CONFIDENTIAL

FISHERIES RESEARCH BOARD OF CANADA

ANNUAL REPORT

FOR

1951

OF THE

PACIFIC BIOLOGICAL STATION

[redacted]

(With [illegible] Appendices)

NANAIMO, B.C.

December, 1951

INDEX TO SUMMARY REPORTS FOR 1951

FISHERIES RESEARCH BOARD OF CANADA

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

The research program of the Pacific Biological Station is planned to provide basic scientific information for the effective administration of fisheries. The greatest effort is devoted to studies on the commercially-important five species of salmon. Their fresh-water spawning areas are in especial danger from human interference, or alternatively, might be substantially improved by well-advised modifications. Other important fisheries are the subjects of more general investigations. A study of the sea as an habitat for fish has been an important part of the program with many and various practical applications.

REVIEW OF INVESTIGATIONS

SALMON

In order to maintain and perpetuate the stocks of each of the five species of Pacific salmon it is necessary: (1) that there be an adequate seeding of eggs each year, and (2) that there be a satisfactory production from that seeding. The principles of management involved are virtually, therefore, the same as in any system of crop management. As in wheat-growing, where the abundance of the crop depends primarily on the amount of seed sown, the character of the soil to develop the young plants and the vagaries of climate and weather to produce the harvest, so in salmon production the size of the population produced depends on the extent of the seed (eggs) deposited in the streams, the conditions in the streams during incubation of eggs and hatch of fry, and the factors affecting the well-being of the young fish during their period of residence in the nursery areas (streams and lakes) and during their sojourn in the ocean.

Furthermore, just as an advance assessment of the crop yield is of value to the farmer, to industry, and to government in estimating the labour and machinery needs for harvesting, in arranging market requirements, etc., so in the salmon fisheries a reliable system of predicting the size of the runs available to the fishery each year can be of great value - to Industry to exploit effectively and to the Department to regulate appropriately.

Within recent years all of the five species of Pacific salmon have been exploited intensively by the commercial fishery. Some of the species - the spring and the coho - suffer additional drain from sport fishing which is rapidly increasing in extent and importance in certain sections of the coast. There is evidence that exploitation is reaching a maximum for the coast and in some areas apparent declines in abundance are of concern. Whether these indicate a state of depletion due to overfishing or whether they are the result of lowered productivity is being investigated. In the case of overfishing, the immediate remedy is an increase in the spawning escapement. If the cause be a lower rate of productivity, the factors responsible must be discovered and rehabilitative measures explored and tested.

Objectives of salmon research

The efforts of the Pacific salmon investigation are directed, therefore, to obtaining and providing to the Department of Fisheries, information on: (1) salmon migrations, and (2) fishing intensities, both of which will aid the field officers in knowing where specific runs of salmon are being tapped by the commercial fishery, the extent of the catch and where and to what degree regulations to provide an adequate spawning escapement or seeding must be applied, and on (3) the results of natural propagation under varying prevailing environmental conditions and (4) aids to increasing natural production, in order to be able to assess and improve productivity from the seedings that occur. A further objective is to investigate and develop useful methods of estimating the extent of young salmon production in order to predict the likely size of the adult salmon runs as they return from the ocean.

Program

For useful prediction there must be established a relation between abundance of adult salmon and either (a) the observable external factors (e.g., climatic, meteorological or hydrographic) which affect the production of salmon, or (b) the numbers of fish observed or estimated at some stage prior to their entrance into the fishery (e.g., as seaward migrating fry or smolts).

For regulation of the salmon fisheries to ensure an adequate spawning escapement or seeding, there must be available migration patterns for the many runs of salmon coming in from the ocean in order to show by what coastal channels the fish approach their spawning streams and where they are taken by the fishing gear. There must be available, also, an assessment of the fishing drain in each area in order that the total "take" by the fishery from each run or population may be computed and a satisfactory ratio between the catch and the spawning escapement established. As fishing operations spread out further and further from the river estuaries and more fishing is done in the coastal passages through which the salmon move, it becomes more and more difficult to set up a desirable catch to escapement ratio in the immediate vicinity of the rivers or streams. Regulation of catch to provide an adequate escapement of salmon to the spawning grounds may have to be applied, consequently, in outside areas as well, i.e., along the migration routes. The information on migration patterns is being obtained by tagging of the adult salmon as they come in from the sea and by marking of the young fish in the streams as they proceed seaward. Data on fishing intensity are obtained from tagging experiments and from the fisheries statistics now being collected by the Department.

For management and increase of salmon stocks, ways and means must be found for reducing natural mortality, so that the losses caused by the fishery can be made good. To some extent Nature herself undertakes to balance the books since a smaller population frequently reproduces itself more efficiently than a larger one. A main problem of conservation is to keep the population at a size which allows the greatest number of fish to be caught without reducing the future supply. However, close control of the size of salmon runs, in the face of varying climatic conditions and fishing intensity, is not feasible at the present time. Attention is therefore directed to understanding the natural processes which cause variations in abundance and assisting those which tend to produce larger quantities of adult salmon.

In specific instances a particular factor (e.g., a stream obstruction or the prosecution of a fishery to the point of near-extinction of a spawning escapement) may be sufficiently obvious to demand immediate remedy. The general problem, however, of obtaining the maximum yield from a spawning stock of salmon demands a thorough knowledge of the extent and causes of losses sustained throughout the life history. Where environmental conditions causing heavy mortality can be corrected or improved, and where artificial aids can be effectively introduced, they should be defined and tested.

The general approach adopted by the current investigations therefore has been to seek quantitative information on the mortality associated with different periods of the life cycle and to compare the survival at each stage with the final abundance of adult fish. At the same time the various factors causing mortality of eggs, fry, seaward-migrating smolts, etc., are being ascertained and corrective measures are being studied. Moreover the feasibility of introducing certain measures of artificial propagation to avoid otherwise natural loss is being investigated.

The results of the work conducted during 1951 to achieve the above ends are given below for each species being studied.

Sockeye salmon

Conditions of the fishery. Fishing for sockeye salmon is confined largely to the estuary areas of the larger river systems of the coast, the Nass, the Skeena, Rivers Inlet, Smith Inlet, and the Fraser, although in recent years there has been a tendency for the fishermen to operate further and further from the river mouth. Commercially-important runs to smaller streams along the coast also occur.

For the Skeena area, catches of this species have shown a declining trend for many years. The average commercial sockeye pack for the 10-year period 1940-49 is approximately 60% of that of the average for the decade 1910-19. Marked fluctuations in the runs from year to year continue to occur. For the Nass the 1940-49 average pack represented less than one-half of that of 1910-19 whereas for Rivers Inlet the overall decline has been much less marked and very large packs are still made in certain years. In the Vancouver Island district, where small but commercially-exploitable runs occur, the catches during the last 8 years have on average been well below those of the previous two decades.

In 1950 the catches reported from the Nass, Rivers Inlet, and Smith Inlet were excellent, even by former standards, but the Skeena River pack was below even the recent average. For 1951 the packs were again excellent, except for the Skeena which, although about one-third greater than in 1950, was still below average.

Types of investigations. In the case of the sockeye salmon, the young of which remain in lakes for one or two years before migrating to sea, the primary phases requiring study and assessment are: (a) the adult escapement to the spawning grounds, or the seeding, (b) the production of fry migrants in the streams, (c) the production of smolt migrants in the lakes, and (d) the proportion of the sockeye population returning from the sea which is taken by the commercial fishery.

Under the present program, investigations are conducted at three localities - at Port John (a coastal area), at Lakelse Lake (on the lower Skeena River), and at Babine Lake (a tributary of the upper Skeena). Each area represents a climatically different type of environment. By carrying on the studies in these three areas, a greater range of conditions is presented for overall observation of production. At the same time the particular problems for each climatic area can be assessed and tackled.

Spawning escapements or seeding. The first requirement is the determination of the annual variations in the size of the adult escapement, i.e., the amount of the seeding or egg deposition. These escapements provide the starting point from which the reproductive success of cycles can be measured. They afford opportunities for relating changes in abundance to environmental conditions, fishing intensity or other factors. For 1951 the adult escapements to the three areas, as represented by sockeye passing the counting weirs, were: Port John - 1,047, a fair run; Lakelse - 5,800, a relatively poor run though almost twice that of the previous year; Babine - approximately 155,000, a very low escapement to the extensive spawning areas of Babine Lake, the small numbers being the result of the rock-slide blockade in the lower Babine River in early summer. Computations of the potential seeding in each of the three areas will depend on the numbers of female fish in each run and the egg content per female, records which are not yet available.

Natural propagation. Success of reproduction up to the time the fry leave the streams and drop down to the adjacent lakes is being measured at the three above-named localities. For Port John it has varied from 1.75% to 25.26% in three seasons. In two tests at Lakelse Lake (in Scully Creek, a tributary sockeye spawning stream), records of 13.7% and 9.4% have been obtained. For the Babine area (in Six-Mile Creek) a 12% fry production was estimated, the estimate subject to considerable possible error because of operational difficulties caused by an extraordinarily heavy spring flood. The wide variation in these fry production figures indicates the potential importance of the stream environment in affecting the survival of the eggs and young fish during the period of incubation and hatch. Studies at Scully Creek and Six-Mile Creek show that there is considerable loss (10% to 40%) in the redds during incubation and hatch and, further, that heavy mortality of fry (65% to 90%) can be attributed to predation taking place during the brief period of fry migration to the lake.

These factors, as well as others associated with the early stream phase of the life cycle, are much more susceptible to practical remedial action than are losses occurring during later stages. Possible remedial measures are being studied. Nevertheless investigation of losses during later stages is necessary since they may tend to dominate or counteract the variations apparent in earlier stages.

Smolt production. Comparisons of sockeye smolt production based on the fry escapement to the lake are being made at Port John where the bulk of the sockeye spawning occurs in a single tributary stream and the fry migrating from it represent the major part of the new sockeye population in the lake. Only one determination is yet available. It indicates a survival during the period of lake residence of not less than 20%. This figure is higher than has been found elsewhere, and may be related to the presence of few predators in the lake.

At Lakelse Lake a counting weir for the enumeration of seaward-migrating sockeye smolts has now been completed, and will be operated in the spring of 1952. At Babine Lake, where the size of the outlet river and the volume of water carried by it make a fixed counting structure impractical, a method of estimating the numbers of smolts by sampling the outgoing fish has been put into operation with a considerable degree of success. It will thus be possible another year to determine for each of these two important sockeye-producing areas the per cent output of seaward-migrating smolts from a known spawning escapement and a known seeding. For the Babine area in particular, the continuance and improvements of smolt production

estimates will be of especial value in assessing the damage to the stock which may have resulted from this year's low escapement due to the Babine River obstruction.

Ratio of commercial catch to escapement. Data concerning the proportion of returning adults which is taken by the commercial fishery have been obtained for the Babine and Lakelse runs. At Babine, migrating smolts were marked during the seasons of 1944 to 1948 inclusive and at Lakelse from 1945 to 1948 inclusive. The present year's recoveries represent the final major return which can be expected from the 1948 marking operations. Marked fish are recovered: (a) by examination of the commercial catch by observers stationed at the Skeena River canneries, and (b) by examination of the escapement at the Babine and Lakelse counting fences. The two sets of figures can then be compared. The ratio between catch and escapement in 1949 was about 50-50 in both cases. In 1950 a greater fishing intensity was indicated, with the commercial catch accounting for 60% of the marked Babine fish and 75% of the marked Lakelse fish. The 1951 figures are not yet complete. Those pertaining to the Babine Lake run will be of limited value, unfortunately, because of the loss of an unknown number of marked fish in the Babine River below the rock-slide obstruction.

Environmental conditions. Obviously the mere recording of variations in the number of young or adult fish from year to year is of very limited usefulness unless records of the accompanying environmental conditions are kept. Reference has been made to one of these conditions, namely, predation on fry migrants, but other biological factors such as the physical conditions in streams (e.g., water levels, current velocity, temperature), and the available food supplies of lakes are involved in the success or failure in young sockeye production. Observations on the flow and temperature of sockeye-producing streams are made at all field stations during the periods of spawning and fry migration and facilities are now available to get year-round records by means of constant-recording thermographs and water-level gauges.

Lake conditions which are encountered by young sockeye during their year's residence and the influence of these factors on the well-being and survival of the young fish are being studied, particularly at Lakelse Lake. Physical and chemical changes in the environment are recorded throughout the year and studies are made of the quality and quantity of the plankton - the microscopic food on which young sockeye subsist. A special column net for the collection of zooplankton has been devised. Attention is also being given to the sources of the essential chemical substances - phosphates, nitrates, silicates - which control, in large degree, the abundance of phytoplankton and zooplankton. The relation of these basic substances to the abundance of plankton will be important if and when organic fertilization of lake waters warrants consideration as a means of restoring or increasing production of sockeye.

In order to relate limnological conditions to the production of young salmon it is necessary to have information on the habits and responses of the latter. Hitherto it has proved extremely difficult to catch young sockeye during the period of lake residence. Hence their distribution, and the proportion of the lake's recoveries which are available to them, remain largely unknown. A start on this problem has been made by confining young sockeye in a vertical column, sections of which can be closed off. The sockeye are allowed to seek their own level in the column and are then trapped there. The conditions of temperature, food organisms, etc., prevailing at the preferred depth are then recorded.

Predation and competition. The relation of populations of fish which prey upon young sockeye or compete with them for food is being investigated also at Lakelse Lake. This requires that each species be studied in all aspects - propagation, rate of growth, food habits and preferences, etc. A special study is being made of the trout populations to determine the relation of trout abundance to young sockeye survival. It is recognized that trout, even if an important predator of salmon, cannot be eliminated in salmon waters but creel census records of angling are being taken to show the annual catch and the extent to which angling may control the numbers of large trout. Age and rate-of-growth material are being collected for study.

Sampling of the commercial fishery. In addition to the experiments and observations conducted at field stations, as outlined above, the sampling of the commercial catch in respect to sex, size, weight, and age has been continued for the sockeye runs to the Skeena, Nass, Rivers Inlet, and Smith Inlet. With the exception of the Smith Inlet area, these samplings have been carried out over a great many years - since 1915 - by various investigators and a valuable body of information is available. The data show the varying composition of the landings as selected by the gill-net fisheries and when related to the spawning-ground escapement records as obtained by Department of Fisheries inspectors, are of value in computing total production from the brood-year seedings. To a limited degree they are useful for forecasting the size of cycle runs. They provide a useful back-log of information which will be essential to future conservation.

