging squawfish mentioned in the preceding summary, and that done in June, 1935, have provided information regarding the rate of growth of the larger squawfish in Cultus lake. Fish used in these experiments were measured when tagged, and again when recaptured. A resume of the results is as follows:

Date of Marking	June, 1935				Nov.-Dec., 1936				March-May, 1937			
Time Elapsed	1	2	3	4	1	2	3	4	1	2	3	4
1 - 100 days	-	-	-	-	5	0	1	-0.2	35	9	17	-2.0
101 - 200 "	2	1	1	+3.5	29	8	13	-1.9	4	2	1	+1.5
201 - 300 "	0				2	1	1	+5.0	2	1	1	+4.5
301 - 400 "	6	2	4	-0.7	1	1	0	+5.0	4	3	1	+5.2
401 - 500 "	0				4	4	0	+5.0	2	2	0	+5.0
501 - 600 "	0				1	0	1	-6.0	-	-	-	-
1000-1100 "	1	1	0	+17.	-	-	-	-	-	-	-	-

1: total recaptures; 2: number which had increased in length; 3: number which had decreased in length; 4: average change in length, in millimetres.

Not included in the above summary are the following three:

From 1935 tagging - a fish 362 days at large, increased 74 mm.
" " " - " " 745 " " " , " 93 mm,
" 1937 " - " " 412 " " " , " 73 mm.

(1) Fish at large for up to 100 days (up to 200 days in the case of autumn-marked fish) show an apparent decrease in length, averaging about 2 mm. Consistent technique and use of the same measuring board in most cases makes it appear that either the fish measures longer when alive than when dead, or that there had really been a certain amount of shrinkage following tagging. In individual cases it appeared much greater than the average values suggest - decrease of 10 or 15 mm. being not uncommon. (Measurements were made to the nearest half centimetre).

(2) Even after the initial period of setback, the fish made very slow growth, as a rule. Even after more than a year at large, several fish still showed a net decrease in length, and the average increase of specimens out more than 200 days is only in the vicinity of 5 mm. Exception is made here however of three specimens, listed at the foot of the schedule, whose apparent growth was so much in excess of others of the same groups as to suggest errors in measurement.

(3) The great majority of the fish under consideration measured between 200 and 300 mm. The data do not indicate any relation between length attained and rate of growth, over that range, although they are not sufficient for a general pronouncement.

(4) Whether or not the growth of these tagged fish is representative of the untagged population is a matter of conjecture.

From seine catches the growth of squawfish less than 200 mm. in length had previously been established at about 50 mm. per annum, with no indication of a falling rate of increase between the four age-classes represented. Further, the maximum length of the squawfish in Cultus lake is considerably above 400 mm.; fish of this size would be of a fantastic age if they increased by only 5 mm. per annum after reaching 200 mm. length. It seems probable therefore that the presence of the tag on the gill-cover has had a retarding effect upon rate of growth of these experimental fish.

W.A. Clemens

No. 7

Contributions to the Life History of the Sockeye Salmon

The Fraser river sockeye salmon run amounted to 160,531 cases of which 100,272 were packed in British Columbia and 60,259 cases in the State of Washington. The random sampling showed that 78 per cent of the run consisted of the 4_2 age-group, 12 per cent of the 5_2 and 5 per cent of the 5_3. The average lengths and weights of the fish were much below the averages of the past seventeen years. The distribution of the sexes was approximately equal, - 49 per cent males and 51 per cent females.

The Rivers Inlet run produced a pack of 84,832 cases. The 4_2 age-group accounted for 60 per cent of the sample and the 5_2, 37 per cent. In this river system very few fish remained two years in the lake. The average lengths and weights were slightly below the averages of preceding years.

While the pack on the Skeena river was only 42,491 cases, this was all that could be expected from the previous cycle years. The age-groups were more evenly distributed in this river system with 45 per cent of 4_2's, 40 per cent of 5_2's, 11 per cent of 5_3's and 4 per cent of 6_3's. The average lengths and weights of the 4_2 age-group were slightly below the averages of past years but for the other age-groups they were much above. There was considerable disparity in the numbers of the sexes,-- the males represented by 42 and the females by 58 per cent.

The Nass river pack amounted to 17,567 cases, which is relatively small but approximately what might be expected from the runs of the cycle years. In this river system the dominant year class has always been the 5_3. Over the past twenty-five years, the average representation of this group has been 67 percent. In this year, this year class constitutes 65 per cent of the sample while the 4_2's make up 22 per cent, the 6_3's, 6 per cent and the 5_2's, 4 per cent. Again the tendency is for the fish of all age-groups to be small. The proportions of the sexes were 51 per cent males and 49 per cent females.

A. L. Pritchard No. 8

The Natural Run of Pink Salmon (Oncorhynchus gorbuscha) in McClinton Creek, Masset Inlet, B. C.

The following report contains a brief resumè of the counts and observations made on the natural run of spawning pink salmon at McClinton creek, Masset inlet, in the autumn of 1938. To permit comparison a table is included in which these data as well as those for the runs of 1930, 1932, 1934 and 1936 are reviewed.

Qualitative observations showed that the spawning fish in the run of 1938 behaved in most respects similarly to those of the other migrations. The first pink salmon entered the pens on August 7. On August 16 and 17 eighty-four and sixty-three respectively arrived, but thereafter only scattered individuals appeared until September 10 when the numbers commenced to show a consistent rise. The main run occurred between September 10 and October 6 with the last individual being taken on October 8. As has been indicated in other cases, the size of the daily migration varied directly with the rainfall and height of water in the creek, there being increased numbers at times of heavy rain and high water.

Males and females appeared at almost the same time at the beginning of the upstream migration. The numbers of both sexes were approximately equal at first but on September 1 relatively more males began to come in. Although about two weeks later proportionately more females made their appearance, the final disposition of sexes on the spawning beds was 52.3 per cent. males and 47.7 per cent. females. These percentages differ significantly.

The measurement of samples taken at random throughout the run again indicated that the males were significantly larger than the females in both weight and length. In the males there also appeared to be an increase in length and weight with the progression of the run. There was no evident change in the females.

The number of eggs per female was again correlated directly with the weight and length of the individuals. The average obtained from forty specimens 1,698 ± 19, resulted in an egg deposition of 8,500,000.

The following is a summary of the counts for the propagation experiment:

	1930	1932	1934	1936	1938
Males	32,955	8,003	77,467	24,221	5,549
Females	33,196	7,597	77,716	28,091	5,028
Total	66,151	15,600	155,183	52,311	10,577
No. of eggs Presumed	1,535 ± 12	1,758 ± 15	1,799 ± 15	1,899 ± 12	1,698 ± 12
deposition	50,950,000	13,360,000	139,000,000	53,345,000	8,500,000
Fry Migrants	5,384,000	2,230,000	12,600,000	3,675,000	
% Hatch	10.6	16.7	9.1	6.9	

In the summary report on the run of 1936 the writer stated that "it is indicated that the low efficiency which results on the spawning beds after a large egg deposition is carried through the life cycle to a greater or less extent". Certainly this statement would appear to be borne out with the minimum return this year from the lowest percentage hatch of the four cycles. In the year 1932, however, with a small egg deposition the percentage hatch rose to the maximum figure of 16.7 per cent. It will be interesting to assess the number of

fry during the spring of 1938 to discover whether this percentage will raise or lower with a still smaller egg deposition.

A. L. Pritchard and W.M. Cameron No. 9

A Method Used in Tagging Pink Salmon to Allow Identification of Individual Fish.

In order to study the details of migration and distribution of mature fish on the spawning grounds it was imperative to be able to identify individuals at sight. Accordingly a system of tagging was designed to accomplish this end. While certain conditions prevented complete exploitation of its possibilities the experience was sufficient to indicate the practicability of its use during the next spawning run.

The principle of "button tagging" was employed. In this method pairs of small circular disks of colored celluloid, one of which is serially numbered, are affixed to the salmon by means of a long nickel pin passed through the dorsal part of the body. These tags are easy to attach, difficult to dislodge, and very conspicuous in the water.

One thousand pairs of disks were used, two hundred pairs of each of the five colors, white, yellow, blue, red, and green. Individual identification was attained by commutating and combining these colors in each of four designated anatomical regions along the dorsum of the fish.

As a concrete example, the particular regions used were, 1. immediately in front of the dorsal fin; 2. underneath the dorsal fin; 3. between the dorsal fin and the adipose, and 4. behind the adipose. The pin was placed at one of three angles, except in the fourth, where due to exigencies of space, only one position was used. A white tag on the right hand side in company with a red tag on the opposite side could thus be placed in one of ten distinctive positions. Using five colors on the left side made possible fifty combinations, and with the five colors possible on the right side, 250 fish could be distinctively tagged.

Since, particularly in the pink salmon, the secondary sex characters are easily distinguishable at a distance, 250 males and 250 females could be differentiated in the above manner. The second 500 fish were contrasted by placing underneath one of the tags, a flat metal strip of such a size that half of it remained visible.

During the actual tagging manipulation each fish was measured, weighed and graded as to its apparent sexual condition, the whole process consuming no more than forty-five seconds. As far as could be seen no ill effects resulted from the attachment or possession of these distinctive adornments.

In field observation the specificity of the fish could be determined almost at a glance. In order, however, to insure absolute identification, the combination was noted in code in the observer's field book, and by later reference to a key, the number, date of tagging, weight, length, and condition, were quickly discovered.

Certain possible improvements in the system to facilitate identification became obvious as the work continued. With slight modification, it would be possible to increase the combinations to handle any practical number of fish and at the same time render them even more distinctive.

W. M. Cameron No. 10

The Distribution of Spawning Fish in McClinton Creek

The differential tagging of spawning individuals described in an accompanying report was instituted primarily as an aid in studying the actual spawning habits of the salmon. However, certain points were observed regarding the migration of the fish in the stream itself. Some of these incidental observations are here set down to illustrate possible applications of the system to the study of other problems.

A number of surveys of the creek were made during the spawning run. Due to inclement weather conditions the majority of these were somewhat incomplete and as a result inconclusive. The observations on two of these surveys, however, have been analyzed and items of interest are noted.

On September 13th, after approximately one-third of the fish had passed the fence, a survey to observe the distribution on the lower half of the creek, revealed the following facts: There appeared to be no correlation between the time the fish had started upstream and the distance which they had travelled. In a few instances two fish which had been tagged on the same day were seen in approximately the same location, yet the general distribution of fish tagged the same day appeared to be definitely random.

Of the fish tagged before the 10th of the month, the males appeared generally to be farther upstream than did the females, yet of those tagged on the 11th, the average distance the females had travelled was over twice that of the males. A possible explanation of this peculiar situation is intriguing. A quick heavy rain occurred on the 10th, which had the immediate effect of causing a distinct migration upstream. This "surge" continued on into the next day, although the water level had dropped back almost to normal. Evidently the difficulties of procession in comparatively low water had served to retard the ungainly males to a greater extent than the females. It is possible that spawning activities had caused this, but the fact that a very small number of fish were preparing to spawn seems to preclude this possibility.

On October the 1st, a trip was made as far as a small falls that acted as a barrier at the head of the creek. A few isolated females were seen in the shallow water among the rocks, yet the farthest advanced male had been able to proceed only to a point a few hundred yards downstream. The distribution of fish here seemed to bear no definite relation to the length of time the fish had been tagged.

There was no concentrated attempt to recover tags from dead or dying fish. The difficulties of such work, however, were very apparent. Even before death the fish showed the ravages of decomposition. Tags in a number of cases wore completely through the flesh of live fish, and were lost. Dead fish quickly macerated, parts floated away, leaving the tags lying on the bars. The predation of bears removed many from the neighbourhood of the stream—tags were found many feet from the banks. Often an examination of bear dung would reveal the presence of devoured tags.

According to the laws of random sampling, these facts should have no statistical effect on the observations. One would expect that the ratio of the fish observed from a given day's tagging, to the total number tagged that day, would be comparable to a similar ratio for any other 24 hour period. No such simple relation existed, however, for the percentages fluctuated inexplicably from 0 to 100. This finding indicates the danger of drawing any quantitative conclusions from the observation of tagged fish without a most thorough and continuous survey of the grounds throughout the length of the spawning run.

A. L. Pritchard and W. M. Cameron No. 11

The Relation of Current and Volume of Flow to the Upstream Migration of Adult Pink Salmon

In a paper published in the Journal of the Biological Board of Canada the senior author reported the finding of a "positive significant mathematical correlation -- between numbers of fish migrating from the sea to the stream each day and both the maximum daily water height in the creek and the daily rainfall in the area." In McClinton creek it was also discovered that when the height of the water reached approximately 3.6 feet, the current was apparently becoming too strong and the numbers reaching the weir began to drop off. At levels exceeding four feet migration had ceased and the pink salmon remained in the back-eddies out of the main stream. No idea of the absolute measurements of the current or volume of flow was submitted for these critical stages. To discover some data on this question a number of readings were made in the creek immediately above the fence with a Gurley current meter during the period of the 1938 run.

The current in any stream will vary considerably with such things as the width and contour of the river, the position and size of obstructions, etc. The absolute determination of this characteristic at one point is therefore of little use for a general statement without qualification, but a single series considered with the measurement of the contour of the stream will permit the calculation of the volume of flow.

To give a very general picture the actual current immediately upstream from the fence is recorded. As stated above this may be different immediately below the fence or at any place of another depth or width. In low water when the height at the fence gauge was .7 feet, the mean vertical flow was approximately .3 feet per sec., at 1.1 feet - .9 foot per sec., at 2.1 feet - 1.2 foot per sec., and at 5.1 feet - 1.6 feet per sec.

The volume of flow as calculated from the series of current measurements and other necessary data was at .7 feet - 17 cu. ft. per sec., at 1.1 feet - 65 cu. ft. per sec., at 2.1 feet - 137 feet per sec., and at 5.1 feet - 454 cu. ft. per sec. The curve between water height at the fence and volume of flow was plotted. From it it was discovered that at the height where migration was slowed down due to the strength of the current viz. 3.6 feet, the volume of flow was about 300 feet per second. At four feet it had reached approximately 350 cu. ft. per second.

It is felt that further more detailed measurements of the current should be made during the fry run in the spring as well as during future adult migrations so that some absolute measurements on this variable factor may be added for comparison with those from other streams where investigations may be going on.

A. L. Pritchard and W. M. Cameron No. 12

Variation in Percentage Saturation of Dissolved Oxygen in McClinton Creek, During the Upstream Migration of the Pink Salmon (O. gorbuscha)

In an attempt to investigate further the factors influencing the upstream spawning migration of pink salmon, demonstrated by Pritchard (1936), a series of observations were made by the second author on the oxygen content of the creek during the months of July, August and September.

Winkler's method for the determination of dissolved oxygen was used. Duplicate samples were usually taken approximately once every two hours from eight in the morning until twelve midnight, but, in a number of instances, once an hour for a period of forty-eight hours.

Some tests were made to approximate the sources of experimental error, and precautions were observed to eliminate as far as possible variations due to these factors.

A study of the curves obtained reveals a daily variation under normal conditions, the oxygen content rising to a maximum shortly after midday and falling to a minimum during the hours of darkness. The average rise and fall was from 8C per cent saturation to 93 per cent, during the time studied. The rise appeared to vary directly with the intensity of light, the maximum and minimum values being more extreme in clear, bright weather. The character of this normal variation points to the agency of aquatic plants in controlling the concentrations, the photosynthetic activity of diatoms probably causing most of the rise, and the continuous metabolism of all living material tending to lower the dissolved oxygen.

Though the above regular variation occurred during clear weather, there was seen to be a definite interference with the rhythm in rainy weather which was accompanied by a marked rise in the creek level. The occurrence of a rain and rise in creek water level was almost immediately reflected by a sharp rise in the oxygen content of the water, such a rise being more apparent when the rain occurred in the afternoon or evening, at which time the oxygen content would normally be on the decline. A rain before noon tended to accentuate the rise and result in a higher maximum for the day.

There was some evidence that on the occasions on which a quick hard rain of short duration took place, the oxygen made a quick rise, and soon fell back to the approximate value which ordinarily obtained on a cloudy day at the corresponding time. When the rain was of longer duration and the creek maintained a high level, the oxygen content remained high. When rainfall occurred in a series of short hard rains, the oxygen values fluctuated in the neighbourhood of the maximum value.

Since the recording of these observations, a review of ecological literature has revealed that in certain English rivers a "diurnal variation in oxygen content" has been observed by Butcher, Pentelow and Woodley, similar in most respects to the variation at McClinton creek. Extensive observations on the effect of rainfall on this variation do not seem to have been made by these authors.

It has already been demonstrated by Pritchard (1936) that rainfall is significantly correlated with the number of upstream migrants and since it appears that a certain set of oxygen conditions is set up by rainfall, it may be found that oxygen content too may be a coincident variable.

Recommendations

In view of the facts that this one physical characteristic has been shown to be affected by rainfall, with which the extent of upstream migration is known to vary and that the determination of the factors influencing upstream migration are of prime importance in the study of the Pacific Salmon, it is strongly recommended that this phase of the investigation be continued and extended to the consideration of other physical and chemical characteristics of McClinton creek.

The Spawning Habits of the Pink Salmon - Oncorhynchus gorbuscha (Walbaum).

Coincident with the operation of the counting fence at McClinton creek, Masset inlet, for assessing the numbers of adult pink salmon (Oncorhynchus gorbuscha), opportunity was afforded to make certain observations with regard to the spawning habits.

To insure positive identification of the individual fish observed approximately 10 per cent of all upstream migrants were tagged using the system described in an accompanying report.

The following discussion is a condensation of comparatively voluminous notes. Due to the necessity for brevity, certain qualifications of most points discussed must be omitted. It is hoped that further observation may insure complete verification of details here set down.

Most of the salmon reached the spawning grounds as "fresh" fish, and it was not until the sexual elements were mature, that any segregation of the sexes took place. Until this time the salmon remained quietly in the deep shady pools, out of the force of the main current. As the secondary sexual characters became more apparent, the fish tended to move into the shallower parts of the stream, where the current was more pronounced.

The actual choice of an area in which to spawn was made by the females, which usually selected a position immediately upstream from a small fall or shallow riffle, in water six to eighteen inches deep. The area above a fallen log embedded in the gravel seemed to be the most favoured. It was observed that in this latter type of location, most of the movement of water was confined to the surface layer. Here the gravel was comparatively fine, but ranged from small pebbles to stones four or six inches in diameter. Backwaters in which the bottom was covered with silt or dense diatomaceous growth were strictly avoided.

The construction of the redd was carried out entirely by the female. Turning at an angle, rolling over on her side, and arching the middle portion of her body, she dug her tail into the gravel, and by a series of violent flexions thus threw a quantity of gravel up into the stronger surface current, which carried it a short distance downstream. This action was repeated at irregular intervals. The result was the formation of a shallow basin, downstream from which was built up a mound of the disturbed material. Within a comparatively few hours, the depression attained a depth of fifteen to twenty inches. The mound, its highest part almost directly behind the hole, sometimes reached a height of six inches, often coming to within an inch of the surface.

The shape of the hole and the adjacent mound set up a peculiar condition in the current. The motion of the water was even more restricted to the surface. Very little water movement could be observed in the bottom of the depression, but what could be seen was in an upstream direction, against the main current.

At about this time the female was approached by one or more males which took up a position a foot or more behind her and to either side. Although females spawning in a location frequented by a large number of fish appeared to be most favoured by the males, the few which spawned in more sheltered or less thickly populated parts of the stream, were in no case permanently deserted by a male.

There was marked rivalry between the males striving for the company of a female at this time. Usually one male, not always the largest, but seemingly the most energetic, claimed the female, and defended his possession by manoeuvering rivals out of the way, maintaining a position between them and the female. Biting was common, but no severe injury was observed to result from this means of offence.

There was no permanent pairing of sexes. Males varied their attentions between adjacent females, sometimes moving some distance upstream to claim another female. Often a large male, partially spawned-out, would drive out a fresher male, smaller than himself, and serve the female in the captured redd. The female apparently showed no preference for one male over another.

Females successfully repelled invasion of their redd by other fish of the same sex. No instance was observed in which one was permanently ousted from her position even by a larger fish.

The actual egg deposition was not seen, nor was any action definitely identifiable as semination observed. Males were noted taking up a position close to a spawning female and quivering violently for a few seconds, but this action has been interpreted by various authorities as a courting movement.

Only once was the covering of eggs observed, and this in the early morning. About 30 uncovered eggs were spotted in the bottom of the depression. The procedure was similar to redd construction, although there were indications that the female made an attempt to control the direction of the moving gravel. This and other evidence may point to the fact that eggs are laid usually at night. There are definitely no eggs extruded during the vigorous activity of gravel disruption.

