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FISHERIES RESEARCH BOARD OF CANADA

ANNUAL REPORT

OF THE

PACIFIC BIOLOGICAL STATION

FOR

1954

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A.W.H. NEEDLER, DIRECTOR

(WITH INVESTIGATORS' SUMMARIES AS APPENDIC ES)

NANAIMO. B.C

DECEMBER, 1954.

FISHERIES RESEARCH BOARD OF CANADA

Annual Report for 1954
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Pacific Biological Station
Nanaimo, B.C.

The fishing industry of British Columbia is well-equipped with men, gear and skills, and it depends in the main on a highly intensive fishery for relatively few species, among which the salmons are by far the most important. Its future depends on the maintenance of these stocks and on the discovery of others which can be exploited profitably. It follows that the Pacific Biological Station, in order to provide the knowledge on which the best development of the industry can be based, must devote a great deal of its efforts to solving the problems of maintaining the important salmon stocks both by regulating the fishery for them and by preserving or improving the conditions for their reproduction in fresh water. Attention must also be given to the problems of regulating intensive fisheries for other species including herring, crab, and some groundfish. A small but increasing effort is spent on exploration for unused stocks. As a background for all these projects it is necessary to improve our knowledge of physical and biological conditions in the sea and in fresh water, and of the factors controlling the numbers and activities of the many species with which we are concerned.

Regulation of fishing. The preponderant importance of salmon to the British Columbia fisheries, and their great vulnerability as they approach and enter rivers to spawn, give the regulation of the salmon fishery a special importance. If entirely unrestricted it could catch almost all the salmon and reduce the stocks to a very low level. The Department of Fisheries, with the support of the industry, has regulated it with commendable success and it has survived more than a half-century of intensive fishing, with yields somewhat reduced but still substantial. There is, however, need for more precise knowledge. The purpose of the regulations is to permit enough salmon to pass through the fishery to the spawning grounds and it is important to know just how many must be allowed to spawn in order to keep the catch at a maximum. The numbers of young salmon produced by known numbers of spawners have been and are being studied in several streams and lakes with varying conditions, emphasis being placed on sockeye salmon, with pink and chum salmon next. It is necessary to learn the effects of changing natural conditions on the production of young salmons and on the size of the salmon stocks and to distinguish these effects from those of the fishery.

Good equipment and organization make possible very intensive fishing of the herring stocks when they concentrate in inshore waters before spawning. There is danger of over-fishing and the fishing is under regulation. The effects of the fishery on the herring stocks is being studied to improve the basis for regulation to keep the yield at a maximum. Other intensive fisheries include those for crab and certain species of groundfish and these, too, are being studied from this point of view.

The whale fishery, being under international regulation, is a special case. In accordance with the policies and program of the International Whaling Commission, the general biology of whales in British Columbian waters and the relation of these stocks to those of other areas are being studied.

Prediction of changes in the abundance of fish stocks is important both to profitable fishing and to effective regulation. The same studies improve the basis for both regulation and for prediction. In some cases, especially that of the herring fishery, predictions have become accurate enough to be useful.

Softening the impact of industrial development. The increasing use of fresh water for power, irrigation, and other industrial and domestic purposes is a serious threat to salmon production both by diverting water to other uses and by installing dams which obstruct both the upstream movements of spawning adults and the return of the young to the sea. These problems are not yet as acute in British Columbia as in some other areas but they are becoming more so. The Station is cooperating with other agencies in developing means of guiding salmon past obstructions.

The extent of various types of industrial pollution is under observation and their effects on valuable species are being studied in the laboratory and in the field. In the case of pulp mill pollution especially, it has been possible to advise the administration and the industry how to avoid damage to fisheries.

Improvement of conditions for salmon reproduction. The growing demand for salmon and the growing effects of industrial development on natural production combine to make it important to examine ways of increasing production artificially. "Fish culture", in the broadest sense, may eventually become essential if stocks are to be maintained at a high level. Some present work has potential value for such a development and more may be needed in the near future. In 1954 an experimental planting of pink salmon eyed eggs was made in an artificial spawning bed. Progress was made in a study of the conitions necessary in the gravel for the survival and development of salmon eggs and fry. Other phases are also under study.

Exploration for fisheries development. The fishing industry in British Columbia has depended in the main on species caught readily in large quantities in inshore waters. The halibut fishery, which is the responsibility of the International Pacific Halibut Commission rather than of this Station, is an exception in that vessels travel considerable distances to the fishing grounds, and there has been a tendency for fishing operators generally to become more mobile and extend farther seaward. It is nevertheless true that the potentialities of more distant fisheries, especially for tuna, are virtually unknown. Exploratory fishing, and even reconnaissance, are very expensive in offshore waters, thus limiting the activity of the industry and making government participation essential. The possible importance of offshore fishing to the long-term future of the industry and the greater knowledge of offshore distribution of salmons needed by the International North Pacific Fisheries Commission are turning attention seaward. In the meantime, explorations have been limited to less ambitious operations to discover unused stocks of inshore species, such as shrimp.

Background for fisheries research and development. All of the research and development projects ~~maintained~~ MENTIONED above and, indeed, the recognition of ~~preserving~~ PROMISING new lines of endeavour depend on a broad knowledge of oceanographic conditions and of the biology of species which do or can contribute to the fisheries. It is necessary to know the conditions in the sea which determine the distribution, movements and numbers of the fish and shellfish on which our fisheries depend. This knowledge, which is essential both to the most efficient fishery and to the most effective regulations alike, has been developed energetically in inshore waters; attention now and in the future must be directed more and more seaward. It is necessary also to learn the manner in which the conditions affect the behaviour and the numbers of the important species. This is being attempted both by experimentation in the laboratory and by observation in the field--the former to reveal the action of individual factors and the latter to discover their actual effect in the complex conditions which prevail in nature. These oceanographic and biological studies, which are so essential to progress in fisheries research and development, must keep pace with more direct studies of the problems of the fishery if the latter are to be solved effectively.

SOCKEYE SALMON

During 1954 progress was made in the research program designed to provide information on (a) the relation of numbers of adult spawning sockeye (the escapement) to the numbers and size of seaward-migrating young produced, (b) the factors affecting and limiting natural production of young sockeye, and (c) the annual variations in age, size and sex composition of the sockeye in the commercial catches of four of the major sockeye-producing areas of the Canadian Pacific coast. Investigations were carried on at Babine Lake which accommodates more than half the spawning escapement of the Skeena River system; at Lakelse Lake, where the effort is directed primarily towards fundamental studies of their life history in fresh water; at Port John, where incidental observations on sockeye in a small, coastal-lake area are made in conjunction with a pink and chum salmon program; and at coastal canneries where the catches of the Rivers Inlet, Smith Inlet, Skeena River and Nass River fisheries are sampled. An important feature of having observations and data from several sockeye areas, which differ in size, geographical position and climate is that a greater range of natural conditions is involved, and hence correlations between production and pertinent limiting factors, such as climate and lake conditions, can be more clearly evaluated.

Smolt production from natural spawning at varying adult population densities. While the studies at all three field stations, Babine, Lakelse, and Port John, are providing information, the data from Babine are of particular significance since they have to do with the major sockeye-producing area of the Skeena River system. Here the program centres around the Babine River adult-counting weir and the installations which have been developed to estimate the size of the annual smolt run from the lake.

(a) Babine Lake spawning runs and seedings. The adult salmon spawning escapement to Babine Lake area each year has been enumerated since 1946, as shown in the following table:

Year	Sockeye	Percentage "jack" sockeye	Spring	Pink	Coho	Chum
1946	475,705	12.2	10,528	28,161	12,489	18
1947	522,561	50.0	15,614	55,421	10,252	7
1948	560,000[x]					
1949	509,132	9.4	7,433	13,663	11,938	5
1950	543,658	33.0	6,838	38,728	11,654	7
1951[xx]	152,457	7.2	2,778	50	2,122	0
1952[xx]	376,947	7.4	5,915	2,706	10,554	1
1953	714,614	3.9	8,353	1,018	7,648	17
1954	503,422	1.9	5,925	4,604	3,094	66

[x] Estimated from comparison with stream survey counts and fence counts of previous years.

[xx] The runs of 1951 and 1952 were blocked by the Babine River rock slide. The effective spawning in 1952 was less than the number of adults indicates, many fish being damaged or delayed so as to prevent spawning.

The sockeye salmon are of particular interest and, since 1951, the runs have shown considerable variation in magnitude and composition as a result of the rock slide in the Babine River early in 1951. This variation in spawning density has made it possible to obtain pertinent information on the percentage production of young sockeye. This will be of value in assessing the adult spawning escapement required in an area such as Babine for the optimum production of young.

Of course, numbers of fish do not give the full picture of the egg deposition potential of a run. The proportion of females, the size of fish, and their physical condition are important factors. All of these are studied each season. Female fish in the 1954 sockeye run represented about 60% of the total, normal males around 38%, while the "jacks" (males maturing in their third year) contributed less than 2%. The high proportion of females, combined with their larger-than-average size produced the second largest potential egg deposition so far recorded for Babine Lake, viz., slightly over one billion eggs. Only the 1953 run of 714,614 sockeye brought more eggs into the area since the investigation commenced in 1946.

A record peak count of 38,755 sockeye on September 1 probably resulted from the special weekly closures (July 31 to August 2 and August 6 to 8) and a week's suspended fishing (August 9 to 14) during a tendermen's strike. A record low number of injured sockeye in the 1954 run gave further evidence of the effectiveness of the removal in early 1953 of the 1951 rock slide. Twenty-four-hour operation of the counting weir during three periods of the season's run indicated that few sockeye moved upstream at night, and that around 90% of the daily run occurred between 7 A.M. and 7 P.M., the usual hours of weir operation.

(b) Babine Lake smolt production. The smolt runs each spring indicate the extent or percentage of production from the egg deposition two years earlier, e.g., the smolts of 1954 resulted mainly from the egg deposition of 1952, since most of the smolts spend one year only in the lake. Smolt estimations commenced only in 1951 and the records of production for the four years are as follows:

Eggs deposited in	1949	1950	1951	1952
Potential deposition	869×10^6	583×10^6	198×10^6	$^x411 \times 10^6$
Smolts resulting	4.2×10^6	4.5×10^6	3.1×10^6	2.8×10^6
Percentage survival	0.48	0.77	1.57	0.68

x Probably two-thirds of these were not actually available (See text). Calculated on presumed actual egg deposition, the percentage survival becomes approximately 2%.

The smolt run of 1954 (brood year 1952) gave the lowest recorded percentage since estimations were begun, if based on the total eggs contained in all females passing the counting weir. However, that part of the 1952 run which passed the rock slide had been seriously delayed, and its up-river ascent severely handicapped. Observations on the spawning grounds indicated that about two-thirds of the females had died unspawned. This appreciably reduced the actual egg deposition and if the smolt production be based on actual egg deposition the rate of survival becomes approximately 2%. Thus, as shown by the 1953 smolt count, there is a tendency for smaller egg depositions to have a greater percentage smolt production, though the actual numbers of smolts migrating are lower than for large egg depositions. The extent of smolt production from the two heavy egg depositions of 1953 and 1954 - to be obtained in 1955 and 1956 - will be of special interest in indicating where the optimum level of sockeye production for the Babine Lake area may lie.

(c) Lakelse Lake smolt production. Only one smolt production determination has been possible since the counting weir for adults and smolts was installed in 1952. From 12,000 adults counted into the lake in 1952, a smolt migration of 379,000 in 1954 indicated a production of 1.8%. For years prior to 1952 (1944, 1945, 1946, 1950, 1951) counts or estimates of the numbers of sockeye on the spawning beds are available, as well as the numbers of smolts produced. These data are being examined critically and the smolt production percentages obtained for the varying spawning population densities which occurred.

Consideration of the smolt counts already available (6 years) indicates that the size of the smolt run from Lakelse Lake has varied within rather narrow limits (mean = 460,000; range = 373,000 to 596,000). Whether or not this lack of wide variability is due to a relative constancy of the spawning escapement awaits examination of data for the 1944-51 spawning runs and presumed egg depositions. Unlike the smolts from other areas, no clear-cut inverse relationship has been found between the mean size of smolts and the magnitude of the migrations.

(d) Port John smolt production. Five years' data are available on smolt production from known egg depositions. Since the smolts emigrating from Port John Lake have been found to be chiefly two-year-old fish, i.e., had spent two years in the lake, consideration must be given to the numbers of one- and two-year smolts in each season's migration. Smolt enumerations have varied from approximately 11,000 to 19,500, with egg depositions ranging from approximately 300,000 to 2,000,000. Tentative calculations suggest a smolt production in the Port John area of from around 0.5% to 6% from calculated egg depositions but precise determinations await completion of full analysis of all the pertinent data.

Factors affecting and limiting natural production of young sockeye. An understanding of the factors that influence, either favourably or adversely, the production of young sockeye to the seaward-migrating smolt stage (1) makes possible a clearer appreciation of the variations in adult sockeye production from year to year, (2) will be of value in predicting the return of adults from known seedings, and (3) provides the information necessary for increasing or rehabilitating stocks in low-producing areas, or for maintaining production in areas where industrial expansion may tend to make conditions less suitable.

Lakelse Lake was selected in 1949 as the site for such study. Techniques have been established for enumerating the sockeye runs each year at various stages of their freshwater life-history, such as egg deposition, fry hatch and smolt migration. Methods describing the physical and organic environment of the sockeye during their freshwater residence, such as, year-round meteorological observations, stream and lake levels and temperatures have been developed. Assessments of the distribution and abundance of food crops (plankton, etc.) are made, as well as annual determinations of the abundance, composition and diet of competitor and predator populations of fish in the lake.

(a) Survival from spawning to emergence of fry. Scully Creek, a small sockeye-producing tributary of Lakelse Lake, has been used for five years as an indicator of fry production from a known number of eggs available. Under varying climatic and adult spawning densities an average fry production of 11.8% (range 9.3% to 13.7%) was obtained. In 1954 a production of 10.1% occurred from an egg deposition of 958,000. In 1953-54 a method of estimating fry production in the main spawning stream of the Lakelse area, Williams Creek, was devised; a production of approximately 7.5% from an estimated 17,750,000 egg deposition was obtained. These fry production records can be compared with the similar data obtained at a test stream, Six Mile Creek, Babine Lake (19% in 1954, 12% in 1951), and at Port John (13.4% in 1954; a mean of 9.5% for earlier years, with range from approximately 1.7% to 25.5%). Stream water flow conditions and abundance and activity of predator fish are found to be important factors affecting survival of eggs, alevins and fry.

(b) Survival during lake residence. During the one-year residence in the lake, heavy losses occur. Records of all factors having an important bearing on survival are being obtained, as stated above. While data on the production of smolts from calculated egg depositions are being obtained from Babine and are available for Lakelse for earlier years, the 1955 smolt counts will give the first determination for Lakelse of smolt survival from estimated fry produced. This and subsequent findings will be comparable with those obtained at Port John, a much smaller area with quite different conditions prevailing.

Since previous studies (at Cultus Lake) have indicated a heavy loss of lake-resident sockeye to predator fish in the lake, whose numbers may be reduced and controlled, special attention is being given to the abundance of predator species in Lakelse Lake, their diets and activities, with a view to subsequent experiments in reduction in their numbers and the effect on sockeye survival. At the same time populations of other lake fish which may compete with sockeye for food are under examination; their reduction and control may also be advantageous. These studies involve extensive creel census work, capture of lake fish by traps and gill nets for

population estimation, food, rate of growth, age composition analyses, etc. Several years' records have been obtained and are being analysed.

Studies conducted by Dr. W.E. Johnson, working under a post-doctoral fellowship from the National Science Foundation of the United States but with some facilities and field assistance from the Fisheries Research Board, are aimed at relating the distribution, growth and survival of lacustrine sockeye with seasonal and annual changes in the density and distribution of zooplankton. In 1954 workable methods were developed for measuring plankton density and distribution and for capturing young sockeye in Lakelse Lake. It is planned to extend observations to a number of lakes with varied conditions.

Studies of the sockeye salmon fishery. Each season for the past 30 years the catches of the Rivers Inlet, Smith Inlet, Skeena River, and Nass River gill-net fisheries, have been sampled to determine the age, sex, and size compositions. The age data indicate the brood years from which the sockeye in the catches originated. For the 1953 and 1954 catches the percentages of the major age-groups in the samples were:

Area	Age-group	1953	1954	40-year average*
Rivers Inlet	4_2	73	60	49
	5_2	26	39	50
Smith Inlet	4_2	89	61	27
	5_2	10	38	72
Skeena River	4_2	48	48	45
	5_2	43	43	43
Nass River	4_2	23	35	18
	5_2	22	20	11
	5_3	46	40	63

* Except for Smith Inlet, which is based on only a 7-year average.

Were it practicable to obtain each season a reasonably approximate estimate of the numbers of sockeye escaping to the spawning grounds and the age composition of the spawners, the numbers of sockeye returning each year from the ocean could be related to the brood-year spawning population and the overall rate of production computed. This has not heretofore been possible. A study was conducted this season, however, to ascertain how the spawning escapement for the Skeena River might be adequately assessed and the pertinent age and sex data collected. It seems that it can best be done immediately above the fishing limits by graduated-mesh gill-net gear or by traps.

For the Skeena River system, past catch sample data have been analyzed to throw light on trends in the sockeye production. The findings suggest that a gradual decline in the catches in the early period of the fishery (1911-33) was associated with decreasing catches of 5-year-old fish rather than 4-year-old fish and that the more recent gradual in the annual commercial catch has been associated with a reversal of this trend. There was also indication that large sockeye catches have contained more 5-year-old than 4-year-old individuals. Examination of past tagging data indicated that the gill-net fishery took more larger than smaller fish, relatively more 5-year-old than 4-year-old individuals, and more males than females.

Review of data for the Rivers Inlet area indicates that the sockeye runs are often dominated by one age-class in both catch and escapement,

particularly when very large runs occur. These runs tend to perpetuate themselves, those dominated by 4-year fish returning in four years and those dominated by 5's returning in five years. Whether age at maturity may have a genetic basis is being examined.

The occurrence of more than one age-group in the sockeye runs complicates greatly the assessment of production from brood years. It makes difficult an analysis of trends and of annual variations. Prediction of returns from known smolt migrations, such as Babine and Lakelse, becomes less definite. Observations now being made will throw further light on the problem which is of importance both to Industry and to the management agency, the Department of Fisheries.

PINK AND CHUM SALMON

Pink and chum salmon, which constitute about 60% by weight of the total salmon landings of British Columbia, have a much wider distribution than sockeye in the smaller streams of the province. This fact, together with the absence of a lake-dwelling phase during the life history, has dictated a somewhat different investigational program.

Since 1947, detailed information on the freshwater conditions which affect abundance has been sought at two field stations -- Nile Creek, on Vancouver Island, and Port John, near Ocean Falls. At the former, certain methods for improving the survival of the eggs and young fish have also been tested. At the same time, efforts have been made to keep in touch with conditions and problems in other areas and other types of stream by surveys and short-term observations. During 1954 the Nile Creek station has been closed since it was felt that it had substantially fulfilled its original objectives and that the freeing of personnel and funds would permit the investigators to apply more widely the information now available and to attack effectively certain problems of current or continuing importance.

Other work on pink and chum salmon has included the tagging of adults in the sea for the purpose of tracing the routes and destinations of the migrating fish and estimating the intensity of the fishery to which various stocks are exposed.

At the present time emphasis is being laid on problems which can be expressed in the questions--What kinds of gravel and what sort of stream flow are required to promote effective reproduction, whether from natural spawning or by artificial planting of eggs? How many spawning fish should be allowed or encouraged to occupy a given area of stream bottom in order to produce the best result for the fishery. The first problem entails laboratory experiments on the porosity of gravel and the oxygen requirements of developing eggs, as well as field observations. The second problem demands field data on the reproductive efficiency of spawning populations of varying density.

Nile Creek. The final operations at this field station included counts and observations on the adult runs of 1953 and on the downstream migration of young fish in 1954.

The adult escapement of both pinks and chums showed a very low survival during the ocean phase (estimated at 0.23% and 0.13% respectively). The former species, however, approximately maintained the numbers present in the parent year, namely, a little over a hundred fish. This stock is of particular interest since it was established two generations previously by introduction of eggs in 1949. The chum run was insignificant (44 fish). The coho run (524 fish) was the second largest recorded.

The percentage output of fry from the small seedings provided by these 1953 pinks and chums was the highest recorded for natural, unprotected spawnings in this stream, representing respectively 23.6% and 13.6% of the available eggs.

General findings from the Nile Creek program include the following:

(1) The output of fry is determined to a large extent by the survival of the eggs during the early stages of development, that is, before the "eyed" stage is reached.

(2) Survival is greater in gravel that is protected from fluctuations in water flow.

(3) Survival of fry during the short downstream migration to the sea has varied from 35% to 62%.

(4) Freshwater survival in Nile Creek has improved during the last few years but the escapements have not increased because of a very low rate of return from the sea. This suggests that the fishing intensity is heavy in relation to the productivity of this stream.

Port John. An important part of the work of this field station has been to follow the annual changes in the numbers of spawning fish and to record the natural conditions associated with varying reproductive efficiency.

The adult pink salmon escapement of 1953 (1,599 fish) represented an abnormally low return from the sea of the fry migrants reaching the ocean in the spring of 1952 (0.67%, as compared with over 3% for all previous returns). Heavy fishing of the Hooknose Creek run may have contributed largely to this result. The chum salmon run of 4,355 fish was the second largest recorded in the seven years during which the station has been operated.

Both species achieved a relatively high output of fry in the spring of 1954, pink salmon showing an efficiency of 13.9%, chums 16.4%. The previously reported tendencies for the two species to show similar survival rates in a given year and to produce better results when the autumn stream flow is low, were maintained.

Estimation of fry by sampling with fyke-nets. In continuation of previous work a series of experiments was performed at Port John to test the efficiency with which fry runs can be estimated by sampling with a standardized type of fyke-net. Nets with an opening 1 ft. x 2 ft. were set in various positions and the catches were compared with the total numbers of fish recorded at the counting weir. A single net was sufficient to reveal the direction of nightly fluctuations in the abundance of migrants but the proportion of the run captured by a net varied according to its position. Five nets spaced across the stream and presenting a total width of one-third of the latter caught approximately one-third of the migrating fish. Eighty-five percent of the fry migrated in the top 6 inches of the water. In the nightly migration, pink salmon fry preceded chums by about half an hour.

Tagging in Johnstone Strait. An intensive salmon fishery is prosecuted in and near Johnstone Strait, which forms a natural funnel for fish migrating to many areas in southern British Columbia. Effective management requires knowledge of the destinations of the fish that are being exploited, the timing of the passage of the various stocks through the Strait, and the extent to which these stocks are fished at other points along their migration routes.

Extensive tagging of pinks and chums was conducted in the latter part of 1953 in the western approaches of Johnstone Strait (Area 12) and also at the eastern end of the channel (Area 13).

Recoveries of pink salmon tagged in Areas 12 and 13 amounted to 45% and 33% respectively. In comparison with results obtained in 1945, the fishing rate in Area 12 was found to have changed little, while in Area 13 the rate showed an increase from 26% to 33%. Distribution of recoveries showed that from late July to early September fish migrating to all the main areas east and south of Johnstone Strait were present in the latter. After early September the Johnstone Strait population consisted entirely of fish bound for the Fraser River. Fraser River fish accounted for about 50% of all tags recovered.

Recoveries of chum salmon tagged in Areas 12 and 13 amounted to 47% and 36% respectively, both these figures representing substantial increases over the findings of 1945, when the corresponding percentages were 34% and 22%. Fish migrating through Johnstone Strait in the early part of the season were moving mainly towards Bute Inlet, Toba Inlet, Puget Sound and the Fraser River. In mid-September these runs were augmented by fish travelling to the east coast of Vancouver Island and, still later, by runs to Burrard and Jervis Inlets. Fraser River fish showed throughout the season and provided 44% of all recoveries.

Experimental planting of pink salmon eggs. Small-scale attempts to establish new runs of pink salmon have met with little success, but the absence of runs in alternate years in some highly productive areas, and in all years in others which appear suitable, suggests that development of successful techniques for this purpose might be very valuable. As an experiment along these lines over 2,500,000 eggs collected in September and October, 1954, at Lakelse River were planted in Jones Creek, a small tributary of the lower Fraser River which has substantial natural spawning of pink salmon in the "odd" years (e.g. 1951, 1953) but hardly any in the "even" years (1952, 1954). The transfer was made when the eggs were in the "eyed" stage of development, and they were planted in an artificial gravel bed with partially controlled water flow. Survival of the eggs and conditions in the gravel are being followed and the production of fry and return of adults will be observed.

SPRING AND COHO SALMON

The troll fisheries catch spring and coho salmon almost exclusively. Recent tagging and marking experiments show that considerable intermixing of stocks exists in the ocean. Because of the need for international co-operation in the conservation of these two valuable species, a close liaison has been maintained with the Pacific Marine Fisheries Commission. For the past few years, the trollers have been concerned over the condition of the stocks of both species and particularly over the catching of many small fish in certain areas. To protect these small fish, certain regulations of minimum sizes and closed seasons have been proposed. In order to evaluate the probable usefulness of such measures information has been obtained on ocean migrations, growth, food, and maturity of spring and coho salmon. In 1954 a study was initiated to assess the tagging and releasing mortalities of troll-caught fish.

Fishery in 1954. The commercial troll catch is usually about two-thirds of the total catch of spring and coho salmon. The sport catch, chiefly in Georgia Strait, is about 3% as large as the commercial catch. In 1954, the catches of both species were poor. This is particularly disappointing in the case of the coho salmon, because the catch in the brood year of 1951 was probably the highest on record. Following a good spawning, the dry summer of 1952 apparently affected the survival of young salmon in the streams severely. Poor ocean-feeding conditions were reported in 1953. The result has been a low adult return.

Sampling of commercial catches. In order to obtain returns from the large marking program conducted in United States streams, approximately 75,000 fish of both spring and coho salmon were scrutinized for missing fins. Over 200 marked fish were found, mostly from catches made off the west coast of Vancouver Island. The findings confirm earlier results that relatively few coho and spring salmon marked in United States get as far as northern Hecate Strait.

The sampling for age and size shows that a large part of the troll fish in both species are caught in their third year. Both older and younger spring salmon are taken by the commercial fisheries and younger coho salmon are often caught by the sportsmen. Most of the small spring salmon are caught off the west coast of Vancouver Island. Early this season the coho salmon were smaller in size than in the previous two years.

Food and maturity. Herring was the dominant food in the stomachs collected, in July 1953, from both spring and coho salmon off the southwest coast of Vancouver Island. The large spring salmon were caught more readily on large lures and contained more herring in their stomachs than small fish. The herring consumed were smaller than most of the fish caught by the nearby summer herring fishery. It appears that the heavy winter fishery of large herring in this region does not directly affect the spring salmon food supply.

Female spring salmon, from the above feeding area, were separated (by the size of the eggs and gonads) into maturing and immature fish at a fork length of 75 centimeters. Both stages were found in male fish up to 85 centimeters. It is estimated that two-thirds of the spring salmon caught in this region were immature. Thus immature spring salmon cannot be clearly separated by size and a minimum size designed to protect immatures would result in the release of many fish.

Mortality when caught and released. By trolling for small spring and coho salmon and then releasing the live fish into a pound, the initial mortality caused by catching and releasing (without tagging) was estimated at 30% to 50% and the final mortality at 50% to 75%. When small salmon are released, during a closed season or below a minimum size, the mortality involved, together with the natural ocean mortality, is probably higher than the gain in weight of the survivors. In tagging experiments, when only fish in good condition are used, the releasing mortality is probably about one-third.

EXPERIMENTAL STUDIES ON FISH BEHAVIOUR AND SURVIVAL

The major reason for commencing experimental research on the behaviour and survival of fish has been the inability of biologists, engineers, or anyone else, to meet the mounting toll which the creation of high dams is having on salmon, particularly the young salmon. Although it is generally conceded that the problem of passing adult salmon over dams (up to 100 feet) is being about half met, that for the young fish going over spillways or

through turbines has hardly been touched. Although the condition is not yet so acute in British Columbia, its future importance is indicated by what is happening on the lower Columbia River. Of 120 large dams planned, 61 have been built. One of the latest, McNary Dam, has cost over $20,000,000 in fishways for adults migrating upstream. Little or no expenditure has gone into safeguarding the young downstream migrants.

One reason why this problem has not been solved is the lack of knowledge of the behaviour, capabilities and responses of the fish; in addition to the complexity of the problem has not been commonly recognized. The aim is to safeguard millions of young fish daily, during peak runs, efficiently and effectively. Not only must this be achieved, but also the problems arising from pollution, silting, impounded waters and changed river flows must be met.

Objectives of present research are twofold. The immediate approach is concerned with determining methods of directing salmon during their downstream or upstream migration. It is during these critical periods that measures to get them past obstructions are needed. The second approach is of a more long-term nature. Laboratory experiments are in progress designed to establish the limits of tolerance, the preferred levels, and the general capabilities of the fish to meet the physical and chemical aspects of their environment - temperature, salinity, oxygen content, and foreign chemicals.

Guiding sockeye smolts. From the study of guiding young salmon, conducted in a large experimental trough, there has emerged a possible system of directing sockeye smolts by the use of a curtain of hanging chain. Efforts have been concentrated on defining the most effective conditions of operation both by testing within the trough and through the construction of a prototype chain deflector in the Lakelse River.

Somewhat conflicting results between the trough and river experments have resulted. These appear to be mostly attributable to the relative direction and rate of flow in the river. Present findings indicate: (1) Unvibrated, illuminated chain placed directly in the path of migrants has nothing but momentary influence on their continued progress downstream. (2) Good deflection can be achieved with sockeye if the chain is vibrated (4-inch interval between stands, 144 r.p.m., 4-inch amplitude) and if the flow does not exceed 0.5 ft. per sec. (3) Much of the initial deflection can be lost if attractive, alternative downstream paths are not presented to the fish. Repeated experiences along the deflector result in breakdown of close schooling and penetration through the curtain of chain.

The results show promise. Research on attractive by-pass openings is planned.

Adult salmon repellent. Work on the isolation of this repellent, present in the skin of some mammals, has moved one step nearer completion. A primary identification of the general nature of the material was achieved last year. Recently, more sensitive techniques of extraction, concentration, and separation have been introduced. The threshold dilution just producing an alarm reaction now appears to be approximately 1 part in 80,000,000,000. Field testing has been conducted by the Pacific Biological Station, chemical extraction by the Pacific Fisheries Experimental Station.

The study has done much to set the pattern of research required for investigation of olfactory perception. If it is possible to obtain some odour concentrate attractive to salmon, the combined use should prove of considerable value in directing the adults.

Toxicity of pollutants. Proposed increases in the production of pulp and paper have made it necessary to examine the potential toxic effects of sulphate effluent from pulp mills on young salmon. The influence of varying temperatures, salinities, oxygen concentrations, time of exposure and developmental stage of the fish precludes any simple treatment. A start has been made by using the oceanographic conditions at the head of Alberni Inlet as a typical pattern for temperature, salinity, and mixing. Maximum safe exposure times for sockeye under-yearlings were determined for a number of concentrations. In the presence of adequate oxygen, four weeks' exposure to a concentration of 3.3% sulphate effluent was considered safe. Oxygen requirements of the fish increase with increasing concentration of effluent. It is concluded that the maintenance of an adequate oxygen level is the most serious problem arising from the presence of kraft mill effluent.

Similar type experiments to determine safe concentrations of sodium arsenite have been performed on young chum salmon. For an exposure of 12 hours a dilution of 12.2 parts per million is required. This chemical has been proposed for use in the treatment of rafts to protect them against teredo infection in saltwater.

CONDITIONS FOR SURVIVAL AND DEVELOPMENT OF SALMON EGGS

Field observations have shown that the survival of salmon eggs to hatching and emergence of fry varies greatly and that changes in abundance of salmon stocks may often be caused in large part by changes in conditions in the gravel of spawning beds. Knowledge of what these conditions are, how they vary and how they affect survival, is important to an understanding of the natural fluctuations of salmon stocks; it is also important if we are to improve these conditions and so increase salmon production. The uses of water for other purposes is already encroaching on salmon spawning grounds and artificial gravel beds are already being tried in a few instances.

Equipment that successfully measures the rate of flow of water past salmon eggs in various kinds of gravel has been developed. Velocities of more than 4 inches per hour are needed for water moderately saturated with oxygen. Laboratory equipment has been developed and installed to measure survival in various combinations of age, temperature, water flow, carbon dioxide and oxygen. The first results show that at a temperature of 41°F. and a flow of about 30 feet per hour, an oxygen content of two parts per million is too low for chum salmon eggs to survive to hatching.

This experimental work is still in progress. Information is also being gathered on the natural survival of eggs in gravel with various conditions of flow and oxygen content so that the laboratory results can be used to explain survivals or mortalities in nature. It is hoped that eventually measures may be taken to assure satisfactory conditions and artificially increase production of young salmon.

HERRING

When they concentrate in inshore areas during the autumn and winter (before spawning in March), herring are fished intensively by a well-equipped and well-organized fleet of purse seiners; there is also some fishing at other times and with other methods. To avoid danger of leaving too few spawners to maintain the catch, herring fishing is under regulation which restricts fishing seasons, gear, and the total quantities which may be caught in a number of defined areas. The purpose of the Station's

investigations on herring is to improve the scientific basis for regulation, so as to avoid either too much or too little, and for prediction of abundance, so as to aid industrial efficiency. For both these objectives it is necessary to recognize and distinguish the effects on the abundance and distribution of herring of natural factors, on the one hand, and of the fishery on the other. The former cannot be controlled but knowledge of them is essential to prediction of abundance and to understanding of the effects of the fishery; the fishery itself can be controlled, as it now is, in order to maintain the long-term yield but unnecessary restriction must be avoided.

Information bearing on these objectives is sought from five sources: (1) The collection of catch statistics provides information not only on the amount of fish taken from each major fishing ground, but also on the amount of fishing effort required. This indicates the level of abundance of the stock. (2) A tagging program permits definition of the limits of the various populations and assessment of their intermixing and, in some cases, rate of exploitation. (3) Samples of fish are examined to show the age composition and the average lengths and weights of fish in the different areas. (4) The amounts of spawn deposited on the beaches are estimated to provide an index of the amounts of fish escaping the fishery. Spawn destruction by seabirds, waves, and exposure to the air is also observed. (5) In certain areas the quantities of young herring in their first year are estimated and their movements followed by marking experiments. It is hoped that these studies will permit better and longer-range predictions of the supply of herring to the fishery.

Catch statistics. In the 1953-54 season a record catch of 210,210 tons of herring was made. The catches in the various areas were as follows:

Vancouver Island						
West coast	Lower east coast	Middle east coast	Upper east coast	Central mainland	Northern mainland	Queen Charlotte Is.
41,350	52,660	19,600	6,650	31,650	29,750	28,530

The catches in the northern and cental areas were somewhat below average in 1953-54, the quota being taken in the former but not in the latter. On the west coast of Vancouver Island the catch, while considerably greater than the catches in 1950-51 and 1951-52, was about average; fishing was better off the southern part of the west coast than off the northern. The catches in the lower and middle areas of the east coast of Vancouver Island were the largest on record; catch quotas were extended because of the indications of and abundance of herring and a suspected greater-than-normal carry-over resulting from the almost complete lack of a fishery in 1952-53. While the quota was not reached in the upper east coast of Vancouver Island area, the catch was about average for recent years. The catch in the Queen Charlotte Islands was 150% greater than the previous record catch in 1951-52; the fishery was centered in Skidegate Inlet, an area not previously exploited.

Tagging and tag-recovery. In 1953-54 a total of 4,615 tags were recovered, 67 by two electronic tag-detectors and 4,548 by magnets in 14 reduction plants. The large number of recoveries reflected the heavy tagging of the populations in recent years.

In general, the pattern of movement was similar to that in previous years. There was a pronounced tendency for tags to be returned from the area where they were tagged. This was least pronounced in the Queen Charlotte Islands, and middle- and lower-east-coast areas of Vancouver Island.

In the Queen Charlotte Islands fish were tagged only in the southern part of the east coast while most of the fishery took place off the northern east coast. It is interesting to note that no tags from the former were recovered in the latter, suggesting that the herring stocks in these two areas may be separate.

The strong reciprocal movement between the populations on the middle and lower parts of the east coast of Vancouver Island, and the emigration of the lower-east-coast fish to the west coast and vice versa, were of approximately the same size as in previous years. The disparity in the apparent movement in the two directions between the west coast and lower east coast may result partially from a different degree of exploitation of the two populations. The main movement of fish from the central mainland was to the northern mainland and vice versa.

In the spring of 1954 all herring populations, except those in the "upper east coast of Vancouver Island" area were tagged. For the first time herring were tagged in both northern and southern parts of the east coast of the Queen Charlotte Islands. A total of 38,465 fish were tagged, compared to 81,390 in 1953.