Pink and chum salmon

Condition of the fishery. Pink salmon stocks in the Skeena and northern Queen Charlotte Islands areas have been at a generally low level (as compared with previous abundance) for about 20 years. The decline appears to be mainly associated with conditions or events in certain specific years rather then representing a continual tendency. In the central region a generally high level has been maintained in annual catches, although fluctuations of some magnitude are not infrequent. Whereas in earlier years the even-year runs were much greater than those of the odd-year, at the present time the catches in each are of the same order of magnitude in both the Skeena and the central districts. In the Fraser and Vancouver Island districts, where the odd-year runs are dominant, there is also no evidence of a long-term decline in annual catches.

Chum salmon catch statistics are not considered adequate to provide a clear record regarding long-term trends. There is, however, considerable irregularity in annual catches, with low levels of abundance occurring in certain years. These fluctuations are believed to be due in considerable degree to the varying physical conditions on the spawning grounds. There appears to have been a long-term decline in the size of escapements in the Vancouver Island district.

Types of investigation. The ultimate objectives of investigations on these species are the same as those which govern the program for sockeye. The steps taken to achieve these ends are necessarily modified, however, by the considerations that: (a) the fresh-water habitats and commercial fisheries of pink and chum salmon are distributed over most of the British Columbia coast instead of being localized in a few important centres, (b) the relative shortness of the period of the life history which is spent in fresh water (to the fry migrant stage only) eliminates certain problems which are important in relation to the

maintenance of sockeye runs, and (c) these salmon for the most part frequent short coastal streams or the lower tributaries of large river systems where water-flow conditions fluctuate greatly, stream conditions are much less stable and success of natural production can vary exceedingly, depending upon environmental conditions.

Since it is not practical in general to distinguish in their marine habitats the populations which have originated in, or which are proceeding towards, individual stream or river systems (many hundreds of which are frequented by these species), the investigation has sought to compile and interpret data on the trends and fluctuations of the catches and escapements of large geographical areas, each of which may contain many individual salmon streams. A comparison between such data and available local records of rainfall and stream flow has led in certain instances to the establishment of a relation between physical conditions at the time of spawning or incubation and the subsequent abundance of adult fish. Such relationships provide a potential basis for the prediction of runs and also demonstrate the importance of the fresh-water phases in determining adult population levels. They therefore provide general evidence that measures taken to increase the survival of the fresh-water phases will, on average, increase the numbers of adult fish.

The requirements for successful reproduction in fresh water are being investigated at two field stations located at Nile Creek, Vancouver Island, and Hooknose Creek (Port John) on King Island, central coast area.

These detailed investigations are for the purpose of determining principles and procedures which can be applied for the conservation of pink and chum salmon generally. They comprise:

Efficiency of natural propagation. This entails the counting of the number of fry escaping to sea from egg depositions of known magnitude; numbers of adults returning from known fry escapements; determination of the fresh-water efficiency required to maintain the stock and the fishery; determination of the variation in reproductive success from year to year.

In so far as the experimental stream can be considered representative of a district or of a widely distributed type of watercourse, the output of fry in a given year will indicate prospects for a large or small return of adults in appropriate areas. In conjunction with studies described below, the measurement of the efficiency of natural propagation indicates the principles on which remedial action should be based and the level of efficiency which should be attained for satisfactory maintenance of the fishery.

In the central region of the British Columbia coast, it is now believed that an average fresh-water efficiency of about 6% for pinks and slightly less for chums is required for maintenance of the spawning stock and the fishery on the existing scale. The recorded efficiency at Hooknose Creek in three previous seasons has varied from about 1% to 8% for both species. In 1950-51, the efficiency showed a remarkable rise to 15%, giving a most favourable outlook for the resulting adult runs.

At Nile Creek, where a generally low efficiency had been observed for five years (for chums), the counting of this year's fry run had to be abandoned because of the destruction of the counting weir by flood.

Factors influencing reproductive efficiency in fresh water. Concurrently with the recording of adults and fry migrants, observations are maintained on stream levels and temperatures to determine general relationships between these factors and reproductive success.

At Nile Creek a special study has been made of the conditions existing in spawning beds with respect to the water flow and oxygen requirements of developing salmon eggs and alevins.

The nature and extent of losses incurred in fresh water, and the periods in which they take effect, are further investigated by the sampling of redds during the interval between egg deposition and emergence of the free-swimming fry.

The effect of predation during the brief period of seaward migration is recognized as a major factor in reducing the final output of young fish from fresh water. Experiments utilizing marked fry have indicated losses of from 21% to 92% at Nile Creek and from 30% to 85% at Hooknose Creek during migration over short distances.

The purpose of these various observations and experiments has been not merely to catalogue the effects of various factors (which may vary widely in different streams), but to determine optimum or favourable conditions of general applicability, departures from which can be recognized in specific instances and the attainment of which can be aimed at when opportunity or necessity arises.

Experimental modification of conditions to produce greater output. At Nile Creek during the last five years the effects of protecting eggs from certain causes of mortality have been investigated. The experiments have involved: (a) the planting of newly-fertilized eggs in a portion of the stream in which water flow is controlled, thereby eliminating the effects of flood and drouth, and (b) the incubation of eggs to a late stage under artificial conditions, with subsequent planting on spawning grounds with a natural (uncontrolled) water supply.

In spite of certain difficulties and set-backs which have been technical or accidental rather than fundamental in nature, both methods have in general shown a considerably improved output (3.4%-13.5%; 0.78%-10.6%) of migrants in comparison with the results of natural propagation (0.08%-6.03%) in the same years. The aim throughout has been to test procedures which would not be too complicated or costly to apply on a considerably larger scale as a definite form of conservation. Experiments at Nile Creek have been strictly limited in scope by the restrictions of available area, by the small number of fish in recent years, and by the necessity for utilizing part of the stream and some of the available fish as natural "controls" for the experimental procedures.

In the summer of 1951, further modification of conditions has been initiated by the introduction and stabilization of gravel in portions of the main stream, to compensate for the destruction of former spawning grounds by flood. Logs have been "dug into" the stream beds in certain locations to prevent the shifting of the gravel by flood waters and to provide sizable areas for effective natural spawning. The effectiveness of this procedure will be observed during the forthcoming season.

As a result of the findings obtained at the two field stations during their several years' operation, together with catch and escapement records and evidence available from other sources, certain general conclusions have been formulated with respect to the factors influencing the abundance of pink and chum salmon and the procedures which might be applied to their conservation. At the present stage of investigations the following findings or working hypotheses appear to provide a logical basis for future work:

1. Losses attending the fresh-water stages of the life cycle are largely independent of ocean mortality, hence reduction of such losses will, on average, produce larger runs.

2. Survival in fresh water has been recorded as varying from 0.89% to 23.8% in pinks and from 0.08% to 15% in chums. Natural survival in the ocean (at least in certain areas) is believed to average in the neighbourhood of 5% from the advent of the fry up to the time of the adult fishery. This fishery, under intermediate conditions of fishing intensity, probably takes about 60% of the maturing pinks and 40 or 50% of the chums. Under such conditions an average reproductive efficiency in fresh water of about 6% for pinks or 4% for chums is required to maintain the spawning stock. To be effective, stream improvement measures should promote an efficiency considerably exceeding these figures.

3. Much of the loss suffered during the fresh-water phases (and the resulting variations in abundance of adult fish) can be related to water levels prevailing at the time when the adult fish enter the streams or during the subsequent stages of spawning and incubation. Annual variations in water conditions may completely obscure the effect of the size of the escapement in determining the size of the returning run, thereby making the determination of a proper escapement a matter of great difficulty. The current (September, 1951) low water levels which are evident in many British Columbia coastal streams can be expected to have an adverse effect on the pink salmon runs of certain areas in 1953. General correlation between stream flow and subsequent catches of large areas, as well as the more precise small-scale experiments at Nile Creek, indicate that production of young fish can be increased by a degree of control over the water supply of spawning streams.

4. Predation during the period of fry migration is commonly a major source of mortality but in general acts with greater severity on small fry populations than on large ones. Hence it tends to hold runs at a low level even when the initial reduction is due to other causes.

It is believed that with these general conclusions as a guide, plus the practical experience gained at Nile Creek, a relatively large-scale attempt could usefully be made in another locality to promote a large output of seagoing fry.

Tagging of pinks and chums. In addition to the general problems to which reference has been made, a special tagging program was carried out in 1950, at the request of the Department of Fisheries, on migrating chum salmon in the Johnstone Strait area. On the basis of tags recovered, about 11% of the fish entering the northern end of the Johnstone Strait region were caught in the upper portion of the strait (Statistical Area 12), a further 11% in the lower part of the strait (Area 13), and 15% in other fishing areas to the south. The latter figure includes 7% from the Fraser River area. Since tag returns provide only minimum figures for number of fish caught, it is considered that the total catch constituted not less than 50% of the run.

Spring and coho salmon

Condition of the fishery. In the last 10 years the number of trolling licences issued in British Columbia has almost doubled to approximately 5,000 yet there has not been any marked increase in the number of fish caught. The average catch is approximately 10 million pounds of spring salmon and 20 million pounds of coho salmon. The majority are taken by trolling (spring 70% and coho 60%) but in certain areas many spring salmon are taken by gill-nets and coho salmon by purse seines. The industry has expressed general concern for the conservation of these two species of salmon. Similar concern for the offshore fisheries of the United States prompted the formation of the Pacific Fisheries Marine Commission in 1947 to co-ordinate the utilization and protection of the fisheries off the coasts of Washington, Oregon, and California.

During the last 20 years little research has been done on these two species, except at Cowichan River, with the result that the present condition of these populations is not accurately known. From early tagging experiments and age studies (1925-30) it was found that the adult spring salmon migrated long distances in a southeasterly direction and that many Columbia River fish were caught off the British Columbia coast. The coho salmon migrated shorter distances in all directions and the populations were more local. The majority of the spring salmon were in their fourth or fifth year of age and the coho salmon were caught in their third year.

Commencing in 1949 these studies are being repeated under present fishing conditions and the following preliminary results may be stated. The fishing is much more intense and extends farther offshore than it did formerly. The ages and weights of the spring salmon caught now are much smaller (mostly in their third year); fewer (25%) tagged fish are returned from American waters than formerly (75%). Coho salmon of all sizes are being fished more intensively by both trollers and purse seiners. In recent years the sport fisheries in the Strait of Georgia have increased their catch to approximately 5% of the total commercial catch. The overall result has been that now many immature fish of small size are taken whereas previously the fish were taken at a larger size in a more mature state. This has produced a demand for regulations pertaining to the offshore capture of immature salmon of both species, particularly in the feeding area of Barkley Sound on the west coast of Vancouver Island.

Tagging and sampling. During the past year a mass of back data has been assembled on the commercial and sport fisheries, on tagging experiments and age studies, and on spawning escapements. Tagging experiments were conducted off the west coast of Vancouver Island in 1949 and 1950. In 1951, fish were tagged at the northern and southern ends of Vancouver Island and off the northern end of Queen Charlotte Islands. In addition to sampling the catches in the above areas for age and size compositions, the blueback (coho) fishery of the Strait of Georgia was sampled in 1950. In 1951, fish landed at Vancouver were sampled during the summer months. Next year it is planned to sample approximately 10% of the landings at Vancouver, Victoria, and Prince Rupert (1) to assure adequate recovery of marked fish from the extensive fin-clipping experiments conducted in many American streams, and (2) to determine the size and age of fish caught in each area of our fishery. Since sufficient data on length, weight, and age have now been obtained to supply conversion factors for discussions concerning regulations on minimum size of fish, only fork length and a subsampling for age will be necessary in 1952.

Catch statistics. In the past it has been impossible to determine accurately the catch of spring and coho salmon due to the large number handled in a fresh or frozen state. Consequently the trend in the catches cannot be evaluated with assurance. With the general introduction of the multiple sales slip system by the Department of Fisheries this year, the first adequate catch records for these two species will be available by area and by week. The data to September 1 indicate that the spring catch this season has been poor and that the coho salmon catch has been good, particularly off the northern part of Vancouver Island. The distribution of white spring salmon along the mainland coast indicates that they probably spawn in this region rather than on Vancouver Island or south towards the Columbia River where white springs are seldom caught. The proportion and distribution of small, red spring salmon are also available from the sales slip returns. These should be useful in considering any regulatory changes

in size. The coho salmon this season were unusually large fish, judging from sampling and sales-slip data.

Ocean studies. Certain general information has been obtained on the ocean phase of these two species, such as the location of the main fishing areas and the depth at which these fish are caught. By postulating the general migration patterns from tag returns, a start has been made at describing the current, temperautre, and salinity conditions of their ocean environment. The present offshore oceanographic survey, particularly the series of observations taken in Hecate Strait in May and along the continental shelf off the west coast of Vancouver Island in July, will add to our understanding of the ocean migration of these fish. More detailed studies are needed in this field. Stomach samples have shown that herring is the chief food of both species but a considerable variety of other available marine animals are used at different seasons in various localities.

Fresh-water studies. Regarding the fresh-water phase, the survival studies at Cowichan River in past years and the data obtained for coho salmon at the field stations at Nile, Port John, and Scully Creeks are being augmented this winter by records taken by the fishery inspectors on various "key streams" in their respective districts. An analysis of the spawning reports by the fishery inspectors indicates that, excluding the important Fraser and Skeena Rivers, there are probably about 200 streams in which spring salmon spawn and at least 1,000 streams in which coho salmon spawn. More accurate data are required for these two species before any catch to escapement ratios can be established.

Regulation problems. Recently emphasis has been placed on gathering data pertinent to discussing the new changes in the offshore trolling regulations adopted by the States of Washington, Oregon, and California, and the Territory of Alaska. With certain local adjustments, these are an opening date of June 15 for offshore coho salmon and a minimum size limit for spring salmon of 26 inches in total length.