As construction continued the female gradually worked upstream filling in the depression behind her until at completion the mound which began behind the early excavation sometimes attained a length of eight feet.

Females were deserted a number of days before the completion of the redd, but even after they displayed no more constructive activity, they maintained their position above or close to the disturbed area. All other females which approached were repelled vigorously, the parent zealously guarding her developing eggs until no longer strong enough to maintain her position in the unrelenting current.

A. L. Pritchard and W. M. Cameron No. 14

The Extent of Fertilization of Pink Salmon Eggs in Natural Reproduction

In connection with the study of Natural Propagation of Pink Salmon at McClinton creek, a programme was initiated to attempt to allocate to the various stages in development those losses occurring between the time of egg deposition and fry migration. During the present autumn examination of eggs recovered from completed redds was carried out to gain information on the percentage fertilization in nature.

The method of recovery used was comparatively simple. Redds were uncovered by means of an ordinary shovel and the eggs, which were thus freed from the surrounding gravel, were collected in a funnel-shaped net placed downstream a short distance from the area excavated.

Since the average age of the eggs studied was about two weeks, they were very sensitive to concussion. The difficulties attendant on the examination of eggs of this age, were partially eliminated by the use of a fixative which had the capacity to render them transparent to a strong light, and at the same time to define the embryonic tissue sufficiently for examination without dissection. Any doubtful eggs were dissected under the binocular microscope.

In the case of eggs which had apparently died after commencing development and before disruption, a certain amount of disintegration was observed, but in almost every instance such as this the embryonic tissue was obvious enough to remove any doubt as to their proper category. Saprolegnia in a few cases prevented absolute determination as to whether the eggs had been fertilized, These were recorded as "unfertilized", but it is possible that some may have been fertilized and died soon after development had commenced.

The redds sampled, five in all, were representative of the average condition as far as could be determined from qualitative observation. No attempt was made to entirely excavate any one redd, the quantity of eggs collected was assumed to be a representative sample.

The following are the recorded results of examination:

Redd No.	No. of eggs	Unfertilized	% unfertilized
1	435	5	1.2
2	296	8	2.7
3	658	4	0.6
4	718	23	3.2
5	246	2	.8
Total	2353	42	1.8

N.B. The percentage 1.8 must be regarded as the maximum number of eggs unfertilized since over half of the eggs in this class were decomposed. There is evidence that non-fertilized eggs are more resistant in the earlier stages to injury, and hence to infection. Considering this, the percentage of non-fertilized eggs may be slightly less than that recorded above.

A. L. Pritchard No. 15

Investigation of the Skeena River, B.C. - The Commercial Catch

In the summary reports of 1937, it was reported that during the year an investigation of the Skeena river had commenced which took the form of a preliminary survey designed to produce data on the general history of the fishery, and the present conditions, and to suggest any action which might lead to an improvement in the situation. In any such investigation the main problem was to discover the size of the population in previous years as well as at the present time. This involved the accurate determination of the numbers taken in the commercial fishery as well as the count of those which escaped to the spawning areas. The sum of these two determinations would give the total in the run from year to year, and comparison would indicate the trend of the fishery as well as the present status. During the present year the catch statistics have been examined and the results of that inspection are set down herewith.

Government records - total pack

During the year just passed a survey has been made of the records of catch available at the Vancouver Office of the Federal Department of Fisheries. In the case of the Federal Department it has been discovered that until recent years very little concentrated attention was paid to the collection of statistics.

A record was maintained on file of the number of licenses issued although no record was made of those which fished. In addition for each cannery usually the weekly and always the final season's pack are recorded. No attempt was made to segregate the catch into places of capture so that it is now impossible to determine with any accuracy how many of the fish included in the final figure were actually the product of the Skeena river and how many were brought in from other areas. In recent years with the appointment of a full-time statistician a more efficient system has been initiated under which the catch is divided more or less accurately under two heads "Skeena river fish regardless of where caught" and "Caught on the Skeena river regardless of where canned." Even in the present system, however, those fish which are taken off the mouth of the Skeena river are assigned to that stream although there is as yet no definite proof that they may not have been proceeding somewhere else. With these limitations in the catch statistics detailed conclusions drawn from close analyses would be unreliable. The most that could be done was to attempt to discover a trend over a long period of years assuming that in that length of time the effect of any introduced fish would be minimized.

From the records of total pack given by the Department for the earlier years and for the numbers caught in the Skeena in recent years, the following general conclusions have been reached by plotting the packs and smoothing the curves to show the trends:

Sockeye salmon - The trend here demonstrates a definite falling off of the catches from a running average of about 130,000 cases for 1909 to about 51,000 cases for 1935. It is granted that one should expect a sudden drop of the fishery at the outset from its usual high level as exploitation becomes more severe but there is no halt in the fall up until 1935. There has been no report from the spawning beds, qualitative though it may be, which would indicate that sufficient fish to compensate had escaped the fishery. During the last two years more rigid restrictions have been placed on the fishery with the result that the packs have not increased greatly but the spawning ground reports sound more optimistic so that fish may be increasing slightly.

As an exceedingly rough measure of the abundance of the fish, the catch per gill net per year has been worked out. This when plotted follows exactly the same downward trend as the total packs.

Pink salmon - In the case of the pink salmon, segregation of the Skeena fish from those of the areas surrounding was impossible of attainment. For the total pack of the area there appears to be a definite rise until approximately 1922 probably the result of increased exploitation as the demand increased for the species other than sockeye. After this year the pack decreased from a high of approximately 300,000 cases to about 100,000. The results of the last two years rigid protection are not discoverable in the analysis although the report of a large escapement to the spawning beds this year would indicate that it is having a great benefit.

Chum salmon - The pack of this species in the Skeena has always been relatively small. Large numbers are usually brought in from other districts. There seems to be very little indication of a change in the trend. The species is apparently holding its own.

Coho salmon - The trend for the pack of coho salmon apparently indicates an increase while the recent reports from the spawning grounds show that the numbers spawning in the various areas are approximately the same. In view of the fact, however, that large numbers of this species are brought in by the trolling fleet from outside areas, such a conclusion is entirely unreliable.

Spring salmon - Until the catches of spring salmon taken by troll outside of the Skeena can be segregated from those of the Skeena and the fish assigned to the river systems to which they belong, no definite evidence of the general history of this species may be deduced.

From a very general and superficial study of the catch statistics, it is apparent that the numbers of sockeye, the most important fish in the Skeena river fishery, has dropped from the original high level of abundance and that there is no definite assurance that this drop may not still be continuing. The pink salmon catches also show signs of decreasing with no corresponding increase in escapement. The chum seems to be maintaining itself. No conclusion can be reached regarding the status of the spring and coho.

Cannery records - Fish ledger records of daily catch of each fisherman

Through the kindness of Mr. J.A. Lamb, the manager of the Cassiar Cannery on the Skeena, opportunity was afforded to copy and examine the fish ledger sheets from that company for the years 1922 to 1936. These gave the daily catch of each species for each man in the employ of the company. They are thus much more detailed than any records procured by the Government but there still remains the possibility that some fish have been brought in and not recorded as being from other areas. From these data it would be possible to work out fairly accurately the catch per gill net and determine how this varied throughout the season and the years. It is doubtful, however, in view of the fact that there is as yet little information on such things as weather, effect of strikes, regulations and economic conditions, whether any definite valuable conclusions would result. From these data, also it would be possible to indicate when the various species went through the fishery in the various years but again the effect of regulation and economic conditions could not be eliminated.

Recommendations:

It is recommended that at the present no further attempt be made to delve into past statistics either from the government offices or the canneries because of the lack of certain data necessary for the interpretation of the findings. Later when a programme has been mapped out for the river it may be desirable to know accurately the commercial catch. At that time the canneries will co-operate in providing the records and may even be persuaded to record the area of capture accurately. With these records a close inspection should be maintained of the weather conditions as well as the regulations and economic factors. In addition a series of concentrated tagging programmes would have to be initiated in those districts off the mouth of the river to provide information to allow the segregation of the catches so that only Skeena river fish may be credited to the Skeena river pack. With this information a fairly accurate estimate of the catch should be attained.

A. L. Pritchard No. 16

Investigation of the Skeena River, B. C. - The Escapement

For the absolute determination of any run it is necessary to know, in addition to the numbers in the commercial catch mentioned in a previous summary, the numbers which escape the fishery and reach the spawning areas. The examination of the reports of the inspectors and other officers in the Skeena area for the period between 1918 and the present time, has lead to the following deductions in this connection.

It is the general practice for the officers to make periodic visits to the rivers, streams and lakes in their area during the time when the salmon are running and from their observations to report the number of fish which are present. These findings, which have been closely examined and copied for record at the Pacific Biological Station, have evident faults. In the first place there has not as yet been devised an accurate means of estimating qualitatively the numbers of spawning fish in a stream. It is granted that in some small rivers where the whole bed of the stream is visible, and where the water is not too deep for estimation, a fairly reliable count may be made. Such is the case in those streams which are tributary to Lakelse lake and Babine lake. In the majority, however, where the body is larger and where freshet conditions may interfere to some extent, only the roughest sort of an estimate may be made. In the second place, the officers, due to the fact that their territory covers such a large area, find it impossible to cover the district more than once during the year. They have thus gained an idea of conditions for a specified time only and have no indications of what may happen in the intervening period. In the third place, the number of streams in which salmon spawn in this province is so great that it has been impossible with the limited staff to visit all even at infrequent intervals. Thus many good beds are not inspected and no information is available on many districts which may be worthy of note.

In any efforts to compare conditions from year to year the utmost care must be exercised for several reasons. The chief among these is that the qualitative comparisons are not always made by the same man. In most cases it is not possible to have the one man make the inspections of a given area over a long period of years. The decisions of a new officer may be made on a quite different basis. Fortunately in the Upper Skeena area the present incumbent has been in office over quite a period of time. In making comparisons, if the desired result is to determine whether the run is maintaining itself, one must of necessity compare cycle with cycle and not year with year. There have been consistent studies made of a general collection of scales taken yearly at the mouth of the Skeena. These do not however indicate accurately the cycle existing in any given area.

The reports, in spite of their severe limitations should not be considered as being useless. They may be used as a general indication of the situation. It is certain that if any great increase or decrease of fish did occur, it would be noticed. In addition in such areas as the Babine where there are a number of small rivers and where conditions are usually favourable, a fairly accurate estimate may be obtained. For these reasons the data have been collected and are now in the process of being summarized. The general findings have been used in the section on the commercial catch when it is stated that the examinations of the spawning grounds did not indicate any great increase in the case of some of the species nor any decrease in the case of others.

In addition to the indication given as to the actual numbers of fish present in spawning season, general information of importance has been gained. A perusal of the reports on the obstruction of the streams has indicated that in the main there has never been any obstacle so severe in its effect that it would blot out a run or severely damage it. Most of the trouble has arisen from small jams which have been attended to as the occasion arose. From the reports and the comments it may be discovered in a general way when the species reach the various spawning grounds.

The examination of the data have also shown that the system is large and that many parts of it have not been consistently and, in some cases, never inspected. Those areas which have been visited have been reported upon and mapped by the officers. In an attempt to get some idea of the whole drainage area a map has been prepared by Mr. J. McHugh of the Federal Department of Fisheries in Vancouver. During the summer just passed this map was taken into the Skeena area and information elicited from prospectors, Hudson Bay factors, Indians, Fishery Officers or any others who had anything to contribute. In addition it has been found that the Federal Topographical Survey Department have mapped one whole area and that this map may soon be available. Thus we have a foundation which indicates those areas which are accessible and those which are more or less inaccessible to which can be added the information concerning other streams and lakes as they are discovered and investigated.

Recommendations:

At the present it is a little early to make concrete recommendations. The thing which is evident is that some method will have to be established by which a more accurate estimate of escapement may be made. It would seem that this will involve the actual counting of the fish going into certain areas and the perfecting of a general method of estimation. It is financially impossible to fence all areas. During the present season, Dr. Clemens, Mr. McHugh and the author visited the Lakelse and the Babine rivers. These two drain lakes whose tributary streams support large runs of the different species. Estimates are now being prepared for the installation of picket fences. It is hoped that with the accurate counts made here and the survey of the system more accurate estimation may result in all areas from the application of the method evolved. In addition, since these are representative areas, the counts at the fences could be taken as indicative of the Skeena as a whole.

For those areas which have been the subject of consistent inspection it is felt that all the general data should be recorded, so that if a more comprehensive system is established in later years, the data may be available as a guide. The map which is being prepared will indicate in a general way those rivers which have as yet not been visited. Information concerning these should be collected and if possible visits made to them.

A. L. Pritchard No. 17

Investigation of the Skeena River, B.C. - Spawning Ground Survey - 1938

During the year just passed a number of visits were made to various areas in the Skeena river watershed. There are here presented briefly some notes on the streams examined. In September and October a fairly detailed survey of the spawning situation in the Babine and Kispiox areas was made. These are reported in most detail.

1. - Lakelse lake area

The general description of this area has been submitted in the summary report for 1937, where some detail of the lake and the various tributaries was presented. The following additional information was gained this year.

The Lakelse river drains Lakelse lake from the south-west corner. The estuary at the river mouth is quite broad and shallow continuing for approximately one-quarter of a mile before it breaks into the river proper. Stands of rooted aquatic plants are widely scattered over this area. Below the estuary the stream is more limited in its width and flows over the usual stone and gravel stretches to join the Skeena. At approximately one-quarter of a mile from the lake at the mouth of a small tributary, Herman creek, the creek is about 150 feet in width and ranges from a gradually sloping shallow bar on the northern side to four feet in depth on the southern side when the flow of water is normal. The bottom is constituted of gravel and small rocks. It is here that the site for an adult counting fence has been proposed so that more detail of the stream is available in the engineer's report. No fish were visible on July 31. On July 31 and August 1 a small school of sockeye were seen off the mouths of both Skully and Granite creeks. A small showing was reported in Williams creek.

It is evident that the sockeye salmon had not reached the area in any numbers at the time of the visit. No estimate of pink salmon could be made without further examination of the Lakelse river.

2. - Kitsumgallum lake area

Kitsumgallum lake, approximately six miles in length and one to two miles in width, lies about twenty miles north-east of the town of Terrace. There are several tributary streams emptying into the northern end. It is drained by the Kitsumgallum river which flows in a general southerly direction to join the Skeena two and one-half miles west of Terrace. The stream is fast-flowing and large, reaching almost 300 feet in width. The water is the typical bluish-gray common to all rivers carrying glacial discharge. The bottom where visible appeared to be of rubble, coarse gravel and stones of varying size. No fish were seen on August 1 but the area is reported to support normally a good spawning population. Only one of the several tributary streams was encountered in the trip to Kitsumgallum lake. This, Deep creek, appears to present a good spawning ground of moderately coarse gravel. It is specially mentioned since there were no signs of erosion due to heavy freshets. Because of this fact, it might be a good area on which to conduct particular experiments on the coho salmon which are said to spawn there in fair numbers. At the time of the visit none of this species or others were observed.

The watershed is further increased by a large number of tributary streams most of which present favourable spawning conditions. A number on the eastern side of the river were crossed by the horse trail and are mentioned in the brief report of spawning which follows. The conditions noted at the various points are set down under each.

Kispiox bridge about one-quarter mile above Skeena.- On August 11 pink salmon were visible in large numbers spawning both above and below this bridge. No other species seen. Seventeen Mile bridge.- No fish of any species were seen here on August 11. Cullen creek.- This creek is tributary to the Kispiox about thirty miles from the mouth near the first cabin on the Yukon Telegraph line. Approximately thirty feet in width with bottom of fairly coarse gravel, it appeared a very suitable spawning area. No fish were present on September 26 or October 13. From reports, the run, consisting mainly of cohoes, apparently comes in at a later date. Corrall creek.- This stream, 30 to 50 feet in width with a bottom of coarse gravel to fairly large stones, at the location of the ford appeared to present eminently favourable conditions for spawning. No fish were seen either on September 27 or October 11. Sweetin creek.- The mouth of this river is approximately twelve miles north of Corrall. Just above its confluence with the Kispiox the stream divides into a large southern branch averaging 70 feet in width, and a smaller northern branch approximately 30 feet wide. The southern branch with bottom of gravel and fine stones is apparently more typical of good spawning ground than the northern with larger boulders. The water is the muddy gray of glacial streams. It is reported that few fish are seen in either branch. Mongese river.- The Mongese lies 6 miles north of the Sweetin. Its bottom of coarse gravel and rubble will support a large number of spawners. On September 28 a few cohoes were seen at the crossing and the bed appeared to be well worked over. On the return trip on October 11 numbers of the same species were observed in the Kispiox at the mouth apparently running up. The seeding of this species should be good although no attempt to estimate numbers would have been reliable. Kitwangulf canyon.- At Kitwangulf canyon, already described, was the first location where any idea could be obtained of the run in the Kispiox proper. A close examination was made here on September 28 when it was found that a large migration of cohoes and steelheads was in progress. On October 11 cohoes were still pressing upstream. Ammonuik river.- This stream is about 4 miles above Kitwangulf. On September 29 the river was very low but the gravel looked promising for spawning. On the return visit on October 11 the river was more swollen but no fish were visible. Kispiox river at Stephens creek ford.- The main stream is about 75 feet in width and possesses a fine gravelly bottom. No fish were visible. Stephens creek.- This is one of the main sources of the Kispiox. The river, 40 feet or more in width with gravelly and sandy bottom, had apparently received a good run. Numerous sockeye and cohoes were seen spawning at various places. On September 29 a fairly steady migration of cohoes were passing into Stephens lake. The next day the same run was still in progress. Club creek.- This flows into the north-east corner of Stephens lake and joins it to Club lake. The size was about 70 to 100 feet. The bottom was very disappointing in that it consisted of flat boulders Apparently this was moderately favourable for spawning as a large run of cohoes and a moderate run of sockeye was in evidence. Many of these were spawning. The Narrows.- Club lake, the second in the chain is joined to Arcy or Swan lake by a narrow channel around the mouth of which there were evidences of dead sockeye. Arcy or Swan lake.- This is a body of water oval in shape about 5 miles in length and 4 in width. Only one creek was visited. That Allen or Falls creek is moderately small, 20 to 30 feet in width, and possesses a fine gravel

3. - Copper or Zymometz river

The Copper river, another large tributary of the Skeena enters it about six miles east of Terrace. It has its source in a series of lakes about sixty miles farther inland, south of the region of Smithers. By a rather circuitous route over a distance of approximately fifty miles it winds down to its junction with the Skeena at Copper city. There was no opportunity to visit the whole water-course but an examination near its confluence demonstrated the fact that the bottom of good gravel would be eminently suitable for the spawning of all species of salmon. Undoubtedly this stream, which is in places 500 feet wide, is subject to wide variations in water height with the result that there are visible many changes in the channels. This might have a deleterious effect on the eggs deposited. The cursory survey has indicated that the stream is worthy of further investigation when the salmon runs are on. No fish were visible on August 1.

4. - Kitseugla river

The Kitseugla river is a relatively small tributary of the Skeena entering at about twenty miles below Hazelton. On August 12 when it was crossed near the mouth, there were no fish in evidence. Condition of the bottom looked fairly suitable for spawning activity.

5. - Kispiox and Upper Skeena area

For orientation it should be stated that the Skeena river divides at Hazelton into two main branches, the northern one retaining the name Skeena, and the southern one being called the Bulkley. About fourteen miles north of this junction the Skeena again divides, the eastern main branch being the Skeena and the western branch, the Kispiox. A visit was made to the confluence of the Skeena and the Kispiox and to a spot seventeen miles upstream on the former on August 11. Later in the autumn, September 26 to October 14, inspection of the upper reaches of the Kispiox was carried out through the medium of a pack train.

The Kispiox may be said to arise from three main branches at a distance of approximately 65 miles north of the place at which it joins the Skeena. The eastern branch takes its source in the mountains separating the Skeena and Nass watersheds. Another tributary Williams creek, drains Williams lake to the westward. At a short distance below these streams, Stephens creek enters, draining three lakes of moderate size, Stephens, Club, and Swan or Arcy.

The main stream from the entrance of Stephens creek to the mouth varies considerably in size due to the effect of freshets and the contour of the land. The width ranges from almost 300 feet to 100 or less. In general in those situations observed en route, the bottom, consisting as it does of fairly coarse gravel or fine stones, is admirable for spawning. There were also visible numbers of sandy or muddy pools which serve as resting places.

