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ANNUAL REPORT

of the

PACIFIC BIOLOGICAL STATION

for

1941

PBS-AR /  
1941

NANAIMO, B.C.

DECEMBER, 1941

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Foerster, R.E.

Report of the Pacific Biological Station,  
Nanaimo, B.C. for 1941

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FISHERIES RESEARCH BOARD OF CANADA

REPORT OF THE  
PACIFIC BIOLOGICAL STATION,  
NANAIMO, B.C.  
FOR 1941

BY R. E. FOERSTER, DIRECTOR

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In spite of war-time conditions and the necessity of modifying both policy and operating routine, the work of the Station during 1941 has progressed most satisfactorily. While it cannot be said that the year's results have directly contributed to the war needs, a fact which has been of serious concern to members of the staff, nevertheless it is abundantly evident that from the long range point of view and considering fisheries conservation generally, the accomplishments have been of definite significance. They add, year by year, more contributions to our knowledge of the trends of the various fisheries or the characteristics of the life history of the commercial fishes, all of which are of value in preparing up-to-date effective measures for regulation and conservation.

Constantly changing conditions in the various fisheries, brought about by the increased value of the fish, the increased efficiency of fishing methods and/or the expansion of the fishing operations into new areas necessitate a close check being kept by the investigators on the trends of the individual fisheries and an attempt to evaluate the effects of such changes. For example, in the herring fishery a quota system of regulation has been under experiment for the past five years. During this time the fishery has been limited each year to specified tonnage and the effect of such regulation upon the catches and more particularly upon the spawning and general abundance of the fish has been closely followed. A second five-year experiment has been commenced in which the quotas have been altered, on the basis of the previously-acquired knowledge, and the reaction of the fishery will be carefully watched.

In the salmon fishery there has developed a tendency for the fish to be caught further and further from the river estuaries until in many cases it is now extremely difficult to tell what fish from which river are being exploited. Obviously for conservation this becomes a serious matter and requires further knowledge of the migratory routes of the salmon. More attention is being given to this problem.

The reduction in available fish products for Canadian consumption, by reason of the heavy shipments to Great Britain, has placed a strain on shellfish resources to fill, in some measure, this shortage. The demand for clams and oysters has risen phenomenally and with consequent very attractive prices offered, the exploitation of the beds has increased. For oysters, largely grown and cropped from commercially leased beds, the problem is of less consequence than for clams which are harvested almost wholly from public beaches.

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Here the danger of over-exploitation and severe reduction of future potential supplies is very real. The extent of present digging, an assessment of the available supplies and the potential rate of recruitment are factors being investigated and on the basis of the data obtained and the situation revealed, directly beneficial conservation measures will be prepared.

The foregoing are but instances of the relationship of the work of the Station to the efficient management of the Dominion's Pacific fisheries, a natural resource which is of direct value in the present war effort but which will be of even more consequence in the post-war period. Other investigations are of equal importance and are being developed and planned to so fit together that with utmost efficiency the essential data may be speedily obtained for practical application in the field of conservation.

#### STAFF

During the year a number of the members volunteered for Active Service, obtained leave of absence and are now on duty. They are Mr. J.L. McHugh (Army), Mr. W.M. Cameron (Meteorological Service), Mr. D.B. Quayle (R.C.A.F.), Mr. Robin Fjarlie (R.C.A.F.) and Mr. L. Quickenden (Navy). With respect to the first three named, each of whom was responsible for certain research projects, special efforts were made to clean up work in hand and to leave records in such shape that the progress of the research was clearly indicated and the investigation could, if necessary, be carried readily ahead. These considerate actions have been very helpful. The departure of all of the men has had a definite effect upon the conduct of the work and has thrown added burdens of organization or routine on the senior members of the staff, particularly since suitable temporary assistance is extremely difficult to obtain.

Due to the enlistment of Mr. Quayle, who was in charge of the shell-fish research and which work it was deemed desirable to continue, a reorganization of the staff was made by transferring Mr. Neave from the Cowichan lake investigation to shell-fish. The Cowichan lake work was divided up, Mr. Neave to continue his interest in and supervision of the trout work, while to Dr. Pritchard was given responsibility for the salmon projects. With Mr. Epps resident at the Cowichan lake hatchery as field officer and directly superintending the routine operations, this new set-up is meeting the situation most admirably.

In July, Mr. Anderson returned to his duties as Junior Technician in Hydrography, after having been absent on compensation since October, 1940, when he was severely injured in an explosion in the Chemical Laboratory.

#### BOATS

The M.V. "A.P. Knight", transferred in the spring to Alberni Inlet for the hydrographical survey of that body of water, failed to meet the conditions demanded of it by the routine of the investigation. Built in 1926 it was equipped with a semi-diesel engine which for a number of years has given very indifferent service. Probably, too, frequent laying-up of the boat and the lack of

an experienced engineer have contributed to its condition. The boat was returned to Departure Bay in September and steps taken, through the Department of Fisheries, to purchase and instal a new power plant.

#### PUBLICATIONS

During 1941, the regular contributions to Progress Reports have been continued and the four issues during the year contained thirteen papers on various aspects of the Station's work. A list of these and of other scientific papers either published during the year or submitted for publication is appended hereto. In addition a number of manuscript reports on minor pieces of research or dealing with phases of major investigations have been prepared and placed in the library.

#### ACKNOWLEDGEMENTS

During the year the Provincial Fisheries Department contributed financially to the pilchard-herring and shell-fish investigations. For this and the advice and co-operation given on many occasions by the Assistant Commissioner, Mr. George J. Alexander, grateful acknowledgement is made. Relations with the officers of the Federal Department of Fisheries have been most harmonious and inspiring and, on behalf of the members of the staff, I should like to express deepest appreciation of the co-operation extended by Major Motherwell, Chief Supervisor of Fisheries for British Columbia, Supervisors Tait, Boyd and MacLeod and their many field officers. Their help is of very material benefit to our work.

#### SALMON INVESTIGATIONS

##### Pink salmon

During the spring of 1941 the sixth test of the efficiency of natural propagation of pink salmon at McClinton creek, Masset Inlet, was completed under Dr. Pritchard's direction. From the presumed deposition of 26,500,000 eggs in the autumn of 1940 a total of 5,061,000 fry migrated seaward, or 19.0 per cent of eggs deposited. This high percentage survival is in line with results obtained from previous small spawnings and tends to confirm by comparison with lower yields from larger age depositions, earlier evidence of a limited capacity for spawning beds, with respect to production of fry.

During the winter of 1940-41 Mr. Cameron remained at McClinton creek and made observations on the mortality of pink salmon eggs, alevins and fry during development. Certain spawning redds were marked at spawning time and subsequently dug up and inspected. While, from one year's findings, conclusions are hardly warranted the 1941 data show that the losses occurring from spawning to migration might be divided up as follows: Predation on adults and incomplete spawning - 10%; exposed by superimposition - 5%; erosion of spawning beds - 10%; during incubation and alevinage - 30%; due to predation on fry - 60%. It may be mere coincidence that the rough estimates above, when

applied to the 1940-41 spawning give a fry survival of 22%, very close to the actual determination - 19.0%. These experiments strongly suggest the practical value of certain stream management procedures such as stream improvement, predator control, etc.

Another important feature of the Masset inlet pink salmon investigation is the tracing of the migratory route of these fish on their return from the sea. The runs have been, in past years, of considerable commercial importance but very erratic in extent and returns in 1940 indicated that some exploitation of this run occurred in southern Alaska waters. Further information is desired and to this end 200,766 fry were marked in McClinton creek in the spring of 1941 by removal of both pelvic fins. These will return as adults in the fall of 1942.

Studies were made by Dr. Pritchard to determine whether, by comparison of mean gill raker or pyloric caeca counts, racial differences could be revealed between pink salmon populations. The results of 560 gill raker examinations suggest certain significant differences between northern areas, but not between streams within each area. Pyloric caeca counts (539) reveal no differences. The study is being extended to southern areas during 1941, for comparison between major areas.

#### Chum salmon

A collection of approximately 1200 chum salmon scale samples was obtained from various fishing areas. These were taken to study the age classes constituting the runs to the various coastal areas. The reading of the scales and the working up of the data will be completed by Dr. Pritchard this winter.

#### Coho salmon

Further data were obtained by Mr. Neave relative to the efficiency of natural propagation of coho salmon in two small tributary streams, Oliver and Beadnell creeks, of the Cowichan river. In 1940 the percentage efficiencies were 11.8 and 40.0 respectively and it was indicated that the difference may have been largely due to the much greater cutthroat trout population in Oliver creek. In 1941, the percentages were 30.4 and 30.1 respectively. Beadnell creek apparently supported the larger trout population but the presumed coho spawning in it was much less (74,100 eggs) than in Oliver creek (481,560 eggs).

Recoveries of marked fish from the Cowichan river have indicated, in the experiment conducted on the individuals of the 1937 brood year, a return of 1.55 per cent of the fingerlings released, or 0.273 per cent of the eggs collected. This represents the spawning escapement which remains after the commercial and sport fisheries have taken their toll of the returning fish. Cohos marked in 1939 (brood year, 1938) are now being recovered on the spawning beds. Returns from the fishing areas show that this Cowichan run was tapped at various points on the west coast of Vancouver island, in the strait

of Juan de Fuca and in the strait of Georgia. These experiments indicate the migratory routes of these salmon and the interesting recoveries in 1941, in spite of relatively little direct publicity, illustrate what valuable data may be obtained in later years when a definite recovery campaign is launched.

Collections of stomachs of coho salmon were made from the various fishing areas of the B.C. coast and the contents examined by Drs. Pritchard and Tester. A great variety of food organisms was found. Although fish occurred in great numbers, invertebrates were also important constituents of the diet.

### Spring salmon

From the release of 25,000 marked spring salmon fingerlings in 1937 and again in 1938, it was anticipated that some recoveries would be made this autumn. No marked springs were reported and the reasons for their non-appearance are not clear. However, information concerning the migratory routes of these fish and also of the extent to which they are taken by the commercial fishery is of considerable importance, hence a collection of 300,000 spring salmon eggs was made on the Cowichan this fall, the resulting fingerlings to be marked next spring.

During 1941, a third collection of spring salmon stomachs was made, embracing as many fishing areas as possible. The 1939 returns showed that herring and sand lance were the two most important food constituents; in 1940, pilchards entered the diet as well. It is expected that the findings from the examination of the 650-700 stomachs collected in 1941 will complete the study, except probably for investigations of individual areas.

## COWICHAN RIVER INVESTIGATIONS

### Salmon

The studies conducted by Mr. Neave on the coho and spring salmon runs to the Cowichan river, pertaining to propagation and migration, have been already dealt with in the preceding section. Reference should be made, however, to the records of the angling activity for spring and coho salmon in Cowichan bay, collected for Mr. Neave by observers during the late summer and fall (Aug. 23 to Oct. 31). Similar data were obtained in 1939 and 1940 and reveal the general size and character of the runs of these species to the Cowichan river.

During 1941 the number of anglers was greater than in either of the two previous years, representing 23,319 line-hours, as compared with 19,006 in 1939 and 16,707 in 1940. The total catch in 1941 - cohos and spring combined - was 5,731, slightly below the 5,782 caught in 1939 and much greater than the 3,472 taken in 1940. Expressed as number of line-hours per fish the three years' records are: 1939 - 3.3; 1940 - 4.8; 1941 - 4.07. In comparison with the escapement to the river the sport fish catch does not severely reduce the populations of either species of salmon.

## Trout

One of the principal studies, with respect to the trout of the Cowichan system, is that of the migratory habits of the various species. Information has been collected largely from releasing and subsequently recovering marked individuals. The following data have been assembled over the past three years:

- (1) For cutthroat trout the 101 recoveries to date have all been within a few miles of the point of liberation but they show local movements between the lake and the river and between the river and its small tributaries.
- (2) For steelheads only 54 recoveries have been made from the 80,834 marked fingerlings liberated and all except one were from fresh water. Recovery of sea-running individuals is expected this winter.
- (3) Of 2,976 rainbow trout liberated in January, 1941, nine have been returned, all near the point of release and of small size.
- (4) For Kamloops trout, only 20 recoveries have been made from 74,161 individuals liberated. All were from the release of 33,097 fingerlings of the 1939 brood. Considerable dispersion throughout the river system had occurred but the paucity of returns is most striking.
- (5) On the contrary, among brown trout, a return of 53 was obtained from a liberation of but 303 during April, 1939. All returns were within half a mile of the point of release. The fish had experienced remarkably rapid growth.

It is not anticipated that any further markings of trout will be attempted in the Cowichan system but efforts to recover those already marked and released will be continued.

The investigation of the steelhead runs in the Cowichan river was continued by Mr. Neave during the 1941 winter fishing season (January to March) and showed a reduced catch, on the basis of catch per unit of effort, namely one fish for 5.8 hours fishing, as compared with 4.9 hours in 1940 and 3.5 in 1939. The reduction in catch was apparently due to a relative scarcity of fourth year fish which in other years constituted the bulk of the winter run. The reduction in this year class is not considered to represent any depletion since the number of fish taken by anglers in recent years has constituted a small part only of the run.

## MARINE FISH INVESTIGATIONS

### Herring

The herring investigation has resolved itself largely into the collection and analysis of the data pertaining to the annual populations, both in the fishing areas and on the spawning grounds. The pertinent features thereof, such as abundance, availability, year classes and size, are studied and their significance evaluated. Certain studies are also being continued on migration of herring and the relationships of the various geographical stocks.

During the 1940-41 herring season the total catch amounted to over 94,000 tons, of which 76.7% was taken in the fishing grounds in the vicinity of Vancouver island, while the balance, 23.3% came from northern areas. In the previous year the larger catch of over 150,000 tons was taken as follows, 45% in waters adjacent to Vancouver island, 37% along the central coast line and 18% in northern areas. The decrease in 1940-41 is largely due to the general failure of herring to appear in the central and northern fishing grounds prior to the closure of the season. In the southern areas, on the contrary, the availability of the fish was much higher than in the previous year.

From 21 samples (2233 fish) taken from the strait of Georgia fishing grounds and 37 samples (3959 fish) from west coast of Vancouver island areas it was found by Dr. Tester that the herring were larger than in the two previous years, suggesting that in 1940-41 no precociously mature fish were present, as in the two former seasons. This was borne out by age analyses which revealed that the 1938 year class (III year fish) made up the bulk of the catch. For the Queen Charlotte sound area, at the north end of Vancouver island, (15 samples containing 1402 fish) great variation in age composition was found between districts. In general the fish from the area were small and they were also older, on the average, than those from older-established fishing grounds.

Studies of herring from northern areas by Dr. Boughton were somewhat less informative as far as comparison with former years is concerned because of the general scarcity of fish during the fishing season. Extensive scouting occurred and several new areas were exploited for the first time. Comparison of mean length and age with samples examined last year is possible in only five cases and the data indicate generally a decrease from the 1939-40 averages. It is suggested that this is due to the reappearance of younger year classes which failed during the previous year to appear in normal numbers.

Spawning ground studies were made by Dr. Tester in all areas, with the co-operation and assistance of Department of Fisheries officers. For the strait of Georgia the spawning appeared to be slightly greater than that of 1940 whereas on the West Coast of Vancouver island it was slightly lighter. In the Alert bay area it was also lower than in 1940 but northern areas showed perhaps a slight increase. These records are exceedingly valuable indices and an effort is to be made to improve their accuracy and significance.

One of the important contributions of the year has been the completion by Dr. Tester of a memorandum covering the five year test of a quota system of regulation for the herring fishery. Quotas were set up for both east and west coast of Vancouver island areas, old-established fishing grounds, and the general reaction of the herring populations to them assessed, it having been found that these major areas were almost completely segregated as far as intermingling of population was concerned. During the five-year period the east coast fishery has been fairly stable and limited by the quota but on the west coast the catch declined in 1938-39 and then increased. The quota was only reached in one year, 1936-37, therefore has not appreciably limited the catch. On the average the spawn deposition has been much less on the

west than on the east coast. As a result of this experiment it was decided to continue the tests for a second five-year period, raising the east coast quota and lowering that for the west coast, continuing, of course, the pertinent observations.

Racial studies among herring have had as their objective, firstly the defining of the individual geographical populations, if possible, and secondly, the extent of their intermingling. The first is accomplished by analyses and statistical comparisons of length and weight ranges, age class representation and vertebral number, the second by tagging and recovery of the populations in individual areas.

For the older-established areas of the east and west coast of Vancouver island the racial studies have been completed and have shown, on the east coast, very definite segregation of the geographical populations with practically no intermingling. On the west coast, the races are distinct but a certain small degree of mixing does occur. For northern areas the studies have been but recently commenced and in some newly-exploited districts information is being obtained for the first time. From samples of herring taken from northern catches Dr. Boughton reports that all areas show distinct rates of growth and that significant differences in "condition" are so apparent that between the four major areas extensive intermingling is unlikely. With respect to vertebral counts and age composition, also, the differences indicate that intermingling was either limited or absent, with one exception.

The tagging experiments, carried out by Dr. Hart, Dr. Tester, Mr. McHugh and Dr. Boughton, reveal much more directly the migratory habits and intermingling tendencies of the individual herring stocks. The returns obtained during the 1940-41 season confirm earlier evidence that for practical purposes the herring of the major areas, i.e., east coast of Vancouver island, west coast of Vancouver island, Queen Charlotte sound, central coastal area, northern districts, may be regarded as separate units with but a small amount of interchange. Ninety-six per cent of the tags were recovered in the same general area in which they were inserted.

The recent increase in herring canning has very significantly affected the herring tag recovery work. The tagging methods were originally devised a number of years ago when the bulk of the catch was taken to reduction plants. In these latter, magnets placed in the meal line recovered the tags. Where herring are canned, however, and in spite of the fact that the offal is taken to reduction plants, the recovery of tags has been low, suggesting that the tags are either being lost in the process or are being canned with the fish. Two induction detectors are in operation which segregate out the fish containing tags as they pass up the conveyer to the plant. These installations are costly and require constant attention, hence are restricted to the most important plants. If herring canning on an extensive scale is to continue, as seems likely, new methods must be inaugurated, either to improve recovery methods or adopt a new tagging system.

### Pilchards

During 1941, approximately 52,000 tons of pilchards were taken by the British Columbia fleet, the largest catch since 1938. Availability calculations derived by Dr. Hart indicate that the fish were more readily available to the fishermen than in any year since 1934, the average catch per seine for the season being 2350 tons. In 1940 it was 1175 with a catch of 28,770 tons and in 1939, 210 tons with a catch of only 5,523 tons. These records show the variability of the pilchard fishery, dependent largely on the extent of the general population which moves north from California waters and its age class composition, since indications have been that only the older fish come as far north as the British Columbia coast.

However, the 1941 population was characterized by the very small size of the fish, none as small having been taken for several years. The unusual abundance, then, in 1941 was evidently due to the presence of two or more abundant year classes of young fish and the development of suitable hydrographic conditions which brought these young fish into the areas.

During the year 21 tags were recovered in British Columbia, 18 of which were of California origin, one from Oregon and the remaining two from British Columbia. In addition, two B.C. tags were recovered in Washington waters and one in California. Three of the California tags had been out for a full four years, six for three years, six for two years and three for one year.

During 1941, one thousand pilchards of the 1939 year-class were tagged at Pender harbour in the strait of Georgia. Other taggings of this year class in other B.C. areas are proposed. The tagging of pilchards in outside waters off the B.C. coast has been discontinued because of the unsuitable condition of the fish for tagging and lack of necessary equipment.

Pilchards of the 1939 year class which invaded British Columbia waters in such unusual numbers last summer, 1940, continued to show up abundantly around the coast. Though heavy mortality occurred during the winter in certain areas, Saanich inlet and Pender harbour, a large part of the population apparently survived. Observations by California authorities indicate that the 1939 year class was unusually abundant along the Pacific coast and therefore may contribute materially to the catch when they enter the fishery.

During 1941, young II year pilchards of the 1940 spawning were observed in west coast areas but not on any large scale.

### Ling cod

The ling cod fishery is an important contributor to the fresh fish trade and information is desired by the Department of Fisheries particularly on rate of growth, age classes and migratory habits of the species

in order to prepare suitable regulatory measures. The investigation conducted by Dr. Hart has been hampered because of limited funds and the unsuitability of the commercial catch as a medium for acquiring the necessary samples.

During the 1941 season migration studies were confined to the tagging of 168 individuals. Of these, however, 16 were subsequently recovered in the commercial catch. In addition, 17 tags of earlier taggings were returned. Of the total 33 recoveries, 14 showed no movement from the area of tagging, 16 indicated slight migration while 3 were taken at some considerable distance.

Preliminary study of the relationship between fecundity of ling cod and size, an important feature in conservation, shows generally that over the size range from 800 to 1100 mm. while length increases 38 per cent weight increases 163 per cent and egg number 250 per cent. Further data are being collected.

#### MISCELLANEOUS STUDIES

##### Smelt

During the year Dr. Hart and Mr. McHugh brought together and prepared for publication as a Bulletin, the existing information concerning the four species of smelt in British Columbia. Two of the species, the capelin and long-finned smelt, are of no commercial value but the surf smelt and eulachon are marketed fresh to some extent, the latter being utilized as food on fur farms.

##### Anchovy

Within the last few years this species has appeared in considerable numbers in west coast of Vancouver island areas and also in the strait of Georgia, frequently mixed with pilchards. Some of them have been caught for reduction purposes. Preliminary sampling by Dr. Hart has been undertaken and has shown that in both 1940 and 1941 anchovies of the 1939 year class were present on both coasts of the island, that on the west coast individuals of the 1940 year class were present this summer, and a school of small fish of a 1941 spawning was observed.

##### Albacore

In 1941 a considerable quantity of these fish was taken by Canadian boats off the Washington and Vancouver island coasts. It is planned to make a study of these fish, particularly with reference to size frequencies and natural food.

##### Rocky Mountain Whitefish

Data collected in past years, relative to food, growth rate and racial characteristics have been brought together by Mr. McHugh and prepared for publication.

Dog-fish

In the summer of 1941 a preliminary tagging program was commenced, using a double disk celluloid tag on the snout of the fish. Only 98 fish were tagged during July but already 3 tags have been returned. A second tagging effort is now under way in the southern waters of the strait of Georgia.