Because the coho regulation is simple to enforce and should produce a higher production in weight by curtailing the capture of small fish early in the season, it has been adopted and will apply to our offshore troll fishery in 1952. For a similar reason it would appear desirable to delay the opening of the coho salmon ("blueback") fishery in the Strait of Georgia later than June 1 and possibly to raise the present minimum size limit (8 inches fork length) for the sport fishery. More data are required, however, before these latter suggestions can be properly evaluated.

The minimum size regulation for spring salmon is under consideration at the present time. This regulation is not too convenient to apply since small spring salmon are caught in most areas throughout the season, nor is it too direct in its conservational value. Small spring salmon would have to be released up to a maximum of 10 pounds (dressed weight) although most of them would be less than 8 pounds. It would include some fish in their fourth year of age but the majority would be in their second and third years. A portion of these small fish are mature and may not require further protection. If protected they may produce a surplus of males on the spawning grounds or they may propagate a race of small fish. The releasing and natural mortality on those returned to the water must be great and it may not compensate for the increase in growth to create the greater production in weight which is desired. In addition, the many small fish taken by gill-nets and purse seines while fishing for other species of

salmon must be taken into account. When all aspects have been fully considered, the chief value of the regulation may probably be the curtailment of the fishing which is now specifically directed towards catching small springs in certain areas under the incentive of high prices.

General

The need for fundamental information on the behaviour and reactions of salmon to environmental conditions at different stages is very great. The success of measures intended either to improve natural conditions or to remedy man-made obstacles may well depend to a large extent on such knowledge. The behaviour of young salmon in relation to water currents and intensity of light have been further investigated by Dr. Hoar, in continuation of work undertaken last year. For this year's experiments, Port John was selected as offering facilities for observations on sockeye, coho, pink, and chum salmon. Chum fry respond more continually to currents than coho fry and hence are displaced downstream more rapidly. The exit of sockeye smolts from lakes is associated with a preference for shallower water and an increase in nocturnal activity.

Through the co-operation of the Department of Fisheries, the salmon investigation is now kept in close touch with conditions and developments in all coastal areas by means of: (1) the tabulated records of catches and fishing effort, which are now for the first time available for each species, by weeks and areas, throughout the season, and (2) the periodic reports supplied by inspectors on "key streams" in each area. These reports supply information on the numbers and species of fish present, meteorological and stream flow data, and seasonal or other changes in conditions. They provide a broad background against which the more detailed but necessarily localized findings of the various field stations can be interpreted and applied.

It has to be recognized that in recent years there have been very significant changes in the conditions of many salmon streams along the coast as well as in the interior of British Columbia through logging off of the forest cover, opening up of districts to settlement, through mining, water diversion for irrigation, etc. These are bound to increase in the future rather than diminish. To them will be added the problem of large-scale water impoundment for hydro-electric power. The changes in the streams can be expected to have an effect on salmon production since, as already indicated, natural production of salmon of all species is governed essentially by the conditions in the streams during spawning, egg incubation, and seaward migration of the young. The data now being obtained through the several investigations referred to above will be particularly pertinent in indicating what the effect of these changes will be and how they may be controlled. It seems imperative that there be close co-operation between logging, forest management and water power development interests and research and administrative fisheries agencies, not only to protect salmon streams in the future but also to devise practical means of restoring those now adversely affected. All of Canada's Pacific natural resources are important. None should be exploited to the detriment of others. By collective action, all can be maintained. Attention to the problem is being given in our salmon researches and co-operation with other interests is being sought.

HERRING

The long-term investigation of Pacific herring seeks to advance knowledge of the fish and of the fishery so that a closer approach to maximum sustained yield may be realized. The present program aims at deter-

mining the relative merits of two contrasting methods of herring management: (1) limiting catch by fixed quota, and (2) allowing the fishery to continue, regardless of the amount caught, until the fish are about ready to spawn (fishing closure date). Two major herring populations of southern British Columbia are involved in this experiment; the lower east coast of Vancouver Island population is fished under a fixed annual quota of 40,000 tons, and the west coast of Vancouver Island population is fished without quota restrictions. The adult stocks of each population are subjected to intensive study to determine the various changes which occur from year to year. In addition, studies of the early life-history stages are undertaken in the west-coast population to investigate the fundamental causes of annual variation in the supply of fish to the fishery.

The adult stocks of the five other main herring populations are investigated to afford a basis for application of results of the more intensive studies and to supply information which serves to guide present administration.

The adult and early life-history phases of the research are sub-divided for convenience into the major projects of the herring investigation. A summary of the objectives towards which the projects are directed and of the results of studies undertaken in the 1950-51 season follows.

Catch statistics

Statistics collected on the fisheries provide catch totals by area, catch per unit of effort, and fishing effort. These data are essential for analysis of information obtained from other adult studies.

The 1950-51 herring catch amounted to 187,300 tons, about 1,900 tons less than the record catch of 1948-49 and 4,000 tons greater than that of the previous season. The following tabulation gives catch and catch per unit of effort in the various sub-district fisheries, with comparable data for 1949-50 in parantheses:

Sub-district	Catch (tons)	Catch per unit of effort (tons per seine per day)
Queen Charlotte Islands	3,150 (----)	110 (---)
Northern	50,650 (40,300)	258 (189)
Central	51,300 (41,500)	123 (93)
Upper east coast of Vancouver Island	3,900 (9,000)	42 (42)
Middle east coast of Vancouver Island	12,050 (14,800)	64 (159)
Lower east coast of Vancouver Island	41,050 (40,300)	111 (98)
West coast of Vancouver Island	25,200 (37,300)	48 (47)

Quota restrictions on catch are imposed on all fisheries except those of the Queen Charlotte Islands and the west coast of Vancouver Island. A fishery developed in the former sub-district for the first time in nine years. In the west-coast sub-district the catch was the smallest of the five years following the removal of quota restrictions. The reduced west-

coast catch reflected a decreased Barkley Sound fishery and a small Esperanza Inlet catch. Poor fishing in Esperanza Inlet in 1950-51 was mainly attributed to lateness of the inshore migration. When the fishing closure date, prior to spawning, was reached, catch per unit of effort was high. In the previous year the catch from this area was also small, apparently a result of failure of herring to move inshore during the fishing season. Catch in Barkley Sound in 1950-51 was slightly curtailed by transference of fishing vessels to more productive fisheries in the north.

In the quota fisheries, the catch quotas were obtained in all but that of the upper east coast of Vancouver Island. Extensions were granted in the northern, central, and middle east-coast sub-districts (20,000 tons, 10,000 tons, and 4,000 tons respectively). In the northern and central sub-districts the extensions were readily taken. Catch per unit of effort was high in both these fisheries, but remarkably great in the northern sub-district where the largest total catch on record was made. Only half of the middle east-coast quota was taken; catch per unit of effort was much lower than in the previous year, suggesting a reduced abundance in the middle east-coast population. The lower east-coast quota was taken with higher catch per unit of effort than in the previous year.

Tagging studies

For the past five years an intensive tagging and tag-recovery program has been carried on in southern British Columbia waters to investigate the movements of herring between and within the various populations. In addition, tag-recovery data have been used in the calculation of certain population statistics on the west-coast population. In 1950 the program was extended to northern herring populations of the province to determine the extent of immigration and emigration of northern and central runs.

A total of 2,317 tags was recovered from the 1950-51 fisheries, over twice the number recovered in the previous season. The increase was due chiefly to the expansion of the tagging program to include the northern British Columbia populations. Also, heavy tagging on the west coast in 1950 increased the concentration of tags in the west-coast catches, and tended towards greater recovery.

Recovery of tags was accomplished by the operation of three electronic tag detectors in certain reduction plants and by magnets placed in the meal lines of all plants. Detector recovery gave specific information on the location of the catches from which recovered tags were taken, whereas doubt frequently existed when determining the fishing grounds from which magnet returns were derived. On the other hand, the magnet returns were much more numerous than detector returns (2,058 and 259 respectively). Thus in the data obtained from each method of recovery there was a major deficiency which tended to limit their applicability to the study of herring movements. Although the comparative accuracy of the results obtained from each source of data was not easily decided, the suggested extent of the movements was similar regardless of the method of tag recovery.

The data suggested that about 15% of the west-coast population emigrated to other populations. Most of the movement was to the central coast and to the lower east coast of Vancouver Island, with a small movement to the middle east coast of Vancouver Island. The movement to the lower east coast was smaller than in the previous year. The significant movement of west-coast tags to the central coast will be further investigated in the second season of intensive tag recovery in northern British Columbia waters next year.

Immigration of lower east-coast fish into the west-coast population was similar to that of 1949-50. The central and middle east-coast populations also contributed fish to west-coast catches.

It was calculated that about 4,700 tons of lower east-coast herring were taken from west-coast catches, and that about 900 tons of west-coast fish were caught on the lower east coast. On the other hand, approximately the same amount of herring was taken in the west-coast catches as west-coast fish taken in central catches (1,000 tons and 1,400 tons respectively). It was noteworthy that most of the interchange of west-coast and central herring took place, as might be expected, in those portions of the populations nearest each other, viz., the more southerly runs of the central coast and the more northerly west-coast runs.

The movement of herring between the middle east-coast and lower east-coast populations was the smallest ever noted. This was partly attributed to the fact that the middle east-coast fishery took place near the northern border of the sub-district, and therefore gave little opportunity of intermixture with lower east-coast fish in the vicinity of the common border of the two sub-districts.

There was no evidence that herring moved into or out of the northern population. The apparent lack of emigration might be partly a result of the small amount of tagging done in the sub-district in the first year of the present northern tagging study.

Information was obtained on the movement of herring within the west-coast and central populations. In the west-coast sub-district there was a distinct tendency, as noted in previous years, for herring to move southeasterly along the west coast rather than northwesterly. However, the apparently light exploitation of the northerly west-coast runs might have biased the results. This factor might also have influenced results, indicating that the "homing" tendency of west-coast herring was less pronounced in 1950-51 than in previous years.

Tag-recovery data from central catches also suggested a southerly movement of herring within the sub-district, as far as the main fishing runs were concerned.

From tag-recovery data it was calculated that the initial population abundance on the west coast was about the same in 1950-51 and in the previous year. Also it was determined that the rate of exploitation in 1950-51 was only about three-fourths that of 1949-50. Thus, it appears that the reduced west-coast catch was chiefly a result of a smaller proportion of the population having been caught. As pointed out previously, lateness of inshore migration in Esperanza Inlet appeared to influence the catch in both seasons, and from the above statistics it seems probable that fewer fish were available to the fishing fleet in 1950-51 than in the previous year.

A total of 56,812 herring was tagged in the spring of 1951 as compared to 56,435 in 1950. Taggings in the northern, central, and lower east-coast sub-districts were increased, whereas fewer fish were tagged in the middle east and west-coast sub-districts.

Age composition and growth

The sampling program involves detailed study of groups of randomly-collected herring from the fishing and spawning runs. Data are provided on age composition, length, weight, sex, and maturity. The relative strengths of successive year-classes contributing to the various fisheries are indicated by analysis of age-composition data. Information can frequently be obtained on the relative abundance of year-classes not fully recruited to the adult stocks, and such knowledge is helpful in prediction of popula-

tion abundance. Growth data are useful in distinguishing small local runs from the major populations, and in suggesting possible differences in food conditions from year to year.

A total of 296 samples, consisting of 28,905 fish, was taken during the 1950-51 season: 271 samples were from fishing runs and 25 from spawning runs.

The prominence of the 1947 year-class (IV-year fish) in the 1950-51 herring fisheries was noteworthy. It dominated all major populations except those of the lower east coast and the upper east coast. In the former sub-district the 1948 year-class (III-year fish) entered the fishing stocks strongly, and population abundance increased over that of the previous year. In the latter sub-district, in which II-year fish generally form an appreciable portion of the fishable population, the 1949 year-class was poorly recruited, and population abundance decreased.

The abundance of the 1947 year-class was predicted on the west coast of Vancouver Island from data accumulated in each year since the year-class was deposited on the spawning beaches. Its strong entry into the west-coast stock in 1950-51 offset the weak production from the 1948 year-class and maintained population abundance. In only two other seasons in the last 20 years have IV-year fish dominated the west coast runs. It appears that its recruitment to the Barkley Sound fishing runs was less pronounced than its entry into Esperanza Inlet runs. This follows the general tendency noted in previous years for the former runs to depend to a greater extent on III-year fish than the latter.

The highly productive fisheries in the central and northern sub-districts in 1950-51 resulted from heavy recruitment of the 1947 year-class. The exceptional strength of the year-class was further indicated by its dominance in all fisheries in 1949-50 as III-year fish.

No major changes in growth rate of herring were noted in the 1950-51 data.

Studies of spawning

The spawn studies have implications on both the adult and early life-history phases of the herring investigation. For convenience, the studies are divided into two sections: (1) those concerned with determination of the extent and intensity of spawn deposition, and (2) those which involve investigation of the factors responsible for spawn mortality. The former are useful in ascertaining the relative size of the portion of the adult stocks which escape the fishery, and also in relating the amount of spawning stock to year-class abundance. No direct relationship between amount of spawn and the supply of fish to the fishery has been shown. The latter studies are undertaken as part of the research designed to follow survival of each year-class during its early life history.

The total extent of herring spawning, as determined from surveys carried out by fisheries officers in all areas and by herring investigators on the west coast of Vancouver Island, amounted to 191.2 statutory miles in the spring of 1951. In 1950 the spawning measured 192.0 miles.

On the upper east coast the greatest decrease in spawning occurred (28%). This corroborated the evidence from catch and age composition that population abundance in that sub-district was smaller in 1949-50 than in the previous year.

Spawning in the northern sub-district decreased by 22%. Considering the large catch it appears possible that the intensive fishery might have reduced the escapement.

The extent of spawning in the Queen Charlotte Islands, the central and the middle east-coast sub-districts showed minor reductions.

Both the lower east coast and west coast of Vancouver Island sub-districts had greater spawn depositions (increases of 34% and 26% respectively). Considering the increase in lower east-coast spawning together with the increased catch per unit of effort during the taking of the fixed catch quota, it appears that population abundance on the lower east coast was greater in 1950-51 than in the previous year, presumably as a result of the strong entry of the 1948 year-class.