About 45 miles from the confluence with the Skeena is found a canyon, Kitwangulf, fairly typical of those of the other rivers in the area. It is rather short, however, the water pouring between a rock wall on the eastern side and an alluvial bank on the other. There is very little evidence that the falls thus formed are any hindrance to the migrating fish at any stage of water.

bottom. Many live sockeye were seen and the large piles of dead and decaying fish bore witness to the fact that there was a very heavy run of this species this year to the area. There were evidently a great quantity of bears in the vicinity which were destroying noticeable numbers of spawners. Williams creek.- the second large source of the Kispiox, was crossed on October 2. The stream appears to be suitable for spawning, 30 to 40 feet in width with a stony bed. No fish were seen but a run of sockeye was reported by the Indians.

In general from the observations it can be gleaned that the Kispiox watershed received a fair run of pinks, a medium to heavy run of cohoes and a good run of sockeye. The large number of sockeye in the upper reaches in Allen creek is encouraging and points to a fairly good seeding in the watershed.

6. - Telkwa river

The Telkwa is a fairly large tributary entering the Bulkley opposite the town of Telkwa. On August 9 when the mouth was inspected the difference in the gray glacial water from that of the Skeena was quite noticeable.

7. - Morice river

This is another large tributary of the Bulkley. A more or less complete description of the headwaters was submitted in the report of last year. On August 9 of the present season a visit was made to the section just above its confluence with the Bulkley to determine the feasibility of fencing. Here the stream is approximately 275 feet in width, 2 to 6 feet in depth and very fast flowing. No fish were seen.

8. - Upper Bulkley

The Upper Bulkley system includes all the rest of the Bulkley from its source in Bulkley lake and several other smaller bodies of water, to the Morice. It is fairly narrow, possesses fine gravel bars, and would appear very suitable for fences. No fish were seen early in August at the time of the visit.

9. - Babine area

Since a general description of the Babine lake districts and the tributary streams was presented in the report of last year, it is only necessary to note briefly the spawning populations present at the time of the visits this year. These data are summarized in the table below. Where not designated the numbers refer to sockeye.

Creek	Aug. 2 - 7	Sept. 10 - 16	1937
Grizzly		400 sockeye 1150 in early run	2800 sockeye 1000 taken by Indian
Fifteen mile	Very few	6500	4500
Twin	325	1100	3100
Pierre	1400	3000	3600
Tachek	Very few	1200 - 1300	900
Fulton	Few sockeye	Fairly heavy	Better than medium
Morrison	Few sockeye	5000 - 6000	6500
Salmon	No report	No report	400
Babine	Few sockeye Few springs Few pinks	Sockeye light Fair springs Heavy pinks Fair coho	Sockeye light Medium springs Heavy pinks Fair coho

In considering these figures it must be noted that the run of sockeye to the Babine river and the Fulton may increase with the late influx which usually comes in. In general the seeding compares favourably with that of 1937 with the exception of Grizzly and Twin creeks. In the case of the latter it is perhaps fortunate that the run was small because the creek was so low that more spawners would only have lead to a waste of eggs due to the inability of the fish to get upstream. Another noteworthy feature is the heavy run of pink salmon to the Babine river this year in what is usually an "off" year for that species in the area. It is possible that the restrictions on fishing for that species at the mouth of the Skeena in force for two years, are beginning to show results in increased escapement.

Notes on Certain Spawning Areas in the Upper Nass River System - 1938

After the survey of the Kispiox river and its tributaries had been completed, the writer accompanied Inspector McDonell on a further trip over the low separating divide to the Nass watershed. Some notes and observations for this area are recorded herewith.

1. - Quinnigese system

Quinnigese lake lies almost due north of the headwaters of the Kispiox on the northern side of the low divide which separates the Nass and Skeena watersheds. In appearance this body of water is typical of northern temperate lakes. The shore line is well serrated with bays and the main portion of the lake dotted with islands. As far as is known there are two tributary creeks, one at the northerly end and the other at the southerly. The southerly or Inlet creek was inspected on October 3. This stream in the main presents a spawning ground of fairly coarse gravel lying between moderately large rocks. The width averages approximately 75 feet. One-quarter to one-half mile from the lake is a fall which appears insurmountable to spawning fish. The mouth of the river is divided into several channels. With the area of spawning ground visible it is evident that a large number of fish could be accommodated. Only six dead sockeye were seen and there was little evidence of wide-spread spawning. It was noteworthy that there were signs of an abundance of predators such as eagles, coyotes, and grizzly bear. Quinnigese river drains the lake from the north-east corner. It is 75 to 100 feet in width on the average and moderately fast-flowing. For a mile below the lake the bottom is rocky and thus poor spawning area. At about four miles there is a stretch of open river with the necessary gravel and stones. No fish were seen here but there were evidences of slight spawning.

On proceeding toward the Nass river the following tributaries of the 25 mile-long Quinnigese were crossed: Lime creek, Melight or Steelhead creek, Bella lake, Saicote creek, and Shanalope. These streams varied in size but the last two mentioned were fairly large. Although usually of the swift mountain type they nevertheless presented fairly good spawning conditions in their coarse gravel bottoms. No fish of any species were seen. On October 8 a visit was made to the junction of the Quinnigese river with the Nass at a distance of approximately 25 miles north of Quinnigese lake. Unfortunately the high water and the resulting freshets had made the water in both rivers so dirty that observation of fish, if there were any, was impossible.

2. - Other tributaries of the Nass

One other stream was visited and inspected over five or six miles from the Nass river inland. This, the Sanskiseet, empties into the Nass river about four or five miles east of the Quinnigese. The width varies considerably from 75 to over 100 feet. The spawning bars of coarse gravel and stones are favourable but their contour gives evidence of heavy scouring and shifting of the channel. No fish were observed in the long stretch examined.

In summary it must be noted that signs of fish and the numbers observed in the area were very disappointing. There was practically no run of sockeye and cohoes were absolutely lacking. Because there are apparently some good spawning grounds in the area, it might be well to investigate further another year to determine whether there is any barrier to spawning fish at present unknown.

OCEAN FISHERIES.

J.L. Hart No. 19

The Pilchard Fishery in 1938.

The pilchard fishing season of 1938 resembled no other year since the reduction of pilchards began in 1925 in that it consisted of two distinct phases rather distinctly separated in time and exploiting widely separated fishing grounds. The first phase of the fishery lasted from the last days of July until the middle of August and centered off the Washington coast. The second phase started about the first of September and continued well into October. Scattered schools were still being taken by herring fishermen in November (in the inlets). The fishing for this phase was concentrated off the northerly part of the west coast of Vancouver island. For the whole season fishermen made somewhat better catches than in the previous year.

The fact that in the last six years four of the years have been dissimilar to what had become to be regarded as the normal pilchard season is rather a surprising chance and leads to speculation about its significance. A review of the situation may be of interest. The general idea of a normal year is one in which large adult pilchards - 95% or more more than 225 mm. standard length - enter the west coast fishing grounds between late June and late July and the fishery lasts until broken up by weather in the latter half of September or early October. In 1933 the pilchards never did come to the region off the west coast of Vancouver island. A few "homesteaders" were captured in inlets and a few loads were brought up from off the American coast. It seems quite possible that had the boats available a few years later been in use then that 1933 might quite closely have resembled 1937. In 1934 and 1935 pilchard fishing corresponded with the idea of a normal season and catches were good. In 1936 for the only time in the history of the fishery the length-frequency distribution showed two distinct size groups of fish. Many small fish were on the grounds to the great discomfiture of the fishermen. In 1937 fish were off the west coast of Vancouver island (Barkley sound) for only about 2 days. They moved back to the south where they lay between Cape Flattery and the mouth of the Columbia river until fishing closed as a result of bad weather. The fish were reasonably easy to catch and for the most part stayed in predictable places so the fishermen did not fare too badly in spite of the long haul to their home plants. The situation in 1938 has been described. A definite relation between these peculiarities and abundance is not apparent. Their presence, however, is not reassuring about a fish population which is suspected of declining abundance.

For details concerning size and vertebral number of the pilchards sampled from the commercial catch and for the conclusions drawn from tagging work reference may be made to other summary reports (Hart and McHugh; Hart).

J.L. Hart and J.L. McHugh No. 20

Sampling the pilchard catch in 1938.

The routine work of sampling the pilchard catch was carried on again during the last pilchard season. The results for lengths are shown below.

	Males Average length	Females Average length	Both Average length
Canadian coast	246.98	251.43	249.35
American coast	245.51	250.36	248.16
Cape Flattery	247.14	252.22	249.90
Destruction island	245.55	250.01	247.91
Grays harbour	242.40	249.00	246.45

The gradation on the American side and the fact that the average lengths for the fish taken off the Canadian coast are greater than for those taken off the American coast will be observed and it is believed that they are significant. A similar state of affairs was evident in the previous year. As Cape Flattery samples are not well represented there is no great certainty that the fish taken there were longer than those taken off Vancouver island.

The average vertebral number for all samples was 50.68. The count was remarkably constant for all sampling areas except for the one hundred specimens examined from Grays harbour which showed an average of 50.60

The general impression obtained from the sampling is that the more apparent effects of the dominant year class which entered the Canadian fishery in 1931 have vanished. It is probable that the dominant year class is merging with the numerous older age groups at the same time as it is being diluted by the less exploited younger ones.

Application and Recovery of Pilchard Tags in 1938.

The programme of pilchard tagging and tag recovery has proceeded for another year. With the increased duration of the investigation there has been an increase in the degree of complication in analysing the results and at the same time an increase in their value.

During the 1938 pilchard season five thousand tags were used. Two thousand five hundred of these were applied off the Washington coast in July and August and the same number off the west coast of Vancouver island in early September.

The recoveries may be summarized in the following way:

Recoveries of Canadian tags used off Washington coast in 1938	
By Canadian plants, off Washington coast	20
By Canadian plants, off Vancouver island	4
By Washington plants & floaters, off Washington coast	23
By Oregon plants	6
Recoveries of Canadian tags used off west coast Vancouver island	
By Canadian plants only	188
Recoveries of Canadian tags used in 1937 and 1936	
By Washington & Oregon plants, off Washington coast	3
By Canadian plants, off Washington coast	3
By Canadian plants, off Vancouver island	7
By California plants, off California (winter 1937-38)	5
Recoveries of Oregon tags	
By Canadian plants, off Vancouver island	3
Recoveries of California tags	
By Canadian plants, off Washington coast	15
By Canadian plants, off Vancouver island	23
Total for the year	30)

In interpreting this summary two facts must be kept in mind: (1) About three-quarters of the season's catch was made off Vancouver island; (2) The fish caught off Vancouver island were passed through the Nootka sound reduction plants which have been shown (Summary Report: Hart, McHugh) to be about two-thirds as efficient in recovering tags as the Barkley sound plants which handled the most of the Washington coast catches.

Consideration of these values shows that (1) the concentration of 1936 and 1937 Canadian tags, Oregon tags, and California tags was roughly the same off Vancouver island as off the Washington coast; (2) the concentration of tags used off the coast of Washington was materially higher off the coast of Washington than off the west coast of Vancouver island; (3) the concentration of tags off the west coast of Vancouver island from those used there was extremely high; (4) some of the tags used off the Washington coast were recovered off the west coast of Vancouver island. These facts are interpreted in the following way: In July and early August there was a very substantial body of fish off the Washington coast. This was a well-mixed group bearing tags from many different taggings and very possibly was the main body of adult pilchards. Around the middle of August a small section of this body of fish became detached from the rest moving to the northwest finally arriving off the west coast of Vancouver island. The movement evidently took place well offshore, as the Canadian fishing fleet failed entirely to intercept it. Part at least of the remaining and larger body of fish moved slowly to the southward. This is indicated by the fishing localities of Canadian and American pilchard fishermen in August and September.

The returns very evidently confirm the interchange of pilchards between California and British Columbia fishing grounds as already shown by the work of previous years.

J.L. Hart No. 21

Calculations shown in last year's summary reports indicate the total pilchard population as 5 million tons. Calculations from this year on the same principle give the following result: 4500 (tons caught by most effective plant in recovering tags) x 12500 (tags used) ÷ 7 (tags recovered) = 8 million tons, which is roughly comparable. It is possible to refine this calculation by allowing for some of the sources of error and it is proposed to approach this problem at an early date.

Other features of interest in this year's results may be briefly listed: The number of recoveries from the 1938 Vancouver island tagging taken in conjunction with the information obtained by testing the efficiencies of the various magnets show that some 13 percent of the pilchards off the west coast of Vancouver island were taken by the fishery during the season. There is no reason to suppose that this is not a minimum estimate. There was a definite contrast between the returns from the Washington coast taggings and the Vancouver island taggings in that most of the former were made within a few days after tagging, but the great majority of the returns for the later taggings were made after a week or more. The tagging returns for the westerly tagging demonstrate a great and presumably continuous mixing of the pilchards off the west coast of Vancouver island.

J.L. Hart No. 22

Comparative Efficiencies of Tagging Pilchards with a Knife and with a Tagging Gun.

Under certain conditions of tagging the use of a tagging gun contributes materially to the comfort and efficiency of the tagger. The question has been raised concerning the effects on the fish of tagging with a gun. This matter has been put to a test by tagging pilchards from the same sets by the old method using a knife with the cutting edge at the end and by the use of a tagging gun. The results to date indicate no significant differences between the percentages of tags returned from the two methods of tagging. It remains possible that a difference may be found among fish which are recaptured long after the close of the tagging period. In the meantime it appears in order to continue the use of the tagging gun where the practical considerations of tagging make it more convenient.

J.L. Hart and J.L. McHugh No. 23

Tests of the Efficiency of Reduction Plant Magnets in Recovering Sardine (pilchard) Tags.

Although the recovery of pilchard and herring tags by electro-magnets in reduction plants is so important in ocean fisheries research there is little information and no accurate knowledge about their efficacy in attracting all the tags passing through the plant or in providing accurate information about the source of all the tags recovered. Accordingly, the magnets were subjected to test by placing 50 pilchards tagged with California tags in the hold of a boat about to be unloaded and keeping track of the returns as to number and accuracy.

Considerable difference exists between plants in their total effectiveness in making recoveries. Three of the seven plants gave results which indicate satisfactory recovery (80 percent or better), three demonstrate medium efficiency (50 to 60 percent) and one appeared to be definitely poor in efficiency in tag recovery (less than 40 percent). Fifty percent of all the tags used and 78 percent of all the tags to be returned were recovered during the day of the experiment and the day following. Fifty-eight percent of all the tags used and 90 percent of all the tags recovered were obtained by the end of the second day. All plants but one returned tags as being recovered as late as the fourth day. One tag was returned as late as the forty-fifth day. The Nootka plant appeared to have an especially long lag. It is possible that the greater of the two lags may have been the result of a clerical error. Whatever the cause, the results indicated the conditions as they affect the results of scientific work.

Sampling the Commercial Herring Catch of Southern B.C.

Sampling of the purse-seine catches for length, weight, sex, age and vertebral count was continued throughout the 1937-38 herring season. The purpose of this is to trace natural fluctuations in abundance caused by variation in the strength of successive year classes and to determine the extent of intermingling of the various runs. Concerning the latter, indirect information derived from an analysis of racial characters will augment direct information regarding the movements of fish derived from the insertion and recovery of herring tags.

During the 1937-38 season 36 samples were collected from the various fishing grounds in the vicinity of Vancouver island. In average length the samples may be arranged in the following order: Quatsino sound (198.7), Kyuquot sound (193.1), s.e. coast (192.8), Nootka sound (191.7), Barkley sound (189.8 mm.). Quatsino sound fish are again outstanding by virtue of their large size. The s.e. coast fish have the largest average length that has been encountered for several years. A partial return to the higher level of length and age composition of the early years of the fishery is indicated.

S.c. coast herring again had a larger percentage of males and a lower mean abdominal vertebral count than Barkley sound fish. The averages of these two characters over a period of several years are included here:

	% males			mean abdominal vertebra.		
	s.c. coast.	Barkley sd.	D.	s.c. coast.	Barkley sd.	D.
1929-30	52.4	44.6	+ 7.8	-	-	-
1930-31	57.2	45.9	+11.3	-	-	-
1931-32	54.9	43.3	+11.6	23.159	23.259	-0.100
1932-33	53.3	49.1	+ 4.4	23.047	23.167	-0.120
1933-34	51.1	46.5	+ 4.6	22.978	23.126	-0.148
1934-35	51.4	48.2	+ 3.2	22.985	23.175	-0.190
1935-36	59.9	47.3	+12.6	23.096	23.262	-0.166
1936-37	55.1	45.6	+ 9.5	23.052	23.094	-0.042
1937-38	55.5	48.3	+ 7.2	23.025	23.092	-0.067

The consistency of the difference between the two localities in these two characters is remarkable and is considered to demonstrate lack of extensive intermingling between the two populations.

During the summer of 1938 time was available to determine the percentage age composition of the 1936-37 samples taken to the north-west of Barkley sound:

	II	III	IV	V	VI	VII	VIII	IX	X	XI
Barkley sd.	4.7	53.2	30.0	7.2	4.5	0.2	-	0.1	-	-
Sydney in.	18.6	67.4	12.8	1.2	-	-	-	-	-	-
Nootka sd. A	1.1	32.9	54.4	10.0	0.9	0.6	-	-	-	-
Nootka sd. B	89.5	7.7	2.3	0.5	-	-	-	-	-	-
Kyuquot sd.	0.3	34.9	53.0	7.6	3.2	0.2	0.4	0.2	0.1	-
Quatsino sd.	0.5	14.4	56.2	9.6	15.4	2.9	0.5	-	-	0.5

In each inlet the age composition differed considerably from that of Barkley sound where III's predominated. The scales of the Sydney inlet fish were particularly difficult to interpret, but the results indicate a predominance of III's with a particularly large proportion of II's. At Nootka sound there were two distinct groups of fish, one consisting of the usual pre-spawning run but with IV's rather than III's forming the dominant group; the other consisted of the typical "recruit" group of small young fish with II's predominating. Fish of the latter group are occasionally encountered in the inlets during the summer but only rarely are they caught commercially during the winter. Samples of the two groups were also collected at spawning time. The gonads of the small recruit group were ripe and apparently successful spawning took place. This suggests that their unusual appearance during the winter fishing season was due to precocious maturity. The age composition at Kyuquot sound was very similar to that of the run of large fish at Nootka sound, with IV's predominating. At Quatsino sound there was a considerable predominance of IV's and a slight predominance of VI's. The presence of a large proportion of old fish is typical of the Quatsino run.

The age composition of the 1937-38 material has not yet been determined. This will be accomplished as soon as possible and data collected since 1934-35 will be analyzed in regard to fluctuations in abundance and intermingling of populations. The results will be compared with those previously obtained and already published.

B.V. Boughton No. 25

Sampling the Commercial Catch of Herring in Northern B.C.

In connection with the extension of the herring investigation to include an intensive study of the herring in the northern coastal waters the writer, during the fall of 1938, was stationed at Namu to sample the commercial catches from that vicinity. Unfortunately the fish failed to appear in quantity and the catches, to date, have been very small. Those samples which have been worked over show distinct differences from those taken during the past two years.

Three areas have been sampled, namely Rivers inlet, Cousins inlet, and Klemtu passage. With regard to length and age compositions the three areas

gave entirely different results. The average length (185.4 mm.) of the herring in Cousins inlet was greater than that in Rivers inlet (158.8 mm.), which, in turn, was greater than that in Klemtu passage (129.2 mm.). Similar differences were present in average age composition. Those in Cousins inlet averaged 4.924 years old, with the 1935 year class (IV's) dominant; those in Rivers inlet averaged 3.282 years old, with the 1937 year class (II's) well represented; while those in Klemtu passage averaged 2.027 years old, with the same year class (II's) strongly dominant. The age composition for Klemtu passage was characterized by a high percentage (18.6) of the 1938 year class (I's).

In the case of vertebral count both the 1935 and 1936 year classes of Rivers and Cousins inlets differed significantly. Further, the 1937 year class of Rivers inlet differed significantly from that of Klemtu passage. These results add to the evidence already accumulated that local runs occur in this general area.

In all three areas the average lengths are less than those determined in previous years. Herring from Cousins inlet averaged approximately 200 mm. in 1936-37, 195 mm. in 1937-38, and 185 mm. in 1938-39. In Rivers inlet the average length of the samples has decreased from approximately 175 mm. in 1937-38 to 159 mm. in 1938-39. In the Klemtu area the average length in 1936-37 averaged approximately 181 mm., whereas in 1938-39 the catch averaged 129.2 mm.