A detailed review has been made of the 20,328 herring tags recovered from 1936 to 1952. Analysis showed that, although there are eight more or less distinct major populations of herring on the coast of British Columbia, some intermixing occurs and in general the amount of interchange between any two of them depends on the distance between them. The analysis indicates eight such divisions of the stock rather than six as previously envisaged.

Age and condition of herring. To provide information on age composition, growth, and sexual maturity, random samples of herring, 364 in all, were taken from all major fisheries and from spawning runs. In each sample approximately 100 fish were weighed and measured; the sex of each was recorded and a scale taken to find the age of the fish.

The 1951 year-class (III-year fish) dominated the 1953-54 runs and appeared to be of average or above-average strength in most areas. It was weakest in the middle east coast of Vancouver Island and, in the northern mainland area, in both of which IV-year fish were dominant. In the Queen Charlotte Islands, the 1949 year-class (V's) dominated the fishery, and the 1951 year-class (III's) the spawning runs. A greater dominance of older fish was expected in this area as it had not been heavily exploited in previous years. The 1952 year-class (II-year fish) was generally poorly represented.

Herring from the lower east coast and the west coast of Vancouver Island were, in general, the longest and heaviest for their age. This is in marked contrast to the previous season when, probably because of poor feeding conditions, these herring were the shortest and lightest on the coast. The Queen Charlotte Island herring were in general the shortest and lightest in 1953-54.

Extent of spawning. The herring fishery is concentrated on fish during their pre-spawning migration; spawning occurs in March after the close of the fishery. Estimates of the extent and intensity of spawn deposition (a) provide information on the size of the stock surviving the fishery and,

consequently, on the intensity of the fishery, and (b) provide an indication of potential production for the next generation and thus form an element in forecasting abundance. Spawn surveys are carried out in all areas by officers of the Department of Fisheries and in certain areas by Station personnel.

In 1953, because of the almost complete lack of a fishery, spawn deposition was the highest on record. In 1954, as was to be expected, it showed a general decrease from the high level of the previous year. The decrease occurred in all areas except the Queen Charlotte Islands, but in only two, the northern mainland and the middle east coast of Vancouver Island, did the deposition fall slightly below average. In the Queen Charlotte Islands spawn deposition increased, especially in the southern-east-coast areas, where only a small fishery occurred because of the greater abundance and availability of fish off the northern part of the east coast.

Studies on the variations in the mortality of spawn related to its position and degree of exposure confirmed the results obtained in 1953. Mortality is greatest in the sites most exposed to heavy seas and in those where a high degree of shelter reduces circulation and salinity; it is least in intermediate situations. Variations in mortality of eggs does not seem likely to be a dominant influence on abundance.

Abundance and distribution of young herring. Preliminary studies have shown that a young herring has a critical period in its life shortly after it emerges from the egg. It has seemed promising, therefore, to study the young fish after this stage, to follow their movements and to develop methods of assessing their abundance, in the hope of using this information to forecast the abundance of commercial fish two and three years later.

This work is at an early stage. Preliminary results indicate that in Barkley Sound juvenile abundance was greater in 1954 than in 1951, 1952, or 1953. Abundance in 1953 was less than in 1952 and about the same as in 1951. When these year-classes enter the fishery it will be possible to discover to what degree these findings indicate their relative importance commercially.

Effectiveness of regulation by catch quotas. An important phase of the herring investigation is a comparative study of two populations to determine how effective quota restrictions on catch are as a means of maintaining population abundance. A quota of 40,000 tons is maintained on the lower east coast of Vancouver Island area while, on the west coast of Vancouver Island, fishing is restricted only by a closing date. Results, so far, have indicated that absence of a quota has not adversely affected abundance on the west coast and that quota restrictions may not be necessary on the lower-east-coast populations. Fluctuations in abundance, attributable to variations from "natural" causes rather than to the effect of fishing, have occurred in both populations.

Abundance of herring in the 1953-54 season. Information on catches, amount of spawning, and age composition have been used to draw conclusions about abundance in the major herring populations. The populations on the lower east coast of Vancouver Island and on the west coast of Vancouver Island have increased. Abundance on the lower east coast is at the highest level of recent years and on the west coast it has returned to about the same level as before the decline in 1951-52. The increase has been more marked in the southern-west-coast areas than in the northern-west-coast areas.

Decreases in population size have occurred in the northern mainland and middle east coast of Vancouver Island. Other populations have remained about the same.

Forecasts of herring abundance. The forecasts of population sizes for the 1953-54 season were generally reliable although there were certain minor descrepancies. A prediction of abundance of herring was published prior to the 1954-55 fishing season. It is expected that herring will show a slight increase in abundance in the southern part of the east coast of the Queen Charlotte Islands and in the central mainland area. In the northern east coast of the Queen Charlotte Islands, the upper-east-coast and lower-east-coast areas of Vancouver Island, little or no change in abundance is expected. A decrease in abundance is expected in the northern mainland, middle east coast of Vancouver Island and possibly west coast of Vancouver Island. Better fishing is expected in the southern west coast than in the northern west coast of Vancouver Island.

Mortality and recruitment of herring. A study has been made of age composition and catch data collected since 1915-16 from the herring fishery of the lower east coast of Vancouver Island with the object of obtaining basic information on recruitment and mortality. A formula has been devised which permits the direct calculation of absolute recruitment and natural mortality rate, assuming that neither has undergone progressive changes in time. Natural mortality rate among recruited fish appears to average about 50% per year. An increase in natural mortality rate with age is indicated. It may be calculated that about 600 million recruits join the fishable stock on the average each year. It may also be calculated that the fishable stock at the start of the fishing season in recent years has averaged about 80 to 90 thousand tons of which about half are taken by the fishery.

Development of a mid-water trawl. During 1954 an attempt to develop a mid-water trawl for herring was started using funds from the Industrial Developement Vote. A trawl has been designed and constructed and will be tested early in 1955. A new type of otter-board has shown promise in preliminary trials.

GROUNDFISH

The continental shelf in most regions of the northern hemisphere is the habitat of many varieties of groundfish which are exploited by otter-trawl, set-line and other types of bottom fishing gear. Off the Pacific coast of Canada the shelf is very narrow, and the fishing banks and the stocks of fish on them are relatively small in size. In view of the suspected limited potential, an investigation was started about a decade ago to assess the consequences of a rapidly evolving otter-trawl fishery and the extent of its competition with the long-established line fisheries. This investigation demands continuing observation and seeks to reveal both long- and short-term changes in yield and their causes. It is complicated by the highly selective fishing methods and the great number of species (about 20, of which six or seven are in fairly constant demand). Most of the catch is taken in international waters in competition with United States vessels.

Trends and fluctuations in yield have been observed which may be the effects of changing natural conditions in the sea on survival of young or movements and distribution of fish, or which, on the other hand, may be caused by changes in fishing efficiency or effort. It is important to

separate the effects of nature from those of fishing and to predict how the various observed conditions will affect the availability of groundfish stocks to the commercial fishery.

Lines of investigation include: (1) The collection of accurate catch statistics to indicate changes in abundance or availability. (2) Tagging experiments to define the geographical limits of various populations and to assess their sizes, rates of fishing, and natural mortalities. (3) Age and growth studies to provide information on variations in the strengths of year-classes and reveal the effects of fishing on growth and mortality rates. (4) Surveys of important fishing banks to determine the geographical relationships of the nursery grounds to the adult grounds, and the year-to-year fluctuations in the strengths of year-classes at the juvenile stage. (5) Attempts to associate biological changes (recruitment, growth, and catchability) with changes in the physical environment.

Trends in catches and availability. Port observers are situated at Vancouver and Prince Rupert who obtain, from otter-trawlers, long-liners and trollers, records of the total catch of each species, area of capture, and the amount of effort expended.

In the year ending September 30, 1954, Canadian otter-trawlers and line vessels caught 19.4 million pounds of groundfish (exclusive of halibut). The trawler share was 14.8 million pounds, but only 8.8% of this total was of species also exploited by line vessels (lingcod, rockfish and blackcod). Attention of the trawlers has been focused on gray cod (5.4 million pounds) and several species of flatfish (5.3 million pounds). For the third time in the past seven years the gray cod (Gadus) has been the dominant single species in the catch.

The total catch by otter-trawlers was about the same in the preceding year. About 11.3 million pounds were taken in international waters (6.6 million in Hecate Strait and 4.7 million off the west coast of Vancouver Island). The remaining 3.5 million pounds were caught in the territorial waters of Georgia Strait. Production in the latter area has increased more than twofold in the past five years largely as a result of a relaxation of trawling regulations. This was recommended on the basis of six years of research to determine whether or not otter trawling can be conducted without undue interference with the hand-line fishery for lingcod.

Statistics of catch and effort are being used to determine annual changes in the availability of various stocks. As predicted, the catch of brill per unit of effort in the waters off the west coast of Vancouver Island is continuing to decline. In 1948 the average catch per hour was 350 pounds and the average catch per trip, 9,700 pounds. Since then there has been a fairly steady decline to a low point in 1954 of 135 pounds per hour and 4,600 pounds per trip. This serious decline does not seem to be the result of over-exploitation but rather of failure in recruitment of young brill to the fishery caused by natural factors affecting survival.

In the Hecate Strait area, the average catch of lemon sole per unit of effort is undergoing no appreciable change and in 1954 stood at 790 pounds per hour, which is approximately the mean value for the past decade. The rock sole presents an interesting contrast, in that the average catch per hour has had a pronounced upward trend in the past seven years. In 1954 it reached an all-time high of 2,550 pounds per hour, well above the mean of 1,370 pounds for the past decade. This seems to have been mainly the result of the recruitment of exceptionally strong year-classes in 1943, 1947, and 1948, and has taken place in spite of a marked upward trend in the annual yield.

Because of fluctuations in demand it has been difficult to interpret trends in availability of gray cod on the important fishing grounds in international waters. However, a study conducted on the inshore fishery at Nanoose Bay shows considerable fluctuation in the average annual catch per hour which seems to result from changes in catchability, not abundance. There is no evidence that the intensity of fishing has affected availability.

Availability of blackcod has been relatively stable over the past decade but at a considerably lower level than during the nineteen thirties. The current level is not the same for all fishing areas and the various levels seem to be related to the history and intensity of the fishery and probably to the cost of production as affected by the distance from railhead markets.

Divisions of stocks and movements -- shown by tagging. About 4,550 flatfish and 450 roundfish were tagged in 1954 -- somewhat fewer than in previous years. The geographical limits of many populations of flatfish have now been established and their sizes estimated. Long-term studies to determine rates of mortality have been slowed by difficulty in finding a tag attachment resistant to salt-water corrosion -- a difficulty largely overcome by the use of stainless steel. New methods of tagging certain roundfish species (particularly gray cod and lingcod) will now permit more extensive quantitative experiments.

Early in 1954 the Station cooperated with the Washington State Fisheries Department in tagging on a newly discovered spawning ground of the brill off the west coast of Vancouver Island. Preliminary results confirm that at least some of the schools of brill which inhabit Queen Charlotte Sound and Hecate Strait during the summer months move southward and into deep water off the west coast of Vancouver Island during their winter spawning.

Tagging of a spawning stock of lemon sole near Point Atkinson, in the Strait of Georgia, for the first time showed that the stock disperses along the estuary of the Fraser River during the summer months and that some fish move into United States waters bordering on Puget Sound. Further tagging experiments on rock sole support the conclusion that this species is not highly migratory. Fish tagged on the Goose Island bank show little movement from that area and no mixing with the large stocks in Hecate Strait.

Recoveries of tagged lingcod continue to show that the adults of that species are relatively sedentary. Preliminary experiments on gray cod have shown some tendency to moderate migrations within the Strait of Georgia.

Age and growth. In the year ending September 30, 1954, 28,600 otoliths (ear-stones) were collected from commercial catch samples of the three most important species of flatfish (brill, lemon sole and rock sole) for age determination. Satisfactory methods have been evolved for sampling commercial catches of lingcod and blackcod and about 12,000 were measured during the summer. Sampling of gray cod has been increased substantially; over 10,500 were measured.

The study of the size and age composition of brill has explained the declining catch of that species off the west coast of Vancouver Island. Young fish have been entering the fishery in below average numbers over the past six years and the average size of fish caught has been steadily increasing. This phenomenon is occurring also in the stocks fished in Queen Charlotte Sound and Hecate Strait. Preliminary results show that broods produced in the years since 1942 or 1943 have been below average in strength.

The year-classes of 1947 and 1948 continue to dominate in the catch of rock sole in northern Hecate Strait and have been at least partially responsible for the marked increase in the success of fishing in recent years. In 1949 and 1950 the butter sole stock in Hecate Strait did not follow its usual habit of congregating in Skidegate Inlet at the time of spawning and it was thought this might seriously affect the survival of young. Investigation has shown, however, that the 1949 and 1950 year-classes are not below average in strength. It must be concluded that successful spawning is not dependent on the adults gaining entrance to Skidegate Inlet, or that the Hecate Strait population draws its recruits mainly from other spawning stocks as yet undiscovered.

Considerable progress has been made in age-determination of the lingcod. Following the change in average size of young fish throughout the year has shown that the lingcod enters the commercial fishery about the end of its third year. This is supported by observations of the number of rings on the vertebrae. To date, ages up to 15 years have been determined from vertebral ring counts.

Distribution of flatfish of various ages. In 1953 and 1954, north-coast banks (Cape Scott, Goose Islands, and Hecate Strait) have been surveyed with small-meshed trawls on the Investigator No. 1. The purpose was to discover the sizes of each species on these banks and especially, whether the young occupy the same grounds as the adults. An attempt is also being made to obtain indices of relative abundance of various age-groups for use in predicting abundance and investigating the factors governing it.

In Hecate Strait it has been found that the young of the rock sole and butter sole inhabit roughly the same depth and locality as the adults. In contrast, the young of the lemon sole are found in shallow water near the shore, while the adults are in deep water and considerably removed from the nursery grounds. On the Goose Island grounds, adult rock soles inhabit deeper water than do the adults in northern Hecate Strait; and are separate from the young which are located in shallow depths. A similar situation seems to exist on the Cape Scott bank. In none of the northern regions so far has there been any sign of nursery areas for brill.

Possible influence of climatic changes on abundance of groundfish. Since long-term climatic changes have been shown to have affected the yield of groundfish in many areas of the North Atlantic, an enquiry is being made into the occurrence of similar changes in the northeastern Pacific. Mean annual air temperatures showed a marked upward trend between 1910 and 1940 in southern regions of British Columbia and between 1920 and 1940 in northern regions. The general trend corresponds well with that which has occurred in the North Atlantic, but only to about 1940. In the latter area temperatures continued to rise at least until 1950, while in the North Pacific they entered a sharp decline which has continued to the present. As yet there is no definite evidence of the effects of these trends on the groundfish stocks off British Columbia.

WHALES

Examination of whales as they are processed has yielded information on breeding, growth, and age, giving a basis for detecting evidence of overfishing and for making most effective use of the resources without imposing unnecessary restrictions. The work is being carried out in conformance with the International Whaling Agreements which require that accurate statistical

data be collected on all whales landed and encourage participation in biological whale studies. Collection of biological field data was curtailed during the 1954 season so that the time might be more profitably spent in analysis of data and material. Essential statistical data were collected during the greater part of the season.

The whale fishery in 1954. The whaling station at Coal Harbour, near the northwestern tip of Vancouver Island, which remains as the only whaling operation off the west coast of North America, completed its seventh successive whaling season in 1954. A catch of 630 whales was taken by 6 catchers operating during a 6-month period from March 15 to September 15. This is the largest catch, the longest season and the largest catching fleet in the history of this operation. In terms of yield per unit of whaling effort, however, it was not the most successful year. The number of whales taken per catcher's day's work was 0.84 in 1954, as compared to 1.05 in 1952 and 0.88 in 1953. The catch consisted of a relatively large proportion of sei and humpback whales - species which are smaller and economically less valuable than the finback, blue or sperm whale.

Whales caught and processed at Coal Harbour, British Columbia, 1948-1954.

Year	Blue	Fin	Hump	Sei	Sperm	Others	Total
1948	-	37	150	2	28	-	182
1949	2	105	76	3	69	-	255
1950	4	150	95	24	40	1(1)	314
1951	9	216	51	5	153	3(2)	437
1952	16	240	61	22	126	-	465
1953	8	181	47	14	275	14(3)	539
1954	11	150	106	134	226	3 (4)	630
Total	50	1,079	551	204	917	21	2,822

(1) One Berardius
(2) One Berardius, one right whale, one gray whale.
(3) Four Beradius, ten gray whales taken under special license.
(4) Three Beradius

Age and growth. Age studies make use of the baleen plates and the numbers of corpora lutea in the ovaries of females. A periodicity in the growth of the baleen plates provides a method for aging young individuals. The number of corpora lutea in the ovaries provides a method of demonstrating relative ages of mature individuals. A combination of the two methods has shown that the British Columbia operation depends largely upon young whales. Age studies to date suggest a need for revision of our understanding of the age at which sexual maturity is attained in finback whales.

Local characteristics of growth. Measurement of body parts, as a means of demonstrating changes in body form with increasing body lengths has revealed differences between whales from this locality and those from others. Finback, blue, and sei whales of given lengths have more mature body characteristics in this locality and grow more slowly than their counterparts from the southern hemisphere.

The growth of humpbacks appears to be faster here than in the southern hemisphere. The changes in the body form of sperm whales, on the other hand, is found to be similar wherever they have been studied.

Maturity. Observations of maturity and of foetus lengths at various times have shown that breeding and parturition are at a maximum during the winter months and that one young is born during a two-year cycle. Humpbacks sometimes breed out of season and may bear more than one young in two years. Average lengths at the attainment of sexual maturity in finbacks from this locality are 58 and 60 feet for the males and females, respectively. These lengths are some 5 feet shorter than corresponding lengths for southern finbacks. Humpbacks in this locality attain sexual maturity at lengths of 38 and 40 feet for the males and females, respectively. All female blue whales longer than 71 feet and all female sei whales longer than 42 feet were found to be sexually mature.

CRAB AND SHRIMP

The Queen Charlotte Islands crab fishery accounts for about 60% of the British Columbia crab production. In one region of the fishery, Hecate Strait, there is joint exploitation by Canadian and American fishermen and American vessels took from 69% to 76% of the catch in the years 1950 to 1952.

There is evidence that the fishery in Hecate Strait has reduced the abundance of older crabs and is now dependent upon the recruitment of younger crabs. The situation is of economic importance since the crabs which moult to become of commercial size in the summer months have a lower content of meat and are unsuitable for sale as the valuable frozen crabs. This situation also exists in McIntyre Bay (Dixon Entrance), where exploitation is solely by Canadian vessels.

The research program is planned to study fluctuations in the abundance of crabs. Tagging has been used to determine the rate of exploitation and population sizes; juvenile crabs are sampled to determine distribution and abundance; the mating behaviour is studied to determine the reproductive potential of the population.

Proportion caught and population size. The extensive tagging program conducted in the three regions of the fishery was discontinued during 1954 but returns from earlier taggings are now being analysed. In Naden Harbour for example, 32.6% of the 261 crabs tagged in 1953 were taken in the fall fishery that year. The catch was 58,916 crabs, giving an estimate of 150,000 for the 1953 Naden Harbour population of crabs of catchable size. This compares with a proportion caught of 35.6% and an estimated population of 118,000 in 1952.

Distribution and abundance of young crabs. Experimental trawling to find jevenile crabs was continued in 1954. The work was primarily concerned with establishing the distribution; however, it has been possible to compare the abundance in 1953 and 1954 at a number of stations. In Naden Harbour the very small crabs (0-age group) were less abundant in 1954 than in 1953; the yearlings (1-age group) were slightly more abundant in 1954. In McIntyre Bay the 0-age group were considerably less abundant in 1954 than in 1953. The 1954 Hecate Strait sampling was insufficient to make this comparison.

Size at which males mature. The present regualtions for crabs have the practical effect of limiting the fishery to male crabs which mature before reaching legal size. Breeding males were identified by the charateristic "wear marks" on the inner surface of the claws. Observations in Naden Harbour during 1953 showed that 42.4% of mating males were under legal size. This indicates that the smaller males form an important part of the breeding population; it is possible that their participation would increase if the abundance of legal-sized males were reduced by an intense fishery.

Food. In a preliminary study the contents of the stomachs of 170 crabs collected in 1952 and 1953 were examined. Small crustaceans were found most frequently, and clams were also important. Since these organisms occur abundantly in the region inhabited by the crabs in the summer months, there is no evidence that production is limited by food supply.

Explorations for shrimps and prawns. In recent years the supply of shrimps has been insufficient for the market demand. Starting in 1953, exploratory fishing has been carried out to locate new fishing grounds, and also to test shrimp fishing gear. Two vessels, the Station trawler, Investigator No. 1, and a chartered vessel, Yuri M, were used for this work in the winter of 1953-54. Localities in the Strait of Georgia, Chatham Sound, and in Queen Charlotte Strait and adjacent inlets were prospected.

Two productive regions were found: near Cape Lazo, Vancouver Island, and in Chatham Sound. Within three months after its discovery the landed value of shrimps from the Cape Lazo ground was approximatley $14,000.

The testing of shrimp gear showed that the otter trawl was more efficient than the beam trawl since it could be towed faster and so catch more shrimps per unit time. However, there are several features which tend to make the otter trawl unsuitable for small boats. The capital outlay of the gear and the operating costs of the vessel are higher; the larger loads of fish increase the work of sorting shrimps. Refrigeration equipment was tested in co-operation with the Pacific Fisheries Experimental Station; and the holding of shrimps aboard a fishing vessel for as long as eight days was found practical.

An extended prospecting program, to include regions of the coast previously unexplored, was started at the end of May, 1954. Localities on the west coast of Vancouver Island, in the Strait of Georgia, and on the northern coast have now been prospected, using an otter trawl and prawn traps. A small shrimp trawling ground was found in Barkley Sound on the west coast of Vancouver Island and two small prawn trap grounds in the Strait of Georgia. The chartered vessel Yuri M has been used for this prospecting.

Both the 1953-54 and 1954 programs were financed from the Industrial Development Vote of the Department of Fisheries.

PATHOLOGY

An investigation of the diseases and parasites of fish and marine mammals was started late in 1952 with the principal aim of learning what effect they have on the numbers or qualities of commercial species and whether remedial measures are possible. In addition to a general survey of the parasites of many species, special attention was given in 1953 and 1954 to a nematode (Anisakis), immature stages of which occur in the body cavity (not the flesh) of herring and are said to impair their suitability for canning.

A statistical analysis of the occurrence of Anisakis larvae in herring of the British Columbia coast has been completed. The level of infection increases with the age of the fish but is not influenced by their sex. Infection occurs in all the herring stocks with some local variation in intensity.

The life-history of Anisakis simplex, which matures in several porpoises and whales, is being studied. The larval stages ingested by the mammals, along with fish, apparently bury their heads in the wall of the stomach, undergo one moult, detach, and remain free in the stomach, where they undergo another moult and mature. Eggs are passed with the feces of the host and hatch in sea water (at least under laboratory conditions) to second stage larvae. Attempts to infect herring with these larvae have been unsuccessful indicating that the parasite occupies a third host (the "primary intermediate host") between leaving the mammal and entering the fish. Attempts to infect several crustacean species with the second stage larvae have so far failed and the intermediate host or hosts remain unknown.

In surveying the parastic fauna of the fishes and sea mammals of the B.C. coast, three new species have been uncovered, viz. Cyamus catodontis (external parasitic amphipod) from the sperm whale, Lecithodesmus spinosus (a liver fluke) from the sei whale, and Crassicauda pacifica (a large kidney nematode) from the fin whale.

EFFECTS OF POLLUTION ON FISHERIES

Industrial development in British Columbia is proceeding at a rapid pace and brings with it the problem of dispersing of wastes with the least possible damage to fisheries but at costs which are not prohibitive. The attack on pollution problems is therefore being intensified and it is the aim of the Station's work in this field to give advance information and advice to the administration and the industry so that development can be planned along lines as satisfactory as possible to all interests. The work involves both studies of the effects of pollution on the fish and shellfish and studies of the distances to which damaging or dangerous pollution extends from its sources. The former require cooperation with those specializing in experimental studies of fish behaviour and survival (see above), and the latter cooperation with the Pacific Oceanographic Group.

A general survey of the present and prospective pollution which may affect fisheries is being commenced. Attention is also being given to immediate problems as they arise and, in 1954, these have been concerned mainly with pulp mill wastes. A survey of Alberni Inlet in September showed that, under present conditions of Somass River discharge, the levels of dissolved oxygen and hydrogen-ion concentration were unaffected except in the immediate vicinity of the sewer outfall from the pulp mill. Another survey was made on which advice has been given on the placing of the sewer outlet from a pulp mill which is under consideration in another area.

INVESTIGATIONS IN THE WESTERN ARCTIC

The Station, through Dr. F. Neave, took part in the joint Canadian-United States expedition to the Beaufort Sea in 1954. This work was in the nature of a reconnaissance in the area covered by crossing the Beaufort Sea, circumnavigation of Banks Island, and brief exploration of the southern side of Viscount Melville Sound. Opportunities for biological work were limited by the fact that the two United States icebreakers ("Northwind" and "Burton Island") engaged were occupied also with other work, especially hydrographic surveying and meteorological and geodetic observations.

Valuable, though very incomplete, information was obtained on the plankton, bottom fauna, fishes, and marine mammals. Plankton was found in considerable quantities; bottom fauna showed a considerable variety and one species (an amphipod) seemed abundant enough to have possible value as a local food supply. The limited effort which could be devoted to operating various kinds of fishing gear failed to reveal any abundance. Observations were made on marine mammals, only the ringed seal being seen with any frequency about Banks Island and Melville Sound. On the whole the findings suggested that more immediate value is to be expected from exploration of the fisheries potential along the mainland coast of the Beaufort Sea.

MISCELLANEOUS

The joint report by Japanese, United States and Canadian scientists on the cooperative fur-seal investigation has now been completed and submitted to the three governments. The purpose of the investigation was to provide dependable information on the abundance and feeding habits of fur seals off the coasts of Japan and North America and the field work was completed in 1952.

A review of records of observations of fur seals in inside coastal waters of British Columbia has revealed some twenty reliable cases of their occurrence there in the past twenty-five years.

E. and C. Berkeley have continued their work on the distributions and life-histories of polychaete worms. Pre-eminent in this field, they are frequently asked to classify material from other areas. Studies at the Station in 1954 were concerned principally with the life-histories of Micronereis nanaimoensis and Dodecaceria fewkesi; attempts to rear these species have met with some success but rearing to maturity has not been completed.

The Station and the Pacific Oceanographic Group are cooperating with the Department of Public Works in an investigation of the possible danger of serious damage by shipworms (Bankia) to the wharves at Steveston, B.C., resulting from alterations to the harbour. Cooperation has also continued with the Forest Products Laboratory, Department of Natural Resources and Development in the testing of the effectiveness of various wood preservatives in preventing attacks by marine borers.

OCEANOGRAPHY

The importance, indeed essentiality, of oceanographic investigations to fisheries research and development has already been noted. They describe the world in which fish move and multiply and if we do not know its climate and its topography we cannot understand how to find and catch fish most effectively nor what changes in their numbers to expect.

The oceanographic work of the Fisheries Research Board is carried out through the Joint Committee on Oceanography which, with scientific personnel supplied mainly by the Board and ships mainly by the Navy, conducts research of basic value to both defence and fisheries, as well as to meteorology and other activities. The Pacific Oceanographic Group, under the Joint Committee, has its headquarters at the Station and there is very close cooperation between the work on biological fisheries problems and that on the related oceanography.

The oceanographic program for fisheries includes first a description of the environment by thorough surveys of important regions in turn, repeated in type situations to show conditions throughout the year in each region. Daily observations are taken at a number of points to indicate the

variations in conditions from season to season and year to year; these form the basis for understanding related variations in fish abundance and movements. As the oceanographic work progresses and the current systems emerge, a better understanding of fish migrations will be possible. The detailed relationship of fish distribution to boundaries between waters of different temperature or salinity is already recognized as important to fishing operations elsewhere and, if we are to get the best out of the resource, such knowledge must be developed here.

It must, of course, be realized that, in many cases, information must be gathered over a long period before the relationship of fish abundance and movements to the oceaonographic environment can be discovered. We are, however, reaching the stage where such analysis and correlation is more and more possible -- and necessary, if the full benefits of the oceanographic work are to be had.

An account of the work of the Pacific Oceanographic Group appears in the report of the Joint Committee on Oceanography.

COOPERATION WITH OTHER BODIES

The Station, in the normal course of its work, cooperates closely with other branches of the Federal fisheries service and many such instances can be found in this report. Cooperation with some other bodies deserves special mention.

International North Pacific Fisheries Commission. Dr. Hart (then Director) and Dr. Needler were scientific advisers to the Canadian delegations to the first meeting of the Commission in Washington, D.C., in February, 1954. Dr. Needler, as convenor of the scientific members of the Committee on Biology and Research, and Dr. Foerster, the other Canadian scientist on the Committee, played an important part in the preparation of the research program which was adopted by the Commission at its second meeting in October, 1954, at Vancouver, B.C. They attended a special meeting for this purpose at Tokyo in May and another with Mr. Jas. Cameron, the Canadian Commissioner on the Committee, at Vancouver just before the Commission's October meeting.

The research which is essential to the work of the Commission is to be carried out mainly by the existing agencies of the three governments--Japan, United States and Canada. Canada's part of the program will be in large part the responsibility of this Station. It is expected to include in 1955: (1) study of the anatomy and parasites of salmon in an attempt to distinguish between salmon of Asian and North American origin and cooperation in obtaining samples for similar studies by Japan and United States, (2) cooperation in a tagging program to study movements of salmon and, in particular, an attempt to discover and tag young salmon in the sea on their way away from their river of origin, and (3) some expansion of high seas oceanographic investigations.

Pacific Marine Fisheries Commission. This organization of the three Pacific coast states attempts to co-ordinate research on fisheries subjects of common interest, some of which are also of interest to Canada. The Station was again represented by observers (Drs. Milne and Ketchen) at the Commission's meeting in December, 1954. Results of investigations were exchanged. Cooperative research projects on troll-caught salmon and brill had been arranged at earlier meetings of the Commission.

British Columbia Natural Resources Conference. This body sponsered by the government of British Columbia, reviews information and ideas bearing on the full and proper use of the natural resources of the province. At its Seventh meeting in February, 1954, in Victoria, Dr. Brett was convenor of the Fisheries section and elected Vice-president of the organization for the ensuing year; Dr. Tully and Mr. Stevenson contributed papers.

Canadian Committee for the Conservation of Migrating Salmonids. This informal committee reviews findings and coodinates planning of research by the International Pacific Salmon Commission, the British Columbia Game Commission, the Department of Zoology of the University of British Columbia, the Fish Culture Development Branch of the Department of Fisheries, and the Station on problems of getting migrating salmon (especially downstream) past obstructions. Dr. Brett was Chairman of the meeting in November, 1954, and an important contributor.

Committee for Management of the Skeena River Salmon Fisheries. The appointment by the Minister of Fisheries in late October of A.J. Whitmore, Chief Supervisor of Fisheries, and the Director as a committee to be responsible for the management of the Skeena River salmon fisheries in a manner similar to that of the Fraser River sockeye salmon by the International Pacific Salmon Fisheries Commission will entail very close cooperation between the Station and the Departmental services under Mr. Whitmore. F.C. Withler has been selected to direct investigations for the Committee and the services of other personnel will be provided as occasion demands.

PERSONNEL

The personnel and organization of the Station are presented in the appended statements. As of November 15 the Station had 82 full-time employees and one vacant position; the Pacific Oceanographic Group had 11 full-time employees, one vacant position and 2 special employees for Western Arctic Investigations.

There were few changes in scientific personnel. Dr. J.L. Hart left the Station late in July to take over directorship of the Atlantic Biological Station and Dr. A.W.H. Needler replaced him at the end of August. Dr. A.L. Tester, formerly in charge of the Station's investigation on herring, but now with the University of Hawaii, returned to the Station for about four months late in the year. A.J. Dodimead and Neil Campbell joined the staff of the Pacific Oceanographic Group in the autumn. Educational leave with half pay was granted to R.W. Trites, for the academic years 1953-54 and 1954-55 at the University of British Columbia. J.G. McDonald took leave without pay for studies at the University of British Columbia for the major part of the academic year 1954-55.

BUILDINGS, GROUNDS AND VESSELS

At the Station a 20-foot by 40-foot addition was made to the Oceanographic Model Laboratory to house a model of Hecate Strait for study of currents in that area; the road around the main building has been hard-surfaced; an additional fresh-water catch basin has been installed to improve the supply.

The M.V. Cancolim II (86 feet; 82 gross tons) was acquired from the Defence Research Board free of cost. A thorough overhaul, at a cost of about $10,000, will be completed early in January.

The Nile Creek field station for salmon investigations has been closed and movable equipment brought to the Station for use elsewhere.

VISITORS

Visitors to the Station during the year included Dr. Niino, Professor of Oceanography and Submarine Geology, Tokyo University of Fisheries; Mr. D. Ellis, Arctic Institute; Mr. Thor V. Gudjonsson, Commissioner of Inland Fisheries of Iceland; Dr. G. Sprugel, Jr., National Science Foundation, Washington, D.C.; Dr. Russel, National Museum, Ottawa; Dr. G.P. Wells, University of London; Dr. W.L. Ford, Director of the Scientific Service of the Canadian Navy; Prof. E. Watson, Queen's University; Dr. K.D. Carlander, Iowa State University; Dr. W.A. Gosline, University of Hawaii; Captain O.C.S. Robertson of H.M.C.S. Labrador; Dr. D.C. Rose, National Research Council; Dr. R. Fredin, Dr. L.A. Walford, and Mr. C. Atkinson, United States Fish and Wildlife Service; Dr. W.F. Thompson, Fisheries Research Institute, Seattle, Washington; Dr. Allan DeLacy, University of Washington; Dr. M. Fujinaga and Mr. Y. Miyake of the Japanese Fisheries Agency, Mr. K. Kawakami, of the Japanese Ministry of Foreign Affairs and Mr. K. Taguchi, Nichiro Fishing Co., Japan; Mr. M. James and Dr. M. Kasahara of the International North Pacific Fisheries Commission. Among those from the Canadian Fisheries Service were: Mr. Stewart Bates, Deptuy Minister of Fisheries; Dr. J.L. Kask, Dr. W.A. Clemens, Dr. C.W. Argue, Dr. W.A. Kennedy, Fisheries Research Board; and Mr. A.J. Whitmore, Chief Supervisor of Fisheries. Members of the Chemical Institute of Canada visited the Station during the September meeting of the Western Section.

PUBLIC RELATIONS

Drs. Foerster and Ketchen addressed a public meeting in Prince Rupert in December, 1953 at which time the salmon and groundfish research programs were discussed. Dr. Ketchen also spoke to a meeting of otter trawl fishermen in Vancouver in December. Fifty-three members of the Fishing Industry and the Federal and Provincial Fisheries Departments and the Press visited the Station in December, 1953, to hear prepared talks by the staff. Several talks were given by staff members to local organizations in Nanaimo. Dr. Hart spoke to the Fishermen's Cooperative Association in Prince Rupert in March. About 350 people from Nanaimo and District attended the Station's Open House on December 9, 1953.

In September, 1954 several thousand people visited the Station's exhibit on herring research at the Nanaimo Fall Fair. About 150 children from local schools, with their teachers, visited the Station during the year to learn about the Station's work.

Several talks by staff members were recorded for broadcast on the daily C.B.C.'s Fisheries Broadcast.

ACKNOWLEDGEMENTS

The members of the staff of the Station are grateful for the continued cooperation of industry, of universities and of agencies of both Federal and Provincial governments, especially that of other branches of the Dominion fisheries service. They wish also to thank scientists of other countries from whom they have received assistance. The importance of the cooperation of the industry, both fishermen and fishing companies deserves special mention. The ultimate purpose of the Station's work is to help them; its effectiveness depends on them.

PUBLICATIONS

Alderdice, D.F., J.R. Brett, D.R. Idler and U. Fagerlund. Further observations on olfactory perception in migrating adult coho and spring salmon--properties of the repellent in mammalian skin. Pacific Prog. Rept., No. 98, pp. 10-12, 1954.

Barraclough, W.E. The development of the dogfish fishery in British Columbia. Proceedings of the 7th Pacific Science Congress, 1949, Vol. 4, pp. 513-519, 1953.

Brill studies on the west coast. Western Fisheries, Vol. 47, No. 5, p. 11, 1954.

A second inshore record of the bathypelagic viperfish Chauliodus macouni from British Columbia. Copeia, No. 1, pp. 75-76, 1954.

Decline in availability of brill on the west coast of Vancouver Island as associated with a decline in recruitment. Pacific Prog. Rept., No. 98, pp. 17-21, 1954.