HYDROGRAPHY

The hydrographical research during 1941 has been confined largely to two major projects, the continuation of sea water observations along the British Columbia coast and the initiation of a hydrographical survey of Alberni inlet.

During the year, sea water samples were taken by the lightkeepers at eleven lighthouses on the coast, through the co-operation of the Department of Transport, and at three special stations, Departure bay, Prince Rupert harbour and in the Fraser river at New Westminster. From the temperature, salinity and density determinations so collected, the trend of conditions in the sea along the coast may be traced and correlated eventually, it is hoped, with the movements of fish, etc. Long-term series of data are necessary before the results are of much significance.

In May the investigation of Alberni inlet was commenced by Mr. Tully, the M.V. "A.P. Knight" having been transferred from Nanaimo for this purpose. After the necessary preliminary field work such as selecting stations and erecting suitable markers, developing a routine, etc., had been carried out, the programme of intensive observations commenced on May 28 and was continued to July 19. Trouble then developed with the engine and the manipulation of the variable pitch propeller and made it impossible to maintain the regular schedule of observations up and down the inlet. Subsequently the work was reduced and confined to the head of the inlet so that the conditions in the head during the presumed critical summer low-water period might be determined. On September 15 the operations were terminated and the "A.P. Knight" returned to Nanaimo. The data collected during the year are being analyzed by Mr. Tully in an effort to determine what leads, with respect to future work, the interrupted observations may reveal.

No plankton collections were made in Alberni inlet in connection with the investigation. During the summer, however, Dr. A.H. Hutchinson devoted considerable time, as a voluntary worker at the Station, to the development of a suitable routine plankton collecting and analyzing technique.

During the year Mr. Tully endeavoured to carry forward the writing up and submission of his wealth of oceanographical data pertaining to the strait of Georgia, Juan de Fuca strait and west coast of Vancouver island. Much field work was accomplished in earlier years and the results will form a valuable contribution to our knowledge of the movements of coastal waters and their relation to the migration of salmon, herring, pilchards, etc. The data are of little value when buried in files.

Recently Mr. Tully has developed a theorem of turbulent flow which will be of direct application in studying the volume transport of water and current velocities in coastal areas. Heretofore the only methods available were current meters, chip logs, and the application of Bjerknes' theorem of pressure differences, all of which were found unsuitable for the studies of coastal channel areas with complicated circulation conditions.

## SHELLFISH

The shellfish research is confined largely to studies of clams and oysters. With respect to the latter, attention has been devoted principally to the determination of the factors which influence the spawning and the setting of the Pacific oyster while for clams problems related to spawning, setting, age class representation, rate of growth, effects of digging, efficacy of regulatory measures, have been investigated.

### Oysters

During July and August extensive natural spawning of oysters occurred in Ladysmith harbour and larvae were present in the water in abundance. However, only a very light spat-fall occurred. In a small lagoon contiguous to Ladysmith harbour, Mr. Quayle had intended to follow conditions closely and with the environmental factors of tide, temperature, etc. more under control endeavour to relate the mortality or the survival of the larvae to certain effects. However, the manipulations within the lagoon were not successful. It is now suggested that small-scale laboratory experiments under carefully controlled conditions might prove more productive than tests in situ.

### Clams

At the time of Mr. Quayle's enlistment in the R.C.A.F., Mr. Neave took over the clam work and has continued with the field programs, viz., collection of commercial clam catch statistics, tests of the productivity of clam beaches under varying types of digging, and the collection of material pertaining to age and rate of growth. The material is being worked up and analyses of the data made. A large scale study of the effects of digging in relation to productivity is being planned for the spring of 1942 at Seal island, near Comox. This clam beach has been closed for three years and now supports a heavy population of clams. Reopening under specified experimental conditions is considered desirable.

Of recent years certain logging companies have been using a dynamite treatment to control the damage caused to submerged timbers and logs by teredos. Little is known concerning the effect of such dynamite treatment on teredos or whether the most effective system is being followed. In view of the obvious saving which would accrue, particularly to Government wharves, break-waters, etc. if such a method could be effectively used, tests are proposed. Related problems are the times of seasonal incidence of teredo larval setting and the effects of the dynamite treatment upon fish and other aquatic life in the vicinity.

## FISH DISEASES

### Furunculosis

During 1941 Dr. Duff continued further tests of the orally administered vaccine developed at the Stanley Park Experimental Hatchery to prevent the occurrence of furunculosis among hatchery-reared trout. By the end of July three tests had been made which gave an average result of 26.3% mortality in vaccinated and 71.1% in untreated cutthroat trout, all of which had been previously infected with B. salmonicida. During August-October a different method of infecting the test fish was attempted, more in keeping, it was felt, with natural conditions. Of 30 non-vaccinated fish, 9 became infected whereas among 30 vaccinated individuals only 3 took infection.

A suitable vaccine having been finally developed, there seemed no need to prolong the investigation, hence on October 31st the work was terminated. Through a grant-in-aid from the special Research Fund of the University of British Columbia, work was carried out on the use of inexpensive growth media. Stock cultures of the bacterium and supplies of the vaccines will be retained at and made available from the Bacteriological Laboratories of the University of British Columbia.

## OTHER INVESTIGATIONS

Taxonomic studies of marine polychaete worms were continued during 1941 by Mr. and Mrs. Berkeley. Collections from various regions of the Pacific Coast of Canada have been examined as well as specimens from Alaska and Bering Sea.

Mr. Munro, Chief Migratory Bird Convention Officer for British Columbia, spent the early spring and late fall months at the Station continuing his study of the economic relations of water-fowl, with particular reference to the food habits.

During the summer, Dr. D.C.G. MacKay completed the preparation of a Bulletin on the Pacific Edible Crabs of British Columbia. Fishing methods, descriptions of the various developmental stages, moulting, time of maturity, etc. are discussed.

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- Cameron, W.M. Killer whales stranded near Masset. Prog. Repts. Pac. No. 49, Sept.
- Carl, G.C. Beware of the broken egg. Prog. Fish-Culturist, No. 53, Jan.- Feb. (See also under Neave, Ferris).
- Foerster, R.E. The mortality of young pilchards. Prog. Repts. Pac. No. 48, June.
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1941

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A.L. Pritchard

No. 1

Natural Propagation of Pink Salmon in McClinton Creek, Masset Inlet,  
B.C. - The Fry Migration in the Spring of 1941

The investigation of the natural propagation of pink salmon was continued in 1941 at McClinton creek, Masset inlet, with the count of the fry migrants leaving the stream in the spring. The data collected are now complete for six cycles, viz.- 1930-31, 1932-33, 1934-35, 1936-37, 1938-39, and 1940-41. The present report gives certain detail of this year's work and submits a general table of counts for comparative purposes.

The first fry migrating seaward was taken at the fence on February 11. Thereafter until March 6 only a few individuals appeared. From March 7, when 245 were taken, the numbers increased. The main portion of the run, amounting to over 70,000 per day, took place between April 3 and May 1, with a maximum of 571,000 on April 28. The migration was approximately two weeks earlier than usual, a condition reported as being fairly general on the coast and ascribed to the comparatively moderate autumn and winter conditions.

The counting fence was operated from February 11 until May 29, a total of 108 days. Water conditions were particularly favourable in that it was necessary to remove the screens on only four nights, - at 2.00 A.M. on March 23, and all night on March 6, May 15, and May 18. It was fortunate that two of these mishaps occurred early in the run when few fish were migrating and that the other two took place when the run was almost over. Even if the fish which escaped were neglected entirely, it is felt that the resulting error in the figure for hatching efficiency would be small. Estimates have been made, however, using certain incomplete counts and the general qualitative knowledge of the behaviour of the fry during migration. The figure is set at 28,000.

The total number migrating, 5,060,725, was calculated as follows: counted - 2,030,979, weighed - 2,995,746, and estimated - 28,000. Since the potential egg deposition was determined to be 26,500,000, the hatching efficiency can be seen to be 19.0.

The following summary includes the counts for six cycles at McClinton creek:

Year	Males	Females	Total	Av. No. of Eggs	Potential Egg Deposition	Fry Migrants	% Hatch
1930	32,955	33,198	66,153	1,535 ± 12	50,950,000	5,384,000	10.6
1932	8,003	7,599	15,600	1,758 ± 15	13,360,000	2,230,000	16.7
1934	77,477	77,710	155,196	1,799 ± 11	139,000,000	12,600,000	9.1
1936	24,221	28,091	52,312	1,899 ± 12	53,345,000	3,675,000	6.9
1938	5,549	5,028	10,577	1,698 ± 19	8,500,000	2,020,000	23.8
1940	19,071	16,454	35,525	1,619 ± 17	26,500,000	5,061,000	19.0

In a Summary Report for 1939 the writer pointed out the fact that the small spawning of 1932 had given rise to the high percentage hatch of 16.7, while that of 1938 produced 23.8%. Thus the relatively small deposition of both years was compensated to a certain extent by the raised efficiency. This advantage was further maintained this season by the 19% return. The fry migration was almost as large as that from the 1930 run where nearly twice as many eggs were involved.

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General conclusions are certainly not warranted without the accompanying intimate discussion of the results. However, attention should be drawn to the fact that from the three relatively small egg depositions, namely, 1932, 1938, and 1940, significantly higher percentages in fry migrants resulted. It is frankly admitted that these do not produce as many young fish in actual numbers. The phenomenon indicates, however, a strong resilience on the part of the species, and suggests that it may build up quickly from a reduced population.

A.L. Pritchard

No. 2

Efficiency of Counting, Weighing and Estimating in Assessing Numbers of Pink Salmon Fry

In the preceding Summary Report, the total count of fry was shown as divided under three captions, viz.- counting, weighing, and estimating. The first two methods might be termed direct and the last indirect. In order to gain an idea of the general accuracy of the whole experiment, it is necessary to assess the efficiency with which all three procedures may be carried out. Each year, insofar as possible, experiments have been conducted to check. The following report summarizes the results obtained during the migration of 1941 and makes comparison with those of other years.

Counting - In the actual counting manipulation, a number of fry are placed in a shallow cheesecloth tray set in a trough filled with water. From this they are dipped with a dessert spoon three or four at a time into a deep wire basket which is also suspended in the same trough. Each hundred is rung on a tally hung in a convenient location. The method of checking involves having the complete crew of workers count out a number of fry which are transferred to a retaining trough, in this case in the eyeing station on the premises. Later a direct recount is made or the number is obtained when the fish are marked out. The difference in the two counts is taken as the possible error.

The following data were obtained from the 1941 experiments:

Date	First Count	Second Count	Error
May 2 & 3	10,156	10,196	+40 or + .4%
May 6	3,857	3,934	+77 or + 2.0%
May 8 & 9	4,520	4,471	-49 or - 1.1%
TOTAL	18,533	18,601	+68 or .4%

The error obtained in 1941 was slightly larger than that shown by the combined checks for 1933 and 1937, .4% as compared with .1%. It still remains so small as to be almost negligible, amounting in the total count of 2,000,000 fry to approximately 8,000 individuals.

Weighing - The method of weighing which was employed this year was similar to that which was previously described in some detail in a Summary Report in 1939. Briefly, a number of fry were poured from a dip net into a wire basket and weighed on a Pelouse dairy scale. Certain of the weighed groups were counted before release while others were dumped without counting. From the ratio obtained between the weight and numbers in the groups counted each day, the fry released without counting could be assessed. Error was minimized by having the same operator carry out all the weighings in as nearly as possible the same manner.

To gain some idea of the accuracy, certain groups which would ordinarily have been dumped without counting were transferred to the hatchery troughs. Later, when the fish were being marked, the actual count was obtained.

The following table lists the results of nine such tests:

Date	Weight in lb.	Estimated No.	Actual No.	Error
April 19	8.37	13,905	13,844	- 61 or - .4%
" 19	8.47	14,071	13,938	-133 or - 1.0%
" 20	8.43	13,692	13,542	-150 or - 1.1%
" 20	8.70	14,131	14,061	- 70 or - .5%
" 21	8.92	14,347	14,548	+201 or + 1.4%
" 21	8.43	13,559	13,664	+105 or + .8%
" 22	8.57	14,087	14,013	- 74 or - .5%
" 30	12.25	19,159	19,973	+814 or + 4.1%
May 1	<u>9.47</u>	<u>15,053</u>	<u>15,380</u>	<u>+327 or + 2.1%</u>
TOTAL	81.61	132,004	132,963	+959 or + .7%

The errors listed above appear quite uniform with the possible exception of that obtained on April 30. In this case the large discrepancy may be due to the fact that near the end of the period of the pink salmon fry migration large numbers of coho and chum salmon fry make their appearance. The mixture of these three species of fry of different sizes lowers the accuracy of the operation.

If the nine experiments are gathered into one, the error amounts to 959 fish or + .7%, a figure which agrees very closely with that obtained from the combined data for 1931, 1935, 1937, and 1939, namely - + 1.1%. In 1941 when approximately 3,000,000 individuals were weighed, there was possibly an over-estimation of about 21,000 fry. This is an amount which is almost negligible in the calculation of the efficiency of hatching since such large figures are involved.

Estimating - The error caused in the final calculations by estimating the run of fry during the period when the fence is out will, of course, vary from year to year. In the spring of 1941 weather conditions were such that it was not necessary to remove the screens for any extended time. The fence did not operate for three complete nights. On March 6, the first of these, the migration was just beginning to increase and amounted to only 200 to 300 per day. On May 15 and 18 there were only 3 or 4 individuals showing every twenty-four hours. Partial loss

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of count occurred on March 23 when the fence was lifted at 2.00 A.M. The fish which escaped were estimated by calculating the number taken per hour of darkness up to the time of lifting and multiplying that figure by the hours which remained before dawn. It is considered that, if anything, this assessment would be high because the fry are known to drop off sharply with the approach of daylight. In all the number which escaped without capture is set at 14,000.

If the error of estimation is considered to be double that which has been set, viz.- 56,000 instead of 28,000 -, the total discrepancy for the year could possibly be: counting - 8,000; weighing - 21,000, and estimating - 56,000 or 85,000 fry. This amount would change the figure for the efficiency of hatch from 19.0 to 19.3% which is a negligible quantity.

A.L. Pritchard

No. 3

Pink Salmon Marking Experiments During 1941

During the autumn of 1940 recoveries were obtained from another marking experiment on pink salmon fry from McClinton creek, Masset inlet. The results have been presented in the Summary Reports for that year (No. 3, Page 3) and in Progress Report (Pacific) No. 48. Three facts were worthy of note. In the first place, at McClinton creek itself only 2.2 per cent. of the marked fry were recaptured as compared with 8.8 per cent. of the unmarked. In the second place, spawned out individuals lacking both ventral fins (the McClinton mark) were discovered in two other rivers tributary to Masset inlet. This condition, involving as it does, an emigration of marked fish from McClinton and the necessary acceptance of the belief of an immigration of unmarked fish to McClinton, was considered to account for at least a part of the discrepancy in proportion above noted. In the third place, a relatively large number of returns were received for the first time from south-eastern Alaska. As a result of these findings, it was recommended that further experiments be conducted to check the indications which had already been given.

The mark assigned for pink salmon fry at McClinton creek in 1941 by the co-ordinating agency for the Pacific Northwest was the adipose and both ventrals. This enabled separation from the previous cycle when both ventrals were removed. It also involved the use of more than one fin and thus reduced the chances of confusion with natural deformities. Unfortunately labour conditions were such that it was impossible to get men for marking who had been previously trained. The workers obtained experienced great difficulty in removing the adipose cleanly. This trouble greatly reduced the speed of manipulation and left the chance of confusion if the poorly cut adipose fins regenerated. Accordingly the use of the double ventral mark was again requested and granted. Although this is the same as that of the previous cycle, it is felt that no confusion can possibly arise since no pink salmon have yet been found which were older than two years.

During the early part of the downstream migration 2,469 fry were marked by the removal of the adipose and both ventral fins. The remaining 198,297 out of the total of 200,766 were marked by removing both ventrals

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only. Every effort was made to mark each day while the other fry were running. The number involved, however, made it necessary to mark most heavily at the end of the run when few fry were going to sea. This unavoidable procedure may slightly affect the proportionate return of marked and unmarked adults since the small numbers at the end of the migration may be more subject to predation. This problem is discussed in another report elsewhere in this series, viz.- W.M. Cameron - Mortality of Pink Salmon Fry During Downstream Migration.

#### Recommendations

The writer has pointed out many times that the returns from marking experiments are almost directly proportional to the energy expended in their collection. For this reason examiners should again be placed in representative canneries in 1942 as they were in 1940. Arrangements are again under way with the United States Fish and Wildlife Service to maintain one inspector in south-eastern Alaska and perhaps increase the number. More intensive efforts will be made to ensure that the cannery managers and other members of the industry as well as the officials of the Fishery Department are entirely familiar with the fact that returns are expected.

W.M. Cameron

No. 4

#### Some Physical Characteristics of Pink Salmon Eggs and their Relation to Redd Sampling

In the study of the mortality of pink salmon during its freshwater existence, one aim was to determine the percentage mortality during incubation and alevinage. This figure, calculated from the ratio of dead to live eggs and dead to live alevins, will be sensibly affected by any decomposition of the individuals to a condition in which there is differential recovery of live and dead. A certain amount of experimentation was therefore necessary to permit the correct interpretation of the material recovered from the digging.

During the winter and early spring of 1939-1940, tests were performed on coho salmon eggs at Cowichan lake in an attempt to determine the proper allotment of shells and egg fragments which were known to constitute a small proportion of every sample. A resume of the findings has been submitted in summary report No. 9 for 1940 (page 13). Throughout the winter of 1940-1941, similar and further experiments were conducted on pink salmon at McClinton creek. All the data are presented in brief herein.

##### 1. The source of whole shells in the sample.

Breakage of live or translucent eggs results in the appearance of shells in the collecting net. These shells are typically clean, translucent, and exhibit a single split seldom embracing more than half the circumference. They may represent either live or infertile eggs which have not become opaque. Experimentation involving the crushing of samples has demonstrated that while individual variation is great, there is no significant difference in the resistance of the "chorion" of the two types to rupture.

The proportionate recovery of these categories under natural conditions was checked by burying known numbers of each together and digging them up in the normal way. The discrepancy favoured the fertile eggs very slightly but it was concluded that in the proportions which are known to exist in nature this difference would have no noticeable effect on the final figure.

### 2. The recovery of disintegrating eggs

Dead eggs are known to break at much lower pressures than live ones. Due to the coagulation of the yolk and subsequent infection by fungus, the shells are usually noticeably different from those of live eggs and can be so allotted. It was necessary, however, to check the possibility of lower recovery which might result from disintegration.

In the case of coho salmon, two lots of eggs were expressed from mature females. One of these groups was fertilized. At the end of six weeks in the hatchery, the infertile eggs were agitated to injure the vitellus and allow infection by fungus. One month later the infertile eggs were heavily fungused, soft and broke up readily when disturbed. Equal numbers (250 of each) of infertile and live eggs were counted out and buried together in the gravel of a small stream nearby. They were immediately collected in the normal manner. From the resulting material it was necessary to estimate the number of a great proportion of the infertile eggs by piecing together small fragments. The greater the fragmentation, the less was the relative recovery of the dead. The average figure for four experiments was .72 with a range from .64 to .90.

In the fall and winter of 1939-1940, closely similar experiments were carried out on pink salmon developing in the colder waters of McClinton creek. Here fragmentation was much less and from five tests the range was .94 to 1.00 with a mean relative recovery of .99.

About the middle of February, 1940, five attempts were made to determine the decomposition of eggs which had been killed during the pre-eyed and eyed stages. Instead of burying these samples, they were placed in a large tub with gravel and an effort was made to duplicate the amount of crushing which would occur in the process of excavation. The eggs were then washed into the net and the recoveries examined. In two cases more eggs were obtained than were used originally due probably to piecing together the dead eggs. The average relative recovery of .98 was not significantly different from perfect efficiency.

### 3. Recovery of dead alevins

Dead alevins were handled in a similar manner to the eggs recorded immediately above. The recovery from five experiments was .98 which was remarkably efficient.

Artificial conditions such as were represented in the experiments do not necessarily produce similar results to those present in nature. It was observed that some alevins recovered from redds showed relatively less growth of fungus than those which had been dead for the same length of time in the hatchery. A light growth might possibly be less effective in holding together the dead material and thus cause a lower recovery. The problem calls for more study in an effort to duplicate a variety of natural conditions. At the present time it is proven that the calculation of mortality from excavated collections should be made with caution but there is a general indication of the error involved.

Mortality of Pink Salmon Eggs During Incubation and Early Alevinage

In summary report No. 8, p. 11, for 1940, an outline was submitted of the beginning of a series of experiments designed to produce quantitative information on the losses occurring during the incubation and early alevinage of the pink salmon eggs in McClinton creek. Detail was submitted of the methods of marking the redds, the apparatus and manipulation involved in sampling, and the general treatment of the material. During the winter further digging was carried out until 84 redds were sampled. These were considered to be representative of most of the conditions present in the stream.

For each sample the eggs or fry were immediately designated as live or dead. The live eggs were then separated into two categories viz. 1 - shells and 2 - complete eggs and alevins. The dead eggs were recorded under 1 - shells, 2 - heavily fungused, 3 - pre-eyed, 4 - eyed and 5 - alevins.

To assist in the comparison of results it was considered advisable to calculate the pre-eyed mortality for each sample. This procedure involved the intelligent assignment of dead shells and heavily fungused eggs to their respective categories. The division of the dead shells in the same ratio as the unbroken, lightly-fungused eggs appeared most reasonable. Heavily fungused eggs were allotted in their entirety to the pre-eyed group. Undoubtedly this procedure is open to criticism but any other division produced, in isolated instances, peculiar values which did not seem compatible with the general situation.

A study of the pre-eyed mortality of the 84 redds demonstrated a great variation in the figure over the length of the sampled area (2.1 to 84.3%). It has been observed that there is a tendency for losses in neighbouring localities to resemble each other in magnitude. Isolated exceptions to this tendency are in some cases due to particular conditions peculiar to the small area in which the redd was situated.

It was beyond the capacity of an investigation such as this to dig all redds immediately before the fry emerged from the gravel. Comparison of pre-eyed mortality shown by the samples which were taken early with that of those dug before hatching, showed a difference which was such that it was felt that the mortality shown by the alevin samples was higher than would have been discovered if all the redds had been dug during alevinage. An attempt was made to calculate what the mortality would have been if the digging had all been delayed until just before emergence.