Corresponding changes have occurred between the average age compositions. In Cousins inlet the average age composition was 6.344 in 1936-37, 5.100 in 1937-38, and 4.924 in 1938-39. Similarly, in Rivers inlet the average age has dropped from 4.539 in 1937-38 to 3.282 in 1938-39. A most remarkable change in age composition occurs in the Klemtu area, where the average age has decreased from 4.240 in 1936-37 to 2.027 in 1938-39. In 1936-37 the 1933 year class (IV's) dominated, whereas in 1938-39 the 1937 year class (II's) dominated.

These changes in length and age compositions may possibly be related to the recent intensive exploitation of the area, although they are more extreme than would be expected in such a short period (3 years). On the other hand, the results of the 1938-39 season should be considered in respect to the failure of large numbers of mature herring to appear in northern waters in the fall of 1938. It is possible that the catches, to date, are represented mostly by schools of immature fish. Such immature fish join the mature schools which return to the inlets from the open sea in the autumn.

The failure of herring to appear in commercial quantities during the fall of 1938 demonstrates the need of a comprehensive investigation of the factors governing abundance and movements of the species.

A.L. Tester and R.V. Boughton No. 26

Investigation of the Herring of Northern B.C.

Because of the recent expansion of the herring fishery into the coastal waters of northern B.C., it has been considered advisable to make an intensive study of the herring runs supporting the new fishing areas. The methods will be similar to those employed in the south, namely, representative sampling of the commercial catch for length, age and weight composition, sex

ratio and vertebral count. From these data it will be possible to broadly define the populations which are present and to trace changes in the relative abundance of each. The data will also yield information such as length and age at maturity, rate of growth in length and weight, rate of mortality, etc., which is indispensible to an understanding of fluctuations in abundance. In addition to sampling, other phases of the investigation will include the collection and analysis of catch statistics, studies of the spawning grounds, and the insertion and recovery of tags. The results of these, however, will be considered elsewhere.

Considerable information derived from sampling has already been published and will form a background for the present study. In addition, during 1936-37 3 samples were obtained from Klemtu passage and Cousins inlet; and during 1937-38 11 samples were obtained from Cousins inlet, Rivers inlet, Bella Bella, Jap inlet, Butler cove, and Prince Rupert harbour. These were examined for percentage age composition with the following results:

Locality	II	III	IV	V	VI	VII	VIII	IX	X	XI	No. samp.
1936-37											
Klemtu pass.	-	26.8	50.9	7.8	6.5	2.3	4.6	1.4	-	-	1
Cousins in.	-	1.4	7.2	18.6	43.9	4.7	12.6	5.4	5.0	1.1	2
1937-38											
Cousins in. A	0.6	29.0	30.7	23.0	7.7	5.4	1.6	1.2	0.3	0.3	3
Cousins in. B	-	2.5	16.7	18.9	14.9	24.5	5.5	9.4	5.6	2.0	2
Rivers in.	1.4	23.9	18.4	42.9	6.6	3.8	1.9	-	0.9	-	2
Bella Bella	-	27.6	34.3	21.0	9.5	5.7	0.9	0.9	-	-	1
Jap in.	-	22.7	57.3	12.7	6.7	0.9	-	-	-	-	1
Butler c.	0.9	26.0	58.0	10.5	3.7	1.4	-	-	-	-	1
Pr. Rupert	1.0	28.0	38.0	11.0	11.0	7.0	1.0	2.0	1.0	-	1

In 1936-37, the Klemtu fish differed radically in age composition from the Cousins inlet, consisting mostly of younger individuals. There were apparently two distinct runs of fish to Cousins inlet in 1937-38; in the early run (A), IV's predominated, whereas in the late run (B), VII's, V's and IX's predominated. The age composition of the latter suggests that it is the same group of fish that was sampled the previous year. The age composition of the Rivers inlet samples differs considerably from that of all other localities, with V's and III's predominating. In all other northern localities, IV's were apparently the dominant group.

In vertebral count the 1933 year class of Cousins inlet differed significantly from that of Rivers inlet, suggesting that the fish belong to two separate populations. Differences between the vertebral counts of the 1934 and 1935 year classes between Cousins inlet and Jap inlet-Butler cover add to the evidence already accumulated that intermingling between the fish of the Prince Rupert and Bella Bella districts is either limited or absent.

During Sept., 1938, both investigators visited the northern area on board the "A.P. Knight". Personal contacts were made with reduction plant operators at Namu, Butedale, Port Edward and Tuck inlet and considerable information pertaining to the fishery was obtained. Dr. Boughton remained at the

Namu reduction plant to sample the commercial herring catches from the various fishing grounds in that vicinity. The results of his investigations are reported elsewhere.

It is recommended that the sampling programme, in conjunction with other phases of the work, be maintained in this northern area over a period of several years. It is also suggested that efforts be specifically directed toward explaining the erratic occurrence of herring on these new fishing grounds.

Catch Statistics of the Herring Fishery During 1937-38.

The object of collecting daily catch statistics of the herring fishery is to determine as accurately as possible the total quantity of fish removed from each fishing ground, the number of boats in operation, and the number of days during which active fishing is in progress. From these statistics it is possible to calculate the availability of herring, i.e., the average catch per seine per day, for each area. The ultimate purpose is to trace and explain fluctuations in availability and abundance.

During the fall of 1937, the quota was attained on the south-east coast of Vancouver island with a total catch of 25,059 tons. The availability of herring was the greatest that has been encountered during the past five years (1933-34 to 1937-38 incl. - 76.4, 94.8, 101.0, 87.3, 144.0 tons). This may be related in part to a greater abundance of fish during the fishing season and in part to the smaller number of boats fishing. In regard to the latter, a negative correlation ($r = -0.86$; $P = 0.02$) has been obtained between yearly availability and number of boats.

On the west coast of Vancouver island, where the total catch amounted to 30,334 tons, the quotas were reached in Barkley and Quatsino sounds, but not in the other three areas. In Quatsino sound, a relatively new fishing ground, the availability was higher than in the previous year. In other west coast areas fishing was relatively poor, particularly in Clayoquot sound. The following table enables a comparison of availability between areas and years to be made:

Season.	Barkley sd.	Nootka sd.	Kyuquot sd.	Quatsino sd.
1935-36	45.1	134.5	117.6	-
1936-37	53.5	37.5	47.8	68.1
1937-38	38.8	26.3	25.1	83.2

In northern British Columbia, encouraged by the success of the Cousins inlet fishery of the previous year, seine boat captains prospected most of the potential fishing grounds on the coast of the mainland and on the Queen Charlotte islands during the first five months of the 1937-38 season (April to August, incl.), but with poor success. During September, October and November, the Bella Bella and Rivers inlet districts yielded fair catches,

but the availability at Cousins inlet was considerably less than in the previous season, the first year of intensive fishing (35.2 as compared with 95 tons). During December, January and the first part of February, herring were particularly abundant in Prince Rupert harbour and good catches were made until the area was closed to fishing. Fish were then located at Surf inlet to the south and this ground was fished until March 12 when the season was closed. The total recorded catch for northern B.C. amounted to 20,844 tons, but this is probably lower than the official total due to incomplete returns. The following table gives the catch and availability per month for the whole northern area:

Month	Catch	Avail'y	Month	Catch	Avail'y
Apr.	20	3.3	Oct.	5771	38.5
May.	203	4.7	Nov.	4869	39.3
Jun.	461	7.4	Dec.	5392	114.7
Jul.	353	3.3	Jan.	480	96.0
Aug.	126	4.5	Feb.	1137	71.1
Sep.	1587	27.4	Mar.	445	74.2

The above statistics of the herring fishery of the province were collected by means of Pilot House Record Books which were printed and distributed to seine boat captains for the first time. As the system has met with considerable success, it is strongly recommended that it be continued in the future. It is also suggested that an effort be made to divide the coastline into a series of numbered statistical areas to facilitate the tabulation and manipulation of daily catch data. If a simple yet suitable system of numbered statistical areas can be worked out, they should be delineated on a map and printed copies should be sent to seine boat captains so that localities of fishing may be recorded wholly or partly in code.

Herring Spawning Conditions in 1938.

In collaboration with the Dominion Department of Fisheries, surveys of the herring spawning grounds of the province were again made in an attempt to arrive at a quantitative estimate of the intensity of spawning in each district, to obtain a comparison of the intensity with that of the previous year, and to determine the mortality of the eggs on the spawning grounds.

On the south-east coast of Vancouver island, spawning intensity ranged from medium to very heavy in the various districts and, on the whole, it was heavier than in the previous year. Very heavy spawning was reported in the Quathiaski district at the north end of the strait. At Esquimalt harbour and lagoon, the eelgrass has disappeared and eggs were deposited on the bare rocks in shallow water.

On the west coast of Vancouver island, spawning was very light in Barkley, Clayoquot and Nootka sounds, light in Quatsino sound, and medium in Kyuquot sound. In all areas except Quatsino, it was lighter than in the previous

year. The lighter spawning appears to correspond with a smaller pre-spawning run as indicated by the very low availability of herring during the fishing season. At Useless inlet in Barkley sound, the eelgrass was brownish and slimy. The eggs failed to adhere to this grass and sifted down into the mud where they probably failed to develop because of lack of oxygen.

In the Alert bay area, north Vancouver island, spawning was heavy as usual. The spawning reports indicate that this area could support a herring fishery if exploitation were economically feasible.

Along the north shore of British Columbia, spawning was light at Smiths inlet, Rivers inlet and Bella Coola, medium in the Bella district, and heavier than usual from the Butedale to the Prince Rupert area. On the Queen Charlotte islands, spawning was of average intensity. As usual, it took place towards the end of June in Masset inlet; this is the latest spawning on record for the province.

An attempt was made during the spring of 1938 to make a quantitative estimate of egg deposition on the Barkley sound spawning grounds with the object of determining the absolute abundance of the spawning population. Unfortunately, spawning was very light and most of the grounds were along exposed shores. On these, the eggs were deposited on a long wiry eelgrass (Phyllospadix) from the low tide level to a depth of 10 feet below low water. This made accurate quantitative sampling impossible with the sampling apparatus that was available. The patches of eelgrass were scattered at irregular intervals over a distance of five miles along the exposed shore. This rendered difficult the task of estimating the area. Similar difficulties were experienced by fishery inspectors at Clayoquot, Nootka and Kyuquot sounds who were assisting in the survey. With the present equipment and resources, there is small hope of determining the absolute size of the spawning runs with any reasonable degree of accuracy from quantitative estimates of egg deposition. Such a procedure may prove feasible elsewhere, e.g., on the south-east coast of Vancouver island, where the spawning grounds are in more or less protected waters and are, for the most part, accessible at low tide.

J.L. Hart and A.L. Tester No. 29

The Insertion and Recovery of Herring Tags.

The programme of herring tagging and recovery begun in 1936 has been continued and expanded. This work, designed to discover the movements of herring, their local population, and the intensity of the fishery, has already yielded interesting results and holds out great promise for the future.

As in the report for last year the tagging phase of the programme may be considered in three divisions. First may be considered the tagging carried out prior to the preparation of summary reports last year and including all tagging carried out on the fishing grounds in the autumn of 1937. It may be summarized as follows:

	1936-37	1937-38
Strait of Juan de Fuca	1,500	1,199
South-east coast Vancouver island	7,090	4,086
Barkley sound	-	2,798
Strait of Georgia	1,898	-
West coast Vancouver island	5,692	-

The second division deals with the spring tagging in 1938. A summary of it in some detail follows:

Mar. 7, 8	2,299	Macoah passage, Barkley sound
Mar. 9	899	Calm creek, Clayoquot sound
Mar. 11	1,293	Queens cove, Esperanza inlet
Mar. 12	995	Plumper harbour, Nootka sound
Mar. 21	1,198	Winter harbour, Quatsino sound
Mar. 25	1,395	Bella Bella, Milbanke sound
Feb. 25	699	Ganges harbour, South-east coast
Mar. 7, 8	791	Horswell point, near Nanaimo
Mar. 15	497	False narrows, SE side
Mar. 16, 17	799	False narrows, NW side
Mar. 23	500	Departure bay, near Nanaimo
Apr. 2, 3	1,196	Union bay, Baynes sound
Apr. 22	797	Birch bay, near Blaine, U.S.A.

The third division consists of tags applied during the current fishing season. The results to date follow:

Oct. 1	1,454	Sooke salmon traps
Oct. 11, 13	1,078	Swanson channel

Barkley sound tagging is in progress and tagging on the northern part of the west coast of Vancouver island is planned for.

During the 1937-38 herring season, 104 tags were recovered by the Galiano detector, 55 by the Ucluelet detector, and 770 from reduction plant magnets. It is not practical to give an account of the magnet returns in summarized form. After careful and impartial examination these returns led to the conclusion that, while free intermingling of populations of herring on the west coast does not take place, there is a certain amount of mixing between areas as widely separated as Kyuquot and Barkley sounds. This mixing would seem to involve about 15 to 20 percent of the fish.

Returns from tagging during the current season have been made from both reduction plant magnets and induction detectors. The results as they have been interpreted to date follow, although some of the recoveries by magnets require confirmation:

Recoveries by Galiano detector from fish taken on south-east coast:

Place released	Date released	No. recovered
Horswell point	Mar. 4, 1937	1
Sooke	Oct. 9, 1937	2
Swanson channel	Nov. 12, 1937	1
Horswell point	Mar. 7, 1938	1
Sooke	Oct. 1, 1938	11
Swanson channel	Oct. 11-13, 1938	13

Recoveries by Ucluelet detector from fish taken off south-east coast:

Sooke	Oct. 1, 1938	1
Swanson channel	Oct. 11-13, 1938	1

Recoveries by magnet at Imperial cannery from fish taken on south-east coast:

Swanson channel	Oct. 6- 8, 1936	1
Swanson channel	Oct. 17-20, 1936	1
Horswell point	Mar. 4, 1937	1
Swanson channel	Oct. 18-23, 1937	1
Horswell point	Mar. 7- 8, 1938	2
Calm creek	Mar. 9, 1938	1
False narrows	Mar. 15, 1938	1
False narrows	Mar. 16-17, 1938	3
Union bay	Apr. 2- 3, 1938	1
Sooke	Oct. 1, 1938	21
Swanson channel	Oct. 11-13, 1938	31

Recoveries by magnet at Kildonan from fish taken on south-east coast:

Swanson channel	Oct. 18-23, 1937	1
Pill point (Barkley sd.)	Nov. 23, Dec. 1-4, 1937	1*
False narrows	Mar. 16-17, 1937	1
Sooke	Oct. 1, 1938	9
Swanson channel	Oct. 11-13, 1938	4

(*to be confirmed)

Recoveries by magnet at Kildonan from fish taken on south-east coast or from Barkley sound fish taken in 1937 and frozen, or from fresh Barkley sound fish.

Calm creek	Mar. 9, 1938	1
Sooke	Oct. 1, 1938	1

Recoveries by magnet at Kildonan from fish taken on south-east coast or from Barkley sound fish taken in 1937 and frozen.

Swanson channel	Oct. 6- 8, 1936	1
Rainy bay	Nov. 18, 25, 1937	1
Sooke	Oct. 1, 1938	3
Swanson channel	Oct. 11-13, 1938	3

Recoveries by magnet at Ucluelet from fish taken on south-east coast:

Tod inlet	Apr. 25, 1937	1
Sooke	Sep. 25, 1937	1
Horswell point	Mar. 7- 8, 1938	1
Calm creek	Mar. 9, 1938	1
False narrows	Mar. 16-17, 1938	2
Sooke	Oct. 1, 1938	26
Swanson channel	Oct. 11-13, 1938	19

Recoveries by magnet at Ucluelet from fish taken in Barkley sound:

Calm creek	Mar. 9, 1938	1

Recovery by chance at the mouth of Fraser river:

Birch bay	Apr. 22, 1938	1

The foregoing results are fairly full for the returns from the fishery off the south-east coast of Vancouver island, but do not really cover any other fishing area. It will be seen that the conclusion drawn for the west coast fishing areas from the results of last year may be extended to the east coast. That is, the herring population on the east coast tends to be a self-contained unit, but it is not exempt from intrusion by fish from other areas.

During the present year it is planned to move the detector unit from the saltery at Galiano island and install it at the Nootka reduction plant. There it will be useful in recovering tags from the more northerly districts. The Ucluelet unit is still giving disappointing results. Efforts are being made to eliminate the difficulties.

The investigation has received help from many sources. Some of those more especially worthy of mention are: The Banfield Packing Company; The Nootka Packing Company (1937); and the Moresby Island Fisheries Company, Ltd., for accommodating equipment. The British Columbia Packers contributed a boat for use on the west coast for the spring tagging; Mr. L. Quickenden and Mr. J.L. McHugh have contributed their help to several phases of the work; and several fishermen have supplied us with fish for tagging. To those and numerous others we are grateful.

A.L. Tester No. 30

Influence of the Tide and Moon on Herring Catches.

An analysis of the herring purse seine catches on the south-east coast of Vancouver island during the 1937-38 season showed that the average catch per seine per day was relatively small during the first, third, fifth and seventh weeks and relatively large during the second, fourth, sixth and eighth weeks of fishing. During the former, average differences between high and low

water were large and the tidal series was passing from springs to neaps, whereas during the latter, average tidal differences were small and the series was passing from neaps to springs. Small average catches and large tidal differences occurred during the full and new phases of the moon; large average catches and small tidal differences occurred during the first and third quarters of the moon. On the average, this same relationship was found to hold over a five-year period - 1933-34 to 1937-38 incl.

By constructing tidal velocity graphs for each day of the 1937-38 season and determining the tidal velocity at the time of each purse seine set it was found that there was no tendency for more sets to be made at the lower speeds of the tide. This shows that the relationship between tide and catches is not due merely to the varying ease of fishing under varying strengths of tidal current. The reaction of herring to different intensities of moonlight has been considered carefully, but has been dismissed as a probable cause of the phenomenon. Tagging returns suggest a possible explanation. During the 1937-38 season relatively more Sooke tags were recovered from Swanson channel fish during the weeks of high availability. This indicates that during these weeks there were substantial influxes of fish from the strait of Juan de Fuca which augmented the supply on the fishing ground. It is suggested that the reason for the relationship lies in the effects of the tide on the movements of herring. Although the fish probably move actively along their migration route, they will also be carried passively forward and backward by tidal movement. Progressive differences between types of tidal fluctuation along the route may induce a bunching of the fish. The problem will be considered further when additional data have been accumulated. For the present, the demonstration of this weekly fluctuation should be both interesting and useful to the industry.

Agnes Gwyn. No. 31

The Development of the Vertebral Column of the Pacific Herring with Relation to the Time of Determination of Vertebral Number.

Vertebral number is a widely used character in racial studies of fishes and it has been rather clearly indicated that the temperature of the water during the developmental period has a definite relation to number of vertebrae formed. The investigation here reported on represents an attempt to discover the time of determination of vertebral number by a detailed study of the embryological development.

From a study of serial sections and alizarin-stained specimens of larvae and post larvae from the strait of Georgia, the development of the vertebral column is traced from the time of hatching over a period of ten weeks. At hatching, myotome formation is complete. Within three weeks, massed precartilage cells in the tail region mark the anlage of the hypurals. In seven weeks, the seven hypurals are formed of hyaline cartilage, the tail is flexed dorsally, and posterior arches of precartilage are present. At the end of the eighth week, the posterior bony ring of the urostyle is laid down and the perichondrium of the hypurals is ossified. In the ninth week the inner bony rings of all centra are formed in the notochordal sheath and in the following week

the outer bony rings are formed in the perichordal sheath. The vertebral number is definitely fixed by the ninth week when general ossification takes place. It is concluded, however, that the ultimate number is already fixed at hatching and that the determination of the number, presumably by environmental factors, takes place during the embryonic period. The critical period of determination may be quite early, within five days after fertilization.

Investigations Dealing with Vertebral Number in Young Herring.

In the herring fishery of the North Sea a considerable degree of success has been attained in predicting the length and age composition of the catches and also the abundance of fish one year in advance. These forecasts are possible because the year classes which eventually form a large percentage of the catch enter the fishery at least a year before they become dominant. In the British Columbia herring fishery advance knowledge of the composition of the schools of mature fish can not be obtained so readily, since the incoming year class always forms a large proportion of the catch.

The value to the fishery of such advance information is of great importance, and the discovery of a reliable method of obtaining it is one of the objects of the herring investigation. It is clear that the solution must be sought in a study of the immature fish. From the time of hatching until the adults enter the commercial fishery almost nothing is known of the habits of these young fish. Isolated schools may be observed at almost any time of the year, but the nature of their movements is still a mystery. If their abundance with respect to the adults can be calculated, and the two can be shown to vary directly, the results will be of great value. A system of tagging may prove successful, since a small number of fish in their second year are always present in the commercial catch. A study of variation in the intensity of spawning or in the amount of mortality at some critical stage in the early life of the fish may be of use in forecasting abundance. Whatever the key to the problem may be, it seems to lie in an understanding of the early life history of the herring.