Barraclough, W.E., and M. Waldichuk. Offshore characteristics in the deep waters of the Strait of Georgia as indicated by bathypelagic fish. J. Fish. Res. Bd., Vol. 11, No. 5, pp. 501-506, 1954.

Berkeley, E. and C. Notes on the life-history of the polychaete Dodecaceria fewkesi (nom. n.). J. Fish. Res. Bd., Vol. 11, No. 3, pp. 326-334, 1954.

Additions to the polychaete fauna of Canada, with comments on some older records. J. Fish. Res. Bd., Vol. 11, No. 4, pp. 454-471, 1954.

Brett, J.R. Behaviour studies in adult salmon. Western Fisheries, Vol. 47, No. 4, pp. 12-13, 1954.

Brett, J.R., and D. MacKinnon. Preliminary experiments using lights and bubbles to deflect migrating young spring salmon. J. Fish. Res. Bd., Vol. 10, No. 8, pp. 548-559, 1953.

Some aspects of olfactory perception in migrating adult coho and spring salmon. J. Fish. Res. Bd., Vol. 11, No. 3, pp. 310-318, 1954.

Brett, J.R., D. MacKinnon and D.F. Alderdice. Trough experiments on guiding sockeye salmon fingerlings. Pacific Prog. Rept., No. 99, pp. 24-27, 1954.

Butler, T.H. Food of the commercial crab in the Queen Charlotte Islands region. Pacific Prog. Rept., No. 99, pp. 3-5, 1954.

Chatwin, B.M. Age and size of chum salmon from the Johnstone Strait area. Pacific Prog. Rept., No. 97, pp. 9-10, 1953.

Growth of young lingcod. Pacific Prog. Rept., No. 99, pp. 14-17, 1954.

Dombroski, E. The sizes of Babine Lake sockeye salmon smolt emigrants, 1950-1953. Pacific Prog. Rept., No. 99, pp. 30-34, 1954.

Foerster, R.E. Fisheries research on the Canadian Pacific coast. Proceedings of the 7th Pacific Science Congress, 1949, Vol. 4, pp. 413-420, 1953.

On the relation of adult sockeye salmon (Oncorhynchus nerka) returns to known smolt seaward migrations. J. Fish. Res. Bd., Vol. 11, No. 4, pp. 339-350, 1954.

A study of the relative merits of natural and artificial propagation of sockeye salmon in British Columbia. The Progressive Fish-Culturist, Vol. 16, No. 2, pp. 92-93, 1954.

Sockeye salmon investigations in 1953. Western Fisheries, Vol. 47, No. 4, pp. 8-9, 1954.

Forrester, C.R. Tagging experiments on gray cod. Pacific Prog. Rept., No. 99, pp. 28-29, 1954.

Foskett, D.R. Contributions to the life-history of the sockeye salmon (No. 38). Report of the British Columbia Fisheries Department for 1952, pp. 33-56, 1953.

Godfrey, H., W.R. Hourston, J.W. Stokes and F.C. Withler. Effects of a rock slide on Babine River salmon. Bull. Fish. Res. Bd., No. 101, 100 pp., 1954.

Hart, J.L. The trawl fishery on the Pacific coast of Canada. Proceedings of the 7th Pacific Science Congress, 1949, Vol. 4, pp. 425-427, 1953.

Herlinveaux, R.H. Surface tidal currents in Juan de Fuca Strait. J. Fish. Res. Bd., Vol. 11, No. 1, pp. 14-31, 1954.

Hoar, W.S. The behaviour of juvenile Pacific salmon, with particular reference to the sockeye (Oncorhynchus nerka). J. Fish. Res. Bd., Vol. 11, No. 1, pp. 69-97, 1954.

Hollister, H.J. What was the temperature of the sea water on the British Columbia coast in 1952? Pacific Prog. Rept., No. 98, pp. 6-9, 1954.

Hourston, A.S. The spawning population of herring in northern British Columbia in 1952. Pacific Prog. Rept., No. 97, pp. 21-26, 1953.

Young herring lead a precarious life. Western Fisheries, Vol. 49, No. 1, p. 44, 1954.

Hunter, J.G. A weir for adult and fry salmon effective under conditions of extremely variable run-off. Canadian Fish Culturist, No. 16, pp. 27-33, 1954.

Pink and chum salmon studies during 1953: Studies at Port John. Western Fisheries, Vol. 47, No. 6, pp. 19-20, 1954.

Ketchen, K.S. The use of catch-effort and tagging data in estimating a flat-fish population. J. Fish. Res. Bd., Vol. 10, No. 8, pp. 459-485, 1953.

The rockfish Sebastodes rubrivinctus in British Columbia waters. J. Fish. Res. Bd., Vol. 11, No. 3, pp. 335-338, 1954.

Groundfish investigations in 1953. Western Fisheries, Vol. 47, No. 5, pp. 10-11, 1954.

Mackay, B.S. Tidal current observations in Hecate Strait. J. Fish. Res. Bd., Vol. 11, No. 1, pp. 48-56, 1954.

MacKinnon, D., and W.S. Hoar. Responses of coho and chum salmon fry to current. J. Fish. Res. Bd., Vol. 10, No. 8, pp. 523-538, 1953.

McMahon, V.H. The abundance and distribution of entomostracan plankton at Lakelse Lake, B.C., 1949-1952. J. Fish. Res. Bd., Vol. 11, No. 4, pp. 479-499, 1954.

Manzer, J.I. Observations on the gray whale. Journal of Mammalogy, Vol. 35, No. 3, pp. 444-445, 1954.

Pink and chum salmon studies during 1953: Johnstone Strait tagging. Western Fisheries, Vol. 47, No. 6, pp. 21, 64, 1954.

Margolis, L. List of the parasites recorded from sea mammals caught off the west coast of North America. J. Fish. Res. Bd., Vol. 11, No. 3, pp. 267-283, 1954.

Three kinds of whale-lice (Cyamidae: Amphipoda) from the Pacific coast of Canada, including a new species. J. Fish. Res. Bd., Vol. 11, No. 3, pp. 319-325, 1954.

Delphinapterus leucas, a new host record for the whale-louse, Paracymus nodosus (Lütken). Journal of Parasitology, Vol. 40, No. 3, p. 365, 1954.

Ulcer disease and furunculosis in a Quebec trout hatchery. Canadian Fish Culturist, No. 15, pp. 16-17, 1954.

Parasites, fish and man. The Canadian Nurse, Vol. 50, No. 7, pp. 556-560, 1954.

Mead, G.W., and F.H.C. Taylor. A collection of oceanic fishes from off north-eastern Japan. J. Fish. Res. Bd. Vol. 10, No. 8, pp. 560-582, 1953.

Milne, D.J. Troll salmon investigation in 1953. Western Fisheries, Vol. 47, No. 4, pp. 9-10, 1954.

Neave, F. Introduction of anadromous fishes on the Pacific coast. Canadian Fish Culturist, No. 16, pp. 25-26, 1954.

Pink and chum salmon studies during 1953. Introduction and summary. Western Fisheries, Vol. 47, No. 6, pp. 18-19, 1954.

Neave, F., and W.P. Wickett. Factors affecting the freshwater development of Pacific salmon in British Columbia. Proceedings of the 7th Pacific Science Congress, 1949, Vol. 4, pp. 548-556, 1953.

Pickard, G.L. Oceanography of British Columbia mainland inlets. II. Currents. Pacific Prog. Rept., No. 97, pp. 12-13, 1953.

Oceanography of British Columbia mainland inlets. III. Internal waves. Pacific Prog. Rept., No. 98, pp. 13-16, 1954.

Oceanography of British Columbia mainland inlets. IV. Dissolved oxygen distribution. Pacific Prog. Rept., No. 99, pp. 9-11, 1954.

Pike, G.C. Whaling on the British Columbia coast. Proceedings of the 7th Pacific Science Congress, 1949, Vol. 4, pp. 370-372, 1953.

The Pacific sea lamprey. Pacific Prog. Rept., No. 97, pp. 3-5, 1953.

The killer whale. Western Fisheries, Vol. 48, No. 1, pp. 14-15, 1954.

Whaling on the coast of British Columbia. Norwegian Whaling Gazette, No. 3, pp. 117-127, 1954.

B. C. whale stocks studied. The Fisherman, Vol. 16, No. 10, p. 12, 1954.

Ricker, W.E. Review of "Haddock Bionomics. 1. The state of the haddock stocks in the North Sea 1946-50 and at Faroe 1914-50. Scottish Home Department, Marine Research, 1952, No. 4, pp. 1-27, 1953." Journal du Conseil, Vol. 19, No. 3, pp. 386-387, 1954.

Effects of compensatory mortality upon population abundance. Journal of Wildlife Management, Vol. 18, No. 1, pp. 45-51, 1954.

Stock and recruitment. J. Fish. Res. Bd., Vol. 11, No. 5, pp. 559-623, 1954.

Pacific salmon for Atlantic waters? Canadian Fish Culturist, No. 16, pp. 6-14, 1954.

Robertson, J.G. The trophic status of Port John Lake, British Columbia. J. Fish. Res. Bd., Vol. 11, No. 5, pp. 624-651, 1954.

Shand, J.A. Internal waves in Georgia Strait. Transactions of the American Geophysical Union, Vol. 34, No. 6, pp. 849-856, 1953.

Shepard, M.P. Sockeye research at Lakelse. The Fisherman, Vol. 16, No. 5, p. 5; No. 6, p. 4, 1954.

Stevenson, J.C. A research project in herring management. Transactions of the 7th British Columbia Natural Resources Conference, pp. 15-25, 1954. (Reprinted in Western Business and Industry, Vol. 28, No. 4).

Spotting herring spawners from the air. Western Fisheries, Vol. 48, No. 2, pp. 14-15, 1954.

Stevenson, J.C., and D.N. Outram. Results of investigation of the herring populations on the west coast and lower east coast of Vancouver Island in 1952-53, with an analysis of fluctuations in population abundance since 1946-47. Report of the British Columbia Fisheries Department for 1952, pp. 57-84, 1953.

Taylor, F.H.C. A summary of herring research in the 1952-53 season. Western Fisheries, Vol. 47, No. 5, pp. 12-13, 1954.

Herring research. The Fisherman, Vol. 16, No. 2, p. 4, 1954.

Waldichuk, M. Pollution study in Nanaimo Harbour. Transactions of the 7th British Columbia Natural Resources Conference, pp. 300-303, 1954.

Waldichuk, M., and J.P. Tully. Pollution study in Nanaimo Harbour. Pacific Prog. Rept., No. 97, pp. 14-17, 1953.

Wickett, W.P. Pink and chum salmon studies during 1953: Studies at Nile Creek. Western Fisheries, Vol. 47, No. 6, p. 20, 1954.

Wickett, W.P., and R.A. Pollard. Measuring the oxygen supply to salmon redds. Pacific Prog. Rept., No. 99, pp. 20-21, 1954.

MANUSCRIPTS SUBMITTED FOR PUBLICATION

Barber, F.G. Water masses in Queen Charlotte Strait. Pacific Prog. Rept.

Barraclough, W.E. An abnormal long-nosed Raja rhina from British Columbia. Canadian Field-Naturalist.

Winter recaptures of tagged brill from deep water off the west coast of Vancouver Island. Pacific Prog. Rept.

Brett, J.R. Some principles in the thermal requirements of fishes. Biological Review.

Butler, T.H. Re-discovery of the parasitic cirripede, Mycetomorpha vancouverensis Potts, in British Columbia waters. Journal of Parasitology.

Doe, L.A.E. Offshore waters of the Canadian Pacific coast. J. Fish. Res. Bd.

Dombroski, E. Cestode and nematode infection of sockeye (Oncorhynchus nerka (Walbaum)) smolts from Babine Lake, British Columbia. J. Fish. Res. Bd.

Foerster, R.E. Sex ratios in sockeye salmon (Oncorhynchus nerka). J. Fish. Res. Bd.

Forrester, C.R., and K.S. Ketchen. The resistance to salt water corrosion of various types of metal wire used in the tagging of flatfish. J. Fish. Res. Bd.

Foskett, D.R. Contributions to the life-history of the sockeye salmon (No. 39). Report of the British Columbia Fisheries Department for 1953.

Herlinveaux, R.H. Tidal currents in Juan de Fuca Strait. J. Fish. Res. Bd.

Hourston, A.S. A study of variation in the maskinonge from three regions of Canada. Contributions of the Royal Ontario Museum of Zoology and Palaeontology.

Hunter, J.G. Juvenile sockeye salmon depth preference. J. Fish. Res. Bd.

Ketchen, K.S., and C.R. Forrester. The sablefish fishery of British Columbia. Bulletin of the Pacific Marine Fisheries Commission.

LaCroix, G.W., and J.P. Tully. The anomaly of mean sea level in Seymour Narrows, B.C. J. Fish. Res. Bd.

MacKinnon, D., and J.R. Brett. Some observations on the movement of Pacific salmon fry through a small impounded water basin. J. Fish. Res. Bd.

Margolis, L. Notes on the morphology, taxonomy, and synonymy of several species of whale-lice (Cyamidae: Amphipoda). J. Fish. Res. Bd.

Margolis, L. and T.H. Butler. An unusual and heavy infection of a prawn, Pandalus borealis Krøyer, by a nematode, Contracaecum sp. Journal of Parasitology.

Margolis, L., and G.C. Pike. Some helminth parasites of Canadian Pacific whales. J. Fish. Res. Bd.

Milne, D.J. The Skeena River salmon fishery with special reference to sockeye salmon. J. Fish. Res. Bd.

Partlo, J.M. Distribution, age, and growth of eastern Pacific albacore (Thunnus alalunga Gmelin). J. Fish. Res. Bd.

Histological studies on albacore (Thunnus alalunga) gonads from the eastern Pacific. J. Fish. Res. Bd.

Ricker, W.E. Nomenclatorial notes on Plecoptera. Proceedings of the Entomological Society of British Columbia.

Stevenson, J.C. The movement of herring in British Columbia waters as determined by tagging, with a description of tagging and tag recovery methods. Conseil Permanent International pour l'Exploration de la Mer, Rapports et Procès-Verbaux.

Tabata, S. Salinity and temperature in Bute Inlet. Pacific Prog. Rept.

Taylor, F.H.C., and D.N. Outram. Results of the investigation of the herring population on the west coast and lower east coast of Vancouver Island in 1953-54. Report of the British Columbia Fisheries Department for 1953.

Tully, J.P. Review of Canadian Pacific oceanography since 1949. Proceedings of the 8th Pacific Science Congress.

Tully, J.P., and A.J. Dodimead. Properties of the water in the Strait of Georgia. J. Fish. Res. Bd.

Wickett, W.P. The oxygen supply to salmon eggs in spawning beds. J. Fish. Res. Bd.

CIRCULARS, MANUSCRIPT REPORTS, ETC.

Aro, K.V. The morphometry of Nilkitkwa Lake. MS Rept. Biol. Sta., No. 569, 8 pp., 1954.

Bilton, T.H. The cut-throat trout (Salmo clarki) population of Lakelse Lake, B.C. Results of the 1950-1953 creel census studies. MS Rept. Biol. Sta., No. 573, 24 pp., 1954.

Butler, T.H., and H.E.J. Legare. Shrimp prospecting in regions of the British Columbia coast, November, 1953 to March, 1954. Pacific Biol. Sta. Circ., No. 31, 42 pp., 1954. (Reprinted in Commercial Fisherman, Vol. 21, No. 6).

Chatwin, B.M. Investigation of the Skidegate Inlet and Hecate Strait butter sole stocks in 1953. Pacific Biol. Sta. Circ., No. 30, 5 pp., 1953.

Ketchen, K.S. Long-term temperature trends in the northeast Pacific and their possible bearing on marine fisheries. MS Rept. Biol. Sta., No. 575, 19 pp., 1954.

A report on the yield of the otter-trawl and hand-line fisheries of Georgia Strait in the fall and winter of 1952-53 and 1953-54. Pacific Biol. Sta. Circ., No. 33, 19 pp., 1954. (Reprinted in Commercial Fisherman, Vol. 21, No. 10).

McMahon, V.H. Plankton counts at Lakelse Lake, B.C. MS Rept. Biol. Sta., No. 561, 6 pp., 1954.

Milne, D.J. Trolling the Pacific. Canadian Department of Fisheries, Trade News, Vol. 6, No. 8, pp. 6-7, 22, 1954.

Pacific Oceanographic Group. Observations of seawater temperature and salinity on the Pacific coast of Canada, 1953. Vol. 13, 64 pp., 1954.

Physical and chemical data record, Strait of Georgia, 1949-1953, with Appendix I: Current measurements, March, 1953. 437 pp., 1954.

Pike, G.C. Guide to the whales, porpoises, and dolphins of the north-east Pacific and Arctic waters of Canada and Alaska. Pacific Biol. Sta. Circ., No. 32, 16 pp., 1954.

Ricker, W.E., Dorothy F. Manzer and Elizabeth A. Neave. The Fraser River eulachon fishery, 1941-1953. MS Rept. Biol. Sta., No. 583, 35 pp., 1954.

Shepard, M.P. The effect of the Lakelse River fence on migrating sockeye smolts. MS Rept. Biol. Sta., No. 559, 20 pp., 1954.

Taylor, F.H.C. Prospects for the 1954-55 herring fishing season. Pacific Biol. Sta. Circ., No. 34, 8 pp., 1954. (Reprinted in Commercial Fisherman, Vol. 21, No. 9; Western Fisheries, Vol. 49, No. 1).

Tully, J.P. The eighth Pacific Science Congress. Canadian Department of Fisheries, Trade News, Vol. 6, No. 9, pp. 6-7, 18, 1954.

Tully, J.P., and L.A.E. Doe. Surface waters off the Canadian Pacific coast. MS Rept. Biol. Sta., No. 550, 14 pp., 1953.

Withler, F.C. Babine sockeye smolts. Canadian Department of Fisheries, Trade News, Vol. 6, No. 6, pp. 3-5, 1953.

STAFF LIST

(from 16 Nov 53 to 15 Nov 54)

SCIENTIFIC - FULL TIME

J.L. Hart, M.A., Ph.D., F.R.S.C.	Director (to 31 Jul 54)
A.W.H. Needler, O.B.E., M.A., Ph.D., D.Sc., F.R.S.C.	Director (from 1 Aug 54)
R.E. Foerster, M.A., Ph.D., F.R.S.C.	Principal Scientist
F. Neave, M.Sc., Ph.D., F.R.S.C.	Principal Scientist
D.F. Alderdice, M.A.	Associate Scientist
J.R. Brett, M.A., Ph.D.	Associate Scientist
J.G. Hunter, M.A.	Associate Scientist
K.S. Ketchen, M.A., Ph.D.	Associate Scientist
L. Margolis, M.Sc., Ph.D.	Associate Scientist
D.J. Milne, M.A., Ph.D.	Associate Scientist
M.P. Shepard, M.A., Ph.D.	Associate Scientist
J.C. Stevenson, M.A.	Associate Scientist
F.H.C. Taylor, M.A.	Associate Scientist
M. Waldichuk, M.A.	Associate Scientist
W.P. Wickett, M.A.	Associate Scientist
F.C. Withler, M.A.	Associate Scientist
K.V. Aro, B.A.	Assistant Scientist
W.E. Barraclough, M.A.	Assistant Scientist
T.H. Butler, M.A.	Assistant Scientist
D.R. Foskett, M.A.	Assistant Scientist
H. Godfrey, M.A.	Assistant Scientist
A.S. Hourston, M.A.	Assistant Scientist
J.I. Manzer, M.A.	Assistant Scientist
D. MacKinnon, M.A.	Assistant Scientist
J.G. McDonald, B.A.	Assistant Scientist (from 1 Nov 54 on educational leave)
D.N. Outram, B.A.	Assistant Scientist
G.C. Pike, M.A.	Assistant Scientist

TECHNICAL - FULL TIME

M.A. Pirart, A.M.I.R.E.	Technician Grade 3
T.H. Bilton, B.A.	Technician Grade 2
L. Quickenden	Technician Grade 2
K.R. Sutherland	Technician Grade 2
R.C. Wilson	Technician Grade 2
J.A. Bond	Technician Grade 1 (to 30 Oct 54)
W. Caulfield	Technician Grade 1
B.M. Chatwin, B.A.	Technician Grade 1
E. Dombroski, B.A.	Technician Grade 1 (to 27 Apr 54)
E.V. Epps	Technician Grade 1 (to 22 Jun 54)
C.R. Forrester	Technician Grade 1
R.E. Hirst	Technician Grade 1
R.S.K. Isaacson	Technician Grade 1
J. Martell	Technician Grade 1
G.T. Taylor	Technician Grade 1
R.M. Wilson	Technician Grade 1

E.A.R. Ball	Asst. Tech. Grade 3
A.S. Coburn	Asst. Tech. Grade 3
G.D.G. Denbigh	Asst. Tech. Grade 3
C.J. Morley	Asst. Tech. Grade 3
H. Neate	Asst. Tech. Grade 3
W.P. Neave	Asst. Tech. Grade 3
J.S. Rees	Asst. Tech. Grade 3
A. Rigby	Asst. Tech. Grade 3
W.G. St. Clair	Asst. Tech. Grade 3
E.W. Stolzenberg	Asst. Tech. Grade 3
D.B. Sutherland	Asst. Tech. Grade 3 (from 1 Sep 54)
B. Wildman	Asst. Tech. Grade 3
J.D. Carswell	Asst. Tech. Grade 2
R.M. Humphreys	Asst. Tech. Grade 2
J.A. Paul	Asst. Tech. Grade 2
D. Pozar	Asst. Tech. Grade 2

SCIENTIFIC AND TECHNICAL - TERM

A.L. Tester, M.A., Ph.D.	Senior Scientist (from 1 Sep 54)
I.V.F. Allen, B.A.	Junior Scientist (30 Mar 54 - 29 Sep 54)
Yvonne M.M. Bishop, B.A.	Junior Scientist (1 May 54 - 30 Jun 54)
R.J. LeBrasseur, M.A.	Junior Scientist (from 19 May 54)
M.D.F. Udvardy, Ph.D.	Technician Grade 2 (3 Jun 54 - 6 Jul 54)
G.V. Dubokovic, B.Sc.	Asst. Tech. Grade 3 (from 31 Mar 54)
O.K.L. Fingerhut, Ph.D.	Asst. Tech. Grade 3 (1 Apr 54 - 30 Sep 54)
F. Petterson	Asst. Tech. Grade 3 (31 Mar 54 - 16 Oct 54)
T.E. Monkman	Asst. Tech. Grade 3 (18 May 54 - 13 Aug 54)
A. Fingerhut	Asst. Tech. Grade 2 (30 Mar 54 - 5 Sep 54)
K. Muenter	Asst. Tech. Grade 2 (19 May 54 - 31 Aug 54)
R.E. Johannes	Asst. Tech. Grade 1 (14 Jun 54 - 9 Sep 54)
M.P. Banno, B.A.	Student Assistant (7 May 54 - 8 Sep 54)
A.W. Beach, B.A.	Student Assistant (17 May 54 - 17 Sep 54)
E.J. Chan	Student Assistant (14 Jun 54 - 31 Aug 54)
S.W. Devine, B.A.	Student Assistant (7 May 54 - 17 Sep 54)
J. Enns	Student Assistant (4 May 54 - 31 Aug 54)
Beverley M. Gartrell	Student Assistant (10 May 54 - 17 Sep 54)
H.J. Heilbron, B.A.	Student Assistant (7 May 54 - 17 Sep 54)
J.R. Hill	Student Assistant (10 May 54 - 31 Aug 54)
L. Naomi R. Johnson	Student Assistant (3 May 54 - 10 Sep 54)
Y.P. Lau, B.Sc.	Student Assistant (4 May 54 - 21 Aug 54)
Mary Lennox, B.A.	Student Assistant (10 May 54 - 3 Sep 54)
H.D. McIntosh	Student Assistant (4 May 54 - 31 Aug 54)
A. Elizabeth Neave	Student Assistant (1 May 54 - 17 Aug 54)
M.O. Opseth	Student Assistant (4 May 54 - 31 Aug 54)
W.B. Syslak	Student Assistant (14 May 54 - 2 Sep 54)
R. Tkachuk, B.A.	Student Assistant (7 May 54 - 1 Sep 54)
Lois Tuck	Student Assistant (3 May 54 - 10 Sep 54)
Deena Wakhroucheff	Student Assistant (3 May 54 - 17 Sep 54)

VOLUNTEER INVESTIGATORS

C.J. Berkeley, F.C.I.C.
Edith Berkeley
W.E. Johnson, Ph.D.

ADMINISTRATIVE AND CLERICAL

G.F. Hart	Administrative Officer Grade 2
Ethel E. Robinson	Clerk Grade 4
Elizabeth H. Dewar	Clerk Grade 3 (to 30 Jun 54)
O.O. Morgan	Clerk Grade 3 (from 25 May 54)
Margaret K. Philp	Clerk Grade 3
S. Grando	Clerk Grade 2B
Evelyn M. Keighley	Clerk Grade 2B
Ruth Taylor	Clerk Grade 2A (to 15 Oct 54)
Laura Rasmussen	Stenographer Grade 2A
S. Diane Blackburn	Stenographer Grade 1
Beatrice M. Gulewich	Stenographer Grade 1
Helen Montgomery	Stenographer Grade 1 (to 1 March 54)
Elizabeth Seslija	Stenographer Grade 1
M. Madeline N. Smith	Stenographer Grade 1 (from 18 Oct 54)
Winnifred A. Swann	Stenographer Grade 1 (from 1 Mar 54)
G. Mares, B.A., LL.D.	Clerk Grade 4 (to 3 Jul 54)(Translator)
H.N. Scott	Clerk Grade 2B (30 Nov 53 - 30 Jan 52)
Mary Galvani	Typist Grade 2A (22 Mar 54 - 21 Apr 54)
Shelagh Fagan	Typist Grade 1 (19 Jul 54 - 10 Sep 54)
Dorothy Manson	Typist Grade 1 (3 May 54 - 17 Sep 54)
Marjorie Lehman	Typist Grade 1 (27 May 54 - 15 Jun 54)

MAINTENANCE

A.G. Paul	Maintenance Supervisor Grade 5
J. Jardine	Caretaker Grade 3
J.C. Wallace	Caretaker Grade 3
E.E. Chandler	Caretaker Grade 3 (from 7 Nov 54)
J. Curtis	Caretaker Grade 1 (to 20 Mar 54)
W.J. Hogan	Cleaner and Helper
G.T. Worden	Cleaner and Helper
O. Perrin	Watchman
T. Russell	Watchman

BOATS

C.E. Watson	Captain (from 21 Jun 54)
A.N. Yates	Technician Grade 1 (Captain)
G.N. Buxton	Ship's Engineer (29 Jun 54 - 15 Oct 54)
R.E. Griffin	Ship's Engineer (from 18 Oct 54)
E.A. Lewis	Ship's Engineer (from 21 Jun 54)
A.E. Ranger	Ship's Engineer (to 13 Jul 54)
E. Bateman	Cook-Deckhand
G. Minard	Cook-Deckhand (from 14 Jul 54)

PART TIME

May Henry	Observer

Personnel of Pacific Oceanographic Group with headquarters at Pacific Biological Station

SCIENTIFIC - FULL TIME

J.P. Tully, M.B.E., M.Sc., Ph.D., A.R.I.C., F.C.I.C.	Senior Scientist
F.G. Barber, B.A.	Assistant Scientist
A.J. Dodimead, M.A.	Assistant Scientist (from 4 Oct 54)
R.A. Pollard, M.Sc.	Assistant Scientist
S. Tabata, B.A.	Assistant Scientist
R.W. Trites, M.A.	Junior Scientist (educational leave to 1 May 54) (educational leave from 20 Sep 54)

TECHNICAL - FULL TIME

H.J. Hollister	Technician Grade 3
R.H. Herlinveaux	Technician Grade 2
A.W. Groll, B.A.	Technician Grade 1 (from 1 Oct 54)
H.E.J. Legare, B.Sc.	Technician Grade 1 (to 30 Sep 54)
L.H. McCracken	Technician Grade 1
B.J. Burns	Asst. Tech. Grade 3 (to 25 Sep 54)
J.A. Stickland	Asst. Tech. Grade 2

SCIENTIFIC AND TECHNICAL - TERM

N.P. Fofonoff, M.A., Ph.D.	Assistant Scientist (from 30 Aug 54)
M. Kirsch, B.Sc., Ph.D.	Assistant Scientist (3 May 54 - 15 Sep 54)
G.L. Pickard, M.B.E., B.A., Ph.D.	Assistant Scientist (3 May 54 - 18 Jun 54)
L.M. McKenzie	Asst. Tech. Grade 1 (21 Jun 54 - 11 Sep 54)
E.B. Bennett	Student Assistant (1 May 54 - 30 Sep 54)
A.W. Groll, B.A. (subsequently full-time indeterminate)	Student Assistant (1 May 54 - 30 Sep 54)
R.F. Platford	Student Assistant (1 May 54 - 22 Sep 54)

CLERICAL

Beverley M. Berisford	Stenographer Grade 3
Margaret A. Smith	Stenographer Grade 1 (from 20 Jul 54)
Ruth Nash	Stenographer Grade 2A (17 Nov 53 - 30 Jan 54)
Marjorie Lehman	Typist Grade 1 (16 Jun 54 - 9 Jul 54)

ORGANIZATION

(as of November 15, but including all seasonals employed during year)

DIRECTOR	A.W.H. Needler, Ph.D.
Asst. Director and Scientific Asst. to Director	J.C. Stevenson, M.A.

INVESTIGATIONAL STAFF

Experimental Biology	
Associate Scientist in charge	J.R. Brett, Ph.D.
Associate Scientist	D.F. Alderdice, M.A.
Asst. Tech. Grade 3	D.B. Sutherland
Student Assistant (term)	Mary Lennox, B.A.
Groundfish	
Associate Scientist in charge	K.S. Ketchen, Ph.D.
Assistant Scientist	W.E. Barraclough, M.A.
Technician Grade 1	B.M. Chatwin, B.A.
Technician Grade 1	C.R. Forrester
Technician Grade 1	R.M. Wilson
Asst. Tech. Grade 3	W.G. St. Clair
Student Assistant (term)	Lois Tuck
Student Assistant (term)	A.W. Beach, B.A.
Herring	
Associate Scientist in charge	F.H.C. Taylor, M.A.
Assistant Scientist	A.S. Hourston, M.A.
Assistant Scientist	D.N. Outram, B.A.
Technician Grade 1	J.A. Bond
Technician Grade 1	R.S.K. Isaacson
Technician Grade 1	G.T. Taylor
Asst. Tech. Grade 3	W.P. Neave
Asst. Tech. Grade 3	J.S. Rees
Asst. Tech. Grade 3	A. Rigby
Asst. Tech. Grade 3	E.W. Stolzenberg
Asst. Tech. Grade 3	B. Wildman
Senior Scientist (term)	A.L. Tester, Ph.D.
Asst. Tech. Grade 1 (term)	R.E. Johannes
Student Assistant (term)	L. Naomi R. Johnson
Marine Crustacea (Crab and Shrimp)	
Assistant Scientist in charge	T.H. Butler, M.A.
Asst. Tech. Grade 3 (term)	G.V. Dubokovic, B.Sc.
Pathology	
Associate Scientist in charge	L. Margolis, Ph.D.
Student Assistant (term)	Deena Wakhroucheff

Pink and Chum Salmon	
Principal Scientist in charge	F. Neave, Ph.D.
Associate Scientist	J.G. Hunter, M.A.
Associate Scientist	W.P. Wickett, M.A.
Assistant Scientist	J.I. Manzer, M.A.
Technician Grade 2	R.C. Wilson
Technician Grade 1	W. Caulfield
Asst. Tech. Grade 2	J.D. Carswell
Asst. Tech. Grade 3 (term)	F. Petterson
Asst. Tech. Grade 2 (term)	K. Muenter
Caretaker-Observer (part-time)	E.E. Chandler
Pollution	
Associate Scientist in charge	M. Waldichuk, M.A.
Sockeye Salmon	
Principal Scientist in charge	R.E. Foerster, Ph.D.
Associate Scientist	M.P. Shepard, Ph.D.
Associate Scientist	F.C. Withler, M.A.
Assistant Scientist	K.V. Aro, B.A.
Assistant Scientist	D.R. Foskett, M.A.
Assistant Scientist	H. Godfrey, M.A.
Assistant Scientist	D. MacKinnon, M.A.
Assistant Scientist	J.G. McDonald, B.A.
Technician Grade 2	T.H. Bilton, B.A.
Technician Grade 1	J. Martell
Asst. Tech. Grade 3	H. Neate
Asst. Tech. Grade 2	R.M. Humphries
Asst. Tech. Grade 2	J.A. Paul
Asst. Tech. Grade 2	D. Pozar
Junior Scientist (term)	I.V.F. Allen, B.A.
Junior Scientist (term)	R.J. LeBrasseur, M.A.
Asst. Tech. Grade 3 (term)	O.K.L. Fingerhut, Ph.D.
Asst. Tech. Grade 2 (term)	A. Fingerhut
Student Assistant (term)	M.P. Banno, B.A.
Student Assistant (term)	S.W. Devine, B.A.
Student Assistant (term)	J. Enns
Student Assistant (term)	H.J. Heilbron, B.A.
Student Assistant (term)	Y.P. Lau, B.Sc.
Student Assistant (term)	H.D. McIntosh
Student Assistant (term)	M.O. Opseth
Student Assistant (term)	W.B. Syslak
Student Assistant (term)	R. Tkachuk, B.A.
Observer (part-time)	May Henry
Troll Salmon	
Associate Scientist in charge	D.J. Milne, Ph.D.
Asst. Tech. Grade 3	E.A.R. Ball
Student Assistant (term)	E.J. Chan
Student Assistant (term)	J.R. Hill
Western Arctic	
Principal Scientist in charge	F. Neave, Ph.D.

Whale	
Assistant Scientist in charge	G.C. Pike, M.A.
Miscellaneous	
Junior Scientist (term)	Yvonne M.M. Bishop, B.A.
Student Assistant (term)	A. Elizabeth Neave
Volunteer Investigator	C.J. Berkeley
Volunteer Investigator	Edith Berkeley
Volunteer Investigator	W.E. Johnson, Ph.D.
TECHNICAL SERVICES	
Associate Scientist in charge	J.C. Stevenson, M.A.
Technician Grade 3 (Electronics Lab.)	M. Pirart
Asst. Tech. Grade 3 (Draughting)	G.D.G. Denbigh
Asst. Tech. Grade 3 (Photography - part-time)	C.J. Morley
Clerk Grade 2B (Library)	Evelyn M. Keighley
Clerk Grade 4 (Translator - term)	G. Mares, LL.D.
Technician Grade 2 (Storage Museum - term)	M.D.F. Udvardy, Ph.D.
Student Assistant (Library - term)	Beverley M. Gartrell
ADMINISTRATIVE AND SECRETARIAL STAFF	
Secretarial Staff	
Clerk Grade 4 in charge	Ethel E. Robinson
Clerk Grade 3	Margaret K. Philp
Stenographer Grade 1	S. Diane Blackburn
Stenographer Grade 1	Beatrice M. Gulewich
Stenographer Grade 1	Elizabeth Seslija
Typist Grade 1 (term)	Dorothy Manson
Administrative Staff	
Administrative Officer Grade 2 in charge	G.F. Hart
Accounting, Purchasing, etc.	
Clerk Grade 3	O.O. Morgan
Clerk Grade 2B	S. Grando
Stenographer Grade 2A	Laura Rasmussen
Stenographer Grade 1	M. Madeline N. Smith
Stenographer Grade 1	Winnifred A. Swann
Typist Grade 1 (term)	Shelagh Fagan
Buildings and Grounds, and General	
Maintenance Supervisor Grade 5	A.G. Paul
Caretaker Grade 3	J. Jardine
Caretaker Grade 3	J.C. Wallace
Cleaner and Helper	W.J. Hogan
Cleaner and Helper	G.T. Worden
Watchman	O. Perrin
Watchman	T. Russell
Technician Grade 2 (part-time)	L. Quickenden
Technician Grade 2	K.R. Sutherland
Technician Grade 1	R.E. Hirst
Asst. Tech. Grade 3	A.S. Coburn
Asst. Tech. Grade 3 (part-time)	C.J. Morley

Boats	
"Investigator No. 1"	
Captain (Technician Grade 1)	A.N. Yates
Engineer	R.E. Griffin
Mate	W.H. Greenfield
Cook-Deckhand	E. Bateman
"Cancolim II"	
Captain	C.E. Watson
Engineer	E.A. Lewis
Mate	L.E. Hoy
Cook-Deckhand	G. Minard
"Alta"	
Captain-Engineer (Technician Grade 2 - part-time)	L. Quickenden
"Siliqua"	
Captain-Engineer (Technician Grade 2)	R.C. Wilson

Pacific Oceanographic Group
(responsible to Joint Committee on Oceanography)

Oceanographer-in-Charge - Senior Scientist	J.P. Tully, Ph.D.

