SH 223
A1H
1942

CONFIDENTIAL

FISHERIES RESEARCH BOARD OF CANADA

- - - - - - - - - - - -

ANNUAL REPORT

of the

PACIFIC BIOLOGICAL STATION

for

1942

With Investigators' Summaries as Appendices

NANAIMO, B.C.

DECEMBER, 1942

FISHERIES RESEARCH BOARD OF CANADA

ANNUAL REPORT

of the

PACIFIC BIOLOGICAL STATION

for

1942

NANAIMO DECEMBER, 1942

FISHERIES RESEARCH BOARD OF CANADA

REPORT OF THE PACIFIC BIOLOGICAL STATION NANAIMO, B. C. FOR 1942

BY R. E. FOERSTER, DIRECTOR

The work of the Station during 1942 has consisted in continuing the investigations of salmon, trout, herring, pilchard, lingcod, dogfish, eulachon, oysters and clams and certain hydrographical studies, all commenced in earlier years. Of necessity, these are relatively long-term problems but each season's operations add materially to the fund of information being compiled. In all cases data are being obtained which are essential to the effective regulation and conservation of the Pacific fisheries.

The prosecution of the war has naturally had some effect upon local fisheries. Greater exploitation of salmon and herring for overseas use has occurred, and, since all of the 1942 canned packs have been reserved for Great Britain, the fish-consuming public has had to rely more extensively upon fresh fish which, in turn, has created a heavier demand for lingcod, flat fish and shellfish. The increased importance of vitamin oil has resulted in greater fishing for pilchards, lingcod and dogfish. As far as possible the resulting trends in these greatly stimulated fisheries are being closely followed. Another effect of the war has been the complete elimination of the Japanese from the Pacific coast fishery. This, together with the shortage of man-power generally on the fishing grounds, by reason either of enlistment in the armed services, the Fishermen's Naval Reserve or the attractiveness of high wages in shipyards, etc., must naturally have an influence on the intensity of fishing, hence must be given due consideration in any analysis of the fishing effort and the well-being of the fishery.

STAFF

Two separations occurred during 1942, those of Mr. H.J. Hollister, Junior Technician in Hydrography in January and Mr. W. Anderson, Junior Technician in Hydrography in August. One temporary appointment was made, that of Miss M.K. Merriam, M.A. (Dalhousie University), as Scientific Assistant in Chemistry, dating from November first.

All members of the staff have continued assiduously the prosecution of their investigations. In many cases their work has been made more onerous because of the scarcity of field assistance and the necessity of having to conduct some parts of the field work in addition to the regular research. To some extent this has delayed completion of certain papers for publication but on the whole the prompt working up of field data has been maintained.

In times such as these community responsibilities and duties increase. Members of the staff have assisted greatly in the organization and development of local Air Raid Precautions and a Pacific Coast Militia Ranger unit and have associated themselves with First Aid and Red Cross work.

During the spring and summer Mr. S. Noel Tibbo, of the Newfoundland Department of Natural Resources, was resident at the Station and actively assisted in the herring work as well as acquainting himself with the other fisheries investigations and the methods used.

BOATS

With the very generous financial assistance of the Department the "A.P. Knight" has been re-engined with a 120 H.P. 6 cylinder Vivian Diesel engine and has been equipped with new mast and boom, winch, etc., for more efficient operation in oceanographic work. The greater speed and better accommodation will permit the vessel being used for other marine investigations as well and it is intended that it shall be so employed to greater extent. When not being utilized for Station work the "Knight" is available to the Department for patrol duty purposes and operated very satisfactorily in such capacity this fall.

PUBLICATIONS

During 1942 only three issues of Progress Reports appeared. They contained ten contributions from this Station. Fourteen scientific papers appeared in the Journal of the Fisheries Research Board of Canada or elsewhere and four manuscripts have been submitted for publication. A list of the publications is appended hereto.

ACKNOWLEDGEMENTS

During the year the Provincial Fisheries Department continued to contribute financially to the pilchard, herring and shellfish 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. During the herring tagging season, the Nootka-Bamfield Company Limited and Nelson Bros. Fisheries Limited kindly provided seine boats for the field operations while this fall the British Columbia Packers Limited and Canadian Fishing Company Limited gave space in their Steveston plants for and helped in the installation of the herring tag induction detectors. Sincere thanks are extended for this generous co-operation.

INVESTIGATIONS

Salmon

All of the salmon research is now coordinated under Dr. Pritchard's direction and with but a few exceptions is concentrated upon a study of migration, the return of the adult fish through the coastal fishing grounds to the

natal streams and the extent to which the populations originating from typical rivers or streams contribute to the commercial fishery. This is deemed to be a very significant phase of the salmon problem and one which will provide very valuable data for regulation and conservation purposes.

The exceptions consist of (1) the continued checking of the efficiency of natural spawning of coho salmon in two small but typical tributaries of the Cowichan river, Oliver and Beadnell creeks, (2) the study of the salmon angling fishery for spring and coho salmon in Cowichan bay to ascertain the extent to which angling affects the spawning escapement, (3) an attempt to estimate the size of the coho spawning escapement to the Cowichan river, since a counting weir is impracticable, and (4) the study of whatever features of the life history of the Pacific salmon it is found feasible, with limited facilities, to undertake..

All of the fundamental salmon problems involve relatively long-term consideration but at the same time it is frequently possible to dove-tail in various minor studies, the findings of which fill in certain of the gaps in our knowledge and will eventually assist greatly in completing the picture of salmon conservation requirements and their solution.

Pink salmon

This autumn saw the completion of the sixth complete cycle of investigation of the pink salmon of McClinton creek, Masset inlet, Queen Charlotte islands. In view of the fact that (1) there has now been obtained a very excellent collection of data pertaining to the natural propagation of pink salmon at McClinton, (2) a continuation of the work would be largely in the nature of repetition unless arrangements could be made to extend the scope of the work to include other essential influencing factors, (3) the remoteness of the location and the scarcity of available personnel made continued operation difficult and (4) similar pink salmon research could be undertaken in southern areas to provide comparative data, it was decided to close down the McClinton field station and transfer the equipment south. The buildings and fences were left, however, in case subsequent events should indicate the desirability of continuing the work there in the near future.

The 1942 operations involved the counting of the returning adults from the seaward migration of 5,061,000 fry in the spring of 1941, a study of the size frequencies, the sex ratios and the egg content of the females. In all, (appendix No. 1), 36,893 adults passed the counting weir of which 19,319 or 52.3% were females and 17,574 or 47.7% were males. The sex ratio was practically the reverse of that occurring in the run of 1940 when the females, 16,454 in number, constituted 46.3% and the males, 19,071, 53.7%. The lengths and weights of the fish did not differ significantly from those of the 1940 run (appendix No. 2), nor did the egg content per female.

In the 1940 study of the return of pink salmon from the sea it was found that a number of pinks, marked by removal of certain fins as they left McClinton creek, were recovered at the Waterfall, Alaska, cannery by American fishermen. This was the first clear evidence that the McClinton creek run was tapped, off the Alaskan coast, by the fisheries there. It suggested that perhaps

this might explain, in part at least, the unusual variations in the Masset inlet catches from year to year. Again in 1942 (appendix No. 3) one marked individual of McClinton creek origin was recovered at the Waterfall cannery, one of two records of marked fish taken outside Masset inlet or in the approaches thereto. The other was caught in Douglas Channel in the central B.C. area. Observers were stationed at a cannery on the Nass, on the Skeena, at Rivers Inlet, at Butedale in the central northern area and at Pacofi, at the southern end of the Queen Charlotte islands, but no recoveries were made except among fish transported to the Skeena from Masset inlet.

One perplexing fact arising from the 1942 returns was the relatively small number of recoveries made, even at McClinton creek. In the 1940 experiment 0.4 per cent of the marked fry returned as adults but in 1942 only 0.11 per cent were retaken. For unmarked adults the proportionate returns in 1940 and 1942 were 1.7 and 0.7 per cent respectively. It is suggested that differential mortality among the marked fish and some interchange of fish between adjacent streams in the Masset inlet area may have been partly responsible.

For some years Dr. Pritchard has been gathering material to determine whether there are any recognizable morphological racial differences between (1) the pink salmon in northern streams and (2) between northern and southern areas. The two most stable characters, i.e. less subject to variation because of environmental factors or size during the adult stage namely, number of gill rakers and number of pyloric caeca, were selected and counts made of representative samples (appendix No. 4). Though significant differences occurred between certain rivers no conclusive evidence was noted that indicated any real difference either between rivers in the same area or between areas.

Chum salmon

An analysis has been made by Dr. Pritchard of approximately 1,300 scale samples taken in various areas of the coast. Although the material has not been completely summarized it may be stated (appendix No. 5), that chum salmon are taken in the fishery in their third to sixth years. In northern areas individuals in their fifth year predominate while in the south four year fish are most abundant.

Coho salmon

The data pertaining to the spawning run of 1941 in the Cowichan river are now complete and may be summarized as follows:

During the summer and autumn angling season at Cowichan bay approximately 4300 cohos were taken by anglers (appendix No. 11). The spawning escapement to the river is estimated (appendix No. 8) at 80,000, of which 65,000 proceeded to the spawning grounds of Cowichan lake and Cowichan river above Skutz falls, while at least 15,000 are considered to have spawned in the tributaries below. Although the fish appeared to move up-river rather rapidly, one to two months elapsed before the spawners entered the tributary streams. Actual spawning did not occur for some time after that (appendix No. 9).

The 1941 spawning run contained individuals which had been marked prior to liberation from the hatchery ponds by having certain fins clipped off. A

total of 32,111 fingerlings were so marked in the summer of 1939 and it was anticipated that the recovery of marked adults would indicate (1) the percentage caught commercially, (2) where these fish entered the commercial fishery, (3) the percentage caught by anglers, (4) the percentage return to the spawning area and (5) the degree of wandering, if any, to other spawning grounds.

The returns (appendix No. 6) showed that in the commercial fishing areas 22 marked individuals were taken and reported, or roughly 6 per cent of the total 359 recoveries. These were caught at various points along the west coast of Vancouver island, strait of Juan de Fuca and in the strait of Georgia. From anglers in Cowichan bay, 14 or 4 per cent were reclaimed while in the parent spawning area 311 or 87 per cent were retaken. Nine marked individuals or 3 per cent were recovered from other spawning streams of the Cowichan system. The total returns, 359 fish, represent only 1.1 per cent of the numbers originally marked and seem unusually low.

In studies of this character the results are verydefinitely influenced by the variable nature of the recovery campaign and in this particular case it is readily realized that the return of but 22 marked fish from the commercial fishery probably does not by any means represent the total actual capture of marked individuals. In many cases the fact that specimens have fins missing is not noted, in others it may be ignored or the significance not appreciated. The efficiency of recovery depends largely on the effort expended in giving publicity to the work and on the co-operation of the fishermen and this phase has to be widely developed to a much higher degree.

The 1941 data do however show the extent of the area in which Cowichan cohos are taken commercially and later efforts may provide better quantitative data. The returns of the marked fish in 1942 (appendix No. 7) do not promise much better results but in this particular experiment the marks assigned to the work were not very suitable. Later years' experiments should prove more fruitful (appendix No. 13).

For the past four years the efficiency of natural propagation of coho salmon in two small tributaries of the Cowichan river has been tested.. Counts of in-going adults and of the resulting out-going fry or yearlings are made. In the autumn of 1941 a total of 574 males and 269 females ascended Oliver creek (appendix No. 10). The egg deposition was calculated to embrace 564,900 eggs. From this spawning 156,887 fry were obtained, representing a survival of 26.0 per cent. The experiment at Beadnell creek was nullified by occurrence of a severe freshet which washed out the weir and presumably allowed uncounted females to ascend. The percentage survival of 26.0 per cent for Oliver creek closely approximates that of 1941, namely 30.37 per cent, but both returns are very much higher than those obtained in 1939 and 1940.

The 1942 angling catch of spring and coho salmon in Cowichan bay, 3.9 line-hours per fish, compared favourably with that in 1941, 4.07 line-hours per fish,(appendix No. 11). During the period when records were kept, August 23 to October 31, which represents the bulk of the season, 1179 more salmon were caught but there were 630 more lines used and the fishing effort was 3,473 line-hours greater. As pointed out elsewhere above, the angling catch, as indicated for cohos, is only a small fraction of the escapement to the river and

its spawning grounds.

Spring salmon

During 1942 returns were expected from 2 marking experiments conducted at the Cowichan lake hatchery, one in 1938 (21,967 fish) and the other in 1939 (25,515 fingerlings). Unfortunately the mark used in 1938 conflicted with one adopted on the Columbia, hence the returns from the commercial fishery could not be used with any degree of confidence. No such confusion applied to the 1939 experiment and the 9 recoveries (appendix No. 12) made in the commercial fishery off the west coast, from Kyuquot to Swiftsure banks, and in the strait of Georgia, give interesting evidence of the spread of these Cowichan spring salmon. No marked springs were noted either in the angling fishery in Cowichan bay or at the fish-way and traps at Skutz falls. The proportion of marked individuals among those comprising the spawning escapement must have been very small.

A further experiment to reveal the extent to which Cowichan springs contribute to the commercial catch and at what points and perhaps to provide some information on the return to the river has been commenced with the marking, in the spring of 1942 (appendix No. 13) of 235,373 fry. Greater publicity among the commercial fishermen will be attempted.

For three years Drs. Pritchard and Tester have been collecting spring salmon stomachs from different areas of the coast and analyzing the contents in order to determine the natural food items of these fish. In 1941 (appendix No. 15) herring and sand lance were the predominant food items. Pilchards, which were fairly numerous in 1940 (21 per cent by volume) were relatively scarce (6 per cent) probably due to the general lack of abundance in B.C. waters of small pilchards as compared with the phenomenal situation in 1940. Other species of fish and invertebrates occurred to more or less the same extent. It was found that the proportions of the various food items occurring in the stomachs are present in practically the same proportions in each area, though between areas quite marked differences are noted.

Trout

A number of years ago the Fisheries Research Board initiated a study on the Cowichan river system to establish a proper trout stocking policy. One of the main problems was the question of the probable degree of migration of the native (cutthroat and steelhead) and introduced (kamloops and brown) species throughout the river and lake system or out to sea. Marked fish were therefore liberated from the hatchery ponds and from their recoveries by anglers information as to presumed movement was obtained.

During 1942 further recoveries were reported to Mr. Neave (appendix No. 16) and are in substantial agreement with previous records. Of particular interest were the returns from an experiment to ascertain whether any difference in habit could be found between the two "races" of Salmo gairdneri which Mr. Neave had previously separated on the basis of scale counts. An equal number of each "race" was reared at the hatchery, marked in different ways and liberated at the same time. Of the steelhead or sea-running "race" only 8 recoveries were obtained, all in fresh water and occurring between the time of liberation and the time when

they reach the sea-going stage. Of the rainbow or non-sea-running "race", 55 returns were received, 27 up to the time of normal young steelhead seaward migration and 28 during the seven months thereafter. This would seem to confirm the belief that these "races" are distinct and that the rainbows are a purely fresh-water strain which, remaining entirely in the river or lake, are available to the anglers throughout the year.

It has seemed of general interest to the Cowichan trout studies to maintain a modified creel census of the trout catches from year to year, largely to indicate the relative numbers of the different species landed and their general availability per season. For the upper part of the river, where most fishing is done, rainbows were most frequently taken (appendix No. 17), followed by cutthroat. Browns were very rarely caught. In the lake fishing, however, cutthroat exceeded the rainbows somewhat. Comparison with data of previous years indicates that these relationships are relatively constant. On the basis of average line-hours per fish, the fishing in the river has remained fairly constant over the last four years but for the lake, the catch in 1942 was very appreciably better than in 1941.

Herring

Because of the heavy war-time demand for canned herring for overseas shipment it was but natural that much interest should centre about the abundance of herring available for capture during the 1941-42 season and that exploitation should be keen. A record pack of 1,563,628 cases (48 lb.) was obtained, most of it taken in the lower east coast of Vancouver island fishery.

During the season the total catch (appendix No. 18) amounted to 111,329 tons, of which 44 per cent was taken in the lower east coast of Vancouver island area, 10 per cent in the Quathiaski and upper east coast districts, 16 per cent on the west coast of Vancouver island and 30 per cent in the central and northern areas, from Queen Charlotte sound to the Nass river. Availability records (average catch per seine per day's active fishing) indicated that while on the lower east coast the availability of herring was the highest on record for single seines (97.3 tons) that for the west coast, excluding the Quatsino area, was relatively low (21.0 tons), similar to conditions in the three past seasons (24.4, 18.2, 17.8 tons). In the small Quatsino area, however, fishing was good and the quota of 3,000 tons practically attained, 2,849.5 tons. In the central area the fishing was again disappointing, only 12,108 tons being obtained out of a quota limit of 40,000 tons. In the north the situation was much better and the quota of 20,000 tons was almost reached, 18,946 tons having been taken.

With such great importance attaching to the herring fishery due concern was felt regarding the amount and success of spawning in 1942. To improve the spawning surveys and place them on a more comprehensive and comprehensible basis Dr. Tester endeavoured (appendix No. 20) to devise a detailed survey plan. For various reasons the scheme was found to be generally impracticable, hence reliance must continue to be placed on the more qualitative observations as made by the officers in the field while on general patrol. From the spawning reports submitted by these officers it is indicated (appendix No. 19) that in the lower east coast of Vancouver island area no definite increase in egg deposition occurred,

on the west coast there was a decrease and in the northern and central areas no indication of any change over the previous year was noted.

During 1942 there occurred two phenomena which boded ill for the herring fishing, namely an extensive mortality among spawning herring along the southern east coast of Vancouver island in February, March and April, and the discovery of large quantities of dead herring spawn in the same area during April. Painstaking efforts were taken to discover the factors responsible for these catastrophes and to estimate the probable effect of the losses. In the case of the herring mortality (appendix No. 22) it is believed that several thousand tons of fish were lost and though some of the dead individuals had evidently spawned, a large proportion had not. Therefore the egg deposition of the original spawning stock was appreciably reduced. No satisfactory explanation of the mortality could be found. Externally and internally the fish appeared to be quite normal except that in many instances the livers were somewhat macerated, soft in texture and frequently reduced to a pulpy mass. It so happened that naval exercises were taking place in the strait at the time the mortality first appeared but whether activities associated with these practices had any relation to the herring situation cannot be determined.

The egg losses presented a somewhat easier problem, however, for it was found (appendix No. 23) that the dead eggs were occurring principally in relatively deep water - below the +3 foot tide level- whereas eggs spawned at higher levels appeared quite normal. During the period of mortality a heavy plankton bloom occurred, the pH of the water was abnormally high and presumably, therefore, a relatively low CO_2 condition prevented adequate respiration of the eggs and they suffocated. At the higher tide levels where exposure to the atmosphere was for longer periods the conditions were less severe or less prolonged. It is realized that this may not be as rare a phenomenon as at first thought and observations will be made in future years to check this feature.

Recovery of tagged herring was continued during 1941-42, both by magnets which have been installed in all reduction plants and by two induction detectors, one of which was operated at Ucluelet, on the west coast of Vancouver island, the other at Steveston, on the Fraser river, strait of Georgia area. From the magnets 399 tags were reclaimed while the induction detectors recovered 43. Since the tags were all numbered, the area of tagging known and the area of recovery generally ascertained, (some magnet recoveries are not quite definite) the tendency of the fish to return to the area of tagging can be determined. From the 1941-42 tagging returns (appendix No. 26) it was found that (1) the interchange between major areas is very small, 96 per cent of the tags being returned from the areas in which they had been used, (2) on the west coast there is a tendency to intermingle between adjacent areas, 60 per cent of the tags being returned from the areas where used and (3) the independence of the central area was maintained only imperfectly in 1941-42. Extensive canning operations in the east coast area and the inability to check the cannery-bound fish for tags reduced the recovery of tags in that area.

During the spring of 1942, 22,521 herring were tagged, 15,559 in the strait of Georgia area, 5,465 in Queen Charlotte sound, and 1,497 in the central area of the coast. One tagging of 496 fish was conducted at Sooke during October. Among the strait of Georgia taggings were some conducted at Departure bay and

the fish. Many preserving fluids were tested but phenol in concentrations of 3 and 5 per cent was finally selected. These have been subjected to a thorough testing to indicate the correction factor required to be used in comparing the weights or measurements of the preserved material with those of fresh specimens.

Pilchards

During the 1942 pilchard fishing season approximately 48,000 tons of fish were taken (to November 10) by the British Columbia fleet, a relatively good catch though lower than that of 1941 (60,000 tons). Oil production however was low. Only 24,000 cases were canned, as compared with 58,000 cases in 1941 and 59,000 in 1940. Most of the catch was made (appendix No. 32) off the west coast of Vancouver island though some pilchards were caught off the Washington coast and in areas north of Vancouver island. In general the fish were small, though not as small as in 1941 when the average lengths were less than they had been for several years. Sampling indicates that two groups of fish were present (appendix No. 33). One with its centre of abundance near 215 mm. standard length was probably composed dominantly of the 1939 year class (III's) whereas the other, near 240 mm. standard length, was a composite of several older age groups. Dr. Hart, who is directing the pilchard investigation, is of the opinion (appendix No. 32) that the pilchard stock is undergoing a marked change, but the significance is yet obscure.