Plotting the mortality shown by the alevin samples against their pre-eyed mortality suggests a definite relation between them. A cubic parabola passing through the origin was fitted to the data and used to calculate the mortality which would probably have been exhibited if the early samples had been dug during alevinage. This method, though an approximate one, permitted the use of all of the available data in estimating the loss during incubation and alevinage.

A study of the derived mortalities in the form of a frequency distribution showed the mean "total" mortality in incubation and early alevinage to be in the neighbourhood of 30%.

Nine redds out of the 84 marked were destroyed by flood action shortly after deposition. The eggs were probably entirely lost. It might be suggested that they would lodge in the gravel downstream. Since, however,

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most of the erosion occurred during the early stages of incubation when the eggs are quite sensitive to jarring, it is possible that they might not survive the disturbance. The possibility of some of the dead eggs being recovered in the collection of other redds must not be overlooked but it is felt that such duplication will affect the average figure very little. The loss through erosion can therefore be approximated at 10%.

The mortality due to superimposition of redds was apparent but was probably largely evidenced in the figure given for redd losses, since the number of eggs uprooted and lodged in adjacent depressions did not make up a large percentage of the total deposition for the area. Five per cent. is considered a maximum limit and will include the eggs lost in spawning under conditions detrimental to their lodging in the redd.

W.M. Cameron

No. 6

The Effect of Physical Conditions on Pink Salmon Eggs During Incubation and Early Alevinage.

In an effort to gain some idea of the effect of the physical conditions of the environment upon the incubation and alevinage of pink salmon eggs, certain observations were made and notes recorded for each of the sample redds which were marked and dug at McClinton creek during the autumn and winter of 1940-1941. Three factors were specially examined, viz.- the size of the gravel, the degree of water circulation, and the general condition of the redd with respect to silting and plant debris. Each of these items was graded according to the following legend:

- Gravel: A - Medium to coarse; B - Fine with a tendency to shift in changing currents, and C - Large rocks or boulders (usually associated with poor circulation, silting and plant debris).
- Circulation: A - Good; B - Fair, and C - Poor.
- Condition: A - Clean; B - Silt; C - Silt and plant debris (twigs, spruce cones, leaves, etc.), and D - Dead branches, logs embedded in redd.

Although these observations were strictly qualitative in nature, a study of the records in comparison with the mortality definitely demonstrated that the best conditions involved medium to coarse gravel, good water circulation and absence of silt or plant material. In some cases good returns were encountered where there was comparatively heavy silting but it is believed that this deposit was of recent origin (probably the result of a freshet) and had not had sufficient time to cause damage before digging was completed.

Mortality of Pink Salmon Fry During Downstream Migration

Pink salmon fry, on emergence from the gravel after completion of alevinage, migrate downstream immediately. The movement to the sea takes place only during the hours of darkness. During the time taken to reach the salt water, the fry are exposed to the depredation of predators. An attempt was made to estimate the losses which might occur from these attacks.

Two methods of studying the problem were evident. The first considered was to examine the food of the predators. In order to reach a final figure for total predation in such a method, it would also be necessary to know the habits, abundance, distribution and behaviour of all the predators. The labour and time involved were manifestly impossible of attainment. The second method which was employed, was to release marked fry at intervals along the stream and calculate the mortality from the number of individuals which were later recovered at the fence near the mouth of the river.

The success of this second chosen method is dependent upon the minimizing of the detrimental affects of marking, transporting and releasing the animals, as well as insuring that they are released in such a way as to react normally. The choice of mark is controlled by the fact that it must be inexpensive and easy of application and of recognition among large quantities of fry, yet it should not handicap the fish in any way. Investigation of the use of stains, scarring, and branding were tried and rejected as unfavourable (Summary Report No. 10 for 1940, p. 14). To date the most satisfactory method was the insertion of variously-colored fine silk threads through the back of the fish under the dorsal fin. The operation was performed under anaesthesia induced by a dilute solution of chloretone. Recovery was rapid and complete. Recovered individuals did not give indication of greater loss than controls when maintained in the protected environment of the troughs.

The general procedure was to select fish at random, mark them and retain them overnight and through the following day in the hatchery. The following evening, when fully recovered, they were taken in quart sealers to the point of release particular care being taken to renew the water on the upstream trip. Retention at the point of liberation for twenty-four hours before release did not appear to affect subsequent mortality so the fish were deposited at selected stations and released on the downstream trip.

On recovery the "threaded" fry appeared to react normally but an effort was made to discover whether there was any differential mortality on exposure to natural conditions. At the beginning and end of the run when the nightly migrations were relatively small so that each fish could be closely examined, fry marked by the removal of fins were handled similarly and released at the same location as "threaded" individuals. For two experiments conducted on March 9 and 12 as the migration was increasing, no difference in susceptibility to mortality could be detected in the various lots. Toward the conclusion of the run (May 5 and May 6) similar tests were made with the result that it was demonstrated that the "threaded" fish were being lost in significantly greater proportion. The reason for the difference in the two sets of experiments is not definite. It is possible that under the degree of predation experienced early in the run (estimated at 50%) there is little or no selection by the predators. As the population of young in the river decreases, the "threaded" fry are taken in increasingly greater numbers. It is also sug-

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gested that the reason for the heavier mortality at the end of the run is an increased capacity in the predator whose appetite might be enlarged and whose diet, exclusively fry, was more limited. It was readily observable that the trout and coho fingerlings were concentrating above the fence, apparently moving down from the upper reaches.

Inspection of the findings suggests that the total recovery was in general determined by the time taken by the fry to get from the point of release to the fence. The more remote stations showed a lower total recovery. The rate of migration was not uniform throughout the season. When the height of the water was above normal, fish moved out more quickly and mortality was relatively smaller than on other days when the stream was low.

This demonstrable increase in mortality with distance travelled indicates the necessity for continual liberation in proportion to the entrance of all fish into the phase of the life history for which estimates are being made. Particularly is this true of fish being marked for migration experiments. The release of a greater proportion of marked fish under conditions tending to excessive mortality may lower the proportion of the marks in the population as a whole.

Realization of the interrelations of the factors causing mortality in a fry migration, prevents a too definite estimate of the losses experienced by the pink salmon in McClinton creek. It is considered however that the mortality should be fairly constant during the main portion of the run. For this reason the losses for the period between March 22 and May 3 are considered. If it is assumed that "threaded" fish during this time did not suffer disproportionately, the figure of 60 per cent. loss due to predation may be considered a reasonable estimate for the main portion of the run.

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General Consideration of Mortalities Occurring in Pink Salmon During their Freshwater Life.

Since the writer has for the time being discontinued the investigation of the mortalities occurring in the life of the pink salmon from the time when they enter fresh water to spawn (Autumn) until the time when the resulting fry migrate to sea (late spring), it is considered appropriate that a general statement of the findings should be made. The results derived from the runs of 1940 are therefore summarized.

Qualitative observations during the adult spawning runs and examination of spawned out females leads to the belief that loss occasioned by the action of predators on the fish and through incomplete spawning is relatively light. It is here placed at approximately 10 per cent. of the potential egg deposition. Mortalities due to the superimposition of redds one on the other was apparent but limited. Five per cent. is considered to be a maximum estimate of the proportion exposed by the action of late spawning females. Mortality due to disturbance without dislodgement will be included in the figure submitted for redd losses. Erosion has been suggested as causing 10 per cent. mortality, since 9 out of 84 redds were completely cut away while the eggs were in an early and

tender stage of development. Loss during incubation and alevinage has been fully discussed in another report and is set at about 30 per cent. No figure is available for the mortality due to non-emergence of fry but a study of water conditions at the time when this occurs and during spawning would lead one to believe that it is not severe. The loss of fry during migration due to predators is heavy having been set elsewhere at 60 per cent.

A tentative table is submitted outlining the estimates in their very approximate value and the proportion of the potential egg deposition which these values will affect:

Mortalities	Percentage of eggs or fry available	Percentage of potential egg deposition	Percentage eggs or fry remaining
Predation on adults and incomplete spawning	10	10	90
Exposed by superimposition	5	5	85
Erosion	10	8	77
Incubation and alevinage	30	23	54
Fry predation	60	32	22

The agreement of the final figure (22%) with 19 per cent. which was the actual efficiency obtained from the enumeration of the runs, is closer than one might expect from the approximate nature of the estimations and should not be accepted as any indication of their accuracy. The study suggests, however, that increase in efficiency may be in the direction of predator control and stream improvement. Decreasing the predator populations should result in an increase in the numbers of fry. In such a programme, however, consideration would have to be given to the fact that some of the predators might be economically valuable in themselves and that the so-called ecological balance might be upset.

The information also suggests that the numbers of adult individuals constituting the spawning escapement may not be the only factor influencing the assurance of an adequate fry migration. In general early migrating adults spawn before those that enter the stream at the end of the run. If these give rise to early-running fry, they may be less subject to predation than those which come later. The establishment of a concentrated spawning period might reduce the effect of predation but might increase losses due to fish having to spawn in unfavorable locations.

Since escapement, predator control, and stream improvement appear to be intimately associated with efficient conservation, continued observation on their interrelation would seem highly desirable.

Racial Studies on Pink Salmon

In the Summary Reports for the Pacific Biological Station for 1940 (No. 11, page 15), a brief synopsis was submitted of a proposed investigation to determine whether so-called racial differences existed between pink salmon runs of different streams. The characters selected to indicate such differences, if they existed, were the number of gill rakers on the first gill arch, and the number of pyloric caeca.

During the 1940 season collections were made from eight streams on the Queen Charlotte islands. The counts and analyses have now been completed and a summary is submitted herein.

GILL RAKERS

In the following table are presented the numbers used in each collection, the ranges and the average.

	Number	Range	Average
McClinton creek	136	27-33	30.32
Deenan river	58	28-33	30.55
Yakoun river	100	27-34	30.22
Mammon river	98	28-34	30.40
Detlamen river	65	28-34	30.34
-----			
MASSET INLET	457	27-34	30.35
-----			
SKIDEGATE INLET (Haan's cr.)	24	27-32	29.83
-----			
CUMSHEWA INLET (Palent cr.)	79	28-32	29.94

If the probable errors of each average are considered in the comparisons, no significant difference exists in number of gill rakers between the collections from any of the rivers in Masset inlet nor between those from Skidegate inlet (Haan's creek) and Cumshewa inlet (Palent creek). A difference was demonstrable between the whole sample from Masset inlet (on Graham island) and that from each of the other inlets on Moresby island. A similar difference was noticeable in most cases when individual rivers from these larger areas were considered.

PYLORIC CAECA

The data for the pyloric caeca counts are tabulated below:

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	Number	Range	Average
McClinton creek	128	106-163	133
Deenan river	55	108-166	131
Yakoun river	104	111-166	133
Mammon river	95	111-156	136
Detlamen river	68	106-160	134
-----			
MASSET INLET	450	106-166	134
-----			
SKIDEGATE INLET (Haan's cr.)	10	107-128	114
-----			
CUMSHEWA INLET (Palent cr.)	79	106-195	136

No significant differences in the pyloric caeca counts can be demonstrated from the above samples with the exception of Haan's creek compared with all the other streams. Little reliance is placed in this variation because the sample used is of such a small size.

In summary the material thus far gathered permits of no definite conclusions concerning racial differentiation in pink salmon. Variations are indicated between rivers in the gill raker counts but none are evident in the counts of caeca. In order to pursue the matter further samples have been taken from southern British Columbia during the present year, viz.- Morrison creek, tributary to Puntledge river on the east coast of Vancouver island, - 100; Harrison river near Harrison rapids, tributary to the Fraser river - 110; Harrison river below railway bridge - ca. 25; Chehalis river, tributary to Harrison river, - 100; Lorenzetti creek, tributary to the Fraser near Hope - 100, Sucker creek, tributary to the Coquahalla river at Hope, - 69. This total of approximately 400 samples is now being worked over.

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No. 10

The Age of Chum Salmon in British Columbia

In a Summary Report for 1940 (No. 12, page 16) the writer pointed out the desirability of making available information on the age of the chum salmon in journals which could easily be procured by the members of the fishing industry and the conservation authorities. The first step in accomplishing this aim was to locate and summarize the data which have already been collected. The second necessity was to obtain further collections from areas which have not been represented and to duplicate in other districts for comparative purposes.

To date approximately 4,600 determinations have been discovered for the following localities: Qualicum, Nanaimo, Chemainus, north coast of the Queen Charlotte islands, and Nootka sound. During the season of 1940, 332 scale samples were collected from fish taken on the east coast of Moresby

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island, Queen Charlotte islands. During 1941 more material was procured with the help of certain canneries as follows: 400 sets of scales from Athlow bay on the west coast of Graham island, Queen Charlotte islands, through British Columbia Packers Pacofi cannery, 180 from the Barkley sound district, west coast of Vancouver island, through British Columbia Packers Kildonan cannery, 542 from the Nootka sound area, west coast of Vancouver island, through Nootka Packing Company's Nootka cannery, and approximately 100 from the strait of Georgia through British Columbia Packers Imperial cannery. Our thanks are extended for the fine co-operation which has been received in this experiment.

The actual examination of the scales and the summarizing of the material is somewhat tedious and will probably consume two to three weeks time. It is hoped, however, that this period will be available during the coming year so that the data on the complete series of approximately 6,000 samples may be presented.

R.E. Foerster and A.L. Pritchard

No. 11

Relation of Egg Content to Total Length and Weight in the Sockeye and Pink Salmon

In the course of the investigations of the natural propagation of the sockeye and the pink salmon in British Columbia, it was necessary to make counts of the eggs contained in a sample of mature females to allow the calculation of an average per individual. From this average and the total number of females in the run, the potential egg deposition was calculated.

The following sockeye salmon were handled at Cultus lake, British Columbia: 1932 - 46; 1933 - 47; 1934 - 75; 1935 - 55; 1937 - 35, and 1938 - 47. In addition 112 females bearing the distinctive Cultus lake mark were taken from the fishing areas in 1933. The total involved was thus 417. For pink salmon at McClinton creek, Masset inlet, British Columbia, the following were employed: 1930 - 97; 1932 - 73; 1934 - 165; 1936 - 91; 1938 - 40, and 1940 - 70, or a total of 536.

All the eggs in each ovary were counted, particular care being exercised to consider only specimens with unbroken ovaries. In order to avoid the introduction of age as a variable factor, only sockeye in their fourth year were considered. This age-class includes the majority of spawners at Cultus lake, and therefore, where the separation on the basis of age was impossible, it is not believed that any appreciable number of older or younger fish was included. Since all pink salmon thus far encountered have been found to mature in their second year, no similar difficulty was apparent.

For both sockeye and pink salmon females, there is a significant positive correlation between the number of eggs contained in the ovaries and 1 - the total length (from the tip of the snout to the middle of the fork of the tail), and 2 - the total weight. The yearly mean number of eggs for the runs, when plotted, show similar trends of increase in each species.

Inspection has shown that for any run the straight line obtained from the original data by the method of least squares, the regression line of eggs on length and eggs on weight calculated from the correlation coefficient

and the "power" curve obtained by applying the method of least squares to the number of eggs and the logarithms of the lengths and weights, for the ranges exhibited, fell very closely together. For this reason the straight line equations were employed for comparisons.

For both species it was evident that the differences in these lines from year to year were not statistically significant, but merely the result of the inherent variability of the sample. Generalized relationships were therefore worked out by calculating the equations of the straight lines for all the data for each species by using the method of least squares on the mean egg numbers for the various length and weight groups. These lines showed that for the ranges involved, for each centimetre increase in length and for each gain of one kilogram in weight the number of eggs rose for sockeye 135 and 1,100 respectively, and for pinks 57 and 472.

Two important implications are suggested:

1. - In the exploitation of salmon any effort which tends to remove larger fish will proportionately reduce the egg deposition and thus militate against the normal conservation of the species.
2. - Since egg content varies directly with size, due caution must be observed in using data pertaining to this characteristic to indicate racial differences between salmon in various streams. Variation as a result of sampling may be sufficient to demonstrate a significant difference between two separate collections from a given run in the same year.

Ferris Neave

No. 12

Natural Propagation of Coho Salmon in Tributaries of the Cowichan River

In continuation of previous investigations, a record was kept of the spawning run of 1940-41 in Oliver and Beadnell creeks, two small tributaries of the Cowichan river. Counts were again made of the fingerlings descending these streams between the beginning of March and the end of August. The work entailed the part-time assistance of one man during about six months.

Figures for the upstream migration of adult fish were as follows:

	<u>Oliver</u>	<u>Beadnell</u>
Total no. of cohoes	810	99
No. of females	293	39
Dead, spent and stripped females	46	1
Females remaining	247	38
Eggs presumed available for deposition at 1,950 per female	481,650	74,100

Downstream migrants resulting from these eggs were counted as follows:

	<u>Oliver</u>	<u>Beadnell</u>
Number of fingerlings	146,279	22,274
Percentage of presumed deposition	30.37	30.06

A few fish remained in Oliver creek when the necessity of providing for the passage of upstream migrants in the fall of 1941 made counting impracticable.

A record was kept of potential predators appearing in the traps with the young cohos. These included yearling cohos and yearling and older brown trout, cutthroat, steelhead and char, in the following numbers:

	<u>Coho</u>	<u>Brown</u>	<u>Cutthroat</u>	<u>Steelhead</u>	<u>Char</u>
Oliver	560	33	608	37	5
Beadnell	1,061	183	316	85	0

While it would seem that the small population of Beadnell creek supported the heavier total population of predators, conclusions on this point would have to take into account the size of individual predators and the relative destructiveness of different species. The cutthroat appears to be the greatest consumer of first-year cohos.

A comparison between the production of cohos in 1941 with findings in previous years is appended.

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	<u>Oliver</u>		<u>Beadnell</u>	
	<u>Potential deposition</u>	<u>Percentage trapped as fingerlings</u>	<u>Potential deposition</u>	<u>Percentage trapped as fingerlings</u>
1939	330,176	14.42	-	-
1940	665,280	11.84	433,440	40.01
1941	481,650	30.37	74,100	30.06

Ferris Neave

No. 13

Return of Marked Cohos of 1937 Brood Year

The 1940-41 coho run in the Cowichan river included fish which had been marked as fingerlings at the Cowichan lake hatchery. Records of these marked cohos from salt water were given in a summary report, 1940. Data regarding the number returning to certain spawning grounds are presented herewith. This information was obtained mainly in connection with the investigation outlined in the previous report.

The marked fish (25,739) were the hatchery-raised product of 146,277 eggs collected from seventy-four females entering the Oliver creek and Beadnell creek traps in the run of 1937-38. They were released in the upper Cowichan river in the fall of 1938 and spring of 1939.

In the spawning run of 1940-41, 315 marked fish were trapped in the two creeks from which the eggs had been taken, this number representing 36.7 percent of the total run of 858 fish of this brood year. Since the eggs from which the marked fish were derived represented only 19.4 percent of the estimated deposition in these streams, mortality of the hatchery fish would seem to have been considerably less than that attending natural propagation in this instance.

An additional twenty-five marked cohos were caught in the upper Cowichan river, thus accounting for 340 which had reached the neighbourhood of their spawning grounds. In view of evidence (through tagging of fish caught in the river) that a considerable number of marked fish did not enter Oliver or Beadnell creek, it is unlikely that fewer than 400 returned to the upper Cowichan river. This would represent a return of 1.55 percent of the fingerlings released, or 0.273 percent of the eggs collected.

It may be added that eight cohos bearing the proper marks of the 1937 brood year have appeared in the 1941 run to these streams. It is tentatively concluded that these fish, or some of them, are cohos which have waited until their fourth year to return to fresh water.

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Return of Marked Cohos of 1938 Breed Year

Hatchery-raised fingerlings released in the Cowichan lake pool in October, 1939 were marked as follows:

- Lot 1. Offspring of third-year males and females, 23,544, adipose and both ventrals removed.
- Lot 2. Offspring of third-year females and second-year ("jack") males, 8,567, dorsal and adipose removed.

Six from lot 1 and three from lot 2 were recovered as jacks in the run of 1940-41 at or near the point of liberation.

Further data regarding marked fish have been obtained in the summer and autumn of 1941 by the present writer in collaboration with Dr. A.L. Pritchard.

Recoveries reported from salt water are as follows:

Lot 1.

<u>Locality</u>	<u>Date</u>	<u>No. of returns</u>
Swiftsure banks	July	3
Cape Flattery	July, August	4
Porlier pass	July	1
Hornby I.	July	1
Cape Lazo	July	1
Ucluelet	August	1
Neah bay	September	3
Point Roberts	October	1
Cowichan bay	September, October	6
	Total	21

Lot 2.

Crofton	December, 1940	1
Kyuquot	August	1
Gamano I.	September	1
Cowichan bay	April, October	4
	Total	7

Nine marked fish (of both lots) were reported from a total of 3,560 cohos landed at Cowichan bay between August 23 and October 31.

Return of marked fish to the Cowichan river system was investigated at Skutz falls in September and October and subsequently in certain tributary streams near Cowichan lake. At the former locality 1,189 cohos (including 67 jacks) were obtained, mainly by dip-net. These included twenty-two marked fish of lot 1 and seven of lot 2. Operations here entailed the attention of three men (including an investigator) for two weeks and the part-time presence of an investigator and an assistant for an additional two weeks. All fish

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secured were tagged for the purpose of securing data regarding the size of the run and the percentages of marked and unmarked fish appearing subsequently on certain spawning grounds near Cowichan lake.

Interim figures relating to the spawning runs in Oliver creek and Beadnell creek (from which the eggs were originally obtained) are as follows:

Number of unmarked cohos (excluding jacks)	197
"    "    marked    "	142
Lot 1,	52
Lot 2,	90
Percentage of marked fish in runs	41.9

It is probable that less than half the total run has entered the creeks to date. The investigation is being continued and observations are being made on other tributaries of the Cowichan river system.