INVESTIGATIONAL STAFF

Assistant Scientist	F.G. Barber, B.A.
Assistant Scientist	A.J. Dodimead, M.A.
Assistant Scientist	R.A. Pollard, M.Sc.
Assistant Scientist	S. Tabata, B.A.
Junior Scientist (on educational leave)	R.W. Trites, M.A.
Technician Grade 3	H.J. Hollister
Technician Grade 2	R.H. Herlinveaux
Technician Grade 1	A.W. Groll, B.A.
Technician Grade 1	L.H. McCracken
Asst. Tech. Grade 2	J.A. Stickland
Assistant Scientist (term)	N.P. Fofonoff, Ph.D.
Assistant Scientist (term)	M. Kirsch, Ph.D.
Assistant Scientist (term)	G.L. Pickard, Ph.D.
Asst. Tech. Grade 1 (term)	L.M. McKenzie
Student Assistant (term)	E.B. Bennett
Student Assistant (term)	R.F. Platford

SECRETARIAL STAFF

Stenographer Grade 3	Beverley M. Berisford
Stenographer Grade 1	Margaret A. Smith

S O C K E Y E S A L M O N - R.E. Foerster

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S O C K E Y E S A L M O N - R.E. Foerster

The principle governing much of the research conducted by the Sockeye Salmon Investigation is that the return of adults to the commercial fishery and the spawning grounds is largely dependent on the output of seaward-migrating young (smolts) from the nursery areas. The aim of the various research projects is to determine the factors controlling the production of smolts resulting from known depositions of eggs and to relate the output of smolts to the return of adult fish.

To achieve this aim, studies are being conducted on the freshwater production of sockeye in three areas--at Babine and Lakelse Lakes in the Skeena River drainage and at Port John in the central coast region. In addition to these projects, annual examinations of the sockeye catches are carried out on the Skeena River and Nass River, and at Rivers Inlet and Smith Inlet fishing areas.

At Babine Lake, the principal sockeye-producing area of the Skeena River, annual assessments are made of adult runs and the resultant smolt seaward migrations. The program is providing critical information on the influence of different-sized egg depositions on the production of smolts. Due to serious reductions in the escapements of 1951 and 1952, resulting from the Babine rock slide, and to an unusually heavy escapement in 1953, a wide range of potential depositions has been observed. These data, extended by subsequent observations, will provide information in three ways. Firstly, they will indicate whether or not production of smolts in Babine is being limited by the freshwater environment and, if so, will provide a basis for establishing the maximum deposition required for the optimum smolt output. Secondly, the premise that the magnitude and composition of adult runs is determined by the abundance, size and age of smolts can be appraised. These studies may provide procedures for predicting the total adult returns from known spawnings. Thirdly, the present annual assessments provide the regulatory branch of the Department of Fisheries with information on the condition of the important Babine runs and their relative reproductive success. This service was invaluable in the study of the effects of the Babine rock slide.

Studies on the survival of fry at Six Mile Creek were terminated this year. The extreme climatic difficulties involved in gaining reliable information made continued operation unprofitable. However, the information collected in the past will be useful for comparison with data on fry production in other areas. The facilities of the Six Mile camp are being maintained for possible experimental studies in the future.

At Lakelse Lake data similar to those collected at Babine on population changes are being interpreted in terms of the physical and organic environment. The objective of the Lakelse researches are to determine and measure the factors which control and limit production of the sockeye, from egg to smolt. Their usefulness will be in development of procedures for augmenting or rehabilitating natural stocks, and maintaining stocks in environments that have been altered through industrial expansion. To this end, counting fences and reliable estimating techniques have been developed to enumerate and sample the adult run to the lake, the adults reaching the spawning streams, the resultant fry, and the smolts leaving the lake. Concurrent with enumeration, continuous records of the changing environment are made. In the last two years the program has involved the development

and assessment of standard techniques. Using the routine program as a basis, three types of research projects have been initiated. Firstly, using information from the routine program, correlations are being sought between the reproductive success of the sockeye in different years and various environmental factors. Secondly, short-term fundamental studies are being conducted on some phases of the life-history of the sockeye. For example, studies of the effects of plankton distribution and density on the growth and abundance of lacustrine sockeye are under way. Thirdly, projects involving manipulation of environmental conditions followed by assessment of the results of the change on the sockeye are planned. An important study of this kind will be a fish removal program, for which the collection of one more year's control data must be obtained.

At Port John, a small watershed in the central coastal region, sockeye enumerations similar to those described for Lakelse Lake are being carried out. The total numbers of sockeye produced in the area are small, but the average rate of survival (from egg to smolt) is higher than that observed in other areas. Comparisons of sockeye-producing capacity and general ecology in different areas will provide some significant correlations between environment and sockeye production. Such comparative studies are long-term; syntheses of data from a wide range of salmon-producing lakes in North America will be necessary.

For many years, the sockeye catches of the central and northern regions--Nass River, Skeena River, Rivers Inlet, Smith Inlet--have been sampled to determine the average size of fish and the age composition of the runs. These data are essential for characterising that segment of the adult salmon population taken by the fisheries and relating production to appropriate brood years, since there are two or more age-groups prominently involved.

The need for providing a closer link between freshwater studies and information derived from the fishery has been recognized. This year critical studies of the Skeena sampling program were undertaken, and past Skeena catch and escapement data were examined to determine trends in the catch and some of the changes which the fishery makes on the composition of the runs returning from the sea.

As a special project, members of the staff have participated in the preparation of the second report on the effects of the rock slide on the adult run to Babine Lake.

THE SKEENA FISHERY

H. Godfrey

During the past summer a large volume of data relating to Skeena sockeye catches and escapements was analysed for the purpose of obtaining useful information on the Skeena sockeye fishery and its relationship to the production of Skeena sockeye salmon. This was combined with a personal familiarization with the fishery and the lower part of the river system.

Much of the results, however informative, is not suitable for presentation here, but the topics that are discussed are considered more complete than others, or at least as complete as the available data and form of analysis will allow.

A. Comparison of catch and escapement.

A gill-net fishery not only removes individuals from the runs of returning adults, but it also changes the size, sex, and age-class composition of the runs. This is because the nets are selective for sizes,

and because there are significant differences between the sizes of fish of different sex and of different age.

Because of changes in the size of the fish as they migrate up the rivers after having passed through the fishery, it is usually impossible to compare directly the kinds of fish taken by the fishery and the kinds of fish in the escapement. Such comparisons can be made, however, using fish tagged before they enter the fishery, if their lengths are recorded when they are tagged.

In 1947 and 1948 a large number of sockeye salmon were captured by seine off the mouth of the Skeena River, and were measured and tagged. Recoveries were made from the catch and from the escapement, for which comparisons are shown in Figure 1. In both years the sizes of fish tagged were very similar to the sizes among the combined recoveries (catch and escapement). It can be said, therefore, that the recoveries were sufficiently representative of the tagged population. There were important differences between the size distributions of recaptures in the escapement, and the recaptures in the commercial catch. In both years recoveries in the commercial catch contained relatively more larger fish, and fewer smaller fish. Since the bi-modality of the curves beyond 17 inches (maximum length of "jacks" or 3-year males) indicates the two major age-classes (4- and 5-year-old fish), it is also evident that more 4-year-old fish escaped than 5-year-old fish. Since, also, males were larger than females (within each age-class), then relatively more females must have escaped than males. This last is an interesting conclusion, since both in the commercial catches and in the escapements (at least the large Babine escapement) there were relatively more females than males among 4- and 5-year-old fish, so that the runs that returned from the sea must have had considerably higher proportions of females than of males. The production of the male "jack" salmon is undoubtedly related to this phenomenon.

B. The trend of the Skeena catch.

Changes in the production of Skeena sockeye could be understood better if it were possible to estimate the numbers of adults of different ages in the escapements as well as in the catch. However, escapements have not been so described, so that only the catches (which were sampled for age determinations) can be used to obtain some approximate indications of trends or changes. The catches of 4- and 5-year-old Skeena sockeye from the same brood stock, in the years 1910 to 1952, are shown in Figure 2, with accompanying regression lines. In the period 1911 to 1933 the catch of the combined 4's (year n) and 5's (year n + 1) declined ($b = -1.63$); during the subsequent period (1933-52) they gradually increased ($b = +1.22$). The decline in the earlier period is associated with a decrease in the average catch of 5-year-old fish ($b = -1.75$), rather than of 4-year-old fish ($b = -0.178$). The average gain in the later period is associated with an increase in the average catch of 5's ($b = +1.16$), rather than of 4's ($b = -0.008$).

An interesting feature of this analysis occurs in the tendency during the early period (1910-25) for a 5-year cycle in the combined catch of 4- and 5-year-old fish from the same brood stock, which was related to an apparent 5-year cycle among the 5-year-old fish. Because of the varying production of 4- and 5-year-old fish in the Skeena, it could not be expected that either 4- or 5-year cycles would persist for long; nor did they do so, at least on the basis of the catch data. The apparent 4-year cycle in the combined catch in the later period (during which time, as already noted, the average catch of 4's remained relatively constant) should not persist if, as stated above, the average catch of 5-year-old fish is increasing. An

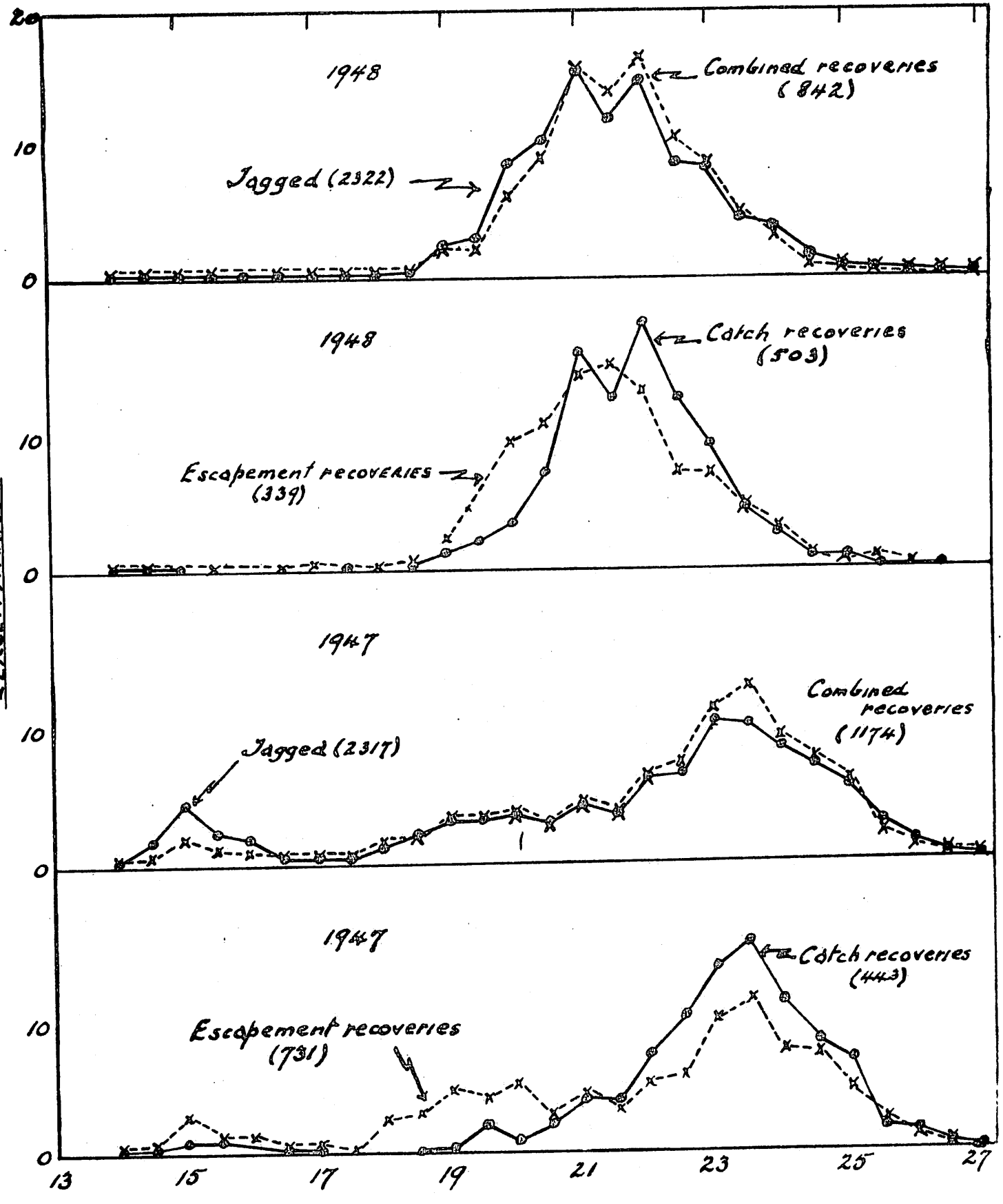


Fig. 1. Comparisons of the percentages of tagged sockeye belonging to different half-inch length classes among the tagged samples, the commercial catch recovery samples, and the escapement samples, 1947 and 1948.

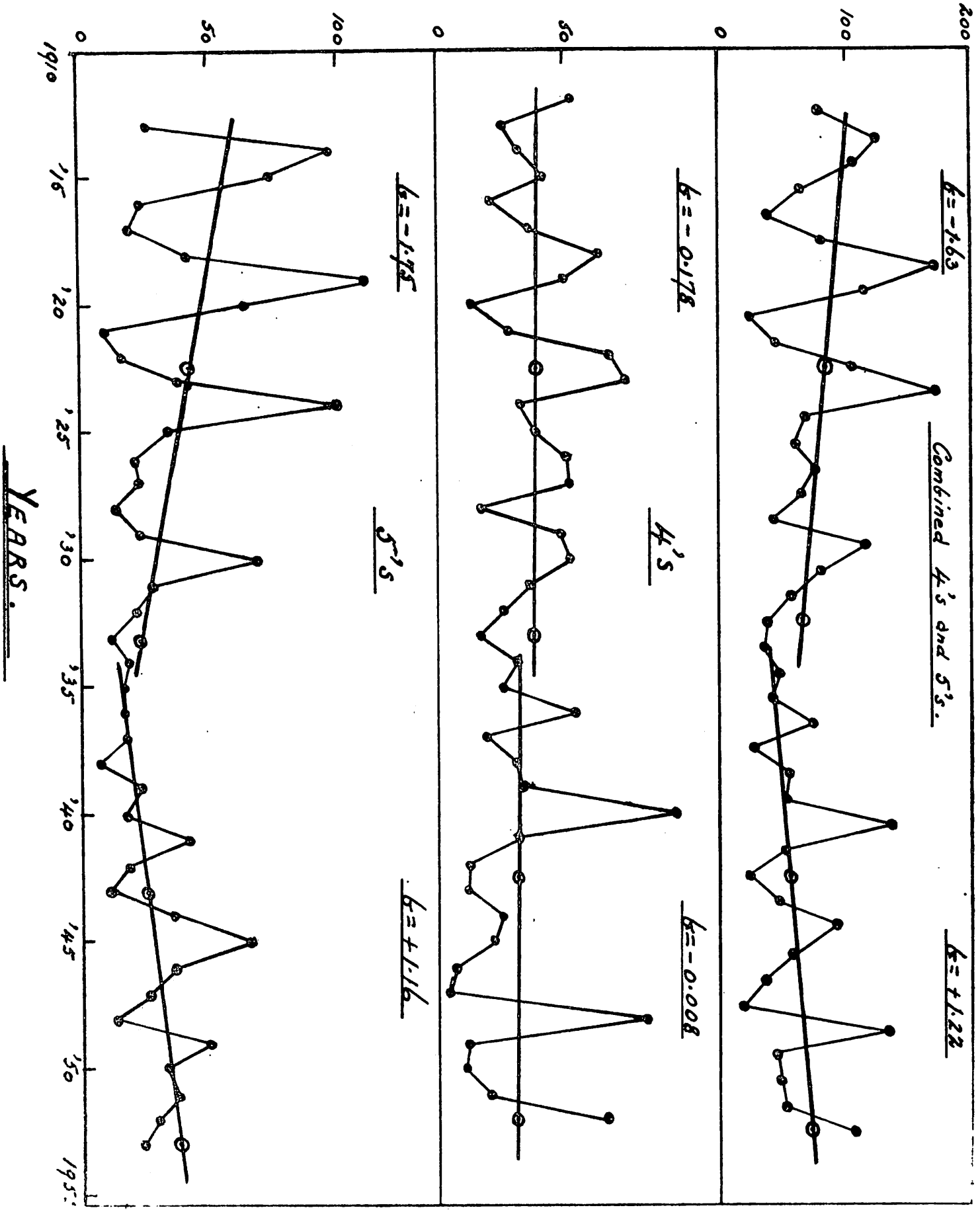


Fig. 2. Trends in the catch of Skeena River sockeye of two age-classes of the same brood stock, 1912-1953.

indication of a relationship between 4- and 5-year-old fish is discussed in the following section.

C. Size of catch and age composition.

One of the more perplexing problems of Skeena sockeye population is that of their age-class composition, and the relationship between age and survival to adult return. Skeena sockeye runs have at least four age-groups, but the two that make up 90% of the runs are the 4_2 and 5_2 fish. Because information is not available on the age composition of the escapement, it is difficult, and perhaps impossible, to demonstrate the true relationship between the production of 4-year-old fish and production of 5-year-old fish. Nevertheless, the attempt has been made, through examining the catch statistics, to determine whether there is a relationship between the magnitude of the catch and the proportions of the two age-classes. The catch will, of course, be that of the same brood stock.

The relationship between the catch of 5's and the catch of 4's plus 5's is highly significant ($r = +0.85 \pm 0.04$). This, of course, is expected, since the combined catch included large numbers of the other variate (5's). The interesting point is that the fitted linear regression line ($b = +1.304$) indicates that as the combined catch increases, the proportions of 5's increase; in other words, that larger catches are usually associated with more 5's than 4's (and small catches with more 4's than 5's). However, when the percentages of 5's are plotted against the combined catch of the common brood stock, the linear relationship is seen to be less valid: the points are scattered, although, still, with the largest catches, there are more 5's than 4's. Now the average catch of 4's (1908-52) was 36.1 (thousands of cases), with a standard deviation of 21.7 ± 3.4; and that of 5's, 34.4, and 25.6 ± 4.0. The similarity of the means results from the fact that most catches were medium-sized, when the proportions of 5's and 4's were fairly similar. It is therefore suggested that the situation in respect to the catches of 4's and 5's of common brood stock is probably as follows: (1) that with most catches the proportions of 4's and 5's fluctuate about a common mean - that is, that with an average catch they tend to be fairly equal; (2) the occasional large catches have a greater proportion of 5's than of 4's. This situation could reflect the phenomena of cyclic trends among the two age-classes. In a preceding section it was said that the decline in the earlier period of the Skeena catches was associated with a decline in the average catch of 5's rather than of 4's; and that the increase in the average catch during the latter period was associated with an increase in the average catch of 5's and not of 4's.

The catches of Rivers Inlet sockeye have also been examined to compare their variability with that of the Skeena catches. Here the picture is a little more definite (perhaps reflecting the greater homogeneity of that population, since it involves only one major spawning area as compared with several in the Skeena system). There seems to be a definite increase in the percentage of 5's as the combined catches of 4's and 5's increased. Furthermore, the catch of 5's showed much greater variability than that of 4's, having a mean and standard deviation of 43.6 and 34.8 ± 5.5, respectively, as compared with 4's, 36.5, and 18.7 ± 3.0. This again resulted from the fact that the less frequent, very large catches consisted mostly of 5-year-old fish.

The analysis must remain incomplete until it is possible to include the age composition of the escapement with that of the catch. If that can be done, and the relationship between the two age-classes determined, the factors affecting adult return will be better understood.

D. Seasonal trends in sex ratios.

The sex ratios of the Skeena sockeye catch for the past 30 years (as determined by sampling) have been analysed to obtain a better understanding of the characteristics of the Skeena runs. There have been occasions when it has been considered that the preponderance of certain sexes or sizes early in the season might be indicative of the kind of run that would follow. The catch consists mostly (about 90%) of the 4_2 and 5_2 age-classes, and the proportions of these two groups have varied greatly from year to year. The seasonal changes in sex ratios have been determined for each of the two age-classes separately; and only the recent years, 1940 to 1953, will be referred to at this time.

Among the 5_2 fish the final proportion of females has always been greater than that of males, roughly 65:35%, on the average. Early in the run the proportion of females has usually been a little greater than, or at least equal to, the proportion of males; after that the proportions of females have increased fairly steadily throughout the season.

In the case of the 4_2 fish the situation is more varied. In the total catches females have usually exceeded males, but less so than among the 5's. In a few instances males have either slightly exceeded, or have been equal to, females. In most years the runs have started off with an excess of males, and as they have progressed the proportions of females have increased. In a few cases there was no definite trend, but merely variation during the season.

E. Comparative sampling of sockeye catch.

In past years the Skeena sockeye catch has been sampled at one cannery. To determine whether this was sufficient to provide a representative sample of the whole Skeena catch it would be necessary to make comparisons with other canneries. This would be particularly necessary, if, as does happen in the Skeena fishery, the effort of different companies is concentrated in different parts of the fishing area. Skeena River, Area 4, is separated by imaginary lines from Area 3 (Nass River) and Area 5 (Banks Island). Some companies expend most of their fishing effort in the outer waters of the area (where intermingling of Skeena fish with other populations is known to occur), while other keep there fleets closer to the river mouth boundary.

To obtain an idea of the effort needed, and of the kind of information that could be gained by comparative sampling, sampling was carried out simultaneously (early in the season) at three canneries.

The analysis has not been completed, but a preliminary examination shows that although there were differences between the samples, they were not very great, and cannot be taken as definitely indicative of different populations having been fished. This does not mean that the same population was being fished. Frequently different salmon populations, or geographic races, show only insignificant size differences; and, furthermore, it could happen that the returning adults were similar in their sex ratios and age-class composition. Indirect evidence, such as the distribution of the Skeena fleet, and observed differences in the quality and the flesh colour of the fish caught, does suggest that if any proposed program calls for a thorough sampling of the Skeena catch, comparative sampling at the several canneries will be necessary to determine the best procedure.

A summary of the comparative data is presented: (all figures are percentages)

	Sex Ratios		
	M	F	Total sample-numbers
North Pacific	46.4	53.6	537
Oceanside	46.5	53.5	348
Sunnyside	46.0	54.0	346

	Age-classes			
	4_2	5_2	5_3	6_3
North Pacific	39.7	43.2	13.0	4.1
Oceanside	37.9	43.7	15.2	3.2
Sunnyside	34.1	50.6	10.7	4.6

	Ratio of 4_2:5_2	
	4_2	5_2
North Pacific	47.9	52.1
Oceanside	46.5	53.5
Sunnyside	40.3	59.7

	Mean lengths and weights of 4_2's					
	North Pacific		Oceanside		Sunnyside	
	M	F	M	F	M	F
Length - inches	22.4	22.5	23.0	22.8	23.3	22.9
Weight - pounds	5.0	4.9	5.5	5.3	5.4	5.2

	Mean lengths and weights of 5_2's					
	North Pacific		Oceanside		Sunnyside	
	M	F	M	F	M	F
Length - inches	26.4	25.0	26.4	25.1	26.4	24.8
Weight - pounds	8.4	7.0	8.3	7.1	8.0	6.5

BABINE LAKE

F. C. Withler

Babine Lake investigations are concerned largely with gross assessment of the sockeye population of the watershed. The lake's large size and numerous spawning areas preclude intensive study of all its spawning areas with the result that most effort is directed toward evaluating the relationship between the size and composition of the runs of adult sockeye to the lake and the resultant smolt outputs.

From 1946 to 1948 the Babine counting fence demonstrated the magnitude of the Babine run as part of the program to evaluate the relative sizes of spawning stocks of the Skeena watershed. Since then the operation has been maintained to provide the background necessary to study the relation of stock to smolt output. In 1951 and 1952 the fence data supplied valuable information on the effects of the Babine River slide and provided a gauge of success of corrective measures instituted by the Department of Fisheries. Other salmon species passing the fence are enumerated and all information on the size of escapements are made available to the Department.

The attempt to estimate the size of the Babine smolt run in 1951 without constructing a standard counting weir proved sufficiently successful to employ the method for obtaining annual estimates of smolt output. The disastrous effects of the Babine River rock slide on the spawning runs of 1951 and 1952 provided otherwise unobtainably small potential egg depositions to illustrate the stock-to-output relationship over a wide range of stock intensity. Smolt production figures for 1953 and 1954 have illustrated the effect of the slide on smolt production. Extensive examinations of smolts taken during the runs demonstrate the effect on smolt size, as well as smolt numbers, of various stock intensities.

Fry survival studies at Six Mile Creek were suspended in the summer of 1954 in the face of difficult operation and a disproportionate drain of effort by the physical conditions attending travel and operation. The estimate of the fry run for 1954 provides a second survival figure for the stream. Studies of predation on fry, the loss between egg and fry, the behaviour of the spawning run and the physical conditions attending the adults and young in the stream were carried out in conjunction with the main objective of providing survival figures.

Where possible, in conjunction with the main work of population assessment, special studies of conditions which are unique to the Babine Lake population or to the watershed are undertaken. Hence considerable effort has been expended to follow up the consequences of the Babine River rock slide; waterfowl predation on young salmon in the strategic Fort Babine area has been examined; and the behaviour of salmon at the counting fence has been investigated. Wherever possible, local studies on spawning behaviour and conditions in the area are pursued in close cooperation with Department of Fisheries personnel.

A. Adult studies.

F. C. Withler and K. V. Aro

Following the construction of the Babine River adult counting fence in 1946 the runs of sockeye salmon to the Babine Lake watershed have been enumerated annually, except in 1948 when floods damaged the structure. The size of the 1948 run was estimated by observations on the spawning grounds. Since the initial discovery that the runs to the Babine watershed constitute about 70% of the Skeena escapement the fence count has been accepted as the best single measure of the sockeye escapement to the Skeena River. The data

from the weir have taken on further importance since 1951 when the blockage on the Babine River occurred.

The 1954 adult count, herein reported, is important not only be-because the run was the second to pass the site of the former blockage but also because the run was the first to return which contained issue of the sockeye which surmounted the slide. These returning sockeye which are a part of the 1951 brood left the lake as yearlings in the spring of 1953 and returned in 1954 as "jacks" or 3-year-olds after spending one year in the sea.

Extensive sampling is carried out on sockeye passing the fence be-cause mere enumeration of the run may give a false picture of the runs' spawn-ing potential. It is possible now to estimate within very narrow limits the number of sockeye eggs potentially available for deposition in the Babine area. These spawning potentials have been shown to vary more widely than the size of annual runs.

Although spring, pink, coho, and chum salmon do not spawn exclusively above the fence, these species are counted each year to provide indices of the sizes of those runs to the river. Many fish of these species were also the progency of fish in runs which had been affected by the Babine slide.

1. Salmon enumeration at the Babine fence in 1954.

The Babine fence was operated from the time the panels were installed on July 22 until they were removed on October 4. Installation of the panels was delayed beyond the usual time because of the possible detrimental effect of the high water conditions on some of the underwater portions of the fence. The counts of the five species of salmon which passed through the weir during the period of operation in 1954 are compared in the following table with counts obtained in other years.

Year	Sockeye	Percentage "jack" sockeye	Spring	Pink	Coho	Chum
1946	475,705	12.2	10,528	28,161	12,489	18
1947	522,561	50.0	15,614	55,421	10,252	7
1948	560,000*					
1949	509,132	9.4	7,433	13,663	11,938	5
1950	543,658	33.0	6,838	38,728	11,654	7
1951	152,457	7.2	2,778	50	2,122	0
1952	376,947	7.4	5,915	2,706	10,554	1
1953	714,614	3.9	8,353	1,018	7,648	17
1954	503,422	1.9	5,925	4,604	3,094	66

* Estimated from comparison with stream survey counts and fence counts of previous years.

The 1954 counts are of interest in that many of the salmon were the progeny fish which were affected by the Babine River rock slide in 1951 and 1952.

The count of sockeye salmon in 1954 was comparable to those in non-slide years. The count of 144 sockeye on July 23, the first day of operation, and the fact that a few sockeye had been caught a few days earlier in the Ind-ian fishery above the fence indicate that a number of sockeye had passed before the panels were installed. However, these numbers were so small as to be of no

significance. After July 23 the run increased to form a characteristic early peak of 15,119 sockeye on July 29, declined to a low of 1,455 sockeye on August 10, and rose again, first slowly and then very rapidly, to form the main peak of 38,755 sockeye on September 1. This peak occurred later than in any other non-slide year with the exception of 1949 when it occurred on September 2. The count on the peak day was 6,000 in excess of the count on the largest peak in previous years. The lateness and large size of the peak suggest that these fish passed through the estuary of the Skeena River during the week-ends when special closures were in effect (July 31 to August 2 and August 6 to August 8) and/or during the week (August 9 to August 14) when the fishery was closed owing to a tendermen's strike. Following the peak the run fell rapidly until October 3 when only 14 sockeye passed the fence.

Spring salmon passed the fence in slightly lesser numbers than in other non-slide years. The lower numbers of springs may be due in part to low returns of 2- and 3-year-old fish which were the progeny of the runs affected by the Babine slide in 1951 and 1952. Since spring salmon spawn below as well as above the fence the count is only an index of the run to the Babine River.

The run of pink salmon was higher than in the cycle year 1952, when the pink run was reduced to a low level by the slide, but was much lower than in the earlier cycle years. As with springs, some pinks spawn below the fence.

Coho salmon appeared in lower numbers than in other non-slide years but somewhat in excess of the number in the slide-affected cycle year 1951.

The chum salmon run was many times greater than that of any previous year but was still too low to be of any significance.

2. Sockeye sampling at the Babine fence. K.V. Aro

To obtain details on the size and sex ratio of Babine sockeye, samples amounting to 1% of the previous half day's count were measured and sexed throughout the period of the run. In addition a "jack count" was made for an hour daily, in which the numbers of jacks (3-year males) and larger sockeye were noted. The proportion of normal, injured, and net-marked individuals among the large sockeye were also recorded.

The jack count, which represented 16.8% of the total sockeye count, showed that 1.9% of the run were jacks. These jacks are the first of the progeny of those fish which spawned in the slide year of 1951 to return from the sea. The percentage and the calculated number of jacks is the lowest which has been recorded since Babine fence operations began. The jack count also showed that among the larger sockeye 8.2% had net marks, 2.5% were injured, and 89.3% were normal. The percentage of injured fish was lower than in any previous year whilst that of fish with net marks was slightly less than average.

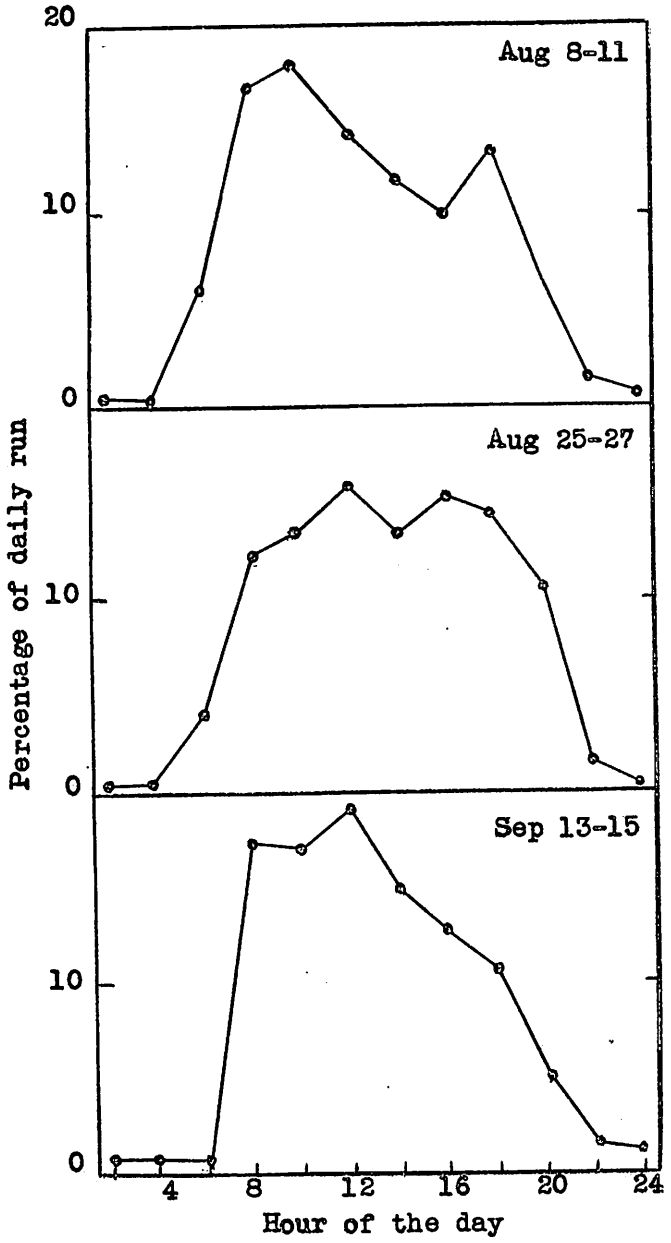
The 1% proportionate sample showed that 39.7% of the large sockeye were males and 60.3% were females. The average sizes of the jacks, larger males, and females were 38.3, 66.6, and 63.0 centimetres respectively. Both the larger males and the females were several centimetres larger than usual.

No egg samples were taken in 1954. Instead a probable egg content of 3,555 was calculated from the regression formula of the number of eggs on length calculated from egg samples of other years. The potential egg deposition is, then, the product of the probable egg content and the calculated number of females (297,574) or about 1,058,000,000. This seeding has only been exceeded by that of 1953 and is due to the large number of females and

to the larger number of eggs which they contained.

Dead spawners drifting against the Babine fence were examined to determine the success of sockeye spawning in the Lower Babine River. On October 3 over 90% of the female and almost 100% of the male dead showed signs of having spawned successfully.

3. Hourly fluctuations in the daily movement of sockeye through the Babine fence. F.C. Withler and K.V. Aro



Twenty-four hour movement of sockeye at the Babine fence.

To determine the preferred hours of ascent through the counting fence sockeye were counted twenty-four hours daily for several consecutive days at three different times in the season. Counts were recorded every two hours on the odd hour (Daylight time) for these periods. The percentages of the daily runs which passed in the two hours straddling the even hour are shown on the accompanying graph. Almost the entire daily run passed the fence in daylight hours between dawn and dusk. The daily peak occurred before or at noon, sometimes with a secondary peak in the afternoon. The study also showed that about 90% of the daily run passed the fence in the usual hours (7:00 A.M. to 7:00 P.M.) of fence operations.

4. Reports on the Babine River rock slide. H. Godfrey

A report on the effects of the rock slide in the Babine River on the salmon runs of 1951 and 1952 has been published as Bulletin No. 101, of the Fisheries Research Board of Canada. The Slide was removed during the winter of 1952-53. Subsequent to its removal investigations were conducted during 1953 to make certain that the cleared channel no longer obstructed migrating fish, and also to compare the spawning of an unblocked run with affected runs of 1951 and 1952. The results of these researches have been described in a second report, which has also been submitted for publication in the Bulletin series.

The effects of the Slide, and the situation since its removal may be summarized briefly:

Sockeye salmon. An estimated two-thirds of the 1951 run, amounting to about 300,000 fish, was lost at the Slide. There were further losses in fish that died unspawned on the spawning grounds. These were not estimated, but were less severe than in the following year.

In 1952, again about two-thirds of the large run perished at the Slide--an estimated 700,000 fish. Because of extremely adverse water conditions, there was almost complete blockage of the early part of the run. Efforts to maintain marginal escape channels were successful in aiding the escape of a large number of fish that otherwise would have perished. Losses in unspawned fish in the Babine streams were serious. It was estimated that only 30-42% of the females that reached Babine Lake spawned successfully; and that these amounted to only 7-10% of the Babine females that had escaped the fishery. In comparison with former years, the spawning of 1952 was only 22-31% of "normal".

In 1953, approximately 90% of fish tagged below the former point of obstruction reached the Babine fence without delay. The large run at the fence was in excellent condition, in respect to both injuries and sexual maturity. An estimated 95% of the females spawned successfully and there were no indications of any abnormal losses in unspawned fish.

Resiliency of reduced spawning stocks has been demonstrated. The survival to smolts from the potential number of eggs available has been 0.48%, 0.77%, 1.52% and 0.68%, for the seedings of 1949 to 1952, respectively. The production rate for 1952, based upon the probable number of eggs deposited (which allowed for the loss in unspawned females), was 1.48-2.07%.

The actual (estimated) numbers of smolts produced in 1953 and 1954 from the two slide years were 3.0 and 2.8 millions, as compared with 4.2 and 4.5 millions in 1951 and 1952. The adult returns of Babine sockeye will therefore probably be lower than average. There may be some compensation in better survival due to larger smolts produced in 1953 and 1954; the magnitude of the total Skeena return will also depend upon the success of spawning in the Slide years in the rest of the Skeena system.