A start has been made by sampling the populations of young herring in different localities as a basis for the investigation of such differences as might occur and for the comparison of young and adult fish. These collections were commenced in 1932 and the data obtained have formed the basis for three earlier reports submitted by Dr. Hart. He reports the following results and conclusions: (1) Significant differences were shown to occur between young herring from different localities. (2) Significant differences occurred between young fish and adult fish captured commercially in the same general locality and the same year. (3) The proportion of abnormal vertebrae was considerably higher in the young fish than in the adults. (4) The standard deviation was found to be greater in the young fish. These results were taken as strong evidence for the belief that factors regulating vertebral number of a herring population are still active to a limited extent after metamorphosis.

Sampling has been carried on each year since 1932. This was continued in 1938, and examination of all the material collected is being brought up to date. The results are such that it is necessary to revise and supplement the conclusions drawn from the earlier data.

In part, the conclusions of the 1933 report are confirmed by the additional data available. Significant differences can be detected in samples of young herring from different localities. The proportion of abnormal vertebrae still appears to be greater than in the adults, the value of 7.3 percent being even greater than that reported by Hart. However, the value obtained for the standard deviation is considerably lower than that obtained by Hart, and does not differ significantly from that of the adult fish. In comparing the vertebral counts of fish of various lengths within a homogeneous sample there was some evidence of a positive correlation between length of fish and average vertebral count. Similarly, there is some evidence suggesting a relationship between the average length of samples from different localities and their average vertebral numbers.

So far the sampling of young herring (with one exception) has been confined to a relatively small area along the south-eastern coast of Vancouver island. Since this covers only a small portion of the waters exploited by the commercial fishery, it is hoped that in future the investigation may be expanded to embrace a much larger area, including the districts where the major herring fisheries of the province are active. In addition, it is proposed to enlarge the scope of the work to include other phases of the life history, as described in the second paragraph of this report.

Summary of the data used by Hart in summary reports for 1932, 1933, 1934.

Locality	Year	No. fish	Av.vert. count	σ	σ_M	% abnormality
Fulford harbour	1932	344	51.88	0.74	0.04	6.4
Saanich arm	1932	322	51.96	0.72	0.04	2.8
Nootka sound	1932	151	51.70	0.65	0.05	2.0
Departure bay	1932	137	51.68	0.76	0.07	12.4
Nanoose bay	1932	59	51.86	0.92	0.13	15.3
Saanich arm	1933	49	52.04	0.73	0.10	-
Fulford harbour	1933	160	51.97	0.65	0.05	5.0

Summary of additional material examined.

Nanoose bay	1934	225	51.72	0.69	0.05	13.3
Fulford harbour	1935	225	51.78	0.59	0.04	6.6
Fulford harbour	1937	300	51.82	0.65	0.04	13.0
Ladysmith harbour	1937	304	51.90	0.68	0.04	8.2
Ganges harbour	1938	285	51.77	0.65	0.04	5.6
Whaleboat passage	1938	234	51.77	0.64	0.04	8.5
Mill bay	1938	187	51.87	0.68	0.05	2.1
Cowichan bay	1938	101	52.23	0.71	0.07	1.0
Average (weighted to no. of indiv.)				0.68		7.3
Adults (Tester)				0.66		2.3

J.L. McHugh No. 33

The Selectivity of Sampling Methods used in Collecting Young Herring.

In the collection of young herring for examination of racial characters several methods of sampling have been employed. Each method has its own merits and is used under circumstances most suited to the capture of a reasonably large sample of fish. When the fish are found close to the surface, and are not readily frightened, a small dip net has been used. If the fish are close to shore, they may be taken by means of a beach seine, while in the event of the schools being offshore, and out of reach of the nets, it has been the custom to bring them to the surface by means of a charge of dynamite, after which they may readily be collected with the dip net.

It is of great importance that such samples be truly representative of the population from which they are taken. In the annual report of the Commissioner of Fisheries for British Columbia for the year 1916 Dr. W.F. Thompson describes the movements of a school of small herring, stating that the smaller fish formed the upper and the inshore portions of the school, while the larger fish formed the deeper layers. To substantiate this observation, he found that samples taken from different parts of the same school differed in length composition.

Since the samples collected during the years 1932-1938 were taken by any of the three methods described above, it is doubtful if the results are entirely comparable. Material for a comparison between seine-caught fish and those taken with a dip-net was collected at Fulford harbour in 1938. The average length of the seined fish was 42.7 millimetres. Those captured by means of a dip-net averaged 36.9 millimetres in length. The difference was found to be highly significant, thus adding weight to the belief that the smaller fish inhabit the upper layers of the school, and indicating the selective action of dip-net sampling.

The results of this experiment emphasize the necessity for a thorough study of the composition of schools of herring, and of the effectiveness of the various sampling methods. Since it is believed that a better knowledge of the early life-history of the herring will do much to solve some of the problems of the commercial fishery, it is essential that the samples taken be truly representative of the populations they are intended to represent. Plans are being made for the solution of this problem in the spring of 1939.

A.L. Tester and R.V. Boughton No. 34

Plankton Investigations in Relation to the Herring of Klemtu Passage.

During the recent cruise of the "A.P. Knight" into the waters of northern B.C. (Sept., 1938), opportunity was afforded of taking a series of plankton hauls at various stations between Swanson bay and FitzHugh sound, with the object of determining whether there was any relationship between the concentration of plankton and the occurrence of summer herring in Klemtu passage.

Horizontal 10-minute tows were taken at depths of 2 and, in some cases, 10-15 metres, with the boat travelling at a uniform slow speed. Later, after bringing the samples to the same volume, the number of organisms in unit volume of each was determined, using a haemocytometer. The results, summarized

below, are averages based on at least 4 and, in the case of copepods, 10 individual counts from each sample:

Locality	Copepods	Copepod nauplii	Micro-zooplankton	Algae
Swanson b.	11.0	1.8	0.8	7.8
Tolmie ch.	11.3	1.6	2.0	4.8
Klemtu pass.	24.2	4.1	6.2	7.6
Seaforth ch.	1.8	0.0	1.0	0.2
Lama pass.	3.2	1.2	77.5	11.3
FitzHugh sd.	5.3	1.6	17.2	12.7

Copepods and copepod nauplii were particularly abundant in Klemtu passage, somewhat less abundant at Swanson bay and Tolmie channel to the north, and relatively scarce at Seaforth channel, Lama passage and FitzHugh sound to the south. On the other hand, microzooplankton and algae were relatively scarce in Klemtu passage and the northern areas, and relatively abundant in the two most southern areas. The most abundant copepod was Acartia, an important food of the herring. Among the microzooplankton, the dinoflagellate Ceratium fusus was particularly abundant at Lama passage. Neither microzooplankton nor algae form an important food of herring of the size which usually frequent Klemtu passage. There was no significant difference between the concentration of organisms at depths of 2 and 10-15 metres, indicating thorough mixing by the tidal current.

The above distribution of copepods corresponds with the known occurrence of summer herring. Large quantities of immature and mature fish are taken from Klemtu passage and smaller quantities are occasionally taken from the more northern areas. On the other hand, herring are not fished and presumably do not occur in either Seaforth channel, Lama passage or FitzHugh sound during the summer. The following evidence is strongly suggestive that Klemtu passage is an habitual summer feeding ground of herring: (1) local fishermen report that herring are always present during the summer; (2) individual sets from this locality usually yield small catches, indicating that the fish are scattered - a characteristic of feeding herring; (3) food was present in the stomachs of fish sampled during the summer of 1936; (4) plankton hauls taken during Sept., 1938, when young herring were visible at the surface, show a concentration of copepods of a genus which forms an important food of young and immature fish.

It is recommended that efforts be made to take additional plankton hauls at different times of the year, and, at the same time, to collect physical and chemical data from water samples. These data will provide a check on the present results and they may enable the reasons for the observed distribution of organisms to be determined.

J.L. Hart, A.L. Tester, D. Beall, and J.P. Tully. No. 35

Proximate Analysis of Herring in Relation to Season and Condition Factor.

In the study of condition in herring the chemical analyses of the various samples have been completed, the calculations of condition factors for all samples to be treated are done, and the results have been organized in a paper. Certain points await confirmation before submitting the paper for publication. The abstract follows as a summary.

Samples of Clupea pallasii from various British Columbia localities and several seasons of the year were analysed by standard methods for water, oil, protein, and ash. They showed herring to be variable in percentage composition, especially in regard to water and oil. The limits were: water, 64.2-80.2%; oil, 4.0-19.4%; protein, 10.1-16.8%; ash, 1.9-2.8%. Oil content is highest in summer, declines during the fall and winter, and falls to a minimum after spawning time in early spring. There is an accompanying decline in the weight of the fish. Herring are highly variable in calorific value (2.41-0.94 C per gram). In general they are among the more nutritive fish. There is less percentage of waste in fat fish. Potential oil yields on reduction as high as 30 gallons per ton are indicated, with a minimum of 7 gallons per ton. Average condition factors for samples were determined by averaging the individual condition factors obtained from

$$K = \frac{1{,}000{,}000\ W}{L^{3.2637}}$$

when K is the condition factor, W is the weight in grams, L is the length in millimetres and 3.2637 is the exponent in the empirically fitted equation $W = cL^x$. This condition factor was found to be positively correlated with oil content and to follow in general the same seasonal trend. Random errors are so great that forecasts of oil production from determination of weight and length can be of little practical value.

A.L. Tester No. 36

Investigation of the Specific Gravity of Herring.

Studies of the condition of herring indicate the need for a condition factor which is independent of the length-weight relationship. The factor $K = W/L^3$ seems artificial and the factor $C = W/L^n$, where n is the slope of the straight line between the logarithms of length and weight, is unwieldy, and is also inaccurate if n varies significantly between samples. These condition factors are intended to describe the general well-being of a fish. If "well-being" is considered to be related to fatness, as seems reasonable, some factor which varies with fatness or oil content would be an ideal measure of condition. It might be expected that a fat, oily fish would have a low specific gravity and a lean, thin fish a high specific gravity (after death). This factor seemed worthy of investigation.

Two methods of determining specific gravity were tried. In the first a copper cylinder with a siphon outlet near the top was used as an "Archimedes" apparatus. This cylinder was filled with fresh water and allowed to drain to

constant volume. After making an incision in the body wall to allow air in the swim bladder and body cavity to escape, each fish was placed in the cylinder and the water displaced was collected and measured with a glass graduate. Specific gravity was taken as volume of water displaced divided by weight in air. In the second method the fish was weighed in air and then in water by means of a beam balance reading to 0.01 g. Specific gravity was taken as weight in air (W_a) divided by weight in air minus weight in water ($W_a - W_w$). In practice, however, a fat-condition factor (f) was calculated which may be defined as follows: $f = 10000\ W_w/W_a$. This varies with specific gravity but is easier to calculate.

The first method was found to give unsatisfactory results. It was very difficult to obtain even approximately constant volume displacement in several trials with the same fish. The second method proved to be more satisfactory. The average f for a sample of 48 fish (Nov. 9/38, Swanson ch.) amounted to 370. In attempting to get constant results (W_w) for the same fish, it was found to be very important to open the mouth, opercular flap and body cavity while the fish was under water to allow free air to escape. With improved technique, a second sample of 36 fish (Nov. 11/38, Swanson ch.) gave an average f value of 432. It is believed that this latter value describes the average f factor of the fish which were sampled with a reasonable degree of accuracy.

Indirect evidence that the f factor varies inversely with the condition (fat content) of the fish is contained in the following table, which gives the average f for fish which are above and below average weight for their length:

	Above	Below	D/S.E. D	No.
Nov. 9/38	362	404	2.1	26
Nov. 11/38	414	462	2.9	25

As might be expected, fish above average weight have a significantly lower average f value (and specific gravity) than those below average weight; the former are considered to be in better condition than the latter, and presumably are fatter. So far, no significant change in f with increase in either length or weight has been detected.

Specific gravity seems to offer definite possibilities as a measure of condition. It is suggested that further determinations be made in an effort to detect seasonal trends in fat content. If these are found it is recommended that the results be checked by chemical analysis. The method may have commercial applications. For example, it may be possible for reduction plant operators to use a modification of the present procedure to determine what oil yield may be expected from a catch of fish.

J.L. Hart No. 37

Survey of the Ling Cod Problem.

The central problem in regard to ling cod is to find out the facts in the life history of the species which are applicable to drawing up the most advantageous method of organizing and regulating the fishery.

From fishery statistics, examination of the fishery, and previous research, the following are known: (1) The total catches from 1927 on. (2) Fishing methods. (3) Certain features of the general life history, including the spawning habits and incubation, general movements of the adults, and a very sketchy account of the larval and juvenile stages. (4) The number of eggs per female; this information, while presented in Wilby's published account, is inadequately supported at present. Since it may prove important in administering the fishery this subject should be more completely worked up. (5) The food of the adults is rather well known. Obviously, there are many gaps in our knowledge. Those considered as most calling for study are listed as follows: (1) Where (possibly at what seasons) catches are made and in what quantities. (2) The absolute size of the populations on different banks. Without both of (1) and (2) no information is possible concerning the intensity of the fishery. (3) Rate of growth. (4) Egg production. (5) Nature and extent of migrations. (6) Life history of larval and juvenile stages - causes and extent of mortality, rate of growth, food, movements, interrelations with other species.

The collection of complete statistics of the catch is a very important part of the investigation. However, the collection of statistics is at present undertaken by the Department of Fisheries and further collection by the Board would constitute a duplication of effort and a duplication of nuisance to the industry. It is urged, accordingly, that for this species at least the Department organize its collection of statistics in such a way as to have the data of some biological value. That is not now the case and it will not be easy of achievement, but the results to be expected justify the effort being made.

The most important method on approaching the ling cod problem appears to be the use of tags. A well-designed tagging-recovery programme is capable of giving the following information: the nature, extent, and speed of migration in fish of different sizes and in relation to season of the year; the intensity of the fishery (if A tags are applied, of which a are lost and B are recovered, the intensity of the fishery may be expressed as B/A - a); the absolute size of each population (if C is the total catch, the population is CB/A - a); the total mortality of the species (if in year 3 the total number of tags recovered from a certain tagging is 60% of the number recovered in the year 2, the total annual mortality is 40%); the natural mortality (total mortality less fishing mortality expressed as percentages); and the rate of growth in general terms. This important part of the investigation will depend upon two things: (1) consistency, (2) the certainty of tags being returned. With this in mind two items of policy may be laid down here: (1) it is advisable to take considerable time in developing a tag and a tagging method which will be useful throughout the course of an extensive investigation and then stick to the method adopted in spite of the possibility of introducing minor improvements; (2) the reward paid for the return of tags should be adequate to assure that the tags are returned and with complete and accurate information. It might be pointed out that after some experimentation on living and dead ling cod a tag has been fixed upon - a monel metal strap tag ducoed red.

Mr. Wilby found it impossible to determine ages of ling cod by scale examination. In this finding I concurred. It is suggested that it is sufficiently important to get accurate information on growth rate to warrant further efforts along the lines of: (1) examining scales under polarized light; (2) silver nitrate impregnation of scales; and (3) otolith examinations. Some attempts with indifferent success have been made to examine otoliths cleared with xylol. It is proposed to try other clearing agents.

The life history will be studied by the traditional methods adapted to suit immediate conditions. Some of the more interesting phases of the life history will be difficult or almost impossible to elucidate, but some trial appears warranted. Studies of egg production should be straight-forward; they should, however, be supplemented by an investigation of the relative success of incubation in egg masses of different sizes.

It should be pointed out that dependable results from a programme such as the one proposed cannot be expected within five or six years.

COWICHAN RIVER.

Cowichan Lake Hatchery

The operation of the hatchery has been continued this year as part of the general programme outlined for the Cowichan river investigation. Early in the season the capacity of the establishment was increased by the construction of six additional rearing ponds making it possible to retain from 150,000 to 250,000 fingerlings, the number depending upon the size of the fish. The auxiliary water system installed in the fall of 1937 was used for the first time permitting the operation of all the ponds throughout the dry season.

Egg collections.

On January 1, 1938, the hatchery contained the following eggs collected during the previous fall:

Spring salmon	70,000
Coho "	141,000
Brown trout	20,000

During January, February and March the following numbers of eggs were collected and held for incubation.

Steelhead trout	64,000
Cut-throat "	15,000

On June 17 a further lot of 60,000 eggs of Kamloops trout from Lloyds creek were received through the courtesy of the Provincial Game Commission. The fry obtained from the incubation and hatching of these various lots of eggs were retained and transferred to rearing ponds except 57,000 Coho which were released in Haslam creek on May 19.

During the month of November 64,000 eggs of Spring salmon have been collected and the collection of a similar number of eggs of Coho has been commenced.

Occurrence of disease.

Several diseases made their appearance among the hatchery stock during the warmer periods of the season with the result that severe losses were suffered in most lots of fish. Total losses in excess of 80 percent occurred in the case of Steelhead and Brown trout and a mortality of over 90 percent was experienced by the Kamloops. Losses in Coho and Spring salmon fingerlings were over 56 percent and 61 percent respectively. A more detailed account of the disease condition is given in another report.

Liberations and stock on hand

The number of fish reared, marked and released this season is as follows:

Species	Stage	Number	Place	Mark
Spring	Fingerlings	25,276	River	Adipose, right ventral
Coho	Fingerlings	26,200	"	" left "
	Fry	57,000	Haslam cr.	Unmarked
Kamloops	Yearlings	40,783	River	Adipose, left ventral
Cut-throat	Yearlings	7,349	Lake	" right "

The following fish are still retained, to be released in the spring.

Brown	Fingerlings	4,200
Cut-throat	"	3,500
Steelhead	"	7,000
Kamloops	"	1,500

Diet and food costs.

During the first part of the season the fish were fed a diet made up as follows:- Liver (wet weight) 20 parts, dry ingredients (equal parts of skimmed milk powder, pilchard meal, cottonseed meal) 60 parts, water 20 parts. Later in the season, as a disease resisting measure, the meat content was increased by the addition of ground beef heart in the following proportion:- Liver - 35 parts, heart - 35 parts, dry ingredients - 20 parts, water - 10 parts.

The total cost of food including delivery charges, for the period January 1 to October 31, 1938, was $ 334.79. The approximate cost of food per fish reared this season and liberated to date is as follows:-

Spring salmon	(25,278)	$ .0035
Coho "	(26,200)	$ .0041

Diesel operation

Commencing on June 1 and continuing until October 24 the hatchery supply was augmented by water drawn from the river by the newly installed pump and Diesel engine. The pumping plant operated without interruption except for short periods at irregular intervals when it was stopped for repairs. The cost of operation of engine and pump over the period of 138 days was as follows:-

Fuel oil	$ 82.15
Lubricating oil	53.41
Repairs (excluding labour)	8.90
Total	$ 144.46

This gives an average daily running cost of $ 1.05

Water temperatures

The increased water supply makes it possible to operate all twelve ponds throughout the season when the gravity water is insufficient but at temperatures appreciably higher than formerly since river temperatures in summer are normally several degrees above those of the supply stream. During the past season the maximum weekly temperatures of the river and of the mixture of the river and gravity supply in the retaining ponds were as follows:

Week ending	River	Ponds	Week ending	River	Ponds
June 4	18.0°C.	12.2°C.	Aug. 6	22.3°C.	20.2°C.
" 11	18.9	14.0	" 13	21.4	19.2
" 18	17.8	15.0	" 20	21.8	20.5
" 25	18.7	18.8	" 27	21.0	19.5
July 2	20.9	19.7	Sept. 3	20.2	19.5
" 9	20.5	19.1	" 10	20.4	19.4
" 16	20.8	21.0	" 17	20.0	19.8
" 23	23.3	22.5	" 24	19.2	18.2
" 30	23.4	20.5	" 31	18.2	16.8

Although the higher temperatures of the rearing pond water may be desirable from the point of view of increased rate of growth it is possible that it also produces more favourable conditions for disease. The continued use of river water in the hatchery ponds may necessitate the adoption of special disease preventative measures during coming seasons.

Spawning Run of Steelhead Trout

Steelhead trout occasionally appear in the Cowichan river in the month of December but the greatest run usually occurs in January and February and a few stragglers appear as late as April and May. During the 1938 spawning migration a total of 105 fish was taken by gill-netting at intervals near the Hatchery from January to April. Of these, 38 were females yielding a total of 64,000 eggs. The average yield per fish was between 2,000 and 3,000 eggs, the maximum being 4,840 eggs. The average weight of both males and females was between 6 and 8 pounds; one male fish weighed 16 pounds. Length measurements and scale samples were taken for future reference.