The larger spawning on the west coast resulted mainly from extensive spawnings in Esperanza Inlet. The great spawn deposition was apparently a logical consequence of the light exploitation which occurred because of the delay in the inshore migration of the runs. The decrease in the Barkley Sound spawnings provided further evidence indicating that exploitation was much higher there than in Esperanza Inlet, and also that the Barkley Sound runs were more affected by the poor recruitment of the 1948 year-class than were the Esperanza Inlet runs.

The average intensity of spawn deposition on the west coast was similar in both the 1950 and 1951 seasons.

Research on mortality of spawn included studies of bird predation on spawn and investigation of other factors responsible for dead eggs on the spawning beaches. The former showed that on one of the main spawning beaches of Barkley Sound, mortality by birds was about 30%, a considerably smaller estimate than that obtained in 1950. The relatively light predation in 1951 was attributed to fewer birds in the vicinity and to the fact that the 1951 studies were carried out on spawnings of lighter intensity.

Various factors were found to cause death of herring eggs. The type of vegetation on which the spawn was deposited appeared to influence survival. Egg mortality over 90% occurred on rockweek (Fucus), and 100% mortality was found on sedge grass. On the other hand, mortality did not exceed 3% on eel-grass (Zostera) or 6% on japweed (Cystophyllum). Apparently the extent to which the vegetation was able to keep moist when exposed at low tides greatly influenced survival of the attached eggs. Experimental plots which were covered by water at all times showed least mortality.

The data suggested that lack of fertilization was generally not an important factor in spawn mortality. Heavy mortality occurred wherever fresh water from creeks invaded the spawning beaches. Although not specifically studied in 1951, heavy wave action is capable of great destruction of herring eggs.

Studies of larvae

Larval herring studies are undertaken to determine whether the larval stage in the early life history may be a critical period in year-class survival, as it apparently is for many animals, and to investigate the factors involved.

In the spring of 1951 the larval studies were continued for the fifth consecutive year, but on a reduced scale. The investigation was restricted to a portion of Barkley Sound on the west coast of Vancouver Island, where comparable data were obtained in 1950. In contrast to the spawning of 1950, the 1951 spawning in that area was the smallest in several years. A total of 611 larval hauls was taken over a two-month period during which larvae developed from the hatching stage to metamorphosis.

The analysis of the data collected since 1947 was begun in the winter of 1950-51 but it is as yet incomplete.

Studies of juveniles

Juvenile herring studies were undertaken to link up abundance during early life history with the entry of the year-class into the fishing stocks. Past evidence suggests that a relationship may exist between juvenile abundance and year-class strength. The establishment of such a relationship would be of great value in predicting population abundance and fishing success.

In the summer and fall of 1951 a total of 89 juvenile samples were taken in Barkley Sound (west-coast sub-district) and Departure Bay (lower east-coast sub-district). Although the 1950 data are sparse, it appears that in Barkley Sound the 1951 year-class as I-year fish is less abundant than the 1950 year-class was at the same age. No such difference in the relative strength of these two year-classes could be detected in the two years' data from Departure Bay.

Tagging and marking experiments were carried out on juvenile herring in 1951 to provide population estimates. Also, data were collected for study of juvenile development and growth.

Scouting for herring

Scouting surveys are undertaken prior to, during, or after the fishing season to locate herring and to assess their abundance on the fishing grounds. Vessels equipped with echo-sounders are placed at the disposal of the herring investigation by the fishing industry and the Department of Fisheries. Much of the information obtained is made available to the fishing companies to aid in the efficient exploitation of the fish stocks, and data of possible conservation value is turned over to the Department of Fisheries.

Four main surveys were conducted in 1950-51. Three of them were carried out primarily to assess the abundance of fish on the fishing grounds of the middle east coast, central, and northern sub-districts to determine whether quota extensions were warranted. In the fourth survey, the fishing grounds of the west-coast sub-district were scouted as part of the winter program of the herring investigation.

Forecasts of fishing success

Predictions of fishing success are attempted each year after consideration of all pertinent data on each population. They make available to the fishing industry information of possible value in the efficient utilization of the resource. Although little information is available on the factors which determine the time of inshore migration of the runs, these forecasts of fishing success have been reasonably accurate. Predictions of year-class strength, population abundance, and the relative size of fish in the various fisheries have generally been correct.

Hitherto, data accumulated from adult herring studies have been mostly used in prediction. However, certain data pertaining to the relative abundance of the 1947 and 1948 year-classes as juvenile fish correctly indicated the relative recruitment of these year-classes. It is hoped that the present studies on juvenile herring will provide a sounder basis for prediction of abundance.

Implications of results for management

Considering the results of 1950-51 and those of the previous four years of the present study, it appears that population abundance in both the population without quota restrictions (west coast of Vancouver Island), and in the population with a fixed catch quota (lower east coast of

Vancouver Island), has been generally high throughout the period. Although certain year-classes have differed greatly in their abundance in these two populations (e.g., the 1948 year-class was recruited to the lower east-coast runs in much greater abundance than to the west-coast runs), the average year-class recruitment to each population has been about the same. Thus, since population abundance has apparently been maintained without catch quotas on the west coast, it appears that there has been no benefit derived from restricting catch by quota on the lower east coast during this period of generally high abundance in both populations. Indeed, data obtained during one season suggest that the quota has on at least one occasion unduly restricted the lower east-coast catch. This interpretation is based on the assumption that the two populations are in most respects comparable. However, the possibility exists that the lower east-coast population may react differently to the west-coast population, if the quota were removed. Hence, further study is essential before the above indications can be considered conclusive.

The strong evidence indicating that in the past two years availability of herring to the fishing fleet has been unusually low in Esperanza Inlet (on the west coast of Vancouver Island) suggests that natural limitations to catch have essentially the same effect as if catch quotas were imposed. To a certain extent these natural limitations complicate the experimental basis of the management study. It appears desirable to have information on their effect over a period of generally low population abundance.

GROUNDFISH

The main objective of the groundfish investigation is to obtain a knowledge of the factors which govern the abundance and availability of bottom-fish species off the Pacific coast. Approximately 20 species (excluding halibut) come under this study but only 9 are classed as major contributors to the fishery. They include 5 flatfish species (brill, lemon sole, rock sole, butter sole, and Dover sole) and 4 roundfish species (gray cod, lingcod, blackcod, and dogfish). The fishery is carried out mainly in extra-territorial waters by otter-trawlers and long-liners.

Within any one year, or over a period of years, trends and fluctuations are observed in the catches of the various groundfish species. These changes may be the result of natural conditions in the sea, such as changes in oceanographic conditions which affect the success of spawning or which affect the migration and distribution of fish on the various banks. On the other hand, they may be the result of fishing or changes in gear efficiency or market conditions. It is important that the effects of all these factors on the catches be accurately interpreted. To be able to separate the effects of nature and man and to be able to predict how the various observed conditions will affect the abundance and availability to the commercial fishery are the basic requirements for a sound program of conservation and management.

It is probable that the long-term studies of the conditions for the survival, growth, distribution, and reproduction of the various groundfish species will supply valuable information on the open ocean phases in the life histories of species comprising the major fisheries (salmon and herring). For example, many of the productive fishing banks for bottom fish are also the sites of productive salmon fishing. There is some evidence that the availabilities of spring salmon and brill vary concurrently. Furthermore, where several of the important bay and channel fisheries for herring take place there also occur cod and dogfish fisheries.

As a basis for investigation of the trends in the abundance and availability of the groundfish species and the factors causing variation in either or both, it is essential that there be obtained: (a) a reliable measure of the catch of fish each season in each fishing area, (b) the rates at which the populations are being exploited by the fishing fleets, (c) the migration of the various stocks and their interdependence, (d) the age and length composition of the fish in each population, and (e) pertinent oceanographic data for correlation with changes in recruitment, growth, and availability. These are discussed in the sections which follow.

Catch statistics

The first and perhaps most useful tool of investigation is a sound system for the collection of catch statistics. Representatives of the Station have been placed at the three most important market centres (Vancouver, Prince Rupert, and Victoria) and over the past four or five years have been collecting catch records from trawlers, long-liners, and trollers. The records of the total catch of each species, the area of capture and the time required to make the catch, yield valuable information on the trends and fluctuations in the fishery.

In 1951 the Canadian catch of bottom-fish species greatly exceeded that of previous years, being 16.0 million pounds, as compared with 12.1 million in 1950, 9.3 million in 1949, 11.7 million in 1948, and 6.2 million in 1947. No one species has persistently led in the total catch from year to year. The dominant species was rock sole in 1947, brill in 1948 and 1949, lemon sole in 1950, and gray (true) cod in 1951. These fluctuations have been more the result of changes in availability and abundance than of changes in economic conditions.

The marked increase in total catch in 1951 can be attributed to four species. The landing of gray cod was 4.5 million pounds as compared with 2.1 million in 1950 and 1.4 million in 1949. The landing of rock sole was 2.9 million pounds as compared with 1.7 million in 1950 and 1.3 million in 1949. The landing of Dover sole was 1.1 million pounds as compared with 0.3 million and 0.1 million in 1950 and 1949, respectively. A major decrease in catch from 4.2 million pounds in 1950 to 1.6 million in 1951 was recorded for lemon sole. The catch of brill declined slightly from 1.7 million pounds in 1950 to 1.5 million in 1951 in line with a general decline observed since 1948.

An understanding of the changes in the size of populations cannot be gained from total catch figures alone because they are dependent on the amount of effort which is expended. Accordingly, in order to rule out the effects of fluctuations in fishing effort, studies of catch per unit of effort are being carried out in respect to the more important flatfish species. Off the west coast of Vancouver Island where the fishery by both Canadians and Americans has been in operation for almost a decade, the Canadian catch per hour of brill has averaged about 400 pounds for the years from 1947 to 1950. In 1951, however, the catch dropped to 300 pounds per hour. In the Queen Charlotte Sound area where the fishery has been in progress since 1944 or 1945, the catch per hour has averaged almost 550 pounds. On the Hecate Strait grounds, which have the most recent history of exploitation (and which are farthest from American ports of landing), the catch per hour has been about 850 pounds. The catch per hour in the more northerly waters has been fluctuating from year to year with no obvious signs of a decline which can be associated with the development of the fishery.

The catch per unit of effort of lemon sole in Hecate Strait dropped to 800 pounds per hour in 1951, following the exceptionally heavy fishery of

1950, during which year the catch exceeded 1,000 pounds per hour. The 1951 catch per hour was, however, over the average for the past six years. On the grounds in the Strait of Georgia where fishing has been in progress for several decades, the catch remained at a low level of slightly over 100 pounds per hour.

The catch per hour of rock sole in Hecate Strait has been increasing since 1948 and reached a new high of 1,600 pounds in 1951. This high availability has resulted partly from the passage of several strong year-classes through the fishery and partly from the relatively low rate of exploitation in past years.

There has been a growing need for the collection of catch records from the large American fleet of trawlers which is now expending almost all its effort in waters off the British Columbia coast. Through the co-operation of the Washington State Fisheries Department, records are now being obtained which will permit a more complete interpretation of the trends in the fishery. These records show that the total catch of food fish species by Washington boats off the Canadian coast has averaged 26 million pounds for the past three years (1948-50). Over 50% of this catch was made north of Vancouver Island (200-500 miles from Washington ports). The Canadian catch for the same period averaged 10.3 million pounds, 75% of which was taken from the waters north of Vancouver Island. Thus it would appear that American vessels are accounting for over 80% of the fish taken off the west coast of Vancouver Island and 60% of the fish taken north of Vancouver Island. The Canadian fleet is not an active participant in the fishery for rockfish species, which has amounted to an average of 10 million pounds for the past three years. Hence the above figures are not truly comparable. If rock-fish are excluded from the comparison, the catch by the American vessels in the two areas is 75% and 50%.

For the few years for which records of total American and Canadian catch from British Columbia waters are available there is no evident trend in the production of either lemon sole, rock sole, flounder, rockfish, or lingcod. There is an upward trend in the total catch of gray cod and Dover sole. There is a downward trend in the catch of brill. In respect to the last-mentioned species, the catch was 11.6 million pounds in 1948, 6.9 million in 1949, 5.8 million in 1950, and an estimated 3.7 million in 1951. This decline is causing concern among American and Canadian fishermen and indicates the need for an acceleration of the brill study. Should international regulation of the trawl fishery be proposed in the near future it will undoubtedly be focussed first upon this species.

Tagging experiments

Tagging and marking (by removing fins) has been continued in 1951 in an effort to extend the knowledge of the interdependence of populations on the various fishing banks and to determine the rates at which the populations are being exploited by the Canadian and American fleets.

Lemon soles tagged off Banks Island in Hecate Strait showed movements of 30 to 50 miles northward. This is an extension of the pattern obtained from the 1950 tagging which showed a strong migration northward in the strait to the vicinity of Dixon Entrance. A few of the spawning lemon soles tagged in 1950 in inlets on the east side of the strait appeared on the offshore bank (30 miles westward) during the spring months of 1951. Although 93% of the 1951 recoveries from the 1950 tagging in Hecate Strait were made in the area of tagging, a few showed extensive dispersion southward during their period of freedom. Three had moved 60 miles to the Horseshoe grounds; 2 had moved 200 miles to the Goose Island grounds; 2 had moved 230 miles to the Cape Scott (Vancouver Island) grounds.

Recoveries during 1950 and 1951 from the Hecate Strait tagging of 1950 have reached 1,346 or 44.8%. The recovery in 1950 alone amounted to 41.4%. This figure approximates the rate of exploitation for the population present at the time of tagging. The rate of exploitation in 1950 for the whole stock was estimated at 37%.

In the Strait of Georgia, tagging has been conducted on the summer feeding grounds and on one of the winter spawning grounds lying along the east coast of Vancouver Island. Migrations of 30-40 miles to the spawning grounds have been recorded. The maximum distance recorded away from the spawning grounds is 75 miles. There is no evidence of mixing with the stocks outside the Strait of Georgia and little evidence of mixing of stocks within the strait itself. Estimates of the rate of exploitation range from 20 to 30%.