A.L. Fritchard and A.L. Tester

No. 15

Studies on the Food of the Coho Salmon in British Columbia

During the three years, 1939, 1940, 1941, during which collections of salmon stomachs have been made from fish taken in the commercial catches, although the major attention was paid to the spring, a goodly number of cohos have also been received. These amounted to 44 in 1939, and 131 in 1940. The returns for 1941 are not yet complete but it now appears certain that a sizeable quantity will be on hand for inspection. The food items have been examined in a similar manner to those contained in the spring salmon.

The following organisms have been identified: Coho salmon (Oncorhynchus kisutch), Lantern fish (Lampanichthys nanochir), Pacific herring (Glupea pallasii), Pilchard (Sardinops caerulea), Anchovy (Engraulis mordax), Sand lance (Ammodytes personatus), Capelin (Mallotus catervarius), Saury (Cololabis saira), Black cod (Anopoploma fimbria), Whiting (Theragra chalcogramma), Hake (Merluccius productus), Rockfish (Sebastes sp.), Red feed (Euphausiids), Amphipods, Isopods, Crab larvae, Goose Barnacles and Velella (Coelenterate).

No attempt should be made to draw definite quantitative conclusions from the data. Such a course is unjustified on the basis of only 175 samples. It may be stated, however, that a wide range of organisms is included in the diet. In addition although fish appear in great numbers, invertebrates occupy a more important proportion than they do in the case of the spring salmon. These studies are being continued in co-ordination with those on the related species.

A.L. Pritchard

No. 16

### Spring Salmon Marking Experiments

During the year 1941 returns were expected from 25,000 spring salmon fingerlings from the brood year of 1937 and a similar number from the brood year of 1938. These were marked on the Cowichan river, the former by the removal of the adipose and right ventral fins and the latter by the removal of both ventrals only. Up to the present no returns have been received.

Several reasons can be advanced for the lack of recoveries. In the first place, the numbers marked each year were comparatively small. If mortality were heavy, only a few individuals could be expected to appear in the commercial fishery and these might easily be overlooked. There is no place on the Cowichan river itself where the springs may be raked and examined. The second explanation of the failure may be in the lack of sufficiently wide advertising of the experiment. At the time of marking the main object was to obtain some idea of what fish were taken in the game fishery in Cowichan bay. The contribution of the Cowichan to the general commercial catch was not under examination. Thus though extensive inspection was made in Cowichan bay itself, other areas were neglected. The third interfering factor was the change in the spring salmon fishery. During recent years individuals of the species have been used principally for the fresh and mild-cure market. In this field extreme care is exercised to procure fish in good condition without blemish (lacking scales or with cuts). If springs are in poor shape or injured, they are immediately graded down to half price or even less. Trollers therefore are chary of removing fin-scars. As a matter of fact they prefer not to report them. A fourth explanation may be that since these fish were held until August before marking, they may well have been retained beyond the time when the natural stimulus to go to sea normally occurs. They may therefore remain at sea an extra year and return next fall, 1942.

In spite of the lack of returns this year further marking experiments are desirable. The spring salmon fishery is highly important and as much information as possible should be obtained to allow sane and efficient regulation and conservation. Not the least important of such data are the migration routes of the various runs. It can readily be realized that no sensible restrictions for a certain river population could be placed unless it was known where the fishery exploited it. Furthermore, with the increase of industrial development on the Columbia river - dams, diversions etc. - some fear is felt for the maintenance of its run which is one of the most important on the coast. It is now an opportune time, therefore, to assess the contribution of a river such as the Cowichan to the general fishery. Although we hope the situation may never arise, it may be that such rivers will eventually be the main support of the industry.

The difficulties listed are not entirely insurmountable. More fish should be marked in any given experiment. Allowance for this has been made by collecting approximately 300,000 spring salmon eggs on the Cowichan this year. A thorough advertising programme should be conducted so that no one will be unfamiliar with the fact that recoveries are expected. A beginning was made during the present year but due to circumstances beyond control, the time at which the start was made was too late. In the next year it is hoped that through the co-operation of the Department of Fisheries, a letter may be handed to each troller who gets a license. During the winter the whole matter will be discussed

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with as many fishermen's organizations as possible and the industry will be fully informed. The actual collection programme will have to be revised to suit the new conditions of the fishery. In this it is hoped that the usual co-operation of the fishery officers and the buyers may be forthcoming. The fisherman can report the mark to the buyer who can keep it separate until inspection can be made by a fishery officer or other accredited examiner. It will thus be unnecessary to damage the fish in removing the scars.

It should be stressed that this effort should be as widespread as possible. There have been at least 50 spring salmon marking experiments carried on in Washington, Oregon and British Columbia from which returns are expected. Every pressure should be exerted to obtain recoveries which will furnish so much valuable information. Already the co-operation of the Washington State Fisheries Department and the United States Fish and Wildlife Service in collecting and paying rewards has been unstintingly offered. No doubt much time will have to be used in advertising and collecting but it would appear that the results would justify the effort expended.

A.L. Pritchard and A.L. Tester

No. 17

Studies of the Food of Spring Salmon in British Columbia in 1941

This is the third year in which spring salmon stomachs have been collected from fishes taken in the commercial catches throughout the fishing areas in British Columbia. During 1939, 333 samples were taken, and during 1940, 467. The results of the analyses have been summarized in Progress Reports (Pacific) No. 42 and 47 respectively. As a result of the analysis in 1939, it was discovered that herring and sand lance were the two most important food items. Red feed (Euphausiids) assumed some prominence in certain districts such as Kyuquot and Barkley sounds. Other fish were taken in considerable numbers. The proportion of the various foods in the diet varied from area to area and from month to month. In 1940, herring, sand lance and pilchards appeared as the three most important items. The addition of pilchards was undoubtedly due to the unusual appearance of large amounts of small individuals of the species along the coast during the spring and summer of 1940. Other conclusions drawn in 1939 were confirmed.

In 1941, an increased effort was made to enlarge the scope of the experiment by increasing the number of collectors, by extending the range of collection, and by thus making available more stomachs for examination. The table which follows will present a comparison of the effort for the three years:

Area of Collection	<u>Number of Collectors</u>		
	1939	1940	1941
Queen Charlotte is. and Prince Rupert areas	6	7	7
Central British Columbia	1	4	3
Strait of Georgia	0	1	5
Cowichan bay	0	1	1
Saanich inlet	0	0	2
Sooke and Victoria	0	0	2
West coast of Vancouver island	<u>2</u>	<u>5</u>	<u>5</u>
	9	18	25

A few collectors have still to make returns but the following have now been received:

Queen Charlotte is. and Prince Rupert areas	149
Central British Columbia	65
Strait of Georgia	51
Cowichan bay	62
Saanich inlet	2
Sooke and Victoria	17
West coast of Vancouver island	<u>309</u>
	655

It is possible that some of the stomachs listed will be found to be devoid of food. In addition a few ocooes may be included. It is fairly certain, however, that the collection will be larger than those of the preceding years and that it will embrace a wider range of territory. To date only about thirty stomachs have been examined from the west coast of Vancouver island with no outstanding discoveries.

#### Recommendations

It must be realized that an experiment such as this has its limitations. The samples obtained from selected individual fishermen at best can only give a sound representation of the food of the spring salmon taken in the commercial catches during the fishing season. It is not the final statement of the diet throughout the life of the fish. Undoubtedly the gear is selective taking mostly larger individuals. Some seasons of the year are not represented. To extend the collection in order to complete the information would involve setting up a major programme, and entail quite sizeable expenditures of money. Until the Fisheries Research Board considers that this is necessary, it is recommended that the investigation be discontinued. The work of the three years has given as much general information as can be expected under the limited conditions.

The Salmon Angling Fishery in Cowichan Bay

In 1941 a record was again kept of angling activities in Cowichan bay. It is felt that these records provide valuable information regarding the relative size and character of the annual spring and coho runs to the Cowichan river and in the case of the latter species an opportunity is afforded for noting the incidence of marked fish among the migrants.

Landings of marked fish and data relating to angling effort were obtained through voluntary assistance from June 4 until August 25. Thereafter, until November 9 an observer was continuously employed. The following statistics were obtained.

	Boats	Lines	Line-hours	Springs		Cohos		Total
				Large	Jacks	Large	Grilse	
June	109	198	558	93	3	16	22	134
July	181	318	838.5	170	2	8	187	367
Aug.	680	1,227	3,477	394	30	19	247	690
Sept. 2	2,015	3,692	11,988.5	824	312	1,205	367	2,708
Oct. 1	1,259	2,451	8,825.5	32	19	2,336	234	2,621
Nov.	78	141	464	0	0	117	5	122
	4,322	8,027	26,151.5	1,513	366	3,701	1,062	6,642

The following table shows comparative figures for three years for the period August 23 to October 31, this period including the most important part of the fishing season.

	1939	1940	1941
No. of boats	2,803	2,464	3,758
No. of lines	5,278	4,629	7,005
No. of line-hours	19,006	16,707	23,319
No. of springs (large)	553	1,121	1,069
(jacks)	750	292	357
No. of cohos (large)	3,410	1,899	3,560
(grilse)	1,069	160	745
Total fish	5,782	3,472	5,731
No. of line-hours per fish	3.3	4.8	4.07

The number of anglers engaged in 1941 was apparently greater than in either of the two preceding years. Cohos were undoubtedly much more plentiful than in 1940 and spring salmon were also present in large numbers.

The fishery does not appear to have any serious effect in reducing the size of the spawning runs to the Cowichan river.

Trout Marking and Recoveries of Marked Fish

In continuation of the trout marking programme, designed to yield information regarding the movements of fish within the river system, the tendency or otherwise of the various forms of Salmo gairdneri to go to sea and the incidence of hatchery-raised fish in anglers' catches, the following liberations of marked fingerlings have been made or are being completed:

	Brood year	Number	Mark
Cutthroat	1940	921	Dorsal & adipose
"	1941	2,044	Both ventrals
Steelhead	1940	34,800	Adipose & right ventral
"	1940	2,976	Dorsal & left ventral
Rainbow	1940	2,976	Both ventrals
Kamloops	1940	109	Adipose & left ventral
Kamloops	1941	50,000	" & " "

The marking of these fish, together with 23,000 spring salmon and kokanee which were also released, represents approximately two months' work by an assistant with part time help by the investigator.

A number of records from previous plantings of marked fish has been obtained in 1941, by gill-netting, in traps and through the co-operation of anglers. These, together with certain other returns, previously unrecorded, are summarized herewith.

Cutthroat

<u>Brood year</u>	<u>Date &amp; number planted</u>	<u>Returns</u>	<u>Date</u>
1937	Apr. 1938 10,000	60	May '38 - Mar. '40
1938	May 1939 1,678	6	June '40 - Jan. '41
1939	Nov. '39, May '40 9,346	35	May '40 - Sept. '41

The returns have all been obtained from localities within a few miles of the point of release but show local movements between lake and river and between river and small tributaries. Growth is considerably greater in individuals which have been caught in the lake than in those from small streams. A few ripe males have been obtained at two and three years of age.

Steelhead

<u>Brood year</u>	<u>Date &amp; number planted</u>	<u>Returns</u>	<u>Date</u>
1938	May '39 7,613	14	Aug. '39 - May '41
1939	Sept. '39 & Mar. '40 35,445	28	July '40 - Aug. '41
1940	Dec. '40 - Jan. '41 37,776	12	Jan. '41 - Oct. '41

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All the above returns were from fresh water except one fish caught in brackish water at the river mouth. Three of the recovered fish had remained in fresh water longer than the maximum period of two years which is usual for sea-running steelhead in this river. Marked fish returning from the sea may be expected in the river during the current winter.

Rainbow

<u>Brood Year</u>	<u>Date &amp; number planted</u>	<u>Returns</u>	<u>Date</u>
1940	Jan. '41 2,976	9	Apr. '41 - June '41

All were recaptured in the course of operations near the point of release, none having reached legal size.

Kamloops Trout

<u>Brood year</u>	<u>Date &amp; number planted</u>	<u>Returns</u>	<u>Date</u>
1937	Apr. - July '38 40,783	0	-
1938	May '39 281	0	-
1939	May - Nov. '40 33,097	20	Sept. '40 - Aug. '41

The twenty fish recovered to date were caught by anglers and in traps in fresh water. Eleven had migrated into small streams and considerable dispersion through the river system from the points of release was evident. The number of returns is considered to be very small in comparison with the number liberated.

Brown Trout

<u>Brood year</u>	<u>Date &amp; number planted</u>	<u>Returns</u>	<u>Date</u>
1937	Apr. '39 303	53	Aug. '39 - Nov. '41

In view of the very low percentage of returns from other species of trout planted in the Cowichan river and similar reports from streams elsewhere, the recapture of over 17 percent of this small planting is of interest. Rapid growth was shown by these fish, which were released at an average length of five inches. An individual captured fifteen months later was nineteen inches long and weighed three and a half pounds. Marked fish of both sexes appeared in the spawning runs of 1940 and 1941 in small streams near the point where they had been released in the river. All returns have been from within half a mile of this locality.

In addition to the marking of hatchery-raised fingerlings, approximately 150 wild trout of larger size have been tagged during the past year as opportunity offered. A number of subsequent records of these fish have been obtained and will be summarized at a future date in connection with other tagging operations.

Efforts will be made during the next few months to recover as many as possible of the marked and tagged trout previously released in the river system.

Studies on the Steelhead Runs of the Cowichan River

The investigation of the status and life history of the anadromous steelhead has been continued, through examination of scale samples and the recording of anglers' catches.

During the winter season (January to March, 1941) anglers in general were less successful than in the two previous years, on the basis of number of fish caught per unit of effort involved. Available records show that one fish was landed for an average of 5.8 hours of fishing, as compared with 4.91 hours and 3.46 hours in 1940 and 1939 respectively. The reduction in catch was apparently due to a relative scarcity of fourth year fish, which in previous years have constituted the greater part of the winter run.

Percentages of Age Groups

Age in years	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	
1938	0	3	75	21	0	(61 fish)
1939	0	4	82	11	4	(82 " )
1940	0	15	68	17	0	(147 " )
1941	1	15	41	40	3	(115 " )

The average weight (9.39 lb.) was about 1 lb. greater than in the two previous years, due to the higher percentage of fifth year fish caught in 1941. The reduction in number of fourth year fish is not considered to indicate any depletion caused by overfishing, since observations show that the number of fish taken by anglers in recent years has constituted an insignificant part of the run.

Returned adults, grouped according to the age at which they had gone to sea, show the following distribution:

	Percentages		
	<u>1 year</u>	<u>2 years</u>	<u>3 years</u>
1938	68.9	31.1	0
1939	64.64	34.15	1.22
1940	53.06	46.25	0.68
1941	43.50	56.50	0

Observations on migrating fish indicate that the individuals which go to sea as yearlings are usually about five to six inches in length when they leave the river. Most two year old migrants are between six and ten inches long. Since the minimum legal length for anglers is eight inches, it is evident that young steelheads are well protected from depletion by fresh water fishermen.

Steelhead fishing in the Cowichan river is practically confined to the winter-run fish but a spring or summer run is known to occur in certain other rivers and has been suspected in the Cowichan. The question was investigated by means of a trap installed at Skutz falls, which was visited daily by the investigator and an assistant for approximately six weeks. A hundred

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and fifty steelheads were caught between April 3 and May 12, these being probably only a small percentage of the fish passing this point. These fish differed in certain respects from the winter migrants, notably in their smaller average size, silvery appearance and in the relatively high percentage which had spawned in a previous year. Average weight was  $6 \frac{3}{4}$  lb. A high proportion (84 percent) had migrated to salt water as two year old fish. Scales indicated that 8.1 percent of the males and 32.7 percent of the females had spawned in a previous season, as compared with a general average of about 4 percent and 12 percent respectively for winter fish examined during the last four years. Observations showed that many of the spring-running fish spawn in tributaries rather than in the main river. Little or no utilization of the spring run is made by anglers.

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Studies of the Scales of Cowichan River Trout

In view of the desirability of estimating the age of individual fish with accuracy and of determining the effect of physical conditions in the Cowichan river system on growth and habits of the fish, a large number of scale samples of trout has been collected for detailed study in relation to seasonal changes. This study is not yet completed.

An examination of approximately 850 scale samples indicates that while annual "checks" occur, these are not formed during the winter months in the case of trout inhabiting the river. Scale growth in these fish is reduced or stopped during the period July to September, when the water temperatures are at a maximum for the year. New growth commonly commences between October and December and the scales continue to exhibit widely spaced circuli throughout the winter and spring. Checks, therefore, though annual, do not coincide with years of age. Deviations from the seasonal cycle indicated above are evident in the scales of spawning and spent fish. The findings apparently apply to rainbow, cutthroat and brown trout living in the river but it is not certain that fish dwelling in Cowichan lake and in small tributaries show the same scale changes.

Catch Statistics of the Herring Fishery during 1940-41

The collection of daily catch statistics by means of Pilot House Record Books was continued. The object is to determine the quantity of herring removed from each area and the fishing effort expended. From these primary data it is possible to calculate the availability of herring, or, the catch per seine per day's active fishing. Availability figures are of considerable importance in tracing fluctuations and trends in the abundance of herring during the period of fishing, both within a season and from year to year.

The total catch in 1940-41 amounted to over 94,000 tons, a decrease from that of 1939-40 (150,000 tons). Of this, 23.3% was taken from areas north of Vancouver island and 76.7% from areas in the vicinity of Vancouver island.

On the east coast of the Queen Charlotte islands herring were most available to the fishermen at Burnaby Strait just prior to the date of closure (March 18). The average availability was less than that in the previous year (31.0 compared with 42.2 tons per seine per day).

In the Prince Rupert area there was no run to Prince Rupert harbour and the boats fished mostly at Union bay and Wark channel. The availability (14.4 tons) was much less than in the previous year (93.5 tons).

In the Butedale-Laredo area, herring were caught during December and January at Aaltanhash inlet, a new fishing ground. The Laredo inlet run did not appear until after the beginning of March and good fishing was encountered for but a short period prior to the date of closure (March 15). The availability for the season (26.0 tons) was much lower than in the previous year (83.4 tons). Fishing during the late summer and early fall was again tried, but with poor success.

The Bella Bella area was prospected during the fall and winter and scattered catches were made in many localities, such as Lama passage, Kwatna inlet, Spider island, etc. There was no large run to Kwakshua passage and good fishing was encountered there for but one week. The availability for the whole area was low (6.0 tons).

In the Rivers-Smith inlet area, scattered catches were made from FitzHugh sound, Rivers inlet, and Fish Egg inlet, and more regular catches were made from Smith inlet. The availability for the season was low (12.9 tons).

The low availabilities in areas along the central and northern coastline are attributed to the failure of the runs to appear during the fishing season, rather than to a sharp decline in abundance of the populations.

In the Queen Charlotte sound area, the best fishing was encountered at the head of Knight inlet and in Clio channel. Scattered catches were also made from numerous localities, widely-distributed over the area. Many new potential fishing grounds were prospected. The availability (14.9 tons) was much less than in the previous year when the area was exploited for the first time.

Fishing in the vicinity of Discovery passage was spasmodic, and, although the 5,000 ton quota was approximated, the availability (26.7 tons) was much less than in the previous year (60 to 70 tons). The area was closed on Dec. 17.

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New grounds in the vicinity of Jervis inlet were fished during January and February, but with relatively poor results (8.2 tons). The catches were made from Princess Louisa and Sechelt inlets.

Fishing on the south-east coast of Vancouver island was more successful than in the previous year and the quota of 30,000 tons was reached and exceeded by Nov. 25. Single seines, operating at Nanoose bay and at Stuart, Trincomali and Satellite channels, averaged 53.4 tons, compared with 34.2 tons in 1939-40. Their activities were temporarily halted from Oct. 20 to Oct. 30 pending price settlement. Double seines, fishing chiefly in Swanson channel, showed an availability of 100.4 tons, compared with 83.6 tons in 1939-40.

On the whole, fishing on the west coast of Vancouver island was better in 1940-41 than in 1939-40 with an availability of 24.4 tons compared with 18.2 tons. The total catch, 25,103 tons, was still considerably below the 40,000 ton quota. The availability was higher in all individual areas except Quatsino sound, where fishing was a failure. A feature of the season was the "outside" fishing in Nicolaye channel, Kyuquot sound, during the week of Dec. 8-14. In the Nootka area, most of the fish were caught in Tasis inlet; in the Clayoquot area, they were mostly caught at Matilda creek; and in the Barkley sound area, fishing was best at Effingham inlet.

A comparison of availability figures as calculated from daily catch records over the past five years with other data on population abundance indicates that the availability figures reflect annual changes in the abundance of the fishable population only when those changes are particularly great. Even under those conditions, availability figures may be rendered useless as a measure of abundance of the total fishable population by major variation in those environmental factors governing the time of appearance of the runs and the ease of capture of fish on the grounds.

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### Revision of the System of Collecting Daily Catch Records of the Herring Fishery

The collection of daily catch records of the herring fishery has been underway over a period of eight years (1933-34 to 1940-41). During this period, various types of record sheets have been used and various methods of distributing and collecting these have been tried. In 1938-39 the record sheets, in duplicate, were bound together into Pilot House Record Books. In 1940-41, the Department of Fisheries undertook the distribution of these books and brought some pressure to bear to aid in the collection of the records. The books have proven to be popular with the captains of the seine boats, to whom they are given, chiefly because they retain a permanent record of their fishing activities. They have also proven to be highly successful, for in 1940-41, returns were made on 91.2% of the fish caught.

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Recently the whole system of distribution and collection, now proven to be workable, has been turned over to the Department of Fisheries. New Record Books have been printed at the expense of the Fisheries Research Board and further improvements have been incorporated. Each book, bound with a heavy cover, is numbered and the number of the book appears on each page, as before. The record sheets are included in triplicate, a blue first copy for the Fisheries Research Board, a yellow second copy for the Department of Fisheries, and a white third copy for the fisherman. In addition to essential information such as name of boat, name of captain, licence number, etc., space is provided for daily records under the following column headings: 1 - Date; 2 - Time of set; 3 - Catch in tons; 4 - Plant delivered to; 5 - Fishing area number; 6 - Fishing locality; and 7 - Remarks. Column 4 was included at the request of the Department of Fisheries. Column 5 was included for convenience in locating particular grounds listed under Column 6. In this regard, the existing salmon purse seine areas were found to fairly closely coincide with herring fishing areas and have been adopted. A map has been included in the Record Book showing the boundaries of these areas and the number assigned to each, for the guidance of the fishermen. Detailed instructions and six sheets of carbon paper are also included at the front and back of the book respectively.