No pilchard tagging was done in 1942 but nine recoveries were made (appendix No. 35), comprising 5 California and 4 Oregon tags. One Canadian tag put out in August, 1939, was recovered at a San Francisco plant, although it is thought to have been a hold-over from the 1941 operations. Of interest is the recovery of a tag used at Monterey, California, from pilchards caught near Aristazabal island, south eastern end of Hecate strait. In reviewing the pilchard tagging operations, 1935-42 (appendix No. 36), it is recommended by Dr. Hart that since the returns already obtained give a reasonably clear picture of general pilchard migration, further work be suspended until it is possible to make a quantitative study which would involve much more extensive operations.

Lingcod

The lingcod investigation, directed by Dr. Hart, has been concerned principally with migration studies in the most important fishing area, the east coast of Vancouver island. Certain tagging experiments were undertaken, utilizing a special "ring" jaw tag and the recoveries of tagged individuals provided information not only as to movement within the fishing area itself or into and out of the region but also on the rate of growth of fish between the times of tagging and recovery.

Previous findings have indicated that the majority of lingcod after tagging remain fairly close to the place where originally caught. They do not seem to wander far either for feeding or spawning purposes. The 1942 returns (appendix No. 37) substantiate these conclusions. Of 42 recoveries, 28 were recorded from the place where tagged and 14 showed migratory activity.

It has not yet been clearly established whether or not young lingcod have a migratory stage or not but, if it is found that they have, consideration has been given to the setting off of "closed areas" for breeding purposes (appendix No. 39) and the probable effect of crowding in such areas upon the fecundity of females. In studying the egg content of mature female lingcod in relation to size it is found that the spread in egg count is much less for weight-egg content relationship than in length-egg content. In round numbers a mature lingcod produces 10,000 eggs per pound of fish, this relationship holding relatively constant throughout the adult stages. The egg-content would therefore seem to be related to the condition of the fish. The difference in egg content of females in "closed" and "open" areas though appreciable is not large enough to affect any establishment of a "closed area" policy of conservation, should such be considered advisable on other bases.

With respect to rate of growth studies (appendix No. 37), the findings, based on 46 recoveries, show that male lingcod increase at an average rate of 5.6 mm. in length or 2.38 oz. in weight, females at an average rate of 6.3 mm. or 4.18 oz. These computations correspond closely with those obtained for 39 recoveries in 1939-40. It will be noted that females grow more rapidly than the males.

Preliminary mortality rates based on the decline in number of tags and the time they are out (appendix No. 37) indicate an annual total mortality rate of around 75 per cent. Allowing a correction for tags too recently put out to be recovered, the rate becomes 67 per cent. On the basis of these values and the average rate of growth for both sexes, it would appear that the lingcod fishery has been exploited rather too actively. However more extended tagging work should be undertaken before arriving at any positive conclusions.

It is proposed (appendix No. 38) to undertake a study to elicit whether age determinations can be made for ling cod by reading the scales. Heretofore experiments have been unsuccessful but it is hoped that refined methods of technique may be more fruitful.

Dogfish

During 1941, 564 dogfish, Squalus suckleyi, were tagged in order to gain some information as to their migratory habits and the probable segregation of populations in the strait of Georgia. Thirty-eight recoveries have been made (appendix No. 44) of which 10 were recovered in the tagging areas, 8 were retaken to the north, 9 to the east and 5 to the south of the tagging centres. The results show definite movement about the Strait. One recovery was made off cape Flattery indicating that migration out to the open coast does occur. One recovery in the strait of Georgia of a State of Washington tag affixed to a dogfish at Swiftsure banks indicates a contrary movement, from the open ocean to inside waters.

Eulachon

The eulachon fishery of the Fraser river is only a minor one, yet of considerable seasonal importance to the fresh fish trade. Eulachons are also

used in quantity for mink and fox food. Certain studies were continued by Dr. Hart.

The 1942 availability calculations (appendix No. 40), as expressed in pounds of fish caught per 100 square fathoms of net per hour, showed no marked change from those of the previous year. Commencing in early April the fishing increased to a peak during the latter half of the month, then diminished. During the peak period the availability (222) closely approximated that of 1941 (200). Mesh of net seems to influence the catch and, where records were sufficient to make valid comparisons (1 1/4 and 1 1/2 inch mesh), the larger mesh appeared to be more effective.

One feature of the study has been consideration (appendix No. 41) of the use of spawned-out, dying and dead eulachons as they drift down-river from the spawning grounds. It is felt that by using suitable collecting devices substantial quantities of fish might be salvaged. Preliminary tests suggest that as far as edibility and oil content are concerned the dead fish should be quite utilizable.

Further life-history studies indicate that, with respect to fecundity of female eulachon (appendix No. 42), egg content is directly correlated with length of mature fish, one cm. in length corresponding to around 6000 eggs. Plankton hauls made in the Fraser river and off the river mouth (appendix No. 43), indicate that the eggs drift down-river and reach the salt water shortly after hatching. It is suggested that plankton studies in the strait of Georgia may provide further information regarding the development and general distribution.

Shellfish

The shellfish research is confined largely to studies of oysters and clams. They have been conducted by Mr. Neave. With respect to oysters, attention has been devoted principally to the determining of the factors which influence the spawning and spatting of the Pacific variety (Ostrea gigas) For clams, problems related to age class representation, rate of growth, effects of digging and efficacy of regulatory measures have been investigated,

Oysters

During the summer of 1942 two spawnings of O. gigas occurred (appendix No. 46). The first took place early in July during a period of hot weather, with water temperatures well over 20°C. On July 14 numerous larvae, ranging from 115μ to 230μ, were taken in the plankton, but a few days later nearly all had disappeared, seemingly coinciding with unsettled weather and day water temperatures of 18° - 19°C. No set of any value resulted.

During early August a second spawning occurred and plankton samples showed large numbers of larvae present. On the night of August 20 and for several days after, widespread setting occurred, oyster shell cultch hung on floats catching from 10 to 44 spat per shell (counted on smooth surface only). Water temperatures during the larval period remained high, 21.1° to 24.7°C.

The probable occurrence of a set was communicated to the oyster growers and a large amount of cultch was put out and ample seed obtained.

No spatting occurred during 1942 on the oyster beds at Boundary bay.

Clams

Two species of clam are exploited on the public beaches of the coast, the "littleneck", Paphia staminea which is largely used for the fresh clam trade and the "butter", Saxidomus giganteus, which has of recent years been taken in large quantities for canning purposes. There is, of course, also the "razor" clam, Siliqua patula which is highly prized as a canned product but it is taken principally on leased beaches and has not yet entered into the present investigation.

Chief attention has been given to the butter clam situation largely because of its greater potential importance and the intensity of exploitation. There were indications that the strait of Georgia beds were declining in abundance and as the digging effort in other areas increased it was felt that similar conditions might arise there.

During the 1941-42 season the records, as compiled by Mr. Neave, show a catch of 3,237,785 lbs. of butter clams and 197,270 lbs. of littleneck (appendix No. 47). The principal butter clam areas were: Prince Rupert, 691 tons; Alert bay, 462 tons and the south east coast of Vancouver island, Comox to Sidney, 284 tons. Of this latter amount, 116 tons came from Seal island, adjacent to Comox, an area which had been closed since 1939 and was reopened for a short period only.

In an effort to systematize the statistics and obtain a more comparable record of the abundance of clams, Mr. Neave continued to collect data giving the results of digging on the basis of average catch per man-tide. These records have but recently been commenced (appendix No. 47) but as they accumulate they should provide a reasonably accurate index of the clam population trends on commercial beaches.

Reference has been made above to the Seal island butter clam area, newly opened in 1942 for a short period. In view of the very evident abundance of clams there, resulting from the protection afforded during the closure to the young clams of the 1934 and 1935 spawnings, there seemed a fine opportunity to test out on a relatively practical scale the benefits to be derived from imposing quotas to control and regulate annual production. Accordingly (appendix No. 48), three adjoining areas of the beach, averaging 9,500 square yards, were staked out, in one of which (C) unrestricted digging was permitted, in another (A) digging was stopped when it was considered that two-thirds of the ground had been dug, while in the third (B) digging ceased when one-quarter had been exploited.

On the basis of average catch per man-tide, area C produced 587 lbs., area A, 696 lbs., and area B, 399 lbs. It remains to be seen how the production is maintained over a period of years. Estimates were made of the populations

of clams, expressed as pounds per square yard, in the three areas as follows: area C - 13.9, area A - 15.55 and area B - 9.73.

The experiment in testing clam productivity by utilizing Latin square plots in five localities along the east coast of Vancouver island was continued by Mr. Neave in 1942 (Appendix No. 49). Commenced in 1938 the experiment involves the digging of five plots in each 25 plot square in the following order: twice each year, once a year, every second year, every third year, and only at the end of the test. All clams above legal size are removed at each digging and the total weight and other data recorded.

In addition to the productivity tests, samples of clams are obtained from various beaches throughout the coast and measurements and age determinations made to ascertain the general growth rate, the age at which legal size is attained and the occurrence of dominant year classes (Appendix No. 50). There is evidence that the amount of setting each year varies very considerably and since this is a fundamental factor in clam production it is being closely studied.

As mentioned above, the littleneck clams are used for the fresh clam trade and have been taken chiefly from the strait of Georgia area. In 1941 around 500,000 lbs. were dug (Appendix No. 47) but during 1942 the occurrence of paralytic shellfish poisoning in certain areas on the west coast of Vancouver island resulted in a general ban on the use of clams. Digging of littlenecks was included and thus cut short most of the summer collecting which normally accounts for a large part of the littleneck catch.

The average catch per man-tide in 1942 has been calculated (Appendix No. 47) and shows that in comparison with similar data for 1941, the abundance has been maintained, even in the heavily-exploited Chemainus area.

Shipworm

In 1941 a study of the seasonal incidence of shipworm (Bankia setacea) settlement on fixed and floating wooden structures in various parts of the coast was commenced by Mr. Quayle and has been continued by Mr. Neave. Test blocks were set out each month at three levels, (a) 3 feet below the surface, (b) a fixed level corresponding to zero tide, and (c) a fixed level 3 feet from the bottom and 3-8 feet below zero tide. Results to date (Appendix No. 51) indicate that while there appears to be a tendency for larval settlement to reach a maximum in the fall, destructive attacks may take place at any season. The floating sub-surface blocks suffered the least, the sub-zero tide blocks the greatest attacks.

Hydrography

The principal study during the past few years has been the investigation of Alberni inlet on the west coast of Vancouver island, from the point of view of the possible or probable effect on marine life there of the operation of a sulphite pulp mill, the construction of which is contemplated. The Department of Fisheries requested information on the tolerable limits of pollution and the probable effect of the release into Alberni inlet of the proposed pulp mill's sulphite effluent. It was also suggested that a study of the conditions before and after the mill commenced operation be made, since the situation seemed a rather ideal one in which to acquire a body of fundamental data. It was felt that the findings might be extremely useful in analyzing situations elsewhere, if and when pulp mills were contemplated.

of clams, expressed as pounds per square yard, in the three areas as follows: area C - 13.9, area A - 15.55 and area B - 9.73.

The experiment in testing clam productivity by utilizing Latin square plots in five localities along the east coast of Vancouver island was continued by Mr. Neave in 1942 (Appendix No. 49). Commenced in 1938 the experiment involves the digging of five plots in each 25 plot square in the following order: twice each year, once a year, every second year, every third year, and only at the end of the test. All clams above legal size are removed at each digging and the total weight and other data recorded.

In addition to the productivity tests, samples of clams are obtained from various beaches throughout the coast and measurements and age determinations made to ascertain the general growth rate, the age at which legal size is attained and the occurrence of dominant year classes (Appendix No. 50). There is evidence that the amount of setting each year varies very considerably and since this is a fundamental factor in clam production it is being closely studied.

As mentioned above, the littleneck clams are used for the fresh clam trade and have been taken chiefly from the strait of Georgia area. In 1941 around 500,000 lbs. were dug (Appendix No. 47) but during 1942 the occurrence of paralytic shellfish poisoning in certain areas on the west coast of Vancouver island resulted in a general ban on the use of clams. Digging of littlenecks was included and thus cut short most of the summer collecting which normally accounts for a large part of the littleneck catch.

The average catch per man-tide in 1942 has been calculated (Appendix No. 47) and shows that in comparison with similar data for 1941, the abundance has been maintained, even in the heavily-exploited Chemainus area.

Shipworm

In 1941 a study of the seasonal incidence of shipworm (Bankia setacea) settlement on fixed and floating wooden structures in various parts of the coast was commenced by Mr. Quayle and has been continued by Mr. Neave. Test blocks were set out each month at three levels, (a) 3 feet below the surface, (b) a fixed level corresponding to zero tide, and (c) a fixed level 3 feet from the bottom and 3-8 feet below zero tide. Results to date (Appendix No. 51) indicate that while there appears to be a tendency for larval settlement to reach a maximum in the fall, destructive attacks may take place at any season. The floating sub-surface blocks suffered the least, the sub-zero tide blocks the greatest attacks.

Hydrography

The principal study during the past few years has been the investigation of Alberni inlet on the west coast of Vancouver island, from the point of view of the possible or probable effect on marine life there of the operation of a sulphite pulp mill, the construction of which is contemplated. The Department of Fisheries requested information on the tolerable limits of pollution and the probable effect of the release into Alberni inlet of the proposed pulp mill's sulphite effluent. It was also suggested that a study of the conditions before and after the mill commenced operation be made, since the situation seemed a rather ideal one in which to acquire a body of fundamental data. It was felt that the findings might be extremely useful in analyzing situations elsewhere, if and when pulp mills were contemplated.

The study involved initially a consideration of (1) the physical state of the inlet, embracing the rate of transport of water down the inlet, the extent of displacement and replacement, the effects of river discharge and tidal action, and the vertical stratification of the water in the area, (2) the chemical state, i.e., oxygen sypply, natural oxygen demand, pH of the water, etc., and (3) the effects of the introduction of the effluent upon the acidity of the water, oxygen supply, etc., particularly in view of the high oxygen demand of the sulphite liquor.

The investigation to date, as conducted by Mr. Tully, has covered the circulation system in the partly enclosed area at the head of the inlet, the general conditions pertaining to rate of transport and circulation of the waters of the inlet and the general oxygen supply available. The preliminary results suggest (Appendix No. 53) that, assuming uniform distribution of the effluent and a constant rate of replacement at average and high water stages of river discharge, there would be available in the inlet sufficient oxygen to adequately support fish and other marine life after the oxygen demand of the introduced pulp mill effluent had been met. Under low water conditions (late summer), however, a deficiency of residual oxygen would arise.

It is possible, though, that the effluent may be discharged at a point where it can be transported out of the area at the head of the inlet without producing uniform distribution. In such a case the critical conditions, even in low water periods, may be overcome. Further investigation of the transport of particular masses of water from the head of the inlet into the main body of the canal and of the probable occurrence of areas of concentration within the inlet itself is planned, preferably by model studies.

Certain intimately related problems, such as the probable effect of the pulp mill effluent on plankton supply, and the tolerance of salmon, trout, etc., to the pollutant, have yet to be investigated.

Daily Seawater Observations along the Coast

The collecting of daily seawater samples for salinity determinations has been continued under Mr. Tully's direction (Appendix No. 54) at a number (13) of lighthouse stations along the Pacific coast of British Columbia. Water temperature readings are also taken. From the compilation of these records the trend of conditions prevailing seasonally and annually in coastal waters can be determined. Such knowledge will be valuable for any future studies of the migration of fishes, unusual appearances of species, sudden mortalities, etc. The industry has, from time to time, appealed for water records, systematically collected, and during the present war the Department of National Defence has found the data of much use. While at the present time the data are placed in a "secret" category, therefore not available for publication, they are being given limited circulation in mimeographed form, and will eventually be distributed more widely.

During the past year the Station co-operated with the Department of Fisheries and the Department of Pensions and National Health in carrying through a bi-weekly sampling of shellfish (butter clams, littleneck clams and sea mussels) to determine the occurrence of paralytic shellfish poisoning in coastal areas. For the east coast of Vancouver island south of Seymour Narrows, and the south and west coasts of the Island, Mr. Neave selected certain typical clam beaches and from those (Appendix No. 55) samples were dug by Department of Fisheries field officers and sent as speedily as possible (within 24 hours) to the Station where the siphons and digestive glands were dissected out and acid-alcohol extracts prepared by Mr. Tully, these latter then shipped air express to the laboratories of the Department of Pensions and National Health in Ottawa. Here the extracts were injected into mice and the toxicity of the clams determined.

The methods first used were those employed by scientists of the Hooper Foundation, University of California, in work of a similar nature on sea mussels. In an effort to cut down the routine work as much as possible and obtain data which would be more readily applicable, those directly concerned at the Station pressed for a fuller consideration of the situation and the adoption of more suitable technique practices. During the fall a conference was called attended by Dr. Sommer of the Hooper Foundation, and new methods of procedure were adopted. At the same time it was requested that the Station undertake preparation of extracts which would correlate the results from the original methods with those from the newer and which would, in addition, test the amount of toxic substance in different organs of the molluscs. These extra extracts were prepared on three separate samples from three different areas where the poison was known to occur.

It is proposed to continue these tests throughout a year, ending June, 1943, thus obtaining essential information as to the seasonal trend of the poison and the need for quarantine both as to area of coast involved and period of year. To date the results have shown that a definitely dangerous period does occur in west coast areas and may at certain times be found in certain areas of the east coast of Vancouver island. Probably a summer season closure will be applied to the former and special closures invoked for other areas, if and when tests show the toxicity to be approaching dangerous levels. The study is of particular significance since it may make unnecessary a complete ban on all clam digging along the coast, and may permit the uninterrupted exploitation of littleneck clams in the strait of Georgia which seem to be generally unaffected.

Other Investigations

Taxonomic studies of marine polychaete worms were continued during 1942 by Mr. and Mrs. Berkeley (Appendix No. 56). Collections from northern latitudes have been examined, particularly a series from the Hudson bay area taken by expeditions to that region in 1927-30. A revision of the polychaete fauna of the Vancouver island region is in progress.

PUBLICATIONS DURING 1942

Berkeley, C. Occurrence of Ctenodrilus in the Pacific. Nature, vol. 149, No. 3774, p. 248, Feb. 28.

Berkeley, E. & C. North Pacific Polychaeta, chiefly from the west coast of Vancouver island, Alaska and Bering Sea. Canadian Journal of Research, Vol. 20, D, pp. 183-208, July.

Duff, D.C.B. The oral immunization of trout against Bacterium salmonicida. J. Immun., Vol. 44, No. 1, pp. 87-94, May.

Foerster, R.E. Fisheries Research at the Pacific Biological Station. The Collecting Net, Vol. 17, No. 4, August.

Dogfish tagging - preliminary results. Prog. Repts. Pac., No. 53, Dec.

Hart, J.L. Reproduction in the Dogfish. Prog. Repts. Pac., No. 51, pp. 16-17, March.

Albacore food. Prog. Repts. Pac. No. 52, pp. 9-10, Sept.

Sand fleas and live bait. Prog. Repts. Pac. No. 52, pp. 16-17, Sept.

Tagging British Columbia pilchards (Sardinops caerulea (Girard)): Insertions and recoveries for 1941-42. Report British Columbia Fisheries Department, 1941, pp. 45-48.

Hart, J.L., A.L. Tester and R.V. Boughton. Tagging of herring (Clupea pallasii) in British Columbia: Apparatus, insertions and recoveries during 1941-42. Report British Columbia Fisheries Department, 1941, pp. 49-78.

Idyll, Clarence. Food of rainbow, cutthroat and brown trout in the Cowichan river system, B.C. J. Fish. Res. Bd. Can., Vol. 5, No. 5, pp. 448-458.

McHugh, J.L. Variation of vertebral centra in young Pacific herring (Clupea pallasii). J. Fish. Res. Bd. Can., Vol. 5, No. 4, pp. 347-360.

Vertebral number of young herring in southern British Columbia. J. Fish. Res. Bd. Can., Vol. 5, No. 5, pp. 474-484.

MacKay, Donald C.G. The Pacific edible crab, Cancer magister. Bull. Fish. Res. Bd. Can., No. 62, 32 pp.

Mottley, C. McC. and Daniel R. Embody. The effect of the full moon on trout fishing. J. Amer. Stat. Assoc., Vol. 37, pp. 41-47.

Neave, Ferris. The Butter clam (Saxidomus giganteus Deshayes): Studies in productivity. Report British Columbia Fisheries Department, 1941, pp. 79-81.

Neave, Ferris and A.L. Pritchard. Recoveries of Cowichan river coho salmon from the 1938 brood year emphasize the value of marking experiments. Prog. Repts. Pac., No. 51, pp. 3-7.

Pritchard, A.L. and Ferris Neave. What did the tagging of coho salmon at Skutz falls, Cowichan river, reveal. Prog. Repts. Pac. No. 51, pp. 8-11.

Pritchard, A.L. and A.L. Tester. The food of spring salmon in British Columbia waters in 1941. Prog. Repts. Pac. No. 53.