The results of brill tagging indicate that fish inhabiting northern Hecate Strait, southern Hecate Strait, Queen Charlotte Sound, and off the west coast of Vancouver Island are separate stocks. Off the west coast, 76.7% of the recoveries from the Clayoquot Sound tagging were made outside that area while dispersion from the Kyuquot Sound area was only 19.6%. In no area to which the fish dispersed were the recoveries greater than those made in the areas of tagging. The brill which occur in the Barkley Sound area during the summer are probably part of one population which migrates southward during the fall to the Washington coast and returns in the spring.

Age and length

The examination of many thousands of samples of otoliths and lengths has continued to be one of the most important segments of the investigation. The results are used in measuring fluctuations and trends in recruitment, growth, and mortality.

Samples of lemon sole and rock sole from northern Hecate Strait have been collected ever since the fishery got under way in 1944. The study of this virgin fishery is supplying valuable information on natural conditions. Several dominant year-classes have been observed to date and suggest that spawning was more successful in 1937, 1939, 1942, and 1943 than in other years between 1937 and 1945. Changes in average size of fish from year to year are mainly the result of these fluctuations in recruitment. A drop of three centimetres in the seasonal average size of rock soles in 1951 resulted from the entrance of a strong 1947 year-class into the fishery.

Off the lower coast of the province, where the fishing grounds have been exploited for many years, lemon soles average more than one and a half years younger than those in northern waters. Also, there is little or no evidence of dominant year-classes.

Age determination of samples of brill have been completed for the years 1944-46. In the short period represented there is no indication of a trend in size or age. Fish taken from the upper coast of Vancouver Island were older (average age 9-10 years) than those taken off the lower coast (average age 7-8 years).

Samples of butter sole from the fishery in Skidegate Inlet show no signs of dominant year-classes which might account for the violent fluctuations in availability from year to year. The average age of female butter soles in 1951 was 7 years.

Oceanographic studies

In conjunction with biological investigations being conducted at sea aboard the research trawler Investigator No. 1, studies are also being made of oceanographic conditions of temperature, salinities, currents, etc., in order to determine their relation to observed biological phenomena.

Through the co-operation of the Pacific Oceanographic Group, several surveys have been undertaken in search of the factors which determine the location of spawning grounds and the direction of migration routes. Although much of the information collected so far is not completely analysed, it is already evident that temperature does not play an important role as a directive factor in the migration of lemon soles. Ocean currents and the effect thereon of wind velocity and direction appear to be of greater significance.

Extensive use is being made of water temperature and wind records from Pacific Oceanographic Group lighthouse reports in an effort to relate fluctuations in year-class strength to ocean conditions.

Forecasting

Although the accumulation of data on fluctuations in the availability and abundance of groundfish species covers only the eight years since the investigation began, there are already indications that these phenomena can be related to and predicted from oceanographic phenomena.

Strengths of lemon sole and rock sole year-classes in Hecate Strait have been correlated with surface water temperature conditions, as recorded by lighthouses in the strait, during the season when the year-classes were produced. Survival of eggs and larvae is apparently better in cold winters than in warm winters.

The availability of lemon soles in Hecate Strait can be related to their depth distribution (depth at which they are caught). In seasons of high availability they occur in relatively deep water while in seasons of low availability they occur in relatively shallow water. Prediction of the success of the fishery each spring appears possible from observation of the depths at which the lemon soles first make their appearance.

The success of the Skidegate Inlet fishery for butter soles appears to be dependent on water temperature conditions at the time of the spawning migration to the inlet from Hecate Strait. It has been observed that in years when the catches were good (1948 and 1951) the water temperature was high. In very cold winters (1949 and 1950) the catches were negligible.

ALBACORE

Fishing for albacore contributes significantly to the economy of the British Columbia fishery since it provides remunerative employment for halibut fishermen and their vessels after the close of the halibut season. Since the opening of the fishery in 1938, catches have varied widely. Although much of the variation has arisen from economic factors, the availability of fish has also varied. The current investigation is planned to study the sources of variation in the supply of albacore to fishermen.

Fishing success relies upon the abundance of fish in the sea and their accessibility to the fishermen. The work accordingly has been directed toward investigating the relative strengths of the various year-broods supplying the fishery and the relationships between water temperatures and the success of fishing. Three kinds of data have been used: (1) the measurements of very many fish from the commercial catch tabulated according to source, (2) the records of catches by areas, and (3) the water temperatures in different fishing grounds. Measurements were obtained by port contact men and samplers in Victoria, Vancouver, and Prince Rupert; catch data were supplied through port contact men and by fishermen; water temperatures were recorded by fishermen in special log-books.

The relative numbers and average lengths of the component size-groups of the fish landed from each fishing area were determined by special mathematical treatments. Four recognizable length-groups were taken by the 1949 and 1950 fisheries. They had average lengths of 21 inches, 24 inches, 28 inches, and 31 inches. Northerly fishing grounds, off Oregon, Washington, and British Columbia, produced fish in the larger three size-groups with landings from northern British Columbia practically confined to fish in the groups centred around the 24-inch and 28-inch averages. Fish of the smallest size-group were not encountered north of Cape Blanco in 1949, or north of Cape Mendocino in 1950. The dominant size-group in both years was the one centred around 28 inches. In 1949 it comprised 66% of the catch and in 1950, 81%. Preliminary examinations of results for 1951 show that sizes centring around 24 inches are most frequent.

The locations of the most productive fishing grounds vary from year to year. In 1950 they were 60 to 100 miles off the State of Washington north of Grays Harbour.

Closely resembling the results in other years, the most productive water temperature for 1950 was 60°F. Seventy-four per cent of the fish were caught at temperatures between 58½°F. and 61½°F. in 1950 as compared with 79% in 1949.

WHALES

The whale investigation was initiated in 1948 with the resumption of whaling operations off the coast of British Columbia. During the four years since its inception, more than 1,000 whales have been examined from the catch of 1,188 whales landed at the Coal Harbour whaling station on Vancouver Island. The purpose of the investigation is to satisfy Canada's obligations as a party to the International Whaling Agreements in the collection of accurate statistical data on all whales landed, and to contribute to the general fund of biological knowledge on whales as a basis for sound regulation of the industry.

Information on breeding, growth and age is obtained by anatomical examinations of the whales as they are landed. Data on length, sex, species, foetuses, reproductive organs, mammary glands, blubber thickness, parasites, and stomach contents are recorded for each whale. Measurements are made of proportional body parts as a means of detecting racial differences and differences in growth rate between whales from this locality and whales from other parts of the world. Age determinations are made for each baleen whale by a method involving a periodicity in the growth of the baleen.

Deductions from catch statistics supplement the information obtained by anatomical examination, but must be considered with reservation. The catch of whales from a shore station operating within a radius of less than 100 miles cannot be truly representative of a stock of animals whose range is not confined to coastal waters. The catch is affected by weather conditions, economic factors and to some extent upon the ease of capture and bonus paid for each species of whale. Humpback and sei whales are offered some immunity to capture at the expense of more easily captured or more remunerative species.

The fishery

The catch of whales as presented below by year and species reflects an increase in catching and processing efficiency during the four years' operations of the Coal Harbour station. Attention is drawn to an

error in the 1950 catch of whales contained in the Annual Report for 1950. The corrected figures presented below are in agreement with those submitted to the International Whaling Committee.

	Blue	Fin	Hump	Sei	Sperm	Others	Total
1948	0	37	115	2	28	0	182
1949	2	105	76	3	69	0	255
1950	4	150	95	24	40	1[1]	314
1951	9	216	51	5	153	3[2]	437
Totals	15	508	337	34	290	4	1,188

1. 1 Baird's beaked whale
2. 1 Baird's beaked whale, 1 right whale, 1 gray whale

The large catch of sperm whales during the 1951 season was characterized by an unusually large proportion of young bulls, 35 feet to 42 feet in length, and by the appearance of 17 females. Female sperms have not been previously recorded from British Columbia. The female sperms averaged only 35 feet in length, but all were mature. Seven were pregnant, 4 resting, 3 lactating, and 2 ovulating. One was not examined.

The California gray whale, the black right whale, and the two Baird's beaked whales caught in 1950 and 1951 are uncommon in catches of whales from this coast and consequently have been given detailed study. The former two species are protected by international agreement and were taken in error. A publication on the two Baird's beaked whales, which constitute first records of this species from British Columbia waters, is in preparation. Permission is to be requested to take ten gray whales for biological study during the 1952 season.

Length at maturity

The matter of estimating average lengths at which sexual maturity occurs in each species is important in allowing estimates to be made of the percentages of immature whales in statistics of catches which give only the species, sex, and length of each whale. This information may be obtained from the examination of whales at the whaling station. Examination of ovaries and mammary glands shows the sexual condition of the females. With the males the determination is more difficult and necessitates the histological treatment of a number of testes samples to permit estimates of sexual maturity to be gained by reference to testes weights. This work is in progress. The sexual condition has been determined for almost every female whale taken during the years 1949, 1950, and 1951. Of the 240 female finbacks examined, 48% were sexually mature. The average length at which female finbacks mature in this locality was found to be about 60 feet, some 5 feet less than the corresponding length for finbacks from the southern hemisphere. Of 70 female humpbacks examined, 72% were sexually immature. The average length at sexual maturity for this species was found to be about 40 feet and slightly less than that for humpbacks from the southern hemisphere. Two of the 15 female sei whales examined were immature. Two of the 9 female blue whales examined were immature. Maturity studies suggest that sexual maturity occurs at smaller average lengths for all baleen whales from this locality than for those from the southern hemisphere.

A series of about 18 measurements of body proportions has been made for each of 655 whales as a means of describing by species the external features and growth of the whales from this locality and to permit comparisons of growth rate with whales from other parts of the world. Preliminary analysis of these data indicates a marked difference in growth pattern between finback, humpback, sei, and blue whales from this coast and their counterparts from the southern hemisphere. Data already collected seem to be sufficient to prove this difference for finbacks, but more data are necessary for the other species, including the sperm.

Age

An integral part of the studies on breeding and growth is the determination of age. Age studies are being made on baleen whales by a method involving the periodicity in the growth of the baleen. Baleen plates from more than 500 whales have been collected during the course of the investigation and the work is progressing satisfactorily. Preliminary results show that the majority of finback and humpback whales landed at the Coal Harbour station are less than 6 years of age. The studies have shown that the majority of female finbacks become mature at 3 years of age, but some become mature at 2 or 4 years of age. Humpback females become sexually mature in their 2nd year.

The knowledge and information obtained in the whale investigation is of value: (1) to science, in the form of original contributions on a stock of whales which have previously received little attention, (2) to industry, as a means of anticipating the effect of exploitation of the stock, and (3) to administration, as a biological basis for effective conservation policy and regulation of the industry.

CRABS

The emphasis of the crab work continues to be on tagging experiments to study the numerical strength and migrations of the very productive populations around Graham Island in northern British Columbia. Data for the 1951 season are not complete at the time of reporting but analysis of the 1950 data has progressed far enough to justify estimates of population abundance in the main fishing areas. These estimates follow, with those based on 1949 results given for comparison.

	East coast of Graham Island	North coast of Graham Island	Naden Harbour
1949	2,700,000	3,000,000	161,000
1950	2,900,000	1,000,000	161,000

The good agreement in the estimates for the east coast and Naden Harbour suggest that the toll taken by the fishery has been for the most part replaced by recruitments. However, the 1951 east-coast catch increased to about 1,000,000, so the limit of safe exploitation may be getting close.

The falling off in numbers of crabs on the north coast in 1950 cannot be attributed to the fishery, and the cause is still uncertain. Tagging indicates that emigration may be a partial explanation, since 42% of the 1951 recoveries of crabs tagged on the north coast in 1950 were from the east coast. By contrast, only 3% of the corresponding recaptures of east-coast tags were from the north coast.

Tagging during 1950 revealed an inshore-offshore movement in the two outside areas, a knowledge of which is of value to fishermen in placing their traps. On the east coast of Graham Island, tag recoveries and relative availability indicated a movement of crabs into the inshore waters during the late spring and summer months. After a period of high inshore availability during July, a movement to offshore waters was noted. At the end of the regular season in October the best yields were obtained 10 to 12 miles off the Graham Island coast. During the winter, tagged crabs were taken by trawlers operating in eastern Hecate Strait.

Work during 1951 has resulted in tagging more than 1,800 crabs. Prospecting in the deeper water of Dixon Entrance is being carried out in co-operation with commercial crab fishermen, with a view to locating crabs which might support an autumn or early winter fishery.

EXPERIMENTAL BIOLOGY

The experimental biology investigation is an effort to satisfy the demand for a knowledge of the physiological limitations and responses of the species of fish of major importance. Lack of knowledge in this field of research has handicapped fisheries biologists in coping with the destructive effects which power installations have had on anadromous fishes. An increasing amount of information on the physical and chemical conditions of both lake and ocean is limited in application to fisheries problems until more is known about the functioning and perceptive powers of the actual fish.

Determination of the maximum and minimum temperatures which salmon fry can tolerate (for periods up to a week) has been completed. These data are necessary for setting the limits of temperature for transporting and planting young salmon, and for determining suitability of changed water conditions due to blockages, reduced flow, and impounded waters.

OCEANOGRAPHY

Oceanography is the description of the sea around us, its form, behaviour, physical properties, and composition. Oceanographers are concerned whenever there is a problem in the sea. At various times the Pacific Oceanographic Group has been asked to define the limits of the Fraser River in the sea, to predict the pollution to be expected from a pulp mill in Alberni Inlet, to show how to rid Vancouver's beaches of sewage, to describe the submarine climate in the Pacific Ocean, and explain why sea level in Seymour Narrows is lower than elsewhere on the coast. The problems are always different, but always require a thorough knowledge of the oceanography of Pacific coast waters.

There are two seas adjacent to British Columbia: the inland seaway between the mainland and the island chain, and the open Pacific Ocean. Associated with these are entrances, estuaries, fiords, inlets, bays, sounds, and straits and narrows. In all these the water is salt, the tide rises and falls, and the seasons follow the same annual cycle. Here the similarity stops. The range of salinity, the range of the tide, the nature of the currents, and the seasonal variations of temperature and salinity are as distinct as the geography and climate of British Columbia's mountains and valleys.

The sea is the environment of the fish stocks, for which the climate varies with location and time. The state of the environment at any one time may be observed by a (synoptic) survey of the currents, temperature, salinity, etc., throughout the length and breadth and depth of the region.