Pink salmon. Pink salmon also suffered very heavy losses at the Slide, but numerical estimates could not be made. Rehabilitation of Babine pink runs is expected to come early from spawning that normally occurs below the Slide, and also from survivors of the block that may have spawned successfully above and below it.

Based upon the results of the 1953 tagging, it was estimated that roughly a third of the total Skeena escapement of pinks was affected by the Slide.

Coho salmon. In 1952, coho salmon experienced relatively fewer losses at the Slide because they arrived there later after conditions had

improved. Cohos also spawn in the main river and tributaries, so that some survivors that did not reach the fence may nevertheless have spawned successfully.

Using results of the 1953 tagging, it was estimated that about a sixth of the total Skeena coho escapements were affected by the Slide.

Spring and chum salmon. The run of springs at the fence in 1952 was about one-half of the average of pre-slide years. Since spring salmon also spawn in the Babine River and its tributaries, survivors of the block may also have done so successfully.

The chum run at the fence has always been small, averaging 8 fish for 1946 to 1953. The run of 1954, of 66 fish, has been the largest of the years the fence has operated.

General. With all species, female salmon suffered heavier losses due to the blockage than males, injured more than uninjured, and mature fish more than fresher fish. Delay at the Slide resulted in fish maturing in the river before they reached the spawning grounds, and this is believed to have contributed greatly to the losses in fish that died in streams without having spawned.

The authors of Bulletin No. 101 were H. Godfrey, W.R. Hourston, J.W. Stokes, and F.C. Withler; those of the second report were H. Godfrey, W.R. Hourston and F.C. Withler.

F.C. Withler

B. Smolt studies.

To circumvent the time- and effort-consuming task of constructing a smolt counting fence in the Babine River, an attempt was made in 1951 to estimate the size of the sockeye smolt emigration from the Babine watershed by marking and recovery technique employing structures available at that time, i.e., the old Fort Babine marking trap and the Babine fence. The measure of success achieved encouraged development of more efficient trapping devices and their operation each year since. Using estimates from Babine fence data of potential egg depositions in the Babine watershed from 1949 to 1952, it has been possible to calculate survival to smolt stage from eggs carried into the system each year. These survivals have ranged from 0.48% to 1.57% - low when compared to egg-to-smolt survival figures for other areas. The Babine River rock slide of 1951-52 reduced escapements to far below normal, providing smaller egg depositions than could otherwise be achieved. Conversely, the estimates of smolts resulting from the blocked runs were valuable in assessing the final effects of the slide on the population. For instance, the smolt run for 1954, reported herein, was the product of the spawners of 1952 which were severely damaged and delayed as well as reduced in number. The 1955 run will result from a deposition of 1.3 billion eggs, the largest recorded since fence operation.

To complement the information on numbers in each run, samples of smolts are taken to give the relationship between size of run and size of smolt. To date, the relationship at Babine appears to be inverse. Supplementary information on sex ratio and parasitism has been obtained.

All Babine sockeye smolts pass through a short river into Nilkitkwa Lake, thence into the Lower Babine River. The possibility of exceptional bird predation on fry and smolts in this region has been investigated by the collection and examination of waterfowl in 1953 and 1954.

1. Estimation of size of runs from 1951 to 1954. F.C. Withler and K.V. Aro

Employing the technique used from 1951 to 1953 to obtain an estimate of the size of the Babine smolt run, the 1954 smolt run was estimated to be 2.8 million, the lowest recorded in four years of operation. The technique involves the capture and marking of portions of the sockeye smolt run as it passes the outlet of Babine Lake, and subsequent examination of large samples of the run at the outlet of Nilkitkwa Lake, some eight miles downstream from the Fort Babine trapping device. Ratios of marked to unmarked smolts in the samples are used to estimate the size of the run which passed the upstream trapping structure.

Total numbers of smolts marked and released annually, the total samples recovered, and total marked fish found therein are given in the following table. Final estimates of the run for each year have been adjusted to conform with known changes in the mark/catch ratio at Fort Babine and to allow for a late installation of trapping structures in 1951, when a portion of the run had passed before trapping began.

Year	No. of smolts marked	No. of marked smolts recovered	Size of sample examined	Estimated size of run	95% limits
1951	34,689	200	21,855	4.2×10^6	3.7 to 4.8×10^6
1952	33,880	646	86,391	4.5×10^6	4.2 to 4.9×10^6
1953	61,950	2,498	124,396	3.1×10^6	3.0 to 3.2×10^6
1954	42,631	1,156	81,082	2.8×10^6	2.7 to 3.0×10^6

Certain errors associated with the possibility of increased mortality due to marking by fin-clipping, and with the likelihood of disproportionate intensities of marking with relation to the run passing Fort Babine each day cannot be assessed and have been treated as constant each year. The annual estimates, therefore, should be proportionate to one another despite discrepancies between actual and estimated numbers each year.

Assuming that all smolts are 1-year-olds (see "Age, sex, growth, and parasite studies of sockeye smolts", below) survival from eggs potentially available in the spawning run to resulting smolts may be calculted from Babine fence data. The figures applying to the brood runs from 1949 to 1952 appear below.

	1949	1950	1951	1952
Eggs potentially available	869×10^6	583×10^6	198×10^6	411×10^6
Year smolts appear	1951	1952	1953	1954
Estimated no. of smolts	4.2×10^6	4.5×10^6	3.1×10^6	2.8×10^6
Survival from egg to smolt	0.48%	0.77%	1.5%	0.68%

A tendency for greater numbers of smolts to result from increased egg depositions probably obtains at Babine; an increase in the survival to smolts from smaller egg depositions is, however, also indicated. The 1952 spawning run was seriously affected by the Babine River rock slide of 1951-52, and estimates made on the spawning grounds in 1952 indicated that only about one-third of the females spawned successfully in that year. Assuming this to be the case, and that only about one-third of the eggs potentially available were

actually available, the percentage survival from that year would be approximately 2%, a higher survival than any so far observed at Babine Lake. (However, there was also an undetermined loss in unspawned females in 1951 which would raise the 1.57% shown in the above table.)

The smolt runs of 1953 and 1954 which resulted from the slide-blocked broods of 1951 and 1952 were lower than the 1951 and 1952 smolt runs, but higher than would be expected in view of the low numbers of the 1951 brood and the damaged and delayed character of the 1952 brood, if a directly proportionate relationship between brood and subsequent smolt production were assumed.

The 1955 smolt run will be the product of the 1953 brood, unaffected by the slide, which also produced the largest potential egg deposition recorded since Babine fence counts began.

2. Time and speed of migration. F.C. Withler

Late ice break-up on Babine Lake delayed installation of smolt estimation apparatus for the 1954 smolt run. The first day of trapping at Fort Babine was delayed one week beyond the latest previous date which occurred in 1952. The catches suggest that the smolt run was correspondingly delayed and most of the run was subjected to marking and recovery. The following table compares the timing of the 1954 run with past years.

Year	Trapping started	Trapping ended	Peak catch
1951	May 23	July 1	June 1 and 6
1952	May 27	July 3	June 5
1953	May 21	June 30	June 8
1954	June 3	July 2	June 9

In conjunction with the run estimation procedure, 3,685 smolts were marked at Fort Babine by passing distinctively coloured threads through the backs before release; subsequently 179 of these were recovered at the Nilkitkwa Lake trap. The length of time required for these fish to travel the eight-mile distance is given below with similar data for other years.

Year	No. of thread marks recovered	Range of time out	Average time out
1951	11	2-6 days	3.4 days
1952	100	1-11 days	3.4 days
1953	62	1-8 days	2.9 days
1954	179	1-9 days	2.4 days

The general high water condition of the Babine Rivers might account for the relatively rapid travel of smolts through Nilkitkwa Lake in 1954; however, higher water levels obtained during the smolt run of 1952.

Throughout the smolt run records of water level, water temperature and weather conditions are kept in addition to the daily readings maintained at the Babine fence throughout the field season.

3. Age, sex, growth, and parasite studies of sockeye smolts. F.C. Withler and E. Dombroski

Daily samples of sockeye smolts have been taken either for special study or in conjunction with the smolt run estimation project from 1950 to 1954. Examination of all samples taken up to and including the spring of 1953 has been completed by Mr. Dombroski.

Examination of scales has shown that the smolts leaving Babine Lake are predominately 1-year-olds. The table following gives the proportions found annually in the samples from 1950 to 1953. Also given are the sex ratios in each age-group, which do not depart significantly from a 50:50 assumption.

Year	1-year-olds		2-year-olds	
	Males	Females	Males	Females
1950	1,296	1,320	9	5
1951	1,428	1,367	6	4
1952	826	828	6	5
1953	629	605	8	14

Lengths and weights of all smolts also have been recorded. That considerable differences exist between average sizes in different years is shown in the table below.

Year	Number in sample	Fork length (mm.) Range	Fork length (mm.) Average	Weight (grams) Range	Weight (grams) Average
1-year fish					
1950	2,616	54-104	83.0 ± 6.3	1.3-10.6	5.5 ± 1.3
1951	2,795	58-111	82.4 ± 6.9	1.6-12.8	5.6 ± 1.5
1952	1,654	55-109	80.4 ± 6.5	1.3-12.7	4.9 ± 1.3
1953	1,234	70-111	86.0 ± 6.5	2.4-13.5	6.2 ± 1.5
2-year fish					
1950	14	104-122	110.4 ± 5.1	7.7-15.8	11.9 ± 2.2
1951	10	91-117	100.7 ± 7.7	6.6-15.4	9.4 ± 2.7
1952	11	96-114	104.4 ± 4.9	8.8-12.1	10.1 ± 1.5
1953	22	90-151	114.7 ± 17.2	7.0-35.1	14.8 ± 7.0

When the average size of smolts for each year is compared with the estimated size of the run in that year (see "Estimation of size of runs from 1951 to 1954" above), for the three years recorded, an inverse relationship between size of run and size of smolt exists.

Included in the examination of smolt samples of 1952 and 1953 was a notation regarding the presence or absence of infection by cestodes or nematodes. In both years about 35% of the smolts were infected with the cestode Eubothrium salvelini (Schrank, 1790) and 20% by the nematode Philonema oncorhynchi Kuitunen-Ekbaum, 1933. Six to 7% of the smolts harboured both parasites. Fish infected by cestodes only, or by cestodes and nematodes both, were significantly smaller than uninfected fish or those with nematodes only. Nematode infected smolts were significantly larger than uninfected individuals in 1952 but not so in 1953.

4. Wildfowl food studies in the Fort Babine area. F.C. Withler and I.V.F. Allen

During the springs and summers of 1953 and 1954 Mr. Allen collected 55 waterfowl in the Fort Babine area to determine the possibility of, and grossly, the extent of, predation upon young salmon, particularly sockeye. The Upper and Lower Babine Rivers provide extensive spawning grounds for sockeye, and all sockeye smolts emigrating seaward must pass through the area.

Eleven species were collected in the two years. The number of specimens of each species and an indication of whether or not salmon remains were found in the digestive tracts are given in the following table.

Species	Common name	No. examined	Young salmon remains
Gavia immer (Brünnich)	Common loon	1	+ smolts
Colymbus grisegena Boddaert	Red-necked grebe	7	
Glaucionetta islandica (Gmelin)	Barrow's goldeneye	4	
Mergus merganser Linnaeus	American merganser	8	+ fry
Larus argentatus Pontoppidan	Herring gull	5	
Larus delawarensis Ord	Ring-billed gull	2	+ fry
Larus canus Linnaeus	Short-billed gull	7	+ fry
Larus philadelphia (Ord)	Bonaparte gull	10	+ fry
Chlidonias nigra (Linnaeus)	Black tern	6	+ fry
Megaceryle alcyon (Linnaeus)	Belted kingfisher	3	
Histrionicus histrionicus (Linnaeus)	Harlequin duck	2	+ fry

Two other waterfowl species were observed in the area - the Spotted sandpiper (Actitis macularia (Linnaeus)) and the American bittern (Botaurus lentiginosus (Montagu)). Neither was collected.

The following table shows the numbers of young salmon found in digestive tracts of birds collected in 1953 and 1954 and the number of specimens of all species which contained them.

	1953	1954	Total
Young salmon taken	64	240	304
Number of specimens containing young salmon	9	7	16

A report of the study is being prepared by Mr. Allen.

C. Fry production studies at Six Mile Creek. K.V. Aro

An adult-fry fence was constructed at Babine Lake in 1950 to illustrate the degree of spawning success of sockeye and to describe the factors limiting the survival from egg to fry. Six Mile Creek was chosen as the site because it was of moderate size, it possessed a moderate-sized run, and it was the most suitable stream on the lake for fencing. Access would be difficult but not impossible.

During the summer and fall of 1951 and 1953 adult sockeye were counted and sampled to determine the potential egg deposition. The effect of stream conditions and the gross behaviour of the spawning run was

assessed by numerous stream surveys and by tagging. Progressive losses during development to fry emergence were followed by examination of the eggs in the redds; and the final survival from egg to fry was determined in the spring from the fry fence counts.

Six Mile, like all smaller streams in the area, is subject to excessively high water levels during the spring run-off and to low water levels during the remainder of the year. High water levels and tremendous amounts of organic debris which are brought down by the water have hampered fry fence operations to the point where counts have had to be suspended for periods during the peak of the run. The numbers of fry therefore, have had to be estimated. During summers of low precipitation water levels have become reduced to the extent where it has been impossible for adult sockeye to enter the stream. In order to have the fry fence operational by the time of the peak of the fry run it is necessary to move personnel and equipment to Six Mile about a month earlier while the ice is still relatively safe for travel. Even at the best of times this is a difficult and hazardous undertaking. This is followed by a period of complete isolation of up to six weeks until the lake becomes navigable. Although these difficulties are not insuperable, the cost in time and effort is prohibitive in view of the limited number of experienced personnel available. Hence following the cessation of the 1954 fry count the investigation was discontinued. Installations and equipment were dismantled and stored for use in any future projects undertaken at Six Mile.

Reports summarizing the work at Six Mile will be prepared.

1. Egg survival in 1953 and 1954.

In the summer and fall of 1953 a total escapement of 1,273 female sockeye spawners carried an estimated 4,344,500 eggs into Six Mile Creek.

During stream surveys carried out throughout the run, 1,193 dead females were examined for eggs retained. From this sample it was found that 3.6% of the eggs carried into the stream had not been deposited but were retained in the bodies of the fish.

Further examinations of egg survival were made on November 6, 1953, and on April 6 and 7, 1954 when five and four redds, respectively, were dug. The materials obtained from these redds will be examined later to determine survival to various stages up to fry emergence.

Adult sockeye were allowed to spawn in the fall of 1953 in two spawning pens which had been sunk into the gravel bottom of the stream. The contents of the two pens were dug up and examined on April 12 to 14, 1954. A pen in which one female and 2 male sockeye had spawned produced 2,016 live alevins, which represents a survival of about 60%. A survival of 16%, representing 931 live alevins, occurred in the other pen in which two pairs of sockeye spawned. Some badly decomposed egg material was found in both pens.

Conditions affecting natural propagation in 1954 up to the time of emergence seemed favourable. Light snowfall during the winter permitted deep frost penetration but good water flows which covered most of the stream bottom kept the developing eggs moist.

2. The sockeye fry run in 1954.

The fry fence at Six Mile Creek was made ready for operation in mid-April 1954. However, because of the abnormally cold spring and the subsequent late run-off, the water flow was insufficient to operate the fence

until May 5 when the first fry appeared. In the period which followed difficulty was experienced at first because low temperatures caused the fence to freeze and later because high water levels and tremendous amounts of debris exceeded the fence's capacity. The fence was operated part of each night until May 10 and from May 22 to 25. Fence operations were totally suspended from May 11 to 21, and on May 26 and 27. From May 28 until June 14, when the count was discontinued, the fence was operated without undue difficulty.

A method of estimating the number of fry migrants by means of sampling nets was used to determine the size of the run during periods when the fence was not in operation. This involved fishing in the stream with sampling nets for certain periods throughout the day both when the fence was operational and non-operational. A significant positive correlation was found to exist between concurrent fence counts and net catches. Using this relationship the number of fry was calculated from net catches during periods when fence counts were suspended.

The estimated number of fry was 819,000, a survival of approximately 19% of the eggs carried into the stream in 1953. Taking into account the inaccuracies introduced by freezing and high-water difficulties, the limits of error of this figure are probably from 15% to 22%. The 1954 survival figure exceeds the 12% figure estimated in 1951.

The 1954 fry run began on May 5 and rose very rapidly to an estimated peak of 98,000 fry on May 13. The intensity of migration appeared to be related to water flow in the stream. After May 13 the run declined slowly with two lesser peaks of 68,000 fry on May 17 and of 26,000 fry on May 26, until only 296 fry were counted on June 14. The sampling net catches indicated that migration took place during twilight and darknwss though some fry were caught in daylight during periods of high water level when scouring probably occurred. During the first half of the run the migration reached a peak between 9:00 and 10:00 P.M. Standard time. However, as the season progressed the nightly peak shifted to between 10:00 and 11:00 P.M.

From observations made at Six Mile since 1951 it is thought that the run-off conditions experienced in the spring of 1951 and 1954 are normal.

LAKELSE LAKE

M.P. Shepard

In 1949, Lakelse Lake was established as a research areas, wherein studies aimed at establishing the principles governing the freshwater production of sockeye salmon could be carried out. The mechanical basis for these studies, namely a series of counting fences, was assembled during the years 1949 to 1952. From 1952 to the present the work has been directed toward the establishment of techniques for enumerating sockeye runs at various stages of their freshwater life-history and toward the development of a standard system for describing the physical and organic environment of the sockeye during their freshwater residence. Considerable effort has been spent on gaining a clear-cut understanding of the effects of enumeration techniques on the sockeye populations. Such studies are necessary to differentiate between natural and artificial effects.

The development phase is, with certain exceptions, at an end. Enumerations are now made of the adult run entering the Lakelse drainage, of the adults reaching the spawning grounds, of the fry resulting from the seeding of these adults, and of the smolts leaving the lake a year or two later. Routine description of the environment includes: year-round observations on meteorology, lake temperatures and levels, and annual assessments

of the abundance, composition and diet of predator and forage species.

Techniques for the routine description of plankton crops, nutrient chemical concentrations and competitor fish populations are still in the process of development and should be on a standard basis by the spring of 1955.

This extensive program of ecological description provides an exceptional basis for the conduct of specific, short-term research programs. While the accumulation of many years' data will provide valuable correlations between sockeye production and environmental factors, intensive and limited research on specific problems is needed to provide fundamental information in a short time. This year several research projects of this nature were undertaken. In August, Dr. W.E. Johnson, recently of the University of Wisconsin, began an intensive study of the relation of sockeye production to plankton distribution and density. As an initial step, Dr. Johnson has developed a workable method for the capture of lacustrine sockeye. Members of the Station staff are conducting studies on the effects of sex ratio on the spawning of adult sockeye, and on the effect of gravel size on the incubation of sockeye eggs. Background information for the planning of a fish control program is being gathered. Certain manipulative studies, including the alteration of the sex ratio of fish entering Scully Creek, were postponed because the small adult run to the lake this year would have prevented the use of past data as a control for this year's experiments.

An important part of the work, not fully covered here, is the tabulation and analysis of data collected at Lakelse from 1944 to 1952. The intensive field program of the last two years has prevented an active attack on this information. Many useful data, especially those concerning the salmon runs, are being examined and assessed in terms of the present program.

A. Sockeye fry studies — J.G. McDonald

The 1954 program was a continuation and expansion of that of past years. Effort was directed mainly toward assessing and comparing the production of sockeye fry from Scully and Williams creeks, the two main spawning areas of the Lakelse watershed.

These two tributaries are utilized by over 90% of the effective escapement to the lake. On the basis of their fry production the fry output of the total spawning area may be estimated. An enumeration of the survivors in 1955 (as seaward migrants) will provide information sufficient to assess the mortality occurring during the period of lake residence.

1. Scully Creek fry production — J.G. McDonald and O.K.L. Fingerhut

a) The escapement and potential egg deposition. A total number of 627 sockeye were passed upstream in a period beginning August 5 and ending September 6. The numbers of each sex, the potential egg deposition and other pertinent data are given in the following table in comparison with similar data from past years:

Year	Escapement Males	Females	Jack Males	Sex ratio* Male:Female	Potential deposition	No. of fry migrants	Percent production
1949-50	565	485	28	1:0.86	1,766,370	242,346	13.7
1950-51	195	121	146	1:0.62	377,775	35,129	9.3
1951-52	809	384	21	1:0.48	1,221,696	165,782	13.6
1952-53	556	507	40	1:0.91	2,053,350	249,882	12.2
1953-54	370	251	6	1:0.67	958,067	97,134	10.1

* jacks excluded

An estimated 100 individuals did not pass through the weir but were observed spawning below. Therefore, the total escapement to the creek was approximately 727 sockeye.

b) The fry migrants. Weir operation began March 22 and continued until May 9 when a break-through from a nearby drainage system rendered the weir inoperative for a period of seven days. Remedial measures were carried out and weir operation was resumed on May 17.

The number of migrants during the period of abnormally high water levels was estimated by the operation of a fry trap (described in last year's report). The operation of the trap concurrent with weir operation before and after the high water period permitted an assessment of the reliability of the estimate. In 22 tests an average of 11.3% of the daily migrants was captured. This ratio was quite constant from day to day (standard deviation = 1.66%). The total number of fry migrating from May 9 to May 16 is therefore estimated to be $\frac{100}{11.3}$ x 2,091 (number captured in trap).= 18,504. The number of fry counted and estimated throughout the migratory period is given below:

Period	Number counted	Number estimated
Mar 22-May 9	40,489	
May 10-May 16	-	18,504
May 17-Jun 6	37,141	
Jun 6	-	1,000
Total	97,134	

c) Percent production of fry. A total of 97,134 fry was estimated to have survived from the potential deposition of 958,067 eggs. The production of fry is therefore 10.1%. The fry production occurring at Scully Creek from 1949 to 1954 is summarized in a previous table.

2. Williams Creek fry production. J.G. McDonald and J.A. Paul

a) The escapement and potential deposition. Pertinent data for 1953 were given in last year's Annual Report. The total number of sockeye spawning in Williams Creek was 8,508. A male to female ratio of 1:0.990 and an average egg content per female of 4,183 resulted in an estimated potential deposition of 17,765,201 eggs.

b) The fry migrants. The construction and operation of a fry weir was not considered feasible in this creek. A method of estimating the mi-

grant population was initiated, based on the premise that if a certain proportion of the discharge was strained for fry then a similar proportion of fry would be captured. In order to avoid error due to a non-random distribution of migrants a "string" of nine traps (trap design described in last year's Annual Report) was placed across the three outlet channels. Each trap strained a section of water extending from the surface to the bottom.

The traps were operated continuously. The fry were removed and counted each hour during the period of migration.

The efficiency of the trap was tested by:

(1) measuring, daily, the percentage of discharge strained;

(2) releasing fry upstream from the traps and calculating the percentage recaptured;

(3) operating a trap at Scully Creek, concurrent with weir enumeration.

These tests demonstrated the following:

(1) Straining efficiency was optimum. The measured discharge strained equalled the calculated discharge strained.

(2) The percentage of fry calculated to have been recovered after release upstream was in close agreement, in two tests, to the percentage of discharge strained. In a third test the calculated percent recovery was high.

(3) In twenty-two tests at Scully Creek an average of 11.3% $\pm$ 1.66 of the migrants were captured daily in the trap straining 11.0% of the flow upstream of the weir.

Trap operation began April 1 and terminated June 8. The weekly number of fry captured is given below:

Week ending	Number of fry captured
Apr 11	677
18	2,922
25	10,387
May 2	12,692
9	27,135
16	26,133
23	29,287
30	18,242
Jun 6	6,137
13	1,074+
Total	136,000

The total number of migrants was estimated on the basis that the percentage captured in each channel was equal to the percentage of discharge in the channels strained by the traps. Main, East and West channels strained 10.8, 8.8 and 6.9% respectively.

The number of migrants carried by each channel and the estimated total run are given below:

	Total Captured	Estimated % migrants captured	Total migrants estimated
Main channel	115,000	10.8	1,064,000
East channel	16,000	8.8	182,000
West channel	5,000	6.9	72,000
Estimated total			1,318,000

Trap operation terminated June 8 when 385 fry were captured. The number migrating after this date is estimated to have been 20,000. This estimate is based on the numbers migrating up to a date at the beginning of the run when a similar number was captured. The total migrant population is therefore estimated to be 1,318,000 + 20,000 = 1,338,000 fry. This number represents the survivors from a deposition of 17,765,201 eggs, giving a survival from egg to fry of 7.5%.

3. Lakelse Lake fry output 1953-54. J.G. McDonald

The total fry output has been estimated on the basis of the success of production reported for Williams and Scully creeks and the total spawning escapement to Lakelse Lake in 1953. As minor spawning streams are more typical of the conditions existing at Scully Creek, a production percentage of 10.1% has been applied to them.

Lakelse escapement - 1953		Sex ratio	Egg deposition	Percent production	Fry output
Williams	8,508	1:0.99	17,765,000	7.5	1,338,000
Scully	627	1:0.67	958,000	10.1	97,134
Others	160	1:1	305,400	10.1	30,845
Totals	9,295		19,028,400	7.7	1,551,934

4. The history of artificially fertilized sockeye eggs placed in artificial redds. J.G. McDonald and O.K.L. Fingerhut

A preliminary experiment was conducted to suggest answers to the following questions:

a. What size of gravel is conducive to optimum egg development and survival?

b. Does a loss of eggs occur? (i.e., do dead or unfertilized eggs disintegrate, thus introducing error into the present methods of redd sampling?)

c. What is the influence on survival of insect and other forms present in the gravel?

A measured amount (by volume) of fertilized eggs was placed in gravel contained in plywood and screen boxes. Three sizes of gravel were used (small, medium and large) which ranged from less than 1/4 inch diameter to 2 inches diameter. Nine boxes of each gravel size were used, each

containing roughly one cubic foot of gravel. The boxes were then placed in the stream bed where there was sufficient depth of water to guard against dessication and freezing.

A sample of eggs in each gravel type was examined in October 1953, six weeks after fertilization and all boxes were throughly examined in March of this year. The following is a general summary of the findings:

(1) Almost all eggs had died by the time the early eyed stage was reached. This was believed due to heavy silting of the gravel resulting from the position of the boxes in respect to water current.

(2) The medium- and large-sized gravel was more conducive to egg development and survival than the small gravel.

(3) A large number of eggs placed in the boxes could not be accounted for.

(4) Fungus was much more prevalent in eggs in the larger gravel types.

(5) At an initial stage of "fungusing", the eggs, upon cursory examination, may be erroneoulsy identified as in the early eyed stage.

(6) The larval forms of insects were found in the boxes and in the egg layer. Chironomid larvae ("blood worms") were extremely abundant. In some instances these larvae were found inside the dead eggs.

The large mortality of the eggs at an early stage greatly reduced the value of this experiment. A repetition with further control is required to evaluate more fully the influence of the various factors discussed above.

B. Smolt studies. M.P. Shepard

The relation between the number of eggs deposited and the number and weight of the resultant smolts provides an index of sockeye production at Lakelse Lake. Since 1952, annual counts and measurements have been made at the Lakelse River fence to provide the key data on sockeye yield.

1. The smolt run of 1954. M.P. Shepard and R.M. Humphreys

The annual count of sockeye smolts at the Lakelse River fence began on April 15, and continued until mid-August. During this period, a total of 375,000 sockeye smolts passed through the weir. The peak of the run occurred on May 27, while 90% of the run was enumerated between May 15 and June 5. For six days near the end of the run, high water permitted only a partial count to be made. During this period it is estimated that about 4,400 sockeye passed through the fence undetected. Thus, the total run was approximately 379,400.

Concurrent with the enumeration of the sockeye smolts, 91,000 coho smolts were passed through the fence. In addition to these fish, it was estimated that about 8,400 smolts passed downstream, undetected during the period in June when the fence was not in operation. Thus the total coho run was approximately 99,400.

As a result of studies on the effects of fence operations on the condition of young sockeye conducted in 1953 (see MS. Rep. Fisheries Research Board of Canada No. 559, 1954), changes in fence design were made to

increase the efficiency of the operation and to ease the passage of fish through the fence. The chief changes were the provision of larger traps and the institution of a visual counting system, wherein fish were enumerated without handling or removal from the water. Using a glass-bottomed viewer, fish were counted as they passed through an underwater shute, It was impossible to differentiate between sockeye and coho smolts passing through the viewer and therefore, daily samples, comprising approximately 25% of the run, were examined to determine the proportional representation of sockeye and coho. Improvement in fence design over the past two years was reflected by a lowering number of smolts killed by the fence operation. In 1952, it was estimated that up to 5% of the run suffered mortality. In 1953 this percentage dropped to 1.61% and in 1954, mortality was cut to less than half of that (0.74%).

In 1953, a marking experiment was carried out on Scully Creek fry to provide information on the age of the smolts emigrating from the lake. By examining samples of smolts at the Lakelse River counting weir for the presence or absence of marks, the tentative conclusion, derived from scale studies, that the majority of the Lakelse smolts are yearlings can be tested. A total of 11,253 fry were marked by excision of the left pelvic fin. At the Lakelse River weir, in the spring of 1954, 54,312 smolts were carefully examined. Of these 12 had deformed fins; 6 of these were probably genuine marks; the others were labelled as possible marks. In 1952 a similar experiment was carried out wherin fry were marked by removal of both pelvic fins. In 1953, 2 smolts out of a sample of 110,500 bore "genuine" marks, while 5 others bore possible evidence of excision.

One of the "possible" marks from the 1954 examination resembled a 1952 mark. Examination of samples of fish in the 1955 run are necessary before any final conclusions are drawn. The evident and extensive differential mortality suffered by marked fish makes quantitative assessment of the results difficult. Tentatively, however, the results of the 1952-54 experiments suggest that the majority of the Lakelse smolts spend only one year in the lake.

2. Size, age and sex composition of Lakelse smolts. M.P. Shepard

Since 1952 annual assessments of the composition of the Lakelse smolt run have been made. In the following table the results of preliminary analyses of the data are summarized. Two sets of observations made in 1946 and 1948 are included.

Year	Sample size	Numbers of fish				Av. length of 1's (cm.)	Av. weight of 1's (gm.)
		Male 1[x]	Female	Male 2[x]	Female		
1946	210	209		1		7.61	4.57
1948	44	43		1		7.63	-
1952	1661	866	778	12	5	8.18	5.60
1953	1377	740	621	5	11	8.52	5.79
1954[xx]	1582	855	719	2	6	8.13	5.55

[x] 1 = yearling fish; 2 = 2-year-old fish
[xx] Figures for 1954 are tentative pending thorough analysis.

Although the early information is scanty, the data suggest that smolts examined from 1952 to 1954 were distinctly larger than those taken

during 1946 and 1948. There is no distinct relation between smolt size and the numbers of smolts emigrating from the lake (see part IV of the Lakelse reports). It is of interest to note that in the last 3 years males have consistently outnumbered females; the average male:female ratio is 1.15:1. This difference is statistically significant.

The proportion of 2-year-old fish in the samples is low, averaging 0.9% for the five years of observations.

C. Adult studies. D. MacKinnon

The chief activity of the adult sockeye program at Lakelse Lake is the annual enumeration of the size and composition of the run. This is accomplished chiefly by counting, sampling, tagging and observing the fish at two critical points in their freshwater history. One of these ponts is at the Lakelse River fence as they enter the lake and the other is at the Williams and Scully creek fences as they enter the major spawning streams. This information is taken to provide a base line for the many problems and potential problems concerning the role of the adult in a sockeye production unit. The chief problem is of a general nature and can be stated as: "What role does the amount of seeding play in the production of sockeye smolts?". The approach to this is to relate the variation in numbers, composition and environment of the runs to variation in numbers of progeny. Until more is known about this and other potential limiting factors (any one of which may decide the carrying capacity of the lake) it is only safe to assume that seeding is a factor limiting production. With this in mind, studies are being carried out to determine what factors limit the deposition of eggs. In this respect the mortality of adults in fresh water prior to spawning has become an important problem. Causal analysis of this mortality has resulted in an intensive study of the effect of the river fence on the condition of the fish. This study has been projected to the mouth of the Lakelse River this year in an attempt to determine whether injuries and subsequent mortality are artificial and caused by the fence or whether they are normal and can be expected to occur in other systems.

Estimation of the size of spawning populations by stream surveys is receiving considerable attention. Originally designed to provide a method of visual estimation they have also served the useful purpose of providing information for the evaluation of past data from stream surveys made before adequate fences were built.

Observation of spawning behaviour and preliminary sex ratio experiments were commenced to determine the minimum proportion of males necessary to fertilize effectively the eggs of the females present.

1. River mouth observations. D. MacKinnon

The high incidence of injury and subsequent mortality of adult sockeye prompted an investigation of the fish before they arrived at the river fence at the entrance to the lake. It was hoped that some clues to the injury problem would result from tagging and observing samples of the run at the mouth of the Lakelse River. As was anticipated, much time was lost in evolving a capturing technique and finding an observation place.

It was found that gill netting in the relatively quiet water at the mouth of the river was the only practical method of capturing fish. It was, of course, necessary to patrol the net and remove fish as soon as they were caught. Observation for incidence of injury as the run passed

through was practised at only one place. This was in a small clearing in a large log jam.

Forty-five fish were captured, tagged, examined for injuries and released. Twenty-four of these fish were captured in the first two days and the remaining 21 during the following two weeks. A striking difference in the success of recapture at the river fence indicated that the first group of fish (83% recovery) were the last of the main body of the Lakelse run, while the last group of fish (33% recovery) were "stragglers" of the Lakelse run and "wanderers" from other Skeena River runs. This is pointed out by the fact that two of the latest fish to be tagged were recaptured in the Skeena River. One went 80 miles downstream and was taken in the commercial fishery while the other went 80 miles upstream and was captured in the Indian fishery. All other recaptures were made at Lakelse Lake.

Of the 21 tagged fish captured at the entrance to the lake, 10 showed no change in condition while the other 11 showed added injuries (average of 2 injuries per fish).

Of the 94 fish observed at the log jam, only 10% bore injuries. This is in contrast to the 33% injury ratio observed at the river fence.

The number of fish tagged and observed is too small to provide any conclusions. However, it is indicated that many of the injuries occur in the Lakelse River.

The average time taken to travel the 12 miles of the Lakelse River was 6 days. Much of this time was probably delay as a result of handling during tagging.

A survey of injury and delay factors in the river shows that predation may cause a small part of the injury. As many as 20 seals were seen in the lower three miles of the Lakelse River. A few signs of bear but no direct evidence of eagle predation were seen. Log jams abound in the river. One of these covers nearly a half-mile of stream bed. In many places the submerged branches provide a reticulum that could easily be a serious cause of injuries.

2. Adult escapement to Lakelse Lake, 1954. M.P. Shepard and R. Tkachuk

A total of 7,671 adult sockeye was counted through the Lakelse River fence between June 17 and August 31. Since then a small late run of sockeye has occurred, but data on this are not yet available. The peak of the run occurred on June 26 when 830 fish were counted. In general the run was somewhat later than in 1952 and 1953, the other years of operation of the Lakelse River fence.

The results of the fence operation are marred by the fact that a gap under the floor of the fence was discovered late in the run. It became evident that an appreciable number of fish escaped through this hole. However, data gathered from tagging studies gives a reasonable estimate of this undetected loss. Three sources of information were used to gain this estimate:

(a) River fence tagging. A total of 357 tags was applied to fish at the river fence. Only 222 of these tags were accounted for on the spawning grounds, indicating a loss of 135 tags. Prior to the spawning run, 6 river tags had been recovered on dead fish in the lake. The proportion of tags in the sample of dead fish found in the lake was 6 times greater than the proportion of tags in the spawning population, indicating that a marked differential tagging mortality had occurred. These data permitted a computation of the lake loss, and when added to the spawning ground count gives an

estimate of the total run to the Lake (see table below).

(b) Lakelse River-mouth tags. Forty-five tags were applied to sockeye at the mouth of the Lakelse River (see Report No.1 of this section). Of these, 21 were trapped at the Lakelse River fence. Records were made of tag numbers. Upstream from the fence (among dead fish washed down on the river fence, among dead floating in the lake, and among fish examined on the spawning grounds), some of these tags were recovered a second time. Other tags could not be traced to the river fence and presumably passed through the gap in the fence. On the basis of these data, an estimate of the total run to the river was made (see table below).

(c) In 1952 and 1953, it was estimated that for each dead fish observed floating in Lakelse Lake, respective totals of 31 and 32 fish had died and were not recovered. In 1954, 33 dead fish were recovered. Assuming that the ratio of dead found: total dead was about the same as in past years, a second and independent estimate of the loss in the lake was obtained. The results of this estimate were added to the spawning ground count to provide a third estimate of the total run (see table below).