Quayle, D.B. The use of dynamite in Teredo control. Prog. Repts. Pac. No. 51, p. 20.

Tester, A.L. Herring mortality along the southeast coast of Vancouver island. Prog. Repts. Pac. No. 52, pp. 11-15.

A high mortality of herring eggs. Prog. Repts. Pac. No. 53.

Tully, John P. Surface non-tidal currents in the approaches to Juan de Fuca strait. J. Fish. Res. Bd. Can., Vol. 5, No. 4, pp. 398-409.

PAPERS SUBMITTED FOR PUBLICATION

Hart, J.L. & J.L. McHugh. The Smelts (Osmeridae) of British Columbia. (Submitted to Bull. Fish. Res. Bd. Can.).

Idyll, Clarence. A study of the bottom fauna of some portions of the Cowichan river, British Columbia (Submitted to J. Fish. Res. Bd. Can.).

Quayle, D.B. Sex, gonad development and gametogenesis in the "littleneck" clam, Paphia staminea Conrad. (Submitted to J. Fish. Res. Bd. Can.)

Seasonal gonad changes in the "littleneck" clam, Paphia staminea Conrad (Submitted to J. Fish. Res. Bd. Can.).

Wailes, G.H. Protozoa, Part III (Submitted to Fish. Res. Bd. Can., for Faunal Series).

Davidson, F.A., Elizabeth Vaughan, S.J. Hutchinson and A.L. Pritchard. Factors influencing the upstream migration of the pink salmon (Oncorhynchus gorbuscha). (Submitted to Ecology).

SCIENTIFIC STAFF

PACIFIC BIOLOGICAL STATION

1942

R.E. Foerster, M.A., Ph.D., F.R.S.C.	Director.
J.L. Hart, M.A., Ph.D.	Associate Biologist.
A.L. Pritchard, M.A., Ph.D.	Associate Biologist.
Ferris Neave, M.Sc.	Assistant Biologist.
A.L. Tester, M.A., Ph.D.	Scientific Assistant in Biology.
J.P. Tully, B.Sc., A.I.C., F.C.I.C.	Scientific Assistant in Hydrography.
R.V. Boughton, M.A., Ph.D.	Scientific Assistant in Biology.
D.B. Quayle, M.A.	Scientific Assistant in Biology (on leave).
J.L. McHugh, M.A.	Scientific Assistant in Biology (on leave).
W.M. Cameron, M.A.	Scientific Assistant in Biology (on leave).
Miss M.K. Merriam	Scientific Assistant in Chemistry.
R. Fjarlie	Junior Technician in Hydrography (on leave).
H.J. Hollister	Junior Technician in Hydrography (resigned).
W. Anderson	Junior Technician in Hydrography (resigned).

- - - - - - - - - - -

D.C.B. Duff, M.A., Ph.D.	Consulting Pathologist (Department of Bacteriology, University of British Columbia).

VOLUNTARY INVESTIGATORS

C. Berkeley, E. Berkeley, J.A. Munro, S. Noel Tibbo.

A. L. Pritchard Appendix No. 1 -

Natural Propagation of Pink Salmon in McClinton Creek, Masset Inlet, B.C. - The Mature Salmon Run of 1942.

In continuation of the investigation of the natural propagation of the pink salmon at McClinton creek, examination and counts of the run of spawning adults were carried out in the autumn of 1942.

As in 1940 the upstream migration period was very extended. The first individual appeared on July 28. Practically none passed the fence thereafter until August 17. From August 17 until September 9, moderate numbers daily produced a total of approximately 10,000. From September 10 to 28, another 15,000 were handled. September 29, 30 and October 1 were the three busiest days with a maximum of 6,397 on the latter. There followed an abrupt decline to the conclusion of the count on October 9.

The numbers of pink salmon reaching the weir were very definitely correlated with rainfall and the consequent changes in the height of water in the creek. The season was very dry and the fish lay off the mouth of the river. With each rainfall a sudden spurt occurred, apparently allowing the ripest individuals to get upstream. With the main heavy rains on September 30, the largest migrations took place.

Individuals of both sexes appeared at approximately the same time. Males, however, maintained a superiority in numbers until October 1, the day of the largest run. Proportionately more females arrived thereafter. The final disposition of sexes on the spawning areas was 47.7% males and 52.3% females. The shortage of males may have been partly traceable to the gill netting carried on at the river mouth. This method of fishing is selective of males because they are more easily caught when the dorsal hump is developed. In any event, the discrepancy from the 50:50 ratio is not considered serious since it is known that one male may serve more than one female.

The average number of eggs per female determined from a random sample of 61 individuals, was 1,573. The potential egg deposition was thus 30,300,000, just slightly larger than that of 1940.

The following table gives a summary of the counts obtained in the natural propagation experiment to date:

Year	Males	Females	Total	Av. No. of Eggs	Potential Deposition	Fry Migrants	% Hatch
1930	32,955	33,198	66,153	1,535	50,950,000	5,384,000	10.6
1932	8,003	7,597	15,600	1,758	13,360,000	2,230,000	16.7
1934	77,477	77,719	155,196	1,799	139,000,000	12,260,000	9.1
1936	24,221	28,091	52,312	1,899	53,345,000	3,675,000	6.9
1938	5,549	5,029	10,577	1,698	8,500,000	2,020,000	23.8
1940	19,071	16,454	35,525	1,619	26,500,000	5,061,000	19.0
1942	17,574	19,319	36,893	1,573	30,300,000		

The run of 1942 was of medium size and resulted in an egg deposition approximately the same as that of 1940. It did not seem wise at the present time to carry the experiment further. It is admitted that the percentage hatch may vary but such variation, if it occurred, could not be explained without a complete record of conditions during the period of incubation - autumn, winter and spring. Such an extension of work was not feasible.

FISHERIES RESEARCH BOARD OF CANADA

INDEX TO SUMMARY REPORTS FOR 1942

	Appendix	Page
Salmon Investigations:		
Pink salmon	1 - 4	1 - 5
Chum salmon	5	5 - 6
Coho salmon	6 - 11	6 - 13
Spring salmon	11 - 13	14 - 16
Salmon marking	14 - 15	16 - 19
Trout Investigations:	16 - 17	19 - 22
Herring Investigations:	18 - 31	23 - 38
Pilchard Investigations:	32 - 37	38 - 42
Lingcod Investigations:	38 - 40	42 - 45
Eulachon Investigation:	41 - 44	45 - 48
Dogfish Investigation:	45	48 - 49
Shellfish Investigations:		
Oysters	46	50
Clams	47 - 50	50 - 54
Shipworm	51 - 52	55 - 57
Hydrography:	53 - 55	58 - 62
Other Studies:	56	63

A. L. Pritchard Appendix No. 1

Natural Propagation of Pink Salmon in McClinton Creek, Masset Inlet, B.C. - The Mature Salmon Run of 1942.

In continuation of the investigation of the natural propagation of the pink salmon at McClinton creek, examination and counts of the run of spawning adults were carried out in the autumn of 1942.

As in 1940 the upstream migration period was very extended. The first individual appeared on July 28. Practically none passed the fence thereafter until August 17. From August 17 until September 9, moderate numbers daily produced a total of approximately 10,000. From September 10 to 28, another 15,000 were handled. September 29, 30 and October 1 were the three busiest days with a maximum of 6,397 on the latter. There followed an abrupt decline to the conclusion of the count on October 9.

The numbers of pink salmon reaching the weir were very definitely correlated with rainfall and the consequent changes in the height of water in the creek. The season was very dry and the fish lay off the mouth of the river. With each rainfall a sudden spurt occurred, apparently allowing the ripest individuals to get upstream. With the main heavy rains on September 30, the largest migrations took place.

Individuals of both sexes appeared at approximately the same time. Males, however, maintained a superiority in numbers until October 1, the day of the largest run. Proportionately more females arrived thereafter. The final disposition of sexes on the spawning areas was 47.7% males and 52.3% females. The shortage of males may have been partly traceable to the gill netting carried on at the river mouth. This method of fishing is selective of males because they are more easily caught when the dorsal hump is developed. In any event, the discrepancy from the 50:50 ratio is not considered serious since it is known that one male may serve more than one female.

The average number of eggs per female determined from a random sample of 61 individuals, was 1,573. The potential egg deposition was thus 30,300,000, just slightly larger than that of 1940.

The following table gives a summary of the counts obtained in the natural propagation experiment to date:

Year	Males	Females	Total	Av. No. of Eggs	Potential Deposition	Fry Migrants	% Hatch
1930	32,955	33,198	66,153	1,535	50,950,000	5,384,000	10.6
1932	8,003	7,597	15,600	1,758	13,360,000	2,230,000	16.7
1934	77,477	77,719	155,196	1,799	139,000,000	12,260,000	9.1
1936	24,221	28,091	52,312	1,899	53,345,000	3,675,000	6.9
1938	5,549	5,029	10,577	1,698	8,500,000	2,020,000	23.8
1940	19,071	16,454	35,525	1,619	26,500,000	5,061,000	19.0
1942	17,574	19,319	36,893	1,573	30,300,000		

The run of 1942 was of medium size and resulted in an egg deposition approximately the same as that of 1940. It did not seem wise at the present time to carry the experiment further. It is admitted that the percentage hatch may vary but such variation, if it occurred, could not be explained without a complete record of conditions during the period of incubation - autumn, winter and spring. Such an extension of work was not feasible.

A. L. Pritchard Appendix No. 3 +

Recovery of Marked Pink Salmon in 1942.

As one part of the investigation of the natural runs of pink salmon entering McClinton creek, Masset inlet, several large marking experiments have been conducted to obtain data concerning the behaviour and migrations during the ocean phase of the life history. The latest of these, completed in the spring of 1941, involved the removal of the adipose and both ventral fins from 2,469 fry and both ventrals from 198,297. The marked young were released with the ordinary fry migration and allowed to proceed to sea.

Recoveries from this programme were expected during the season of 1942. Every effort was made to locate them. In certain representative areas along the coast observers were stationed with the sole responsibility of observing the catches for scars. In British Columbia these men operated at Arrandale cannery on the Nass river, Sunnyside and Claxton canneries on the Skeena river, Butedale cannery in the central northern district, Goose bay cannery in Rivers inlet, and Pacofi cannery on the southern end of the Queen Charlotte islands. In addition, the U. S. Fish and Wildlife Service again co-operated by placing an examiner in Waterfall cannery on Prince of Wales island in south-eastern Alaska. In those districts not covered by observers, posters were supplied advising that marked pink salmon were expected. Throughout the greater portion of British Columbia personal contact was made with the fishermen and the industry to explain the experiment and to seek co-operation.

The complete data are not yet thoroughly worked over, but several outstanding differences between this and other collections may even now be noticed. In spite of the facts that greater numbers of pink salmon were examined throughout the season and that the original marking involved more fry, the number of recoveries is much smaller. At the present no definite explanation of this condition can be advanced.

The distribution of the recoveries is very similar to that of other years as shown in the following table:

Waterfall, south-eastern Alaska	1
Douglas channel	1
Langara island, Queen Charlotte islands	1
Masset inlet (Fishery)	40
McClinton creek (Fence)	233

In the examinations in British Columbia, only one fish was discovered in catches other than those made in Masset inlet itself. This was reported as being caught in Douglas channel. Only one marked fish was found at Waterfall cannery in south-eastern Alaska although the collection arrangements appeared to be much more efficient than before. This lack of recoveries may be due to the fact that the weather was such that the purse seines could not operate to any great extent in the areas offshore from Prince of Wales island. Most of the catches were made close inshore in the bays.

The returns to McClinton creek amounted to only .11 per cent. of the original marking as compared with .4 per cent. in the experiment completed in 1940.

A. L. Pritchard Appendix No. 3

The proportionate returns for unmarked individuals in 1940 and 1942 were 1.7 and .7 per cent. respectively. The discrepancy between marked and unmarked which has appeared in every marking experiment to date, still exists. The two main reasons for it are considered to be differential mortality and a wandering of marked salmon coupled with immigration of unmarked.

Eighteen rivers on the Queen Charlotte islands were closely inspected for marked fish through the co-operation of the Federal Fishery officers. Five thousand pinks were examined but not one marked adult was discovered.

Pink salmon marking experiments are being discontinued in the Masset inlet area because it now appears that there has been obtained as much information of a general type as could be expected under the limitations of the experiments themselves. To discover greater detail would involve the application of effort which is not at present available.

A. L. Pritchard Appendix No. 4

Racial Studies on Pink Salmon

In continuation of the investigation designed to determine whether evident so-called racial differences exist between pink salmon runs to different streams, further collections of pyloric caeca and gill rakers were examined and analysed during 1942.

The following is a brief summary of all the counts to date:

GILL RAKERS	Number	Range	Average
McClinton cr., Queen Charlotte is.	136	27 - 33	30.32
Deenan r., " " "	58	28 - 33	30.55
Yakoun r., " " "	100	27 - 34	30.22
Mammon r., " " "	98	28 - 34	30.40
Datlamen r., " " "	65	28 - 34	30.34
Haan's cr., " " "	24	27 - 32	29.83
Palent cr., " " "	79	28 - 32	29.94
Morrison cr., Vancouver is.	99	28 - 34	30.78
Harrison r. (Lower), Mainland area	26	29 - 33	30.81
Harrison r. (Upper), " "	89	27 - 35	30.48
Chehalis r., " "	106	24 - 34	30.40
Lorenzetti cr. " "	103	26 - 33	30.23
Sucker cr., " "	62	28 - 33	30.00
	1,045		

A. L. Pritchard

Appendix No. 4

PYLORIC CAECA	Number	Range	Average
McClinton cr., Queen Charlotte is.	128	106 - 163	133
Deenan r., " " "	55	108 - 166	131
Yakoun r., " " "	104	111 - 166	133
Mammon r., " " "	95	111 - 156	136
Detlamen r., " " "	68	106 - 160	134
Haan's cr., " " "	10	107 - 128	114
Palent cr., " " "	79	106 - 195	136
Morrison cr., Vancouver is.	95	110 - 167	137
Harrison r. (Lower), Mainland area	27	115 - 185	143
Harrison r. (Upper), " "	136	110 - 165	136
Chehalis r., " "	79	118 - 159	133
Lorenzetti cr., " "	103	111 - 185	139
Sucker cr., " "	59	105 - 162	131
	1,038		

In making comparisons between the counts for various rivers the probable errors of the averages have been calculated and considered.

Even with the material which has been added this year for rivers in southern British Columbia, no definite conclusion that there is a consistent difference between the various populations is warranted. In other words, counts of gill rakers and caeca, although they have varied significantly in some cases from stream to stream, will apparently not suffice as a means of separation of various populations.

The existence of separate races has not been demonstrated nor has it been proved that such races do not exist. One of the weaknesses of analysis on the basis of body characteristics is that two distinct populations might conceivably have the same characters and yet be absolutely separate. For the purpose of record, the figures for the counts of gill rakers and caeca will be completely worked over. No further collections will be made since it is indicated that neither character will suffice as an easily usable means of separation of the pink salmon from various areas.

A. L. Pritchard

Appendix No. 5

The Age of Chum Salmon in British Columbia

The investigation of the age of the chum salmon taken in the commercial catches in British Columbia has progressed during 1942 with the analysis of approximately 1,300 samples from the following area: Kyuquot sound, Quatsino sound, Esperanza inlet, Nootka sound, Barkley sound, the Gulf of Georgia, and Athlow bay on the west coast of the Queen Charlotte islands.

A. L. Pritchard Appendix No. 5

The material has not yet been finally summarized but certain conclusions are nevertheless evident. Chum salmon may appear in the fishery in their third, fourth, fifth, and perhaps sixth year. On the west coast of the Queen Charlotte islands fish in their fifth year apparently predominate. In the southern portion of the province, in the gulf of Georgia and on the west coast of Vancouver island, the greater proportion were found to be in their fourth year.

Recently, isolated collections have been made to fill out the information by including areas not already sampled. These will be examined and all available records summarized for publication as soon as possible.

A. L. Pritchard Appendix No. 6 +

Return of Cowichan River Marked Cohoes of the 1938 Brood Year.

The marked cohoes discussed in this report resulted from the collection of 106,000 eggs from females migrating into Oliver and Beadnell creeks, Cowichan river, during the autumn of 1938. These were divided into two lots - one part being fertilized with milt from normal 3-year-old males and the other with milt from precocious 2-year-old "jack" males. All were transferred to the hatchery which is supplied by water from Oliver creek, hatched, raised to a suitable size, marked and released late in the next summer (1939) into the Hatchery pool, an enlarged portion of the Cowichan river proper lying off the Board's property. The following is a brief statement of the detail of the experiment:

Parents	Fins Removed	Number
Normal 3-year-old males and females	Adipose and both ventrals	23,544
Precocious 2-year-old males and normal 3-year-old females	Adipose and dorsal	8,567

Recoveries in the year 1940 (at 2-years of age)

During the spring of 1940 fry screens were installed in Oliver and Beadnell creeks on March 13 thus closing off the streams and preventing fry from entering or leaving without observation. During the run from the creeks 54 individuals lacking the adipose and both ventral fins and 12 without adipose and dorsal were discovered. This is proof that some individuals had migrated the short distance down the Cowichan from the Hatchery pool, and had entered Oliver and Beadnell, between the time of release in late 1939 and March 13, 1940, when the screens were installed. These were released and allowed to proceed with the outgoing fry.

In August, September, and October 2 cohoes lacking the adipose and both ventrals and 1 lacking adipose and dorsal were taken in the Cowichan bay area. In September 2 sea-run individuals lacking adipose and both ventrals were taken on the troll in the Cowichan near the hatchery. Four of the adipose and both ventral type and 3 of the adipose and dorsal entered Oliver and Beadnell creeks with the spawning run of 1940 as precociously developed "jack" males.

These scattered recoveries thus indicate a seaward migration as yearlings and the return to spawn of some individuals in their second year.

Recoveries in the year 1941 (at 3 years of age)

1. Distribution in the sea. The detail of these recoveries has been reported by Mr. Neave and the author in Progress Report (Pacific) No. 51 and by Mr. Neave in last year's Summary Report, No. 14. The following is a terse summary:

	Adipose and Both Ventrals	Adipose and Dorsal
Cowichan bay	8	4
Other areas	20	2

The distribution of the fish was wide including the west coast of Vancouver island as far north as Kyuquot, Swiftsure banks, the strait of Juan de Fuca, Puget sound and the gulf of Georgia.

2. Occurrence in the main Cowichan river. During the upstream migration some 1,156 cohoes were dipped and examined at Skutz falls about 8 miles below the lake. These included 23 lacking adipose and both ventral fins and 7 lacking the dorsal and adipose. Apparently the marked fish were not confined to any particular portion of the run in point of time. All were tagged and released to continue upstream.

3. Occurrence in the parent streams. The following is a summary of the complete run into Oliver and Beadnell creeks:

	Unmarked	Marked		Total
		Ad. + 2V	Ad. + Dor.	
Oliver cr.	525	175	110	285
Beadnell cr.	99	12	7	19
	624	187	117	304

4. Occurrence in other creeks in the Cowichan system. Examination of certain other creeks in the Cowichan system revealed that some at least of the progeny from Oliver and Beadnell did not return there. Whether this "wandering" is due to the hatchery handling awaits further proof. At any rate adipose and both ventral fish were discovered in the following locations: Sutton creek - 1, Robertson river - 1, Grant's creek - 1, and Green's creek - 3. Three cohoes lacking the adipose and dorsal fins appeared in Sutton creek.

Total Returns

In order to give an idea of the minimum percentage return, a compilation has been made of all recoveries where the fish were not again released.

A. L. Pritchard — Appendix No. 6

	Ad. + 2V	Ad. + Dor.
1940 - Cowichan bay	2	1
Cowichan river	2	
Oliver and Beadnell	4	3
1941 - Outside areas (Sea)	29	2
- Cowichan bay	8	4
- Oliver and Beadnell	187	117
- Other streams - Cowichan system	6	3
Total	229	130
Percent. return	.9	1.5

The return of marked cohoes from the 1938 brood year on the Cowichan has thus given a picture of the downstream migration as yearlings, the return of a few to spawn in the second year, the appearance of the majority both in the fishery at sea and on the spawning areas in the third year. It has also indicated a limited wandering from the parent stream. The work is being repeated on later years.

A. L. Pritchard — Appendix No. 7

Return of Cowichan River Marked Cohoes of the 1939 Brood Year.

During the spring of 1940 an attempt was made to mark all the coho salmon fry leaving Oliver and Beadnell creeks in an effort to discover whether there was any appreciable wandering of the mature fish from the "parent" stream or any noticeable influx of individuals from other creeks. In addition it was desired to discover the behaviour of fry under as close to natural conditions as possible. For this reason in each creek the fish were taken from the trap as they migrated downstream each day, marked, and released immediately. They were not exposed to the conditions of the hatchery and the ponds as were those of the brood year of 1938 described elsewhere. The experiment completed under the supervision of Dr. Carl and Mr. Neave involved the following:

Oliver creek	Dorsal and adipose	73,768
Beadnell creek	Dorsal and left ventral	169,991

The recoveries are by no means nearly complete since the cohoes are just now moving up the Cowichan river and have not yet entered the tributaries to spawn. Mr. Neave reports the capture of fingerlings later in the season of 1940 in various places in the Cowichan even as far down as Quamichan. This indicates a migration seaward after marking. No records of the whereabouts of the fish during

A. L. Pritchard Appendix No. 7

their second year of life (1941) have been sent in. In 1942 one of each type was taken on the troll off Kyuquot on the west coast of Vancouver island. These reports confirm the conclusions drawn from the data on the 1938 brood, namely,- that the Cowichan cohoes may range far up the west coast of Vancouver island. One fish lacking the dorsal and adipose fins was captured in Cowichan bay in October of the same year. In November, two females lacking the dorsal and left ventral fins and one the dorsal and adipose were dipped at Skutz falls on the Cowichan.