In this case the oceanographers go to sea in ships and observe the properties of the water. The data and samples are brought to the laboratory where they are analysed, and put into usable form as charts, tables, and descriptions. In addition, it is usually necessary to know the climatic changes with tide and season, and to monitor these indefinitely in order to distinguish the conditions which are favourable to a fishery from those which are not, in order to control pollution and in order to recognize the differences from one region to another. This is accomplished by repeating the surveys at suitable intervals throughout one year, and relating the cycle of conditions to daily observations of sea-water temperature and salinity at a lighthouse in the region. The surveys define the oceanographic states and the daily sea-water observations provide an index of their occurrence and duration which can be maintained indefinitely at a small cost.

These daily observations have been made continuously in 13 regions since 1933 to provide a back-log of climatological data, which is yet to be compared with the surveys of the regions. Only a few of the surveys have been made and fewer still have been fully analysed. However, when this is completed and the comparisons made, it will be possible to describe the oceanographic state at any time during the period. In effect, the daily sea-water observations allow the synoptic surveys to be utilized over a period of years.

In certain cases it is more convenient to study a region in a hydraulic model than in nature. The problem of introducing fresh and sea water, and simulating the tides in a natural manner, has been solved by researches on the Alberni Harbour model. This fundamental advance permits the detailed study of harbours and estuaries where the observation in nature would be extremely tedious, and frequently ineffectual. In such a model, a typical state can be simulated, checked with data from nature, and repeated as often as necessary until the whole mechanism is understood. This is a new and powerful approach to coastal oceanography whose usefulness is not yet fully explored.

The British Columbia area is large and complex so that it is most practical to study one region at a time, such as a sound, an inlet, or an estuary. Fortunately, there is considerable similarity in the structure and mechanisms of geographically similar regions, and if the laws of behaviour in one example of the type have been determined, it is possible to predict the state in another, or describe it with relatively few observations. Although this fundamental research promises great profit, and the data are available from several type regions, it has not yet been possible to allow time for studying it adequately.

The study of type regions is being carried forward by these three methods: synoptic surveys from ships at sea define the oceanographic state and its cycle of variations; daily sea-water observations from lighthouses serve to monitor the climate and provide an index of the state; hydraulic models allow the study of the more complex situations where great detail is required.

As the various type regions are studied and reported, it is planned to accumulate the information in an Oceanographic Atlas of the British Columbia Coast which will be a ready reference for all purposes. In the meantime, the order of investigation is determined by the demand. This approach may be haphazard in a sense, but there are so many types and so many areas that the order of study is of little concern. It is the general policy that each project should be complete and worth while on its own merits, and that the Oceanographic Atlas should be a consequence of organizing the data accumulated in this way.

In most cases the oceanography contributes to the solution of a specific problem in the sea. To predict the pollution that would be caused by a pulp mill in Alberni Inlet it was necessary to know the currents, dilution, and rate of exchange of the surface inlet waters with the sea, and combine these with knowledge of the properties of the mill sewage and the tolerance of the fish. To clean the sewage off Vancouver beaches it was necessary to find a practical site for the sewer outlet from which the discharge would always be carried to sea.

Sometimes a comprehensive description of the oceanographic state and its seasonal climatology is required, as in the search for a cause of mortality of young herring in Barkley Sound, or the attempt to understand the spawning migration of flatfish in Baynes Sound. The comprehensive studies of Chatham Sound, Georgia Strait, and Juan de Fuca Strait are part of the attempt to find the factors governing the movement of salmon in the sea.

The early investigations explored Georgia Strait (1927-32), the inlets (1931), and along the ocean coast (1933-35), and the present Offshore project is exploring the Pacific Ocean for 500 miles off the British Columbia coast. These surveys show the principal oceanographic features: whether the temperature and salinity are high or low, variable from place to place, or constant; the magnitude of river influence; the nature of tidal and drift currents, and so on. If there is great variability as in Georgia Strait and Alberni Inlet, then the study must be very detailed. If the conditions are uniform, as in Baynes Sound or Dixon Entrance, or the area is similar to one previously studied as Bute Inlet, a few surveys may suffice to define the structure and behaviour.

In general, the limited problems have been answered as they arose. There are reports explaining the extent of Fraser River influence in the sea, making use of the pre-war data in Georgia Strait, Juan de Fuca Strait and off the west coast of Vancouver Island. Pulp mill pollution in Alberni Inlet was predicted and industry was assisted to select a mill that would be tolerable. Furthermore, the method of predicting such pollution in natural waterways was evolved, and has been applied in other situations. In this same research the behaviour of fresh water entering the sea was first described quantitatively. The Nootka study is a description of the properties of that sound, its inlets and approaches, during the summer.

The most intensive studies have been made in Georgia Strait where there were 13 synoptic surveys of the whole area, and 7 detailed surveys of the Fraser River Estuary region in 1950. These data have been organized and collected into Data Records which are being published to make them readily available to other researchers. It is planned to issue reports and charts describing the seasonal cycle of the oceanographic state in terms of temperature, distribution of Fraser River water, and the currents, and leave the deduction of laws and behaviour for later study. This program has been delayed by the priority of the study of Baynes Sound, to determine if the oceanographic conditions in the winter affect the spawning migration of flatfish. This is now complete and the principal study will be resumed.

The Offshore program was undertaken to explore the ocean waters off the British Columbia coast. Two surveys last year and one this year have shown that there is considerably more structure and variation than was anticipated. The tedious analyses of the data are incomplete, but it can be said that the areas of warm water offshore are local, and not continuous across the north Pacific Ocean as formerly supposed. Plans are under way to support this program with daily observations of temperature at the weather ship on Station Peter, 500 miles west of the coast.

An oceanographic exploration of all the inlets along the mainland coast was undertaken jointly with the University of British Columbia's Institute of Oceanography. The previous intensive studies of Alberni and Bute Inlet have established the oceanographic pattern of these seaways; those that follow the pattern can be characterized with relatively little data, and those that differ can be catalogued for further study.

As time goes on, and the back-log of data increases, it will become more and more possible to use the data on hand to solve oceanographic problems and the necessity for special surveys will decrease. Most problems concerning Georgia Strait and the approaches to the Fraser River can now be answered by studying the data records of those surveys. At the most it is only necessary to investigate specific points.

Recently the Group was asked to propose a route for a submarine pipeline to carry natural gas from the mainland to Vancouver Island. It was possible to answer all the questions except the load-bearing capacity of the bottom. This can be determined by a short examination since the feasible routes have been determined by oceanographic knowledge on hand.

The demand for records of the daily observations of sea-water temperature and salinity is increasing as they prove useful for correlating the submarine climate with the fishery. Recently they have been examined at the Institute of Oceanography and the distinct climates in different parts of the coast is defined. From these data alone it was possible to show the summer temperature distribution in the coastal waters. This coincides with the data from the coastal surveys and proves that these data are indices of the oceanographic state.

Juan de Fuca Strait is the principal entrance to Georgia Strait, and its oceanography is a necessary prerequisite for the solution of many fisheries and hydrographic problems. A series of surveys are being undertaken and will continue into next year.

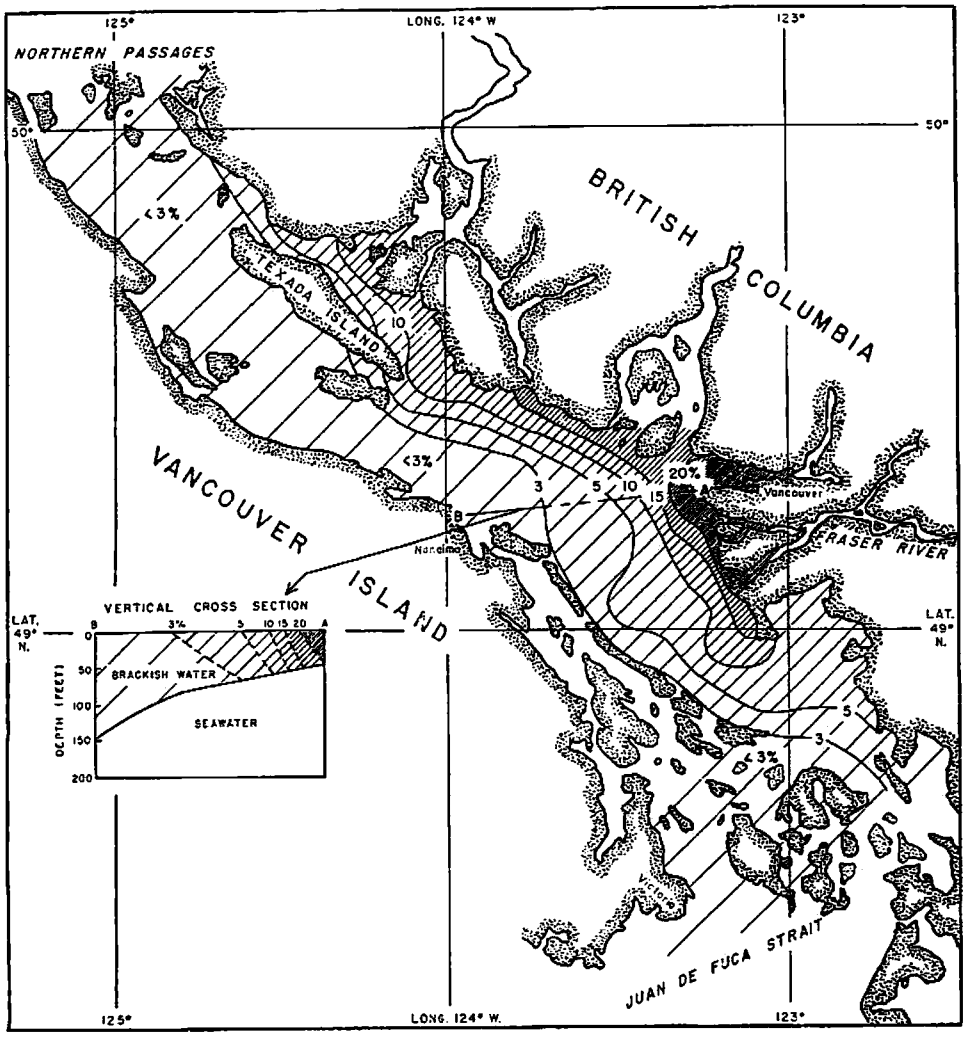
The regions surveyed are shown in Fig. 1, and the development of the data are given in Table I. The state of incompleteness may be charged to lack of qualified scientists. Before the war, surveys were infrequent because shipping was scarce and there was time to study and report much of the data. Since the war, two ships, HMCS Cedarwood and CNAV Ehkoli, have been made available full time, and the data are being collected much faster than they can be analysed and reported. In general there are enough scientists and technicians to make the observations, and provide Progress Reports in the Pacific series, but seldom enough to analyze the data or make complete reports. Because there were no qualified oceanographers available, it became necessary to provide professional training at the post-graduate level. It is not practical to provide this training in the Group, so the Institute of Oceanography at the University of British Columbia was established. Although this withdrew a senior scientist from the Group, it should provide a return of professionally trained scientists, and utilize some of the data in student researches. In the meantime, data are being stockpiled until more scientists are available.

The increasing demand for detailed and precise oceanographic information, and the limited resources, has necessitated increased efficiency in observation and processing of data. New equipment, including winches, sampling bottles, and salinity-analysis equipment, have been put into service. The organization of work is being streamlined so that observations at sea, analyses of sea-water samples, and computations of the data are made by qualified technicians. The scientific staff concentrates its attention on the design of research program, supervision of observation, and the analyses of data, but still the stockpile grows.

This stockpile now includes the surveys of approaches to Juan de Fuca Strait, Dixon Entrance, Chatham Sound, Fraser River Estuary, Juan de Fuca Strait, and the daily sea-water observations. Evidently some provision must be made to engage personnel to analyse and report these data.

TABLE I

Type	Region	Year of study	Daily sea-water reference	State of development
Sound	Nootka Sound	1933 Summer	Nootka	Reported-complete
Coastal	West coast Vancouver Is.	1936 Summer	Amphitrite Kains Is.	Partially reported
Coastal	Approaches to Juan de Fuca	1936-38	Amphitrite	Partially reported
Coastal entrance	Dixon Entrance	1937-38 Summers	Langara	Stockpiled
Fiord estuary	Alberni Inlet	1941	Alberni	Reported-complete
Sound	Chatham Sound	1948	Triple Is.	Stockpiled
Inland sea	Georgia Strait	1927-29 Summers		Reported
		1932, 44, 45		Stockpiled
		1949, 50, 51		Being analysed
Channel	Nodales Channel	1948-51	Cape Mudge	Stockpiled
Estuary	Fraser River Estuary	1950	Entrance Is. Fraser River	Partly reported Stockpiled
Sound	Barkley Sound	1950 April	Amphitrite	Reported
Ocean	Offshore	1950-51	West coast "Peter"	Being analysed
Sound	Baynes Sound	1951 Winter	Cape Mudge	Reported
Inlets	B.C. Inlets	1951 Summer		At Institute of Oceanography
Coastal entrance	Juan de Fuca	1951-52	Race Rocks	Being observed



Percentage and distribution of fresh water in Georgia Strait, May 1950.

OTHER INVESTIGATIONS

Several other investigations have been continued during the year. Data on the California fishery for sardines was interpreted as an indication of the prospects for a Canadian pilchard fishery, resulting in a gloomy forecast. The work of assembling a report on anchovy is continuing and analyses for growth and maturity studies are complete. The statistics of the 1951 eulachon fishery in the Fraser River show a great increase in availability over last year's low. Several studies have been concerned with the parasites which depreciate the salability of fisheries products. Two new British Columbia records of marine polychaetes have resulted from collections made in connection with other investigations, and work on a monograph of Polychaeta Sedentaria was completed. The effect on teredos of the phenyl resin used in plywood manufacturing is being tested. Biological data associated with an oceanographic survey of British Columbia inlets have been collected and are being analysed.

