

10
DFO - Library / MPO - Bibliothèque



04056280

FISHERIES RESEARCH BOARD OF CANADA

R E P O R T

of the

PACIFIC BIOLOGICAL STATION

for

1940

by

R.E. Foerster, Director

PBS-AR /
1940

NANAIMO, B.C.

DECEMBER, 1940

FISHERIES RESEARCH BOARD OF CANADA

REPORT OF THE
PACIFIC BIOLOGICAL STATION,
NANAIMO, B.C.
FOR 1940

BY R. E. FOERSTER, DIRECTOR.

INTRODUCTION

The main objective of the work of the Pacific Biological Station is to undertake those scientific studies of the commercially important fishes of British Columbia which will provide the Department of Fisheries with accurate data for its guidance in establishing suitable regulatory and conservation measures for the continued safe exploitation of the fisheries. Some of these studies, - those recently commenced, - are fairly general in nature and result in an increase in our knowledge of life-histories, etc. Others have been carried somewhat further and embrace particular features, such as growth rate, migration, variation in abundance, etc. Then there are those that have reached the point where fundamental factors governing the reactions of the fish are being investigated, such as those which control migration, those which produce variations in growth rate, abundance of fish, propagation, etc. All are definitely of what might be termed economic importance as well as of scientific value but some naturally seem of more obvious significance than others. As research progresses, however, the fundamental phases become the primary concern of investigation and, in final analysis, they constitute the essential problem. They hold in so many cases the key to the explanation of the phenomena which, on the surface, are of importance in regulation and conservation.

The work of the Station during 1940 has progressed most satisfactorily. Some investigations have made notable progress. Others have added a wealth of data which has yet to be analyzed. Some have encountered obstacles which have had to be overcome before further advance could be made and in some cases other more pressing problems have interrupted the main research. Nevertheless the contributions for the year are quite gratifying.

In three studies, salmon, herring and shell-fish, where the research is passing into the more fundamental stages of population densities and variations therein, whether on the spawning grounds or in the feeding areas, in the sea or in the streams, of propagation efficiencies, etc., it is becoming increasingly necessary to keep well abreast of the literature. Research elsewhere is expanding and advancing so rapidly that, relatively speaking, the opinions of today are replaced tomorrow by new ideas revealed by some new method of attack. The staff members have kept themselves fully in touch with the published literature and, by correspondence or personal contact, are made

THE LIBRARY
BEDFORD INSTITUTE OF
OCEANOGRAPHY
BOX 1006
DARTMOUTH, N.S. B2Y 4A2

acquainted with current research in other institutions. Thus they may properly analyze the data collected and arrange their research programs and methods to conform to the newer approaches and understandings. This requires a considerable portion of their time yet is effort well invested for it undoubtedly eliminates ineffective and inaccurate methods and interpretations.

The unsettled conditions within the Dominion, brought about by the war situation, and the concentration of effort throughout the country designed to meet the demands created are clearly appreciated. Every member of the staff is prepared to co-operate in whatever way he can best serve. For the present the attitude adopted is that in prosecuting his research as keenly as possible, a valuable service is being rendered but there will be no hesitation if, in the opinions of those directing the policies of the Station, the individual effort may better be expended in another direction. As suggested in last year's report there may arise need for intensification in certain investigations and initiation of new ones. At the same time there are a number of studies in progress in which a break in the continuity of observations or collections of material would be rather serious. These can probably be carried forward, in skeleton fashion at least, while diverting most of the effort elsewhere.

With reference to staff changes during the year, the most important undoubtedly was the resignation of Dr. Clemens from the Directorship after sixteen years' continuous occupancy of that position. During that period Dr. Clemens has seen the scientific staff increase from two to eleven. The extent of the research increased accordingly. The organization and supervision of such expansion was no small undertaking and there is abundant evidence that Dr. Clemens' endeavours and leadership were eminently successful. Dr. Clemens accepted the position of Head of the Department and Professor of Zoology at the University of British Columbia and it is heartening to know that in that office he will continue his interest in the work of the Station and be ever ready to lend advice and assistance whenever desired.

A second staff separation occurred in September when Dr. G.C. Carl accepted the position of Assistant Director, later Acting-Director, of the Provincial Museum at Victoria. In his research connected with the Cowichan lake investigation Dr. Carl had undertaken a very comprehensive and ambitious program of limnological and fresh-water biological studies, intended to demonstrate the relationship between the trout populations and ecological conditions, food, etc. in the lake. Dr. Carl was also keenly interested in conditions governing the artificial propagation of salmonidae and the pond rearing of young.

Perhaps it would not be too out of place for the writer to indicate here his great pleasure in returning again to the service of the Board, particularly at the Pacific Biological Station. It is earnestly hoped that the high quality of the work will be maintained and the interests of the Board as keenly prosecuted. The members of the staff have co-operated most generously and a very stimulating feeling of fellowship and mutual interest in the Station's success prevails.

Another development of considerable interest and grave concern occurred when Mr. Wm. Anderson, Technician in the Chemistry laboratory, suffered severe injuries from an explosion on October 18. Mr. Anderson had been carrying through a routine recovery of silver nitrate from a mixture of concentrated nitric acid and metallic silver, the latter previously reclaimed from an accumulation of silver chloride, the product of chloride determinations of sea water. Most of the silver nitrate had been recovered successfully but in the process of washing the last small lot with alcohol, the mixture exploded in the beaker. Two fingers of his left hand were so badly injured that they had later to be amputated and his right ear was severely cut. The greatest concern, however, was felt for his eyes into which had been blown some of the silver nitrate and alcohol. Mr. Anderson was given first aid treatment, rushed immediately to the hospital and medical aid summoned. Suffice it to say that he is still in hospital having recovered from all other injuries except his eyes and these are clearing up gradually, the left one rather slowly. His sight, it is expected, will not be seriously impaired.

A court of inquiry, consisting of senior members of the staff, was set up after the accident to investigate the cause and fix responsibility. It was the finding of the court that apparently in the recovery procedure, after nitric acid and the silver had been combined, some nitric acid and free silver must have been present when the alcohol was added and thus silver fulminate, a very unstable explosive, was formed. When the crystals of silver nitrate were dried and scraped in the act of removing them from the beaker to an evaporating dish, sufficient friction was applied to detonate the fulminate. In view of the fact that (1) the recovery method had been tested before being adopted and had been satisfactorily used on a number of previous occasions, (2) all of the steps in the procedure were standard chemical practice when considered individually and (3) the possibility of fulminating silver being produced had been investigated by Mr. Tully, by reference to standard inorganic chemistry texts, no responsibility for the accident could be fixed. Needless to say the procedure for recovery of silver nitrate was immediately changed.