Aluminium strap tags were attached to 58 fish before release. One fish tagged on January 13 and released in the Hatchery pool was taken 2 days later in the trap at Beadnell Creek which enters the river 300 yards downstream. A second trout tagged and released at the Hatchery was taken by gill net on April 2nd in Diespecker pool, two miles downstream. No other returns have been obtained to date. Since the strap type of tag seems to prevent normal healing of the wound it is planned to make use of the button type of tag during the coming season.

Spawning Run of Cut-throat Trout

Little progress has been made in determining the time and place of spawning of Cut-throat trout in the Cowichan river system. The results of the operation of traps and nets in several likely places during the season of 1937-38 seemed to show that the breeding period of the Cut-throat is not restricted to the spring months as formerly supposed. A pair in spawning colours was taken in Oliver creek trap as early as November 21, 1937, while a recently spawned female was taken by gill net in Bear lake as late as April 20, 1938. It would seem that river fish spawn in tributary streams but that lake fish spawn on or near gravel bars off the mouths of rivers.

During the season a total of 128 fish was taken of which 14 females yielded 20,000 eggs. The fish varied in weight from 3/4 pound to 10 pounds, the average of fish taken in the river being about 1 1/2 pounds and of fish taken in the lake about 3 1/2 pounds. Forty trout were tagged to obtain information regarding their movements and rate of growth. One female released at the mouth of Sutton creek on January 18, 1938 was retaken by gill net in Bear lake on March 11, 1938. Only a slight development of the eggs had taken place in the interval. No other records of the capture of tagged fish have been obtained as yet.

G.C. Carl No. 41

Spawning Run of Spring Salmon

According to angling records Spring salmon did not appear in numbers in Cowichan Bay until the middle of August, 1938, when many good catches were made. During September salmon were seen collecting in the deep pools in the lower reaches of the river but due to the abnormally low level of the water apparently none passed upstream except the small Jack springsuntil heavy rains occurred on October 11 and 12. At this time the river level rose 4 3/4 inches and a large run of both Springs and Coho took place, particularly on October 13 and 14. During the run 20 Indians spearing along the Quamichan Reserve area were able to take an average of 35 fish apiece. On October 16 the migrating fish reached Skutz falls about 18 miles upstream where they were able to pass up the main channel at the rate of 90 fish per hour. Springs made up 65 percent of the run at this time; the remainder were Coho salmon. A fresh run of fish occurred on October 28 with a southeast wind blowing into the mouth of the river and by November 2 when the river had risen 2 feet rendering the Falls impassable, salmon were passing up the ladder and improved fishway at the rate of 1148 per hour. At this time only 10 percent of the run was made up of Springs. On the following day the number of fish ascending the falls had dropped to 430 per hour and on the 6th, 50 per hour of which 25 percent were Springs.

Gill net operations commenced at the hatchery on November 1, yielded very few fish at the start, 10 only being taken in the first week and of these 2 only were females. After a slight rise in the river level in the second week, netting operations were more successful and at the time of writing 52 fish have been taken of which 21 were females yielding 64,000 eggs, the average yield per fish being 3,000 eggs. The male salmon varied in weight from 8 1/2 to 42 pounds (av. 18 1/2) and the females, stripped of eggs, ranged from 11 to 17 pounds (av. 14 1/2). Measurements of length and samples of scales were taken for future study.

G.C. Carl No. 42

Spawning Run of Coho Salmon

The Coho salmon occur in the Cowichan river system in numbers probably exceeding any other species of game fish. This salmon usually appears in Cowichan Bay near the mouth of the river during September and October and starts to run up the river towards the end of the latter month.

During the season of 1937 - 38 the first Coho were seen in the upper reaches of the river on October 13th and the first fish were taken at the spawning fence in Oliver Creek on November 9th. Fish continued to appear in the traps situated on both Oliver and Beadnell creeks thereafter until January 28th after which none was seen until March 20th when a single male of the "Jack" type was taken. The total number of Coho salmon taken in the two traps was 1,164 in the ratio of 736 males to 428 females. The males ranged in weight from 5 to 14 pounds, the average being 9 pounds while the females - stripped of their eggs varied from 4 to 8 1/2 pounds, averaging 6 pounds in weight. A total of 146,000 eggs was taken from 74 females, the average yield per fish being about 2,000 eggs. The results of this census indicate that the small tributaries of the Cowichan river are heavily over-seeded with Coho salmon eggs.

G.C. Carl No. 43

Methods in Egg Collection

Since heavy losses have been experienced in former years during the early incubation period of both Spring and Coho salmon eggs an attempt is being made to determine the efficiency of various methods of collecting and handling eggs of these species. During the past season tests were made of the efficiency of taking eggs by hand stripping as compared with the incision method and of transporting eggs hardened in water as compared with carrying "green" eggs in milt ("dry method"). Tests were also made of the degree of fertility or virility of both males and females, and of the presence of material from broken eggs.

At the time of writing the results indicate that:

1) eggs taken by hand stripping suffered no ill effects provided care was taken to exclude water, blood and broken eggs.
2) there appeared to be no significant difference in the viability of eggs carried in water as compared with those carried in milt.
3) none of the male fish tested appeared to be lacking in virility.
4) females seemed to vary considerably in the quality of eggs produced.
5) when abnormal eggs or eggs with fragile shells were obtained losses were high.
6) when material from broken eggs was added to freshly spawned eggs before the addition of milt, losses ranged from 90 to 100 percent.
7) eggs washed in supertonic salt solution after the addition of broken egg material and before the addition of milt suffered losses considerably less than eggs from the same lot untreated with saline solution.

Further experiments of this nature are planned for the present season.

G.C. Carl No. 44

Cowichan Bay Sport Fish Census

To obtain information regarding the catch of sport fish in Cowichan Bay each season and its relation to the fish production of the Cowichan river and of the Hatchery, a system of recording anglers' catches has been inaugurated. Mimeographed forms providing space for data such as species, length and weights of fish caught, number of lines and number of hours fishing have been supplied to boat-renting establishments and posters announcing the purpose of the investigation have been placed at strategic points.

At the time of writing the fishing season is still in progress but the results indicate that the catch records will be far from complete since some of the establishments have failed to collect data regularly and in addition unrecorded catches of considerable size have been made from privately owned boats. Nevertheless, the forms on hand contain records of the capture of 140 Spring salmon ranging from 5 to 44 pounds in weight (average 17 1/2 pounds) and of 150 Coho salmon varying from 2 1/2 to 22 1/2 pounds in weight (average 10 1/2 pounds). A few grilse and fish of unidentified species are also recorded. More accurate records may be collected during the next season if the cooperation of all the boat-renters and private fishermen be obtained.

G.C. Carl

No. 45

Occurrence of Fish Diseases at Cowichan Lake Hatchery

Commencing about the first week in July of this season the daily losses in fry and fingerlings held in the out-door retaining tanks began to show increases beyond the normal expectations but no definite signs of disease nor other abnormal conditions were apparent. Some of the sick and dying fish appeared to be in a bloated condition and shortly after death lesions were observed in the body wall. Although the mortalities continued to increase in an alarming manner no relief was given by salt bath treatments. Coho salmon which were in tanks receiving water from those containing the afflicted Springs also began to suffer severe losses and many of the dying fish showed definite blue patches on the side of the body. From dead specimens sent on ice at this time (July 25) Dr. Duff obtained no evidence of infection by a recognizable disease but living specimens of both Coho and Spring salmon examined later at the Hatchery (Aug. 2) by him showed all the symptoms of Furunculosis and from cultures taken, B. salmonicida was isolated and identified. In the case of the Steelhead and other trout positive evidence of disease was not obtained but later the typical lesions began to appear in them also.

The following table of weekly percentage losses for the various species indicates the time of appearance of disease and the extent of mortality. Water temperature at the time varied between 16 and 22 C. with the maximum readings during the third week in July.

Percentage Weekly Loss - Cowichan Lake Hatchery

Week ending	Springs (60,000)	Coho (60,000)	Steelhead (60,000)	Kamloops (60,000)	Brown (15,000)	Cutthroat (15,000)
June 4	0.47%	0.43%	2.2%	no fish	12.1%	1.3%
" 11	0.25	0.38	1.8	" "	10.9	0.8
" 18	0.27	0.27	2.7	" "	11.2	1.6
" 25	0.26	0.23	3.4	2.7	8.9	6.9
July 2	1.1	0.53	14.3	4.2	35.4	29.1
" 9	3.1	0.63	12.5	23.6	11.3	21.4
" 16	4.3	1.8	10.2	22.6	2.7	8.7
" 23	22.8	10.5	12.2	20.1	1.5	8.5
" 30	10.8	16.8	12.2	9.7	1.2	3.0
Aug. 6	19.0	12.0	11.8	8.7	1.9	3.3
" 13	24.2	5.5	3.6	6.8	1.7	2.0
" 20	5.6	3.2	43.1	4.3	6.9	28.9
" 27	2.6	1.8	35.3	2.8	19.2	15.9
Sept. 3	2.3	1.3	13.7	21.1	4.4	0.9
" 10	1.3	0.7	7.6	12.0	0.3	0.1
" 17	1.9	0.5	1.3	0.3	0.1	0.1

Disregarding the trout losses for the present, it will be seen that the Spring salmon appeared to be infected first, with the disease reaching epidemic proportions from the second week in July to the end of August. Although the concentration of the fish was reduced by heavy losses and release of apparently healthy fish, mortalities still remained severe. The Coho salmon which received water from the Spring salmon ponds did not suffer heavy losses until about the 15th of July when the epidemic was at its greatest in the upper ponds.

G.C. Carl

No. 45

With regard to the trout, the losses during the early part of the season did not seem to be caused by the same disease as no outward evidence of infection was observed. Although examinations of dead specimens by Dr. Duff failed to disclose any causative organism, the fish seemed to be suffering from a gill congestion which produced heavy losses. The mortalities, however, showed a definite decrease about the time of the Furunculosis epidemic in the salmon fingerlings. During the week ending August 20 losses were again very high in tanks containing Steelhead, Cut-throat and Brown trout and high mortalities extended to the Kamloops tank two weeks later. The deaths during this period appeared to be caused by a heavy infestation of the ciliated protozoan Ichthyophthirius which was easily detected by the naked eye. Treatments with solutions of copper sulphate or of common salt seemed to have little effect in checking the disease.

In addition to Furunculosis and Ichthiophthirius most fish of all species retained in the hatchery ponds are heavily infected with an encysted stage of an unidentified parasitic worm which produces black lumps under the skin and on the fins. Moreover, some fish appear to be infected with internal parasites since individuals are sometimes seen with open wounds leading from the abdominal cavity from which may project a flatworm. No fish are entirely free from some parasitic organism.

Recommendations

Since it is likely that all these parasitic organisms have been introduced through the water system it seems necessary that steps be taken to disinfect the water before it enters the hatchery. This may be accomplished by the addition of a chlorinating and de-chlorinating system or of a filtering device to the present water system so as to destroy or remove all disease producing organisms. If a non-bacteria-proof filter be installed it may be necessary to attempt to render the fish stock immune to bacterial infection by some method of vaccination.

G.C. Carl

No. 46

Limnology of Cowichan Lake and River

The limnological phase of the Cowichan river investigation is being carried on by continuing the programme commenced last season of taking a series of temperature readings, water and plankton samples at intervals during the year. The data collected this past season indicate that a) a minimum surface temperature of 5.0 C. was reached on February 14, 1938, b) a maximum surface temperature of 21.6 C. was attained on July 24, c) the bottom temperature (35 metres) rose from 4.9 to 7.8 C. between these dates, d) a thermocline, formed between the 12 and 15 metre level about June 19 gradually dropped to the 20 metre level and apparently disappeared near the end of October, e) a minimum constant of dissolved oxygen (67 °/o saturation at 35 metres) obtained on June 19 and f) the plankton population remained small throughout the year.

Temperature readings of the river and of several stations in the outlet arm of the lake seem to point to the fact that river temperatures are affected to a measurable degree by wind direction since the temperature of the river is raised by westerly winds blowing toward the lake outlet. The effect of these river-lake temperature conditions upon the movement of fish in and out of the lake has not yet been determined.

G.C. Carl No. 47

Meade Creek Survey

Most of the streams entering Cowichan lake vary greatly in the volume of water which they deliver with the result that flood conditions often exist during the rainy season and are followed by low water periods when parts of the stream bed may be completely dry. Since the extent of the effect of these extreme conditions upon the fish life in the tributaries is unknown, information regarding the biology of these streams is very desirable.

During the summer months of 1938 a study of conditions in Meade creek flowing into the North Arm of Cowichan lake was voluntarily undertaken by Miss Ottilie Boyd to determine the rate of drying and its effect upon the life in the stream. When first examined on May 14 the stream was flowing throughout its length but by June 1 the flow was reduced to about half its former volume in the lower reaches and on June 20 the water no longer flowed directly into the lake but disappeared into the gravel at a point about 2/3 mile from the mouth leaving a series of isolated pools and stretches of running water each of which gradually began to shrink in size. By July 1, about one mile of stream bed was dry except for a few protected pools and by Sept. 8 (last day examined) the bed was exposed for its greatest length for the season, i.e. about 2 miles. At this time a considerable flow of water existed in the upper reaches of the stream but on emerging from a rocky canyon it seemed to disappear into the gravel possibly finding its way to the lake by subterranean channels.

At the beginning of the season a considerable number of aquatic insects including nymphs of mayflies, stoneflies and larvae of blackflies, craneflies and midges were found throughout the portion of the stream examined. Coho fingerlings were also fairly numerous but no trout were seen. When the stream had ceased to flow in the lower portion the same organisms were found stranded in isolated pools, except blackfly larvae and nymphs of certain species of mayflies and stoneflies which are capable of living only in flowing water. In most instances the pools became dry causing the death of the trapped animals but in a few cases where the pools were of considerable size and appeared to receive water from an underground source some of the organisms survived until the end of the summer and no doubt existed until water conditions returned to normal. Tests made at intervals in one pool which persisted throughout the dry season showed that the amount of dissolved oxygen did not drop below 3.77 cc. per litre (64.5 % saturation) and that the temperature varied between 7.9°C. and 13.7°C.

From this study it would seem that the drying of the tributary toward the mouth is due mainly to the lowering of the water table allowing the stream to flow for part of its length beneath the gravel bed. Except for those organisms trapped in permanent pools, a considerable number are killed each season. The regular drying of the stream may prevent the establishment of bottom organisms such as molluscs and amphipods which appear to be lacking. Fishes destroyed by the drying of tributary streams are mainly Coho salmon fingerlings.

C. Idyll No. 48

The Foods of the Trouts of the Cowichan River System

The study of the food of the trouts of the Cowichan river system, which was begun in the spring of 1937, was continued this year.

During 1937, collections were made of the stomachs of the three species of trout in the Cowichan system. These included 93 Rainbow trout (Salmo gairdneri), 56 Cutthroat trout (S. clarkii), and 54 Brown trout (S. trutta).

Analysis of the stomach contents showed the food to consist of insects and fish, with some other invertebrates, notably molluscs. The relative amounts of these three groups taken vary to a greater or lesser degree, according to their availability. Also, these amounts and their predominating forms vary with the species of trout.

For Rainbow trout, insects (chiefly Trichoptera and Simuliidae) constituted the most important food item, while fishes were relatively insignificant (10%). Rainbows caught in the lake had eaten slightly more fish than those caught in the river, the difference being due chiefly to the diet of sticklebacks. There was no significant change in the food from a size of 5 1/2 inches up to 20 inches.

For cutthroat trout, fishes were the most important food item, occurring in 70 percent of the stomachs. There was a definite and steady increase in the number of fish eaten with increase in size of the trout.

For brown trout, fish and invertebrates occurred in about equal proportions in the diet.

In order to compare the fish-eating tendencies of these three species, the data are restricted to river fish between the lengths of 10 and 19 inches. Of 36 rainbows in this category, two or 5.5 percent had eaten fish. Of 15 cutthroats, 9 or 60 percent had eaten fish. Of 39 brown trout, 23 or 59 percent had eaten fish.

The following table presents all the data in regard to fishes eaten:

	Rainbow		Cutthroat		Brown
	river	lake	river	lake	river
Trout					1
Coho			3		1
Kokanee		1		3	1
Salmonidae (unidentified)	3	1	13	18	30
Stickleback		23	15	76	16
Sculpin		1		2	3
Unidentified	2	3	6	12	5

It is suspected that the majority of the river Salmonidae unidentified were coho salmon.

As part of the general investigation of the foods of the trout of the Cowichan river system a study of the productivity of the invertebrates of the Cowichan river was begun in the summer of 1938. Qualitative bottom samples from representative portions of the river bottom were taken for a comparison of the productivity of pools, riffles, etc. Examination of the data has not proceeded far enough to warrant presentation of any conclusions.

FISH DISEASES.

Immunity Experiments

(1) Goldfish:- Previously reported experiments have been repeated, using a total of 48 goldfish. These experiments differ from the former ones only in the nature of the vaccine used. This time, the vaccine consisted of a chloroform-killed strain of a smooth culture of B. salmonicida, belonging to the serological group S=R+n (Duff, Journal of Bacteriology, 36, 57, 1938 The vaccine heretofore used had been a Rough culture of the group R=S+n. After six bi-weekly parenteral inoculations, the fish were left for 2 weeks. They were then, together with controls, inoculated with 3 times the normal lethal dose of a virulent S strain of B. salmonicida. The result of a typical experiment may be stated as follows: Of 6 vaccinated and 6 unvaccinated fish, all inoculated with B. salmonicida, 1 vaccinated fish and 5 unvaccinated fish died of specific furunculosis. Four such experiments were carried out, resulting on the average in a 25% mortality amongst vaccinated goldfish and in a 79% mortality amongst the controls. The results therefore indicate highly significant amount of protection throughvaccination by the parenteral method.

(2) Cutthroat Trout:- Vaccination by mouth had been started, with some 2000 cutthroat trout fry, on August 9, 1937. The vaccine consisted of a chloroform-killed Rough strain (R=S+n) of the same type which in 1936 and 1937 had given results with goldfish. The vaccine was provided in concentrated suspension, and was thoroughly incorporated in the food given to the fish. This method of administration was continued twice weekly until April 30, 1938. In May, 400 vaccinated and 400 unvaccinated controls were placed in a tank. Toward the end of May, attempts were commenced to produce B. salmonicida infection in this tank (No. 6). Two methods were used: (a) continuously dosing the incoming water with virulent B. salmonicida from an automatic dropper, (b) the inoculation of several unvaccinated fish with a heavy inoculum of the organism, with a view to having these fish develop the disease and consequently discharge the bacillus into the water. Unfortunately the water temperature remained below 14° C. during all of June and the first 10 days of July. As a consequence, even the unvaccinated controls failed to develop symptoms of furunculosis, and no results were forthcoming.

It was then decided to give direct inoculations of B. salmonicida to 50 vaccinated and 50 control trout. This was done about July 20, when temperatures had risen to 16° to 18° C. Again by the end of the month, temperatures had dropped back to 15° and 16° C., remaining usually well below 15 throughout August. As a consequence deaths were just commencing in this group when the temperature began to drop. The few results obtained are not significant one way or the other.

These fiascos indicated the complete dependence of this type of experiment on temperature conditions, since in many cases even heavily inoculated susceptible fish failed to show symptoms of any description. As a result, a water-heater has been designed and made, so as to supply water at temperatures up to 22° C. to small troughs for small-scale experiments. This installation should render the hatchery independent of weather conditions so far as the present type of experiments are concerned, and it is expected that the questions in hand will be cleared up expeditiously by its aid. The installation is still in the experimental stage, but is expected to be in operation by the middle of December.

(3) Serological Investigations:- During the Spring and Summer months work was continued on the serological analysis of various strains of B. salmonicida.

This type of investigation is considered necessary, since the antigenic constitution of strains is reflected in their ability to produce immunity when used as vaccines. In each of 14 strains, reciprocal absorptions showed antigenic composition of the form R=S+n. In 5 other strains, S=R+n. With all 19 strains, the G phase appeared to possess some antigen common to both R and S together with some specific G antigen. Antigenic variation among several S strains could not be correlated with virulence. Sixteen culturally true single-cell S strains were pathogenic for goldfish, but possessed varying virulence, 3 strains were non-pathogenic. No R or G phase ever produced disease.

Recommendations.