Data source	Total river run	95% Fiducial[A] limits
(a) River fence tagging	8,368	7,967 - 9,104
(b) Lakelse River mouth tagging	8,483	8,295 - 9,505
(c) Dead on lake surveys	8,569	-
Average	8,473	

A Fiducial limits = total number of fish actually counted through the fence or on the spawning grounds + fiducial limits of estimated loss through the fence or estimated loss in lake.

Thus there is a close agreement between the three estimates. It is felt, therefore, that the average estimate of 8,473 is a close appromimation of the true run to the Lakelse River fence.

A sample of the run was tagged. The length, sex, condition of the fish and a scale sample were taken. The results of the tagging experiment and of the injury descriptions are included in Report No. 4 of this section. The provision of more pens this year increased the precision of the sampling.

Analysis of the length, age and sex data has not yet been made. Tabulations of last year's results are included in the next report.

3. Age, size and sex composition of the 1953 adult run. M.P. Shepard and D.R. Foskett

In 1952 and 1953, samples of the adult run to Lakelse Lake were taken for determination of length, age and sex. In the following table the 1952 and 1953 data are summarized. As outlined in last year's report, the determination of sex of the river fish is not completely accurate. Data from tagging experiments wherein sexing of fish tagged at the river fence is carried out on the spawning grounds, is required before further breakdown of the data is possible.

Age class	Per cent composition 1952	1953
3_2	0.4	0.0
4_2	11.5	28.1
5_2	82.1	60.5
5_3	0.0	9.7
$5_2 + 5_3$	82.1	70.2
6_2	0.2	0.3
6_3	5.7	1.0
$6_2 - 6_3$	5.9	1.3
Total number in sample	927	288

Although the proportions of the various age classes have varied somewhat, 5_2 fish formed the dominant group in both years. The appearance of 5_3 fish in the 1953 run contrasts with the complete lack of this group in 1952.

4. Distribution, survival and injuries of adult sockeye. M.P. Shepard, D. MacKinnon, and R.M. Humphreys.

As outlined in the preceding reports, the run of adult sockeye at Lakelse was examined at three locations: at the mouth of the Lakelse River, at the Lakelse River fence (located near the outlet of Lakelse Lake into the river), and on the spawning grounds. Comparisons of counts, estimates and data on the composition of the run at the different localities give information on the extent of mortality occurring after the adults have begun their migration into the Lakelse drainage and on their distribution on the spawning grounds.

a) Distribution and survival. As outlined in Report No. 2 of this section, it was estimated that 8,473 adult sockeye entered Lakelse Lake prior to July 31. Fence counts on the two main spawning streams of the lake (Williams and Scully) and estimates on the other streams indicate that no more than 7,698 sockeye reached the spawning grounds. The others, (775) were presumed to have died in the lake. Calculations based on tag recoveries (see Report No. 2) support this figure. Thus, it is estimated that a 9% mortality occurred. As shown in the following table, this figure is less than in 1952 and 1953 when losses of 32.1% and 21.4% were estimated by the same method.

	1952		1953		1954	
	Number	Percent	Number	Percent	Number	Percent
Lakelse River	17,726	100	11,815	100	8,473	100
Williams Cr.	9,932	56.0	8,508	71.9	6,789	80.1
Scully Cr.	1,103	6.2	627	5.3	714	8.4
Others	1,000	5.6	160	1.4	195	2.3
Total spawning	12,035	67.8	9,295	78.6	7,698	90.8
Presumed dead	5,691	32.1	2,520	21.4	775	9.2

The distribution of spawners in the lake is also summarized in the table. It will be noted that the ratio of Scully to Williams spawning fish has remained about the same over the three-year period. The 1954 run is probably the second lowest since the Lakelse field station began operation in 1944. Although reliable data are lacking for several years, the 1950 run is believed to have been lower than 7,000. The production of fry next spring and smolts in 1956 will be watched with interest.

5. The Williams Creek spawning run. D. MacKinnon and H.D. MacIntosh

This year's run to Williams Creek was slightly later than in previous years. The run began August 8 and rapidly built up to a peak on August 12. By August 17, 90% of the fish were through the fence. The remaining 10% moved through the fence in small groups. By September 1, the run was virtually completed. The count through the fence was 3,213 males and 3,576 females giving a maximum deposition of 14,661,600 eggs. The average length of females was 61.1 and of males 67.1 cm. Analysis of tag returns, sex product retention, and length frequency of the fish found dead on the fence is not yet completed.

The distribution of these fish on the spawning ground was followed by a series of stream surveys. The stream was divided into four sections this year. Sections 1, 2 and 3 compare with the downstream area reported in the 1952 and 1953 Annual Reports while Section 4 is the upstream area. The table below shows the relative distribution of adults on the spawning grounds.

	Total No. observed	Section 1	Section 2	Section 3	Section 4
Aug 9	75	24.0	64.0	12.0	0
16	2,332	9.3	39.2	29.5	22.0
24	4,026	13.9	39.7	30.4	15.7
Sep 3	1,010	20.0	55.8	9.8	14.4

Roughly 20% of the run spawned in Section 4. This is in striking contrast to the distribution in the previous two years when 67% and 57% of the fish sapwned in this area. One of the main reasons for this difference is that, in the upper reaches of the creek, less spawning ground was available this year. The stream divided above this area and the new branch cut through a heavily wooded area with few stretches of gravel. Another possible

reason is that a marked improvement occurred in the stream bed immediately downstream from this area. Winter freshets apparently cleared debris and created new spawning stretches. A third possible reason is that the run was 20% smaller than that of 1953 and 40% smaller than that of 1952. It may be that reduced population pressure in the lower stretches obviated the full utilization of upstream area.

6. Observations on spawning activity. D. MacKinnon

The dynamics of a section of Williams Creek spawning ground was followed daily from the time the first fish arrived (August 8) until the last fish died and drifted away (September 11). The main object of this study was to determine the role of the male in an integrated group of spawners.

A section of spawning ground measuring 100 feet by 40 feet was divided into 10 equal 20-foot by 20-foot squares by means of a string stretched between stakes above the surface of the water. The daily number of fish of each sex in each square were recorded along with qualitative observations on behaviour. These observations were made from a 16-foot tower. Attempts were made to recognize and follow individual fish by distinctive marks, scars or tags. It was important to know whether the males would attend more than one female and whether the females would dig more than one redd.

The spawning sections filled with fish in a fairly predictable manner. The downstream sections characterized by shallow (15 to 20 inches) fast-moving water were chosen first while the upstream section characterized by deeper (20 to 40 inches) slow-moving water was chosen only after the lower sections were fully utilized. The fish also moved to the periphery where the water in some cases was shallow enough (under 12 inches) to expose their dorsal fins; many of these peripheral redds were left high and dry by receding water.

Immediately prior to the peak of spawning activity (August 16), a freshet washed out the grid. High murky water suspended observation for eight days. The grid was reconstructed and observations resumed on August 24. It was interesting to mote that the fish that could be identified were still in the same position.

The chief damage by the freshet was that much of the opportunity to identify particular fish was lost. Despite this loss, enough observations were taken to point out that the females stayed on their own redds throughout the whole spawning period. The few exceptions were those that were spawning at the periphery of the group. Receding water in these cases caused the fish to leave partially developed redds. The males did not leave their females during the complete course of spawning activity. Late in the spawning period, however, the males left their females to guard the nests and gathered in groups of from 2 to 10 fish. The few fresh females and the occasional partially spawned female on the grounds were attended by these "roaming" groups of males.

The sex ratio changed from predominately male early in the run to exactly equal at the peak of the run, then to a slight excess of females for two days after the peak and finally back to a male predominance for the balance of active spawning. The last few fish on the grounds were females holding over their nest in the last stages of life. Many of the excess males in the later stages probably came from the periphery which was outside the grid and not quantitatively followed.

At the peak of spawning, 70 pairs occupied the 444-square-yard grid. This allowed approximately 6.3 square yards per redd. In the most concentrated sections there were approximately 4 square yards per pair. Last year's data for roughly the same area showed approximately 3.5 square yards for each redd.

The behaviour pattern was essentially the same as that reported in the Annual Report for 1953. The only obvious exception was that there was much less substitute male activity this year. A typical spawning unit this year was one male to one female during the major spawning period and generally four or five partially spent males to each female during the later stages of the spawning period. At no time this year or last year was actual deposition witnessed.

7. Sex ratio experiments. D. MacKinnon

Three pens, each measuring 10 feet by 6 feet with four-foot picket-type walls, heavy screen bottoms and removable screen tops were constructed to confine spawning sockeye. These pens were set in the water near the mouth of the west channel of Williams Creek at a point where a 10-inch layer of gravel on the bottom of the pen provided a water depth of 18 inches. Ripe sockeye taken from the Williams Creek fence were tagged distinctively and put in the pens in such a way that one pen had a surplus of males (6 males to 2 females), another had a surplus of females (6 females to 2 females) and a third had an even sex ratio (4 males to 4 females). Observations were recorded at least once a day until all fish were dead. Samples of the eggs in the gravel of each pen were taken at the end of the experiment.

The salient observations were:

(a) Fish paired and spawned in all three boxes

(b) The pens were large enough to support a maximum of 3 redds.

(c) The 3 surplus females (without room for redds) were vigorously attacked by the 3 territory-defending females and died unspawned within 3 days of confinement. The 2 males and the remaining 3 females spawned completely.

(d) The 4 surplus males (without mates) also died within a week. However, 3 of them died spawned out while the fourth died 2/3 spawned. The interesting feature is that at no time during observations were these surplus males seen to enter into the spawning act. They gathered at the downstream wall of the pen as did the surplus females mentioned above. This suggests that deposition of fertilized eggs takes place at night.

(e) In the control pen one fish of each sex died within a few days of being introduced into the pens. Again the female died unspawned while the male had spent 2/3 of its milt.

(f) The redds in both the control pen and in the pen with surplus females were in identical positions. One redd was slightly upstream from centre and the others were at the extreme left and right sides of the downstream end. Presumably water flowing through the upstream redd would miss the two downstream redds.

(g) Approximately 3,000 eggs were recovered from the gravel of each pen by redd sampling. During sampling, it was noted that the eggs were in concentrated groups at the very bottom of the gravel. It was surprising to find in each pen the main source of eggs was the extreme right and left sides about 3 feet above the downstream end. Observations consistently showed the chosen position of the dominant female to be slightly upstream from centre. A comparison of the efficiency of fertilization will result from the analysis of the egg samples.

D. Sockeye production at Lakelse Lake, 1944-54. M.P. Shepard

With the completion of the 1954 sockeye smolt enumeration, 6 years' data relating depositions of eggs with resultant smolt outputs have been obtained. From 1944 to 1952, the estimation of annual egg depositions involved spawning ground surveys in conjunction with tagging programs. The results derived in this period are therefore approximations, subject to considerable error. In the past three years, the establishment of sound enumeration techniques, including fences, has permitted detailed studies on estimation methods. The application of the new knowledge to the assessment of old data will bring about extensive revisions in the estimates of spawning escapements made in the past. The reassessment work is in the preliminary stage and cannot be reported on at this time. Dependable information on the magnitude of 5 smolt runs is available. The estimates of adult runs from 1952 to 1954 are also considered to be accurate. In addition to these measures, the first estimation of the total fry output into Lakelse Lake was made this year (see section A of the Lakelse report). In the following table the known production figures are summarized:

Brood year	Adult run	Potential deposition	Fry	Smolts	Av. weight of smolts (grams)	Percent survival from egg to smolt
1944	※	※	-	557,000	4.57	※
1945	※	※	-	373,000	-	※
1946	※	※	-	※	※	※
1950	※	※	-	596,000	5.60	※
1951	※	※	-	394,000	5.75	※
1952	12,000	21.6×10^6	-	379,000	5.55	1.8
1953	9,300	19.9×10^6	1.5×10^6	-	-	-
1954	7,700	17.5×10^6	-	-	-	-

※ Estimates are being re-examined and corrected; revised data are not yet available.

- No data taken, or data not yet available.

Two general conclusions may be drawn from the data:

(a) The size of the smolt run at Lakelse has varied within rather narrow limits (mean = 460,000, range 373,000 to 596,000). It is not believed that the estimate of the 1948 smolt run (1946 brood-year) will deviate seriously from this general order. Whether or not this lack of extreme variability is due to a relative constancy of the spawning escapement cannot be determined until amended estimates of the adult runs of 1944 to 1951 are made.

(b) Unlike the smolts of certain other areas (e.g., Babine and Cultus Lakes, B.C.), there is no clear-cut relationship between the size of individual smolts and the magnitude of runs. At Babine and Cultus, an inverse relationship existed between smolt size and the number of emigrants.

E. Limnology of Lakelse Lake. R.J. LeBrasseur

The emphasis of the 1954 limnological program has been on the assessment of past plankton sampling methods and the characterization of water circulation in the lake. These studies are directed towards the development of a routine description of the environment of the young sockeye during their year-long stay in the lake.

Efforts are being made to summarize past data on plankton abundance, water temperatures and meteorology.

1. Plankton.

As in the past, the plankton program was aimed at assessing the size of the entomostracan crop. This year critical studies on plankton sampling methods were carried out as well as routine samplings of the crop. Bi-weekly sampling was undertaken throughout as much of the year as possible to give a picture of the relative magnitude of the crop and of seasonal variations in the crop size.

Sampling methods. In last year's Annual Report, it was suggested that B.C.-Wisconsin-type plankton nets were inadequate for quantitative sampling of plankton populations. To test the efficiency of the nets, a pump was used to sample plankton concurrently with standard net sampling.

The disadvantages of quantitative sampling with the net which are obviated by the pump are:

(1) clogging of the meshes and the resultant back flow;
(2) the volume of water is not accurately known;
(3) the initial disturbance of the water column caused by the lowering of the net;
(4) the presence of the tow rope which could disturb the plankton;
(5) the difficulty of obtaining samples from a given level.

To compare the sampling efficiences of the net and pump, twelve series of duplicate samples were taken. The calculations of the density of the most predominant entomostracan, Cyclops sp., based on the net samples were 23% lower than similar computations from the pump samples.

To test the reliability of one sample, taken either by net or pump, replicate hauls were made at one station. The variations between the replicate hauls with either equipment in the same area and at the same time were nearly equal (standard deviation = approximately 10% of the mean for large counts). The observed variations were greater than if the discrepancies had been due solely to sampling error; the plankton counts do not conform to the theoretical distribution. However, the observed variations are not excessive, and it is likely that gross changes in the seasonal or annual density of plankton can be detected by the present methods.

It has been suggested that sampling at the deepest station would give an adequate representation of the plankton in the lake as a whole. To test this, comparisons of the average concentration of plankton for a number

of stations with the concentration for the deep-hole station were made. Examination of past and present data (1949-54) shows that the ratio between the deep-hole station density estimates and those for the lake as a whole varied between 0.13 and 2.27. The mean was 1.11 and the standard error was 0.105.

These studies, and further analyses yet to be carried out, will permit a critical analysis of ten years of plankton collections at Lakelse. The prime purpose will be to establish whether or not annual variations have occurred in the abundance of Lakelse plankton and if so, whether or not these changes in density are associated with variations in the output of sockeye smolts from the lake.

The design of an effective routine sampling program awaits completion of the analyses. At the time of writing, extensive sampling is being undertaken on the fall populations of plankton at Lakelse, using a Clarke-Bumpus sampler, and dry-weight analyses of the samples are being carried out as opposed to the present net sampling and counting methods.

Distribution studies. Partial analysis of the sampling data (involving 80 samples taken at night at 5 to 11 stations) indicates that the distribution of plankton in the lake was similar to that noted in previous years (see V.H. McMahon, J. Fish. Res. Bd. Can. 11:1954); the concentration of plankton increased from the south to the north end of the lake. As in other years, the spring concentrations of the dominant species (Cyclops sp., Epischura spp.) were higher than during the summer.

Examination of the influent streams for plankton showed that only Clearwater Creek, which drains two lakes, had plankton. Plankton samples taken in the Clearwater lakes showed that the plankton was very sparse, only Cyclops, Cladocera and insect larvae being found. Samples were also taken at the Lakelse River fence. Qualitative analyses of these samples indicate that a considerable volume of plankton is lost to the river. Further analyses of the present data supplemented by another summer's sampling should provide an accurate picture of this loss and yield very valuable information on the distribution of plankton in the lake. Comparison of plankton distribution and currents will be made when counts of the late summer plankton samples have been completed.

Acknowledgement is made of the very valuable assistance given by Mr. V.H. McMahon. He was responsible for nearly all the identifications and counts made of the entomostracan plankton during the summer as well as helping in other ways.

2. Physical-chemical environment.

(a) Meteorology. Meteorological data from 1944 to the present are being abstracted. They include observations of air temperature, surface water temperature, wind force and direction, precipitation, cloud cover, barometric pressures and ice cover and lake levels. Data have also been obtained from the Department of Transport to supplement the Lake observations.

The winter conditions of 1953-54 were quite similar to the long-term average. The exceptional feature was a freshet in the first week of February when a sudden rise in temperature was accompanied by heavy rains. During a 4-day period the lake rose 24 inches. One of the possible results of the freshet was the movement of trout and char into the Lakelse River much earlier than usual, and before the River fence could safely be put into

operation. The summer was cooler (by 2-4°F.) than the long-term average and the prevailing winds were more persistent than usual. The colder conditions were accompanied by a general lateness in biological events (e.g., smolt run).

(b) Chemistry. The lake chemistry program was essentially the same as that for 1953. Data from 1949 to the present have been summarized. The year 1954 shows an increase in nutrients (phosphates and nitrates) over 1953 and 1952. The relatively complete plankton enumerations and consistent collection of chemical data in 1954 will show whether the variations in plankton concentration are associated with variations in nutrients. These determinations await the completion of the plankton counts now in progress.

(c) Temperature. Lake temperatures are taken bi-weekly at the deepest station. A summary of the observations at this Station since 1944 has been prepared. The results are expressed in terms of the mean water temperature of the 80-foot column of water. The data cover a relatively long period but they are incomplete, particularly for the winter and early spring months. In 1954 the bi-weekly mean temperature varied between 1° and 2° F. below the long-term average.

In a series of replicate plankton samples the variability of the counts was found to exceed that attributable to the sampling techniques. The question then arose as to whether this variation could be caused by water movements. To describe the circulation of water in the lake, 14 bathythermograph stations were selected and observations were made throughout the summer. Three series of observations were taken when the prevailing wind force was greater than one (Beaufort Scale). Two were taken when the wind was absent or less than one. By following the distribution of the isotherms, the water movements could be determined.

The distribution of the surface isotherms for the steady state, a prevailing southerly wind, shows a piling up of warm water along the east shore and towards the north end of the lake. Immediately below the warm water is an isothermal gradient rising from the north end to the south end. Below this region the isotherms run parallel to the lake surface.

On the basis of these observations a very general description of the currents in Lakelse Lake can be postulated. A surface current flows northward in the direction of the wind. Along the northeast shore vertical mixing between the warm surface and the colder profundal zone occurs. The mixed water moves southward along the lake, rising from a depth of 40 to 60 feet at the north end to the surface at the south end. The water of the profundal zone shows no horizontal movement and only slight vertical mixing.

During the period of calm the isotherms all run nearly parallel to the surface and the once cold areas of the shallow south and west shores now have the warmest water. This is probably a result of more efficient heating in the shallow areas than in the deeper zones. The only evidence of horizontal flow is in the region of the outlet of the lake. The river discharge, as in the former case, is made up largely of the very warm water found along the southwest shore. Only one observation of cold water moving down the river has been made. In this instance the movement of water was from a region of upwelling off the southeast shore, at a time of south winds with a Beaufort force greater than three.

Attempts are being made to relate the distribution of the plankton to the known circulation patterns. The completion of late season plankton counts are required before further analyses can be made.

F. Fishes of Lakelse Lake. T.H. Bilton and M.P. Shepard

Studies of the fishes have centered on the description of the life histories of the piscivorous species present in the lake. The emphasis of the 1954 program has been on increasing the prescision of estimates of the adult cut-throat and squawfish populations of the lake. As field work is continuing at the time of writing, opportunity for analysis of this year's results has been restricted. Utilizing knowledge gained from the routine program, plans are being laid to conduct a final intensive study of the lake fish (including juvenile fishes) preparatory to the conduct of a fish removal program. In view of the low seeding at Lakelse this year, tentative plans for a squawfish removal program in 1955 have been postponed until 1956.

1. Gill-netting experiments. T.H. Bilton and M.P. Shepard

A standard gill-netting program, aimed at establishing the relative densities and compositions of lake fish populations was initiated in the fall of 1952. All parts of the lake are sampled with approximately the same intensity three times a year; in the spring, in the fall and in the winter. The catches of major species per net-night are compared in the table below.

Species	Spring		Fall		Winter	
	1953	1954	1952	1953	1952-53[X]	1953-54
Peamouth	3.70	3.72	4.98	1.77	-	.01
Cut-throat	1.39	0.82	1.67	1.69	-	.50
Squawfish	0.65	0.69	1.48	0.65	-	.20
Dolly varden	0.10	0.18	1.51	0.33	-	.15
Average water temperature	10.0	9.7	12.0	9.7	-	1.0

[X] Lack of solid ice during the winter of 1953 prevented netting.

Before interpretations on the relative abundance of the various species can be drawn from catch data, the sources of variability associated with gill-net sampling must be clearly understood. Some of the factors affecting the catch/net-night for any series of sets are outlined below:

(a) Sampling error. In the Annual Report of 1952 data on the variability of individual sets and of netting series involving up to 36 sets was presented. The 95% confidence limits on the mean catch of such series were approximately $\bar{x} \pm .25\bar{x}$.

(b) Distribution. The catches will reflect the presence or absence of fish at the sampling stations. For example in the table above, the low catches of dolly varden observed in the spring are probably due to the emigration of these fish from the lake.

(c) Activity. The number of fish caught in gill-nets is undoubtedly affected by the behaviour of the various species at the time of netting. Wide-ranging and rapidly-swimming fish will tend to be caught more often than fish whose movements are localized and not rapid. In this respect, lake temperature and the stage of maturity of the fish will affect the catches. In the table above, it will be noted that the fall catches of peamouth, squawfish and dolly

varden were much higher in 1952 than in 1953. The chief difference in the environment in these two years was in water temperature. It is postulated that the higher catches of these three species in 1952 were due primarily to the stimulating effect of higher temperatures. Plots of catches per net-night against water temperature suggest that peamouth and squawfish are most affected by temperature.

It will be noted that the catches of cut-throat were almost equal in the fall of both years. Study of gill-net and trap-net data show that, with the exception of the early spring spawning period, cut-throat maintain a similar, dispersed distribution throughout the year. Evidence from experimental sets also indicate that cut-throat are wide-ranging. Repeated sets at a single position tend to deplete local populations of peamouth and squawfish, whereas continual recruitment of cut-throat into a local area prevents depletion of this species. It will also be noted that seasonal variation in cut-throat catches is less than variations in the catches of other species, suggesting that the effect of temperature on the activity of cut-throat is less than that on the other species involved. These data suggest that the habits and activity of the cut-throat are less affected by seasonal environmental changes than those of the other species and that as a result, catches of cut-throat are less subject to variability than those of the more sensitive fish.

The relatively low catches of all species in the winter months probably reflect the restrictive effects of cold temperatures on their movements.

As yet there is no clear-cut reason for the discrepancy between the peamouth catches of the fall of 1953 and the spring of 1954.

(d) Abundance. From the foregoing descriptions of some of the sources of variability in gill-net sampling, it is apparent that a very thorough knowledge of the factors affecting "catchability" is needed before quantitative assessment of relative abundance is possible. In conjunction with marking programs, and limnological investigations, it is felt that within two years sufficient standard set series will have been made to permit fairly precise annual estimations, based solely on gill-net results.

While the data collected in the past two years are scarcely sufficient to draw conclusions on population changes during that period, certain suggestions can be made. Limnological conditions during the netting carried out during the springs of 1953 and 1954 were quite similar; the catches of all species, excepting the cut-throat of 1954, were quite close in magnitude, suggesting that these populations had not changed in size in the past year. The 1954 cut-throat catch was only 60% of that of 1953. Although analyses of marking data for 1954 are not yet complete, there are preliminary indications that a decline in cut-throat abundance did occur.

2. Marking experiments. T.H. Bilton and M.P. Shepard

In last year's report, tentative estimates of the size of certain predator and forage fish populations were presented. In the fall of 1953 and the spring of 1954 further marking experiments were conducted to increase the precision of these estimates. Information on the recovery of marked fish and the computation of population sizes awaits the completion of this year's field program (in late November).

Marking of dolly varden and cut-throat trout was conducted at the Lakelse River fence in October of 1953. Marking and tagging of dolly varden, cut-throat and squawfish taken from trap nets in the various influent streams

and along the shoreline of the lake was carried out from April to July of 1954. In all 2,866 predator fishes were marked or tagged. To date, 217 recoveries have been made and subsequent samplings should add to this number by approximately 50%. Thus about 10% of the fish marked during the 1953-54 season will probably be recaptured by the end of November. The results of these experiments combined with data on the continuing returns from the 1952 marking experiments should increase the precision of the population estimates greatly.

Cursory examination of the marking and tagging data reveals the following information:

(a) Cut-throat trout marked in Lakelse Lake have been recaptured at the Lakelse River fence. To date only two such recaptures have been made. No fish marked at the river fence, either in 1952 or 1954, have been recovered in the lake. These data suggest that while there is some mixing of lake and river populations, the interchange is not great.

(b) Dolly varden marked at the river fence in the fall were recaptured in the lake during the same fall and again at the river fence the following spring, indicating an annual migration of some of the fish to and from Lakelse Lake. In the fall of 1952, there were two unconfirmed reports of marked fish being taken in the Copper River (approximately 12 miles from the mouth of the Lakelse River). Further evidence of the mixing of Lakelse dolly varden stocks with other groups of fish in the Skeena River was obtained this year. A tagged dolly varden released downstream from the Lakelse River fence was recaptured at Telegraph Point near Prince Rupert, approximately 80 miles from the point of tagging.

(c) Squawfish and peamouth marked in 1952 again tended to return to localized areas (e.g., Mailbox Point, Hotsprings Creek) to spawn. The implications of this finding in the design of a fish removal program are evident.

3. Creel census, 1954. T.H. Bilton

The creel census began its fifth year on May 5. As in past years as many fishermen as possible were contacted. From each, the following information was collected; the number of hours fished, the numbers of each species of fish caught, time of catch, type of bait or lure used, area in which fish were caught, the weather and number of marked or tagged fish recaptured. When time permitted, all the fish in each angler's catch were sampled for length, sex, state of sexual maturity and scales.

(a) The catch.

Cut-throat. Following a general trend over the five-year period of the creel census, the catch per hour of cut-throat taken in the lake rose above that of past years and the catch per hour on the Lakelse River (draining the lake) dropped to a new low. In the table below, the catch figures for the past five years are summarized. The drop in the river catch is no doubt a true reflection of the abundance of the trout at the time of angling; the count of cut-throat at the Lakelse River weir has dropped for the last two years. As mentioned in last year's report, the great majority of the angling is restricted to the area of the river upstream from the weir. As in 1953,

it is felt that the low return to fishermen angling above the weir was due to a shift in the concentration of fish from above to below. The increase in the catch per hour on the lake cannot be assessed until marking and tagging data are analysed. Preliminary evidence from the population estimate program suggests that the increased catch in 1954 was due more to a change in availability of the fish than to a change in abundance.

It was estimated that approximately 40% of the anglers fishing at the lake were contacted. Thus, assuming that those contacted were representative of all fishermen, the total number of fish examined would approximate 40% of the total removal of cut-throat. On this basis it is estimated that, in 1954, anglers took about 1,650 cut-throat from the lake.

Dolly varden. Capture of dolly varden was restricted to the river. The catch per hour was the second highest observed in the 5 years of the creel census. The recorded catches are not true measures of the number of dollies caught; in years when cut-throat catches are good, anglers tend to return dollies to the water, while in years when cut-throat catches are low (e.g., 1954) anglers retain the dollies rather than return home with few or no fish.

Location	Year	Hours fished	Cut-throat		Dolly varden	
			Observed catch	Catch per hour	Observed catch	Catch per hour
River	1950	409.5	574	1.40	20	.048
	1951	382.0	418	1.08	88	.230
	1952	821.5	912	1.11	397	.899
	1953	883	625	0.71	242	.274
	1954	482.5	306	0.64	158	.328
Lake	1950	647	668	1.03	13	.020
	1951	442.5	383	0.82	8	.018
	1952	620	669	1.08	0	0
	1953	415	534	1.29	0	0
	1954	185.5	355	1.93	0	0

(b) Catch figures and population abundance.

Whether or not catch per effort accurately reflects the abundance of fish in the lake depends, in part, on the extent to which factors other than abundance influence catch. Analyses of data on cut-throat catches from 1950 to 1953 were carried out to determine to what extent various factors such as meteorology, gear and skill effect the catch figures. The following conclusions were drawn:

(1) The success of angling was not clearly related to weather, time of day or gear.

(2) The catch per hour of individual fishermen varied greatly. By classifying anglers according to their fishing experience and local knowledge into "good, medium and poor" groupings, it was found that the catches of the "good" anglers were the least variable. From these studies it is felt that the catches of the experienced residents, fishing the lake in a similar manner each year are more likely to reflect changes in abundance than the combined catches of all types of anglers. The average catch of these "good" anglers has remained relatively constant over the period 1950-1952 (average catches per hour: 2.29 in 1950, 2.05 in 1951 and 2.26 in 1952,

no breakdown available for 1953), suggesting that there was no radical change in the cut-throat population during these years.

(c) Rates of exploitation

It was estimated (see Annual Report, 1953) that the catchable cut-throat population of Lakelse during 1952 and 1953 was approximately 20,000 (approximate limits 14,000 to 34,000). In these years the annual removal of trout by anglers averaged 2,100 fish, suggesting a rate of exploitation of about 10.5% (approximate limits 6.2 to 15.0).

PORT JOHN

J.G. Hunter

At Port John, in the central coast area, the operation of a system of counting fences presents an unusually complete picture of the losses occurring at various stages of the freshwater life-history of the sockeye salmon population. Enumerations are made of the number of adults entering fresh water from the sea, the number of adults reaching the spawning grounds, the number of fry moving into the nursery lake and the number of smolts moving to sea two years later. The data, gathered in the past 5 years, have indicated that the rate of production of smolts is, in some years, higher than in any other area previously studied. The biological implications of this finding have yet to be assessed in detail and must await the gathering of comparable material from other areas (e.g., Lakelse Lake, B.C., Bare Lake, Alaska).

A. Adult sockeye salmon escapement, Port John, 1953

Adult sockeye at Port John began their upstream movement in Hooknose Creek on June 18. Hooknose Creek is 1.5 miles long so that the fish need spend very little time in the stream before passing into the lake. The first sockeye entered the main spawning stream, Tally Creek (tributary to the lake), on August 30. Therefore, the maximum time spent in the lake before spawning must have been at least 73 days. Data in the following table suggest that considerable numbers of salmon are lost through natural mortality during this extended pre-spawning period.

	Jacks	Males	Total Males	Females	Total
Hooknose weir count	559				1,279
Computed Hooknose composition	559	256	815	464	1,279
Accounted for above Hooknose weir:					
Through Tally Creek weir	405	163	568	295	863
Estimated spawned below Tally Creek weir	5	15	20	13	33
Estimated spawned in other streams	19	14	33	13	46
Dead at Hooknose weir	2	2	4	2	6
Number accounted for	431	194	625	323	948
Number unaccounted for	128	62	190	141	331
Percent loss	24.66	24.22	23.31	30.39	25.89

It is not possible to determine at the Hooknose Creek weir the sex of those sockeye which enter early in the season; counts at the Hooknose weir distinguish only "jack" salmon from the remainder. The numbers of males, apart from "jacks", and females entering through Hooknose weir are calculated from the ratio of males and females found in Tally Creek at spawning time.

Egg deposition. Eight females were examined for egg content and 108 were examined for egg retention. Thirteen entered Tally Creek but failed to spawn. Deposition and egg loss are shown in the following tabulation:

	Number of females spawned	Average egg content	Potential deposition	Percent egg loss by retention
Tally Creek	274	2,809	769,666	0.73
Remainder of lake	33	2,809	92,697	0.73
Total	307	2,809	862,363	0.73

The total run of sockeye salmon into Port John this fall was about average when compared to runs of previous years. The same percent of the total Port John run entered Tally Creek as in the year previous and the percentage loss of sockeye in the lake is the same as in the previous year.

B. Production of sockeye salmon fry at Port John in 1954

Sockeye fry began their downstream movement from Tally Creek into Port John Lake on April 12 and 95% of the migration was completed by June 10. The time required for egress was a full month longer than in the preceding year. From a potential deposition of 769,666 eggs in Tally Creek in 1953, 103,040 sockeye fry emerged to pass downstream. This production from Tally Creek constituted a 13.4% survival which, though not the greatest survival recorded, is considered high.

The total production of fry for the whole lake area, based upon this percentage survival, was 115,450 fry. Mortality from fence operations removed 489 of these fish, leaving an estimated total of 114,961 sockeye fry in Port John Lake.

This number of fry is the largest yet recorded entering the lake.

Stream temperature and water-level readings are available for the period of fry migration.

C. Sockeye smolt production at Port John in 1954

Sockeye smolts commenced their downstream movement through Hooknose fence on April 12, reached a peak near May 10 and completed their egress by June 10. A count of 19,483 smolts was recorded. Before assigning the smolts to the appropriate brood-year egg deposition and fry release, the ages must be determined. This is now underway.

Of the total smolts, 31 were killed by fence operations, and 101 marked fish and 189 smolts for age analysis were removed from the run. A total of 19,162 smolts was released to sea.

In the spring of 1952, 5,075 sockeye fry were marked by the removal of the two pelvic fins to confirm the reading of 1- and 2-year scales. The returns of marked fish from this release are as follows:

Year	Age	Number of marks recovered	Percent of all returns
1953	1	21	4.03
1954	2	500	95.97

These 521 mark recoveries constitute a 10.3% survival from the 5,075 marked fry. It has been shown from both scale reading and length frequency distribution that the greatest part of the Port John smolt run is made up of 2-year-old smolts. Survival of unmarked fry to age II smolts varies from approximately 30 to 60%. This suggests an additional mortality has been incurred by marking the fry.

SOCKEYE SALMON SAMPLING

D.R. Foskett

This study continues the analysis of samples taken each year from the Nass River, Skeena River, Rivers Inlet and Smith Inlet sockeye salmon catches which was begun by the Provincial Fisheries Department in 1912. The age and size composition are determined each season, and also the sex ratios, to build up a very useful series of data on the changes in the composition of the catch from year to year. For the Rivers Inlet area a special study is being made of the composition of the spawning escapement to determine in what respects the gill-net fishery may be selective and influence the perpetuation of the populations. A survey has also been made, for the last few years, of the size of the escapement and its distribution to the many spawning areas in and tributary to Owikeno Lake. The Rivers Inlet area represents a sockeye-producing region as yet little affected by logging, etc., and in that respect represents an opportunity to follow the effect on salmon streams and on salmon production of removal of the forest cover, whenever that commences.

A. Sockeye salmon catch sampling

The analysis of the 1953 catch samples has been completed and paper No. 39 in the series "Contributions to the Life History of the Sockeye Salmon" has been prepared and submitted to the British Columbia Department of Fisheries for inclusion in their Annual Report for 1953. An outline of the information given in this paper is presented below. The 1954 samples have not yet been completely analysed. Data on the percentage of the various ages in the samples, however, are included for comparison.

1. Nass River sockeye

A total of 1,694 sockeye was sampled from the 1953 Nass River sockeye catch of 18,162⅛ cases. Of these 45.7% were in the 5_3 age-group, 22.8% in the 4_2 age-group, and 21.5% in the 5_2 age-group. These figures agree fairly well with those of 1952 when the respective percentages were 46, 28, and 19 and are not too far from the averages for the previous 10 years which were 52%, 22% and 13% respectively for the 5_3, 4_2 and 5_2 age-groups.

The 1953 sockeye were relatively large, the 5_3 fish coming very close to the largest recorded since 1941 in both length and weight in both sexes. The 4_2 male fish equalled the length records and exceeded the weight records of the previous 12 years while the female fish of the same group, though slightly under the previous length records, exceeded the average weight records for the same period.

The sex ratio was fairly normal, the percentage of males being 46, 50, and 44 in the 5_3, 4_2 and 5_2 age-groups respectively.

The 1954 sockeye samples in the Nass River area consisted of the same three main age-classes in the same order of relative abundance. They varied only slightly in the percentage of abundance, the percentages being 40.1, 35.0, and 20.1, respectively, for the 5_3, 4_2 and 5_2 age-groups.