It is disappointing that so few returns have been received from the commercial and game fisheries since they might have produced interesting records on distribution which would either confirm or augment those already discovered for the 1938 brood. On the other hand, the primary object of the experiment was to get information on the return to the "parent" river, or the lack of it. Arrangements have been made to examine all fish entering Oliver and Beadnell creeks and to examine the runs to many of the streams in the Cowichan system.

A. L. Pritchard Appendix No. 8

The Size of the Coho Salmon Run in the Cowichan River in the Autumn of 1941.

Regarding the numbers of coho salmon spawning in a river of medium size such as the Cowichan, there is little but rough qualitative information. It is essential to have at least a fairly accurate estimate of the size of these runs before attempting to pass judgement on the contribution of the streams to the fishery as a whole. It is just possible, when the full facts are analysed, that such contributions, considered in the aggregate, may bulk larger than those of the bigger rivers, e.g. the Fraser, the Skeena, etc. Furthermore, reliable yearly estimates provide a valuable indication of whether the runs are maintaining themselves.

The size of the Cowichan, the heavy discharge and the strength of its current, presented insurmountable barriers against the installation of counting fences for making an absolute assessment of numbers. An alternative, but less accurate, method was chosen to arrive at a moderately correct estimate. This plan, used on plaice by Dr. Petersen in Norwegian waters, was adapted to suit the local conditions. A known number of the individuals in the run were tagged. Later the fish were again observed. From the ratio of tagged to untagged fish and the known number tagged, the total can be calculated by simple arithmetic. For example, if 100 fish were tagged originally and released, and, if later in the season, 10 tagged and 100 untagged individuals were recovered, the total would be $\frac{100 \times 100}{10}$ + 100 or 1,100.

The application of the method of tagging to this problem is a substitute for a definite count and can, at best, produce only a moderately accurate estimate. The writer and his associates have already tested the method in the case of sockeye salmon in Williams creek, Lakelse lake, Skeena river, and in the case of pink salmon at McClinton creek, Masset inlet, and found it wanting under certain conditions. The details have been reported in previous summary reports. From the tests, it was determined that to obtain the best accuracy in estimation, one should tag a definite proportion of the fish throughout the run, and that the correctness of

the final calculation will eventually depend upon the completeness of the examination for marked individuals as well as upon the randomness with which the fish are distributed. If the fish live for a relatively long period after tagging, there will be more chance of thorough mixing and the elimination of isolated selected samples. If, too, the area in which mixing occurs is large and includes lakes which are not suddenly and seriously affected by rainfall and freshets, greater possibility of random distribution is offered.

In the case of the Cowichan experiments fish were obtained by dipping at Skutz falls each day throughout the run. When a large migration was taking place, the fish were easier to catch, and more were tagged, and vice versa. For mixing there was available about 8 miles of river and a big lake. A period of up to 60 days elapsed before spawning was completed. Thus proportionality was obtained and distribution had every possibility of being fairly random. Conditions, although not perfect, nevertheless approached the ideal.

From October 2 to October 25, 1941, serially numbered button tags were affixed below the dorsal fins of 1,156 cohoes captured at random at Skutz falls. This group was made up as follows: Males - 600, Jacks (two-year-old males) - 67, and females - 489. In 22 spawning rivers where inspections were made (not including Oliver and Beadnell creeks) 1,256 untagged and 23 tagged cohoes were observed although not all were captured. The size of the run would thus be $\frac{1156 \times 1256}{23} + 1156$ or 64,000. In Oliver and Beadnell creeks, where counting fences were operated, there appeared 1,005 untagged and 18 tagged. The total would thus be: $\frac{1156 \times 1005}{18} + 1156$ or 66,000. The close agreement between these figures may be coincidence but it is our belief that it indicates that the cohoes had become randomly distributed.

It would appear that 65,000 is a fairly accurate figure for the escapement of cohoes above Skutz falls in 1941. There is no reasonable basis for estimation of the spawning population below the falls, but 15,000 would certainly be a conservative number. This would result in a grand total of 80,000.

It is interesting to consider the value to the commercial and game fisheries which a run such as that to the Cowichan may have. To determine how many were actually caught, one would have to know the intensity of the fishery. The only data available are certain figures for the sockeye. If the lowest ratio is accepted, the fishery should have taken 50 per cent. of the population or 80,000 fish. At an average of ten pounds per fish and 10 cents per pound, the value would be $80,000. These figures may be high in spite of attempts to avoid that fault, yet it must be admitted that the Cowichan river contribution is important.

A similar experiment is being conducted at present on the 1942 coho run.

A. L. Pritchard Appendix No. 9

The Behaviour and Distribution of the Coho Salmon above Skutz Falls in the Cowichan River during the Spawning Run of 1941.

The tagging with serially numbered tags of coho salmon from the 1941 spawning run at Skutz falls on the Cowichan river, mentioned in another report, provided excellent opportunity for accurate observation of the behaviour of the individuals. Certain information indicated by the recoveries is therefore submitted.

Close inspection of the coho salmon as they fight the current at Skutz falls, leap frantically at the rock barriers, and slither over the smooth stone surfaces which are on occasion hardly covered with water, would lead one to believe that the fish were bound for areas above the rapids. Apparently this view is erroneous in some cases since four individuals, which were taken at a point at least two-thirds of the way up the falls and tagged, were recovered later on the spawning areas approximately fifteen miles below,- one at the railway bridge at Duncan, one at Koksilah and two in the Quamichan. Tagging may have upset the normal reactions of the four cohoes in question, but, since at least forty-two others were recovered upstream, we cannot entirely dismiss the possibility that cohoes may migrate up to a partial barrier such as Skutz, and then drop back to spawning areas below even though such a barrier may be definitely passable.

As intimated above, the salmon tagged in this experiment, were obtained from pools at least half way up the falls. When tagged fish were recovered later in the day of operation, it was evident that they did not move away immediately. As a matter of fact eight were recaptured ascending the falls a second time 2 to 8 days after tagging. They must have descended and made the ascent again. There are no data to show that the action might not have been repeated several times. The important implication is that, if one is estimating fish by counting them as they run upstream, one may find the estimate too large unless it is impossible for the individuals to go downstream for a second trial.

Good observational evidence for years previous to 1941 indicates that many cohoes reached the Hatchery and Gordon's pools, about 8 miles above Skutz falls, within one or two days. The eight recoveries from the 1941 tagging indicated that it took from 9 to 18 days. Fish entered Oliver creek, just below the Hatchery pool, 27 to 58 days after passing Skutz. Certain individuals in the Robertson river about 5 miles west of the lake outlet, were still alive and spawning 60 days after tagging. It is evident that, even though the cohoes may move upstream relatively quickly, 1 to 2 months may elapse before the fish enter the tributary creeks, and even longer before spawning is completed.

A number of tagged coho passed through the counting fence at the mouth of Oliver creek. They were picked up later after they had deposited their eggs and milt. The period which had elapsed amounted in two cases to 18 days and in another to 11.

Further observations are being made on the behaviour and distribution of the cohoes in the 1942 run.

A. L. Pritchard Appendix No. 10

Natural Propagation of Coho Salmon in Oliver and Beadnell Creeks in 1941-42.

In continuation of investigations commenced by Dr. Carl and Mr. Neave, records were maintained of the numbers of cohos running to spawn in Oliver and Beadnell creeks in the autumn of 1941. From the average number of eggs per female calculated from a random sample, the potential deposition was determined. During the spring of 1942 counts were made of the fry descending the stream. Although some yearlings may perhaps be added to this latter compilation, it is felt that the quantity would be small since the streams go almost dry during the summer leaving few pools.

The following figures were obtained for the autumn spawning migration:

	Oliver	Beadnell*
No. of males	574	85
No. of females	269	43
Dead and spent Females	47	8
Total	890	136
Av. No. of eggs per female	2,100	2,200
Presumed deposition	564,900	94,600

* During the fall migration, a heavy freshet caused a wash-out in the Beadnell fence. It is not thought that many fish escaped but in view of the small total numbers, they still may affect the total greatly as pointed out later.

Downstream fry migrants in the spring of 1942 from March to July were as follows:

	Oliver	Beadnell
Number	156,887	91,248
Percent. return	26.0	96.3

As pointed out above little reliance can be placed on the Beadnell count because of the possible inaccuracy of the adult count. The improbability is demonstrated here in the percentage efficiency.

A comparison of the production of cohoes in recent years is submitted below. The figures for seasons prior to 1942 are from Carl and Neave.

	Oliver		Beadnell	
	Egg deposition	% hatch	Egg deposition	% hatch
1939	330,176	14.42		
1940	665,280	11.84	433,400	40.01
1941	481,650	30.37	74,100	30.06
1942	564,900	26.0	Discarded due to error	

It is apparent that percentage efficiency of hatch is very similar to the year previous. Conditions must therefore have been equally as favourable.

A. L. Pritchard Appendix No. 11

The Salmon Angling Fishery in Cowichan Bay in 1942.

Since 1939 a record has been taken of the angling fishery in Cowichan bay. This practice was continued during 1942 because the figures obtained appear to give an indication of the relative size and behaviour of the spring and coho salmon runs to the area. Such work also gives the opportunity of examining the catches for marked fish such as were expected this year.

During the period from August 9 until November 10 when the main fishery was being prosecuted, only one marked fish was discovered, that being a coho lacking the dorsal and adipose fin. This was marked in Cliver creek farther up the Cowichan river.

The following is a record of the catches:

	Lines	Line-hours	Springs		Cohoes		Total
			Large	Jacks	Large	Grilse	
August	1,870	5,606	325	33	12	232	602
September	3,192	10,214	466	878	530	544	2,418
October	3,460	13,556	101	304	3,389	327	4,121
November	161	591	3		117	20	140
	8,683	29,967	895	1,215	4,048	1,123	7,281

These figures show that in spite of war conditions, a great deal of effort was expended in sport fishing in this area. The main spring salmon run through the area occurred in September and the coho run in October.

The following table shows comparative figures for the several years in which examination has been carried out. The period includes Aug. 23 to Oct. 31 which embodies most of the important fishing season.

	1939	1940	1941	1942
Lines	5,278	4,629	7,005	7,635
Line-hours	19,006	16,707	23,314	26,787
Springs - Large	552	1,121	1,069	748
· Jacks	750	292	357	1,210
Cohoes - Large	3,410	1,899	3,560	3,928
Grilse	1,069	160	745	1,024
Total fish	5,782	3,472	5,731	6,910
Line - hours per fish	3.3	4.8	4.07	3.9

The number of lines used and the line-hours were much higher in 1942 than in any previous year examined. This is perhaps to be expected since Cowichan bay is one of the more accessible areas for sport fishing - a fact to be considered in these times. On the other hand, collection may have been more efficient thus resulting in more records.

Especially important is the fact that the number of line-hours per fish remained the same thus indicating that the abundance of the salmon was practically constant. As a matter of fact, it would appear that the runs were slightly larger during the current year - a prediction which is now being borne out through the examinations of the adults migrating up Skutz Falls.

A. L. Pritchard

Appendix No. 12

Recoveries from Cowichen River Spring Salmon Marking Experiments.

In another report by the writer in this series, a discussion is submitted of the difficulties facing the investigator in the collection of returns of marked salmon. While the efforts to overcome these obstacles have not been entirely successful, they have produced some results and have indicated that further application will be even more productive. The recoveries for the Cowichan experiments are here briefly discussed.

During the year 1942, returns were expected from the following experiments conducted at the Cowichan lake hatchery by Dr. Carl and Mr. Neave:

Brood Year	Mark	No. Marked
1937	Adipose & Right Ventral	21,967
1938	Both Ventrals	25,515

Recoveries from the 1937 Brood Year

Unfortunately the adipose and right ventral mark used for the spring salmon of the 1937 brood on the Cowichan was duplicated by the United States Fish and Wildlife Service on Delph creek, a tributary of the Clackamas river which flows into the Columbia. It is evident, therefore, that any captures of spring salmon lacking these fins cannot be definitely assigned to one or other of these programmes. This fact is especially true of recoveries made in the open ocean. Fortunately, as explained elsewhere, this conflict is not likely to arise again. Recoveries in the Cowichan are difficult since it is impossible to rack the stream and examine all the fish.

The records which have been submitted to the Pacific Biological Station are here reported even though they may not be entirely assignable. In 1941, at the age of four years, one fish was captured off Sekiu, Washington, and one off Long Beach on the west coast of Vancouver island. In 1942, three spring salmon lacking the adipose and right ventral fins were reported from the west coast of Vancouver island at Raffel point, Rugged point, and off the entrance to Uchuelet harbour. These individuals would be in their fifth year.

Recoveries from the 1938 Brood Year

The mark used on spring salmon of the brood year of 1938 in the Cowichan (Both ventrals) was not duplicated on the same species elsewhere. The data collected, therefore, are extremely valuable and reliable.

In the summer of 1942, when the salmon would be in their fourth year, 9 recoveries were made. Three of these were from the troll fishery off Kyuquot, one was taken between Raffel point and Hesquiat, and two came from off the mouth of Barkley sound. One record was turned in by Mr. Royal of the Washington State Fisheries Department from Swiftsure bank off the mouth of the strait of Juan de Fuca. One spring salmon lacking the required fins was captured near cape Mudge in the strait of Georgia. The last record was from Langara island on the north coast of the Queen Charlotte islands. No scar was submitted so that this will have to await further confirmation in later years.

A. L. Pritchard Appendix No. 12

Even though the results obtained from these experiments could not be considered in any sense exhaustive, they do allow certain very definite conclusions. Cowichan spring salmon appear in the fishery mainly in their fourth and fifth years. They may be distributed as far north as Kyuquot on the west coast of Vancouver island and may appear in the strait of Georgia.

A. L. Pritchard and A. L. Tester Appendix No. 13

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

In Summary Report No. 17 for 1941, the authors reported that spring salmon stomachs had been collected for examination for the third consecutive year. The fish were obtained directly from the commercial catches spread as widely as possible throughout all the fishing areas in British Columbia. These have now been examined and the results are reported herein.

In order to give a general picture of the three years' experiments the following numbers are submitted:

Year	No. of Collectors	No. of Stomachs
1939	9	333
1940	18	467
1941	25	537

In so far as the number of different organisms contained in the food is concerned, the three years collections are quite similar, viz.- 13 in 1939 and 1940, and 12 in 1941. Certain forms have appeared throughout,- namely, herring, sand lance, whiting, rockfish, squid, and red feed. Pilchard, anchovy, gray cod, eulachon, capelin, amphipods and crab larvae were discovered in two out of three seasons. Tomcod, surf smelt, sandfish, stickleback, yellow shiner, and wolf eel occurred in one year only and then usually in one out of many areas and in a limited number of stomachs.

In 1941 herring and sand lance were again by far the most important food items. Pilchards made a relatively small contribution when compared with that of 1940 (6% compared with 21% by volume). This is undoubtedly due to the fact that small pilchards were not present on the coast in 1941 in anything like the same abundance which was exhibited in 1940. The proportionate contribution of other species of fish and invertebrates has varied little in the three seasons.

Although, as would be expected, variations in proportions of the various items occur from year to year, there is a general similarity in the findings for each separate area sampled in one or more seasons. The strait of Georgia presents a study in contrasts. Around Campbell river young herring constituted about twenty-five per cent of the food. Sand lance were frequent. At Baynes sound, a short distance south, large herring made up ninety-six per cent. In areas around the Gulf islands, herring were prevalent, pilchards were eaten, but no lance were encountered. Off the shore of the mainland herring were important, there were no sand lance, and anchovies made up at least twenty-four per cent.

A. L. Pritchard and A. L. Tester — Appendix No. 13

There is again an indication that the proportion of a given organism may change from month to month and from year to year. This is particularly well illustrated by the appearance of crab larvae in great abundance in May in the stomachs from the west coast of Vancouver island, and only incidentally in one or two other months.

As was explained last year no further large collections are being made. The experiments have their limitations. There is now available all the general information which could be expected. Isolated samples are being taken to round out the information for certain areas and to settle specific problems. The rest of the information is being worked over for final publication.

A. L. Pritchard — Appendix No. 14

Marking of Salmon Fry during 1942.

Spring Salmon

Previous to the year 1942 several experiments involving the marking of spring salmon fry from the Cowichan river were conducted by investigators of the Fisheries Research Board. In 1938 on fry hatched from the eggs of the 1937 brood, the mark used unfortunately conflicted with the one employed in the same year in the Columbia river by the U.S. Fish and Wildlife Service. Those on the brood years of 1938, 1939, and 1940 involved less than thirty thousand individuals, and thus limited the number of returns. In 1941 the possibility of conflict was removed through agreement and much larger numbers were handled.

Eggs were taken from spring salmon gill netted near the hatchery on the Cowichan river in the autumn of 1942. The total collection amounted to 302,000. During the spring of 1942, from March 25 to June 5, 235,373 fry were released into the hatchery pool after removal of both ventral fins. The recoveries from this group, expected in 1945, should produce valuable information on the distribution and contribution of the Cowichan river spring salmon.

It is interesting to contemplate the gross cost of such a marking programme. The rate of marking averaged about 2,000 fish per day so that approximately 100 man-days were involved. The total expenditure was $400.00. The rate is thus .17 cents per fish.

Coho Salmon

The coho salmon fry-marking experiment was conducted in connection with the investigation of the natural propagation of the species at Oliver and Beadnell creeks, Cowichan river. The main purpose was to mark all the individuals leaving the stream and thus check definitely the return to the parent stream when these young fish return to spawn as adults in 1944. The mark used was both ventral fins. The numbers were as follows: Oliver - 155,183 and Beadnell - 88,053. Care will also have to be taken to mark in a similar manner the few yearlings which migrate downstream next spring since they are the product of the same brood year.

The costs of this experiment would appear to be slightly higher than that for the spring salmon. This is probably due to the fact that the expenses for the counting are included. The expenditure was approximately $600.00 or .25 cents per fish. The rate of marking was approximately 2,000 fish per day per man.

A. L. Pritchard

Appendix No. 14

Pink Salmon

Information is desired regarding the behaviour of the pink salmon in southern British Columbia especially in the Courtenay area on Vancouver island where at one time the runs of the species were extremely large. Particularly, the distribution of the fish in the sea and the percentage return to the parent stream should be known. Accordingly during the spring of 1942, as a start in this investigation of these problems, 101,194 pink salmon fry were trapped, marked by the removal of both ventrals, and released into Morrison creek, a tributary of the Puntledge. The recoveries should be forthcoming in 1943.

In this experiment the rate of marking averaged about 2,000 per day per man. On the other hand, traps had to be constructed and the traps operated. Fortunately the services of a highly experienced marker were available at the time and helped greatly to reduce the costs. Expenditures amounted to $375.00 or .37 cents per fish.

Chum Salmon

Each year in the lower reaches of the Cowichan river large numbers of chum salmon fry are trapped in enclosed pools and left in the gravel. This phenomenon is due to the fact that the water is much lower at the time when the fry are migrating seaward than at the time when the parent fish spawned. The Federal Department of Fisheries has been carrying out salvage programmes by digging ditches and putting in temporary dams which flood areas and allow the fry to leave the gravel. In order to discover the fate of these salvaged chums, 99,906 were marked by the removal of both ventral fins and released. The return would be expected mainly in 1945.

The expenditures in this experiment were light since the men were already available in the other marking experiments. They amounted to $200.00 or approximately .2 cents per fish.

Almost 680,000 fry have been marked in four experiments. This is a large number of fish and the costs were considerable. On the other hand the policy has now been established that fewer experiments should be attempted, but in each enough individuals should be marked to insure a large return so that the information will be sufficiently reliable for definite conclusions.

A. L. Pritchard

Appendix No. 15 ✓

Salmon Marking Experiments on the Pacific Coast

Marking experiments i.e. the removal of certain combinations of fins from young fish to ensure their later identification as adults, seem to be at present the only feasible means of obtaining information on the contribution of certain rivers to the fishery, the areas in which these fisheries prey upon the populations from given rivers, and the question of return or wandering from the parent stream. It is for this reason that every effort has been made to remove as many difficulties as possible standing in the way of getting recoveries.

A. L. Pritchard

Appendix No. 15

Some years ago it was realized that unless a central control committee was set up for assigning and recording marks, each individual organization would carry on with any mark of their choice. This would lead to the duplication of the same combination of fins in the same year on the same species. The result would be that adults would not be assignable definitely to any experiment and the information would become practically useless. Accordingly three years ago a committee consisting of Mr. J.A. Craig and the writer was set up to get requests for marks each year, to assign them so no conflicts existed, and to see that each agency received a list of marks. Recently the whole operation has been turned over to the writer. Each year a complete list is made of all salmon and trout experiments and mailed to each organization and others involved.