To a great extent the experiments at Stanley Park are now being made independent of temperature conditions. This will undoubtedly expedite the answers to all the problems under consideration. It is however, impossible for the investigator or his assistant to give much time to this work throughout the winter, although a special effort is being made to get results with the immunity work before early spring. Most of the work on the acriflavine experiments and on susceptibility of Kamloops and Steelhead trout will therefore, have to wait until the spring and summer. Providing favourable results are obtained from the immunity work, duplication should of course, be attempted next summer also. There seems to be a very good chance that the investigations may be successfully concluded during the fall and winter of 1939. I, therefore, recommend the continuation of the investigation.

Experiments on Efficacy of Acriflavine

In September 1937, thirty adult cutthroat trout were brought from Smith Falls hatchery at Cultus Lake, and were lodged in a tank at the Stanley Park hatchery. On February 1, 1938, an equal number of the same species were also brought down and placed in another tank. The object was to infect these fish with B. salmonicida, to obtain their eggs, and to treat half of these eggs with acriflavine. The progeny from the eggs were then to be held for as long a period as necessary to demonstrate two points (1) can infection be transferred by or through the egg to the next generation, (2) is acriflavine an effective treatment for the prevention of such transfer of infection?

On February 13 all these trout were inoculated parenterally with a lethal dose (calculated on body-weight) of B. salmonicida. The low temperature of the water (2° - 4°C.) was relied on to prevent the development of symptoms.

Both batches of trout ripened satisfactorily under the conditions provided. It is interesting to note that a somewhat greater yield of eggs was obtained from those trout which had been longest at the Stanley Park hatchery. Spawning took place during the period April 30 to May 3. All trout were sacrificed, autopsied and cultured after spawning. Of 55 trout autopsied, 21 showed the presence of B. salmonicida in kidney and heart blood, showing that approximately one-half the parents were definitely infected. The fertilized eggs reached the eyed stage about May 12, and commenced hatching about June 6th.

The total number of fry at present alive is not accurately known, but is probably in the neighborhood of 20,000. Losses were as follows:

D.C.B. Duff No. 50

Egg Losses: Acriflavine treated eggs 8856, untreated 4738, total . . .	13,594
Alevin Losses: From acriflavine treated eggs 2215, untreated 1844, total	4,059
Free-swimming fry losses to July 22	2,306
Total losses during early stages	19,959

So far, no furunculosis has appeared, either among treated or untreated fry. This of course may have been due to the very short period of high water temperature during the summer. With the installation of the water-heater mentioned before, it will be possible to raise the temperature of batches of these fish in order to see if infection breaks out. It is also planned shortly to sacrifice and culture a large number of the fry to see if latent infection exists.

D.C.B.Duff No. 51

Susceptibility of Kamloops and Steelhead Trout to B. salmonicida Infection

Unsuccessful attempts to initiate epizootic furunculosis among Kamloops and Steelhead trout have previously been reported. This year a large number of yearling and two-year old Kamloops and Steelhead again resisted continuous exposure to B. salmonicida in the water. This result is unfortunately without significance, again on account of the low water temperature. Direct inoculation, however, showed that Kamloops were definitely more susceptible than Steelhead. Thirty-eight of Kamloops died with typical furunculosis lesions and recovery of the organism. Only two Steelhead died, and while the organism was recovered from the kidneys of these fish, typical symptoms were absent, and it was impossible to record these two deaths as specific. It is planned to repeat these experiments using warmed water.

D.C.B. Duff No. 52

Cowichan Lake Hatchery Investigation

On August 3 a trip was made to Cowichan Lake Hatchery. A report has already been submitted indicating the definite presence of furunculosis in the Spring and Coho salmon fry, and its probable presence during the same period in the trout fry. A second visit was made in September, during which consultation was held with Drs. Clemens, Neave and Carl as to the nature of the steps that should be taken to avoid outbreaks in the future. It was suggested that we await the results of the immunity experiments being conducted at Stanley Park. With the water-heating plant in operation, it should be possible to give an opinion on the usefulness of vaccines before the spring of 1939. Providing immunization proves a practical procedure, my recommendation for the Cowichan hatchery situation would be as follows: a rapid sand filtration plant to be installed, following a report on the practicability of such an installation from a competent engineer. Protection against furunculosis would then consist of two factors - mass immunization of the hatchery population, and probable significant reduction of infecting doses due to the sand filter, particularly if flocculation of the water is practiced before filtration. The special value of their combined procedure would seem to lie in the fact that elaborate training of the hatchery staff would not be necessary, as would certainly be the case where no immunization of the fish was practiced. This statement is not to be taken, however, as meaning that the best reasonable precautions against infection may be neglected.

There is the further advantage that the rapid sand filter would probably remove all of the larger parasites, including Octomitus, from the water supply. An efficiently operated mechanical filter with flocculation is capable of eliminating 95 - 98% of the bacteria from a water supply, and it follows that all larger organisms will be held back with even greater efficiency. The details of a rapid sand filtration plant should be in the hands of a competent hydraulic engineer. Generally speaking, I should recommend a duplicate installation, consisting of two pressure-type units approximately 13 feet in diameter, containing 12" of graded gravel in the bottom, and 30" of clean sand of effective size 0.4 to 0.6 mm. The duplicate units should be connected in such a way that the clear water flowing through one could be diverted for short periods through the other as a reverse flow for cleaning purposes. The comparative advantage of a compressed-air vs. a mechanical type sand agitator would have to be considered.

Diseases Other Than Furunculosis

Gyrodactylus - considerable losses were suffered among yearling cutthroat trout at Stanley Park hatchery through Gyrodactylus infection. The disease was fortunately confined to 2 tanks and was finally brought under control by means of acetic acid baths. A noteworthy point was that the severity of the infection did not appear to vary directly as the temperature of the water.

Ichthyophthirius - At the suggestion of Dr. Hart, a private pond of Goldfish in Vancouver was investigated. A few fish were suffering from what appeared to be Ichthyophthirius infection, and recommendations were made on this basis.

Suspected Furunculosis - Samples of Cowichan Lake Kokanee were submitted by Dr. Carl in May. The exterior lesions were in some cases suggestive of furunculosis lesions, although not typical. No cultures of B. salmonicida were recovered, and I do not consider this disease to be furunculosis. An interesting microorganism was however, recovered from the lesions of these fish, and is being kept for future reference.

In November a bacterial culture suspected to be B. salmonicida was sent in by Dr. F.P. Griffiths of Oregon State Agricultural College. This culture was definitely not the organism of furunculosis, as it proved to be a highly motile, non-pigment forming vibrio. A report has been sent to Dr. Griffiths.

SHELLFISH.

Japanese Oysters

A peculiar situation has arisen in Ladysmith Harbour in regard to the propagation of Japanese oysters.

The oyster industry in this harbour is represented by two groups of growers:

1. "Outside companies" whose growing beds are located elsewhere and whose interest in the harbour lies in the seed catching possibilities.
2. The original local companies whose growing beds are located in the harbour.

The first group is naturally desirous of obtaining an annual "set" and of rather large proportions. The second group desires only occasional sets, spaced, if possible, four or five years apart. This is sufficient to supply the needs for that length of time, whereas heavy annual sets would soon make the harbour useless as an oyster culture area because of the distortion in growth and the general difficulty in handling occasioned by the setting of one generation upon another. In some parts of Ladysmith Harbour there are already as many as three generations massed together. Consequently the local growers now passively oppose a program of artificial stimulation for inducing sets in view of the fact that the 1936 catch has stocked their beds with enough oysters to last for a period of about four years, much as the 1932 set did, for it is only now that the last of that set is being used. Since the local growers control all but a relatively small proportion of the beds in Ladysmith Harbour, very little stimulation was carried out. Attempts to stimulate spawning on the small number of oysters upon which work was permitted were made. Only one spawning of importance occurred from these efforts; that on July 7, but no results were observed in the plankton.

However, several so-called natural spawnings occurred, the results of which appeared in the plankton. On June 29 a number of straight hinge Japanese oyster larvae were found. Growing larvae were obtained until July 7, when they disappeared from the plankton. At this time they were nearly two-thirds grown. It is interesting to note that the majority survived a heavy rain which occurred on July 1 - 2. Apparently a few of the larvae survived and spatted, for a very light set, about 20 spat per bushel, was found on suspended shell bags. The origin of this spawning was a few tons of small oysters high on the beach. The beds were carefully examined and it was estimated that slightly more than one-third of the oysters in the harbour had spawned.

On August 22 another group of straight hinge larvae appeared in the plankton. These declined in numbers until they disappeared on Sept. 8 when some of them were two-thirds grown. The source of the spawn was found to be a large group of two-year-old oysters, a part of the 1936 set.

Summary.

1. A difference of opinion has developed among the oyster growers in Ladysmith Harbour as to the desirability of heavy annual settings.
2. Due to the small quantity of oysters available, very little artificial stimulation was carried out in 1938, but opportunity for artificial stimulation may be greater in the near future because of the increased quantity of mature oysters available.
3. Spatting from artificial stimulation was a failure but from natural was slightly successful. The annual occurrence of even very light sets is encouraging and natural spawnings seem to have become more frequent in recent years.

Native Oysters

The native oyster (Ostrea lurida), also called the Olympia oyster, is the only true oyster indigenous to British Columbia. It is a small species, seldom exceeding two inches in length. The flavor is delicate and it is used for many dishes in preference to the larger imported Eastern and Japanese oysters. In the Olympia district of the State of Washington, with intensive cultivation, 500 acres of tidal bottom have produced an annual yield of this species valued from $ 300,000 to $ 500,000. At the present time the price per two-bushel sack containing 3,000 to 4,000 oysters is $ 10 to $ 16, depending on quality. The place of this oyster in the shellfish market is assured and the demand far exceeds the supply.

The area of natural oyster ground in B.C. is relatively small. The location of the largest acreage is at Boundary Bay on the lower mainland. Next in importance is Ladysmith Harbour on Vancouver Island. The other areas are small and scattered widely over the coast.

In Boundary Bay the production of native oysters has been maintained at a more or less constant level. Here a single large dyke, 8 acres in extent, is in operation, and is used for winter storage after the oysters have matured in the eelgrass sloughs, which are a considerable distance from the dyke and the shipping point. The function of dykes is to keep the oysters covered with water in order to prevent exposure to frost.

In Ladysmith Harbour there has been a marked decline in native oyster production during the last decade. The oyster bottom in this bay is very hard, and it is only at the lowest levels on the tidal flats that the oysters are protected from frost by residual pools of water and extremely wet mud. Continued exploitation, high mortality in several seasons due to heavy frost, and neglect in making suitable preparations for spat collection, coupled with concentration on the culture of the more easily grown Japanese species, have aided in the decline. Last season (1937-38) approximately 75 sacks of native oysters were shipped from Ladysmith Harbour; this season none will be shipped.

The quantity of "set" of native oysters obtained this summer (1938) indicates that the spawning stock in Ladysmith Harbour is still considerable, and is much larger than is needed to produce a commercially valuable "set". The "set" on shell bags suspended from floats averaged 40 spat per shell. Ten spat per shell constitutes a commercially valuable "set". While at the present time the spawning stock is in no danger of being further reduced by exploitation, there is the ever present possibility of it being considerably reduced by the occurrence of heavy frosts. This possibility can only be eliminated by the use of dykes.

Too much blame should not be attached to the oyster grower for the present situation because:

1. It has not been demonstrated conclusively that Pacific (O. gigas) and native oysters can be grown together successfully where dykes are used, for there is the complication of occasional sets of Pacific oysters.
2. Dykes which are almost necessary for the successful culture of the native species where it occurs alone, are costly to construct and the small operator is generally in no position to experiment.

At Toquart in Barkley Sound and at Sooke, near Victoria, small quantities of native oysters are being produced. Most of the other small beds have been practically exhausted by clam diggers and by oyster growers for restocking their own beds.

It is regrettable that the culture of this valuable species is being neglected. By the use of dykes much ground could be added to the small area of natural bottom now useful for oyster culture. It is hoped that after a more thorough survey of the possible shellfish producing areas in B.C. has been completed, some recommendations in regard to the native oyster industry may be made.

Ferris Neave No. 56

On the Causes of Mortality Among Japanese Oyster Larvae in Ladysmith Harbour

In an attempt to elucidate the cause of the frequent heavy mortality of Japanese oyster larvae in Ladysmith Harbour, numerous attempts were made during the summer of 1938 to rear this species in the laboratory. Ova and sperms were obtained from ripe oysters and the resulting larvae were subjected to varying conditions of temperature, oxygen, nitrates, food supply, etc. In nearly every case larvae attained the straight-hinged condition but with one exception none progressed beyond this stage. The maximum length of life from the time of fertilization varied from two to twelve days. In the final experiment of the season some of the larvae passed considerably beyond the straight-hinged condition, attaining a size of 110 x 100 μ, with appropriate development of umbones, etc. Some of these larvae were still in a healthy condition when the experiment was discontinued after nine days. The conditions under which they developed were as follows: The larvae were maintained in quart scaler jars of fresh sea water which had been filtered through a # 20 silk net and was changed once or twice daily. Temperature was kept about 27° - 28°. Agitation of the water was effected by Plymouth plungers. In order to change the water without heavy loss of the minute larvae, the latter were concentrated with a centrifuge.

Two considerable bursts of spawning occurred among the oysters in the harbour. Larvae resulting from the first of these were present in the plankton during the latter part of June. Heavy mortality occurred at the beginning of July but a light setting of oysters became apparent in August. On August 22nd young larvae appeared again in numbers in plankton samples. Larvae of increasingly larger size were obtained regularly up to September 3rd at which time they became scarce and were completely absent from many hauls. None were found after September 8th.

Among the possible causes of such heavy and frequent mortality, the following factors suggest themselves: 1) salinity 2) other chemical conditions 3) lack of suitable food 4) predators or competitors 5) temperature. Critical consideration of these would indicate that low temperature is the important limiting factor. It is well known that successful reproduction of the eastern, Japanese and other species of oysters does not take place every year at the colder limits of their distributional range. That oysters spawn at times when the water is too cold for complete larval development is indicated by Galtsoff (1938) in the case of the eastern oyster. Japanese investigators consider that the optimum temperature for the development of the Japanese oyster up to the shelled condition lies between 23° and 26° C. However, the completely successful rearing experiment reported later by two of these investigators was apparently conducted at a still higher temperature.

A recording thermometer kept in the channel of Ladysmith Harbour showed that during the summer of 1938 the temperature at this spot only occasionally remained above 20° C for more than a few hours at a time. The highest temperature recorded was about 24° C. Though temperature conditions in the bay are undoubtedly complex and much higher values can be obtained temporarily when the tide is spreading over sun-heated flats, there is little doubt that general temperature conditions in Ladysmith Harbour are below the optimum for the development of the species. There are therefore strong general grounds for regarding temperature as a chief factor in causing mortality.

D.B. Quayle No. 57

Clam Survey of the Eastern Coast of Vancouver Island

A knowledge of the condition, position and extent of the beds was considered to be a prerequisite to the analysis of the clam situation and to the preparation of a program of investigation.

Three preliminary surveys, covering the main clam producing areas, were made. The first and most complete survey was carried out in the Saanich district on the south eastern coast of Vancouver Island. This area has been dug commercially for at least forty years. The second district investigated is in the Comox region in the approximate centre of the East coast. This area has also been producing clams for many years. The third district is centred at Alert Bay at the north eastern part of the Island and has rather recently been heavily dug.

A

The investigation of the Saanich area was made in December, 1937. More than twenty beaches were visited. Sample diggings were made and as much information as possible was elicited from the commercial diggers. The following is the summarized result of the survey.

1. Judging from previous observations on virgin clam beds of the west coast of Vancouver Island, and from discussions with diggers, there is no doubt the clam beds of the Saanich area have been exploited to such an extent as to cause marked depletion.

2. Due to lack of adequate statistics it is difficult to determine to what extent depletion has occurred.

3. Conversations with diggers who are regularly in the business indicate that the present catch per man is approximately one-third of what it was four or five years ago, and that the real depletion has taken place within that time.

4. The relative status of the three commercial species (Paphia staminea, little neck clam; Saxidomus giganteus, butter clam; Schizothaerus nuttallii, horse clam) in regard to depletion could not be determined with any degree of accuracy.

5. Contributing factors to the decline in production are as follows:

a. Extensive digging and consequent reduction of the spawning populations, especially of butter clams, for the previous size limit of 1.5 inches protected only the little neck clam. The butter clam according to Fraser and Smith (1928) does not spawn before reaching a size of slightly less than two inches. The recent regulation limiting the minimum size of the butter clam for commercial purposes to two and one half inches should be an important measure in recovery and conservation.

b. Probability of "off" years in which successful "settings" did not occur.

c. The opening up of the United States market causing an increased drain on the beds which were already probably being dug to their maximum productivity.

6. A new method of gathering catch statistics in order to determine productivity of more limited areas and to measure variation in digging effort, is proposed.

B

The Comox area was investigated in August, 1938. The area is quite small and the beaches are not numerous. The most important beach is Seal Island which has been practically the sole source of supply for a small cannery at Deep Bay for many years. Examination proved the clam beds of this Island to be almost completely exhausted and digging unprofitable. Most of the other beaches in the area still contain a considerable supply of clams.

D.B. Quayle No. 57

C

The Alert Bay area was investigated in July, 1938. At this time of the year, of course, no diggers were operating, but as many beaches as possible were visited and sampled. The whole area is a very large one but the clam beaches are very scattered and confined mostly to small pockets between the rocks. Excepting the one or two large beds, the beaches visited were in good condition. Exploitation of this area was first begun three or four years ago. The clams are very large and must be quite old for it is believed the growth rate is slow due to low water temperatures. For this reason and from the fact that small beds can be more easily dug out than large ones, it seems probable that the clam beaches of this area will not stand intensive digging to the same extent as the southern beds.

D.B. Quayle No. 58

The Sexuality and Gonad Development of the Little Neck Clam, Paphia staminea

A histological study of the gonad and its development in the little neck clam (Paphia staminea) has been made in order to determine with accuracy

1. The size and age at maturity
2. The spawning season
3. The time of gamete formation
4. The most suitable periods for exploitation in regard to edibility.

These problems are of the greatest importance in the life history and economics of the clams, and the histological approach is the quickest and most accurate method for their solution.

Samples of 50 to 75 clams, ranging in size from 1 mm. to 60 mm. were collected at monthly intervals from a small clam beach in Ladysmith Harbour. Histological sections of the gonads were prepared; serial sections of the smaller clams; a few sections in the case of the larger specimens. More than 1,000 slides were prepared from about 800 clams. The following is a summary of the facts obtained from a study of these slides.

1. The primary gonad of the little neck clam is different from most pelecypods in being composed of profusely branching tubules filled with thin walled vacuolated follicle cells, whose function is nutritive. The gonad structure is similar to that of Mya arenaria, a species of clam investigated by Coe and Turner in 1937.

2. Growth of the primary gonad, which starts from two primordia, one on each side of the body, is by extension and growth of the germinal epithelium. The growth is forward and ventral into the tissues surrounding the stomach and intestine.

3. The gonia are not differentiated on the germinal epithelium until the alveoli of the gonad are fully formed. This takes place when the animals reach a size of between 1.5 and 5.0 cm. in length. The indifferent gonia develop immediately into male or female cells, depending on the sex of the clam. Spawning may take place shortly after, but is dependent on the time of year. The species is generally unisexual; it is not protandric and there is evidently no change of sex.

4. The development of the gametes causes disintegration of the follicle cells until they are completely replaced by sex cells. The follicle cells are reformed after spawning.

D.B. Quayle No. 58

5. The spawning season is a long one, lasting from early spring to early fall.

6. After spawning, in the female there is slight growth of the gonia, but active ovogenesis does not begin till December and January. Females with ripe ova are found in February. In the male there is very little spermatogenic activity till January and February, although some indication of spermatogenesis may be found in some individuals in each month of the year. Peak activity is reached in February and March. Morphologically mature sperms can be found throughout the year.

A similar study should be instituted for the other commercial species, and continued on the little neck clam. The work, however, entails a great deal of routine technical work, requiring much time. It is recommended that some provision be made in order that these and other fundamental histological problems might be solved as soon as possible.

D.B. Quayle No. 59

The Recognition of Bivalve Larvae

Work on the recognition of bivalve larvae was continued when opportunity presented itself. The importance of this investigation lies in the fact that the larval period is the most delicate stage in the life history of pelecypods. It also is one method of determining spawning seasons and to what degree spawning has been successful. The quantity of larvae present in any year provides a basis for the estimation of mortality at different stages in the development of that year class.