During the year three members of the staff, Messrs. Neave, McHugh and Anderson, joined local units of the non-permanent active militia. This involved weekly training periods and a two-weeks' residence in camp. Mr. McHugh recently completed his Officers Training Course and has been gazetted as a 2nd Lieutenant. Mr. Hollister is now serving his thirty day training under the National Resources Mobilization Act, although not yet called, in order that his proposed work on Alberni Canal during the next year will not be interrupted.

In concluding this general section of the report, thanks are tendered, on behalf of all members of the staff, those officials of both Federal and Provincial Fisheries Departments who have assisted so generously with information or facilities during 1940. The happy relationships thus existing add greatly to the interest in and success of the work. The Provincial Fisheries Department continued to share financially in the herring, pilchard and shellfish investigations.

Salmon Investigations

Pink Salmon.

The pink salmon investigation at McClinton creek, Masset inlet, Queen Charlotte islands, under the direction of Dr. Pritchard assisted by Mr. Cameron, is now the principal salmon study undertaken by the Station. It is essentially a direct study of the natural propagation of the pink salmon in situ, i.e., under definitely natural conditions. The primary objective has been to follow through, from the arrival of the mature adults upon the spawning beds to the seaward migration of the fry, the various stages of spawning, embryo, alevin and fry development. The conditions prevailing at each stage and the factors affecting survival and mortality are investigated, hence the critical periods of development and the factors affecting them are revealed. By such means a better understanding of the variations in productivity in different years, as resulting from varying physico-chemical conditions or varying numbers of spawners on the beds, etc. is obtained.

By marking portions of the seaward migration by removing certain fins, an attempt has been made to trace the return of pink salmon to the creek. Information is being obtained as to the route of migration from the sea, areas in which the returning run is subject to drain through commercial fishing, the possible wandering of spawners to other areas or streams, and the degree of return to the parent stream.

In addition, data are obtained as to size, sex ratio, etc. of returning adults, size and condition of seaward migrants and physico-chemical factors affecting migration.

During 1940, the return of adults to McClinton creek was studied, this being the sixth such count made. A very moderate run occurred, 35,525 individuals. The 16,454 females, having an average egg content of 1,619 eggs, indicated a potential deposition of 26,500,000 eggs. This run of 1940 was the return from the spawning of but 10,577 adult pinks in 1938, demonstrating again a very unusual correlation in which after a "small" year a significantly larger return results, and vice versa. Of course the extent of the relative commercial catch each year is an integral factor in such a relationship and until further information is available concerning these catches, no conclusions can be derived. From the recovery of marked adults in the commercial fishery in 1940, it was found that some recoveries were made in Alaskan waters. This indicates that the Alaskan fishery may in some years exploit the Masset inlet pink salmon run to a certain extent. Until a clear picture of the migration of adult pinks from the sea and the points of commercial drain are known, together with some general data as to the extent of such drain, the complement reaching the spawning stream means little. With further reference to the return of marked adults in 1940, it has again been found that much the greater recoveries were made in McClinton creek or in the Masset inlet fishery. In spite of careful observation of the pink salmon fishery of the Nass, Skeena river and more remote fishing areas, only 2 returns of marked pinks were obtained, both from the Skeena. For Masset inlet itself, examination

of samples of pink spawning in tributary streams showed that while 791 marked individuals were taken in McClinton, one was found in the Mammon river, out of 3,400 examined, and one in the Detlamen out of 400 observed. These latter recoveries indicate that possibly some slight wandering of spawners to streams adjacent to the parent stream may occur.

One interesting study at McClinton creek has been the distribution of spawners on the spawning grounds and the effect of freshets upon such distribution. By tagging the fish as they pass the counting fence in such a way that they can be individually recognized again, it has been found that, immediately before or during a rise in creek level, the fish proceed to the upper areas of the stream. Those tagged after the peak of the rise congregate in the lower reaches. When a later freshet occurs if these latter are approaching maturity, they move farther up along with new arrivals. If, however, they are about to spawn, they pass into the adjacent shallower water and begin to construct their nests.

This study has incidentally provided valuable information concerning the accuracy of using tagging of a small fraction of a run to estimate the size of that run. Such a scheme has been suggested for streams where counting fences are not practicable. It is found that since the distribution of fish in a stream is not random, but influenced by water conditions such as freshets which affect also the proportion of fish tagged at that time, serious error must inevitably result unless a large portion of the dead fish population can be examined throughout the length of the stream and the season. This is an important problem and is being given more statistical study.

Another promising phase of the pink salmon investigation relates to the losses occurring during incubation of the eggs. Natural redds are marked after spawning has been completed and careful examination made during the winter and spring to determine the percentage loss during various stages of development. Critical periods of survival are thus indicated. Factors affecting the survival at each stage are also investigated. The data are being obtained by Mr. Cameron who is spending the winter at McClinton.

Racial studies of pink salmon have also been commenced, with particular reference to gill raker, pyloric caecae, vertebrae and scale counts. The value of such work in isolating different races or populations is being tested. If significant differences are obtainable, the method has a wide usefulness.

Sockeye Salmon.

The only sockeye salmon study conducted during 1940 was the annual analysis of the size, age and sex ratio of the catches in the Rivers inlet, Skeena and Nass river areas during 1939, by Dr. Clemens, on behalf of the Provincial Fisheries Department. It represents the twenty-eighth consecutive report on these sockeye populations.

Age-classes were present in all areas in practically the same ratios as in former years, but sizes varied notably. For Rivers inlet both lengths and weights were low; for the Nass the lengths were somewhat higher, the weights somewhat lower than average; while for the Skeena the lengths were considerably above the average for the past 27 years of record, and the weights decidedly below the past twenty-five year aver-

age. For the Skeena the sex ratio showed a very low male representation, only 38 per cent, the lowest in twenty-five years.

Chum salmon.

During the spring of 1940, a preliminary investigation of chum salmon natural spawning in two small streams near Ladysmith was made by Dr. Pritchard and Mr. Cameron. While conditions did not permit an early study of the nests after spawning, to determine the percentage of fertilization, the subsequent data suggest that, in general, fertilization was probably high, comparing favourably with that, approximately 98 per cent, found elsewhere for sockeye and pink salmon. The nests were dug up when the eggs were well advanced. The results indicate a variation in mortality of from 2.0 to 100.0 per cent depending largely on the type of gravel in which the eggs were deposited and the subsequent degree of silting. Further work of this nature with attention paid to the amount of stream bed of each type of gravel, numbers of fish frequenting same, and possible means of improving unfavourable areas, would have very definite practical importance.

An attack is being made also, by Dr. Pritchard, upon the age analyses of chum salmon runs to various areas and streams. This is essential to determine the incidence of cyclic runs and general growth rates. Racial analyses may also be undertaken in the future to determine the probability of segregation of runs to different river systems, etc.

Spring Salmon.