The amount of information gained from any marking experiment seems to depend on the effort put into collection. During the present year this effort has been increased. In the first place the writer persuaded the organizations involved,- the International Salmon Fisheries Commission, the U.S. Fish and Wildlife Service, the Washington State Department of Fisheries, and the Oregon Fish Commission - to pay the same rewards as the Fisheries Research Board (50 cents) for legitimate records taken in British Columbia. In return for this concession the responsibility of advertising, collecting, etc. was assumed by the Pacific Biological Station.

Early in the year a mimeographed letter was prepared to acquaint the fishermen with the fact that marked salmon might appear in the catches. Through the kindness of Major Motherwell, one of these was handed out with each fishing license. Later posters were prepared showing what Canadian experiments were expected to yield results. These notices were widely distributed with the co-operation of the Federal Fishery Officers. Further the cannery observers of the International Salmon Fisheries Commission, the Washington State Department of Fisheries, and the Fisheries Research Board, advertised and observed in the areas in which they were located.

When recoveries were reported, data were examined, the age of the fish determined, the whole assigned to the proper experiment, the organization involved notified, and the reward and thanks forwarded to the collector. While the system has not been perfect, by far the greatest number of isolated returns of any year have been received. In all about 367 records have been handled. Of these, almost one-half were legitimate. The following summary gives some idea of the variety:

Species	No. of Experiments Producing Returns	No. of Legitimate Returns
Spring	8	43
Coho	7	55
Pink	1	2
Sockeye		Handled by International Salmon Commission

This year's experience has shown that all difficulties have not been overcome. On the other hand, in spite of the work involved and the shortcomings in the method, it is certain that the information gathered more than justified the effort. The writer is of the opinion that further endeavours should be made.

A. L. Pritchard Appendix No. 15

The troubles confronting the organizations are small when considered in their proper perspective. With the inter-organizational co-operation which has been evolved, they can easily be overcome. In addition present plans indicate that more extensive personal attention may be possible next summer for advertising, and contacting individual fishermen, canners, etc. Certainly the opportunity for collecting essential data should not be lost for want of further trial.

Ferris Neave Appendix No. 16

Returns of Marked Trout in the Cowichan River System

During 1942 no marked trout were liberated from the Cowichan Lake hatchery. Efforts were made, however, by contact with anglers, advertisement and the operation of certain nets and traps, to obtain records of fish released in previous years. The results may be summarized as follows:

Species	Brood year	No.	Place of release	Place of recovery	No. of returns 1942	Total
Cutthroat	1939	9,346	River	River and lake	5	40
"	1940	921	Meade creek	Lake and river	5	5
"	1941	2,044	River	Oliver and Beadnell	10	10
Brown	1937	303	River	Oliver creek	3	56
"	1939	1,632	River	Beadnell creek	1	1
Kamloops	1940	109	Lake	River	2	2
"	1941	52,384	Lake	Oliver creek	3	3
Steelhead	1938	7,613	River	River and Oliver creek (sea-run)	2	16
"	1940a	34,800	Lake	River and lake	4	12
"	1940b	2,976	River	River	4	8
Rainbow	1940	2,976	River	River and lake	46	55

("Place of recovery" refers to those caught during the past year only)

These records supplement previous returns and are in agreement with previous findings regarding the movements of trout between lake, river and tribu-

Ferris Neave Appendix No. 16

taries in the upper part of the river system. The recapture in the Cowichan river system of marked steelhead of the 1938 brood year constitutes the first direct evidence of a return to the parent stream in the case of this river. The scales of these fish confirm the interpretation which has been placed on the scales of unmarked steelhead.

Of particular interest is the progress of an experiment started in February 1940 in order to compare the life-histories of offspring of sea-run and non-sea-run Salmo gairdneri. 2,976 fingerlings from non-sea-run parents ("rainbow trout") were released in the upper river in January 1941. An equal number of fish of similar size and age, but derived from sea-run parents ("steelhead"), was released at the same place and time, the two lots being marked distinctively. Since then only eight returns of the steelheads, all from the river or from a small tributary, have been obtained, the last being on April 19, 1942. This date represents nearly the maximum age commonly reached in fresh water by the sea-going fish of this river. On the other hand the rainbow trout have provided fifty-five returns, twenty-eight of which have been subsequent to the last steelhead record. These extend to the time of writing (November, 1942). Moreover, eight out of twelve rainbows recaptured between May 15 and October 15, 1942, had gone up the river into the lake. This seasonal lakeward migration is known to be quite usual in fish of the non-sea-going type over two years old. It takes place about the same time of year as the seaward migration of the steelheads.

These findings tend to confirm the view, previously expressed on the basis of scale counts, that two racially distinct strains of Salmo gairdneri occur in the Cowichan river. From the point of view of conservation, the two types present quite different problems.

Ferris Neave Appendix No. 17

Trout Angling Records, Cowichan River System.

Records of trout fishing in the Cowichan river system were collected during 1942 by interviewing anglers at localities where fishing was most intensive and through the voluntary submission of reports by other fishermen. The percentage of the total catch which is represented by these records is quite uncertain, but they serve nevertheless to indicate the relative numbers of different species landed and the availability of fish as compared with previous seasons.

Records obtained apply mainly to the upper mile or two of the Cowichan river and to Cowichan lake, these being the most productive parts of the river system. A brief analysis of the recorded catch in these localities, together with a measure of the effort involved, is presented herewith. The fish listed do not include a few sea-run steelheads, mostly kelts, which were taken incidentally during "trout" fishing operations.

Ferris Neave

Appendix No. 17

Upper River:

Month	Line-hours	Number of fish	Rainbow	Cutthroat	Brown	Dolly Varden
March	270	163	118	42	3	0
April	267.5	235	192	41	1	0
May	77	76	62	12	0	2
October	62.75	42	41	1	0	0
Totals	677.5	516	413	96	4	2

The percentages of the various species represented in recorded catches during the last four years are tabulated below. Figures apply to the whole season. The average time involved per fish landed is also shown.

Year	Rainbow	Cutthroat	Brown	Dolly Varden	Average line-hours per fish
1939	80.1	16.0	2.0	2.0	1.43
1940	90.1	7.1	2.5	0.3	1.17
1941	90.5	7.1	2.4	0	1.36
1942	80.0	18.6	0.8	0.4	1.31

Cowichan Lake

Fishing records from Cowichan lake refer mainly to the south and north arms and the neighbourhood of the narrows, these being the portions most accessible to tourists. Data are as follows:

Month	Line-hours	Number of fish	Rainbow	Cutthroat	Kokanee
Mar./Apr.	55	41	14	26	1
May	186.5	152	60	91	1
June	139.5	89	53	36	0
Totals	381	282	127	153	2

The increased proportion of rainbow trout represented in the June catch coincides with the annual immigration into the lake of fish which have spent the winter and spring in the river.

Percentages of lake-caught fish during 1941 and 1942 are as follows:

Year	Rainbow	Cutthroat	Kokanee	Average line-hours per fish
1941	45.7	54.3	0	2.30
1942	45.0	54.2	0.7	1.35

In both 1941 and 1942 the lake yielded a much higher percentage of cutthroats than the upper part of the river. No satisfactory explanation can be given for the marked difference in availability of fish which is indicated for these two years. Although kokanees cannot be considered to be really abundant in Cowichan lake, their incidence in anglers' catches certainly does not represent their true level in the general fish population. However, they do not appear to occur in any numbers during spring and early summer in the relatively shallow areas where most of the fishing takes place. Their small size may also reduce their chance of being caught on the tackle commonly used.

A. L. Tester

Appendix No. 18

Catch Statistics of the Herring Fishery during 1941-42.

The collection of daily catch statistics by means of Pilot House Record Books was continued, with the Department of Fisheries undertaking the distribution of the books and the collection of the records. The returns (75%) were less complete than in the previous season (91%). As in past years, the availability of herring (average catch per seine per day's active fishing) has been calculated from the records.

The total catch for B. C. amounted to 111,329 tons, with 33,541 tons (30%) from areas north of Vancouver island, and 77,788 tons (70%) from areas in the vicinity of Vancouver island. Prior to the opening of the season, old quotas were revised and new quotas were imposed on certain major fishing localities by the Department of Fisheries.

Along the east coast of the Queen Charlotte islands fair catches were made, chiefly from Burnaby strait, towards the close of the season. The availability has shown a progressive decline during the last three years (42.2, 31.0, 15.9 tons per seine per day).

In the Prince Rupert district, fishing was considerably improved over that of last season, and the quota (20,000 tons) was almost reached. The fish were all taken from grounds to the north of Prince Rupert harbour, chiefly Khutzeymateen inlet which was particularly productive during late January and early February.

In the central area fishing was again somewhat disappointing. The formerly richly-productive Kwakshua passage failed to yield catches, and at Laredo inlet the fish arrived towards the close of the season and then disappeared after a short period of good fishing. The catch fell far short of the quota (40,000 tons). Spasmodic fishing also took place in various scattered localities of the Bella Bella, Bella Coola and Rivers inlet areas during the winter months.

In Queen Charlotte strait fishing was pursued for the third successive year but the catch fell far short of the newly-imposed quota of 8,000 tons. Knight inlet fish were too small for canning and the sub-area was closed in keeping with the war-time policy of conservation of the stock for canning purposes. Most of the fish taken during the season came from Clio channel and Simoon sound. The availability (13.9 tons) was slightly less than in the previous year (14.9 tons) although fewer boats were fishing.

At Discovery passage, where mixtures of small and large fish were taken, the original quota of 5,000 tons was reached and an extension of 5,000 tons was granted, but not attained. The availability has shown a progressive decline during the three years of fishing (60-70, 26.7 18.1 tons).

On the south-east coast of Vancouver island herring were plentiful and excellent fishing took place, particularly at Nanoose bay and off Montague harbour. The quota of 30,000 tons was reached (Nov. 27) and three extensions granted,--5,000 tons (Nov. 29), 5,000 tons (Dec. 7) and 10,000 tons (Jan. 29). The availability to single seines (97.3 tons) was the highest since these have operated in the area, even though during most of the season the catches were limited to the capacity of the plants and packers.

In the area between cape Beale and cape Cook on the west coast of Vancouver island, herring fishing was very poor in some inlets and fair in others.

A. L. Tester Appendix No. 18

On the whole, the availability for the season (21.0 tons) was similar to that of the previous three seasons (24.4, 18.2 17.8 tons), i.e., relatively low. In all areas time extensions were granted beyond the regular closing date of Feb. 5. The blanket quota of 25,000 tons for the west coast (including the Quatsino area) was not reached.

In the Quatsino area, the sub-quota of 3,000 tons was attained and fishing closed on Feb. 16. For a short period at the end of January, a few good catches were made in Klaskish inlet. During February herring were fished in Forward inlet.

A feature of the season on the west coast of Vancouver island was the presence of sufficiently large quantities of pilchards in Barkley and Clayoquot sounds to support a winter pilchard fishery. In Barkley sound the herring seine boats concentrated on pilchard fishing during January and part of February. At Clayoquot sound during the same period catches of either herring, pilchards, or mixtures of herring and pilchards were made. Pilchard catches were also made by herring boats to a smaller extent in Nootka sound and in Klaskish inlet.

A. L. Tester Appendix No. 19

Herring Spawning Conditions in 1942.

The collection of herring spawning reports, compiled by officers of the Dominion Department of Fisheries, was continued. As a result of the distribution of complete instructions and a new data form requiring more detailed information, there was a considerable improvement in the records as a whole. Additional facilities provided by the Department resulted in more complete coverage in certain areas. Several of the inspectors submitted maps showing the exact location of the spawning grounds.

Although considerable doubt has been thrown on the reliability of the records when used quantitatively, nevertheless the "intensity index" has again been calculated. This may still give a more accurate conception of major fluctuations than personal impressions. The results for 1942, with those of 1941 for comparison, follow:

A. L. Tester

Appendix No. 19

Area	Time Spread 1942	Intensity 1942	Intensity compared with 1941	Calculated Intensity Index 1941	Calculated Intensity Index 1942
Victoria	Mar. 1-Apr.26	M	"very similar"	16	2
Cowichan	Feb.10-Mar. 4	-	similar	40	60
Ladysmith	Mar. 6-Mar.29	H	"similar"	403	705
Nanaimo	Mar. 6-Apr. 9	M-H	"similar"	290	291
Comox	Feb.13-Apr. 1	M	less intensive, more extensive	882	585
Quathiaski	Mar.22-Apr. 5	VL	"much lighter"	(503?)	(1)
Pender harbour	Mar. 1-Apr. 2	H	"heavier"	477	195
Strait of Georgia				2108	1838
Barkley	Feb.15-Mar.21	L	"lighter"	389	32
Clayoquot	Jan.27-Feb. 2	L	lighter	183	29
Nootka	Feb. 9-Mar.10	L-M	"much lighter"	140	46
Kyuquot	Feb. 7-Apr. 1	M	"much heavier"	30	97
Brooks bay	Feb.20-Feb.24	M	"similar"	101	29
Quatsino proper	Feb.28-Mar.30	M	"similar"		174
West coast of Vancouver island				843	407
Alert bay	Mar. 2-Apr.19	M	"lighter"	1424	126
Rivers inlet	Mar.14-Mar.21	VL	"lighter"		
Smith inlet	Mar.26-Mar.31	VH	"much heavier"	1555	1620
Bella Bella	Mar.17-Apr. 6	VH	"heavier"		
Bella Coola	Feb.25-Mar.15	M	"about same"		
Butedale	Mar. 8-Apr. 9	VH	"much heavier"	1146	1718
Grenville-Principe	Mar.25-Apr.10	L	"lighter"	57	11
Skeena	Mar.23-Apr.18	H	"similar"	465	509
Nass	(no spawning seen)				
South Q.C.I.	Apr. 1-Apr. 5	H	"similar"	1210	1230

The following comparisons in relative abundance seem justified: (1) no pronounced increase in egg deposition in the strait of Georgia as a whole, in spite of the apparent abundance of herring during the fishing season; (2) a pronounced decrease in the Quathiaski area; this has been evident in the last two years from the failure of fish to spawn on customary grounds (1941 results include a reported but doubtful large spawning in Bute inlet); (3) a decrease in egg deposition in southern areas along the west coast of Vancouver island as

A. L. Tester Appendix No. 19

compared with the previous year; (4) a decrease in the Alert bay area, due partly to the failure of spawning along the shores and at the head of Knight inlet; (5) no certain indications of pronounced increase or decrease in other major areas, except possibly in the Butedale area where observations indicated particularly heavy spawning.

The following observations are noteworthy: (1) in most areas a large proportion of the spawning probably took place below the low tide mark as indicated by the recorded depths of egg deposition; (2) a large spawning on kelp beds over deep water (60 fathoms) took place off shore from Big bay (Skeena area); (3) there was an early spawning in the Bella Coola area (starting February 25), which is exceptional for the central coastline; (4) in several areas, mortality from the feeding of birds ranging up to 50%, and in one area up to 95%, was reported.

The collection of herring spawning reports will be continued in 1943.

A. L. Tester Appendix No. 20

Attempt at Detailed Herring Spawning Survey, 1942.

This investigation was undertaken to determine the possibility of obtaining a measure of the quantity of eggs deposited and the number of spawning fish in each area. If the latter could be determined with reasonable accuracy from improved surveys made by fisheries inspectors, supported by scientific data, it would provide a direct approach to the problem of determining the reaction of the population to the fishery, and hence of judging the utility of the quota system of regulation. The work was conducted as thoroughly as possible (of necessity, in conjunction with tagging field work) and consumed considerable time during March, April, May and June, with Dr. Boughton and Mr. Tibbo assisting during March. A manuscript report, including a full discussion of the problem and of the results has been presented to the Director.

The study embraced (a) a preliminary investigation of method (sampling of eggs on beach, chemical agents for removing eggs from vegetation, estimation of number in samples); (b) detailed sectional surveys of particular spawning grounds in the strait of Georgia and Alert bay area (estimation of length, width, per cent. coverage; and sampling); (c) examination of samples and compilation of data in the laboratory; (d) issuance of detailed instructions to fisheries inspectors in all areas for improving and standardizing their surveys; (e) preparation and utilization of a new survey form for inspectors, which made provision for additional essential information; (f) contact with the Department for re-allocation of boats and personnel for more adequate coverage during the spawning period; (g) where possible, comparison of results of superficial surveys by inspectors with detailed studies by the scientific workers; (h) preparation of a comprehensive manuscript report.

The conclusions are summarized as follows:

1. At the present time, it seems impossible to make reasonably accurate estimates of the quantity of eggs deposited, and hence of the quantity of spawning fish, on particular spawning grounds even with careful scientific investigation. While this could be done for small grounds in favourable locations if sufficient time and man-power were available, it could not be done for the majority of individual

A. L. Tester Appendix No. 20

spawnings which were studied. Some of the reasons are: large error involved in area estimation because of magnitude of some grounds, "patchy" distribution of vegetation and depth of egg deposition; inability to obtain quantitative samples from submerged grounds; great variation between samples requiring a large and unwieldy number; large error introduced by loss of eggs from the feeding of birds, storms, etc.

2. Little or no reliance can be placed on herring spawning reports by fisheries inspectors even for roughly quantitative estimates of intensity of deposition and abundance. This is not surprising in view of the difficulties encountered by scientific workers. In tracing relative changes in intensity and abundance they are reliable only in indicating extremes, i.e., very small or very large depositions in any one area and year.

3. Herring spawning surveys by fisheries inspectors are still very valuable in yielding qualitative information, thus adding to our knowledge of the spawning habits of the herring. For this reason they should be continued and efforts should be made to further improve their accuracy and completeness.

4. In view of the failure of this preliminary attempt at quantitative estimation of the abundance of spawning fish, it would seem that at present there is no direct approach to the solution of the major herring problem, that of appraising the utility of quotas, and that recourse will have to be made to other methods which are not likely to yield quick results if a "safe" policy of exploitation is continued.

A. L. Tester Appendix No. 21

The Spawning of Herring in British Columbia.

The preparation of a comprehensive bulletin on this subject has been delayed (a) through lack of time, and (b) pending the collection of additional essential information.

A. L. Tester Appendix No. 22

Mortality of Herring.

Large numbers of herring died along the south-east coast of Vancouver island, approximately from Comox to Ladysmith, during the spawning period in the late winter and early spring of 1942. An investigation was undertaken with the assistance of Dr. Boughton and Mr. Tibbo (voluntary worker). Bacteriological studies were made by Dr. Duff. The mortality has been fully described and the results discussed in Progress Report No. 52.

The mortality appeared to start at Deep bay in February and to extend gradually to the southward. The behavior of dying herring was similar to that of dying pilchards in the previous year, but external and internal symptoms were different, i.e., no external bleeding and dark red "liquid" liver in the herring;

A. L. Tester

Appendix No. 22

external bleeding and yellowish-green but solid liver in the pilchards. Following the period of heavy mortality the herring exhibited a peculiar lethargic condition and crowded in shallow water close to the shoreline. It is believed that several thousand of tons of herring died over the entire range.

No adequate explanation of the mortality can be given. Bacteriological examination yielded negative results. Physical and chemical conditions in the water probably fluctuated widely as a result of the spring bloom of plankton but as far as is known they would not be classed as abnormal for the time of year. The mortality was not related to the act of spawning, affecting ripe and spent fish alike. There are objections to attributing it to gunfire and depth charge explosions which took place prior to and during the period while the herring were densely schooled.

Some information on the influence of the unusual mortality on the supply of fish may be obtained from several thousand tags which were used during the period of mortality and subsequent lethargy.

A. L. Tester

Appendix No. 23

Mortality of Herring Eggs.

Several cases of excessive mortality of herring eggs on spawning grounds in the strait of Georgia were found in 1942. Dr. Boughton and Mr. Tibbo assisted in the collections and Mr. Tibbo also assisted in the subsequent examination of material collected in both 1941 and 1942. The results have been prepared for publication in Progress Reports.

The data for samples showing high mortalities follow: February 25, Selby creek (over 50%, below +3 foot level); April 8, Hammond bay (98%, below +3 foot level); April 13, Protection and Newcastle islands (100%, below +2 foot level); April 15, Parminter bay (100%, below +2 foot level); April 15, Vesuvius bay (100%, below +3 foot level); and April 16, Booth bay (90%, +4 to +6 foot levels). The eggs had died after partial development, in some cases at the hatching stage.

Similar mortalities were not found in samples taken during March, 1942 in the strait of Georgia, nor in samples taken during March, 1941 from various spawning grounds along the B. C. coast. However, a manuscript report by Dr. H. C. Williamson describes similar cases on the west coast of Vancouver island in 1928 and 1929 which occurred towards the close of the spawning period.

The usual factors (infertility, desiccation, mechanical injury, etc.) to which a small annual mortality is usually attributed, cannot be regarded as causes. Two facts may have some significance (1) that, with one exception, the mortality was confined to eggs deposited at the lower levels, and (2) that, with one exception, the mortalities took place late in the spawning season.