ACKNOWLEDGEMENTS

Many parts of the work at the Pacific Biological Station need the interest and help of various branches of the fishing industry and the Department of Fisheries in order to be carried out effectively. The extensive tagging programs must have the active co-operation of a large part of the fishing industry, either as individuals returning tags directly or as companies accommodating in their plants equipment for the mechanical recovery of tags. The Fishermen's Co-operative Federation, and the Prince Rupert Fishermen's Co-operative Association have accommodated Station representatives engaged in salmon tagging. British Columbia Packers Limited, The Canadian Fishing Co. Ltd., and Nelson Bros. Fisheries Ltd., have loaned boats for the herring tagging program as a result of arrangements made by the Chairman of the Pacific Sub-Executive Committee. The Skeena River Advisory Committee has continued its interest in the salmon work in northern British Columbia.

Other kinds of assistance have been given. Bloedel, Stewart & Welch Ltd. have made grants facilitating the equipment of the Ocean Model Laboratory. The Hydrographic Service has loaned equipment and co-operated in work at sea. The Lighthouse Service has facilitated the sampling for the daily sea-water observation program. The Meteorological Service has supplied transcripts of data. Department of Fisheries officers have co-operated freely in many matters. The engineers of the Pacific Experimental Station have given valuable professional advice.

BUILDINGS AND GROUNDS

Cold-rooms to hold temperatures at 32° to 34°F. and 0° to 2°F. have been installed in the main building. These rooms are used for storing specimens and samples, and maintaining food supplies for fish used in experiments.

Plans are in preparation to equip the three basement laboratories with facilities for work in experimental biology.

Ventilation in the furnace-room and the supplying of special services (gas, compressed air, etc.) are continuing problems in the main building.

A lunch-room for the staff is nearing completion in the old oceanographic laboratory. When it is completed the second-floor general laboratory now used by the staff will be free for use as a draughting- and computing-room.

The former residence building, now referred to as the Annex, is being used in three ways. The Pacific Oceanographic Group now occupies the ground floor where provision is made for the Chief Oceanographer's office, general office, draughting-room, titrations-laboratory, workshop and receiving-room, storage-room, and eight office-laboratories. A concrete vault outside the building but contiguous to it provides suitable storage for irreplaceable data.

Two large rooms in the Annex basement are to be used as a museum.

On the upper floor of the Annex, two self-contained furnished suites have been installed to accommodate staff members who are normally absent in the field or who have recently joined the staff.

Many details of arrangements on the grounds have had to await completion of the work on the salt-water fire protection system. The tenders for this work have been let and construction is due to begin in November.

The fresh-water system installed last year has given satisfactory service, although rather onerous manual operation was necessary following a period of prolonged droughts. It seems probable that this can be corrected by minor adjustments. An additional catch basin should be installed to increase general water availability.

VESSELS

The Investigator No. I continues to give reasonably good service. There is, however, continuing need for an additional large vessel regularly in the Station's service. Plans have been completed for an 85-foot Station seiner fitted with suitable laboratory and other special provisions for scientific work at sea.

Arrangements are under way to purchase and refit a 42-foot seaworthy troller for use as a service vessel in the salmon investigations.

PUBLIC RELATIONS AND RELATIONS WITH OTHER AGENCIES

If the Station is to achieve its greatest possible usefulness, the results of its work must be generally known and applied. Many of the results are made known to scientists through formal publications reported elsewhere. More direct approaches are necessary to inform the general public and to satisfy special needs.

In most cases, co-operation with representatives of the Fisheries Department has resulted in mutual advantage with a helpful exchange of opinions and an addition to available information. Instances in which the Station has been consulted follow:

The staff has helped and been helped by the Statistics Department.

Records of the counts of migrating sockeye entering Babine Lake were supplied regularly to Departmental officers. These counts gave early indication of unprecedented difficulty for fish in passing through the Babine Canyon. Assistance was given to the Department in diagnosing and locating the obstruction.

A staff member was consulted on the installation and operation of the Bridge River eyeing station.

There has been mutually beneficial co-operation with the Department of Fisheries in setting up the "key stream" program intended to furnish information on reproductive success in coastal areas and to provide a basis for prediction of runs.

Advantage was taken of an opportunity provided by the Chief Supervisor to outline for the supervisors and other senior officers the research program for the Station.

On another occasion the herring program was discussed fully with the fisheries officers whose aid was sought (and enthusiastically given) in assessing the amount of herring spawn deposition.

Copy has been provided to Departmental publicity officers for several Fisheries Fact Sheets. These sheets have proved useful on several occasions in meeting requests for information at the Station.

As a basis for the negotiations of the fisheries provisions of the Peace Treaty with Japan, a full submission was made to the Department on certain aspects of the fisheries and investigations of the salmons, the groundfish, herring, pilchard, crab, and albacore.

Certain services to the fishing industry have been given directly. A survey of nematode parasites in herring was undertaken and the results interpreted for the industry. Forecasts for the herring and pilchard fisheries have been provided. Information on the availability of herring and anchovy schools has been provided to the people most interested. Certain aspects of the program were described to senior representatives of the fishing industry at a meeting arranged through the Chairman of the Pacific Sub-Executive Committee.

Possibly some of the most useful work has been in cases when the Station has attempted to combine services to the Fisheries Department and to the fishing industry. The Station has taken an active part in the adjustment of herring quotas so that a good spawning stock was preserved while not allowing the resource to be wasted. Areas closed to trawling have been opened on an experimental basis to the advantage of both the industry and the economy of the country. A very useful service was provided when a memorandum submitted to Canada's delegate to the 1951 International Whaling meetings was instrumental in staving off a critical blow to the Canadian whaling industry. In view of the evidence that finback whales from the British Columbia coast reach sexual maturity at average lengths some 5 feet less than do those from the southern hemisphere and that the growth rate for this species is greater in the southern hemisphere, an amendment was made to the general proposal that the size limit for finback whales be increased by 5 feet. The schedule of the International Whaling Convention was subsequently amended to increase the length limit only for finbacks of the southern hemisphere.

Other government agencies have been helped in various ways. Data were analyzed for the Tidal Branch of the Hydrographic Survey to determine the reasons for the anomalous depression of mean sea level at Seymour Narrows, and general laws relating mean level with net tidal flow established. At the request of the Provincial Game Department, pollution by coal-mine effluent in the Trent and Tsable Rivers was assessed. Advice on other pollution problems has been given from time to time.

Other industries have been assisted also. Advice was given to the California Solar Salt Company about the practicability of salt making in British Columbia. The B. C. Electric Company and the B. C. Power Commission were helped in regard to installing submarine gas-pipe lines and power lines respectively.

The general public continues to show considerable interest in the Station and there are many casual visitors. Prepared demonstrations of the general work of the Station have been arranged for the New Westminster Board of Trade, the executive of the western section of the combined Canadian Clubs, the Vancouver Natural History Society, and several school

groups. A formal demonstration of the Alberni Harbour Model was given to an invited audience. Lectures on phases of the Station's activities have been given to service clubs, university groups, and to the University Women's Club of Nanaimo. Information has been supplied to several radio stations for programs dealing with the Station's work.

As a feature to interest visitors, and to help explain the work of the Station to them, the Station museum is being reorganized and enlarged. When completed the museum will occupy the two basement rooms of the Annex Building. In one room the displays, now virtually completed, will consist of a series of nine 8-foot by 6-foot wall boards explaining by pictures and captions the history and organization of the Fisheries Research Board of Canada and the Pacific Biological Station, and the work of the herring, salmon, groundfish, tuna, and whale investigations, together with panels illustrating different methods of determining the age of fish and different methods of tagging them. A display on the crab fishery is also planned. In the second room will be housed exhibits of the marine invertebrates and fishes of British Columbia. The invertebrate collection will be arranged primarily to illustrate a "family-tree" type chart, showing the probable order of evolution and the relationship between the major groups of animals. The fish collection, representative of the more common groups found along the British Columbia coast, will be arranged in somewhat the same manner to show the relationship between the various groups and to varying degrees of specialization. In addition to these collections there will be illustrated charts showing the different modes of development and life histories of such invertebrates as a jellyfish, a worm, a squid, an oyster, a starfish, and a crab. To emphasize the illustrations, actual examples of the different stages will be provided where possible. There will also be displays illustrating the life histories of a typical pelagic, demersal and anadromous fish; the herring, lemon sole, and salmon will be used as examples. These displays will be arranged so that the differences in size of the various stages (egg, larva, etc.) will be readily apparent. Explanatory cards will accompany these exhibits, pointing out the ecological significance of the various differences between the stages. It is felt that a museum organized along these lines will be a useful way of explaining to the public the work done at the Station.

Staff members continue to play an important part in various scientific organizations and conferences. Several members attended the meetings of the Pacific Fisheries Biologists at Harrison Lake and took active parts in the discussions. Dr. R.E. Foerster was invited to be one of the panel of speakers on Fish and Power at the B. C. Resources Conference.

The growing value of the Station's contributions to practical fisheries research was recognized through the Director when he was included in the delegation to discuss the fisheries section of the treaty for the North Pacific Ocean.

PAPERS PUBLISHED DURING PERIOD NOVEMBER 1, 1950 TO OCTOBER 31, 1951

Andrew[illegible]son, A., and D.R. Foskett. Contributions to the life history of the sockeye salmon (No. 35). Report British Columbia Fisheries Department, 1949, pp. 26-40 (published in 1950).

[illegible], F.T. The return of sockeye salmon marked at Babine and Lakelse [illegible]es. Prog. Rept. Pac., no. 87, pp. 37-38.

Bilton, T.H. Creel census studies at Lakelse Lake, Skeena River. Prog. Rept. Pac. no. 87, pp. 39-41

Brett, J.R. A study of the Skeena River climatological conditions with particular reference to their significance in sockeye production. J. Fish. Res. Bd. Can., vol. 8, no. 3, pp. 178-187.

Butler, T.H. Two records of shrimps from English Bay, British Columbia. Canadian Field Naturalist, vol. 64, no. 5, Sept.-Oct., 1950, p. 188.

Doe, L.A.E. Sea surface temperatures. Prog. Rept. Pac. no. 88, pp. 53-56.

Foerster, R.E. The effect of power dams on Pacific salmon production. Transactions Fourth British Columbia Natural Resources Conference, pp. 128-140.

Pacific salmon investigations. Canadian Department of Fisheries Trade News, Sept., 1951, vol. 4, no. 3, pp. 3-5, 20.

Foskett, D.R. Young salmon in Nanaimo area. Prog. Rept. Pac. no. 86, pp. 18-19.

Hart, J.L. Pacific herring investigation. Canadian Department of Fisheries Trade News, April, 1951, vol. 3, no. 10, pp. 6-7.

Address: Chairman, Western Division, American Fisheries Society, Proceedings 30th Annual Conference Western Association State Game & Fish Commissioners, p. 5.

Hoar, W.S. The chum and pink salmon fisheries of British Columbia, 1917-47. Bull. Fish. Res. Bd. Can., no. 90, pp. 1-46.

Hollister, H.J. Daily sea-water observations along the west coast of Vancouver Island. Prog. Rept. Pac. no. 86, pp. 6-11.

Hunter, J.G. Efficiency of reproduction of pink salmon (Oncorhynchus gorbuscha) in the north central coastal area of British Columbia. Prog. Rept. Pac. no. 88, pp. 70-71.

Ketchen, K.S. The migration of lemon soles in northern Hecate Strait. Prog. Rept. Pac. no. 85, pp. 75-79.

Preliminary experiments to determine the working gape of trawling gear. Prog. Rept. Pac. no. 88, pp. 62-65.

Ketchen, K.S., R.I. Peterson and C.R. Forrester. Fluctuations in the length and age composition of lemon soles and rock soles in northern Hecate Strait. Prog. Rept. Pac. no. 87, pp. 27-31.

Manzer, J.I. Growth in lemon soles in northern Hecate Strait. Prog. Rept. Pac. no. 86, pp. 13-15.

McHugh, J.L., and W.E. Barraclough. An abnormal carp, Cyprinus carpis, from California waters. California Fish & Game, vol. 37, no. 4, pp. 391-393.

McMynn, R.G. A study of the crab (Cancer magister Dana) fishery off Graham Island, British Columbia. Bull. Fish. Res. Bd. Can., no. 91, pp. 1-21.

Milne, D.J. The difference in the growth of coho salmon on the east and west coasts of Vancouver Island in 1950. Prog. Rept. Pac., no. 85, pp. 80-82.

Neave, F. Observations on troll-caught salmon of the west coast of Vancouver Island, 1949. Pacific Marine Fisheries Commission, no. 2, pp. 93-101.

Outram, D.N. Observations on the retention and spawning of the Pacific herring. Prog. Rept. Pac., no. 87, pp. 32-33.

Stevenson, J.C., and J.A. Lanigan. Results of the west coast of Vancouver Island herring investigation, 1949-50. Report British Columbia Fisheries Department, 1949, pp. 41-80 (published in 1950).

Tully, J.P. Seasonal cycles in the sea. Prog. Rept. Pac., no. 85, pp. 88-90.

MANUSCRIPTS SUBMITTED FOR PUBLICATION DURING PERIOD
NOVEMBER 1, 1950 TO OCTOBER 31, 1951

Barraclough, W.E. The agonid fish Pallasina barbata aix (Starks) from British Columbia. J. Fish. Res. Bd. Can.

Berkeley, E., and C. Berkeley. Annelida Polychaeta Sedentaria. Canadian Pacific Fauna Series.

Rediscovery of the polychaete worm, Trypanosyllis ingens Johnson. J. Fish. Res. Bd. Can.

Brett, J.R. Temperature tolerance in young Pacific salmon, genus Oncorhynchus. J. Fish. Res. Bd. Can.

Doe, L.A.E. Physical oceanography of Loudoun Channel. J. Fish. Res. Bd. Can.

Foskett, D.R. Contributions to the life history of the sockeye salmon. (No. 36). Report British Columbia Fisheries Department.

Hoar, W.S. The behaviour of chum, pink, and coho salmon in relation to their seaward migration. J. Fish. Res. Bd. Can.

The chum and pink salmon fisheries of British Columbia, 1917-1947. Bull. Fish. Res. Bd. Can.

Manzer, J.I. Some notes on dispersion and growth of some British Columbia bottom fishes. J. Fish. Res. Bd. Can.

The effects of tagging upon a Pacific coast flounder, Parophrys vetulus. J. Fish. Res. Bd. Can.