The books are to be distributed to each seine boat captain when his licence is issued, and at the same time the captain's attention is called to ways in which his records might be improved over those of the previous year from data supplied to the Department by the writer. Instead of submitting the records at irregular intervals as in the past, the captain is to send the blue and yellow sheets to the Department of Fisheries at the end of each week of fishing. In turn, the blue sheets are forwarded to the writer by the Department.

It is believed that the above system will work to the mutual advantage of all concerned. The form of the record sheets may be regarded as final, unless additional information is required by the Department of Fisheries.

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The Sampling of Herring in Southern B.C. in the 1940-41 Season

The sampling of herring catches provides material for studying variation in the relative abundance of successive year classes of fish by means of length and age composition, and for detecting the presence of local populations by means of racial characters.

During the season, efforts were again made to sample the major fisheries as completely as possible. A total of 86 samples, comprising 8,954 individual fish, were taken as follows:

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Area	Fishing Season	Spawning Season
Strait of Georgia		
Swanson channel	(15) 1696	-
Gabriola island	-	(2) 190
Hammond bay	-	(1) 110
Nanoose bay	(3) 286	(1) 110
Bargain harbour	-	(1) 106
Discovery passage	(3) 251	-
West coast of Vancouver island		
Barkley sound	(15) 1539	(2) 220
Olayoquot sound	(1) 110	(1) 74
Nootka sound	(12) 1320	(2) 220
Kyuquot sound	(9) 990	(2) 220
Quatsino sound	-	(1) 110
Queen Charlotte sound		
Head Knight inlet	(6) 477	-
Minstrel is.-Bones bay	(2) 220	-
Retreat passage	(2) 155	-
Simoon sound	(1) 110	-
Belleisle sound	(2) 230	-
Mackenzie sound	(2) 210	-
	(73) 7594	(13) 1360

Samples from Swanson channel were obtained through Inspector A. McKinnon, Ladysmith. Those from Nanoose bay and from the west coast were obtained from the Ucluelet and Nootka plants of the Nootka-Banfield Packing Co. Ltd., and were examined by members of the staff operating tag detectors. Samples from Discovery passage and from the Queen Charlotte sound area were collected, salted and shipped to the Station through the courtesy of Mr. J. V. Hardy, Manager Alert Bay plant, B.C. Packers Ltd. Those taken during the spawning season were from fish caught for tagging purposes by various staff members.

Assisting in the sampling program were Drs. Hart and Boughton and Messrs. McHugh and Quickenden.

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The Length and Age Composition of Herring in Southern B.C. during 1940-41

These studies are designed to trace fluctuations in the abundance of successive year classes of herring in the catches from the various fishing grounds.

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On several of the fishing grounds in the strait of Georgia and on the west coast of Vancouver island, the herring were larger than in the previous two years, suggesting that in 1940-41 there had not been an unusual addition of precociously mature fish in their second year similar to that which had occurred in both 1938-39 and 1939-40. This was borne out by age determinations. The average lengths were as follows: Barkley sound, 199.0; Nanoose bay, 196.0; Kyuquot sound, 195.8; Nootka sound, 195.4; Swanson channel, 192.5; and Clayoquot sound, 184.1 mm. In general, the herring from the Queen Charlotte sound area, except Retreat passage, were small, but corrections for salt shrinkage must yet be made.

The percentage age composition of herring in the various fishing areas in 1940-41 follows:

Area	II	III	IV	V	VI	VII	VIII	IX	X+
Swanson channel	2.8	<u>76.5</u>	13.2	5.0	1.9	0.4	-	0.1	-
Nanoose bay	0.8	<u>79.8</u>	11.2	5.4	2.3	3.5	-	-	-
Discovery passage	6.4	<u>39.3</u>	<u>43.0</u>	4.0	<u>4.8</u>	2.4	-	-	-
Barkley sound	4.2	<u>40.4</u>	38.5	12.8	3.3	0.5	0.2	0.1	-
Clayoquot sound	-	<u>82.7</u>	15.4	1.0	1.0	-	-	-	-
Nootka sound	2.7	<u>80.0</u>	10.6	4.7	1.8	0.2	-	-	-
Kyuquot sound	3.4	<u>80.7</u>	10.9	2.6	1.9	0.4	9.3	-	-
Head Knight inlet	2.4	16.6	<u>22.0</u>	3.2	<u>40.3</u>	5.1	8.4	1.0	1.1
Bones bay, etc.	13.6	<u>51.4</u>	<u>21.8</u>	4.0	<u>4.8</u>	1.0	<u>2.0</u>	0.9	0.5
Retreat passage	11.9	<u>33.1</u>	18.6	6.4	<u>12.1</u>	10.4	<u>6.4</u>	-	1.1
Simoon sound	<u>65.6</u>	<u>30.4</u>	2.0	1.0	-	1.0	-	-	-
Belleisle sound	6.0	<u>72.1</u>	4.6	2.2	<u>6.0</u>	2.2	<u>5.0</u>	1.9	-
Mackenzie sound	23.2	<u>45.6</u>	17.4	2.6	<u>5.4</u>	3.2	<u>1.6</u>	1.0	-

The large percentages of III's in most areas in the strait of Georgia and on the west coast of Vancouver island indicates that the 1938 year class was relatively rich. Two exceptions are Discovery passage and Barkley sound, where in both 1939-40 as II's, and in 1940-41 as III's, the 1938 year class was relatively less well represented than in other localities. The persistence of this difference for two seasons is interesting and suggests the independence of the populations.

The great variation in age composition between samples from different areas in the Queen Charlotte sound area is worthy of note. II's dominated at Simoon sound, III's at Bones bay and Clio channel, at Belleisle sound and at Mackenzie sound, and VI's at the head of Knight inlet. In most areas, both VI's (1935 year class) and VIII's (1933 year class) tended to predominate among the older age groups. These same year classes predominated last year as V's and VII's in some areas. It was fairly difficult to make age determinations from the scales of Queen Charlotte sound fish, particularly in the case of one sample of very large herring from Retreat passage. In general, as was the case last year, the herring from the Queen Charlotte sound area are older on the average than those from older-established fishing grounds in other areas.

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The Spawning of Herring in British Columbia from 1929 to 1941

Considerable time was spent during the year on summarizing the information contained in the spawning reports submitted by fisheries inspectors of the Dominion Department of Fisheries over a 13-year period, and on preparing this information for publication. When completed, it is proposed to submit this to the editor of the Board as a Bulletin.

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Herring Spawning Conditions in 1941

With the cooperation of the Dominion Department of Fisheries, herring spawning reports compiled by fisheries inspectors were again collected in the 1941 season.

The data are presented in tabular form along with those of the previous year for comparison. Where available, information is included on the time spread (date of first and last reported spawnings), the intensity and a comparison with that of the previous year (as estimated by the inspectors), and the intensity index (a roughly quantitative measure of intensity calculated from the reports in a manner explained in the summary report for 1940).

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Area	Time spread 1941	1941	Intensity compared with 1940	Calculated Intensity Index	
				1940	1941
Victoria	Mar.16-Mar.21	M	"similar"	15	16
Cowichan	Feb.12-Feb.23	L	"equal"	49	40
Ladysmith	Jan.29-Apr.12	M	"much lighter"	1018	403
Nanaimo	Mar. 6-Mar.12	M	"same"	548	290
Comox	Mar. 3-Apr.17	M	"less intensive, more extensive"	324	882
Quathiaski	Mar. 1-Apr.25	VL	"very much lighter"	135	503*
Pender Harbour	Mar. 9-Apr. ?	M	"increase"	398	477
Strait of Georgia				2487	2601
Barkley	Feb.10-Apr.15	M	"increase"	223	389
Clayoquot	Feb.11-Apr.11	L	"heavier"	365	183
Nootka	Feb.15-Mar.29	H	"best in 5 years"	214	140
Kyuquot	Feb.12-Apr.19	VL	"light"	39	30
Quatsino	Feb.27-Apr. 6	L-M	"heavier"	94	101
West coast of Vancouver is.				935	843
Alert Bay	Mar. 2-Apr.28	H	"increase"	1698	1424
Rivers-Smith	Mar. 7-Mar.20	M	"increase"		
Bella Bella	Mar.17-Apr. 6	H	"increase"	1182	1555
Bella Coola	Mar. 1-Mar. 7	L	"some increase"		
Butedale	Mar.12-Apr. 2	M-H	"same"	858?	1146
Grenville- Principe	Mar.15-approx.	M-H	"heavier"	30?	57
Skeena	Mar.16-Apr.19	H	"heavy"	624	465
South Q.C.I.	Mar.29-Apr. 5	H	---	1332	1210
North Q.C.I.	end June	?	---	192	?

\*including Bute inlet, unreported in previous years.

The spawning indices are considered to be only very rough quantitative approximations but, in general, they are believed to be more reliable for yearly comparisons than the opinions of individuals. Several cases of lack of agreement between the stated comparisons and those shown by calculation from the data submitted may be seen in the table.

For the strait of Georgia, the intensity of spawning would seem to be slightly greater than that of last year. Included, however, is an extensive spawning in the Quathiaski area at Bute inlet, a locality which may not have been covered in previous years. The intensity was appreciably

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heavier at Comox and Pender harbour and lighter at Nanaimo and Ladysmith than in 1940. On the west coast of Vancouver island, the spawning intensity appears to have been slightly less than in the previous year. It was heavier in Barkley and Quatsino sounds, and lighter in Clayoquot, Nootka and Kyuquot sounds. The index was also lower in the Alert bay area than in 1940. In most of the northern areas it was approximately equal to or slightly heavier than that of the previous year. The usual summer spawning was not observed in Masset inlet, north Q.C.I., although there is some reason to believe that the fish spawned there.

Loss from storms and from the feeding of birds was relatively low in most areas. In the Alert bay area and along the central coastline there were no birds present on several of the grounds, an unusual event.

On several grounds in the strait of Georgia, spawnings took place partly on bare rock rather than on seaweed.

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### A Proposed Study of Herring Spawning Grounds and Improvement of Surveys

Reliable estimates of the absolute size of the adult populations supporting the herring fishery are highly desirable, and perhaps even essential, for the successful pursuance of the herring investigation towards its ultimate goal--to determine whether or not close regulation of the fishery is beneficial and, if so, to determine the optimum catch which will produce the maximum yield over a period of years. Rough estimates have already been made from herring spawning ground surveys conducted by fisheries inspectors of the Dominion Department of Fisheries, but the adequacy of these estimates is very questionable. It is unknown whether or not the surveys could be improved to the point where they would yield estimates of sufficient accuracy for the purpose, but an attempt at this is considered to be worthwhile.

Realizing that there is a scarcity of funds for new lines of research at the present time, it is proposed that a modest start be made as soon as possible in investigating the spawning grounds and improving the records, according to the following programme:

1. Intensive scientific study of one or more typical spawning grounds to determine the best methods to use, the sources of error and the limits of accuracy in quantitative estimates of egg deposition.
2. The preparation of a series of photographs of egg depositions of various intensities (determined by actual count) on various types of vegetation for the guidance of fisheries inspectors and the standardization of their intensity estimates.
3. Standardization of the method used by fisheries inspectors in estimating the extent of the grounds.
4. Compilation of a set of instructions for the guidance of fisheries inspectors, and education by correspondence and by personal contact as to the purpose of the surveys and the need for accuracy, completeness and standardization of method.

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5. Application to the Dominion Department of Fisheries for further support in making these surveys an essential routine duty of each fisheries inspector; and in ensuring that all areas are covered as completely and adequately as possible during the whole spawning season.

If the above programme is carried out, further information will be available as to the feasibility of making estimates of population abundance from spawning ground surveys, and at the same time steps will have been taken towards the improvement of future records.

**RECOMMENDATION:** It is recommended that the spawning ground survey, as outlined in this report, be undertaken and that the Department be asked to cooperate by extending and enlarging its field service so that all essential areas be adequately covered.

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Factors Bearing on the Regulation of the British Columbia Herring Fishery by the Quota System

In a confidential report to the Fisheries Research Board, the Dominion Department of Fisheries, and the B.C. Provincial Fisheries Department, the biological information collected on herring over a five-year period of study was summarized, and its bearing on the regulation of the herring fishery by the quota system was discussed. Much of the information contained in this report was drawn from the work of other members of the staff also working on herring, but the author assumes responsibility for the general interpretation. The report formed a basis for discussion of herring fishery regulations at a meeting held at Vancouver on August 7 and 8, 1941. A summary included in the report is reproduced here, with certain slight amendments:

Background

Catch restrictions were applied to various fishing grounds in B.C. in 1936 as a safeguard against a progressive decline in abundance of the populations, and were to last for a period of five years (1936-37 to 1940-41) pending the results of further investigations.

The Integrity of the runs

**Racial investigations:** These give evidence similar to that of previous years in regard to the essential isolation of the runs to major areas and the probable presence of local runs within the major areas.

**Tagging investigations:** They largely confirm the results of racial analysis, but give more definite information regarding the nature and extent of interchange that is shown to take place. Interchange between major areas amounts roughly to about 5%, and between individual areas on the west coast of Vancouver island roughly to about 35% on the average. The latter varies between areas and between years. The Discovery passage area is supplied in part by fish which spawn towards the northern part of the strait of Georgia.

### Fluctuations in catch and availability

These have been more pronounced on the west than on the east coast of Vancouver island. The east coast fishery has been fairly stable and limited by the quotas. The west coast catch declined to a low level in 1938-39 and then increased to some extent. The restrictions have not greatly limited the catch on the west coast.

### Fluctuations in the runs of spawning fish

These have been studied by the use of spawning reports which are neither particularly accurate nor complete, but represent the best information that is at present available. In the strait of Georgia, fluctuations in spawn deposition have been independent of fluctuations in catch and availability over the period. On the west coast spawn deposition declined to 1937-38 and then increased slightly in subsequent years. On the average, spawn deposition, and hence the spawning population, has been much less on the west than on the east coast over the period.

Estimate of the spawning populations: This estimate is obtained by calculation from spawning reports, making several assumptions. The results indicate that the spawning populations are not particularly large and that fishing mortality averages about 44% of the total adult population on the east coast and 62% on the west coast. The estimate is only as accurate as the spawning reports.

### Fluctuations in age composition

Fish in their second year have been relatively abundant on the east coast and relatively more abundant on the west coast; they represent an unusually early addition of new recruits and their presence on the west coast is not necessarily related to the decline in the catch. Age composition of the Quatsino run has been basically different from that of other west coast runs.

Age composition in terms of abundance: This is calculated from estimates of total abundance of adult fish. On both the east and west coasts, recent year classes may be placed in the following order of decreasing magnitude: 1938; 1937; 1936. However, all three were less abundant on the west than on the east coast and this is the reason for the decline in the latter area, coupled with the action of the fishery. There appears to be no direct relationship between the quantity of eggs deposited and the size of the resultant brood from year to year, but there are indications that in any one year the more eggs deposited the greater will be the resultant brood, but not necessarily proportionately so.

### Action of the fishery

This has been to greatly accentuate a downward fluctuation primarily due to the presence of poor year classes on the west coast.

### The feasibility of the quota system

Biological justification for the quota system hinges on the extent to which increase in the spawning population increases the abundance of the resultant year classes. This is illustrated by calculations. Pending the collection of further information on this point, continuance of the quota system, with further trials at stabilization, seems worthwhile.

A.L. Tester

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Revision of quotas

If it is decided to continue the quota system, this section discusses possible boundaries of areas and possible sizes of quotas for each major fishing district of British Columbia.

The integrity of the conclusions arrived at in this report are dependent on the accuracy of the spawning records and on certain assumptions that have been made in connection with them. The calculations of population abundance are admittedly rough approximations with practically unknown limits of accuracy, but at the present time they represent the best information that is available. The possibility of improving these records is discussed elsewhere.

A.L. Tester

No. 30

"Belly burn" in Nanoose bay Herring

On Oct. 31, 1941, the Department of Fisheries requested information on the nature and extent of feeding of herring at Nanoose bay. Since the onset of fishing, about the middle of October, the fish were said to deteriorate rapidly (within 12 hours) because of the development of "belly burn" due to the presence of "red feed" in the stomachs, thus rendering the fish unfit for canning.

The feeding was investigated on the evening and morning of Oct. 31-Nov. 1, Nov. 3-Nov. 4 and Nov. 7-Nov. 8, using the Fisheries Patrol Boat "Vanidis". Samples were taken and examined from as many different sets as possible.

"Belly burn" is presumably the result of the continued action of digestive ferments or enzymes present in the intestinal tract after the death of the fish, and is characterized by softening, reddening and ultimate rotting of the flesh adjacent to the stomach. The "red feed" was found to consist of Euphausiids, a common food of herring. However, it is rare for herring to feed during the fall and winter, only three other instances having been encountered in over ten years of sampling.

In all, 19 samples each consisting of 100 fish and each from a different set were examined. The results are summarized in the following table:

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	Oct. 31-Nov. 1		Nov. 3-Nov. 4		Nov. 7-Nov. 8	
	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.
Number of sets sampled	2	3	6	4	1	3
Av. percent. of stomachs empty	82.5	93.7	93.3	97.5	99.0	99.7
Av. percent. with trace of food	2.5	2.7	3.0	1.2	0	0.3
Av. percent. 1/4-full or more	15.0	3.6	3.7	1.3	1.0	0
Av. volume of contents per 100 fish (ml.)	33.0	7.0	7.2	4.0	1.0	+

There is evidence, although not conclusive because of the great variation between individual samples, that more food is present in the evening than in the morning catches. If this could be proven, "belly burn" might be reduced by having the fishermen concentrate on the morning fishing.

The results demonstrate that the feeding condition was gradually abating during the course of the study until finally it had practically disappeared. Other samples, taken by Dr. R.V. Boughton at the Imperial Cannery give similar indications. There is reason to believe that feeding was much more extensive and the "belly burn" condition much more acute in the catches made earlier in the month.

The sample in which the largest percentage of fish had food in their stomachs (20%) was kept in a pail for several days and examined at intervals. After 12 hours, and again after 36 hours, there was no outward sign of "belly burn" on any of the fish. After 84 hours, it was evident in those containing food, and was most pronounced in those with the largest quantity of food present in the stomach. It is practically certain that the condition develops more rapidly than is indicated by these results when the fish are subjected to pressure, as would be the case with those at or towards the bottom of the load in a boat-hold. Possibly spoilage would take place less rapidly if the fish were transported in scows.

As samples taken on and after Nov. 3-4 contained such small quantities of food, it seems unlikely that on and after that date any great difficulty would be encountered from "belly burn" in holding the catches for a reasonable length of time prior to canning. Should the feeding again become pronounced, it is recommended that the investigation be resumed.

A.L. Tester and R.V. Boughton

No. 31

Local Populations of Herring in B.C. as Revealed by Vertebral Data

An article is being prepared for publication bearing a title similar to the above, and embodying all of the material which has been collected to date in B.C. waters.

One conclusion, which is important in directing research work along the most profitable channels, is that racial studies of this type are useful in making preliminary general surveys to determine whether there is evidence of lack of interchange between groups, but that they are of doubtful value in yielding information on the degree of isolation or the stability of particular groups. For this reason, the collection of vertebral data from runs in southern waters has been discontinued, thereby materially reducing the time and labour involved in sampling and subsequent analysis. Further consideration of the data may reveal that sufficient general information is available from northern waters to likewise discontinue the collections.

A complete summary of the conclusions will be included in the summary reports for 1942.

A.L. Tester and R.V. Boughton

No. 32

The Relationship of Water Temperatures to the Variation in Mean Vertebral Count of Herring

It has generally been assumed that the gradation along the coast in mean vertebral number of herring is influenced by the water temperatures existing during the embryonic and larval stages of development. However this has been difficult to prove for there has been a lack of reliable information on water temperatures. A spawning sample taken from Masset inlet in the Queen Charlotte islands illustrates an exception to the general gradation and adds to the evidence that water temperature is one of the primary factors responsible for the gradation.

Samples, with the exception of the one taken from Masset inlet, were taken in random routine sampling of the commercial catch. For the west coast of Vancouver island data are given for Barkley sound and Quatsino sound. The data for northern waters have been grouped into four main areas: Southern central, Northern Central, Northern, and the Queen Charlotte islands with the exception of Masset inlet for which the data have been treated separately.

Daily temperature and salinity records are available for several stations along the coast for the years 1940 and 1941. The stations include Amphitrite light at the entrance to Barkley sound; Kains island light at the entrance to Quatsino sound; Ivory island light in the central area; Prince Rupert harbour in the northern area, and Shannon bay in Masset inlet.

The average vertebral counts for the 1934-37 year classes inclusive, the approximate latitude and the average temperature and salinity over the period of spawning and early development are given in the following table. Temperature and salinity data are not available for the south-east coast of the Queen Charlotte islands.

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Area and station	Av. Vert. Count	Latitude	Av. Temp.	Av. Salinity
Barkley sound Amphitrite light	51.840	48°55'	10.0	16.0
Quatsino sound Kains island	51.875	50°30'	10.0	16.2
Southern central Ivory island	52.090	51°40'	8.7	16.5
Northern central Ivory island	52.188	52°40'	8.7	16.5
Queen Charlotte is.	52.109	52°40'		
Masset inlet Shannon bay	51.186	53°45'	15.4	11.7
Northern Prince Rupert	52.325	54°20'	7.7	16.0

From the table it may be seen that, apart from one major exception, there is a general gradation between vertebral count and latitude. The major exception applies to the Masset inlet fish and actually involves all four year classes, although the data for separate year classes are not presented. That latitude is not a primary factor responsible for the gradation along the coast is shown by subjecting the data to statistical analysis. Excluding the Masset inlet data, the positive correlation between mean count and latitude is high and significant ( $r = 0.96$ ;  $t = 7.6$ ); including the Masset inlet data there is no significant correlation ( $r = 0.05$ ;  $t = 0.11$ ).

The abnormally low counts at Masset inlet may be explained on the basis of higher water temperatures prevailing during an abnormally late period of spawning and larval development (June 20 - July 15). In contrast, the main period of influence for the west coast of Vancouver island can be considered to extend from about March 1 to April 15, and from about March 15 to April 15 for the central and northern areas and the east coast of the Queen Charlotte islands.