The study of the natural food of spring salmon in various areas of the British Columbia coast, initiated in 1939 by Drs. Pritchard and Tester, has been continued during 1940, with the collection of double the number of stomachs, 618, and an increase in the areas of collection. The results have not been completed but from an examination of 124 stomachs from the west coast of Vancouver island, from March to June, it was found that the contents, - sand lance, young herring, euphausiids and anchovies, - were roughly similar in quantity to the previous year's findings. Young pilchards appeared in some stomachs, these fish showing up quite unexpectedly along the coast during the season.

Dr. Pritchard completed a study of the ages of spring salmon taken in the troll fishery, from 1927 to 1930. A total of 2,834 samples of scales were read. For west coast of Vancouver island areas, the average age increased as the sampling area moved north. Samples at Ucluelet had an average age of 3.8 years; at Kyuquot and Quatsino - 4.4; off the Queen Charlottes - 5.5 years. Samples from "offshore" areas contained older fish - average age, 5.0 to 5.6 years - than "inshore" districts, such as Hecate strait, Milbanke and Fitzhugh sounds, etc., where the average age ranged from 3.7 to 4.4 years.

The explanation suggested is that the young fish migrating from their natal streams, Columbia, Fraser, etc., move northward along the coast of Vancouver island on a leisurely "feeding" migration, and subsequently return on a more rapid spawning migration. Catches providing a cross section of the spring salmon population will include more immature fish in the south while the northern samples will contain preponderantly older fish near the limit of their northern movement. Similarly for inshore and offshore populations.

Coho Salmon.

As part of the Cowichan river investigation, carried out by Mr. Neave and Dr. Carl, certain work was done on coho salmon which might here be reviewed.

The production of young coho from two small streams, Oliver and Beadnell creeks, adjacent to the Cowichan lake hatchery, was studied. Counting fences permitted a count of the adult spawners entering the creeks and the young fish passing seaward. In Oliver creek, from a presumed deposition of 665,000 eggs, 78,789 fry or fingerlings were obtained, or 11.84 per cent of eggs deposited. In 1939, a survival of 15.52 per cent was reported. In Beadnell creek, from 433,000 eggs, 174,036 young cohos resulted, or 40.01 per cent of eggs deposited. The notable difference in per cent survival was accounted for, in part at least, by the presence in Oliver creek of considerably more predator fish, particularly cutthroat trout, viz. 985 in Oliver and 231 in Beadnell. Other fish, coho yearlings and brown trout, were present in the creeks in relatively the same abundance.

In 1938 and 1939 young cohos of the brood of 1937, which had been reared in the hatchery, were marked and liberated in the upper Cowichan in the vicinity of Oliver creek. A total of 26,000 fingerlings was used, being marked by the removal of adipose and left ventral fins. During 1940 rewards were offered for the recovery of such marked cohos, and to date fifty-nine have been reported from the fishery. They were taken in areas extending from Cape Flattery, through Puget sound and lower Georgia strait, to Cape Mudge at the south end of Seymour narrows. Twenty-two were taken in commercial gear, the remainder by anglers, chiefly in Cowichan bay.

In the Cowichan river itself, complete counts are possible only at Oliver creek, to which had already returned 127 coho, of which 93 were marked. Further data are being collected. Nevertheless the tentative findings indicate the value of such work in tracing the extent of migration of salmon from known streams or rivers and the extent to which the fish form a part of the commercial fishery

Mortality among Salmon.

Again in 1940 a sudden mortality of salmon occurred, this time in Cowichan bay and involving primarily spring salmon. About 500 deaths are reported to have occurred and sport fishing was largely at a standstill for two weeks. The writer and Mr. Tully investigated the situation, at the request of the Department through the Fisheries Officer, Mr. Sherman, and after a number of visits to the bay concluded that unusually high alkaline conditions of the water very likely caused a disturbance of the respiratory system which proved fatal. No factors such as dynamiting, poisoning, etc. seemed to be involved. The occurrence but emphasizes the need for further knowledge of the optimum limits of tolerance of salmon to environmental factors and conditions.

Cowichan River Investigation

As intimated in the report for 1939, the problem in the Cowichan river system investigation is to determine the deficiencies in the production of the various fish, rainbow, cutthroat, and brown trouts, spring, coho and chum salmon, and to develop effective measures for overcoming them. In short, some type of fisheries management was desired. The river system, including Cowichan lake and tributaries, is too large for a general, inclusive program of study, hence certain features only could be studied. These have been selected for their general applicability and for their fundamental importance. It was the hope of the investigators, Mr. Neave and Dr. Carl, that in time the data could be all gathered together and a general understanding of the system and the necessary management scheme derived.

For the salmon one of the first endeavours was to obtain some measure of the anglers' catch in Cowichan bay in order that the variation in this drain from year to year might be determined. At the same time the composition of the run, as sampled by angling gear, could be revealed, as to age, size and sex ratio of individuals. For coho, only two age classes are commonly found, two-year grilse and three-year adults. For spring salmon, while four and five year individuals most commonly appear, others of two and six years may occur.

A comparison of the angling activity of 1939 and 1940 indicates that while for a similar period, August 23 to October 31, the number of line-hours dropped from 19,006 to 16,707, the catch of large spring salmon was doubled (553 to 1,121) while that for "Jacks" decreased from 750 to 292. The 1940 catch of coho was much reduced, from 3,410 large and 1,069 grilse to 1,899 and 160 respectively. The abundance of small fish varies exceedingly from year to year, and is only very indirectly indicative of a trend in the fishery. The general result of the two-year comparison is reflected in the line-hours per fish index, which was 3.3 for 1939 and 4.8 for 1940.

For trout, a study was made of the seasonal variation in Cowichan lake pool, below the lake, which is the most productive stretch of the river. Gill nets were used to sample the population. Rainbow trout proved to be the dominant form during winter, September to May, while brown trout were most abundant in July and August. The summer decline of the rainbow is attributed to a migration to the lake during late spring, that of the brown trout in early winter to their spawning migration to the small river tributaries. The brown trout appears to exhibit a stronger tendency to remain in the river during the summer than the rainbows and hence are tending to fulfil the hopes of the anglers. The rod catch of brown trout, however, is not proportional to their percentage occurrence in gill-net catches, presumably because there is less fishing in summer months and the feeding habits of the browns give them greater protection from anglers.

One problem in the Cowichan sport fishery has been to determine definitely the relationship between sea-run and stream-dwelling forms of Salmo gairdneri, the steelhead. Three varieties seem to be present in the system, the normal sea-running steelhead and a fresh-water type, provisionally termed "rainbows", and also Kamloops which have been introduced. To get accurate data, specimens of each type have been raised

in the hatchery, marked and then liberated in the river. Subsequent recoveries by anglers and others will permit collection of size measurements, scale samples, and other material for racial analysis.

During the year a limnological study of Cowichan lake was continued by Dr. Carl. This involved chiefly regular periodic temperature readings at fixed stations and determination of oxygen content and pH. Quantitative plankton samples were taken in vertical series at regular intervals by means of a plankton trap. The data are being analyzed.