2. Skeena River sockeye

The 1953 Skeena River sockeye sample consisted of 2,121 fish from a catch yielding 65,003 cases. This catch was approximately 5,000 cases below the average for recent cycles. Two age-groups, 4_2 and 5_2, formed 90% of the catch sample, the former being 48.0% and the latter 42.8% of the total. These percentages show a variation from the average situation, the percentages for the previous 10 years averaging 34% 4_2 fish and 62% 5_2 fish. In length the fish compared very favourably with those of previous years, exceeding length records of the past 12 years except for the 4_2 males, which were exceeded only by 0.1 inch by the 1952 sample. In average weight the fish in these two age-classes exceeded the samples of the past dozen years.

The 1954 Skeena River sockeye sample was very similar to that of 1953, the two dominant age-groups again being the 4_2 and 5_2 groups and the percentages being the same as in 1953, namely, 48 and 43 respectively.

3. Rivers Inlet sockeye

The Rivers Inlet sockeye catch in 1953 was mainly the return of the 1949 spawning, 73% of the sample being 4_2 age-group fish and 26% being 5_2 age-group. The catch of 132,925 cases, the fifth largest for the area, was the result of a very heavy spawning since the poor catch of 39,495 cases in the cycle year, 1949, was a reflection of poor weather conditions affecting the fishery rather than of a poor run. The 4_2 fish were fairly large though less than the averages of the same group in 1951 and 1952. However, the 5_2 sockeye in the sample exceeded the records of the past 12 years in both length and weight. Sex ratios again showed the prevalent trend of this and the Smith Inlet area in that males were in excess in the 4_2 age-group and females in the 5_2 age-group. Though it does not show up in the commercial catch records, spawning-ground surveys reveal that in some years at least, large numbers of males mature at 3 years of age.

The 1954 catch sample was composed of 59.8% 4_2 fish and 38.8% 5_2 fish, indicating that the main return was from the 1950 spawning and the bulk of the remainder came from the 1949 spawning. The 1950 spawning was largely 5-year-old fish whose progeny may be expected to return chiefly as 5-year fish in 1955. The 1949 spawning was predominantly 4-year fish whose progeny, returning in 1953, were chiefly responsible for the large pack in that year. Thus, with no large segment of either population due to return in 1954, the result was the small run experienced this year.

4. Smith Inlet sockeye

The 1953 Smith Inlet sockeye sample was comprised of 89% 4_2 age-group fish and 10% 5_2 age-group fish. As in the Rivers Inlet area, the 4_2 fish were fairly large but did not make any records while the 5_2 age-group either equalled or exceeded the length and weight records of recent years for both sexes. This would suggest that oceanic conditions are similar in the feeding areas of both these large central area runs.

The 1954 Smith Inlet sockeye sample was also dominated by 4_2 age-group fish but the percentage of 60.7 was considerably lower than that of the 1953 sample. The 5_2 group was represented by 37.9%.

B. Rivers Inlet area - special studies

Scouring conditions due to heavy rains and consequent flash floods in the Rivers Inlet area during the spawning survey trip in 1953, though not severe enough to affect the redds, did reduce the number of spawned-out fish available for sampling on certain streams and thus satisfactory comparisons of catch and escapement could not be made. Plankton samples were obtained, however, for study of lake productivity, and for comparison with other sockeye nursery areas.

Sockeye runs in the Rivers Inlet area are often dominated by one age-class in both the catch and escapement, this situation being particularly noticeable in the very large runs which have resulted in catches of over 100,000 cases. These runs tend to perpetuate themselves, those dominated by 4-year-old fish returning in 4 years and those dominated by 5-year-old fish returning in 5 years. This seems to indicate that the age of maturity of these sockeye has a genetical basis. In addition, the fact that the majority of large runs in the Rivers Inlet area are predominantly of one age-class would suggest that perhaps there is a greater percentage survival of eggs when both parents are of the same age than when they are of different ages. A small experiment was initiated in the Rivers Inlet area this fall to test this hypothesis; it could not be carried out in duplicate, however, as originally planned. Spawnings of each age-group were made, together with reciprocal crosses. The eggs were placed in baskets and buried in the gravel of one of the streams. Results will be determined by the percentage of eggs hatched.

PINK AND CHUM SALMON - F. Neave

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PINK AND CHUM SALMON - F. Neave

As was stated in last year's report, the work of this investigation is mainly directed to establishing facts, principles and prodecures which can be used (a) in diagnosing the biological condition of a fishery; (b) in determining the effectiveness and feasibility of remedial or improvement measures; and (c) in prediction of abundance from year to year or over longer periods.

In recent years these studies have been mainly carried out at field stations located at Nile Creek on Vancouver Island, and at Port John near Ocean Falls. During 1954 the Nile Creek field station was closed since it was felt that it had substantially fulfilled its original objectives and that the freeing of personnel and funds would permit a broader attack on problems which are regarded as particularly important.

One such problem is represented by the recurrent question: What constitutes an optimum, or at least a desirable escapement of salmon? It is felt at the present time that information in this field can be accumulated more rapidly by comparative data from streams with different densities of spawning populations than by an intensive study of a single locality. Another long-standing problem is the non-occurrence of pink salmon in alternate years in certain important fishing areas and the lack of clear understanding as to the cause of this absence and the possibility or otherwise of remedying the situation.

A contribution to the former problem can be expected from the appearance at Port John in 1954 of an escapement permitting examination of much higher densities of spawning fish than have hitherto been under observation at this station. An experimental introduction of a missing cycle of pink salmon is being made in a tributary of the Fraser River. Neither of these projects is reported elsewhere in the present account, since the initial field work is only now in progress.

In the present report, the year's activities have been grouped into four categories, the two field stations being separated from studies which are not or are only in part carried out at these places. The categories are artificial, since major contributions to "Spawning Ground Studies" have been made at Nile Creek and Port John and "Applied Studies" also make use of information derived from these sources. Individual investigators have spent varying periods at the field stations and elsewhere, their work being distributed as seemed in best accordance with the general objectives outlined in the first paragraph above.

An extension of the pink and chum salmon investigation to include a limited programme of "Ocean Studies" was proposed for 1954-55. This was to have included observations on the distribution and growth of young salmon after reaching the sea and on the selective effects of the fishery on the maturing fish. Limitations of funds and personnel prevented adoption of this project.

NILE CREEK — W. P. Wickett

This field station on the southeast coast of Vancouver Island was operated from September 1945 to July 1954. Data on the freshwater survival of chum and pink salmon have been recorded for the natural populations and

for eggs in an area protected from water fluctuations. Large changes in water flow can take place because of the nature of the watershed. The lower two-thirds of the Nile Creek watershed was logged from 1932 to 1938 by the large, clear-cut method. In 1938 a severe fire destroyed old vegetation on the logging area. The area is now fully reforested with trees 6 to 8 feet high from 1941 and 1945 seedlings.

The program of assessment of natural survival acts as a control for studies on incubation improvement. A change from the previous years was made in 1953. Adult salmon were carried in fry cans from the weir to the controlled-water section so that the eggs could be planted by the fish. The experiment was not carried out as planned because the supply of fish was very small and bears removed completely both live and dead fish. However, useful information on survival at a low spawning intensity and on spawning behaviour was obtained.

A. Adult studies, 1953

Both pink and chum runs showed very small ocean survival. The pink run replaced itself but the chum run was only 44 fish. The coho run of 524 fish was the second largest to date.

The female pink salmon were very small and some escaped through the pickets of the trap. Counts of live and dead fish indicate that an estimate of 48 females would be the maximum.

Data on 1953 survival in the sea and egg deposition are as follows:

	Brood year migrants	Adult return			Ocean survival %	Egg count per female	Egg deposition	
		Male	Female	Total			Natural	Protected
Pink	51,038	58	48*	106*	0.23	1800*	48,600	37,800
Chum	32,747	30	14	44	0.13	2500*	22,500	5,000
Coho	5,950	284	240	524	8.8	2900	702,000	-

* Estimated

B. Fry studies, 1954

For the third consecutive year winter conditions were favourable with no extremes of temperature or discharge. The combination of favourable conditions and lack of competitors for spawning sites explains the high survivals recorded.

The protected pink salmon eggs (i.e., from fish spawning in the controlled-water section) were deposited in very unfavourable, dirty and compacted gravel. The corresponding chum eggs were deposited in loose relatively clean gravel. The salmon were removed by bears after most of them had spawned, so that the interference was not too great. Three of the pink salmon died unspawned and this loss is accepted in the production percentage though not in the emergence percentage.

The coho fry counts have little meaning since there is no complete migration through the weir at this stage, but the yearling migrants count is again apparently related to rainfall.

Data on 1953-54 freshwater survival are as follows:

	Eggs available in 1953	Percent emergence	Migrants: Live	Dead	Total	Percent survival during migration	Percent output
Pink							
Natural	48,600	38.4	14,422	1,322	15,744	61.1	32.5
Protected	37,800	14.5	3,933	16	3,949	84	10.5
Chum							
Natural	22,500	29.3	3,048	12	3,060	46.2	13.6
Protected	5,000	49.2	2,013	7	2,020	82	40.4
Coho			Yearlings				
Natural	702,000		6,994	-	6,994		0.75

C. Preliminary findings from Nile Creek chum salmon studies, 1945-53

A study of Departmental reports and an examination of meterological records indicated floods in brood years could be the cause of large reductions in subsequent populations. Therefore, two methods of protecting eggs during the time of maximum floods were devised. In the first procedure, eggs were eyed in "drip-incubators" and then planted in the main stream above a counting weir. In the second, "green" eggs were planted in a controlled-water-flow section of gravel. Natural reproduction above a counting weir at the head of tidal influence served as a control as well as giving information on the level of freshwater survival in this stream.

Preliminary findings are:

1. The movement of chum salmon into the stream is influenced by strong onshore southeast winds and by rise of water, though the reaction to rise of water is not so marked as that of the coho salmon.

The percentage of chum reaching the second fence is related to the mean gauge height during the migration (October-November).

2. From natural spawnings, 1945-52, the percentage production (or survival from deposition to migration) has been 0.08-7.0%. It varied with the percentage survivals during the pre-eyed stage, for the four years that data are available.

	Percent survivals	
	To eyeing	To migration
1949	0.69	0.08
1947	2.2	0.38
1946	8.2	0.40
1948	87.0	6.03

The survival to the eyed stage has been calculated, knowing the survival of planted eyed eggs and the survival of naturally-spawned eggs for the full period. The survival for the later stage of both sets of eggs is assumed to be similar. The planting of eyed eggs was discontinued after 1949.

The importance of survival to the eyed stage in determining the subsequent output of fry has led to a study of the oxygen supply to eggs during their early development. The main demand of the pre-eyed egg on its environment is an adequate supply of oxygen. A report now in press on this phase shows that inadequate oxygen supplies can exist in the gravel.

3. The survivals from the eyed stage to emergence from the gravel have been 18% to 31%.

4. The survival of the fry from predators during downstream migration has varied from 35% to 62%.

5. Survival in the sea has varied from 0.40% to 1.8%.

6. Survival to emergence is greater in gravel that is protected from fluctuating water discharge, as shown below:

	Percent emergence
Natural	0.21-18.0
Pre-eyed stage in hatchery; remainder in natural stream	2.1 -17.4
Full period in controlled section	5.1 -25.7

7. Freshwater survivals were very low but have improved. Survival in the sea has been too low to compensate for the low freshwater survival. This might suggest that reduced fishing effort is required.

D. Observations on pink salmon behaviour

1. Spawning

The actual spawning of Pacific salmon has seldom been observed and conflicting views have been expressed regarding the behaviour of the fish at this time. At Nile Creek the deposition of eggs and milt was clearly observed from a distance of 6 feet. In the controlled-water section a

partially blind female was paired with a mate also partially blinded by fungus. Because deposition has not been seen in daylight to the writer's knowledge, it is assumed that reduced light is normally required for the act.

No eggs or milt were observed in over an hour's close observation while standing in the stream (1,500-1,600 hours). The male would attack a stable-broom when it was moved within 3 feet of the female. The female carried out digging around the periphery and in the centre of the redd, frequently passing under the male after digging. A few eggs were dropped incidentally during digging. A large male with normal vision became the dominant male with increasing familiarity with observer and broom. The latter was made to simulate the actions of a dominant male. The sighted male was driven off easily but a quite violent blow was required to drive off the partially-blinded male. The dominant male was inclined to hold over the redd regardless of the wanderings of the female. After about an hour and a quarter, the female made a few slow upstream passes through the centre of the redd. Suddenly the female and 6 males (including the partially-blinded one) sank into the deepest part of the redd and a dense cloud of milt was ejected by the males. Eggs were briefly roiled up in it. After a brief milling, the procedure was repeated. The pattern of generalized digging by the female, and fighting amongst the males was then resumed.

2. Fry migration

At night, migrants were observed and timed swimming downstream in the surface film of that portion of the stream illuminated upstream from the fence. They followed the path of the fastest moving water, water speed 0.5 ft./sec. Fry speed observed was 2.0 ft./sec. or 1.5 ft./sec. in excess of current. In addition, marked fry released 400 yards upstream at 2,200 hours were dipped out of the water as they approached the fence 10 to 20 minutes later.

In daylight, between 0625 and 0715 P.D.T., a school of 11 pink fry that had been prevented from entering the migrant trap was observed to swim upstream into the fastest part of the current, where the velocity was 0.5 ft./sec.

The cruising speed at a temperature of 6-7° C. was calculated as follows:

Distance fry moved upstream over the bottom	= 170 ft.
Time taken 0625-0715 P.D.T.	= 3,000 sec.
Water speed = 0.5 ft./sec.	= 1,500 ft./3,000 sec.
Cruising speed of fry = 1,670 ft./3,000 sec.	= 0.56 ft./sec.

PORT JOHN

J.G. Hunter

The Port John field station is continuing to provide increasingly useful data on the relation between salmon abundance and freshwater conditions. The advantage which it holds over the Nile Creek station (except in relation to the effects of extreme water levels which the latter was set up to examine) is due to the larger size of the salmon runs and the greater variety of species. In addition to providing a quantitative record of changes in the local salmon populations, Hooknose Creek is being used as a testing ground for widely applicable methods of sampling and estimating populations of adult and juvenile salmon.

It should be pointed out that work of the Port John personnel, directed by Mr. J.G. Hunter, is not confined to pink and chum salmon and that certain aspects are reported under "Sockeye Salmon" and "Experimental Biology".

A. Adult studies

Adult pink and chum salmon migration at Port John, 1953

The pink and chum salmon run occurred in Hooknose Creek at the same time as it has in previous years, creek water levels controlling the upstream movement to a large extent. A summary of the statistics gathered during the course of the migration is shown in the following table:

Species	Number of adults	Percent female	Average egg content	Potential deposition	Percent loss of eggs by retention
Pinks	1,599	55.60	1,672	1,464,672	0.12
Chums	4,355	51.21	2,741	6,016,495	0.66

Average egg content and retention for pink salmon was based on 11 and 43 samples respectively, and for chum salmon 35 and 37 samples respectively.

Meteorological, stream discharge and water temperature readings were made twice daily.

The numbers of pink salmon returning in 1953 were far below the number expected. The 1,599 pink salmon constitute an ocean survival of 0.67% from fry escapements while all returns from previous fry releases gave ocean survivals over 3.0%. Commercial fishery statistics suggest increased fishing intensity could have been responsible for this low ocean survival.

Chum salmon entering in 1954 constitute the second largest run recorded in the creek. The escapement is considered to be good and is the result of many 3-year-old fish returning from the large fry escapement in the spring of 1951.

B. Fry and smolt studies

1. Output of pink and chum fry from Hooknose Creek, 1954

The downstream weir on Hooknose Creek was installed March 24, which is about the same time as in previous years. The pink and chum fry were just beginning their seaward migration. The peak of their migrations occurred at the end of April for pink salmon and the first week in May for chum salmon. The output of fry in relation to the egg deposition is shown in the following tabulation:

Species	Average egg content	Potential deposition	Number of fry	Percent survival
Pinks	1,672	1,464,672	204,250	13.9
Chums	2,741	6,016,495	984,504	16.4

A good correlation exists between percent survival of pink and chum fry and October water discharge. The continued operation of Port John is building up a body of statistics permitting comparison and correlation of different survival values and the factors controlling these values. Data in the following two tables permit comparison between results of the different years of operation of the Port John field station.

Pink salmon - Hooknose Creek

Year of spawning	Spawning stock	Fry produced	Percentage survival Freshwater	Ocean
1947	5,576	33,349	0.9	5.2
1949	1,173	54,061	6.4	3.2
1951	1,670	242,993	16.4	0.7
1953	1,599	204,250	13.9	-
1948	1,160	64,312	8.2	3.1
1950	1,857	234,396	15.1	3.7
1952	8,685	1,227,025	14.4	-

Chum salmon - Hooknose Creek

Year of spawning	Spawning stock	Fry produced	Percentage freshwater survival
1947	10,191	108,746	1.0
1948	1,022	77,539	7.4
1949	718	44,463	6.2
1950	2,382	431,399	15.1
1951	1,329	269,701	16.9
1952	871	182,200	19.4
1953	4,355	984,504	16.4

Since chum salmon spawn at different ages, ocean survival cannot be readily ascertained from a known fry release. A marking experiment on chum salmon of the 1947 year-class showed an ocean survival value of 2.6%. An average ocean survival for chum salmon can also be shown by the sum of the adult returns in the years 1951, 1952, and 1953 based upon the sum of the fry escapements of 1947, 1948, and 1949 year-classes. This calculation suggests an average ocean survival of 2.8%. This survival may be considered as higher than actually occurred since the 3-year-old returns from the low and partially marked fry escapements of 1948 have not

been included while the three-year-old returns from the large fry escapement of 1950 are included.

Pink salmon ocean survival is slightly more than chum survival when returns from the 1951 year-class are not considered. Evidence suggests that heavy fishing may have markedly affected the normal return of this year.

2. Sampling for pink and chum salmon fry, Port John, 1954

An effort to evaluate the efficiency of small nets in capturing a sample of the migrating pink and chum fry was made at Port John this spring.

A series of five nets (fyke type) with openings 1 ft. x 2 ft. were placed at intervals across the stream. These nets covered one-third of the stream width to a depth of one foot. Calculated on the basis of water volume these nets covered 36% of the stream.

Correlation of net catches and fence count gave highly significant results for single net catches of both pink and chum fry.

The different nets did not capture fry in the same ratio as volume of water passed by each net. Nets near mid stream caught more fry. The relative catches of different nets, although showing a variance, tended to maintain the same distribution throughout the migration.

Pink and chum fry both showed the same behaviour in relation to depth in their downstream movement. The top 3 inches of water carried 65% of the fry, the top 6 inches 85% while the top 9 inches carried 95% of the migrating fry.

A slight time difference between pink and chum fry was noted in their daily downstream movements. Neither species began their egress until dark and then the pink fry preceded the chum fry by about one-half hour.

The nets covered a total of one-third the stream width, suggesting a factor of 3.00 for ascertaining total fry run from the net catches. The results actually obtained gave a factor of 3.15.

3. Coho studies, Port John, 1954

The small run of coho salmon that enters Hooknose Creek cannot readily be dealt with in a manner comparable to the studies of pink and chum salmon. Coho salmon fry continue to pass downstream after the fry collecting weirs have been removed and replaced by the adult fence used for trapping the mature pink, chum and sockeye salmon. Although it is not possible to measure the survival from egg to fry nor from fry to smolt stage in the coho, some measure of egg to smolt and smolt to adult is possible. In the spring of 1954, 5,987 smolts were counted out of Hooknose weir from a calculated potential deposition of 573,648 eggs. This constitutes a survival from eggs to smolts of 0.958%. Survivals from 1949 to 1954 range from 0.645% to 2.152%.

From a release of 3,620 smolts in 1952, 106 jack coho returned the same fall and 189 mature three-year-old fish in the fall of 1953. This made a total return of 295 adults or an ocean survival of 8.14%. Ocean survival of smolts from 1946 to 1952 has ranged from 19.09% to 3.79%.

SPAWNING GROUND STUDIES

W. P. Wickett

As pointed out in the Nile Creek studies, pre-eyed losses seem to determine the population size of chum salmon. The oxygen supply has been shown to be inadequate in certain portions of the gravel where pre-eyed eggs have died. Data have been gathered on two phases of the problem, (a) lethal concentration of O_2 for hatching chum eggs, and (b) development of a satisfactory model of standpipe for sampling the gravel water for oxygen concentration and determining the hydraulic head and permeability in the gravel at the depths that eggs are deposited.

The results referred to above are reported in the sections under "Experimental Biology" and "Oceanography" as the major portion of the work was carried out by these groups.

APPLIED STUDIES

In 1953 two projects were undertaken by the investigation in response to wishes of the Industry and the Department of Fisheries.

The results of these undertakings became known in 1954 and in the case of one of them represented the main work of an investigator during the latter year.

A. The 1952-54 pink salmon cycle in the Queen Charlotte Islands

F. Neave

In the spring of 1953 an attempt was made to evaluate the fry-migrant production resulting from the heavy escapement of pink salmon which occurred in the Queen Charlotte Islands in 1952 (see Annual Report, 1953). Fry runs were sampled during the period of downstream migration in a number of streams in the Masset Inlet and Skidegate Channel areas. The opinion was expressed that the fry output was sufficient to produce another large run of adults in 1954 unless marine conditions proved to be unusually unfavourable.

On the basis of the catches made during August and September, 1954, it appears that the anticipated large run failed in part to materialize. In the west central area of the Islands catches were greater than those of the parent year. In other areas they were much lower.

The total magnitude of the 1954 run will not be known until the size of the spawning escapements to the various streams has been reported. If the escapements confirm the pattern shown by the catches the marked difference in survival between closely adjacent areas will merit further study. It is recognized that ocean conditions subsequent to the seaward migration of young fish can be responsible for discrepancies. It is also possible that some or all of the Queen Charlotte Island stocks of fish normally require a higher percentage output of fry to maintain their numbers than do the fish of the areas from which ideas of reproductive sufficiency have been largely derived.

That there is considerable validity in the principle of forecasting adult runs from fry output was shown again at Port John this year, where the advent of a record run of mature fish was accurately anticipated from the numbers of fry observed in 1953. It is felt that further study can rather rapidly improve the usefulness of this prediction technique.

B. Pink and chum salmon tagging experiments in Johnstone Strait and Discovery Passage, 1953 J. I. Manzer

At the request of the Department of Fisheries, pink and chum salmon were tagged in 1953 in Johnstone Strait and Discovery Passage to determine (1) the destination and migration period of the different stocks migrating through these waters, (2) the intensity of fishing to which each was subjected, as compared with earlier years, (3) the catch in Johnstone Strait and Discovery Passage of fish migrating to various fishery administrative areas, and (4) speed and pattern of migration. In Area 12 (Upper Johnstone Strait) tagging of both species was carried out mainly near Alert Bay; in Area 13, in Discovery Passage. Since tagging in each area occurred during the period when 99% of the total seasonal catch was made, it is unlikely that any major runs were omitted from the tagging. The method of conducting the experiments was outlined in this Station's 1953 Annual Report (page 63). Locations or areas referred to in this report are shown in the accompanying figure.

Pink salmon. A total of 3,448 pink salmon were tagged: 1,663 in Area 12 and 1,775 in Area 13. Recoveries made outside the tagging areas indicate that migration was mainly to the east and southeast. All major mainland inlets and sounds from Loughborough Inlet to Puget Sound yielded tags, with the Fraser River producing the greatest number. Limited migration occurred to the east coast of Vancouver Island.

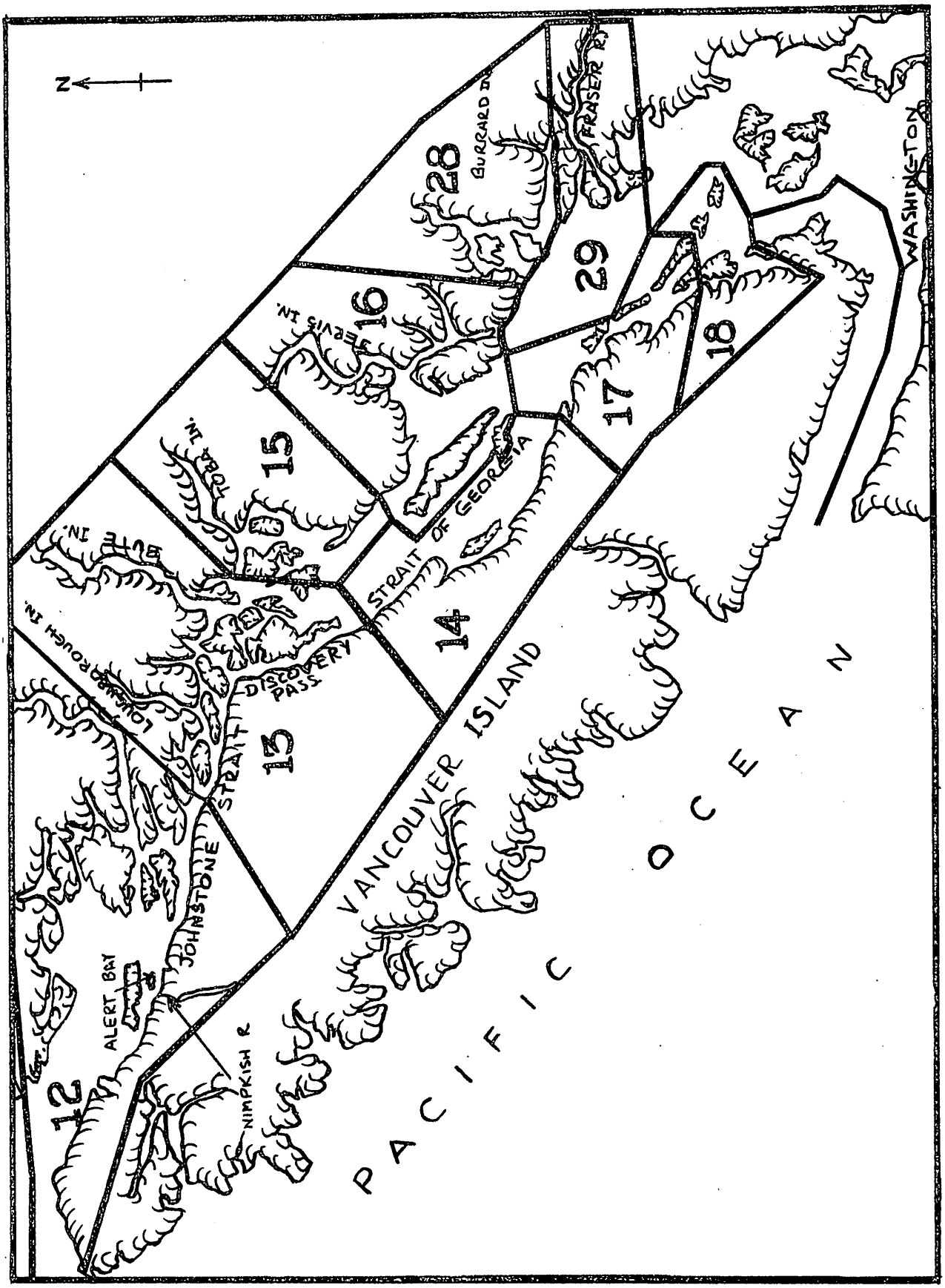
The migration period of the different stocks through Johnstone Strait and Discovery Passage overlapped to a considerable extent. From late July until early September all stocks were present, the important ones being those to Area 28, Area 16, Washington and the Fraser River. After early September and until early October only Fraser River fish were found.

Recoveries of fish tagged in Areas 12 and 13 amounted to 45% and 33% respectively. A comparison of these rates with those for 1945 indicates that the fishing rate for Area 12 fish has not changed appreciably, while that for Area 13 fish has increased from 26% to 33%.

During the main pink salmon season, fish migrating at the beginning and end of the season were exploited less heavily than those migrating during mid-season.

The catch of pink salmon in Johnstone Strait and Discovery Passage during tagging amounted to 4,858,000 fish. On the basis of tag recoveries the division of this catch according to the presumed destination of the fish was estimated to be:

Stock	No. of fish	Percent
Area 13 Inlets	383,000	7.9
Area 14	39,000	0.8
Area 15	55,000	1.1
Area 16	866,000	17.8
Area 18	37,000	0.8
Area 28	408,000	8.4
Area 29	2,381,000	49.0
Washington	689,000	14.2
Total	4,858,000	100.0



Tagging and recovery areas of pink and chum salmon in Johnstone Strait and Discovery Passage

Since these estimates cannot be corrected for the catch of fish migrating to streams in Area 12 and Area 13, nor for fish recovered in an area while migrating southward, they are too high for northern stocks and too low for southern ones. However, they indicate the predominance of the Fraser River fish in the Johnstone Strait and Discovery Passage catch.

A study of the rate of travel indicates that, in general, the average time between tagging and recovery increased with the distance between the two points. It was again found that Fraser River recoveries were made later than those in adjacent areas immediately to the north and south, supporting the belief that fish to that area remain off the mouth of the river before resuming migration.

Chum salmon. A total of 2,604 chum salmon were tagged: 894 in Area 12 and 1,710 in Area 13. Tags recovered outside the tagging areas indicate that migration was to the east and southeast, with 81% of the recoveries being returned from the mainland coast and 19% from the east coast of Vancouver Island. Along the mainland, all fishery administrative areas yielded tags, but Area 29 produced the greatest number. Area 16 yielded the second highest. Along the east coast of Vancouver Island recoveries were mainly obtained from Area 14 and Area 17, with the latter producing the greatest number. Of the 9 tags taken to the west of the tagging locations, 2 were recovered from the Nimpkish River area.

Several stocks of chum salmon migrated through Johnstone Strait and Discovery Passage at the same time. Bute Inlet, Toba Inlet, Washington, and Fraser River fish appeared first during the latter part of August. During mid-September these runs were augmented by runs to the east coast of Vancouver Island. Towards the end of September and early October runs to Burrard Inlet and Jervis Inlet appeared. With the exception of the Burrard Inlet run, all runs were present on the tagging grounds when fishing terminated on November 3rd.

Since 1945 the total rate of exploitation of fish tagged in Area 12 has increased from 34% to 47%, and for Area 13 fish from 22% to 36%. The increase in the rates for each area amounts to 38% and 64%, respectively. The increase in exploitation of Area 12 fish was mainly due to the heavier fishing in Area 13 and in the Strait of Georgia. In the Strait of Georgia the greatest increase occurred in Area 16, while the rate in Area 29 remained relatively constant. The increased rate in 1953 for Area 13 fish was due to the increase in fishing throughout the Strait of Georgia generally, but especially in Area 16 and Area 29.

Chum salmon migrating during the early and late parts of the season were not exploited as heavily as those during mid-season.

The catch of chum salmon in Johnstone Strait and Discovery Passage totalled 1,513,000 fish. The division of this catch according to various stocks was estimated to be:

Stock	No. of Fish	Percent
Area 13 Inlets	26,000	1.7
Area 14	130,000	8.6
Area 15	35,000	2.3
Area 16	313,000	20.7
Area 17	140,000	9.3
Area 18	32,000	2.1
Area 28	143,000	9.4
Area 29	667,000	44.1
Washington	27,000	1.8
Total	1,513,000	100.0

Predominance of the Fraser River fish is again indicated.

The pattern of migration for chum salmon was found to be similar to that for pink salmon.

A summary of the results of the experiments which were thought to be of administrative significance was prepared and forwarded to Fisheries Department personnel whose districts are particularly involved. The experiments will be reported on fully in the Board's Bulletin series.

T R O L L S A L M O N - D.J. Milne

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TROLL SALMON - D.J. Milne

Both the commercial and sport troll fisheries catch spring and coho salmon almost exclusively. Each catch is usually a mixture of fish that have originated from many streams. The general biological condition of these stocks and, in particular, the effects of catching large numbers of small fish in certain areas have aroused much concern among the trollers of British Columbia. For the last few years some have proposed an opening date of July 1 for offshore coho salmon and a minimum length of 28 inches for spring salmon.

In 1949 the states of Washington and Oregon adopted an opening date of June 15 for coho salmon and a minimum size of 26 inches (total length) for spring salmon, designed to protect small fish. The Pacific Marine Fisheries Commission has recently recommended the adoption of July 1 for coho salmon, but is still considering the advisability of a 28-inch size limit for spring salmon. As a guest at the meetings of the Commission, the writer has had close contact with biologists in Alaska and the states of Washington, Oregon and California and a coastwide tagging and sampling program has been carried out in friendly cooperation.

In 1952, an opening date of June 16 was adopted for outside coho salmon in British Columbia, but the minimum size of 2½ pounds dressed weight (about 20 inches total length) for all species of salmon has been retained.

In assessing the situation off the British Columbian coast, the chief objectives have been to establish the ocean migration patterns and to determine facts on the growth, mortality and maturity of the fish that are caught in the most heavily exploited areas of the troll fisheries. As the facts accumulate, the probable effectiveness and feasibility of adopting regulatory changes, such as minimum sizes and closed areas or seasons, are evaluated. In each report of the last four years a discussion of the proposed regulations to protect small salmon has been presented. The ultimate aim is to achieve the best long-term utilization of these two valuable species of salmon.

The following work has been carried out:

1. Seven tagging experiments were conducted from 1949 to 1952 off Vancouver Island and the Queen Charlotte Islands. The results have been summarized and compared with earlier experiments from 1925 to 1930 and a manuscript will be submitted for publication soon. The intermingling of fish from many streams indicates the need for international cooperation.

2. Extensive sampling of the commercial troll landings, for size of fish and for the abundance and distribution of fish marked in United States streams, has been carried out for the last three seasons. A summary is contained in this report.

3. In 1953, a detailed study was made of the fish on the various banks in the important feeding area off the southwestern coast of Vancouver Island. The size and species of fish that are caught by each of the more common types of trolling lures was presented last year. Reports on the amount of immaturity in relation to the size of spring salmon and on the stomach contents of four species of salmon are included herein.

4. In 1954, a series of experiments to determine the tagging and releasing mortality of troll-caught salmon was initiated in the Gulf of Georgia. Preliminary results are indicated.

TROLL CATCHES OF SPRING AND COHO SALMON

The commercial troll fleet of 1,500 to 2,000 boats operated a total of about 125,000 fishing days a year and catch approximately two-thirds of the total British Columbia catch of spring and coho salmon. Reliable catch statistics, by species and gear, are available only since the start of the sales slip system in 1951. The fluctuations in the annual troll catch and the average catch per day are presented below. For comparison the average catches per day, based on trip reports of a select group of large "ice" trollers, are also shown.

	B.C. Troll Catch		"Ice Boat" Catch
	Total in lb. (round weight)	Average per boat-day in lb. (dressed weight)	Average per boat-day in lb. (dressed weight)
Spring Salmon			
1951	8,400,000	56	71
1952	10,310,000	69	62
1953	10,650,000	70	81
1954	-	-	80
Coho Salmon			
1951	19,510,000	130	384
1952	17,200,000	115	342
1953	13,710,000	98	350
1954	-	-	250

The troll catch of spring salmon in 1954 has been poor and the final total will probably be less than in 1951. The catch of red spring salmon was small during the whole season, but the Gulf of Georgia produced a good catch of white spring salmon in July and August. This latter fact accounts for the good showing of the "ice boats" that landed at Vancouver.

The troll catch of coho salmon in 1954 will probably be about one-half of that caught in the brood year 1951, the highest catch produced in recent years. Only a small part of this drop can be attributed to the tendermen's strike between August 7 and 14. Since the spawning escapement in most areas was better than average in 1951, it appears that the dry summer of 1952 must have severely affected the survival of young salmon in the streams. In addition, poor ocean feeding conditions were reported in 1953. The result has been a very low return from a large coho salmon population in 1951. This year the catch of "bluebacks" in the Gulf of Georgia was poor and the fish were small in size.

With the catches of both spring and coho salmon the lowest in recent years and with the lack of a tuna fishery, the commercial trollers experienced a poor season this year.

The sport troll fishery, which operates in many locations in inshore waters, also experienced a poor season. The catch of coho salmon was particularly low. Records for recent years, obtained by the fishery inspectors, indicate that this fishery catches a large proportion of small fish of both species but that the total catch by weight is only about 3% of the total commercial catch. However, in the Gulf of Georgia, where over 90% of the sport fishing takes place, it is estimated that the spring salmon catch is about one-third and the coho salmon catch is about one-quarter as large as the commercial troll catch in this region.

SAMPLING PROGRAM

Since 1952, extensive sampling of the landings of spring and coho salmon has been carried out at Vancouver and Prince Rupert. The three types of sampling employed were: (a) a small random sample of each species was examined for length and weight measurements and scales were taken for age determinations; (b) a larger random sample of each species was measured for length; and (c) entire loads of individual boats were tallied for number of fish and total weight of each species. In each type all fish were examined for missing fins.