It can readily be assumed that water temperatures during the period of embryonic and larval development at Masset inlet would be higher than those from other areas under discussion, particularly when the difference in spawning time is taken into consideration. Temperature data for the period 1934-37 are not available. The only records on hand are those for 1940 and 1941, which are years not represented by vertebral data. However, if both the vertebral data and temperature data are averaged they may be considered to approximate general conditions. That temperature is a primary factor responsible for the gradation along the coast is shown by the negative coefficient of correlation between mean vertebral count and mean temperature being very high and significant ( $r = -0.98$ ;  $t = 15.6$ ).

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The results then give evidence that the presence of the gradation in mean vertebral count of herring with latitude is a secondary relationship arising from the primary inverse correlation between mean count and the temperature prevailing during the plastic period of embryonic and larval development.

The mean salinities included in the table appear to vary independently of mean vertebral count, and are not considered further as an environmental factor influencing in any marked degree the number of vertebrae in the backbone.

The work is now in preparation for publication.

R.V. Boughton

No. 33

Comparisons of the Average Length and Age of the Herring Catch in Northern B.C.

Sampling of the commercial herring catch has been continued in the northern waters of B.C. during the past season. The purpose of the investigation is to trace natural fluctuations in abundance caused by variation in the strength of successive year classes. The general scarcity of fish led to extensive scouting operations and resulted in a number of new localities being fished for the first time. A total of 43 samples, containing approximately 4700 fish was taken from both fishing and spawning grounds from various localities throughout the northern waters of the province during the past season. Sampling necessitated three months work in the field. Routine examination required determinations be made for length, weight, sex, age and vertebral number.

The areas exploited were as follows: first the central area in which the major portion of the catch was taken, from Aaltanhash inlet, Laredo sound, Smith inlet and Klemtu passage; second the northern area where practically all the catch was taken from Union bay; and third the Queen Charlotte islands where fish were taken from Burnaby strait, Lagoon bay, Alti inlet, and Bigsby inlet. Aaltanhash inlet, Union bay, Alti inlet and Bigsby inlet were areas from which herring were taken for the first time.

Distinct differences occurred in both average length and age between samples from the three major areas and considerable variation occurred between samples from different fishing grounds around the Queen Charlotte islands and in the central area. In average length the samples may be arranged in the following order: Bigsby inlet 205.8 mm.; Burnaby strait 190.0 mm.; Klemtu passage 185.0 mm.; Union bay 184.0 mm.; Lagoon bay 180.8 mm.; Smith inlet 167.4 mm.; Aaltanhash inlet 164.3 mm.; and Bella Bella 149.2 mm. The great variation between localities is evident.

Differences in average age are also apparent. These are illustrated by the following figures giving average and dominant age groups (latter in brackets); Bigsby inlet 5.3 (IV); Burnaby strait 5.3 (III); Klemtu passage 4.3 (IV); Union bay 4.2 (IV); Alti inlet 4.2 (III); Laredo sound 3.8 (III); Lagoon bay 4.2 (III); Smith inlet 5.1 (III); and Aaltanhash inlet 3.4 (II).

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Comparison of average length and age with samples examined last year is only possible in five cases. With the exception of the Klemtu passage herring, which have always varied in average length and age from year to year, the data illustrate that there has been a decrease in average length and age. This decrease is shown by the following figures (average age in brackets): Union bay (compared with Prince Rupert harbour) 184.0, 194.3 (4.2, 5.1); Laredo sound 181.9, 199.7 (3.8, 5.5); Burnaby strait 190.0, 202.7 (5.3, 5.7); Lagoon bay 180.8, 188.4 (4.1, 4.2); and Klemtu passage 185.0, 143.7 (4.3, 2.5).

Examination of the data from previous years may possibly disclose the cause of the decrease in average length and age during the 1940-41 season. Previous studies suggest that in 1938-39 there was a premature entry of herring belonging to the younger year classes into the commercial fishery. Fish belonging to these same year classes apparently failed to return in normal numbers in 1939-40 (possibly due to fishermen capturing a large proportion in 1938-39). The partial failure of these younger year classes in 1939-40 in all probability accounted for the increase in average length and age of the fish. Data for the 1940-41 season suggest that herring belonging to the younger year classes again entered the fishery in large numbers which resulted in a general decrease in average length and age when compared with the 1939-40 season.

R.V. Boughton

No. 34

Racial Studies (Length-weight Relationships) on Herring North of Vancouver Island

Differences in length, weight and age relationships are being employed to supplement the work on vertebral counts and age composition, with a view to procuring additional evidence of the extent of intermingling of herring runs north of Vancouver island. The affinities of the Aaltanhash inlet run to the other major herring runs adjacent to the mainland (namely Laredo sound, Smith inlet and Union bay) has not been clearly shown by studies on vertebral counts or age composition. Vertebral studies have not demonstrated lack of extensive intermingling between the runs to Aaltanhash inlet and Laredo sound. Evidence that intermingling is limited or absent between the run to Aaltanhash inlet and those to Smith inlet and Union bay has only been clearly demonstrated for one year class in each case. In the case of age composition significant differences occur between individual samples from the Aaltanhash run. This variation makes the task of comparing differences a difficult one. Length-weight studies, however, clearly demonstrate the individuality of the runs under discussion. Figures for the average length and weight at each age follow:

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Locality	II	III	IV	V	VI	VII	VIII	IX	
				length					
Smith		154.6	165.0	172.4	172.9	175.7	180.6	190.2	
Laredo		173.1	184.3	191.4	197.1	204.1	208.1	211.0	
Union	145.6	171.6	183.6	194.0	200.3	206.3	214.5	221.0	
Aaltanhash	134.4	165.7	188.0	199.5	205.3	215.5	216.2	223.5	
				weight					
Smith		43.3	53.3	60.0	61.4	65.1	70.9	84.2	
Union	30.7	56.3	70.6	84.5	92.5	102.7	113.9	115.0	
Laredo		64.9	79.7	95.8	99.8	112.6	121.3	125.5	
Aaltanhash	25.7	57.9	94.6	116.1	124.6	144.3	148.4	166.4	

All areas show a distinct rate of growth. With the exception of the III year old group, fish of a given age from Aaltanhash inlet are longer and heavier than fish of the same age from Laredo sound. Union bay fish are outstanding in being lighter, but nevertheless longer (except in the III's and IV's) at all ages than fish from Laredo sound. Herring in the northern areas rarely enter the commercial fishery before they are three or four years old. Such groups of fish, therefore, would only migrate to feeding grounds characteristic of the run the following spring. Because of this would not expect differences in length and weight to be as great or consistent in the younger age groups as in the older age groups. This condition then may account for the exceptions mentioned above in the III and IV year old fish.

Differences in the length-weight relationship may be further emphasized by comparing the "condition"  $\left( C = \frac{1,000,000 \text{ weight}}{\text{length}^{3.3}} \right)$  of the fish at different ages. Figures obtained for the various runs were as follows:

Locality	II	III	IV	V	VI	VII	VIII	IX
Union	2.24	2.44	2.39	2.44	2.35	2.36	2.31	2.11
Smith		2.58	2.56	2.50	2.54	2.61	2.53	2.53
Laredo		2.69	2.66	2.83	2.68	2.69	2.71	2.68
Aaltanhash	2.49	2.73	2.96	2.98	2.92	2.88	2.92	2.94

The table clearly illustrates that significant differences in condition occur between the four major runs. Consistent differences, in fact, are so apparent that extensive intermingling between the runs is unlikely.

Analyses of length-weight and age relationships will be continued in the future since additional information may be gained on the extent of intermingling of the various herring runs.

Racial Studies (Vertebral counts and Age Composition) on Herring north of Vancouver island

Racial data are being used to supplement the results of tagging to determine the extent of intermingling of the various runs north of Vancouver island. Work being undertaken at present includes comparisons of vertebral counts, age composition, and length-weight relationships. Length-weight studies are embodied in a separate report.

The data at hand indicates that intermingling of herring is limited or absent between runs to the major areas, namely, the Queen Charlotte islands (which includes runs to Burnaby strait, Lagoon bay, Atli and Bigsby inlets), the Central area (including runs to Klemtu passage, Smith inlet, Bella Bella, Laredo sound, and Aaltanhash inlet), and the Northern area (Union bay).

Within the central area the affinities of the Aaltanhash run are obscure. Evidence that intermingling is limited or absent between the run to Aaltanhash inlet and those to Laredo sound and Klemtu passage is not available from vertebral data. Further, vertebral data are insufficient to disclose the true affinities between runs around the Queen Charlotte islands. Sampling of the catches in that area has never been adequate, consequently vertebral counts to date have been based on small numbers of fish.

Studies in age composition, however, suggest the isolation of all but one of the runs sampled. The following table gives the percentage age composition of the runs sampled during the 1940-41 season.

Locality	II	III	IV	V	VI	VII	VIII	IX+	Av.
Union bay	1.2	28.3	42.2	14.6	7.9	4.6	0.8	0.3	4.2
Aaltanhash	48.9	14.0	10.8	5.8	8.1	5.3	4.8	2.4	3.4
Laredo		61.8	18.0	6.6	6.4	4.9	1.8	0.3	3.8
Bella Bella	6.0	73.0	13.0	2.0	1.0	4.0			3.4
Smith		33.3	17.8	6.6	14.6	8.4	15.6	3.8	5.1
Klemtu	10.1	21.5	31.6	12.7	12.7	10.1		1.3	4.3
Burnaby		31.8	26.7	6.4	10.6	12.4	5.0	6.9	4.9
Lagoon	9.3	42.0	20.6	10.3	3.7	2.8	1.9	5.6	4.2
Atli		40.2	34.0	6.2	10.3	3.1	4.1	2.0	4.2
Bigsby	1.9	4.6	34.3	17.1	12.4	12.4	9.5	7.6	5.6

From the table it is evident that the runs adjacent to the mainland have distinct differences in their age composition and therefore may (except for the Aaltanhash run) be considered as distinct units or groups. In the case of the Aaltanhash run, however, significant differences occur in age composition between individual samples. These variations make it difficult to compare differences in age composition.

In the Queen Charlotte islands differences in age composition also suggest the isolation of the four runs sampled. Statistical comparison between the runs to Lagoon bay and Atli inlets, which have the same average age, indicate that there is at least a 200 to 1 chance against extensive intermingling.

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Differences then in either vertebral counts or in age composition, or in both these characters indicate that intermingling was either limited or absent between the various runs under discussion, with the exception of the one to Aaltanhash inlet. This run forms a unique group and no definite conclusion can be made (see length-weight studies), either on the basis of vertebral counts or age composition.

Racial studies will be continued in northern B.C. in an effort to determine, the extent of intermingling between runs, fluctuations in abundance, and to provide essential data necessary for the control of the fishery.

J.L. Hart, A.L. Tester and J.L. McHugh

No. 36

The insertion and recovery of herring tags in 1940-41

The programme of herring tagging and tag recovery, designed to yield information on the movements of herring and the existence and stability of local populations has been continued. The methods were the same as those described in previous reports and involve the use of internal metal belly tags and the recovery of these by means of magnets in the meal lines of reduction plants and induction detectors which isolate the tagged fish from conveyors. The results for the 1940-41 season have been published in detail in the Report of the B.C. Fisheries Department, 1940, but are reviewed here briefly.

In all of the recoveries made by tag detectors and in some of those made by magnets, the fishing ground from which the fish bearing the tag was taken is known with certainty. In many of the recoveries made by magnets, however, there is some doubt as to the origin of the fish and it has been necessary, as in previous years, to determine the most probable place of capture from an impartial consideration of the origin and tonnage of fish processed prior to the date of recovery.

The following conclusions and comments arise from the results:

1. The results give additional evidence that for practical purposes the herring of major areas, viz., the east coast of Vancouver island, the west coast of Vancouver island, Queen Charlotte sound, the central coastline and the northern coastline, may be regarded as separate units with but a small extent of interchange between them. This is shown by the following summary of the results:

General locality of recovery

General locality of tagging	West coast of Vancouver is.	East coast of Vancouver is.	Discovery passage	Queen Charlotte sound	Central British Columbia	Northern British Columbia	Queen Charlotte islands	No interpretation offered
West coast of Vancouver is.	399	—	—	—	1	—	—	10
East coast of Vancouver is.	6	24	11	2	1	—	—	4
Discovery passage	—	—	8	8	—	—	—	2
Queen Charlotte sound	—	—	—	240	—	—	—	10
Central British Columbia	1	—	—	—	41	—	—	3
Northern British Columbia	—	—	—	—	2	6	1	1
Queen Charlotte Islands	—	—	—	—	—	—	3	—

This table indicates that 96 percent. of the tags were recovered from the same general area in which they were inserted. The results for Discovery passage are included to show the interrelation between fish caught in this area and those from the strait of Georgia and Queen Charlotte sound.

2. The following table shows that on the west coast of Vancouver island there is a tendency for tags to be recovered from the same areas in which they were used, although considerable interchange takes place.

Locality of recovery

Locality of tagging	Barkley sound	Sydney inlet and Clayoquot sound	Nootka sound and Esperanza inlet	Kyuquot sound	Quatsino sound	Outside West coast
Barkley sound	86	—	4	5	—	—
Sydney inlet and Clayoquot sound	25	27	10	5	—	—
Nootka sound and Esperanza inlet	21	6	76	29	—	—
Kyuquot sound	9	7	22	40	—	—
Quatsino sound	1	—	4	19	3	1
Outside West Coast	5	—	2	—	—	347

It may be calculated that of the 399 west coast recoveries 232 or 63% were recovered from the same tagging area, or, if Nootka sound-Esperanza inlet-Kyuquot sound is considered as a unit, 283, or 71% were recovered from the same tagging area. Of particular interest is the large number of Quatsino sound tags recovered from Kyuquot sound, chiefly from "outside" waters. However, calculations indicate a lower concentration of Quatsino tags in Kyuquot sound fish than in the few tons actually caught in Quatsino sound.

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3. Tags taken on the east coast of Vancouver island were relatively fewer in number than might have been anticipated from the tonnage of fish caught. This is related to the small quantity of fish reduced and the large quantity canned. In the latter process, many of the tags are either lost or are carried with the fish, for there are very few magnet recoveries from the offal.

4. There is additional evidence that fish spawning on strait of Georgia grounds, particularly those in the northern portion, contribute to the fishery at Discovery passage. A movement of fish tagged on spawning grounds near Discovery passage to Queen Charlotte sound fishing grounds is indicated but not proven, owing to the doubtful nature of some of the recoveries.

5. Apart from the movement indicated above, the Queen Charlotte sound herring may be regarded as distinctly independent of those in other major areas. There is evidence of a tendency to form local populations in various sub-areas of the sound.

6. The relatively low number of returns from central and northern British Columbia is due to the small tonnage of fish reduced.

7. The results for the Central area are in keeping with those of last year in indicating tags inserted near Kwakshua passage were mostly recovered from that same fishing ground and those inserted near Laredo inlet were mostly recovered from Laredo inlet. The status of the population at Aaltanhash inlet, a new fishing ground, is uncertain.

8. In northern British Columbia, the indications are that some of the fish which spawned in Big bay and Duncan bay were taken later in the Wark canal and Union bay.

#### Tagging

The tagging during the 1940-41 season was continued and a total of 24,471 tags were inserted. Towards the close of the fishing season, 1,197 tags were used on the south-east coast of Vancouver island. During the spawning season, tags were used as follows: strait of Georgia, 4,947; Queen Charlotte sound, 200; west coast of Vancouver island, 9,759; central British Columbia, 5,877; northern British Columbia, 2,491. Tagging in the Discovery passage and Queen Charlotte sound areas was disappointing, the former because of a comparative failure in herring spawning in the area and the latter because of unfortunate timing of the tagging trip through the area.

Seine boats used in tagging were loaned through the courtesy of British Columbia Packers, Ltd., and the Canadian Fishing Company, Ltd.

The investigation has enjoyed the following help: R.V. Boughton, tagging; L. quickenden, tagging and installing equipment; Miss A. Russell, filing and tabulating records; temporary help comprising three boat crews for about a month during the tagging period.

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The investigation is being continued in the 1941-42 season to extend knowledge of the movements of herring in localities in which the work has not been extensive or concerning whose status there is considerable doubt. It should be pointed out that with the large quantities of herring being canned, the number of tags recovered and thus the amount of information obtained, will doubtless be less than in previous years.

J.L. McHugh

No. 37

### Studies on young herring

The work on young herring has been tentatively brought to a close and the results obtained so far brought together in two papers prepared for publication.

Examinations of the vertebral number and growth of young herring lead to the following comments: (1) Significant differences in average vertebral number which tend to remain constant from year to year can be demonstrated between the young from different spawning grounds in the strait of Georgia. Partial segregation of these groups throughout their life would tend to preserve such differences. In a fishery such as that carried out in the Saltspring island area, where many of these groups are undoubtedly exploited, it is evident that lack of complete intermingling increases the difficulty of sampling the fishery. (2) A relationship was established between date of hatching and mean vertebral number for fish hatched in Departure bay, suggesting that groups hatched earliest have the highest number of vertebrae. (3) Within a sample, the largest fish tend to have a higher number of vertebrae. Since it is likely that many of the samples examined are the result of single spawnings, the individuals in each must have developed under almost identical environmental conditions. It is therefore more probable that the phenomenon is caused by differences in inherent developmental rate than by environmental factors. (4) As in adults, the variation in mean total count between localities is made up almost entirely of a difference in the mean abdominal count. Within a sample, however, both abdominal and caudal counts vary, and an increase in total count produces a disproportionately large gain in mean caudal count. This must also be an effect of variation or inherent developmental rate, since the caudal count varies about the same mean in almost all samples. (5) A disproportionate rise in mean tail vertebrae in individuals having higher total counts has been observed within a sample. Between samples, the tail count may differ significantly where no difference in total count exists, and it is thus possible that this character might be used in separating populations.

The following comments are based on the study of vertebral variation or abnormality: (1) Vertebral abnormalities can be classified according to general type. (2) Most abnormalities are bilaterally asymmetrical. (3) Examination of various stages in the development of the young shows that abnormalities of the "complex-centrum" type do not occur in very early stages and suggest accordingly that they are a consequence of subsequent fusion. (4) Herring populations differ significantly in the frequency of occurrence

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of abnormalities. The proportion of these seems highest in samples with relatively low average vertebral numbers and since vertebral number is known to vary inversely with water temperature during early development, temperature may be a factor in the production of fused centra. (5) Abnormalities of the fusion type tend to occur most frequently in the region of the twentieth vertebra, and this appears to be associated with differential growth in the vertebral column

(This report prepared by Dr. Hart in the absence, on leave, of Mr. McHugh).

J.L. Hart

No. 38

The pilchard fishery in 1941

From the points of view of tonnage landed and catch per seine boat the season of 1941 was highly successful.

The season was characterized by the small size of the fish which were taken by the fishery. A majority of the fish were less than 230 mm. in length. The radical change indicated by this condition is emphasized by consideration of the fact that in several years practically no fish were less than this length.

The abundance of fish was evidently due to two features: (1) the existence of two or more abundant year classes of young fish, and (2) the suitable hydrographic conditions which made these young fish available to the fishery at younger ages than would otherwise have been the case.

The prognosis for the fishery, while improved in view of the good season just experienced, is still uncertain and hinges around the actual abundance of the small pilchards which were certainly highly available during the 1941 season. If the fish were really as abundant as their high availability away from the recognized center of abundance would indicate, they should usher in a series of good years. If on the other hand, the availability depended largely upon fortunate hydrographic conditions alone, the absence of large fish--of what would formerly have been regarded as normal size--must still be regarded as a danger signal. As pointed out elsewhere there is reason to hope that the fish of the 1939 year class are really abundant. If this is really the case, they should start demonstrating their dominance in the fishery in 1942 or 1943.

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Sampling the pilchard catch in 1941

Pilchard sampling was continued at Kildonan and Hecate during the season of 1941. The downward trend in length observed over the last four years was continued as is shown by the following figures.

Year	Males mm.	Females mm.
1937	248.0	252.0
1938	246.4	251.0
1939	241.0	245.4
1940	236.7	241.9
1941	220.0	222.0

The decline in size of the major group of fish supplying the fishery is not so great as that indicated since the averages were brought down by the presence in the fishery of a secondary group of small fish with lengths centering around 200 mm. The central tendency for the major groups is 225 mm. for males and 232 mm. for females.

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Grouped according to fishing areas the samples again show differences with latitude. In the following list the areas are cited from south to north from the Washington coast to north of Estevan point on Vancouver island.

Fishing area	Males mm.	Females mm.
IX	207.24	202.83 (1 sample)
X	227.67	229.92 (2 samples)
XI	215.41	217.41
XII	226.85	229.97

The difference between areas XI and XII (where most of the catch was made and which are best represented by samples) results from both an increased representation of the secondary group of small fish in XI and a lower central tendency in the major group.

The numerical preponderance of males observed for the first time two seasons ago has continued. The sex ratio was 1 male to 0.966 females.

Through co-operation with the United States Fish and Wildlife Service, age diagnoses are to be made on a large sample of scales collected in connection with the length sampling programme. The results of these determinations will be made available to the Board in due course.

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Availability of pilchards to fishermen

As in former years data have been supplied by the fishing industry concerning the activities of pilchard seine boats. Calculations based on the data show that the average catch per seine for the season was approximately 2,350 tons (not including boats operating for part of the season only), on the west coast of Vancouver island. This estimate of availability may be compared with that of former years in the accompanying tabulation:

1941 --- 2350	1937 --- 1500 c.
1940 --- 1175	1936 --- 1520
1939 --- 210	1935 --- 2220
1938 --- 2150	1934 --- 2120

A certain amount of pilchard fishing was carried out in the area north of Vancouver island during 1941. The complete data are not yet at hand for the fishing but partial returns indicate that availability was considerably lower there.

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Pilchard tagging

The pilchard tagging programme has been reduced by dropping pilchard tagging from the commercial catch. This was done for two reasons: (1) Examination of the results indicated that fish taken from commercial seines in open water are not, for the most part, in suitable condition for tagging. (2) Economy of effort. The programme at present consists of: (1) attending to the recovery of tags put out in former years or by other organizations, and (2) of tagging small pilchards in inside waters. It is recommended that tagging in outside waters off the British Columbia coast should not be undertaken in the future without special equipment.