During the summer Mr. Idyll continued his study of the food habits of the trout of Cowichan river and lake. Additional data concerning the natural food and feeding of the rainbow, cutthroat and brown trout were obtained, to be added to a very comprehensive and valuable report now in preparation. A quantitative study of the bottom fauna at a series of stations in the river and tributaries was also made by Mr. Idyll.

Ocean Fisheries Investigations

Herring.

The herring investigation represents perhaps the most direct and comprehensive biological study of a fisheries yet undertaken by the Station. It embraces a thorough study of the trend of the abundance of the populations, spawning intensity from year to year, age composition, intensity of the fishing effort, etc., as well as pertinent biological features such as migration, distinction of races and the characteristic features of populations, e.g., size, vertebral counts and rates of growth. The work has been carried on by Drs. Hart, Tester, Boughton and Mr. McHugh.

At the present time four major herring fishing areas are recognized, namely, west coast of Vancouver island, east coast of Vancouver island, central area of the mainland coast and northern area (Queen Charlotte islands, Prince Rupert, etc.). These are believed to have distinct populations of herring, with very little if any, intermingling. Hence the exploitation of the fisheries therein represents separate problems and involves individual study.

During the 1939-40 season the system of Pilot House Record Books was continued. This provides for the collection of daily catch statistics whereby the catch in each area and the fishing effort involved can be calculated and the availability of herring computed as the average catch per seine per day's active fishing. The total catch in 1939-40 amounted to over 150,000 tons, the largest in the history of the fishery. The old established areas of the east and west coasts of Vancouver island contributed 32%, the central area, 37%, the northern area, 18%, and 13% was taken on new grounds on the north-east coast of Vancouver island (Alert bay area). Comparison of the abundance of herring in the respective areas with previous years, as indicated by availability figures, shows that, on the south-east coast of Vancouver island, herring were less abundant and individual sets were smaller (83.6 tons per double seine per day); on the west coast, while still very poor, the fishing improved slightly (17.5 tons); in the central area the catch (78 tons/

seine/day) was considerably less than 1938-39 (111 tons/seine/day); in Prince Rupert harbour the yield was relatively very good (93.5 tons/seine/day). Excellent catches were made in the area immediately north of the strait of Georgia (Deepwater bay and Okisollo channel) in late January and early February, the recovery of tags suggesting that these fish belonged in part to the population normally supplying the south-east coast fishery, while in the fall a new area (Alert bay) adjacent to Queen Charlotte sound was prospected with considerable success. For the Queen Charlotte islands area, summer fishing on the east and west coasts resulted in low catches, the fish being quite scattered, but from December to March, east coast fishing was fairly successful (42 tons/seine/day).

With the enthusiastic co-operation of the Department of Fisheries and its field officers, a very informative spawning area survey system has been developed, in which from records of average intensity of spawning, arranged in five categories from very light to very heavy, and calculated acreage of spawning ground, a spawning intensity index can be derived. From these indices it is found that in most general districts spawning in 1940 was somewhat heavier than in 1939. The much greater spawning acreage of the strait of Georgia (615 acres in 1940) presumably indicates why this region is more productive than the west coast of Vancouver island (315 acres in 1940).

During the 1939-40 season a total of 137 samples of herring were collected and examined in order to determine the age composition, size, rate of growth, necessary to a clear understanding of the trend of the fishery. They were taken as follows: east coast - 37, west coast - 36, Alert bay area - 17, northern and central areas - 37. Some 14,000 fish were thus studied. The general findings from these data are:

East coast - An unusual abundance of II year fish as in 1938-39 and a greater average length for each age class from II to VIII. The presence of II year individuals in 1938-39 and 1939-40 probably represents an unusually early addition of fish rather than the presence of an unusually abundant year class. They differ from the II year class of central and northern waters in being for the most part mature rather than immature. The analysis of size and age classes of the fish caught in Deepwater bay, somewhat to the north of the main east coast area, indicates that they are probably a mixture of strait of Georgia and Queen Charlotte sound populations.

West coast - Considerable variation in age composition between areas. III's predominated in Barkley sound, II's in Nootka and Quatsino. For remaining areas of the west coast, with the falling-off in availability of fish to the fishermen, there has occurred a relative decrease in fish of age IV and older and in the last two years a spectacular increase in individuals of age II. Other evidence indicates there has been a severe decline in the abundance of older fish and that the II year fish are therefore relatively but not actually of great abundance. Both the II's and III's of 1939-40 were of very large size.

Central and northern areas - Great variation occurred between localities both in size and age composition. A general increase was found in both average length and age. This increase is attributed largely to the failure of the younger age-classes to appear, possibly due to un-

favourable oceanographic conditions, migration to other areas or to a heavy catch of the younger fish in 1938-39.

Queen Charlotte sound and adjacent waters - The fish of this newly-exploited region were found to be very small and slow-growing. Fish of age VII at Belleisle sound were smaller than fish of age III in the east coast area. An exceptionally large percentage of older age groups occurred.

The existence of races or discrete populations of herring in the various fishing areas has been investigated from two angles, tagging and vertebral count studies.

With reference to tagging experiments, it has been shown in other reports that if the fishing grounds are divided into the four major areas, mentioned earlier, the recoveries of tags are almost entirely of those put in in the same area. In other words, the runs to these major areas tend to form distinct units. Some limited mixing may occur on the west coast. During the spring of 1940, 28,305 herring were tagged. Practically all tagging was carried out on the spawning grounds, a notable departure from other years' operations. Tagging was extended to include the Queen Charlotte area (400 tags) and Queen Charlotte sound (3,796 tags).

Vertebral counts were made of several northern herring areas and significant differences in average counts of similar year classes indicated that intermingling was very limited or absent, for example between runs to the Queen Charlotte islands, the northern and central areas.

In the study of young herring, an investigation of the occurrence of abnormal vertebrae has been continued. Five types of fusion of centra have been determined. Differential growth appears to be the causative factor, pressures being set-up by the action of growth gradients in the developing vertebral column and surrounding tissue.

Studies of vertebral columns have shown that the abdominal and caudal regions vary in almost equal proportions between localities in the strait of Georgia and similar changes with vertebral counts occur within individual samples. Values for "tail" vertebrae, those having the haemal arches "cross-tied" to the centrum, are more erratic. Further evidence has been found that larger fish in a sample tend to have higher vertebral counts.

To ascertain the general effect of a decline of both size and age classes as a result of severe commercial exploitation, the fecundity of herring was investigated with particular reference to the correlation of number of eggs to size and age. The ovaries of 101 females were collected and egg counts made by weighing and counting a small portion of the eggs in each ovary and calculating the total number. A definite tendency for the average egg count per fish to increase with size was found. The egg count for a given length varied, however, in different areas. For example, in 10 out of 11 length classes, Laredo herring had a higher egg count than Prince Rupert herring. The difference was attributed to the "condition" of the fish. Seasonal changes in egg weight were also studied.