Pike, G.C. Lamprey marks on whales. J. Fish. Res. Bd. Can.

Quayle, D.B. The butter clam (Saxidomus giganteus Deshayes): studies in productivity - digging frequencies. J. Fish. Res. Bd. Can.

Stevenson, J.C., A.S. Hourston, and J.A. Lanigan. Results of the west coast of Vancouver Island herring investigation, 1950-51. Report British Columbia Fisheries Department.

Ricker, W.E. The benthos of Cultus Lake. J. Fish. Res. Bd. Can.

MANUSCRIPT REPORTS AND CIRCULARS PREPARED DURING PERIOD NOVEMBER 1, 1950 to OCTOBER 31, 1951.

Anon. Observations of sea-water temperature, salinity, and density on the Pacific coast of Canada, vol. X. MS. Rept. Fish. Res. Bd. Can., no. 438.

Fjarlie, R.L.I. The oceanographic phase of the Vancouver sewage problem. MS. Rept. Fish. Res. Bd. Can., no. 412.

Hart, J.L. Prospects for the pilchard fishery. Pac. Biol. Sta. Circ., no. 22.

Hart, J.L., F. Neave, and D.B. Quayle. Brief on the fishery wealth of British Columbia. MS. Rept. Fish. Res. Bd. Can., no. 425. (Reprocessed).

Hourston, A.S. Preliminary studies of the juvenile stage of the Pacific herring (Clupea pallasii). MS. Rept. Fish. Res. Bd. Can., no. 411.

Nuttall, J.S. Interim report: hydraulic model of Alberni Harbour. MS. Rept. Fish. Res. Bd. Can., no. 413.

Partlo, J.M. A report on the 1950 albacore fishery of British Columbia. Pac. Biol. Sta. Circ., no. 23.

Stevenson, J.C. Marking and recovery as a means of studying the movements of fish. MS. Rept. Fish. Res. Bd. Can., no. 410.

Prospects for the 1951-52 herring fishing season. Pac. Biol. Sta. Circ., no. 24.

UNPUBLISHED MANUSCRIPTS SUBMITTED PRIOR TO OCTOBER 31, 1951

Barraclough, W.E. The development of the dogfish fishery in British Columbia. Seventh Pacific Science Congress.

Brett, J.R. Skeena River sockeye escapement and distribution. Bull. Fish. Res. Bd. Can.

Fisher, H.D. The biology and economic status of the harbour seal (Phoca vitulina Richardii) in the Skeena River, British Columbia. Bull. Fish. Res. Bd. Can.

Foerster, R.E. Fisheries research along the Canadian Pacific coast. Seventh Pacific Science Congress.

Hart, J.L. The trawl fishery in British Columbia. Seventh Pacific Science Congress.

Neave, F., and W.P. Wickett. Factors influencing the fresh-water development and production of salmon. Seventh Pacific Science Congress.

Pike, G.C. Whaling along the British Columbia coast. Seventh Pacific Science Congress.

Tully, J.P. Notes on fresh water entering the sea. Seventh Pacific Science Congress.

Oceanographic data of the western Canadian Arctic region, 1935-37. J. Fish. Res. Bd. Can.

STAFF

The work of the Station is benefiting by the return to full duty at the Station of several staff members, Dr. J.R. Brett, Messrs. W.E. Barraclough, T.H. Butler, J.C. Stevenson, and F.H.C. Taylor. Messrs. J.G. Hunter and F.C. Withler have been granted educational leave at half pay. Mr. Hunter is registered at the University of Washington and is arranging to do some work at the University of Paris, and Mr. Withler is planning to work from Cambridge, England. Mr. J.G. Robertson has been given leave without pay to continue his work at the University of British Columbia.

Three staff members in the scientific classifications have resigned during the year, Messrs. Fjarlie and Lanigan, and Mrs. Anne Herlinveaux. One addition has been made to the scientific staff in Mr. M.P. Shepard. Mr. Shepard will assist with the salmon investigations.

The Board's editorial staff is accommodated at the Pacific Biological Station, which has profited by the advice of the Editor, Dr. W.E. Ricker.

Following is a list of Station staff and classifications to November 1, 1951.

SCIENTIFIC - FULL-TIME

J.L. Hart, M.A., Ph.D., F.R.S.C.	Director
R.E. Foerster, M.A., Ph.D., F.R.S.C.	Principal Scientist
F. Neave, M.Sc., Ph.D.	Principal Scientist
J.P. Tully, M.B.E., B.Sc., Ph.D., A.I.C., F.C.I.C.	Principal Scientist
J.R. Brett, M.A., Ph.D.	Associate Scientist
K.S. Ketchen, M.A.	Associate Scientist
D.J. Milne, M.A., Ph.D.	Associate Scientist
J.C. Stevenson, M.A.	Associate Scientist
W.E. Barraclough, M.A.	Assistant Scientist
T.H. Butler, B.A.	Assistant Scientist
L.A. Doe, M.A.	Assistant Scientist
R.L. Fjarlie, B.Sc.E.	Assistant Scientist (to 31 Jul 51)
D.R. Foskett, M.A.	Assistant Scientist

A.S. Hourston, M.A.	Assistant Scientist
J.G. Hunter, M.A.	Assistant Scientist (on educational leave)
J.I. Manzer, B.Sc., M.A.	Assistant Scientist
D. McKinnon, M.A.	Assistant Scientist
V.H. McMahon, B.A.	Assistant Scientist
G.C. Pike, M.A.	Assistant Scientist
J.G. Robertson, B.Sc., M.A.	Assistant Scientist (on educational leave)
M.P. Shepard, M.A.	Assistant Scientist (from 1 Sep 51)
F.H. Taylor, M.A.	Assistant Scientist
R.J. Waldie, M.C., B.A.	Assistant Scientist
W.P. Wickett, M.A.	Assistant Scientist
F.C. Withler, M.A.	Assistant Scientist (on educational leave)
K.V. Aro, B.A.	Junior Scientist
G.R. Harris, B.A.	Junior Scientist (to 12 Jan 51)
Anne Herlinveaux, M.A.	Junior Scientist (to 16 Nov 51)
K.J. Jackson, B.A.	Junior Scientist
J.A. Lanigan, B.Sc.	Junior Scientist (to 3 Nov 51)
J.G. McDonald, B.A.	Junior Scientist
D.N. Outram, B.A.	Junior Scientist
J.M. Partlo, B.A.	Junior Scientist
J.A. Shand, B.Sc.	Junior Scientist (to 31 May 51)

TECHNICAL AND ADMINISTRATION - FULL-TIME

G.F. Hart	Executive Assistant
E.K. Inch	Clerk Grade 4
Ethel Robinson	Clerk Grade 4
G.T. Taylor	Clerk Grade 3
Evelyn Keighley	Clerk Grade 2B
Margaret Philp	Stenographer Grade 2B
Beverley Berisford	Stenographer Grade 2A
Fay Dorman	Stenographer Grade 2A
Marjorie Elliott	Stenographer Grade 2A (to 22 Aug 51)
Ruth Taylor	Clerk Grade 2A
Mary Cairns	Stenographer Grade 1 (from 1 Jun 51)
Marjorie Moore	Stenographer Grade 1 (from 1 Aug 51)
Alice Nyquist	Stenographer Grade 1
Kay Rausch	Stenographer Grade 1 (from 16 Aug 51)
Agnes McLean	Typist Grade 1 (to 18 Jul 51)
Laura Nicholson	Typist Grade 1
H.J. Hollister	Technician Grade 3
J. Martell	Technician Grade 2
A.G. Paul	Technician Grade 2
R.C. Wilson	Technician Grade 2
R.H. Eaton	Technician Grade 1
E.V. Epps	Technician Grade 1
E. Louise Harper, B.A.	Technician Grade 1
R.E. Hirst	Technician Grade 1
Ruth Peterson, B.A.	Technician Grade 1 (to 7 Sep 51)
K.R. Sutherland	Technician Grade 1
A.N. Yates	Technician Grade 1
W. Caulfield	Assistant Technician Grade 3
A.S. Coburn	Assistant Technician Grade 3
C.R. Forrester	Assistant Technician Grade 3
R.S. Isaacson	Assistant Technician Grade 3

J.H. Larkman	Assistant Technician Grade 3
D.H. McDermott	Assistant Technician Grade 3 (to 15 Apr 51)
C.J. Morley	Assistant Technician Grade 3
H. Neate	Assistant Technician Grade 3
W.G. St. Clair	Assistant Technician Grade 3
R.M. Wilson	Assistant Technician Grade 3
K.A. Herlinveaux	Assistant Technician Grade 2
W.W. Morgan	Assistant Technician Grade 2 (to 20 Oct 51)
D.J. Odlum	Assistant Technician Grade 2
J.A. Saker	Assistant Technician Grade 2
W.C. Stephenson	Assistant Technician Grade 2 (to 31 Mar 51)
D.A. Sutherland	Assistant Technician Grade 2 (from 1 Jun to 15 Jul 51)
R.D. Thicke	Assistant Technician Grade 2 (from 16 Sep 51)
B. Wildman	Assistant Technician Grade 2
R.G. Grubb	Assistant Technician Grade 1 (1 Jan 51 to 30 Apr 51)
N.J. Robson	Assistant Technician Grade 1 (to 9 Oct 51)
J.A. Stickland	Assistant Technician Grade 1 (from 1 Sep 51)
T. Russell	Caretaker Grade 6
A. Rigby	Caretaker Grade 4
J.C. Wallace	Caretaker Grade 3 (from 1 Dec 51)
E. Baldwin	Watchman
O. Perrin	Watchman
W.J. Hogan	Cleaner & Helper
G.T. Worden	Cleaner & Helper

BOAT CREWS

W. Duprey	Ship's Captain (29 Jan to 21 May 51)
H.K. Pinchin	Ship's Captain (to 10 Feb 51)
W.R. Brandon	Ship's Engineer (to 17 Mar 51)
D.H. Peerenboom	Cook-Deckhand (to 31 Mar 51)
	Ship's Engineer (from 1 Apr 51)
R.T. Hearns	Ship's Mate (to 4 Aug 51)
A.E. Ranger	Ship's Mate (from 25 Jul 51)
P. McKie	Cook-Deckhand (from 1 Sep 51)

TERM

T.H. Bilton, B.A.	Technician Grade 1 (to Sep 52)
B.M. Chatwin, B.A.	Technician Grade 1 (to Sep 52)
E. Dombroski, B.A.	Technician Grade 1 (to Sep 52)
H.G. Irwin, B.A.	Technician Grade 1 (to 31 Mar 51)
E.A. Ball	Assistant Technician Grade 2 (to 30 Sep 52)
J.S. Gibson, M.A.	Caretaker Grade 1 - Port John (from 4 Nov 50 to 31 Mar 51)

PART-TIME

N.R. Barwick	Observer - Babine
S. Dales, B.A.	Observer - Vancouver (from 21 Sep 51)
R.J. Karjala	Observer - Vancouver (to 30 Apr 51)

SEASONAL

G.L. Pickard, M.B.E., M.A., Ph.D.	Associate Scientist (15 May to 15 Sep 51)
W.S. Hoar, M.A., Ph.D.	Assistant Scientist (14 May to 13 Jul 51)
J.B. Nuttall, M.Sc.	Assistant Scientist (1 Jun to 30 Jun 51)
R.C. Arrowsmith, B.A.	Junior Research Assistant (29 May to 26 Aug 51)
A.W. Beach	Junior Research Assistant (10 May to 15 Sep 51)
N.F. Bourne	Junior Research Assistant (10 May to 13 Sep 51)
S. Dales, B.A.	Junior Research Assistant (1 May to 20 Sep 51)
R.R. Gardner, B.A.	Junior Research Assistant (14 May to 15 Sep 51)
M.H. Keenleyside	Junior Research Assistant (17 May to 30 Aug 51)
T.M. Mitchell, B.A.	Junior Research Assistant (28 May to 30 Aug 51)
W.J. Mitchell	Junior Research Assistant (28 May to 5 Sep 51)
V.R. Taylor, B.Sc.	Junior Research Assistant (1 May to 20 Sep 51)
L. Margolis, M.A.	Assistant Technician Grade 1 (10 May to 30 Sep 51)
P.W. O'Shaughnessy	Assistant Technician Grade 1 (16 Jun to 14 Aug 51)
R.F. O'Shaughnessy	Assistant Technician Grade 1 (16 Jun to 14 Sep 51)
J.A. Thomson	Assistant Technician Grade 1 (17 May to 13 Sep 51)

VOLUNTEER INVESTIGATORS

C. Berkeley, F.C.I.C.	
E. Berkeley (Mrs.)	
L. Margolis, M.A.	(1 Oct to 4 Nov 51)

ORGANIZATION

The organization of the staff within the various investigations is dealt with in the Summary Reports. The scientists in charge of each group consult with the Director concerning scientific programs and with the Executive Assistant concerning details of finance and supply. Assisting the Director are Miss Robinson and Mr. F.H.C. Taylor. It is planned to provide Miss Robinson with clerical assistance. The Executive Assistant, Mr. G.F. Hart, reports directly to the Director. Answering to him are the Accountant, Mr. E.K. Inch (resigned), the Bookkeeper, Mr. G.T. Taylor (transferred), a Clerk, Miss K.A. Rausch, and the Switchboard Operator, Miss M.C. Cairns. The

File Clerk, Miss L. Nicholson, reports directly to the Executive Assistant, as do the maintenance technicians, E.V. Epps, K.R. Sutherland, and C.J. Morley. The Chief Caretaker, T. Russell, or his second, A. Rigby, report directly to the Executive Assistant and they are responsible for the Assistant Caretaker, J.C. Wallace, the watchmen, E. Baldwin and O. Perrin, and the cleaners, W.J. Hogan and G.T. Worden. The skippers of the boats, Investigator No. I (A.N. Yates) and Siliqua (R.C. Wilson) are responsible for maintenance, etc., to the Executive Assistant and for program to the scientists in charge of the respective investigations. It is understood that a skipper cannot be instructed to place his ship in jeopardy. Many of the technicians are now rather specially trained and are permanently attached to investigations. Others (designated as pool technicians) are less specialized or more versatile and are transferred to other investigations or assist with developing the general plants on the close of field work or special assignments for investigations.