Two theories might be advanced. The first is that the death of the eggs was related to the death of herring along the south-east coast of Vancouver island during the 1942 spawning season. Possibly the eggs lacked viability as they were deposited by herring which were suffering from some unknown "disease" or unfavourable environmental influence. With this theory it would be difficult to explain the differential mortality in respect to depth and a lack of coincidence

A. L. Tester Appendix No. 23

in the observed range of mortality of fish and eggs along the coast. The second theory relates the egg mortality to an observed high pH, caused by plankton bloom, and a consequent low CO_2 and high O_2 content of the water which might interfere with normal respiration. Exposure of the eggs to air at low tide might periodically restore the balance of those in the intertidal zone, enabling them to survive. The effect of low CO_2 tensions on herring eggs could readily be tested by laboratory experiments in the spring were time and materials available. If the second theory applied, excessive mortality might be expected to be a usual rather than an unusual occurrence, and to follow the spring plankton bloom.

Plankton hauls made in April indicated a scarcity of herring larvae. However, subsequent reports by fisheries inspectors on the abundance of young herring of the year, supported by personal observation in the vicinity of Departure bay, show no cause for alarm regarding the effect of the egg mortality on the future supply of new recruits to the fishery.

If time permits, observations on herring egg mortality, particularly during April, will be continued in 1943.

A. L. Tester Appendix No. 24

Use of an Echo Sounder to Locate Schools of Herring.

The possibility of using an echo sounder to locate schools of herring in B. C. waters was discussed in Summary Reports for 1940 (No. 38). Correspondence with European workers revealed that, as far as was known, it had not been used successfully on commercial fishing boats, but that conditions considered to be essential for its successful use (a considerable depth of water and a layering of the fish) were present on B. C. fishing grounds.

Recently, additional information has been obtained. Mr. Stanley Hiller, President of the Santa Cruz Oil Company, San Francisco, has obtained clear records of schools of fish, presumably herring, at Humber arm, Bay-Of-Islands, Newfoundland, and he expresses the belief that there are definite possibilities in the use of a machine of the proper type. Unconfirmed reports of similar records by B. C. coastal vessels have also been received.

B. C. Packers Ltd., who have been interested in the instrument for several years, offered to purchase and install an echo sounder in one of their boats providing that its use in locating herring was thoroughly tested by scientific investigation. It was agreed that any results should be made public by the investigator through the usual channels.

A Type M.S. Huson Admiralty Recorder Echo Sounder has been procured from The Ontario Hughes Owens Company Ltd., through R. F. Bovey Ltd., Vancouver, at a coast of approximately $3500.00. At present this is being installed on the 55-foot motor-vessel "Nishga" belonging to the company. When installation is completed it is planned to test the machine on fishing grounds in the strait of Georgia where herring are known to be present. Further plans will depend on what success is encountered.

The writer has obtained permission from the Board to conduct the investigation.

A.L. Tester and R.V. Boughton — Appendix No. 25

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

Preparation of an article for publication, bearing a title similar to the above, has been delayed because of the pressure of other work, which is regarded as more important.

J.L. Hart, A.L. Tester and R.V. Boughton — Appendix No. 26

The Insertion and Recovery of Herring Tags in 1941-42

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. Methods of tagging, using internal metal tags, and of recovery, using induction detectors and magnets, have been fully described in previous reports. The results for the 1941-42 season have been published in the Report of the B.C. Provincial Fisheries Department, 1941, but are reviewed here briefly.

Recovery

It might be pointed out again that the place of capture of the fish bearing the tag is known with certainty in recoveries with tag detectors and in some cases with magnets. In the majority of magnet recoveries, however, the most probable place of capture must be impartially judged from knowledge of the "lag" in time of transit of a tag through particular plants and the origin and tonnage of fish processed prior to the date of recovery. In 1941-42, recoveries were obtained from magnets in ten plants at various points along the coast and from a tag detector located at Steveston, near Vancouver. A second tag detector was operated at Ucluelet, Barkley sound, but failed to give satisfactory performance.

The following observations and conclusions are made:

1. There is additional evidence confirming the conclusion of previous years that, for practical purposes, the herring of major areas may be regarded as separate units with but a small extent of intermingling between them. The percentage of tags recovered from the same general area as that in which they were used (96%) was the same as in the previous year.
2. On the west coast of Vancouver island there is additional evidence of a tendency for tags to be recovered from the same area in which they were used, although there was again considerable interchange between areas. The percentage recovered from the same tagging area in which they were used (60%) is similar to that obtained in the previous year (63%). There were indications of a limitation of movement between such closely-situated areas as Nootka sound - Esperanza inlet and Kyuquot sound - Ououkinsh inlet (considered separate areas in the calculation yielding the above percentage). On the other hand, a tendency for fish of one Barkley sound tagging to wander, noted in 1940-41, was continued in 1941-42.

3. As in the preceding year, relatively few tags were recovered from catches on the east coast of Vancouver island, largely because of extensive canning operations and consequent reduced opportunity for recovery. In direct contrast to the results of last year, there was little movement out of the area, but some movement into the area. There were further indications of heterogeneity among populations spawning in the strait of Georgia.
4. The number of returns from Central British Columbia was again low. It would seem that this is related to a change in the life history of the fish or in the relationship of the fish population to the fishery, rather than to a decline in catch, deterioration in tagging technique, or reduced opportunity for recovery. The independence of the Central area was maintained only imperfectly in 1941-42.
5. In Northern British Columbia it was again evident that fish spawning in Big bay occur in substantial numbers during the subsequent fishing season on fishing grounds to the north: Khutzeymateen inlet, Union bay, etc. The independence of the major area was reasonably well maintained.

Tagging

A review of the results obtained to date indicates that the information on hand is probably about as complete as will be obtained with a continuation of the tagging and recovery programme on a similar scale. The investigation has thus reached an initial phase of completion. An ideal second phase would involve intensification of tagging recovery in all major areas to study the details of movement and intermingling, but this is not feasible at the present time. Under existing wartime conditions it has been considered best to reduce to a minimum the expenditure of resources in the more distant areas and to concentrate all available effort in an intensive study of two of the more accessible major areas, Queen Charlotte sound and the strait of Georgia, where much has yet to be learned concerning the details of the movements and mixtures of the various spawning populations.

Tags totalling 23,017, were used during the season. Of these 496 were inserted during the Fall at Sooke. The remainder were used during the spring spawning season as follows: strait of Georgia, 15,559; Queen Charlotte sound, 5,465; Central British Columbia, 1,497. An attempt at tagging on the west coast of Vancouver island was made, but no fish were encountered during the trip. Four separate taggings were carried out in Departure bay and three others along the south-east coast of Vancouver island in areas where an unprecendented mortality of herring occurred. This mortality may reduce the number of returns in 1942-43. However, it is hoped that some estimate of the influence of the unusual mortality on the supply of fish may be deduced by comparing returns for these taggings among themselves and with other taggings.

During the 1941-42 season Mr. S. Noel Tibbo of the Newfoundland Department of Natural Resources assisted in the tagging work. Seine boats used in tagging were supplied through the courtesy of the Nootka-Banfield Company, Ltd., and Nelson Bros. Fisheries, Ltd.

A.L. Tester and R.V. Boughton Appendix No. 27

The Recovery of Herring Tags in 1942-43.

The revised tagging and tag recovery programme, designed to study in greater detail the degree of movement and mixing of spawning populations within and between two major areas, the strait of Georgia and Queen Charlotte sound, requires not only more intensive tagging in the spring but also more intensive recovery during the fall and winter.

As the majority of the fish are being canned during the present emergency, the opportunity for recovering tags on magnets in reduction plants has been materially lessened. However it was decided to continue the collection of recoveries from magnets located throughout British Columbia even though usually considerable doubt surrounds the returns in respect to place of capture of the fish originally bearing the tag. Some information of value might be obtained. In addition, a new magnet installation was made at the Gulf of Georgia reduction plant, Steveston, which operates chiefly on fish caught within the two major areas under intensive study.

In an effort to stimulate interest in magnet recoveries at reduction plants, and also in an attempt to recover tags which may become dislodged from the body cavities of herring while they are being gutted, cleaned and packed in canneries, herring tag reward placards have been printed and distributed to all major processing establishments.

Two induction tag detectors are available. These have the advantage of producing "certain" returns but the disadvantages of being difficult to keep in repair and of requiring the employment of full-time operators. It was decided to place these detectors in canneries which would handle the greatest volume of fish from the two major areas. After careful consideration, one was installed at the Imperial Cannery (B.C. Packers Ltd.) and the other at the Gulf of Georgia Cannery (Canadian Fishing Co., Ltd.), Steveston, B.C. The new installations differ only in detail from those previously used, the former recovering tagged fish from a chute by means of a trap-door, and the latter recovering tagged fish from a moving belt by means of a pivoted gate. At the present time both machines are giving satisfactory performance and tags are being recovered. However, considerable technical difficulties have been experienced during the course of the season with these complicated pieces of apparatus. As expert radio technicians are no longer available, the writers have had to rely on their own experience and ingenuity to make repairs. This had not only consumed considerable time but the repair work has also been hampered by the difficulty and in some cases the impossibility of procuring replacement parts when these were needed because of lack of adequate priority privileges. It is strongly urged that steps be taken to procure the necessary operational and replacement priority, otherwise the investigation may have to be abandoned.

At the present time Mr. A. Paul and Mr. F. Johnston are being employed to operate the tag detectors and to perform other duties. We are greatly indebted to Dr. E.H. Dahlgren, U.S. Bureau of Fisheries, Seattle, for the loan of a pair of balancing coils which has made possible the operation of the tag detector formerly used unsuccessfully on the west coast of Vancouver island.

R.V. Boughton

Appendix No. 28

The Sampling of Herring in B.C. during the 1941-42 Season

The sampling of herring is designed to trace fluctuations in the abundance of successive year classes occurring in the catches, and to detect the presence of local populations by means of racial characters.

During 1942 some reorganization of work in the herring investigation was made. Sampling of the catch in southern B.C. (strait of Georgia, west coast, Discovery passage, and Queen Charlotte sound), which was formerly carried on by Dr. Tester was taken over by the writer, vertebral studies were discontinued and emphasis was placed on the length and age composition data.

During the season efforts were made to sample the major herring runs as completely as possible. A total of 143 samples comprising 15,423 individual fish were taken as follows:

Area	Time of Sampling: Fishing season	Time of Sampling: Spawning season
Strait of Georgia		
Nanoose bay	(24) 2591	
Swanson channel	(11) 1185	
Trincomali channel	(6) 649	
Squirrel cove		(1) 48
Scuttle bay		(1) 110
Union bay		(1) 110
Porpoise bay		(1) 110
Departure bay		(2) 220
Nanaimo hbr.		(2) 220
Ganges hbr.		(1) 110
Kulleet bay		(1) 110
Kuper is.		(1) 110
Selby cr.		(1) 110
Von. Donop cr.		(1) 110
Discovery passage		
Deepwater bay	(12) 1310	
Okisollo channel	(6) 660	
Cahnish bay		(1) 110
West coast		
Barkley sound	(8) 879	
Nootka sound	(3) 330	
Kyuquot sound	(2) 220	
Quatsino sound	(1) 110	

R.V. Boughton

Appendix No. 28

Queen Charlotte sound				
Clio channel - Bones bay	(6)	660	(1)	110
Seymour inlet	(1)	110		
Knight inlet	(1)	110		
Simoon sound	(4)	440		
Retreat passage			(1)	110
Kingcome inlet			(1)	110
Central area				
Laredo sound	(15)	1590		
Bella Bella	(3)	300		
Campbell is.			(1)	110
Northern area				
Khutzemateen inlet	(9)	970		
Union bay	(5)	550		
Queen Charlotte Islands				
Burnaby strait	(5)	550		
Sewell inlet	(2)	220		
Richardson inlet	(1)	119		

Samples from Trincomali channel, Nanoose bay, and Swanson channel were examined by members of the staff operating the tag detector at Imperial cannery, Steveston. Those from the west coast were obtained by a member of the staff operating a tag detector at Ucluelet. Samples from Discovery passage, the Queen Charlotte sound area, and from the Queen Charlotte islands were collected, preserved in phenol, and shipped to the station through the courtesy of B.C. Packers Ltd. Those samples from the central and northern areas as well as those obtained during the spawning season were taken by various staff members.

The results to date are embodied in three separate reports each dealing with one or more of the major fishing areas of B.C. These follow.

R.V. Boughton

Appendix No. 29

Length and Age Composition of Herring in Southern B.C. During the 1941-42 Season.

In the strait of Georgia (east coast) herring were larger than in the previous year, whereas herring from the west coast (where comparisons are possible) were smaller than the previous year. These differences in average

length suggested that the 1938 year class, which was dominant in 1940-41 in both south-east and west coast catches, again formed a considerable portion of the catch in the strait of Georgia, but was considerably less important in the west coast catches. These conditions were borne out by age determinations. The average lengths for the various localities were as follows: (1940-41 figures in brackets) Barkley sound, 197.8 (199.7); strait of Georgia, 195.2 (193.1); Nootka sound, 191.1 (195.4); Kyuquot sound, 190.0 (195.8); Quatsino sound (188.9 (none); Discovery passage 174.4 mm. (none).

The percentage age compositions of herring in the various fishing areas in 1941-42 follow:

Area	II	III	IV	V	VI	VII	VIII	IX
Swanson channel	2.0	25.9	57.0	11.3	2.5	0.7	0.4	0.3
Nanoose bay	2.7	42.2	42.3	10.0	1.9	0.6	0.2	
Trincomali channel	3.1	33.6	51.4	9.2	1.8	0.7	0.2	
Discovery passage	22.2	41.4	20.1	12.6	1.6	0.8	0.5	
Barkley sound	1.9	40.1	24.4	25.3	6.4	1.3	0.4	0.1
Nootka sound	1.3	50.4	42.4	4.9	0.7	0.3		
Kyuquot sound	3.6	67.2	25.0	2.6	1.1	0.5		
Quatsino sound	3.9	54.9	34.3	4.9	2.0			

Changes in the relative abundance of the 1938 year class are particularly outstanding. This year class continued to dominate the catches in the strait of Georgia (the 1938 and 1939 year classes being approximately equal in Nanoose bay catches) whereas on the west coast of Vancouver island the 1939 year class was dominant in all localities from which fish were examined (10 out of 14 samples). The predominance of the 1940 year class (II's) in the catches of herring from Discovery passage is particularly striking.

Additional evidence of the essential isolation of the Discovery passage run can be shown by comparing the rate of growth. Figures for the average length at each age follow:

Area	II	III	IV	V	VI	VII	VIII
Strait of Georgia	167.9	188.3	198.8	204.6	211.2	216.9	228.8
W. coast (Barkley sd.)	174.6	198.7	199.4	204.4	211.1	213.8	214.8
Discovery passage	151.1	171.1	190.0	197.6	206.4	214.8	221.8

The striking difference in the growth rate between fish from Discovery passage and those from the strait of Georgia and the west coast are sufficient to warrant the conclusion that Discovery passage herring constitute a distinct population. Tagging operations have demonstrated however that at least limited intermingling occurs between herring from Discovery passage and the strait of Georgia and the west coast areas.

As in the past the exact status of the west coast runs is doubtful. Studies in the age composition for the Barkley sound run show considerable variation between individual samples. For example, the percentage of III's varied

R.V. Boughton Appendix No. 29

from 7.5 to 65.7 per cent. Variations, in fact, in age composition between samples from this locality are greater than the variations between west coast areas. This variation, together with the doubt surrounding the extent of intermingling between areas makes it extremely difficult to interpret annual changes in age composition for the west coast.

R.V. Boughton Appendix No. 30

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

In the area north of Vancouver island only a few localities were exploited for herring during the 1941-42 season. In the central area most of the herring caught were taken near Laredo sound. In the northern area most of the fish were caught in either Union bay or Khutzemateen inlet, both in the Prince Rupert area. Samples from the Queen Charlotte islands were taken in Burnaby strait, Richardson inlet, and Sewell inlet.

In average length considerable variation between localities is evident. The samples may be arranged in the following order: Burnaby strait 194.9; Richardson inlet 194.1; Laredo sound 190.4; Rupert area 181.4; and Sewell inlet 173.8 mm.

Age compositions for the various localities are shown in the following tabulation:

	II	III	IV	V	VI	VII	VIII	IX+
Burnaby	0.2	5.8	49.5	24.9	5.1	8.3	4.7	1.5
Richardson		6.4	31.2	27.5	14.7	8.3	7.3	4.5
Sewell	9.4	20.1	30.8	24.3	9.8	3.8	1.4	0.4
Rupert area	3.4	26.4	42.8	19.2	4.2	2.2	1.4	0.3
Laredo		17.5	59.7	9.6	5.3	5.3	1.6	0.8

The data from all localities are remarkably uniform in showing an outstanding dominance of the 1938 year class (IV's). However in localities around the Queen Charlotte islands the 1937 year class (V's) was relatively more abundant than the 1939 year class (III's) in areas adjacent to the mainland (Prince Rupert area and Laredo sound). This difference suggests that little or no intermingling takes place between herring which spawn adjacent to the mainland and those in the Queen Charlotte islands.

Figures for the average length at each age follow:

R.V. Boughton

Appendix No. 30

	II	III	IV	V	VI	VII	VIII
Burnaby	170.0	179.5	190.3	198.3	201.4	209.7	211.9
Richardson		173.3	183.3	195.3	203.0	208.4	210.4
Sewell	149.8	163.2	176.4	180.2	184.1	193.8	198.8
Rupert area	144.7	171.7	181.4	191.1	198.4	201.5	206.3
Laredo		179.3	188.9	194.8	201.9	209.9	213.4

Herring from the three localities in the Queen Charlotte islands show a distinct rate of growth, and there is also a significant difference in the rate of growth between herring in the Rupert and Laredo areas.

Differences in either age composition or rate of growth suggest that the herring runs sampled during the 1941-42 season in the central and northern areas comprise distinct units or groups and that little or no intermingling of herring takes place between these localities.

Racial studies will be continued in northern B.C. areas 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.

R.V. Boughton

Appendix No. 31

Herring of Queen Charlotte Sound and Adjacent Waters.

Herring fishing in the Queen Charlotte sound area was comparatively poor during the 1941-42 season. This was somewhat unexpected since the area had only been fished intensively for two years. Contrary to the two previous years, the herring from this area were younger on the average than those from older established fishing grounds in other areas. In length the herring from these areas were even smaller than previously encountered, averaging 134.4 mm. for Knight inlet, 142.8 mm. for Seymour inlet, 145.6 mm. for Simoon sound, and 173.3 mm. for the Bones bay area, as compared with 174.4 mm. for Discovery passage and 195.3 mm. for the strait of Georgia.

Age compositions are shown in the following tabulation, together with those for Discovery passage and the strait of Georgia:

Locality	I	II	III	IV	V	VI	VII	VIII
Knight inlet		95.4	4.5	0.9				
Simoon sound	3.6	68.6	11.8	12.6	2.4	0.3	0.5	0.3
Seymour inlet		14.0	31.8	14.0	19.6	15.0	2.8	2.8
Bones bay area		35.5	19.4	27.3	10.4	2.5	2.5	2.4
Discovery passage	0.7	22.2	41.4	20.1	12.6	1.6	0.8	0.5
St. Georgia		2.5	36.6	47.5	10.3	2.0	0.7	0.4

R.V. Boughton

Appendix No. 31

The great variation in age composition between samples from different localities in the Queen Charlotte sound area is worthy of note. II's dominated at Knight inlet, Simoon sound and at Bones bay and in contrast to previous years there was only a small percentage of fish in the older age groups. III's dominated the sample from Seymour inlet which was fished for the first time.

Figures for the average length at each age follow:

Locality	II	III	IV	V	VI	VII	VIII
Knight inlet	134.0	157.0	172.9				
Seymour inlet	132.5	130.2	141.5	150.8	164.4	165.7	168.5
Simoon sound	133.3	156.8	167.5	186.7	185.0	191.0	
Bones bay area	142.1	173.2	191.4	197.3	212.2	201.6	223.4
Discovery passage	151.1	171.1	190.0	197.6	206.4	214.8	221.8
St. Georgia	167.9	188.3	198.8	204.6	211.2	216.9	228.2

With the exception of Knight inlet, herring from all localities in the Queen Charlotte sound area show a distinct rate of growth. Herring from all four localities have a much slower rate of growth than those in the strait of Georgia, and herring from all localities, except Bones bay, show a rate of growth less than Discovery passage. The very slow growth of the fish from Seymour inlet is particularly striking.

Differences in either or both age composition and rate of growth suggest that the herring runs to Seymour inlet, Knight inlet, and Simoon sound comprise distinct units or groups and that little or no intermingling takes place between these runs and those occurring in Discovery passage and the strait of Georgia. The affinities of the Bones bay fish are obscure. The data apparently indicate that the Bones bay herring may be more closely allied to those of Discovery passage than to the other runs in the Queen Charlotte sound area, or to the run in the strait of Georgia.

R.V. Boughton

Appendix No. 32

Herring Shrinkage When Preserved in Phenol

During the past year phenol was used extensively for preserving herring samples and consequently it was necessary to determine the amount of shrinkage in standard length and weight so that corrections might be applied to render the measurements of preserved fish comparable with those of fresh specimens.