Pilchards.

Research into the pilchard, conducted by Dr. Hart, has involved principally a general study of the fishery, migration or tagging experi-

ments and sampling of the annual populations to trace size and age trends.

The pilchard fishery has of recent years been exceedingly variable both as to quantities of fish appearing and their location. In 1940, fishing, with a total catch of slightly more than 28,000 tons, was not particularly successful. The catch per seine boat for the season was approximately 1,175 tons, as compared with 210 tons in 1939 and 2,150 in 1938. As in 1938, two fishing phases were evident, one off the United States coast followed by one in Canadian waters. No clear-cut distinction, however, could be made, fishing being largely simultaneously conducted. Nor was the Canadian phase very productive.

The future of the fishery is uncertain, the long term prospects appearing to depend on the possible dominance and abundance of the 1939 class of pilchards.

Sampling of the 1940 population was carried out at Ucluelet. The average lengths of 236.7 mm. for males and 241.9 mm. for females followed the downward trend noted in the three previous years. Males represented 51.0% of the samples, a slight predominance similar to 1939 which differs from earlier years when the males formed but 45% of the samples. The average vertebral count was 50.76, higher than any previous year sampled, perhaps indicating the disappearance of the effect of the low-vertebral-number year class which entered the fishery in 1931.

Tagging during 1940 was carried out off the coasts of Washington and Oregon. In all, 2,600 tags were applied. By the time the fish appeared in Canadian waters the supply of tags was exhausted. Ninety tags were recovered during the season, 38 Canadian tags of 1940, 8 of earlier years, 3 Oregon tags and 39 California. Eight of the 38 recoveries in 1940 were made in Oregon waters, while, for the earlier years, 6 were taken in California, 2 in British Columbia. The large recovery of California tags in Canadian waters is believed due to the presence, among the California-tagged pilchards in Canadian fishing grounds, of fish tagged in 1937 and 1938, heretofore too young to reach northern waters. The recovery of a Canadian 1936 in California and a California 1936 tag in Canadian waters indicates the length of time pilchards may remain in the fishery.

The tagging and tag recovery program has been maintained under a co-operative research arrangement with Pacific Coast states. It is hoped to continue it next year.

Young pilchards in great abundance appeared in British Columbia during the summer of 1940. They were first noticed in Barkley sound during the first week of May, by May 28 they were reported at Nootka sound and on June 15 in Quatsino sound. They were present in all fishery areas of the west coast. For the east coast, they were first observed at Departure bay on May 20 and from reports they had by that time spread over most of the strait of Georgia. Later reports indicate the presence of young pilchards as far north as the Queen Charlotte islands. Throughout most of the summer they remained abundant off both Canadian and American coasts until late August when they appeared to be growing less abundant off the west coast. Except for schools still being observed in the strait of Georgia they are believed to have generally disappeared by November 25.

During the season eight samples from various localities were collected, extending from May 17 to November 23. In that period the fish had increased roughly 60% in length, from 95 mm. to 155 mm., while weight increased by from 200 to 300 per cent. From scale examinations it was found that the fish were in their second year, i.e., of the 1939 year class.

On September 10, one thousand young pilchards were caught by seine in Cowichan bay and tagged. Returns are not expected for two years.

Ling cod.

During recent years the ling cod fishery has become important as a primary source of supply for the fresh-fish market. Increasing exploitation has drawn the attention of the Department of Fisheries to the adequacy of its regulatory measures. Some scientific investigation was desired. Dr. Hart has been in charge of the research.

The first objective was a study of the ling cod population and that portion of it affected by commercial fishing. In connection with a tagging program to reveal the migration tendencies of ling cod, fishing was carried out which provided a representative sample of fish taken by the "jigging" method. Such sample, however, will be representative rather of the fish on the grounds than of the catch, for the commercial fishermen are more interested in large fish and in weight, rather than number. Fish between the lengths of 600 and 650 mm. are most frequently taken. No fish less than 370 mm. were caught, and the data indicate that the gear is selective against fish shorter than 550 mm.

It has been suggested that a minimum size limit of either 3 or 5 lbs. should be enforced in the ling cod fishery, largely to protect the growing stock and to ensure most profitable exploitation. A length-weight relationship for the species has been calculated from available data as follows: $\text{Weight (ounces)} = 0.0000678 \text{ Length (mm.) to the power of } 3.245$. From this it is found that a minimum weight of 3 lbs. would correspond to a length of 540 mm. while that of 5 lbs. would correspond to a length of 610 mm. The first minimum would reject but 17 per cent of the unselected catch, whereas the latter would eliminate 44 per cent. The latter would seriously affect the catch, perhaps the livelihood of some fishermen and such is not recommended unless radical curtailment is demanded by the state of the fishery or is found, by further biological study, to be of distinct advantage to the fishery as a whole. The 3 lb. limit, however, would protect the younger stock and not seriously hamper the fishery.

In the majority of cases, tagged fish have been recovered in the same area in which they were tagged. Little migration has occurred. Even at the south end of Vancouver island, where it was suggested that movement into the strait of Georgia occurred, no indication of inward migration was observed.

From the tagging records, data are provided concerning the growth rate of ling cod. The fish appear to grow at the average rate of 6 mm. and 3 ounces per month, or 2.8 inches and 2.2 pounds per year.

This study is being continued and extended in order to permit collection of data over a wider area and of more general application. It has not been found suitable to obtain fish from commercial fishermen, hence a separate fishing effort must be made. Other means of collecting specimens for tagging and sampling are being investigated.

Smelts.

Preliminary studies of the life-histories of the four species of smelts (Osmeridae) in British Columbia waters, the eulachon, capelin, surf smelt and long-finned smelt, have been continued by Dr. Hart and Mr. McHugh as opportunity permitted. The eulachon and surf smelt are of some seasonal importance to the fishing industry and, with the capelin, are taken in some numbers by local residents.

The eulachon ascends most of the large rivers in April and May. The majority are in their second year. Males predominate in samples taken. Populations proceeding to the main rivers seem to be distinct, with little, if any, intermingling. Studies on the Fraser river indicated that spawning takes place on the river bottom where proper sand conditions prevail, the eggs adhering to sand particles. Absence of well-developed larvae in the net hauls suggests that the fish proceed to sea shortly after hatching. The eulachon appears to spawn but once in a season.

The surf smelt appears in spawning migrations from June to September. Several age groups are involved, from I to III. Males predominate and are smaller than the females in average length. The runs to various beaches tend to form local populations. Spawning takes place at night in the surf at the water's edge. The eggs adhere to stones and particles of coarse sand and hatch in about two weeks, the larvae rapidly disappearing. Ova measurements indicate that spawning occurs more than once in the season.