The following table summarizes the tag recoveries:

Tags considered	<u>Place of recovery</u>			Total
	British Columbia	Washington	California	
Canadian Tags				
1938	---	---	1	1
1939	---	1	---	1
1940	1	1	---	2
Spring 1940 ("Homesteader")	1	---	---	1
Oregon Tags	1	---	---	1
California Tags	18	---	---	<u>18</u>
				24

Three of the California tags have been out for a full four years. The approximate times out for the California tags are as follows: four years,- 3; three years,- 6; two years,- 6; one year,- 3.

The comparatively low number of California tags per thousand ton of fish (0.4) as compared with last year (1.4) is believed due to two causes: (1) less satisfactory recovery and (2) the predominance in the catches of small fish in which the concentration of tags was low.

Tags put out so far during 1941 comprise 1000 tags put in pilchards of the 1939-year class at Pender harbour. The work is in progress at the present time and it is hoped that it will be possible to tag several other lots of 1939-year-class pilchards in other localities around the strait of Georgia.

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No. 42

Young pilchards in British Columbia

During the early summer of 1940 there was a phenomenal invasion of British Columbia waters by pilchards of the 1939 year class. The available information on these fish was summarized in the Summary Reports for 1940

under the headings, Survey, Canvass for information, Sampling and Tagging. Advantage has been taken of all opportunities to study young pilchards in British Columbia waters and the results are presented briefly herewith.

Sampling. The measurements of young fish may be regarded as belonging to 18 samples as follows:

Date, 1941	Source of sample	Length (central tendency or range) mm.
Jan. 6	Saanich inlet (dead)	148
Jan. 8	Pender harbour (dead)	158
Jan. 27	Brentwood (dead)	151
Feb. 22	Narrows arm	165
Feb. 22	China Hat	160
Mar. 6	Gabriola bluff	163
Mar. 9	Kendrick arm	176
June 1	Barkley sound	104, 146
June 2	Barkley sound	109
June 2	Sydney inlet	170
June 7	Nootka	170
June 8	Hesquiat	173
June 14	Barkley sound	112 (range 106-162)
June 17 & 10	Barkley sound	105-169 (range)
June 23	Neuchatlitz	180
July	Barkley sound (commercial)	186
September	West coast (commercial)	200 c.
Nov. 20	Pender harbour	200

The most interesting inference from these data is that again in 1941 there was an immigration into British Columbia waters of II-year pilchards. This is in line with the report of Mr. McHugh and a reliable fisherman that pilchards "of the year" were observed in herring catches made during the winter of 1940-41. The immigration evidently did not occur on anything like the same scale as that of the previous season and after the first few catches the young fish disappeared. Fish of the 1939 year-class were again widely distributed around the coast as is indicated by the variety of localities from which samples have been obtainable. Growth rates under existing conditions can be estimated but the results are not capable of general application. Comparisons of growth rate between east and west coast samples are not in order because of the existence of two groups of 1939 fish of different sizes on the outside coast. These are not separable in our data. Age estimates have been checked by Dr. Walford who visited the Station for the purpose of examining the material on hand.

Mortality. The mortality of young pilchards will be dealt with in another report (Dr. Foerster et al.). It is sufficient here to state that the mortality occurred, and to call attention to the following remark in the Summary Report for 1940, "...interest attaches to reports from three sources of pilchards being stranded and killed in fresh water creeks and on tide flats." Early in November, 1941 considerable numbers of pilchards were stranded and killed on the tide flats at the head of Pender harbour. It will be interesting to see if this occurrence is again the precursor of a general mortality.

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Abundance of the 1939 year class. In the Summary Report for last year it was reported that attempts to have Mr. J.B. Phillips of the California State Fisheries Laboratory extend his young fish survey into northern waters had fallen through. Since that time J.L. Hart has had the opportunity of discussing the matter with Mr. Phillips. Mr. Phillips reports that in 1938, which was evidently a very good one for young pilchards, he saw and recorded in the course of a month's cruise 818 schools of fish estimated to contain 4,400 tons of pilchards. It is the author's opinion based on personal observations and on discussions with fishermen that a similar cruise between the mouth of the Columbia river and Cape Scott would have led to the recording of many more schools and greater tonnages. This would suggest that the 1939 year class of fish is really abundant and should contribute materially to our fishery. The conclusion should, however, be drawn with reservations due to the method of estimation and to the unknown and unpredictable effects of the mortality which occurred during the winter of 1940-41. Mr. Loyd Royal of the Washington State Department of Fisheries reports that large numbers of dead pilchards were brought up from open water by otter trawlers. This means that by no means all of the mortality will have been readily observed.

Tagging. The tagging of young pilchards is recorded in the Summary Report dealing with pilchard tagging.

Foerster, R.E.

No. 43

The mortality of young pilchards

During early January heavy mortalities occurred among pilchards frequenting Pender harbour and Saanich inlet, in the strait of Georgia. Examination of affected fish disclosed no external wounds, only very definite red, haemorrhagic areas on the skin, in many cases the blood oozing out from underneath the scales. No internal lesions were noticed except for a highly inflamed gut and haemorrhaged muscle tissue. Field studies of environmental conditions were made and specimens submitted to Dr. Duff for bacteriological and pathological examination.

This phenomenon has been reported in Progress Reports No. 48, indicating the tentative conclusion that an adequate supply of food was lacking, which led to a lowering of the general metabolic condition and a lowering of resistance to bacterial infection. Death presumably occurred due to the necrosis and non-functioning of liver and other organs and/or the failure in the oxygen supply to the tissues because of extensive hemolysis and loss of blood.

Assisting in making field observations were Drs. Pritchard, Tester and Boughton. Mr. Tully conducted numerous water sample analysis in the field and Dr. Duff made bacteriological and pathological studies both on samples submitted to him at the University of British Columbia and also in the field.

J.L. Hart

No. 44

### Ling cod tagging

The ling cod tagging programme suffered during 1941 as a result of the involvement of personnel with the herring tagging and recovery programme. In consequence, the number of fish tagged was comparatively small.

Considerable time and effort was expended in devising a new type of tag which was adaptable to ling cod. The strap tags which had been used during the first two seasons were found to be not dependable for consistent results. On some fish the tags appeared to be very effective, but on others (since the opercular bones of a ling cod are thin in spite of the large size of the fish) the bone was eroded away until the tag was on the point of being lost, and many tags no doubt were lost in this way. Several of the accepted tagging methods were tried on fish confined in a bait box. The most satisfactory method was found to be a new one involving the use of a tag made from a numbered strip of red celluloid bent into a circle which overlapped itself by about one half a turn. These tags were placed around the maxillary bone (which forms the upper jaw) which is obviously too heavy to be eroded away. Data accompanying the returns of this type of tag used on freed fish indicated that the rate of increase in weight, and hence, by inference, the feeding are not impaired by its presence.

Only 168 fish were tagged during the season. One hundred and fifty-six of these were tagged with the new type of celluloid tag, 151 on commercial fishing grounds. From these 16 returns were made. This indicates a recovery rate of more than 10 percent in the first nine months which compares favourably with the general rate. The recoveries made since the preparation of the last Summary Reports continue to indicate small movements as being the rule for ling cod. Of the 33 recoveries for which the data may be considered 14 show no movement, 16 show little movement, and 3 show considerable movement--this in spite of the fact that errors in reporting localities of recovery will give false indications that migration has taken place.

J.L. Hart

No. 45

### Ling cod sampling

Sampling the commercial catch of ling cod is practically impossible since each catch differs from every other depending on the grounds visited by the fisherman in the course of his trip. The ling cod sampling programme depends therefore upon the fishing for scientific purposes, and it has, accordingly, like the tagging programme, suffered as a consequence of the distraction of effort to the herring tagging programme.

The results obtained may be analysed on the basis of large fish (more than 1000 mm. in length) and small fish (less than 540 mm. in length or 3 pounds in weight) caught in the strait of Georgia in general and caught in the closed area of Saanich inlet as follows:

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	Percentage 1000 mm. or more (c.24 lb.)	Percentage 540 mm. or less (c. 3 lb.)
General area	0	21.4
Closed area	20	0

In view of the small number of specimens involved, the similarity between these data and those for last year is more striking than the differences, and the new records can be regarded as largely confirmatory of the earlier ones.

J.L. Hart

No. 46

Fecundity of ling cod

The relationship of fecundity of ling cod to size and habitat has a definite bearing upon the conservation of the species and, accordingly, upon the administration of the fishery.

The smoothed data from a preliminary study of the relationship between egg number and size in ling cod from the commercial grounds in the strait of Georgia gave the following indications:

Length mm.	Weight oz.	Egg no.
800	180	100,000
950	315	225,000
1100	500	350,000

From these figures it is evident that while the length of the fish increases 38 percent, weight increases 163 percent, and egg number increases 250 percent. Further investigation will be necessary to improve the accuracy of these estimates and to discover whether they hold on over-populated grounds.

J.L. Hart

No. 47

Ling cod statistics and questionnaire

The available ling cod statistics are of little biological significance. It is, accordingly, proposed to introduce a system of collecting ling cod statistics which will give adequate information on the exact locality of fishing and upon the fishing effort required to produce the recorded catch. For former years, and for general information, it is proposed to obtain information by a questionnaire submitted to fishermen. While the questionnaire is being circulated it is proposed to include inquiries of a sociological and technical nature. It is intended to visit fishermen personally as far as possible and to assist them with filling in the answers. A condensation from the tentative form of the questionnaire follows:

1. Fisherman: name, address, racial origin, nationality, age, sex, married?

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no. of children, years of experience in the ling cod fishery, general localities fished in different years.

2. Boat: name, length, breadth, draft, tonnage, engine, power gurdies?, has the boat always been the same since the fisherman fished it?, if not, what changes have been made?, has the fisherman always used the same boat?, if not, describe former boat(s) as per above, what increase in ability to catch fish does the fisherman consider resulted from the changes made in regard to boats?

3. Crew: does the fisherman fish alone?, any change in this regard, sex of assistant, fisherman's estimate of the value of assistant in actually producing more fish.

4. Gear: line, weights, spreader bars, number of hooks per spreader bar, kind of hooks, length and weight of leader, bait, lead line, spoons or other artificial lures, what changes have been made in the fisherman's practice in regard to each of the above?, what increase in the ability to catch fish does the fisherman consider has resulted from whatever changes have been made?, what ideas has the fisherman about other types of gear.

5. Fishing grounds: what fishing grounds have been exploited by the fisherman in each year of his experience?, time spent on each one, to what extent, if any, has the fisherman had to travel farther in successive years in order to maintain a satisfactory catch?, has the fisherman found it necessary to fish for longer hours or harder to maintain a satisfactory catch?, changes in size of fish caught on various grounds, are certain grounds noted for fish of certain sizes?, does the fisherman have any knowledge of nursery grounds for young ling cod.

6. Condition of the fishery: what is the fisherman's opinion concerning the condition of the fishery with details of specific grounds and of different types of grounds (reefs vs. beach fishing) as far as possible?, if the condition is considered unsatisfactory what does the fisherman consider the cause of the difficulty?, if the condition is considered unsatisfactory what remedies does the fisherman recommend?, if the condition is considered satisfactory does the fisherman consider that control measures are necessary to maintain the fishery in that condition?, what suggestions has the fisherman to offer about the practice of killing the ling cod for liver and discarding the carcass?

7. Collection of statistics: for the purposes of investigating the ling cod it is desirable to obtain as complete a record as possible of the catch with data as to the size of the fish caught, the number of fish caught, place the fish caught, and the approximate day fish caught. what suggestions has the fisherman to offer as to the most effective method of collecting this information, taking into consideration the understandable reluctance of the fisherman to broadcast the details of his fishing activities.

J.L. Hart and J.L. McHugh

No. 48

The smelts of British Columbia

A bulletin has been prepared on the four species of smelt found in British Columbia, covering the identification of the species, life history, commercial and other uses, and the condition of the fishery. Two of the species dealt with, the capelin and the long-finned smelt are of no commercial importance, and no protective measures appear warranted. The supply of silver smelt or surf smelt appears to have declined but the present regulations are probably sufficient to provide for continuance of the supply of fish at the present level. The availability of eulachon has been the subject of considerable variations, some, if not all of which, appear to have been the consequences of natural fluctuations. In order to obtain clearer knowledge concerning changes in the availability of eulachon in the Fraser river a more complete system for collecting statistics has been introduced.

With the exception which follows it is recommended that direct work on the British Columbia smelts be stopped. The eulachon, like the Pacific salmon, dies after spawning, and the dead fish drift downstream in large numbers. These fish appear to be in good condition and it is likely that they are so since the current is swift enough to carry a passive object from the spawning grounds to the sea in less than twenty-four hours. It is proposed that provided the work can be done without serious interference with major investigations an examination be made of (1) the feasibility of catching large quantities of dead eulachon, and (2) the suitability of the dead eulachon so captured for (a) food for fur bearing animals on fur farms, (b) reduction. It is evident that, if the dead spent fish can be used in quantity, considerable economic gain would be achieved without possible repercussions to the conservation of the fish.

J.L. McHugh

No. 49

The collection of eulachon catch statistics

The collection of eulachon catch statistics was begun as part of the response to a request from the Department of Fisheries for advice concerning the advisability of acceding to certain suggestions from a section of the fishing industry which, if followed, would have led to a great increase in the take of eulachon from the Fraser river. No dependable information bearing on the present or former abundance of eulachons was available or could be derived from the catch statistics on file. It was, accordingly, suggested to the Department that catch records be collected in such a way as to give a clear indication of the effort expended in making the eulachon catch. With such statistics as a basis calculations of availability of fish can be readily made. It is recognized that availability and abundance are not synonymous, but they are undoubtedly related, and to date a better measure of abundance than availability has not presented itself for situations where it is not possible to make counts of the fish.

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Daily records filled out by the fisherman and collected by the Department of Fisheries have permitted the calculation of the amount of fish caught by 100 square fathoms of net in an hour, which is regarded as the catch per unit of effort. The following analysis of the first year's fishery illustrates the type of information which is available through the collection of such statistics: In 1941 fishing on the Fraser began on March 16, and the catch per unit of effort remained relatively low (less than 30 lb.) until April 10. By April 20 the catch per unit had risen to more than 200 lbs., and it remained greater than 150 lb. until May 3. After May 5 the catches were negligible (less than 10 lb. per unit).

(Prepared by J.L. Hart)

J.L. Hart

No. 50

### Anchovy Fishing

For many years the anchovy has been a sporadic entrant to British Columbia waters. Recently they have been exploited on the west coast of Vancouver island and have supported a substantial minor fishery. As the species appear to be capable of representing some 40,000 dollars in good years, it was decided to collect data on it when this could be done without interfering with the investigations of more valuable species.

The sampling work so done has demonstrated the status of the anchovy populations present in British Columbia waters during the last two years: In the early summer of 1940 anchovies of the 1939 year class in the company of pilchards of the same age invaded the strait of Georgia and the inlets on the west coast of Vancouver island, supplying minor fisheries on both sides of Vancouver island. In 1941 anchovies of the 1940-year class entered the west coast inlets and formed the basis of a considerable fishery. In our rather sparse data there is no indication of anchovies of this year class in the strait of Georgia and the samples examined appeared to be drawn from the remnants of the fish which entered the strait in the previous year. The regular occurrence of second year anchovies on the west coast of Vancouver island cannot be depended upon. A large proportion of the anchovies present in 1939 were of the third year group (F.H.C. Taylor Summary Reports, 1939) and in some seasons anchovies are not observed in British Columbia waters.

There is evidence of breeding in British Columbia waters in 1941, as a school of fish-of-the-year was observed in Barkley sound and the identification confirmed by the capture of one specimen 56 mm. long with a bucket. Although anchovies are known to spawn and produce young in local waters, it is not believed that the supply of fish depends upon local spawnings.

J.L. Hart

No. 51

Albacore Fishery

The fishery for albacore is one of unknown but possibly large potentialities for British Columbia. Data on the Canadian landings can be exchanged for similar information from American investigators and consequently make available to the Board the results of very extensive and costly studies.

Data now on hand show that most of the Canadian catch came from off (25 mi.) the Washington coast, although some of it originated from as far north as cape Cook on Vancouver island. One sample which was measured had an average length of 27 inches (to the fork of the tail), and an average weight of 12.6 pounds.

At the present time the Canadian catch is in cold storage pending processing. It is hoped to carry out tentative arrangements (1) to measure the fish, and (2) to make food studies, when the fish are removed from storage prior to canning. The extra time involved in carrying out the whole investigation should not amount to as much as one week.

J.L. McHugh

No. 52

Studies on the Rocky Mountain whitefish

The work on the Rocky Mountain whitefish has been completed and the results have been presented in three reports, two of which have been submitted for publication, and the third of which is on file at the Pacific Biological Station.

Food studies (published in 1940) showed that although the species is essentially a bottom feeder with a preference for insect larvae it will turn to whatever available food it can handle. As they compete for food with and take the eggs of other species of fish, the desirability of introducing it in any body of water must be considered in view of the other species present.

Growth rates vary with locality and can be related with the altitude and temperature of the habitat. Fast-growing individuals tend to maintain their superiority in growth rate throughout their existence. Slow-growing populations eventually reach a maximum length similar to that of the fast-growing fish, and, accordingly, reach a greater age.

Biometric studies of Rocky Mountain whitefish show the species to vary considerably in body proportions with locality and age. Taxonomically the species is in need of a revision for which the data on file should prove of great value.

(Prepared by J.L. Hart).

R.E. Foerster

No. 53

Dogfish tagging

Due to the increasing value attaching to dogfish (grayfish) because of the high vitamin A content, its exploitation has notably increased. Information was desired concerning the migratory habits of the fish to determine whether the populations were more or less restricted to certain areas or whether such migration occurred that the same populations were fished in various areas during the season.

Early in June Mr. Paul Parizeau was engaged to conduct the work under the writer's direction and immediately commenced a study to determine what type of tag might best be used. Strap tags applied to the caudal fin and to the dorsal fin were tested, also celluloid disk tags affixed by metal silver pins to the back below one or other of the dorsal fins and in the snout region. The disk tags appeared to be most suitable and the snout the most desirable location as there appeared to be less growth, also movement, in this region than along the dorsal area.

From set lines operated off Departure bay during the first half of July a total of 86 dogfish were caught, tagged and released, while 22 individuals were obtained and tagged at Deep bay, above Qualicum. At this time of the year most of the commercial fishing was done by sunken gill nets and supplies of fish suitable for tagging were not readily available. Three tags from these tests have already been returned, one from Departure bay taken in the north arm of the Fraser after one month's freedom, another from Departure bay recovered off point Grey three months after tagging, while the third, tagged at Deep bay, was retaken in that same area three months later.

Late in November another tagging program was commenced, this time in the general vicinity of Saltspring island, and Swanson channel. Arrangements here were made for a tagger to accompany a regular dogfish fisherman and select a certain number of each day's catch, as it was taken off the hooks, for tagging and release. If funds permit, this tagging will be continued at intervals throughout the winter and spring. It is anticipated that in the course of his ling cod tagging work, Dr. Hart will be able, also, to tag dogfish taken on the ling cod gear, thus swelling the body of tagged dogfish in the strait of Georgia for subsequent recovery.

Ferris Neave

No. 54

Natural Propagation of the Japanese Oyster in Ladysmith Harbour

During the spawning season of the Japanese oyster (i.e. from June to the end of August) field observations were carried out by Mr. D.B. Quayle, the present writer being also involved during the latter part of the summer.

Extensive natural spawning took place in July and by August 5 it was estimated that 65 percent. of the individuals in the bay were spawned out. The progress of larval development was followed through the examination of daily plankton samples. Growth and survival were considered to be satisfactory until a late larval stage was reached and by August 12 numerous larvae had attained approximately full size. In spite of this, only a very light spatfall resulted and though the number of setting oysters was undoubtedly greater than in the four previous years, propagation must be regarded as another failure from the commercial standpoint.

Throughout the summer daily records of water temperatures, chlorinity, pH, oxygen, etc., were obtained but no correlation has been established between any of these physical or chemical conditions and the failure of the larvae to spat.

Ferris Neave

No. 55

Experiments in the Pond Propagation of Japanese Oysters

Further attempts were made to propagate Japanese oysters in a lagoon, the entrance to which was closed by a dam. The set-up is described in a summary report, 1940.

The dam was closed on July 14, a large population of oyster larvae being impounded. Physical and chemical conditions were recorded daily (or more frequently) at five stations in the lagoon and at depths from surface to bottom. Regular plankton samples were also taken and examined. Very warm weather was experienced during the ensuing week and water temperatures reached 85°F. Larvae remained numerous until July 19, when heavy mortality apparently occurred. The oxygen content of the lagoon water was reduced to an exceedingly low point by July 18 and much mortality was observed in fishes, crustaceans and polychaetes. The dam was opened on July 22 to permit renewal of oxygen supplies and removal of some of the products of decomposition.

On July 31 and August 7 stimulated spawnings of oysters took place in the lagoon, the discharge being particularly heavy and prolonged on the second occasion. No larval populations of any magnitude resulted from these spawnings.

The lagoon experiments were undertaken in view of the opportunities afforded for a careful study of the physical and chemical conditions attending larval development or mortality in a small and well-defined system, in contrast with the complex and constantly changing environment of the bay. Two special difficulties, however, were encountered:

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- (1) The great reduction in oxygen content during the course of the first experiment.
- (2) In the stagnant water of the lagoon the eggs after emission tended to sink and form an ooze on the bottom instead of being buoyed up and dispersed by currents. Such a condition is probably unfavourable to development.

In view of the very large amount of field work which has been carried out over a period of years in attempting to determine the cause of larval mortality, and the lack of success which has attended it, it is felt that it would not be profitable to continue this investigation along the same lines. It is suggested that small-scale laboratory experiments under carefully controlled conditions might yield more information than further attempts to analyze the complex conditions obtaining in the sea. The experimental creation of favourable conditions for larval development might render feasible the production of spat on a commercial scale in tanks.