Preliminary tests with a number of solutions showed that of tannic acid (5, 10, and 15 per cent solutions), potassium permanganate (5 and 10 per cent solutions), concentrated salt solutions with 5 and 30 per cent glycerine, crude phenol (5 per cent solution), crude cresol (3 per cent solution), and phenol(1, 3 and 5 per cent U.S.P. crystals solution) only the 3 and 5 per cent pure phenol solutions prevented putrefaction. These were

R.V. Boughton

Appendix No. 32

made from a standard solution S.G. 1.060 which was produced by adding 400 cc. of water to 4.5 Kg. of phenol crystals (U.S.P.).

In order to determine the shrinkage in length and weight as a result of preservation in phenol, two series of 50 fresh herring were measured, weighed and serially numbered. One series of fish were immersed in a 2.5 per cent phenol solution, the other in a 5 per cent. The specimens were again remeasured and weighed at intervals up to 26 days, and again after soaking in water for 24 hours.

The original data showed a general tendency for the amount of shrinkage to increase with standard length and weight in a relationship which appeared to be linear. Assuming this to be the case the method of least squares was used to obtain a relationship between standard length and weight of preserved fish and shrinkage, and from the data obtained correction graphs were constructed. From these were calculated the necessary corrections which are to be added to the length and weights of preserved fish.

The corrections so obtained are now being applied to specimens which have been preserved in phenol and shipped to the station for routine examination.

Data with respect to the preservative tests are being prepared.

J.L. Hart

Appendix No. 33

The Pilchard Fishery of British Columbia

The 1942 pilchard season in British Columbia was successful as far as volume of fish is concerned. Oil production was low and the amount of fish canned was relatively small. More than eighty per cent of the catch was made and landed off the westerly part of the west coast of Vancouver island, much of the fish being taken in the inlets. Most of the rest of the pilchards were taken off the Barkley sound region or off the Washington coast, although a few thousand tons (3,000?) were taken north of Vancouver island. A negligible remnant of the 1939 year class in the strait of Georgia was taken. In general the fish were small although larger than in the preceding year.

For the first time an attempt has been made to obtain detailed information about fishing activities direct from fishermen by the use of pilot house log books. The attempt has met with indifferent success owing to incomplete returns but the data on hand will be of value in interpreting information supplied by the companies as in previous years. Without analyses it may be stated that the catch per unit was good.

Either because of (1) the influence of the fishery, (2) a succession of strong year classes, or (3) undetected cyclical changes in ocean conditions, the pilchard stock is undergoing a marked change. See report on pilchard sampling for length, No. 34. What the significance of the change may be as far as future productivity of the fisheries may be is not known. Both the changes and their concomitants are of considerable economic and scientific importance and it is recommended that they be studied and recorded.

J.L. Hart

Appendix No. 34

Pilchard Sampling for Length.

Routine sampling of the pilchard catch for length has been continued on the west coast of Vancouver island as in former years. The average lengths for the different areas were found to be:

	Males mm.	Females mm.
North of Estevan point	221.3	224.4
Estevan pt. to cape Flattery	218.0	222.4
Washington coast	209.7	214.0

Females which were preponderate toward the north were in the minority off the Washington coast.

As in several recent years average lengths fail to give an adequate representation of the pilchard fishery. Examinations of length frequency data show that, as was the case last year, two groups of fish were present in the catches. One of these groups has its center of abundance near 215 mm. standard length and the other near 240 mm. standard length. The first group mentioned is probably composed dominantly of the 1939-year-class of which the center of abundance was close to 200 mm. during the 1941 season. The other group is a composite one of the several older age groups. It may be noted that although the position of the mode for the larger fish indicates them as being larger than in the previous year, the larger fish are materially smaller than in the years prior to 1940. These facts are illustrated in the following tabulation.

Average lengths of male and female pilchards by seasons

Year	Male	Female	Year	Male	Female
1929	247.7	252.8	1936+	229.4	234.5
1930*	246.8	252.4		243.6	248.0
1931*	241.6	246.8	1937	248.0	252.0
1932*	244.0	248.2	1938	246.4	251.0
1933*	247.4	251.7	1939	241.0	245.9
1934	249.5	252.9	1940	236.7	241.9
1935	250.0	254.8	1941	220.0	222.0
			1942	220.0	223.7

* Values obtained by averaging two or more averages for different fishing areas.
+ The first average includes a group of small fish which were plentiful on the fishing grounds but which appear to be of little significance on the supply of fish since no trace of them was evident in subsequent seasons.

It is proposed to continue the systematic sampling of pilchards as such a programme is the only dependable means of keeping a record of the quality of the stock of fish supplying the fishery. This is important since ultimately quantity will depend upon quality.

J.L. Hart

Appendix No. 35

Sampling the Pilchard Population for Age (1940).

It has proven most difficult to read pilchard scales but Dr. L.A. Walford of the U.S. Fish and Wildlife Service has developed criteria which give consistent results yielding convincing internal evidence of reliability. Through a co-operative arrangement sub-samples of scales taken in connection with the regular pilchard sampling programme have been submitted to Dr. Walford. The age determinations for samples taken during the 1940 season are now available and show the following results:

	Year of Life											
	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
No.	6	-	67	301	187	155	55	35	22	8	-	1
%	0.7	-	8.0	36.0	22.3	18.5	6.6	4.2	2.6	0.9	-	0.1

It is proposed to continue the arrangement or a modification of it.

J.L. Hart

Appendix No. 36

Pilchard Tagging

No further pilchard tags have been put out by Canadian workers but recovery work has been continued. The total number of recoveries is small because (1) no quick recoveries of Canadian tags were made; (2) the general run of fish were young and had accordingly been exposed to the possibility of being tagged for relatively few seasons; and (3) the fishery took place, for the most part, in the part of the coast with the poorest facilities for recovering tags.

Ten recoveries were made: Five California tags, four Oregon tags and one Canadian tag put out in August, 1939 and recovered at San Francisco where it was found under conditions indicating it to be a hold-over from the operations of 1941. Interest attaches to the recovery from pilchards taken near Aristazabel island of a tag used at Monterey. This is a northern record for the recovery of a pilchard which is known to have been in California waters.

J.L. Hart

Appendix No. 37

Review of Pilchard Tagging Operations.

The results of all pilchard tagging work carried out since 1935 have been brought together and analysed. The following points have been established:

Pilchards tagged in connection with British Columbia summer and fall fishing operations are captured in California sardine fishing operations four to seven months later and in subsequent seasons.

J.L. Hart

Appendix No. 37

Sardines tagged in California during the fall and winter months are taken in the following and subsequent seasons by the Canadian pilchard fleet. These exchanges are much too frequent to be regarded as the results of straying.

There is evidence that Canadian tags are significantly more concentrated on Canadian fishing grounds than on California fishing grounds. This would indicate that the migration from Canadian to California waters, although substantial, was not complete.

Canadian tags are more concentrated in the fishery off San Pedro than off San Francisco and Monterey. However, Canadian tags which have been out for more than one season are more abundant at the latter ports.

Average dates of recovery of Canadian tags are: San Francisco January 9, Monterey January 16, San Pedro March 12. There is less variation in the recovery dates of tags out less than one year than there is for older ones. The calculated speeds of migration for the fish recovered in their first year are variable but the actual speeds are probably not less than eight miles per day.

The British Columbia "homesteader" population is indicated as being a part of the main pilchard population.

Movements on the pilchard fishing grounds are indicated as being very confused. This is in contrast to the indications for the main migration from north to south which is indicated as being rather orderly.

Total mortality rates are calculated from tag returns as near to 71 per cent. Owing to the high initial mortality, calculations of fishing mortality and natural mortality are not practical.

The detailed examination of the tagging returns justifies the decision to close the investigation at the present time. However, the uses of tagging data have not been exhausted. Intensified studies of the quantitative aspects in which larger numbers of tags are used to increase the accuracy of calculations and in which more attention can be given to the recovery of the tags and the early mortality associated with tagging are capable of supplying (in about seven years) very critical information about the pilchard fishery. It is possible that at some future date such an investigation may prove advisable.

J.L. Hart

Appendix No. 38

Lingcod Tagging

The programme of lingcod tagging and recovery of lingcod tags has been continued with the use of "ring" tags placed around the upper jaw of the fish as already described in summary reports. The results as concern migration are largely in agreement with those of previous years in that they show the species to be essentially sedentary; with a small number of fish moving and a few showing considerable migrations. Of 42 recent returns for which data are available, 28 were recorded from the same place as tagging took place and 14 showed longer or shorter migrations. In considering the number of returns showing movement, due regard should be given to the circumstance that any error or carelessness on the part of the fisherman in reporting recovery of locality will indicate migration whereas it is most improbable that lack of movement can be indicated erroneously. It is

of interest to note on the basis of a rough analysis of recent data that Japanese fishermen's results indicated ten cases of migration as compared with four by white fishermen, although the numbers of fish reported from the original tagging area were the same for both groups. The observed difference would have arisen by chance once in five times if the two groups of fishermen were equally trustworthy and the fish were non-migratory. Two individual recoveries are of interest. One fish tagged at Race rocks, B.C. was recaptured off port Discovery in the State of Washington. Another taken off Entrance island lighthouse was brought to the Biological Station float, tagged as a demonstration and released. It was recaptured approximately a year later at Entrance Island lighthouse.

More information has been derived from the new recoveries on the rate of growth in length and weight of the lingcod. Averages based on the 46 pertinent recoveries made between November 26, 1940 and October 31, 1942 are presented herewith:

	Males	Females	Average Males and Females
Average growth in length per month	5.6 mm.	6.3 mm.	5.7 mm.
Average growth in weight per month	2.38 oz.	4.18 oz.	2.80 oz.

These figures are in substantial agreement with those obtained from 39 recoveries for the earlier period November 1, 1939 to November 30, 1940, viz.,

	Males	Females	Average Males and Females
Average growth in length per month	6.2 mm.	6.3 mm.	6.2 mm.
Average growth in weight per month	2.43 oz.	3.62 oz.	2.94 oz.

The consistently higher rate of growth of the females will be observed. No relationship is evident in the data between growth rate and size, in the length range under examination.

Preliminary calculations of the annual total mortality rates of lingcod on the basis of the decline in number of tags out with time give a result of 75 per cent. When a first correction applied to allow for the lack of opportunity of recent tags to be recovered is applied, the total annual mortality rate is 67 per cent.

Calculations making use of these values and the average rate of growth for both sexes together as shown above indicate that the lingcod fishery has been pursued more actively than is economically advisable. However, this conclusion must be accepted with caution for the meanwhile since (1) the correction

J.L. Hart

Appendix No. 38

applied above is necessarily approximate and (2) the composite nature of the fishing ground already established dictates that all samplings for movement, growth rate, age composition or mortality rate must be very thorough in order to yield conclusions which are applicable to the whole strait of Georgia area. An investigation intensive enough to neutralize sources of error arising from the heterogeneous nature of the population will be necessary at some time.

If the desirability of curtailing the catch is established, differential growth rate between sexes and other peculiar features of the life history will require investigation and consideration in drawing conclusions as to the most advantageous administration of the fishery.

Price changes in regard to the lingcod fishery have changed the situation in regard to the tagging programme. At one time the reward paid for a lingcod tag was considerably more than the value of an average-sized fish and it accordingly was worth a fishermen's while to attend to the tags. At the present time a six-pound fish produces the same revenue as the reward offered and it pays the fisherman to neglect the tag and spend his time in trying to catch more fish. For this reason it is suggested that the effort of the lingcod tagging work should be devoted to attempting to encourage and facilitate the recovery of tags rather than to intensifying the actual tagging operations. It would appear, however, that at some time the latter will become desirable.

J.L. Hart

Appendix No. 39

Age Determination in Lingcod

Earlier investigations of lingcod scales by another investigator indicated these to be impossible of interpretation in terms of age. In view of the importance of being able to determine ages, the problem of age determination has been reopened. The scales are admittedly difficult to read but it appears that by the use of revised methods age determinations of acceptable accuracy may be obtained. If refinements of technique and accumulating experience make such an investigation possible, it is proposed to devote considerable effort to it.

J.L. Hart

Appendix No. 40

Fecundity Studies in Lingcod

The maintenance of closed areas for lingcod breeding stock is a suggested method of assuring continuance of the supply of lingcod. If a series of breeding grounds is to be maintained, the effects of crowding on fecundity must be considered. To do this the egg numbers of fish taken on ordinary fishing grounds were compared with those for fish taken in a closed area. The material used may be summarized thus: Fishing ground fish: 1938, 4; 1940, 13; 1941, 32; Closed area fish: 1942, 6. The 1941 and 1942 samples are directly comparable as they were taken in the winter about one month apart.

The results of the counts plotted as logarithms showed (1) that lingcod

J.L. Hart

Appendix No. 40

produce from 100,000 to 500,000 eggs per season after reaching maturity at about 740 mm. total length; (2) lingcod 800 mm. long average around 150,000 eggs and lingcod 1000 mm. long average about 300,000 eggs; (3) there is great spread in the eggs produced by lingcod of a given length; (4) there is considerable spread in the number of eggs produced by lingcod at a given weight but the spread is smaller than where lengths are taken as the independent variable; (5) in round figures a mature female lingcod produces 10,000 eggs per pound of fish and this relationship holds relatively constant throughout the life of the fish; (6) as far as can be judged from the limited number of samples taken from the supposedly crowded closed area, female lingcod held length for length about 85% the number of eggs of those taken in the commercial fishing grounds; (7) there was no evidence of significant difference between the number of eggs found in the two types of habitat where comparisons were made on a weight for weight basis.

The data indicate a difference in egg number associated with habitat between lingcod. The difference is considerable but is probably not large enough to affect a conservation policy involving the establishment of closed areas if this appeared advisable on the basis of other investigations. The difference between the relationship between length and egg-number and weight and egg-number indicates that the fecundity is related to the general condition of the fish. Unless it appears that the establishment of closed areas is to be recommended on the basis of other studies, further investigation along these lines is not recommended.

J.L. Hart

Appendix No. 41

Eulachon Catch Statistics.

Continuing the investigation of availability of eulachon started in 1941 by Mr. McHugh in response to suggestions from the Fisheries Department, forms, distributed and collected by fisheries officers, were filled out by eulachon fishermen and returned to the Biological Station for consideration. From these forms calculations were made of the catch in pounds per hundred square fathoms of net per hour throughout the season. The results are shown on a weekly basis in the following tabulation compared with those for the previous year.

Week 1942	Availability Pounds per 100f^2	Period 1941	Availability Pounds per 100f^2
April 4	7	March 16 – April 10	<30
April 5 – 11	32		
April 12 - 18	57		
April 19 - 25	222	April 20	>200
April 26 - May 2	219	April 21 - May 3	>150
May 3---	102	May 5---	<10

There is no evidence of marked change in abundance between the two seasons. In making comparisons between seasons or within seasons extraneous sources of error must be considered. The data are insufficient in quantity and

J.L. Hart

Appendix No. 41

too lacking in uniformity to permit of extensive analyses but certain points have been considered in general terms with the following results: Mesh of net appears to influence the catch. Considering all net meshes used, data are somewhat erratic probably due to the small numbers of units of effort involved for some net sizes. Apparently valid comparisons between 1 1/4--inch mesh and 1 1/2--inch mesh indicate the latter as more effective. Some fishermen appear to be consistently more successful than others and some fishing grounds are more productive but their advantages seem in some cases at least to be rather temporary. The estimated length of time of sets seems to accompany irregularities in the calculated reward for effort but this effect may be purely a result of small absolute errors being relatively large for short sets. It is believed that the weekly values indicated above are not greatly distorted by the sources of error but that any further break down of the data is not justified.

It may be noted that fishing starts at a lower level of availability than observed at the close of the season. This is associated with the favourable response to the first eulachons placed on the fresh fish markets which soon become satisfied.

J.L. Hart

Appendix No. 42

Studies of Potential Uses of Dead and Dying Eulachon.

All probably and certainly most eulachon die shortly after spawning. If feasible, it would be obviously advantageous to make use of the freshly dead fish as they can be used to an unlimited extent without jeopardizing the future supply of fish as might be done by intensive fishing for unspawned individuals.

Experiments were made by holding a large dip net in the current in the expectation that dead or weak fish would be swept into it. This expectation was realized to varying degrees. The following data show the numbers of fish taken after varying periods of time at different places in the river near New Westminster:

10 minutes:	1, 2, 3, 1, 1, 0.
30 minutes:	7
1 hour:	7, 2, 0
3 hours:	2
all night:	40, 12

Other experiments were tried making use of a seine but they had the disadvantage of involving considerable effort and taking young sockeye salmon on their downstream migration.

The work was carried on under two disadvantages: (1) The net employed was somewhat coarse in mesh and some certainly (it is not known how many) fish slipped through the webs. Considerable numbers of moribund fish may have done so. (2) Unavoidably, the investigation was carried on too late in the eulachon run. About May 4 spring salmon fishermen were finding 40 - 60 lbs. of eulachon entangled in their large meshed gill nets. About May 10 when our examination of conditions was made only one or two eulachon would be taken per set. If our

J.L. Hart

Appendix No. 42

captures were increased proportionately, landings of several hundred pounds per lift might be anticipated from a night's set, constituting a worthwhile return for the labour and material involved.

Further experiments at the height of the run might be undertaken profitably. It is suggested that these employ a larger hoop net (6 - 7 ft. in diameter) of small meshed web (3/4 in. c.) hung so as to have a comparatively short bag (5 or 6 ft.) to reduce the possibility of taking young salmon.

A number of the dead or dying eulachon which drifted into the dip net in the course of the investigation were cooked and eaten and were pronounced excellent.

Oil analyses of samples of spent drifting, and full migrating eulachon were made by Mr. Tully with the following results:

	Per cent oil	
	Male	Female
Gill netted full fish, May 4, 1942		
Sample (1)	12.7	12.1
Sample (2)	--	10.4
Seined sample of spent and dying fish, May 10	9.7	9.0
Dip net sample of spent and dying fish, May 9	7.8	3.1*

* 2 fish only, unsatisfactory sample.

These analyses were made by a digestion method involving modifications of W.W. Johnston's method (Atlantic Progress Report, No. 32). They indicate a drop in oil content which may be described as moderate.

J.L. Hart

Appendix No. 43

Fecundity of Eulachon.

In connection with the study of smelts in British Columbia a study was made of the fecundity of eulachon. In spite of the difficulty experienced due to the small size of the eggs estimates were completed for ten fish. These indicated that fish of average length (165 mm. standard length) contain between twenty-eight and twenty-nine thousand eggs. Length and egg number are closely and directly related so that one centimetre in length corresponds to nearly six thousand eggs.

J.L. Hart

Appendix No. 44

Life History Studies in connection with Eulachon.

Four ten minute surface plankton hauls were made and examined in connection with the eulachon investigation. Two of these were made in the Fraser river at New Westminster and two were made at the mouth of the river inside and outside the lightship. All hauls showed eulachon larvae in them and in addition the river hauls showed eulachon eggs. The salt water hauls showed larvae in an early stage of development confirming the previous supposition that the young fish reached the mouth of the river shortly after hatching. They were found in heavy concentrations of marine crustacean plankton. Examinations of collections of summer plankton and young fish collections made in the area influenced by Fraser river water should be carried out with the idea of getting further knowledge of distribution and later developmental stages of eulachon.

R.E. Foerster

Appendix No. 45

Dogfish (Gray Fish) Tagging Returns

In 1941 a dogfish tagging programme was undertaken to determine whether in the strait of Georgia area where a relatively intense fishery was in operation the dogfish population was a separate geographical one, perhaps even composed of smaller individual local stocks or whether there was interchange between it and the open coast.

During June and July, 1941, 86 dogfish were caught by set-line off Departure bay and tagged. At Deep bay, north of Qualicum, 23 were tagged. Later in the year, November and December, 430 fish were caught, tagged and released in the area from Moresby island north to Nanaimo, though most of the tagging was done in the southern part of this district. Incidental to ling cod tagging operations, Dr. Hart caught and tagged 25 dogfish, 2 at the entrance to Saanich inlet, 23 off Northwest bay.

To date, November 30, of 564 tagged fish liberated, 38 have been recovered. The movements in relation to place of liberation were as follows:

Number tagged	Number recovered				Per cent.
	In area of tagging	north	east	south	recovery
23	1	0	0	2	13
86	0	2	3	2	8
430	15	5	6	1	6
25	0	1	0	0	4
564	16	8	9	5	7

The returns suggest that considerable movement does take place among the dogfish in all directions but the recoveries are too few to draw any conclusions as to seasonal migrations. In the case of those recoveries from the 430 fish tagged in Nov.-Dec. 1941 which were made some months after tagging

there is no means of knowing whether the fish had moved away and returned.

One interesting recovery was made on Oct. 24, 1942, when tag number 246, affixed to a fish on Nov. 26, 1941, one mile east of Porlier pass in the gulf of Georgia, was retaken 5 miles south of cape Flattery. This is the only evidence of movement from the strait of Georgia to the open ocean. By coincidence a dogfish tagged by Mr. R.T. Smith of the Washington State Fisheries Department at Swiftsure banks on Oct. 9, 1940, was recovered by a Canadian fisherman near point Roberts on Oct. 30, 1942, thus indicating an offshore to inshore migration.

Ferris Neave Appendix No. 46

Reproduction of Japanese Oysters.