The capelin spawns in the same manner as the surf smelt, but during the fall, September and October. All fish appear to be in their second year. Males are found predominating in samples taken. No evidence of distinct local populations has been found.

The long-finned smelt spawns in fresh water streams from October to December. Samples in their first and second years have been collected. In one sample of the latter the females predominated and averaged 110 mm. in standard length.

Shellfish Investigations

The shellfish investigations carried out by Mr. Quayle with one temporary assistant, Mr. E.P. Kent, represent one of the minor researches of the Station. The Provincial Fisheries Department is deeply concerned with the commercial future of the commercial industry, particularly with regard to clams, and has contributed financially to the clam studies. For the oyster work, a very small appropriation was allotted but for certain phases of the field work, grants were made by the British Columbia Packers and the Crescent Oyster Company.

Oysters.

The outlook for the oyster industry is not very bright. Not only has natural propagation in Ladysmith harbour been a failure for a number of years but the continued annual purchase of Japanese oyster seed from Japan is extremely uncertain. During the summer of 1940 successful spawnings of both Japanese and native oysters occurred but the larvae died off before spatting.

Because of the unfavourable outlook Mr. Quayle deemed it desirable

to make a further trial of artificial propagation in a small, controllable lagoon adjacent to Ladysmith harbour. A dam was constructed at the open end of the lagoon and in the enclosed space oysters could be planted and allowed to spawn. The physical and chemical conditions of the impounded waters and the plankton population could be readily studied and organic enrichment of the water could be made, if thought necessary. In this somewhat experimental fashion, it was felt that the factors influencing the survival of the oysters could more readily be determined. Unfortunately the dam was not completed in time to permit the experiment being undertaken in 1940, but it is hoped that during 1941 a definite test can be made. The work will require relatively little expense. Some attention can simultaneously be given to the native oyster life-history.

Clams.

In the clam research a certain amount of attention has been given to the biology of the commercial species, particularly with reference to size and age at maturity, and the spawning season. This knowledge is essential to the understanding of proper stages for commercial exploitation, most suitable time of collecting for the market and desirable periods of protection. The required information is gradually being collected.

Tests were also conducted to determine whether, when clam beds were dug over, the clams below legal size would burrow back into the beach or perish. Experimental plots of "hard" undug, and "soft" dug-over beach were prepared and similar lots of both "butter" and "little neck" clams were placed on them. After 24 hours, the plots were inspected and it was found that most of the clams did burrow back into the sand and gravel within that period. Tests were made for summer and winter conditions and there was some indication that in the summer period when low tides and long exposure coincided with relatively high air and water temperatures, the percentage of clams burrowing back was somewhat lower than in winter. Possibly a higher seasonal mortality resulted during the summer.

The principal aim of the clam investigation, however, was to collect such pertinent information as would be of particular value in setting up proper regulations for the most efficient exploitation without endangering the continuance of the stock. For this purpose a modified system of statistical reports was set up so that in addition to the total quantity of clams dug and the variation in quantity from year to year there might be available a measure of the digging intensity. This digging intensity is represented by the number of man-tides, or, for each beach or area, the number of diggers times the number of low tides. The unit of effort, then, is found for each area by dividing the catch of that area by the number of man-tides. Such statistics are being developed for both commercial species, the "butter" and the "little neck", but those for the former, the species utilized in canning, are most complete, for 1940 representing about 60 per cent of the total catch.

The productivity of clam beaches is a very important phase of the fishery. On it depends largely the extent and method of regulation to be applied. Productivity studies are being conducted on an approved statis-

tical basis, utilizing the Latin Square method of testing and sampling. Such experimental squares have been set up in seven strategic clam areas from near Victoria to Alert bay on the east coast of Vancouver island and will be in service for a period of six years. The experiment is now entering its third year.

Associated with the statistical research are studies of growth rate in relation to season, to locality and to tidal elevation on the beach as well as annual variations in length and age composition of the commercial clam catches. The data from these studies are being prepared for publication.

Mr. Quayle is also carrying forward an investigation commenced in 1939 with respect to the spawning periods, growth rates, etc. of the larvae of the various bivalves present in Ladysmith harbour and Departure bay. The identification, in the plankton, of species of mollusc larvae is proceeding and will form a most valuable contribution.

Hydrographical Investigations

This phase of the work of the Station may perhaps be less obviously of "economic" importance or application than the others. In its initial stages it is essentially a fact-finding undertaking. Once the facts are made known, however, their application in defining movements of water, i.e. the direction and velocity of flow, seasonal changes, etc., and their correlation with distribution, migration, etc. of fish become of definite value.

If, for example, the hydrographic conditions of the Strait of Georgia were known it might be possible to explain why in some years the sock-eye proceed rapidly up the Fraser river when they first approach it, while in other years they linger for long periods in the Strait. It might be possible to indicate why, in certain seasons, trolling for springs and cohos is good, in others not so good. If a better understanding were had of hydrographic conditions off the west coast of Vancouver island some explanation might be given as to the great variation in the pilchard distribution, herring abundance, etc. It may not be too much a stretch of imagination to suppose that the old adage "To be forewarned is to be forearmed" is applicable to the fishing industry. The function of the hydrographical studies is largely that of providing knowledge of the relationship between hydrographic conditions and fish movements to the end that a better understanding may be had of the variations in fish movements and their causes. Forecasting may later result.

In previous years the co-operation of the Royal Canadian Naval Service in providing accommodation on its vessels for the hydrographer or assistant has helped immeasurably in conducting the field research. Occasionally the routine voyages of the vessels have been altered to coincide with the hydrographic program. This assistance has been greatly appreciated and it is unfortunate but quite understandable that, under present war conditions, such co-operative arrangements cannot be maintained.

The general field work has therefore been largely abandoned temporarily. Sufficient data have been collected, however, to keep Mr. Tully fully occupied in analyzing and working up the results and it is anticipated that completed reports will soon be available. As Mr. Tully is

the only chemist on the staff his concentration upon the hydrographic research is too frequently interrupted by other pressing problems. The progress in completing the hydrographic studies is thus considerably delayed. As much time as possibly has been given to working up the data obtained some years ago on the hydrography of the Strait of Georgia, the Strait of Juan de Fuca and approaches thereto, particularly with reference to theoretical considerations of the hydrographic conditions in highly-stratified enclosed and coastal waters. Hydrodynamic calculations and stream diagrams have been prepared for all series of data but the tidal, seasonal and weather dynamic systems, of the area have yet to be analyzed.

One of the important programs of the hydrographic division is the study of the coastal sea water conditions, chiefly temperature and salinity, the changes which occur because of meteorological conditions and the variation from year to year. Since the majority of our fisheries are in coastal waters, the study of hydrographic conditions in such regions may provide very valuable data in the study of the variation in the fishery, fish movements, etc. It might be possible, for example, to explain why young pilchards were present in such abundance in British Columbia waters in 1940.