Ferris Neave

No. 56

#### Statistics of the Commercial Clam Catch

Catch statistics are essential to an understanding of the present condition of the clam fishery, the potential future condition and the manner in which production should be regulated. In order to indicate trends in productivity, statistics should provide information on (1) quantities of clams taken annually from the various areas involved (2) the effort expended in obtaining them. Data on these points have been gathered from the following sources: Records of the Department of Fisheries; records of companies concerned with the canning of clams; special report forms, distributed to all the clam-buying centres, providing for a record of the clams produced by each digger and the number of digging tides involved. Such forms have been in use for three years and efforts are being made to cover all areas as completely as possible during the present season. Generally speaking, records for 1940-41 were considered satisfactory and an analysis of the results will be available shortly.

Ferris Neave

No. 57

#### Clam Productivity as Tested by Latin Square Plot Experiments

In order to obtain information on the productivity of clam beaches and the relation between production and frequency of digging, experimental plots were established in 1938 and treatment of these has proceeded according to the plan devised at that time. Each square consists of twenty-five plots, five plots being allotted to each of the following digging treatments. (1) Twice a year (2) once a year (3) every second year (4) every third year (5) only at end of the experimental period. All clams above legal size are removed at each digging and the total weight and other data are recorded.

Ferris Neave

No. 57

These experiments have now been in progress for more than three of the six years over which they were planned to extend. No analysis of results has yet been made and in view of the length of time required for observations on treatments (4) and (5) the main conclusions must await the end of the experiments.

It is hoped that a study on a larger scale of the effects of digging operations in relation to productivity may be possible at Seal island, near Comox. This area, which has been closed to diggers for three years, now supports a heavy population of clams. The opening of this area, under conditions specified by the Board, would enable the effect of experimental regulation of production to be observed.

Ferris Neave

No. 58

#### Determination of Age and Growth Rate of Clams

Conclusions regarding the degree to which clam resources are being, or should be, exploited, should depend in part upon a knowledge of (1) the age at which clams attain legal size (2) the age composition of the commercial catch over a series of years.

Evidence as to age may be obtained by (1) plotting of size frequencies (2) examination of growth lines on the shells (3) direct observations on marked individuals at suitable intervals of time. A large amount of data has been obtained by each of these methods but still requires further analysis. Samples of the commercial clam catches from all the main areas were obtained in 1941 and many additional samples were dug from specific beaches by Mr. Quayle, who also concluded a series of experiments on the growth of marked clams retained in pens under different conditions. Evidence was forthcoming of wide variation in the growth rate of clams from different beaches. It also appears probable that clams from the northern waters of British Columbia require, on average, about two years longer to attain legal size than those from southern areas.

Material on hand will be worked up and the composition of the commercial catch will be investigated again during the current season.

Ferris Neave

No. 59

Natural Propagation of the Butter Clam

While heavy digging operations are generally believed to have been the main cause of recent low production in southern areas, the possibility that other factors may contribute to considerable fluctuations in the annual catch should be considered.

Comparatively little is known concerning the conditions under which the butter clam spawns, while the larva has not yet been identified with certainty. Field observations by Mr. Quayle have suggested that the occurrence of heavy annual spawnings should not be accepted as an unquestioned fact, and that the incidence of certain recent year-classes in the clam populations of various localities is very low. Attention should be given to the effect of natural fluctuations in the annual production of young clams as well as to the depletion caused by human activities.

It is proposed to investigate the spawning and early life history of the butter clam and the relative abundance of different year-classes.

D.B. Quayle

No. 60

Seasonal Infestation by Teredo, in Relation to Control Measures

Teredo infestation of wooden structures such as wharf piling, dolphins, breakwaters and floats and of ships' bottoms is one of the most aggravating and costly problems besetting marine interests.

Certain logging companies in British Columbia and Washington have adopted the use of explosives as a means of preventing or reducing the destruction caused by teredo (*Bankia setacea*). As a result of certain experiments by the Olympic Forest Products Company of Port Angeles, piling there is treated with charges of dynamite within three months after the piling is driven. Further treatment is given at intervals of three months for the first year, after which yearly treatment is considered sufficient. At Ladysmith B.C., the practice is to give dynamite treatment once per month. Beneficial results are claimed in both localities but it is evident that the procedures adopted are not based upon any real knowledge of the action of dynamite explosions on teredos, the minimum force necessary to produce mortality or the frequency with which the explosive force should be applied. Further, little is known concerning the effect of explosives upon the fish and shellfish life in the vicinity of the treated structures.

Efficient treatment should probably be related to the time of settling down of the free-swimming larvae. The seasonal incidence of larval setting is now being investigated experimentally at six localities on the coast of Vancouver island. In each instance, wooden blocks are immersed at three different levels. They are removed and replaced at intervals of one month and three months and will be examined for the degree of infestation exhibited.

Daily Seawater Observations

Since 1934 daily observations of the temperature and salinity of the sea water have been made at a number of exposed and sheltered locations on the British Columbia coast.

The data from stations in exposed positions are required to provide a record of the surface oceanographic conditions which may be used:-

1. As a general reference, similar to the meteorological records.
2. As a means of determining the duration of typical conditions in coastal waters, which have been examined in detail by dynamic surveys.
3. For comparison, and where possible, correlation to meteorological conditions.
4. For comparison, and where possible, correlation to the fishery.

The data from the stations in sheltered positions are required:-

1. To measure local phenomena of interest to some specific investigation, (pink salmon, shellfish, etc.)
2. To demonstrate the difference between local and general conditions.

The system of investigation may be briefly outlined as follows:-

Cases of sample bottles are sent to each observing station, where the observer takes a sample of the sea water at depth of three feet (with a specially designed apparatus) each day, and notes the temperature. When a case of bottles is filled (about three months) it is returned to this station, where the salinities of the sea water samples are determined (by titration), the bottles washed, etc. and returned to the observer. Co-incidentally the meteorological records of precipitation, air temperature, cloudiness, and wind direction and force are obtained from the meteorological service. These data representing two sea water, and five meteorological observations are smoothed by seven day running averages, to eliminate the lunar cycles, and are plotted as functions of time.

The process of smoothing and graphing the data is necessary to eliminate the large daily fluctuations and to present the data in a visual form in which they are readily compared.

It should be noted that there is a delay of about three months while the cases of water samples are being filled, and a further delay while the samples are being analysed, the calculations made, and the graphs prepared. As a consequence the completed records are usually about six months behind the actual observations.

The exposed stations are generally located at suitable lighthouses and the services of the lightkeepers as observers, have been arranged in co-operation with the Department of Transport. The sheltered stations are operated by observers already in the service of the Board, or by arrangement with local persons.

For illustrative purposes, the stations now in operation are listed with the data when observations were started, and the mean annual temperature for 1939 and 1940. The records for 1941 are not yet complete.

J.P. Tully

No. 61

Station	Location	Duration	Mean Annual Temperature	
			1939	1940
<u>EXPOSED STATIONS - Pacific Ocean</u>			°F	°F
1. Amphitrite	Barclay sound	Aug. 1934 to present	Not complete	52.0
2. Nootka	Nootka sound	Aug. 1934 to present	50.7	52.3
3. Kains island	Quatsino sound	Jan. 1935 to present	50.2	50.5
4. Cape St. James	Queen Charlotte islands-south	July 1934 to present	43.9	48.3
5. Langara	Queen Charlotte islands - north	Sept. 1940 to present	No record	Not complete
<u>Inland waters</u>				
6. William head	Juan de Fuca strait	Jan. 1921 to July 1940	49.1	Not complete
Race rocks	"	April 1941 to present	No record	No record
7. Entrance island	Georgia strait	May 1936 to present	50.9	52.8
8. Cape Mudge	" "	Nov. 1936 to present	51.7	Not complete
9. Pine island	Queen Charlotte strait	Jan. 1936 to present	47.0	49.1
10. Ivory island	Milbanke sound	July 1937 to present	50.4	51.4
11. Triple island	Hecate strait	Oct. 1939 to present	Not complete	51.2
<u>SHELTERED STATIONS</u>				
12. Poplar island	Fraser river	Feb. 1927 to present	48.2	48.6
13. Ladysmith harbour		1934 to present	70.0	69.3
		July & August only		
14. Departure bay		Jan. 1919 to present	53.5	53.6
15. Prince Rupert harbour		Jan. 1940 to present	No record	48.7
16. Shannon bay	Masset inlet	Dec. 1939 to present	Not complete	55.5
17. Masset	Masset inlet	Nov. 1939 to present	Not complete	50.9
18. Port Alberni	Alberni inlet	Apr. 1940 to present	No record	Not complete

The labour involved in this program is comparable to that required for the collection of the meteorological data in this province, and requires the full time of one technical assistant and about three quarters of the time of another.

It has been proposed to collect and publish these data in the form of a bulletin to make the information readily available to research workers, the meteorological bureau, fishermen and other interested parties. One years' data have been prepared and submitted but to date no action has been taken to attempt publication.

The titrations, calculating and compiling have been carried out principally by Messrs. Hollister, Anderson and Fjarlie.

Second Alberni Inlet Investigation

The construction of a sulphite pulp mill at Port Alberni, at the head of Alberni inlet, on the west coast of Vancouver island, has been proposed. For commercial reasons it is most expedient to dump the effluent, waste sulphite liquor, into the head waters of the inlet. If such a mill can safely be established it is probable that other mills will be built at corresponding positions on the B.C. coast. The Department of Fisheries has requested that an investigation be undertaken to:-

1. Predict whether such a mill may safely dispose of its effluent in Alberni inlet.
2. Completely examine the inlet oceanographically before and after the mill is established, so that it may serve as an example in event of a similar problem arising in other inlets.

Waste sulphite liquor has been proven to be a serious pollutant because it utilizes the dissolved oxygen from the water, and in a restricted circulatory system, may so reduce the oxygen content that the fish population may become affected. The head of Alberni inlet, in common with the heads of most of the coast inlets, is a schooling ground for salmon and trout both on the spawning migration and the seaward run, and any disastrous mortality might have a noticeable effect on the fishery.

In a previous report, arbitrary criteria of permissible pollution were suggested, but no guarantee was offered that the state of pollution would remain within the permissible limits during continuous operation of the proposed mill.

A new study has been initiated in order to establish:

1. An estimate of the tolerable limit of daily sulphite liquor pollution under all natural conditions.
2. A prediction of the probable effects of the proposed mill under all natural conditions.
3. A complete description of the chemical and physical state of the inlet before pollution occurs, so that by comparison with similar observations taken after the mill is in operation, it will be possible to measure the degree of pollution occurring.

The problem may be illustrated by comparing the head of the inlet to a tank containing (for argument's sake) 100 tons of oxygen, of which 50 tons are required for the fish life and natural oxygen demand. Then the remaining 50 tons could be used to supply the demands of the waste sulphite liquor. However, if in this hypothetical tank, 10% of the total amount of oxygen was renewed each day (10% 50 = 5) 5 tons per day would be the maximum daily oxygen demand which could be tolerated. If the demand were greater, it would eventually overtake the reserve supply and reduce the oxygen available for the fish. From this it is evident that the oxygen content of the inlet is only important as a reserve, and that the limit of the permissible pollution is to be determined by the rate of replacement of the oxygen supply.

On this basis the study resolves itself into three investigations,

1. A determination of the oxygen content of the system.
2. The position, with regard to depth and area, which the pollutant will occupy in the system.
3. The rate of exchange of water between various parts of the system and the sea.

Then if the rate of oxygen demand of the pollutant is known, a reasonable approximation of the equilibrium state in the inlet can be made.

The natural factors affecting these conditions are volume of river flow (R), wind direction and velocity (W), and the height of tidal rise (H). These may be related mathematically to the volume of flow ( $Q_1$ ) through a section (i) across the inlet, in the form,

$$Q_1 = k_1R + k_2W + k_3 \sqrt{H}$$

then the integral of this function during a period of time will represent the exchange of water in and out of the system through the selected section. The constants in the above equation are functions of the location of the section, and the direction of flow, hence it is necessary to make observations of the flow under varying conditions so that they may be determined. Previous direct measurements of the current velocity were found to be inadequate for this purpose, and a theorem of turbulent flow has been developed to fill the requirements.

At present, the investigation includes continuous observations of:-

1. Complete weather records from Port Alberni, and the drainage area of the inlet, by courtesy of the Meteorological Service.
2. Records of the daily rate of discharge of the Sproat and Stamp rivers, obtained through co-operation with the Water Power and Hydrometric Bureau.
3. Tidal records in Alberni harbour, obtained through co-operation with the Hydrographic Service, and Messrs. Bloedel, Stewart and Welch.
4. Daily observation of the surface water temperature and salinity in Alberni Harbour. Samples obtained by courtesy of Messrs. Bloedel, Stewart and Welch.

During the period May 28 to July 19, and August 15 to September 15, intensive observations were made of:-

5. Velocity of flow in the inlet, to determine the rate of exchange between various parts of the system.
6. Distribution of dissolved oxygen in the head of the inlet (area of probable highest pollution), and down the length of the inlet.
7. Present oxygen demand of the water in the head of the inlet, at the temperature existing in the inlet, to determine the present state of pollution, if any.
8. Stratification of the water in the head and length of the inlet to determine the probable distribution of the effluent.

In addition to the expected cyclic variations in chemical and physical properties of the water, with tide, season, etc., it was found that there was a monthly variation in the dissolved oxygen content from about 20% to 100% saturation, in the zone of probable pollution. This introduces a limiting factor which was not recognised in the previous report.

J.P. Tully

No. 62

The investigation was discontinued due to failure of the equipment, but the work already done will serve as a guide to the extent and requirements of the program, when or if the investigation is resumed.

From the present investigation it has been learned that the observations must be large in number and very precise in regard to time and position, so as to measure the effect of tidal movements, the varying rate of transport in different parts of the system, and to obtain an accurate estimation of the oxygen content of the water, its stratification, and path of flow. During the present season the writer and one technical assistant, Mr. Hollister, with a crew of three men in the M.V. "A.P. Knight", have been making the required observations, which include the sampling procedure, surveying, and analyses. The mathematical analysis of the data, a tedious mathematical process, is being carried out by the scientist and assistant, and will require about twice as much time as the field operations.

J.P. Tully

No. 63

A Theorem of Turbulent Flow

At the present time sea water current velocities may be measured directly by means of current meters and chip logs, whose use is restricted to surface observations or to very protected waters, such as harbour works, etc. In the open ocean an indirect means, based on Bjerknes' theorem of pressure differences, is available.

In many of the researches required of this department, neither of these methods were applicable. For instance, in Georgia strait, Alberni inlet etc., it is required to determine the volume transport under widely varying conditions. Direct observation would entail occupation of a number of stations for periods of several years, and Bjerknes' theorem cannot be applied in the presence of complicated boundary conditions.

To fit these needs a theorem of turbulent flow has been developed relating the change of density gradient per unit distance of flow to the change of density gradient per unit depth, of the form,

$$\left(\frac{du}{dz}\right)_{AB}^2 \cong \frac{gk^2 h^2}{Y\rho_m} \left(\frac{d\rho}{dz}\right)_A^B$$

where  $\frac{du}{dz}$  represents the average velocity difference per unit depth in a section from A to B, g represents gravity, k is a constant, Y is the distance A to B h is the depth of the section,  $\rho_m$  is the mean density and  $\left(\frac{d\rho}{dz}\right)_A^B$  is the change in density gradient from A to B.

From the above equation the velocity difference between the surface and the bottom in any section can be determined. Then the velocity difference in any depth interval can be determined from,

$$\left(\frac{du^*}{dz} - \frac{du}{dz}\right)_{AB}^2 = \frac{gk^2}{Y} \left[ \left(\frac{h^2}{\rho_m} \left(\frac{d\rho}{dz}\right)_A^B\right)^* - \left(\frac{h^2}{\rho_m} \left(\frac{d\rho}{dz}\right)_A^B\right) \right]$$

where the starred quantities refer to the whole depth, and the unstarred quantities refer to any included interval.

J.P. Tully

No. 63

This theorem is a new fundamental development of the theory of turbulent flow, and it is believed that it will provide an instrument for oceanographic analyses which has been required for some time.

Its application has been compared to Bjerknes' theorem on suitable data and an excellent agreement has been obtained, (velocity gradients agree within 5%). Further application may be found in the estimation of divergence and diffusion in areas of known velocity gradients, and in determination of the nature of flow in channels and passages such as occur on the British Columbia coast.

Furunculosis Investigations, 1941

During 1939 it was decided to concentrate upon the development of a prophylactic vaccine as a means of controlling the development of furunculosis in hatcheries. During 1940 certain tests were made with such vaccines, orally administered and the results were very encouraging.

While the number of fish involved in the 1940 tests appeared ample to support the findings, it was felt advisable to practice conservatism in a new field of immunology, and to withhold final recommendations until it could be shown that such results could be repeated. The work was therefore continued on almost identical lines throughout 1941. By the end of July, 3 further tests had been completed, which gave an average result of 26.3% mortality in vaccinated, contrasted with 71.1% in untreated cutthroat trout.

During August-October variations in the manner of infecting the fish were tried out. Two tests (involving 60 fish) were performed in which infection was attempted by placing a heavily infected trout in the same tank as the test fish. This procedure caused infection of 9 out of 30 non vaccinated fish and 3 out of 30 vaccinated individuals, in a period of 5 weeks. The suggestion here was that the previous method of establishing infection, i.e. by adding large amounts of living virulent culture to the tank water, was actually a more severe mode of infection than was the natural route. Two further experiments were carried out in which 35 treated and 30 control trout were infected by subcutaneous inoculation of an approximately 3-fold lethal dose of the virulent culture. (The exact "lethal dose" of this organism for cutthroat trout of a given age is difficult to establish with exactitude). This method of infection appeared definitely more severe than either of the two previous methods, since 24 of 35 (68%) vaccinated fish died, and 27 of 30 (90%) in the non-vaccinated group. It was clear that inoculation constituted the severest test of all, and one of an order not likely to be encountered under natural conditions. There was still, however, a differential in favour of the vaccinated individuals.

During 1941 also, a grant-in-aid of the Furunculosis Investigation was kindly made from the Special Research Fund of the University of British Columbia. It was thus made possible to begin an attack on the following problem. If vaccine should be called for on a large scale necessary to supply several hatcheries for a season, it would be advisable to utilize a cheaper medium for growth than is afforded by the standard Difco media upon which the experimental-scale vaccines were grown. Many inexpensive means of growing bacteria are available, but at times transfer of a culture to a new medium has been known to affect its antigenic structure. This in turn may have an effect upon the protective powers of the preparation.

Mr. Victor Freeman was therefore, engaged to continue work on the antigenic structure of B. salmonicida, and some progress was made upon the lines indicated. During his investigations Mr. Freeman observed a new and interesting variation of the organism, in which the shape of the bacterium became changed, with no corresponding change in cultural, colonial or pathogenic characteristics.

D.C.B. Duff

No. 64

Recommendations. As a result of the immunity experiments of 1940-41, it is pointed out that a properly prepared vaccine, administered in the food of cutthroat trout fry, appears at present the most promising means of producing a satisfactory rise in the level of herd immunity to Bacterium salmonicida infection.

As a result of the immunity experiments of 1940-41, it is pointed out that a vaccine, prepared according to the indicated specifications (Summary Report 1940), and administered by admixture with the usual liver-containing hatchery food of cutthroat trout, presents a most promising means of effecting a rise in the level of herd immunity to furunculosis. While the preparation of the vaccine is a technical matter, its administration may be left in the hands of any faithful hatchery operator. It is recommended that the method developed be utilized in British Columbia Hatcheries. It is at the same time suggested that the application of this treatment be considered not to supplant, but rather to augment, the usual precautions as to transfer of infection from place to place within the Province.

Other Investigations, 1941

In January and February, bacteriological and pathological investigations were undertaken in connection with the mortality among pilchards in and around Pender Harbour, Brentwood Bay and Tod Inlet. The work was carried out as part of a general attack on the problem by members of the staff of the Pacific Biological Station. A special report has been submitted to the Director.

C and E. Berkeley

No. 65

Polychaete Studies

The paper on the polychaeta of Southern California, referred to in the last report, was published by the Southern California Academy of Science in a recent issue of their journal.

Work is now complete on the material collected on the west coast of Vancouver island in 1934, to which also we referred in the last report. We have also completed examination of material collected by Prof. Fraser in the Queen Charlotte islands in 1935 and by Mr. Williams, of the yacht "Stranger" in Alaska and the Bering Sea in 1937. We have combined the accounts of these three collections, together with that of other material taken in the same regions by other collectors during the past few years, into one paper which is now ready for publication.

During the year a number of specimens have been submitted to us for determination by other workers. Amongst these the most noteworthy was a primitive cirratulid Ctenodrilus serratus which was observed by Dr. A.H. Hutchinson in material taken in a plankton net from a confined area of water in Ladysmith harbour which has been created in connection with work on oysters. Ctenodrilus serratus has been known in Europe for nearly a century and has often been noted there in marine aquaria. It has been the subject of special interest and of several investigations by reason of its primitive morphological characters (which have given rise to questions, not yet finally answered, as to its affinities) and its method of reproduction by autotomy. It has not previously been recorded outside Europe so that its occurrence in quantity at Ladysmith is worthy of special note. We intend to record it in a suitable journal in the near future.

J.A. Munro

No. 66

Studies of the Economic Relations of Waterfowl

An investigation of the food habits of scaup ducks, Nyroca americana, Nyroca affinis, based on a study of food materials from a total of 136 specimens, was completed in 1940.

In the case of N. americana the principal winter food on salt water is small molluscs, the largest whole specimen found (Alectrion mendicus) measuring 12 mm.; sea lettuce is second and small crustaceans third in importance. Field observations showed that herring eggs are an important food although only one specimen contained this item. Specimens taken on fresh water had eaten seeds of Scirpus, Carex and miscellaneous vegetable matter; salmon eggs, which occurred twice, and salmon flesh from the bodies of partly decomposed fish which occurred three times, are more important food than the analyses indicated. Specimens taken on Okanagan Lake showed Chara to be the most important food both in frequency of occurrence and average percentage volume. Potamogeton and other vegetable matter are second and mollusca third in total percentage volume; insects are of slight importance in the winter months.

Amphipods predominated in the food of N. affinis in the interior of the province; these were taken by young a few days old, by adolescents and by adults. Chara and other plant material were the chief food of three winter-taken specimens from Okanagan Lake; plant material and insects predominated in the food of eight late fall and winter specimens from Swan Lake; on the coast molluscs and vegetable matter were represented in about equal proportions.