Young clams with minute amounts of dissoconch growth were collected from shells and from cardboards dipped in pitch. Prodissoconch shapes were figured and measured. Attempts were then made to correlate these, after they had been specifically identified, with larvae taken from the plankton. Some success was obtained with what might be termed the more "exotic" forms, those species with very outstanding distinguishing features, such as the byssal notch of Pododosmus and the extremely large size of Kellia.

The following bivalve larvae can now be recognized: Ostrea lurida; Ostrea gigas; Mytilus edulis; Mya arenaria; Paphia philippinarum; Paphia staminea; Pododesmus macroschisma; Kellia laperousi; Bankia setacea; Saxidomus giganteus; An unidentified species of the Cyclocardia group.

The last six named species have not been previously figured.

It is now realized that if much further work is to be done in this field, it must be done by cultural methods. It is strongly recommended that opportunity be given someone to carry on the work on the culture of larvae begun by Professor Neave during the summer of 1938.

OCEANOGRAPHIC INVESTIGATIONS.

Hydrographical Investigations.

The dynamical surveys in the fishing waters in the Swiftsure Banks area off the entrance to Juan de Fuca strait have been continued. To date the following records have been obtained:

	1936	1937	1938
Winter	x	x	x
Spring		x	x
Early Summer	x		x
Late Summer	x	x	x
Autumn		x	x

There are complete data for the dynamical current charts, cross sections, and isentropic charts, in the area sufficient to determine the differences between the seasons and the annual cycles of change. The series have been sufficiently repeated to determine the nature of the annual differences between the corresponding seasons.

In addition to these dynamic data the state of the sea has been observed daily at a number of lightstations along the coast as has been previously described (Progress Reports 1936-37).

By means of the data from the seasonal dynamical surveys it is possible to interpret the state of the sea at the time of the survey and relate this to the daily observations in that period. Then on the basis of these specific interpretations the nature of the sea between the dynamic surveys can be interpolated.

That is, instead of making direct linear interpolations between the surveys, the specific intensity and duration of the observed states and the date and rate of change from one to the other can be determined.

The first and second phases of the investigation, namely

(a) The determination of the problem and the method of investigation
(b) Collection of suitable data to determine qualitatively the relations concerned in this one small area.

are practically complete, and the third and fourth phases,

(c) Correlation of the data.
(d) Formulation of the state of the sea, and deduction of the laws of change.

are proceeding actively.

The mechanics of the treatment of this mass of data does not concern this report and it is sufficient to say that the extensive calculations are nearly completed and the current plans and the cross sections are under construction.

Several primary conclusions have been reached and proven.

1. Type seasons.

(a) Winter has been determined as a season when the coast waters are practically homogeneous both vertically and laterally, except very close to the shore where the land drainage waters accumulate under the influence of the continuous southerly winds. The whole surface water movement is in general northwards at this season and very strong immediately adjacent to the coast.

(b) In the spring a vertical density gradient develops but no appreciable lateral gradient except very near the shore where land drainage waters cause a lowering of the density. The northwestward coast current persists although the northward flow practically disappears in the offshore waters.

(c) The summer is divided into two seasons, the early and late summer.

The Early Summer occurs during the freshet season when the winter's accumulation of snow is draining from the mountains. This lowers the chlorinity along the shore and as an effect the northwestward coast current attains a maximum. At the same time the northwesterly winds set in so that the offshore southward current is well developed. Both these currents are present at a maximum in this season.

In Late Summer the accumulated drainage is cleared and the northwesterly winds develop an offshore drift so that the density of the water along the coast is appreciably higher than that to seaward. In this season practically all the water movement is to the southward.

(d) Autumn is a season of transition to winter and may be considered as the reverse of spring. The lateral and vertical density gradients are being broken down and the state of the coast waters approaches homogeneity.

The varying nature of the coast current system as a function of the wind and the influence of land drainage has been determined qualitatively. The integration of these factors under the various seasonal conditions determines the resultant structure of the sea and the currents in the coast zone.

2. Variations of Type Seasons

The study of the data has shown that not only the intensity but the duration of the type seasons vary. That is the distribution of the properties of the coast waters may be classified into winter, spring, early and late summer, and autumn types, but the water in one summer may be warmer or more dense than in another, and these conditions may last for a longer or a shorter time. Such differences may only be determined from a study of the continuous daily observations which in conjunction with the seasonal dynamic surveys define the state of the sea in the area.

3. Correlation with Atmospheric Weather

The correlation of the atmospheric weather with the nature of the coast ocean waters has been qualitatively determined. That is the data concerning the effect of the wind precipitation, and temperature, on the coast waters are being continuously recorded and the further development of the quantitative relations is being studied.

The large number of relations that are necessary in the development of these data are necessarily tedious and exist to the third and in some cases to the fourth degree, so that it is necessary to develop the whole research as a unit rather than one phase at a time. As a result considerable time is required before conclusions can be presented.

4. Dynamic Nature of Coast Circulation

Numerous observations have been made of cyclonic rotation in the sea off the west coast of Vancouver island, with upwelling in the center of the vortex and water being thrown off around the edge. At first glance this appears to be opposite to the deductions of the hydrodynamical theories. However it is a natural consequence of the presence of the shoreline along the right hand side of the current. The presence of a northward shore current and southward offshore current at the same time has been directly related to this phenomenon.

That is from each sound and inlet along the coast there is a seaward flow which turns to the right northwestwards along the coast. Reaction *against* the shore causes this to turn seaward. The presence of the current causes upwelling on the seaward side which in turn forms a center around which the current rotates. The sum of a series of these vortices along the coast constitutes a northward current along the shore and a southward flow to seaward.

J.P. Tully No. 61

Hydrographic Investigations in Dixon Entrance

A complete hydrodynamical survey was made in Dixon Entrance in May and June, and developed by the methods found to be most advantageous off the West Coast of Vancouver island. For this work Nelson Bros. provided a boat, the "Amlac".

A current chart and cross sections are being prepared which will define the nature of the circulation in that area and on which future surveys may be based.

Unfortunately there are no daily observations of the sea being made in this area, and it is impossible to determine the duration or rate of variation of the observed conditions. As a consequence there is not much value in extending these investigations to determine the laws governing the physical characteristics of the area until arrangements have been made to ensure the continuous daily observations of the sea water at well-located lighthouses or other observation points.

J.P. Tully No. 62

Georgia Strait

In continuation of the studies of Hutchinson, Lucas and others, the quantitative nature of the Georgia strait drainage is being studied from the combined data taken by workers from this station and the University of Washington Station at Friday Harbour. It has been determined that these waters are released continuously to the sea, but in the summer when the density gradient is at a maximum the forces resisting the vertical mixing forces are great enough to preserve a distinct surface zone in the strait proper, but not in the southern or northern passages where the current velocities are high. In autumn, winter and spring, the circulation forces are great enough to overcome the stability of the stratification in all parts of the system.

J.P. Tully No. 63

The Nature of Flow in the Passages from Juan de Fuca Strait.

The drainage from Georgia strait does not reach the sea as water of lower salinity than that already in the coast zone. The rate of tidal flow in Juan de Fuca and Discovery passages is so great that a rotary force is developed which is sufficient to mix the dense deep water with the light surface water, so that the resultant surface waters in these passages are more dense than in the surface of the sea immediately to seaward of these straits.

That is when approaching the entrance to the northern or southern passages to Juan de Fuca strait the density of the water in the surface 150 metres increases as the straits are approached to a point well within the passages, and from there on decreases toward the Fraser river.

This should have significance in the study of fisheries.

A point of industrial interest arises from the exceptionally high den-

sity of the surface waters in the southern and northern passages to the sea. The sea water in these contains a higher concentration of dissolved salts than most coast waters and could be advantageously employed for the recovery of such chemicals as iodine, bromine, etc.

J.P. Tully No. 64

Experiments in Chlorinity Determinations

In order to eliminate some of the fatigue of the chlorinity determinations, investigations have been made of several alternative methods for determining the density of sea water.

(a) The determination of density by the apparent loss in weight of a sinker suspended in a sample of sea water was found to be less sensitive than was required by the determination.

(b) A very sensitive method has been tried which depends on the electrical capacity of a standard sample of sea water. The sample is placed within a coil in one arm of a wheatstone bridge and a current of high frequency is allowed to pass through both arms of the bridge. The other arms are tuned to the same frequency as the one containing the sea water sample and the density determined by the amount of tuning necessary to attain matched frequency in both arms of the bridge.

This method has the advantage of having no action on the sea water and appears to be independent of small fluctuations in temperature.

(c) An automatic mechanical titrometric method is being considered in which the reflected light from the titration vessel is made to actuate a sensitive photoelectric cell which controls the delivery of the burette. At the end point the colour changes from a pale yellow to dark red. This method is directly comparable to the present and standard method, and is independent of debris, plankton, and the normal temperature fluctuation.

J.P. Tully No. 65

Distribution Rule

A very valuable rule has been determined from observation. The concentration of a retained property (such as chlorinity) which is present in only one of two mixing waters varies as the logarithm of the depth and the distance down stream in any simple current system. This has been proven theoretically and in the field.

Hence if the nature of the circulation system in any area is established, then the chlorinity at any point in the continuous current system may be projected from a few surface observations within the limits of accuracy of the current determinations.

J.P. Tully No. 66

Salmon Catch Records and Water Temperature

During the salmon trolling season off the west coast of Vancouver island about fifteen reversing thermometers were supplied to fishermen on the agreement that they would make frequent observations of the temperature at th surface and depth of fishing, and return reports of these and the statistics of their catches.

It is proposed to group these data with regard to catch, tidal phase, temperature, and weather conditions to determine whether there are any direct relations between these physical factors and the catch.

This procedure is necessary since there are no detailed catch records for salmon such as are available for the pilchard and herring fisheries.

It is impossible to review these records yet, as there are not enough of them on hand. It is believed that about four years will be required to properly judge the value of this program.

OTHER INVESTIGATIONS.

Josephine F.L. Hart No. 67

Zooplankton from the West Coast of Vancouver Island

The zooplankton collected by Mr. E.G. Hart in 1934 during the oceanographic investigations off the west coast of Vancouver Island has been examined. The collection comprises some 200 samples, taken with a marquisette closing net 10" in diameter at 30 localities from May to August inclusive. With two exceptions, all the stations sampled were less than 200 metres in depth and all were in the area between longitude 49°52' and 48°36' N. and latitude 127°20.5' and 124°55' W. As the number of organisms in each sample was small, the total number was counted and calculations made as to the number per cubic metre of water at the various depths. Unfortunately the results are of little value for comparative quantitative analysis as the numbers involved were small, the area covered large and the interval of time considerable. So far it has been impossible to establish correlations with the physico-chemical factors.

The study of this collection, however, is of value in that it suggests certain areas of concentration of the macro-plankton both vertically and horizontally. For example, the copepod, Calanus, occurred in 27 localities in the largest numbers about 100 metres from the surface, apparently being replaced at greater depths by other species such as Euchaeta and Metridia. There would appear to be an abundance of organisms at points of upwelling of the water, caused by the meeting of opposing currents. The samples are also of considerable interest taxonomically as a number of the species have not been previously recorded from this region. To judge from the results of this collection, it would seem essential to have a special expedition, with a specially organized program and other collecting methods if a satisfactory knowledge of the quantitative distribution of zooplankton is to be obtained in this area.

Josephine F.L. Hart No. 68

Western Canadian Arctic Fauna

Sergeant H.A. Larsen, Master of the R.C.M.P. Schooner "St. Roch" took a number of bottom dredgings in Western Canadian Arctic waters in the summers of 1936 and 1937. These were deposited at the Pacific Biological Station for examination. The organisms found have been sorted into the major groups and submitted to various investigators.

The collection is particularly rich in species of Crustacea, six samples containing over 50. There is a decided predominance of European forms, and as this part of the Arctic region has been practically untouched zoologically, considerable extension of range has therefore resulted. The work is not yet completed on the Amphipoda, Isopoda and Mysids but a report has been prepared on the Cumacea and Decapoda.

Sixteen species of Cumacea were obtained from five localities southwest of Victoria island. Although the Canadian Arctic Expedition investigated part of the same area only three species were obtained. These occur in the present collection and the other species seem to be new records. On the whole the species are North Atlantic or Arctic forms rather than Alaskan.

The decapod collection comprises seven species of shrimps. Six of these were obtained by the Canadian Arctic Expedition from much the same area and the seventh, Argis dentata has been taken in the Bering sea, off Baffin land and in Hudson's bay.

C. McLean Fraser No. 69

Hydroids of the Western Canadian Arctic Region, 1935-37.

The hydroids here reported upon were obtained by Sergeant H.A. Larsen of the Royal Canadian Mounted Police vessel the St. Roch in July and August, 1936 and 1937. During the time the vessel was stuck in the ice, Sergeant Larsen made use of the delay by making a dredge which was then lowered to the bottom and pulled along by the drift of the ice. The material was preserved and later deposited with the Pacific Biological Station where it was sorted out by Dr. Josephine F.L. Hart.

I wish to express thanks to Dr. W.A. Clemens and the Fisheries Research Board of Canada for the opportunity of examing the hydroids; to Sergeant Larsen for collecting and preserving the material, to Dr. Hart for the sorting, and to Miss Ursula Dale for the drawings used in the illustration.

Although this material was not very extensive, it proved to be as interesting as any yet obtained from the Canadian Arctic. Of the five species in the collection, two appear to be new and one of these belongs to a genus quite different to anything previously described.

In Dease strait, 68°58' N., 106°20' W., in 40 fathoms, the four species, Calycella syringa (Linnaeus), Thuiaria similis (Clark), Thuiaria tenera (Sars) and a new species of Bonneviella (B. gracilis) were obtained, and off cape Bexley, Dolphin and Union strait, 68°59' N., 115°40' W., in 9 fathoms, the new genus with the new species (Meganima claviformis).

C.J. and E. Berkeley No. 70

Polychaeta of the Pacific Coast of N.A.

The year has been devoted to further work on the collection of Polychaeta from the coast of California, which was referred to in the last Summary Report, and to another, from the coast of Mexico, which was submitted to us for examination. Both collections have afforded interesting forms and they have made possible a study of the variation of several species already known from more northerly waters. Thirty-four species were identified of which five were new to science and seven were new records for the west coast of North America. Of the remaining twenty-two species five (Eunice biannulata Moore, Diopatra ornata Moore, Idanthyrsus johnstoni (McIntosh), Thelepus setosus (Quatrefages), Terebellides stroemi Sars) have been taken off the British Columbia coast. The rest are known either from the coast of California or from the Panama region.

Work on the Californian collection is still in progress. That on the material from Mexico has been completed and the results incorporated in a paper which has recently been submitted for publication. The paper included descriptions of five new species and seven new records for the west coast of North America.

J. A. Munro No. 71

Studies of the Economic Relations of Waterfowl

An investigation of the food habits of Golden-eye ducks, Clangula americana americana, Clangula islandica, was the principal activity in 1937 and 1938. Field studies were carried on in the Okanagan and Cariboo districts and the materials from the digestive tracts of forty specimens, taken in various parts of British Columbia, were studied in collaboration with Dr. W.A. Clemens.

In the case of both species collected during the winter months the principal food items are: salmon eggs, caddis and mollusca. The food of Clangula islandica in the interior during summer comprised chiefly amphipods, caddis and other aquatic insects.

In connection with food studies of other waterfowl a total of 106 stomachs, representing thirty-three species, was examined.

The principal food items of the more important species are summarized as follows:

Horned Grebe - crabs and crustaceans.
Double-crested Cormorant - blennies, herring.
Pelagic Cormorant - shrimps, gobies, blennies, rockfish, perch.
Mallard - seeds of Potamogetons and Scirpus.
Green-winged Teal - Chara oospores, snails, seeds of Potamogetons.
Redhead - Chara, Bryozoan statoblasts, seeds of Potamogetons, Carex and Scirpus.
Lesser Scaup - Amphipods, Carex seeds, aquatic insects.
Buffle-head - Amphipods, dragon-fly nymphs, chironomid larvae, seeds of Potamogetons.
American Merganser - Sculpins, sticklebacks, squawfish, salmonoids.

W. A. Clemens No. 72

The Eelgrass Situation

In the March issue of the Canadian Research Journal, Mr. Edward Lorraine Young III reports the occurrence of Labyrinthula macrocystis on eelgrass sent to him from Departure Bay. Since this organism has been considered as the or one of the agents responsible for the disappearance of eelgrass along the Atlantic coast, considerable apprehension has been felt concerning the fate of the eelgrass on the Pacific coast. Through the kindness of Major Motherwell, the fishery officers along the British Columbia coast were asked to report on the condition of the eelgrass in their respective areas. No report to date indicates any noticeable decline.

Mr. Clarence Cottam of the United States Bureau of Biological Survey reports that inspections along the California, Washington and Alaska coasts indicate that the growth of eelgrass has been perfectly normal during the 1938 season.

J. L. McHugh No. 73

A Study of Variation in the Rocky Mountain Whitefish, Prosopium williamsoni (Girard)

The genus Prosopium is an extremely variable group. Considerable confusion exists as to the status of the various species which have been described. It is believed that the group is of comparatively recent origin and that, therefore, the factors contributing to the differentiation of species have had little time to work their effect.

As a preliminary to a complete revision of the genus, a detailed study has been made of the racial characters of Prosopium williamsoni from as many localities as possible throughout its range. The material was obtained from various sources, including collections supplied by Dr. D. S. Rawson and a considerable amount loaned by Dr. Leonard P. Schultz of the U.S. National Museum. An additional series of specimens has been obtained recently from Dr. Carl L. Hubbs of the University of Michigan and will be examined as time permits.

The fish examined show a relatively wide range of variation in most of the thirty-odd characters subjected to measurement. It was found possible to correlate most of these variations quite definitely with the type of habitat, and in this way four main races were found to exist, each characterized by a special type of environment which apparently showed its effect on growth rate and body proportions. The first group is composed entirely of lake-dwelling fish, and includes the samples from Waterton and Maskinonge lakes in Waterton lakes National Park, Alberta, lake Minnewanka and Third lake in Banff National Park, Alberta, and Bowman, Logging and McDonald lakes in Glacier National Park, Montana. These populations are all similar to the typical williamsoni in body proportions. The second group includes the Cultus lake fish and the samples from the Tolt and Nooksack rivers in the state of Washington. These probably spend a good proportion of their life in the streams, and are characterized by a rapid growth in the first few years of life, small head, long bases on dorsal and anal fins, fairly short pectorals, and a large adipose. The pectoral fin rays and the lateral line scales are probably more numerous than in any other group. Group three is distinctive in possessing a slow growth rate and therefore a small size at maturity. In it are placed the fish from Bow lake and lake Louise in Banff National Park. These are cold, heavily silted glacial lakes. The fish are small, with relatively large heads and short snouts. The sample from the Elk river in southeastern British Columbia falls in the fourth group characterized by a slow growth in the first year and consisting of fish with long heads and snouts, high dorsal and anal fins, and small adipose.

It is hoped that the work will not cease here, and that some day a complete revision of the whole group will be possible. At present this is out of the question, for it is probable that a great amount of widespread and rather difficult field work must be carried out to bridge the wide gaps in present collections.

Course of Instruction for Fisherman - Port Alberni - December, 1938.

In August, 1938, the Kyuquot Trollers' Co-operative Association through its secretary, requested that a series of lectures somewhat similar to those given in 1937, be presented immediately prior to the annual meeting of the organization in December. Accordingly the following presentations were made on December 7,8 and 9, at Norway Hall, in Port Alberni, B.C.

Dec. 7 -	A.M. -	Dr. A.L. Pritchard	- Introduction.
	P.M. -	Mr. O.C. Young	- Preservation of Fresh Fish.
Dec. 8 -	A.M. -	Mr. O.C. Young	- Refrigeration.
	- P.M. -	Dr. L.I. Pugsley	- Vitamins in Fish Oils.
Dec. 9 -	A.M. -	Dr. J.L. Hart	- Pilchard and Herring - Migration and Tagging.
		Dr. A.L. Pritchard	- Columbia River Power Developments and their Relation to the Fisheries.
			Status of Predator Control in Relation to Sockeye Production.

On December 7 the attendance averaged only four, on December 8, seven and on December 9, thirteen. Unfortunately circumstances beyond the control of the association militated against the members appearing. High winds and gales made it practically impossible for the boats to reach Alberni. On the other hand, more listeners would have been present if more general advertisement had been made. Such a procedure is urgently recommended in future undertakings of this sort in order that the expenditure may be better justified. Those who did attend the lectures showed keenest interest in all problems and it is felt that many problems were discussed to advantage.

The writer is deeply indebted to all speakers who contributed.