Such a study obviously requires a continuous series of observations all along the coast. This has been made very conveniently possible, through the co-operation of the Department of Transport, Lighthouse Division, whereby lighthouse keepers at eleven stations, in return for a small remuneration, take daily samples of water and temperature readings. The Meteorological Service of Canada generously co-operates by providing meteorological data. The water samples are titrated in the laboratory for chloride content (salinity) and are correlated with the water temperature and meteorological conditions.

Similar series of observations are being made by the Station staff at Departure bay, for Prince Rupert harbour by the staff of the Fisheries Experimental Station, and by the Department of Fisheries, through Mr. W.A. Bowcott, for the Fraser river. Samples were also taken at William Head Quarantine Station by Captain G. Hansen.

In this way a general picture of the trend of conditions in coastal regions is being obtained and now that the series have been continued for a considerable period of years it will be possible to issue a general report on the situation and trace, by comparison, the annual changes in future years. This study shows every promise of being exceedingly valuable as the years pass in its association with fisheries investigations.

Within the past year another problem having hydrographic implications has arisen, namely the proposed construction of a sulphite pulp mill at Port Alberni at the head of Alberni Canal. The canal and outside waters of Barkley sound support a fairly valuable commercial fishery, chiefly salmon and herring. A flourishing sport fishery is also maintained in the inlet. The question arose as to the possible effects upon these fisheries of the discharge of quantities of waste sulphite liquor into the waters of the area, in other words, whether a state of pollution might not arise. The matter was investigated by the Department of Fisheries, through the Fisheries Research Board, and Bloedel, Stewart and Welch Ltd., the operators of the proposed pulp mill. A study was made of the present conditions of the inlet, water movements, tidal conditions, etc., and a working model constructed to check more accurately upon tidal action, land drainage, wind and density gradients of the water. From this study and the perusal of pertinent literature, it was found that serious pollutions probably would not result (1) if the effluent from the mill was greatly

diluted and impounded for a time before entering the head of the inlet, (2) if rapid and complete mixing occurred with all the water in the head of the inlet, or (3) if the effluent were piped seaward from the inlet head and discharged near shore.

However the situation is one in which absolute certainty of predictions cannot be assured. It has been agreed, therefore, that a further hydrographic survey should be made of Alberni inlet for a period of one year prior to the operation of the pulp mill, in order to understand fully the present conditions at all times of year and under all conditions of weather, tide, river flow, etc. and for one year or more after the mill has been in operation, in order to note the effect of the sulphite effluent upon the waters of the inlet and, if a critical situation should arise, indicate a feasible remedy.

Accordingly a comprehensive hydrographic program has been drawn up to provide all the essential data. It has been critically reviewed many times to cut out non-essentials, reduce sampling procedures, etc. in order that a minimum amount of effort and expense will be involved, yet effectively collect the pertinent information. Mr. Tully has prepared a very thorough and detailed plan of procedure, has introduced and tested many labour-saving techniques and will have general direction of the survey. Bloedel, Stewart and Welch Ltd., are contributing financially to the undertaking.

Fish Diseases

Furunculosis.

The investigation of furunculosis, a bacterial disease of fishes produced by infection with Bacterium salmonicida, has been carried on by Dr. Duff at the Stanley Park hatchery, Vancouver, and the Department of Bacteriology, University of British Columbia, for some years. The purpose has been to study the cause, progress of the infection, control and possible cure in natural as well as hatchery waters.

While the experimental work has been confined largely to trout, the incidence of the disease is by no means so restricted. It is known to attack the Atlantic salmon (Great Britain), it has on occasion affected Pacific salmon reared in hatchery ponds (Cultus and Cowichan) and it is frequently met with in the rearing of both Atlantic and Pacific trouts. Much work has been done in Great Britain where the disease has been found attacking Atlantic salmon in natural waters and it may at some time be of concern in Eastern Canada. Thus the importance of any findings is by no means restricted to British Columbia nor to game fish only.

During the present year the experimental work has progressed most satisfactorily and Dr. Duff reports the production of an oral vaccine which shows most promising results. Preliminary tests have shown that the feeding of this vaccine along with the regular food has definitely reduced mortality among infected trout from 75.3% in the controls to 24.3% in the vaccinated group. It is felt that with improvement in the preparation of the vaccine and in its administration, much greater success can be achieved. The method is by no means costly and may be readily incorporated into hatchery technique.

Other Investigations

Continued taxonomic studies of marine polychaete worms were made by Mr. and Mrs. C. Berkeley. Collections from Southern California have been examined and a report prepared. Attention is now being given to material collected on the west coast of Vancouver island in 1935.

Studies of the economic relations of waterfowl were continued by Mr. Munro, Chief Migratory Bird Conservation Officer for British Columbia. Mr. Munro spent the winter months at the Station collecting specimens of local waterfowl and analyzing the material so obtained, as well as that sent in from other coast areas or collected in other parts of the Province.

During the summer Mr. G.E. MacGinitie, Director of the William G. Kerckhoff Marine Laboratory at Corona del Mar, California, and Dr. B.R. Coonfield, Brooklyn College, N.Y., visited the Station. The former investigated the ecology of mud flats, with particular reference to the occurrence of commensal forms, while the latter studied regeneration in Ctenophores and pigmentation in embryonic and larval stages of marine fishes.

EDUCATIONAL ACTIVITIES

During the year members of the staff addressed a number of meetings of various organizations in Vancouver and on Vancouver island. Fisheries problems or the work of the Station were the subjects. An exhibit from the Station was displayed at the Nanaimo Fall Fair and proved very popular. Much favourable comment was received.

PUBLICATIONS

The regular series of quarterly Progress Reports was issued during the year, under the editorship of Dr. Carter. The staff contributed twelve articles, three per issue. Some of these were later reproduced in fisheries journals, Western Fisheries, Commercial Fishermen's Weekly, etc.

A list of the publications, based upon the results of investigations, appearing during 1940 is given below. Those reports, completed and submitted for publication, are also listed.