The summer of 1942 provided the first commercially valuable set of Japanese oysters in the Ladysmith area since 1936.

Periodic examination of plankton samples from Ladysmith harbour was made throughout July and August in order to detect the presence of larvae and to follow the course of larval development.

During the first few days of July considerable spawning of oysters took place. The weather at this time was hot and water temperatures were well over 20°C. By July 11 numerous larvae had attained a size of 115 μ to 180 μ. On July 14 some larvae of 230 μ were found but the average size was about the same as on the previous date and during the next two days nearly all the larvae disappeared from the water. The weather at this time was unsettled, with day water temperatures between 18°C. and 19°C. over the oyster beds. No set of any value resulted from these early spawnings.

Further spawnings took place during the first week of August. Plankton samples thereafter showed very numerous larvae, which developed well. Spatting occurred during the night of August 20-21 and for several ensuing days. Oyster shell cultch hung on floating structures and examined at intervals during the two weeks following the commencement of spatting, showed an average of from 10 to 44 spat per shell (counted on smooth face only). A considerable set was also apparent on cultch spread on the bottom in certain localities. Water temperatures taken during the main period of larval development were between 21.1° and 24.7°. A few larvae were still present in samples taken on September 5.

Before spatting occurred, the industry was apprised of the imminence of a good set and a large amount of cultch was put out by certain growers, with excellent results.

No spatting nor any abundance of larval stages was noted at any time during the season at Boundary bay.

A visit was paid to the oyster beds at Pender Harbour on September 1. A light set of oyster spat was found on the shells of live oysters held in a sink-float over the beds. The size of the spat indicated that setting had occurred within the previous week or ten days. As no cultch had been set out, the extent of the set was not apparent at the time of the visit.

During the summer a concrete tank was constructed at the Biological Station for the purpose of investigating the feasibility of obtaining spat under controlled conditions. The tank has a surface area of 950 square feet and can be filled by tide to a maximum depth of 8'6", the volume at this level being in the neighbourhood of 23,000 gallons. It will be used for experiments during the 1943 season.

Ferris Neave Appendix No. 47

Commercial Clam Catch, 1941-42.

Statistics of last season's commercial catch were again sought, through distribution of forms to fishery officers and clam buyers throughout the coastal area. This was done through the co-operation of the Department of Fisheries. The

forms provide for a record of the quantities of clams obtained, locality, date, number of men engaged and number of tides involved. The quantities reported on these forms should not be regarded as an entirely accurate statement of the total commercial production in the province. They serve, however, to indicate the relative importance of different areas and species and the productivity in terms of average yield per unit of effort involved.

It is probable that the total clam production for 1941-42 was only about three-quarters as great as in the preceding year. (The year is taken from October 1, i.e. the opening of the season for butter clams).

Butter Clams

The total quantity of butter clams reported was 3,237,785 lbs., distributed geographically as follows:

Locality	Lb.
Prince Rupert district	1,382,124
Bella Bella "	140,400
Alert Bay "	923,055
Quathiaski "	20,160
Seal Island	235,757
Chemainus district	290,010
Sidney "	40,891

These figures emphasize the northward shift which has taken place in recent years in the centre of production, about four-fifths of the catch, according to these data, coming from north of Seymour narrows. This is in spite of the considerable quantity obtained through the opening for a limited period of the closed area at Seal island.

The average quantity of clams dug by one man during one low tide period has been calculated for each area, as a guide to the trend of productivity from year to year. The results obtained for the past three seasons are shown below. Figures relating to 1939-40 and 1940-41 were obtained by Mr. D. B. Quayle, who instituted the system of detailed reports.

	Average Catch (lb.) per Man-Tide		
Locality	1939-40	1940-41	1941-42
Prince Rupert dist.	-	-	558.1
Bella Bella dist.	-	182.7	272.3
Alert Bay dist.	200.7	198.2	186.7
Seal island	-	-	599.9
Chemainus dist.	120.0	124.7	153.8
Sidney dist.	138.0	149.9	159.1

The productivity of beaches in the Alert bay district, which has been heavily exploited for five or six years, appears to be falling off, while a rise in productivity is indicated for the Chemainus-Sidney area during the three years covered by the investigation.

Littleneck Clams

Reported production of littleneck clams amounted to only 197,270 lb., as compared with approximately 500,000 lb. in the preceding year. An important factor in reducing the catch was the issuing of an order prohibiting the sale of clams, following cases of shellfish poisoning on the west coast of Vancouver island. This eliminated the greater part of the summer digging which ordinarily accounts for a considerable proportion of the year's catch, due to the occurrence of low daylight tides and the closure of the butter clam season. Increased employment in other industries undoubtedly had some effect in reducing the number of diggers prior to the issuing of the order.

Production was allotted as follows:

Locality	Lb.
Vancouver district	10,800
Jervis inlet district	2,560
Milbanke sound dist.	25,730
Chemainus district	158,180

The area designated as "Chemainus district" includes various localities along the south-east coast of Vancouver island and among the Gulf islands.

The average catch per man-tide has been calculated for the past two seasons from such reports as gave complete data.

Area	1940-41	1941-42
Vancouver	74.7	73.8
Jervis inlet	77.3	92.3
Milbanke sound	70.7	54.4
Chemainus	122.5	127.0
Nanaimo	89.6	-

"Chemainus district", which has supplied from 70 percent. to 80 percent. of the reported catch during the past two years, thus shows also the highest yield per unit of effort.

Horse Clams

This species is of little importance at the present time. A total of 8,418 lb. was reported from Sidney and Alert bay districts, these being taken incidentally in the course of digging for butter clams. The species is frequently discarded from catches.

Ferris Neave

Appendix No. 48

Investigation of Butter Clam Productivity at Seal Island.

A general study of the productivity of a known area of beach, including an investigation of the effect of imposing quotas on annual production, was begun at Seal island, near Comox, in January 1942. This large beach had been closed to diggers since 1939 and was known to have a heavy population of clams.

Arrangements for the digging of certain portions of the beach under specified conditions were made through the co-operation of the British Columbia Fisheries Department and British Columbia Packers, Limited. Three contiguous areas (A, B and C) were staked out, these being respectively 10,766 square yards, 10,657 square yards and 7,195 square yards in extent.* Digging operations on these were carried out during two sets of low tides in January and February. Digging in Area A was stopped when it was considered that two-thirds of the territory had been fully exploited, about one-quarter of Area B was dug, while in Area C digging was continued until no digger considered it worth further attention. The following statistics were obtained:

Area	No. of tides	No. of diggers (Man-tides)	Man-hours	Catch (lb.)	No. of Clams	Average Catch per man-tide (lb.)	Average Catch per man-hour (lb.)
A	2	160	655.35	111,292	386,100	695.57	169.82
B	4	65	250.75	25,920	90,288	398.77	103.37
C	2	168	680	98,545	342,600	586.58	144.92
Totals	8	393	1,586.10	235,757	818,988	599.89	148.64

On the basis of the known size of the areas and the estimated extent to which each was "dug out", the following figures were obtained for the total population of marketable clams before digging commenced:

Area	Lbs.	No. of clams	Average lbs. per sq. yd.
A	166,938	579,150	15.51
B	103,680	361,152	9.73
C	100,000	347,648	13.90

A fairly constant relation was found to exist between the estimated population of marketable clams per square yard and the average catch per man-hour. The average amount of work done by one digger in one night was estimated to be equivalent to 43.07 square yards completely dug.

Under the conditions prevailing, both of the following equations were found to give a close approximation to the previous estimates of the marketable population.

* These figures, and calculations based thereon, differ from those given in an account published in Rept. B.C. Fisheries Dept., 1941, having been revised after a re-survey of the ground under daylight conditions. The differences are small and are not considered to be important.

Ferris Neave Appendix No. 48

(1) Population (lb. per square yard)= (Average catch per man-hour) X 0.0938

(2) Population (lb. per square yard)= $\frac{\text{Total Catch}}{\text{(No. of man-tides) X 43.07}}$

Estimates would be:

	A	B	C
(1)	15.93	9.70	13.59
(2)	16.15	9.26	13.61
(Previous estimate)	15.51	9.73	13.90

It is intended to continue this investigation during several seasons.

Ferris Neave Appendix No. 49

Production of Butter Clams in Experimental Plots

The periodic digging of specific plots at five localities between Sidney and Alert bay has been continued. The form of the experiments has been described previously (Summary Repts., 1939, 1941). The purpose is to obtain information concerning the productivity of certain typical beaches and the most efficient manner of exploitation. The experiments, devised to run for at least six years, are now entering their fifth year. In general, conclusions must await the end of the experimental period. It is already evident that considerable fluctuations in the supply of clams may occur, owing to the marked variations in the abundance of different year classes and consequent variations in the number attaining legal size in a given year.

Ferris Neave Appendix No. 50

Growth Rate and Representation of Year Classes of Butter Clams in Different Beaches

A considerable number of samples from various butter clam beaches between Sidney and Alert bay has been obtained. Measurements and age determinations are being made in order to obtain information on (1) general growth rate and age at which legal size is attained, (2) the importance or otherwise of particular year classes in individual beaches and throughout broader areas.

In spite of the difficulties of sampling adequately, repeated visits to certain localities have given strong evidence that very marked variations occur in the amount of the annual seeding received by beaches. It is possible that these natural variations may be as important in determining production as the effects of heavy digging or closing of areas. Considerable differences in growth rate are apparent in some instances and these of course affect the time period which must elapse before a deficiency in certain size groups can be made good.

Ferris Neave

Appendix No. 51

Seasonal Settlement of Shipworm Larvae.

In 1941 several stations were established on the east coast of Vancouver island by Mr. D.B. Quayle for observations on the seasonal incidence of attacks by Bankia setacea on fixed and floating wooden structures. Test blocks of fir were immersed at each station, at three levels, viz., (a) 3 feet below the surface, suspended from a float, (b) a fixed level, corresponding to a zero tide, (c) a fixed level 3 feet from the bottom and 3 - 8 feet below zero tide. The programme called for the monthly removal of blocks from each level and replacement by fresh blocks. Counts have been made of the number of Bankia present in the exposed face of each block, presenting an average area of 17.5 square inches.

Results from Cowichan bay, Ladysmith harbour and Departure bay can be tabulated as follows. Monthly figures represent a combined total of one block from each level.

1941	Cowichan bay	Ladysmith	Departure bay
May	-	0	1
June	-	30 (approx.)	3
July	1	12	19
August	0	11	118
September	20	18	130
October	11	16	54
November	3	0	215
December	0	0	8
1942			
January	3	1	31
February	0	0	4
March	0	0	3
April	0	0	2
May	0	0	12
June	3	2	3
July	1	2	4
August	0	0	(44
September	0	10	(
October	-	40	72

A test station was also operated at Comox but due to the loss, through storms, of certain blocks and difficulties experienced in attending at regular intervals, the record here is less detailed, though it covers a continuous period of one year. The figures in this case refer to blocks from the zero and sub-zero levels only.

Ferris Neave

Appendix No. 51

Period	No. of Bankia
May 5/41 - Aug. 1/41	7
Aug. 1 - Sept. 1	0
Sept. 1 - Nov. 21	8
Nov. 21 - Dec. 29	13
Dec. 29/41 - Feb. 1/42	12
Feb. 1 - Apr. 1	1
Apr. 1 - May 1	1
May 1 - June 4	2
June 4 - July 10	0

While there appears to be a tendency for larval settlement to reach a maximum in the fall or early winter in these localities, there are no sharply defined seasonal limitations such as some Pacific coast investigators have suggested and it is evident that destructive attacks can take place at almost any time of the year. Some settlement has been found during every month at Departure bay. No evidence of a definite annual spring peak, reported by certain observers, is forthcoming from the present series of experiments.

While the number of shipworms counted in the test blocks varied greatly in the different localities, it may be mentioned that even in the places where infestation was relatively light, the boards to which the blocks were attached became riddled and virtually destroyed after six to ten months' immersion.

A comparison between the number of Bankia found at the three levels is given below. The figures include those given above and also counts made on blocks immersed for longer periods. The number of blocks and the periods of exposure were of course the same for each level at a given locality, but are not always the same for different localities.

Locality	Floating	Zero	Sub-zero
Cowichan bay	6	47	200
Ladysmith	33	85	346
Departure bay	329	520	2,054
Comox	3	13	51

It will be seen that in each locality the floating blocks yielded the fewest and the sub-zero blocks the most numerous Bankia.

Ferris Neave

Appendix No. 52

Destruction by Bankia in a Vancouver Shipyard.

A destructive attack by shipworm on timbers in the launching ways of West Coast Shipbuilders, Ltd., False Creek, Vancouver, was reported to the Station in June. A visit was paid to these yards on June 18. Damage was found to be heavy in a limited area, replacement of piling being necessary in May although the

piling had only been driven in November 1941, six months previously. The attacks were mainly concentrated at or a little below zero tide level.

From the comparatively large and uniform size of the burrows it was concluded that all or most of the larvae had settled within a short period, soon after the driving of the piles. This part of False creek has been considered by local interests to be more or less immune from shipworm attacks and untreated timber has been used for marine structures. It is now evident that severe attacks can occur, though the present outbreak appears to have been quite limited in area and in the period of settlement of the larvae. Protection of sound piling at the locality in question has been effected by putting a gravel and sand fill around certain timbers and surrounding other piles with concrete sleeves.

J. P. Tully

Appendix No. 53

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 during 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 limits 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, and if by inflow and discharge, 10% of the total amount of oxygen was renewed each day (10% x 100 = 10) 10 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, and this equilibrium can be defined as:

Oxygen supply -- oxygen demand = oxygen residue

In estimating the oxygen supply it was necessary to determine the depth in which the effluent would be contained in both the harbour and the inlet, and to determine the amount of new water, from the rivers, and from the depths, entering this zone on each tide cycle. This new water displaces a proportion of the polluted water from the inlet, dilutes the residue, and brings new oxygen into the zone of pollution. The oxygen supply in the harbour is contained in the new water brought in by the replacement process. The data has been analysed and the complicated function of replacement has been solved.

The oxygen demand depends on the rate of operation of the mill which is assumed to be full capacity (135 tons of pulp per day). Assuming that the effluent is discharged into the harbour so that it is uniformly distributed, the demand per tidal period must be calculated on the basis that some new effluent is being added and a proportion of the old effluent is being removed. These calculations are proceeding at the present time.

The next and final step in the estimation of the proposed pollution is the substitution of these values of oxygen supply and demand in the above equation and the determination of the oxygen residue. Three sample results have been completed to indicate the trend of the conclusions, namely:

	River Discharge cfs	O_2 Supply ppm per tide	O_2 Demand ppm per tide	Demand / Supply	O_2 Margin ppm
High Water	5300	4.76	0.200	4.0%	+4.76
Average	2381	1.79	0.340	19.0%	+1.45
Low Water	198	0.517	0.650	126%	-0.133

These results indicate that assuming uniform distribution of the effluent and a constant rate of replacement, the pollutant will be dispersed and its oxygen demand satisfied during maximum and average river discharge, without impairing the oxygen content of the harbour, but during the low water the demand is greater than the supply and a condition of pollution would result as soon as the oxygen reservoir in the harbour was reduced to the lethal limit. Assuming this to be 5.0 ppm of oxygen, pollution would occur in about 9 days, and since these conditions exist for one to two months it is apparent that the pollution would be real.

From previous studies of a model, which were checked by drift measurements in Alberni harbour, it was found that there was a zone along the south shore from which little or no diffusion occurs into the harbour. It is possible that by utilizing this current that the effluent could be transported out of the harbour to the lower inlet before diffusion occurs. Such a system would leave part of the surface relatively free of pollution in the harbour area. Further

J. P. Tully Appendix No. 53

investigation of this possibility would be desirable, particularly if the probability of dangerous pollution is confirmed by the present examination of the data. Such a study would involve the tracing of full scale discharges into the harbour, or construction and studies of a model of the inlet.

The examination of the present data is near completion and as shown above it appears probable that the natural system would become polluted during low river flow, consequently some artifice must be employed to insure adequate disposal of the pollutant.

In this investigation no account has been taken of the probable effects of plankton on the supply or the tolerence of the fish to the pollutant. It has been determined that the pollution can be retained in the surface 15 to 25 feet of depth and it is assumed that the adult fish live at greater depths, and that the fry will avoid polluted zones by descending to depths below the pollution.

J. P. Tully Appendix No. 54

Daily Seawater Observations.

The program of daily seawater observations has been continued as outlined in the last summary report (#61, 1941).

These seawater observations have proven to be of strategic value to coast defence, and it is most important to maintain the high standard of reliability and continuity. For the same reason, the resulting data is being kept secret and no publication of results will be made during the war.

The data is being prepared for publication in the form of a mimeographed bulletin, to appear after the war. It is proposed to present the present data in two or three volumes and thereafter to issue an annual bulletin, similar in form to the weather reports.

For illustrative purposes the data on hand is listed:

J. P. Tully

Appendix No. 54

Station	Location	Duration
	EXPOSED STATIONS--Pacific Ocean	
1. Amphitrite	Barclay sound	Aug. 1934 to present
2. Nootka	Nootka sound	Aug. 1934 to present
3. Kains island	Quatsino sound	Jan. 1935 to present
4. Cape St. James	Queen Charlotte islands south	July 1934 to present
5. Langara	Queen Charlotte islands north	Sept. 1940 to present
	Inland Waters	
6. William head	Juan de Fuca strait	Jan. 1921 to July 1940
Race Rocks	" " " "	April 1941 to present
7. Entrance island	Georgia strait	May 1936 to present
8. Cape Mudge	" "	Nov. 1936 to present
9. Pine island	Queen Charlotte strait	Jan. 1936 to present
10. Ivory island	Milbanke sound	July 1937 to present
11. Triple island	Hecate strait	Oct. 1939 to present
12. Green island	Chatham sound	Jan. 1935 to Sept. 1936
	SHELTERED STATIONS	
13. Poplar island	Fraser river	Feb. 1927 to present
14. Ladysmith harbour		1934 to present
15. Departure bay		Jan. 1919 to present
16. Prince Rupert harbour		Jan. 1940 to present
17. Shannon bay	Masset inlet	Dec. 1939 to Sept. 1942
18. Masset	Masset inlet	Nov. 1939 to Sept. 1942
19. Port Alberni	Alberni inlet	Apr. 1940 to Sept. 1942

J. P. Tully

Appendix No. 55

Paralytic Shellfish Poisoning.

Following an instance of shellfish poisoning in March, the Department of Pensions and National Health requested that samples of shellfish, particularly Butter clams (Saxidomus giganteus), Littleneck clams (Paphia staminea), and Sea mussels (Mytilus edulis), from representative commercial beds be prepared for biological assay. It was decided that Fisheries inspectors should collect the samples during the two neap tide periods each month and ship them to the nearest preparation laboratory at Prince Rupert, Vancouver or Nanaimo. Dried extracts were then to be prepared and rushed to Ottawa by Air Express.

At this laboratory samples have been received regularly from the following places:

J. P. Tully

Appendix No. 55

Origin of Samples	Area Represented	Number of Collections	Number of Samples Prepared
Cape Mudge	Northern Georgia strait	8	26
Cape Lazo	Comox	9	38
False Narrows	Nanaimo	11	34
Departure bay	Departure bay	2	8
Gallows Point	Ladysmith	10	32
James Point	Cowichan	10	32
Sooke harbour	Sooke	10	63
Ucluelet	Barkley sound	7	51
Dodger's cove	Barkley sound	9	65
Effingham island	Barkley sound	5	37
	Total	81	385

During the first six collections the estimations were based on preparations of the siphons and liver, and during the summer a definite indication of toxicity was observed, particularly from Barkley sound.

In September, it was recommended that a standard be devised, suitable for estimation of the toxicity in fresh and canned material, and that a legal tolerance of the poison be recommended, so that reasonable legal protective measures could be taken.

Series of tests were made to determine the relative toxicity of the various organs as well as the whole clams by two procedures. The suitability of the procedures was also to be examined. The extracts prepared in accordance with these tests have presumably been assayed in the Food and Drugs Laboratory at Ottawa, but no returns have yet been received.

In conjunction with the Department of Pensions and National Health, it is proposed to define the methods of analyses and the tolerance limit of the poison in a manner suitable for legal application. The present series of preparations will continue until June, 1943.

C. and E. Berkeley Appendix No. 56

Polychaete Studies

An account of our work on polychaeta from the west coast of Vancouver island, the Queen Charlotte islands, Alaska, and Bering sea appeared in the Canadian Journal of Research in July last.

The work of the past year has been concerned chiefly with material collected in northerly latitudes. A small collection made by H.A. Larsen, of the N.W.M.P. off the North-West Territories in 1936 has been examined and, recently, we have completed a study of a rather extensive collection made by Messrs. Johansen, Taylor, and Hachey during the years 1927, 1928, 1929, and 1930 in Hudson bay. Nearly all the species represented in these collections constitute new locality records though many of them are well known Arctic forms. Some rarities, which have not been observed for many years, have turned up and enabled us in some cases to amplify the old descriptions and it has been found necessary to set up one new genus to cover two of the species.

We are at present engaged in a revision of our collection from Vancouver island and the vicinity in the light of knowledge which has accumulated during the past several years.