PUBLICATIONS DURING 1940

- Boughton, R.V. Laredo herring. Prog. Repts. Pac., No. 45, Sept.
- Cameron, W.M. The efficiency of fertilization in the natural spawning of Pacific salmon. Prog. Repts. Pac., No. 45, Sept. (See also under Pritchard, A.L.).
- Carl, G.C. Some ecological conditions in a brackish lagoon. Ecology, Vol. 21, No. 1, pp. 65-74.
- A closed water system for a hatchery. Prog. Fish-Culturist, Mem. 1-131, No. 47, pp. 20-24, November-December.
- The distribution of some Cladocera and free-living Copepoda in British Columbia. Ecol. Mono. Vol. 10, No. 1, pp. 55-110. January.
- Marked Fish. Angler and Hunter, Vol. 5, No. 5, pp. 10-11, May.
- Comparison of coho salmon fry from eggs incubated in gravel and in hatchery baskets. Trans. Amer. Fish. Soc. Vol. 69, pp. 132-134.
- Duff, D.C.B., M.I. MacArthur and H.G. Thompson. Observations on the viability of Bacterium salmonicida. J. Fish. Res. Bd. Can., Vol. 5, No. 1, pp. 1-7.
- Foerster, R.E. and J.P. Tully. The mortality of salmon in Cowichan bay, 1940. Prog. Repts. Pac., No. 46, December.
- Gwyn, A.M. The development of the vertebral column of the Pacific herring (Clupea pallasii). J. Fish. Res. Bd. Can., Vol. 5, No. 1, pp. 11-22.
- Hart, J.F.L. Reptant Decapod crustacea of the west coasts of Vancouver and Queen Charlotte islands, British Columbia. Can. Journ. Res., Vol. 18, No. 3, pp. 86-105.
- Hart, J.L. Growth in Ling Cod. Prog. Repts. Pac. No. 44, June.
- Tagging British Columbia pilchards (Sardinops caerulea Girard): Insertions and recoveries during 1939-40. Rept. B.C. Comm. Fish. for 1939.
- Hart, J.L. and A.L. Tester. The tagging of herring (Clupea pallasii) in British Columbia: Insertions and recoveries during 1939-40. Rept. B.C. Comm. Fish. for 1939.

- Hart, J.L. and A.L. Tester. The return of herring tags during the 1939-40 season. Prog. Repts. Pac. No. 45, September
- Hart, J.L., A.L. Tester, D. Beall and J.P. Tully. Proximate analysis of British Columbia herring in relation to season and condition factor. J. Fish. Res. Bd. Can., Vol. 4, No. 5, pp. 478-490.
- McHugh, J.L. Growth of young herring in Departure bay in 1939. Prog. Repts. Pac. No. 43, March.
- Where does the eulachon spawn? Prog. Repts. Pac. No. 44, June.
- Food of the Rocky Mountain whitefish, Prosopium williamsoni (Girard). J. Fish. Res. Bd. Can. Vol. 5, No. 2, pp. 131-137.
- Mottley, C. McC. The production of Rainbow trout at Paul lake, British Columbia. Trans. Amer. Fish. Soc. Vol. 69, pp. 187-191.
- Neave, Ferris. On the histology and regeneration of the Teleost scale. Quart. Journ. Micro. Sci., Vol. 51, pt. IV, January.
- The steelhead in the Cowichan river. Prog. Repts. Pac. No. 46, December.
- Pritchard, A.L. A study of the natural propagation of the pink salmon, Oncorhynchus gorbuscha, in British Columbia. Trans. Amer. Fish. Soc., Vol. 69, pp. 237-239.
- The age of spring salmon in the commercial catches in British Columbia. Prog. Repts. Pac. No. 44, June.
- Blueback salmon. Angler and Hunter, Vol. 5, No. 10, October.
- Studies on the age of the coho salmon (Oncorhynchus kisutch) and of the spring salmon (Oncorhynchus tshawytscha) in British Columbia. Trans. Roy. Soc. Can. Sec. V.
- Pritchard, A.L. and W.M. Cameron. Observations on the sockeye salmon run at Lakelse lake (Skeena river) in the year 1939. Prog. Rept. Pac. No. 43, March.
- Quayle, D.B. Japanese oyster propagation. Prog. Rept. Pac. No. 43, March.
- A preliminary report on the British Columbia clam investigation. Rept. B.C. Comm. Fish. for 1939.
- How to identify some common British Columbia clams. Prog. Repts. Pac. No. 46, December.

Ricker, W.E. Relation of "catch per unit of effort" to abundance and rate of exploitation. J. Fish. Res. Bd. Can. Vol. 5, No. 1, pp. 43-70.

On the origin of Kokanee, a fresh-water type of sockeye salmon. Trans. Roy. Soc. Can. Sec. V.

Tester, A.L. A specific gravity method for determining fatness (condition) in herring (Clupea pallasii). J. Fish. Res. Bd. Can. Vol. 4, No. 5, pp. 461-471.

(See also under Hart, J.L., two papers; also under Hart, J.L., D. Beall and J.P. Tully).

Tully, J.P. See under Foerster, R.E.; also under Hart, J.L., A.L. Tester and D. Beall.

PAPERS SUBMITTED FOR PUBLICATION

Berkeley, E. and C. On a collection of Polychaeta from Southern California. (Submitted to Southern California Academy of Sciences).

Foerster, R.E. and W.E. Ricker. The effect of reduction of predaceous fish populations upon the survival of young sockeye salmon (Oncorhynchus nerka) at Cultus lake, British Columbia. (Submitted to J. Fish. Res. Board).

Mottley, C. McC. The effect of increasing the stock in a lake on the size and condition of Rainbow trout. (Submitted to Amer. Fisher. Soc. 1940 meeting).

The covariance method of comparing the head-lengths of trout from different environments. (Submitted to Amer. Soc. Ichy. and Herp., 1940 meeting).

Mottley, C. McC. and D.R. Embury. An efficient sampling method for taking a creel census. (Submitted to J. Fish. Res. Bd.).

Mottley, C. McC. and Jean C. Mottley. The effect on the food supply of increasing the stock of Rainbow trout in a lake. (Submitted to Ecological Society, 1940 meeting).

Ricker, W.E. The consumption of young sockeye salmon by predaceous fish. (Submitted to J. Fish. Res. Bd.).

Tester, A.L. A modified scale projector. (Submitted to Amer. Fish. Soc. 1940 meeting).

Wailles, G.H. Protozoa, Part III. (Submitted to Fisheries Research Board).

SCIENTIFIC STAFF OF PACIFIC BIOLOGICAL STATION

W.A. Clemens, M.A., Ph.D., F.R.S.C., Director (to July 31).
R.E. Foerster, M.A., Ph.D., F.R.S.C., Director (from August 1).
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.
G.C. Carl, M.A., Ph.D., Scientific Assistant in Biology (resigned September 30).
R.V. Boughton, M.A., Ph.D., Scientific Assistant in Biology.
D.B. Quayle, M.A., Scientific Assistant in Biology.
J.L. McHugh, M.A., Scientific Assistant in Biology.
W.M. Cameron, M.A., Scientific Assistant in Biology.

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

TEMPORARY

Research Assistant: C. Idyll, M.A. (Cowichan river investigation).

VOLUNTARY INVESTIGATORS

Mrs. Edith Berkeley, C. Berkeley, Mrs. G.C. Carl, Ph.D., J.A. Munro, G.E. MacGinitie (Director, William G. Kerckhoff Marine Laboratory, California Institute of Technology), B.R. Coonfield, Ph.D. (Brooklyn College, N.Y.).