The number of fish examined by each of the three methods in 1954 and in the two previous years are given below:

	Spring Salmon			Coho Salmon		
	(a)	(b)	(c)	(a)	(b)	(c)
At Vancouver	652	16,703	41,464	565	10,286	53,231
At Prince Rupert	501	5,831	8,619	499	5,085	10,064
Totals - 1954	1,153	22,534	50,083	1,064	15,371	63,295
- 1953	963	25,068	56,315	998	22,588	75,917
- 1952	997	34,628	--	1,010	44,650	--

The data on length and age are used for growth studies and for discussions on regulations by size limits and closed seasons. The fish with missing fins indicate the distribution of fish marked in certain streams of the United States.

A. Mark returns for spring and coho salmon

Since 1950 over six million spring and coho salmon fingerlings have been marked in various streams of Washington, Oregon and California. No markings took place in British Columbia or Alaska. These markings were done by removing two or more fins, using distinctive combinations for each stream. In the last three years, thousands of fish have been examined for missing fins along the entire Pacific Coast in order to record the ocean

distribution and abundance of these fish of known origin. No rewards have been offered for returns from fishermen. Besides the double-fin experiments, many small single-fin experiments have been carried out in United States streams to solve local problems.

A summary of the recoveries from the troll fishery in the five sampling areas of British Columbia follows:

	North coast of Queen Charlotte Is.	North Hecate Strait	South Hecate Strait	Gulf of Georgia	West coast of Vancouver Island	Total British Columbia
Coho salmon						
Double fin						
1954	--	--	1	8	11	20
1953	--	--	--	3	24	27
1952	--	--	--	--	4	4
Single fin						
1954	4	10	5	5	39	63
1953	8	2	10	20	80	120
1952	--	--	1	2	20	23
Spring salmon						
Double fin						
1954	--	1	--	2	10	13
1953	1	--	--	--	47	48
1952	--	--	1	--	35	36
Single fin						
1954	13	9	1	4	86	113
1953	9	5	1	1	64	80
1952	--	--	2	--	36	38

Coastwide sampling will continue until 1956 before the final results can be stated by the marking agencies. However, some preliminary observations based on the above recoveries can be set forth.

The sampling was distributed to include from 5 to 10% of the fish landed in each area. It is apparent that almost all of the double-fin clipped fish were caught in the southern part of British Columbia with 75% of the coho salmon recoveries and 95% of the spring salmon recoveries caught off the west coast of Vancouver Island. This substantiates the earlier findings of the tagging experiments for coho salmon but not for spring salmon. Since a high proportion of spring salmon, tagged off northern

British Columbia and southeast Alaska, were later recovered in United States streams, it is peculiar that more marked fish have not been found in northern waters.

The single-fin recoveries indicate a similar but wider distribution with 67% of the coho salmon and 81% of the spring salmon caught off the west coast of Vancouver Island. The wider distribution is no doubt because some are not legitimate marks but are the result of natural causes. Since fewer fish were marked with single fins than with double fins, and the number of recoveries for single fins are greater, many single-fin marks must be the result of incomplete marking and subsequent regeneration of the second fin.

The number of double-fin clipped fish that probably originated in the streams of each state follows:

		Washington	Oregon	California
Spring salmon	1954	7	2	2
	1953	33	6	4
	1952	23	4	9
Coho salmon	1954	20	--	--
	1953	17	10	--
	1952	1	3	--

For spring salmon, approximately 70% were from Washington with 15% from both Oregon and California. Many were from tributaries of the Columbia River and a few were from the Sacramento River. Fewer recoveries were made this season because, in order to avoid confusion between overlapping size groups, no fish were marked in the 1950 and 1952 brood years.

For coho salmon, most were from Washington, chiefly from streams in Puget Sound, and the remainder were from Oregon.

The intermixing of stocks during their ocean migrations along the coast is demonstrated similar to the results of tagging adult fish, except that few marked spring salmon have been recovered from northern British Columbia or Alaska. To date, quantitative comparisons of the recoveries in British Columbia with those from other areas, for any single experiment, have had high sampling errors owing to the low availability of marked fish in such large catches.

B. Growth studies

1. Coho salmon

Although the majority of the coho salmon are caught during their third year there is still considerable variation in size between fish from different areas in different seasons. These differences must reflect in part the different ocean conditions encountered. This season during June many fish were caught in the Gulf of Georgia less than the minimum weight of 2½ pounds dressed. The following table shows the average fork lengths in

centimetres for coho salmon sampled during the last three seasons on both sides of Vancouver Island:

	June	July	August	No. of fish	Season opened
Caught inside Vancouver Island					
1952	52.8	55.1	54.1	9,690	June 1
1953	52.8	53.1	54.1	6,309	June 1
1954	51.4	53.4	54.6	5,666	June 1
Caught outside Vancouver Island					
1952	58.8	64.1	65.9	9,362	June 15
1953	58.3	60.1	64.8	6,225	June 15
1954	55.7	60.9	64.7	3,744	June 15

In 1954 the weather was cold and the average size of coho salmon was smaller in June than in the two preceding years in both regions. By July the average size was similar to that in 1953 but did not reach the large size attained in 1952. For July, 1953, poor feeding conditions were reported outside Vancouver Island. By August in each year the fish were of more uniform size in both regions. The difference in size between fish caught in the two regions is most marked. Since the size of the 1954 catch, in both regions, was smaller than in the two preceding years, the feeding conditions were apparently very poor early this season.

2. Spring salmon

Last year a discussion of the complexity of obtaining consistent age determinations from spring salmon scales was presented. Further checks by means of scale measurements were made on some of the 1953 scale samples. The result has been that the ages are now read older and with more stream types than formerly, when the ages were determined by inspection. The ages of the marked fish recoveries should enable us to decide which method gives the truest age. The percentages in each age-group for the 1953 samples, read by scale measurements, are as follows:

Area	No. of fish	Ocean type 1	2	3	4	5	Total	Stream type 3	4	5	Total
West Coast of Vancouver Island	269	-	15	56	11	1	83	12	5	-	17
Southwest Coast of Vancouver Island	152	2	24	50	11	-	87	7	5	1	13
Gulf of Georgia	62	-	10	82	5	-	97	3	-	-	3
Fraser River	103	-	14	34	17	2	67	15	12	6	33
Marked Fish	36	-	-	3	78	-	81	-	14	5	19

Approximately two-thirds of the fish sampled from the west coast of Vancouver Island were in their third year. The catch, during the study of immature fish off the southwest coast, contained more young fish. The troll sample from the Gulf of Georgia was predominately fish in their third year which had gone to sea as fry. The gill-net catch from the Fraser River contained many older fish that had spent the first year in the stream. Most of the marked fish were in their fourth year, presumably from the marking experiments of the 1949 brood-year. If this method is substantiated by mark recoveries then past scale samples will be interpreted by this means.

Length measurements for the past three seasons, are now available to show the regional and seasonal variations in size of spring salmon caught by the troll fleet. Most of the small spring salmon are caught off the west coast of Vancouver Island. For example, this season the percentage of fish in the west coast samples, less than 26 inches (total length) was 30% and less than 28 inches was 47%. It is estimated that these comprised 73% of the fish less than 26 inches and 67% of the fish less than 28 inches in the total troll catch. These small fish include all of the two-year-olds and approximately one-half of the three-year-olds in the catches.

OCEAN STUDIES ON SPRING AND COHO SALMON

In July, 1953, a detailed study was made of the spring and coho salmon fishery on the important feeding banks off Barkley Sound on the west coast of Vancouver Island. Last year a description of the various banks and the results of a study on the efficiency of four types of common trolling lures were reported. The gonad and stomach samples have now been analysed and the results are presented below.

During the summer of 1954, observations were made on the sport fishery in the southern part of the Gulf of Georgia and several experiments were conducted to assess the tagging and releasing mortality for spring and coho salmon caught by trolling gear.

A. Further observations on spring and coho salmon off Barkley Sound in 1953.

1. A maturity study of spring salmon

A total of 159 gonad samples of spring salmon were obtained during the experimental fishing operations off Barkley Sound in July, 1953. For comparison 61 gonad samples of spring salmon were collected from the Fraser River gill-net fishery.

An attempt was made to separate the fish, for state of maturity, by weighing the gonads of both sexes and by measuring the egg diameters of the females. The samples from the Fraser River, as well as those from coho salmon, were used as checks since they were presumably both from fish that would mature the same season.

The results show that a clear separation can be made, between female fish that would mature later in the season and those that would not. The separation is at a gonad weight above 60 grams and below 35 grams, or an average egg diameter above 2.7 millimetres and below 2.0 millimetres. In terms of length, maturing and immature females are divided at a fork length of approximately 75 centimetres or a total length of 30 inches. In the case of male fish, the separation was not as clear cut and both maturing and immature fish were found over the entire length range up to a fork length of 85 centimetres. Above this length all were maturing fish.

For the commercial troll catch off Barkley Sound in 1953, it is estimated that approximately two-thirds of the spring salmon were immature. Above the proposed minimum size of 26 inches (total length), less than one-half of the fish would be maturing (both sexes) and below 26 inches approximately 10% would be maturing fish (all males). It is apparent that no minimum size limit will satisfactorily separate spring salmon into mature and immature fish and if most of the immature fish were not to be landed then a large portion of the catch would have to be released.

2. Stomach contents of Pacific salmon with particular reference to herring in the diet of spring salmon.

During the fishing operations of the "Karmsund" off Barkley Sound in July 1953, a total of 281 stomach samples was obtained. A summary of the contents follows:

	Spring salmon			Coho	Pink	Sockeye
	Red	White	Total	salmon	salmon	salmon
Number of stomachs	130	23	153	110	13	5
Percent of stomachs empty	41	22	39	31	31	60
Percent of stomachs containing: herring	27	65	32	43	30	-
sandlance	14	4	12	5	-	-
other fish	9	4	7	8	15	-
invertebrates	18	17	17	36	52	40
Percent of stomach contents by volume:						
herring	69	82	73	66	29	-
sandlance	12	1	8	1	-	-
other fish	1	-	0.5	3	7	-
invertebrates	19	17	18.5	30	64	100

The spring salmon were feeding heavily on herring, particularly the white springs, with one-third of the stomachs containing three-quarters of the total stomach contents by volume. Sandlance and invertebrates, such as Euphausiids and pelagic shrimp, were also important items in their diet. The coho salmon were feeding on the same group of organisms but there was more variety in the type of food in each stomach. Euphausiids were present in one-third of the stomachs and composed one-third of the total stomach contents by volume. The pink salmon stomachs contained fewer fish and more invertebrates while the few stomachs from sockeye salmon were either empty or contained only Euphausiids.

It was reported last year that the larger trolling lures, in both plugs and spoons, caught more large spring salmon than the smaller lures of each type. The stomach contents reveal that the larger spring salmon eat more fish (mostly herring) than the smaller spring salmon and that those caught by the larger lures were feeding more on fish than those caught by the smaller lures, as show below:

	Percent of stomachs containing:		
	Fish	Invertebrates	No food
Size of spring salmon - above 26 inches	61	8	31
- below 26 inches	33	13	53
Type of lure - large plug	76	-	24
- small plug	34	8	58
- large spoon	52	19	29
- small spoon	43	10	47

The most marked relationship is that the large plugs catch mainly large spring salmon (90% were over 26 inches) that are feeding heavily on a fish diet (76% of the stomachs contained fish). The other relationships between sizes of gear, fish and food follow the same pattern but are not as marked. The small spring salmon were taken more readily on small lures while feeding on invertebrates or when their stomachs were empty.

None of the above relationships were apparent for coho salmon, probably because they are almost all the same age and hence are more uniform in size.

In this study, one-half of the stomachs of spring salmon above 26 inches contained herring, while for those below this length only one-fifth contained herring. The size of the herring consumed ranged from 150 to 190 millimetres in standard length. (It is of interest that this is the same length as the 6- and 7-inch plugs commonly used as lures.) However, during the same period, only 30% of the herring sampled from the small summer fishery on Swiftsure Bank, was in the size range less than 190 millimetres. Thus the herring eaten by spring salmon were smaller than the majority of the herring caught nearby. The herring, less than 190 millimetres were all age III or younger and are mostly recruited to the fishery in the two following winters.

The banks off Barkley Sound constitute a feeding area for immature spring salmon and many trollers attribute part of the decrease in production of

spring salmon to the heavy winter fishing of herring. If for some reason, such as mouth size, spring salmon are limited to eating only small herring, then a heavy herring fishery could not directly affect the food supply since the catch is mainly large herring taken at a later period. In fact the large herring are probably competing for the same basic plankton forms as the organisms that make up the diet of spring salmon. Furthermore, it is held among herring workers that the abundance of small herring is not so much influenced by the fishery as by the size of the losses sustained in very early life. In any case, previous work has shown that at other seasons and in other localities, alternative organisms, such as sandlance and Euphausiids, can be dominant items in the diet of spring salmon. Concerning any decline in the abundance of spring salmon, it is also known that much of it must be attributed to the many unfavourable changes that have occurred in their freshwater environment.

B. Observations on spring and coho salmon in the southern part of the Gulf of Georgia in 1954.

It has been mentioned earlier that the coho salmon, caught by the commercial trollers, are smaller in the Gulf of Georgia than outside Vancouver Island and that the sportsmen catch many "grilse" or small spring and coho salmon. Recent sport catch statistics indicate that most grilse are caught early in the year along the southwest part of the Gulf of Georgia and late in the summer along the eastern side.

From July 4 to September 16 the Station's boat, "Alta", was used for trolling with Mr. L. Quickenden as skipper and Mr. E. A. R. Ball as assistant. This year the sport catch was poor and the catches were too light to undertake a successful tagging program of "grilse". A total of 24 spring salmon and 113 coho salmon were caught. The chief emphasis was placed on capturing small fish, holding them in a live-box on the boat and delivering them to a floating pound near Nanaimo for the purpose of assessing the releasing and tagging mortality of troll-caught fish. A smaller experiment was carried out with fish from Sooke traps and an unsuccessful attempt was made to capture small fish with a gill-net. The data, collected on the efficiency of different troll lures, the depths and temperatures at which the fish were found, and the food and maturity of the fish, will be reported next year. Preliminary results of the study on releasing and tagging mortality are given below.

The mortality involved in releasing troll-caught fish is important in evaluating the effect of minimum size and closed season regulations for the protection of small fish. In the Gulf of Georgia the minimum size for salmon caught by sportsmen is 8 inches fork length (20 centimetres) and for commercial trollers it is 2.5 pounds dressed (about 48 centimetres or 19 inches). The opening of the commercial season is June 1. The mortality involved in tagging troll-caught fish must be determined before fishing or natural ocean mortalities can be estimated from the recent tagging experiments.

Equal numbers of fish were tagged with (a) plastic discs pinned through the back, (b) aluminum straps clamped on the tail, and (c) either left untagged or marked by removing the adipose fin. No marked difference in mortality was noted between the three groups, except that the fish lacking the adipose fin had a higher mortality than either the tagged or untagged fish. It appears that most of the mortality is incurred in catching and releasing the fish, rather than the actual tagging operation itself, although further experiments are necessary to confirm this point.

During July, the initial mortality of catching, tagging and releasing troll-caught coho salmon (40 to 60 centimetres in length) was estimated at 30% and the total mortality up to the end of a month in the pound was 40%. Based on a few spring salmon (40 to 70 centimetres) similar mortality estimates were almost twice these amounts.

In September, the initial mortality for "grilse" coho salmon (20 to 40 centimetres) was estimated at 50%. By using barbless hooks this mortality was reduced to 40%. For a few "grilse" spring salmon (20 to 30 centimetres) the mortality was less than that for coho salmon.

In all cases, most of the mortality occurred either before the fish was landed or shortly after it was released. Hooking in the gills resulted in total mortality; when caught in the eye there was about 50% mortality. Fish hooked in the jaw produced the lowest mortality of approximately 25%.

At the end of a month in the pound, a total of 5 tagged spring salmon and 41 tagged coho salmon was released. These fish were in good condition and to date 6 coho salmon have been recovered from various parts of the Gulf of Georgia.

In conclusion, the mortality involved in catching and releasing small spring and coho salmon from commercial trolling gear is probably from 30 to 50%, initially, and may result in a final loss of 50 to 75%. This substantiates the field observations made last year off Barkley Sound and the results of the recent tagging experiments, which had both indicated a high mortality. In releasing either small coho salmon caught prior to an opening date or small spring salmon under a minimum size limit, a mortality of 50% might be compensated for by a doubling in the weight of the survivors but no gain in net production could result, since only a portion of the fish could be recaptured and the remainder would die of natural causes or escape to spawn. Barbless hooks do not appear to substantially reduce the mortality in "grilse". Even if only the fish in good condition are released, as was done in all previous tagging experiments, the initial mortality is probably from 20 to 30% and the final mortality may be as much as 30 to 40%.

H E R R I N G - F.H.C. Taylor

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H E R R I N G - F.H.C. Taylor

Herring research seeks (1) to define the major herring populations in British Columbia and to estimate the amount of mixing between these populations, (2) to assess changes in abundance in the various populations, (3) to obtain information that will form the basis of an effective system of herring management permitting the maximum utilization of the resource consistent with the future maintenance of the stocks, and (4) to predict the annual recruitment to each of the major populations.

Various studies on all the adult populations are undertaken to provide information on the first two objectives. An intensive comparative study of the lower east coast of Vancouver Island and the west coast of Vancouver Island populations under contrasting methods of management provides information on the third objective. Information on the fourth objective is at present provided largely by the adult studies; however, studies on survival during early life-history stages are in progress with the aim of providing a firmer and more reliable basis for prediction.

Data presented in this report refer to adult studies carried out from April 1953 to March 1954, and early life-history studies carried out in the summer of 1954. The accompanying map shows the sub-districts and areas of the British Columbia coast, referred to in this report.

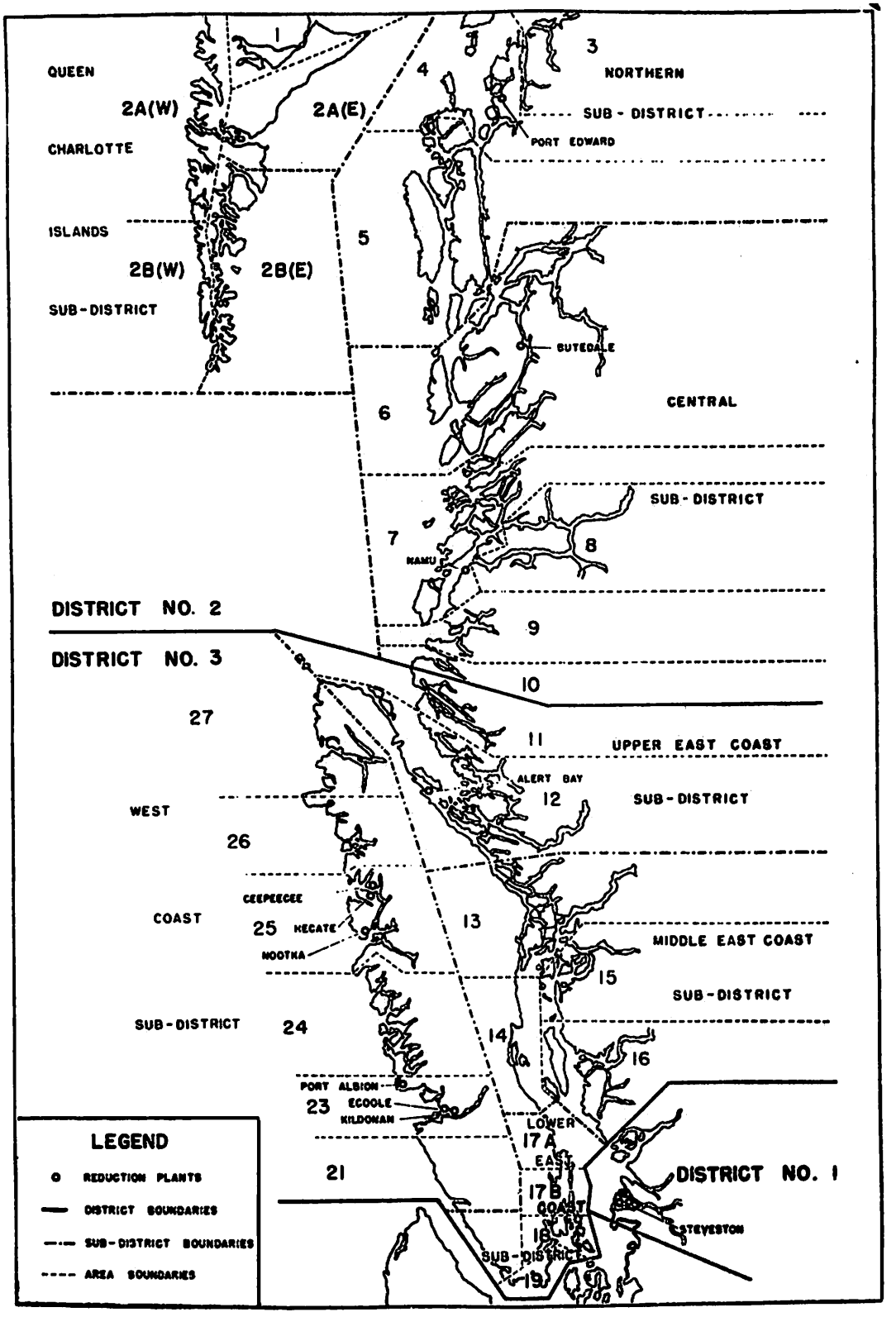
ADULT HERRING STUDIES

Studies on adult herring populations include the collection of catch statistics from the various fisheries, a tagging and tag-recovery program, sampling the catches and the spawning runs, the assessment of the extent and intensity of spawn deposition in all populations, and the comparison of the effect of different catch regulations on abundance in two populations.

The almost complete lack of a fishery in most areas in 1952-53, as a result of an industrial dispute, to some extent affected research in 1953-54. It was not possible to calculate certain population statistics dependent on results from two successive years' fishing.

A. The 1953-54 fishery — G. T. Taylor

A record British Columbia herring catch of 210,210 tons was made in 1953-54. The previous best season was 1951-52 when 198,000 tons were landed. The distribution of the catch by sub-districts is given in the following tabulation. There was no regular reduction fishery in 1952-53 so that the comparative figures in parentheses are those for the 1951-52 season.



Map showing the division of the British Columbia coast into districts, sub-districts, and areas.

Sub-district	Catch (in tons)	Catch per unit of effort (tons per seine per day)
Queen Charlotte Islands	28,550(11,200)	217.7 (171.4)
Northern	29,750(57,300)	76.6 (265.3)
Central	31,650(39,900)	55.5 (63.3)
Upper east coast of Vancouver Island	6,650(8,250)	36.7 (48.6)
Middle east coast of Vancouver Island	19,600(10,350)	48.9 (90.5)
Lower east coast of Vancouver Island	52,660(51,000)	81.4 (66.9)
West coast of Vancouver Island	41,350(30,000)	44.0 (76.1)

The west coast of Vancouver Island and Queen Charlotte Islands sub-districts were free of quota restrictions; quotas for the other sub-districts were unchanged. Three extensions were granted. In the Queen Charlotte Islands, a time extension of 9 days beyond the normal closing date of March 10 was granted; only 6 days were used. In the middle-east-coast sub-district, a 15,000 ton extension - 10,000 tons for reduction and 5,000 tons for bait, canning, and kippering.

On February 25 fishing commenced in the Queen Charlotte Islands at Skidegate Inlet (Area 2A-E) and at Burnaby Narrows (Area 2B-E). By February 28, 22 seine boats had moved to the grounds. Good catches were made in Burnaby Narrows at first, but the fish disappeared and all vessels concentrated in Skidegate Inlet. Here, for the first time, an intensive fishery developed, limited only by the capacity of the packers and plants. The area was closed on March 16 by mutual agreement between the industry and Department of Fisheries. The total catch for the sub-district was a record 28,550 tons. Fourteen vessels submitted Pilot House Records accounting for 82% of the sub-district catch; catch per unit of effort in Area 2A-E was 221.7 tons per seine day and in Area 2B-E 162.0 tons per seine day, compared to 171.4 tons per seine day for Area 2B-E in 1951-52.

Herring were abundant in the northern sub-district from 1949-50 to 1951-52. However, in 1953-54, the catch was disappointing and although the quota was reached it was taken with difficulty. First catches were made on November 24 in Ogden Channel. Fair fishing was experienced with 33 boats taking part. Gasboat Pass (Area 5) again produced good catches but fishing in Chismore Pass, Edye Pass, and Butler's Cove, all in Area 4, was poor. The sub-district was closed on December 14 with a total catch of 29,750 tons. Of this, 27,500 tons came from Ogden Channel and Gasboat Pass and 2,250 tons from Butler's Cove, Edye Pass, and Chismore Pass. The catch per unit of effort was 76.6 tons per seine day. After the Christmas closure an extension was requested. In view of the scarcity of available fish the extension was not allowed.

In the central sub-district only 31,650 tons of the quota of 40,000 tons were taken, the average catch per unit of effort was 55.5 tons per seine day. Prior to the middle of November, three local seiners fished the sub-district with some success, taking 7,500 tons. Good catches were made in Smith Inlet (Area 10), Moses Inlet (Area 9), Evans Arm (Area 8), Gardner Canal and Klemtu (Area 6). With the entry of the main fleet into the fishery in the middle of November the whole sub-district was scouted but only small

catches were made, mainly in Meyers Pass (Area 6), Barnard Cove (Area 6), Boddy Pass (Area 7), and Ivory Island (Area 7). By November 24 all the boats had moved to the northern sub-district and did not return until December 14. Scratch fishing continued until the Christmas recess. Fishing recommenced on January 6 and fish were found in quantity in Thompson Bay (Area 7) and Boddy Pass (Area 7). Good catches were made for the next 8 days. However, freezing weather during the last two weeks of January curtailed fishing. From January 31 to February 5, small catches were made in Boddy Pass, Lama Pass, off Ivory Island, and near Bella Bella. After a week's lay-off, 22 boats recommenced fishing in the central sub-district on February 14. Catches were made in Area 6 in Meyers Pass and Surf Inlet. Laredo Inlet and Green Inlet (Area 6) were scouted. In Area 7, catches were made in Boddy Pass, Cultus Sound, Spider Anchorage, Bella Bella, and Lama Pass. However, the excellent fishing in the Queen Charlotte Islands attracted the boats and no further fishing took place in the central sub-district after February 26.

After the completion of the lower-east-coast fishery, active fishing began in the upper-east-coast sub-district the week of November 15-20. A catch of 31 tons had been made in Knights Inlet (Area 12) early in September. Ten boats fished the sub-district with varying success. By the Christmas recess only 2,900 tons had been taken, mainly from Clio Channel, Bones Bay, Knights Inlet, Belleisle Sound, and MacKenzie Sound. Fishing recommenced on January 6; 15 seine boats fished in Kingcome Inlet, taking 3,300 tons in the next 8 days before freezing weather temporarily closed down the fishery. During the last week of the season, 9 boats fished in Retreat Pass (Area 12) but made only small catches. A total of 6,500 tons out of a quota of 10,000 tons was landed from the upper-east-coast sub-district. The catch per unit of effort for the sub-district was 36.7 tons per seine day.

In the middle-east-coast sub-district there was a summer fishery in addition to the regular winter fishery. In July and August two seine-boats exploited a concentration of herring near Cape Lazo (Area 14). In September, 18 vessels fished this locality. At first fishing was good but later fell off and the vessels dispersed to other areas. As a result of the summer fishery off Cape Lazo and in Area 15, 8,500 tons were caught; catch per unit of effort was 38.5 tons per seine day. A request was made for an extension of 10,000 tons to be taken from the usually productive Deepwater Bay locality (Area 13). This was granted and fish commenced on October 4. At first, catches were poor but improved over the next three weeks, until by the first week in November over 10,000 tons had been taken from Area 13. Thereafter, there was no fishing in the sub-district until the last week of the season when two boats seined 400 tons from Deepwater Bay. The total catch for the sub-district was 19,600 tons, 10,800 tons from Area 13, 8,050 tons from Area 14, and 750 tons from Area 16.

Fishing for summer herring also took place in the lower-east-coast sub-district. From May to the first week of October small catches were made in Nanoose Bay (Area 17A) and off Williams Head and Albert Head (Area 19). The main lower-east-coast fishery commenced during the week October 11-16 in Nanoose Bay (Area 17A) and Trincomali Channel (Area 17B). Good fishing resulted in Nanoose Bay but not in Trincomali Channel. Later in the month excellent catches were made at Porlier Pass (Area 17B) and Swanson Channel (Area 18) by over 40 seine boats. Porlier Pass was fished in the early morning and Swanson Channel at night. By November 2 the quota for the sub-district was taken. An extension of 10,000 tons for reduction and 5,000 tons for special purposes was granted. Fishing by the whole fleet of 56 seines recommenced at noon November 10 and by evening of November 12 the reduction extention was taken.

The special quota was fished by one seine boat from each company but was not attained. The final catch for the sub-district was a record 52,660 tons: 4,000 tons from Area 17A, 18,350 tons from Area 17B, 30,000 tons from Area 18, 250 tons from Area 19, and 60 tons from Area 20. The catch per unit of effort was 81.4 tons per seine day for the sub-district as a whole. In Area 17B the catch per unit of effort was 89.6 tons per seine day, in Area 18, 85.9 tons per seine day, in Area 17A, 55.0 tons per seine day and in Area 19, 12.2 tons per seine day.

In the west coast sub-district a summer fishery developed off Swiftsure Bank (Area 21). During the first two weeks of July, 10 seines fished this area but found the fish difficult to catch; one boat continued to fish until the end of July. A total catch of 2,000 tons was made. The main west-coast fishery began on November 15. Good catches were made by 16 boats in Effingham and in Uchucklesit Inlets (Area 23). Two boats also took 500 tons from Sydney Inlet (Area 24). Steady but not spectacular fishing continued in various localities in Barkley Sound (Area 23) until the week of December 13-18 when the boats moved to Sydney Inlet (Area 24) where several large sets were made. During the pre-Christmas fishery, Esperanza Inlet and Nootka Sound (Area 25) were scouted but no herring were found. By the Christmas recess 26,500 tons had been taken from the sub-district, 21,500 from Barkley Sound (Area 23) and 3,000 from Clayoquot Sound (Area 24). On January 6, 28 seines recommenced fishing in Barkley Sound (Area 23). Fishing was poor and the fleet dispersed to other areas of the west coast. Sydney Inlet (Area 24), Tahsis and Nootka Inlets (Area 25), and Quatsino Sound (Area 27) all yielded small catches. The week January 10-15 saw boats which were fishing in the more northerly sections of the west coast move to the central sub-district. Small catches were made in Barkley Sound (Area 23), Sydney Inlet (Area 24), Tahsis Inlet and Nootka Sound (Area 25), and Ououkinsh and Malksope Inlets (Area 26). From January 17 to 19 freezing weather closed down herring fishing operations. For the remainder of the week, fishing continued all along the west coast with Esperanza Inlet (Area 25), Nasparti and Ououkinsh Inlets (Area 26), Sydney Inlet (Area 24), and Barkley Sound (Area 23) giving small catches. A similar pattern prevailed until the end of the season with the addition of Klaskish and Klaskino Inlets and Quatsino Sound (Area 27) to the localities producing fish. The total catch for the west coast was 41,350 tons, the largest catch since 1948-49. Barkley Sound (Area 23) yielded 24,200 tons, the summer fishing off Swiftsure Bank (Area 21) 2,000 tons, Sydney Inlet (Area 24) 5,350 tons, Esperanza Inlet and Nootka Sound (Area 25) 5,000 tons, Kyuquot Sound (Area 26) 2,700 tons, and Quatsino Sound (Area 27) 2,100 tons. The catch in Area 23 was the largest since the 1949-50 season and in Area 24 the largest since 1946-47. The catch in Area 25 was the lowest since 1949-50 season. Areas 26 and 27 produced the largest catches since 1942-43. The catch per unit of effort for the sub-district as a whole was 44.0 tons per seine day; without the summer fishery it was 43.7 tons per seine day.

B. Tagging and tag-recovery — F.H.C. Taylor

The herring tagging and tag-recovery program provides information on (1) the inshore regions occupied by the various herring populations and the relative discreteness of these populations, (2) the amount of mixing both between and within the various populations, and (3) certain population statistics.

Herring tags are recovered either by tag-detectors operated by investigational personnel or by magnets in the meal lines of the reduction

plants. Tag-detector recoveries, although considerably fewer in number, provide more accurate information than plant magnet recoveries, where a considerable degree of uncertainty often exists as to the area, and at times, the sub-district of recovery.

A total of 4,615 herring tags was recovered in 1953-54. Of these, 67 were recovered by tag-detectors and 4,548 by magnets in 14 reduction plants.

1. Tag-detector recoveries F.H.C. Taylor

During the 1953-54 season two induction type tag-detectors were operated, one at the Gulf of Georgia plant in Steveston from October 7 to February 6 but operating for only 3 days in the post-Christmas period, and one at the Seal Cove plant in Prince Rupert from December 7 to 17.

The percentage efficiency of the Gulf of Georgia detector compiled over the full season was 51% as compared to 80% for the previous season (1951-52) in which it operated. The lower efficiency in 1953-54 resulted from mechanical difficulties and from instability caused by voltage fluctuations in the power supplies of both the detector and induction coil. While the mechanical difficulties were largely overcome by the latter part of the season, the solution to the problem of unstable operation lay in redesigning the detectors. This work was carried out during the summer of 1954. It is hoped that detector efficiency in 1954-55 will be greatly improved. Tag-detector operations at Seal Cove again proved most unsatisfactory; the fault lay both in the site of installation and in the inherent instability of the present type of detector. Because of these difficulties, the short period of operation, and the small number of tags recovered it was not possible to calculate the percentage efficiency of this detector.

Because of changes in unloading methods no detector could be operated in the Imperial reduction plant at Steveston in 1953-54. A new detector was built and installed in the Colonial reduction plant at Steveston. Unfortunately the installation was not completed until the Christmas break and the plant did not operate in the post-Christmas period.

Detector recoveries in 1953-54 amounted to between one-quarter and one-third of those of previous seasons. A total of 67 tags were recovered, 64 at the Gulf of Georgia plant and 3 at the Seal Cove plant. The operation of one instead of two detectors at Steveston, and the lower efficiency of this detector accounted for this marked drop.

The probable numbers of tags in the catches of each sub-district, derived by applying corrections for detector efficiency and the tonnage not searched by the detectors, are given in the table below (actual numbers of tags are shown in parentheses). Because of the inefficiency of both detector and plant magnets at Seal Cove, recoveries from this plant have not been used in calculating the probable number of tags in the catches. Recoveries were too few to form a reliable basis for the calculations of the probable numbers of tags in the catches and to permit the assessment of the movement of herring between the various sub-districts. Limited confidence can possibly be placed in the probable numbers of tags in the catches in the middle-east-coast, lower-east-coast, and west-coast sub-districts. Movements of 23% (49/215) of middle-east-coast herring to the lower-east-coast and of 14% (85/597) of west-coast herring to the lower east coast are indicated. These movements are of about the same general order of size as those found in previous years.

Sub-district of tagging	Sub-district of recovery							
	Queen Charlotte Islands	Northern	Central	Upper east coast	Middle east coast	Lower east coast	West coast	Total
Queen Charlotte Islands	----	----	----	----	----	----	----	----
Northern	----	(3)*	----	----	----	----	----	(3)*
Central	----	1,191 (1)	1,964(12)	----	----	----	----	3,155(13)
Upper east coast	----	----	----	63(4)	----	----	----	63(4)
Middle east coast	----	----	----	----	166(8)	49(5)	----	215(13)
Lower east coast	----	----	----	----	----	132(14)	----	132(14)
West coast	----	----	----	----	----	85(9)	512(11)	597(20)
Total	----	1,191 (4)	1,964(12)	63(4)	166(8)	266(28)	512(11)	4,162(67)

* Seal Cove recoveries

2. Plant recoveries

F.H.C. Taylor

In 1953-54, 4,548 tags were recovered from magnets and plant machinery in 14 reduction plants. This total represents a slight increase over the previous record total of 4,512, obtained in 1951-52. A large number of recoveries were expected because of the heavy taggings in 1952 (60,887) and 1953 (81,390), and the very reduced fishery of 1952-53.

Plant magnet returns are generally of more limited value in studying herring movements than tag-detector recoveries because doubt is often attached to the area in which fish bearing the tags were caught. However, because of the small number of detector recoveries in 1953-54, the analysis of plant magnet recoveries is considered the more reliable method. Calculations of the probable number of tags in the catches of the various sub-districts can be made by applying corrections for magnet efficiency and tonnage not searched by plant magnets. Before applying these corrections, "doubtful" recoveries were arbitrarily assigned to the sub-district of tagging. An analysis of the "certain" recoveries showed that this procedure would result in the correct assignment of the area of recovery in at least 80% of the cases. Tags recovered by 3 west-coast reduction plants at which magnet efficiency tests were not carried out are omitted in the determinations of the probable numbers of tags. As these plants receive a large proportion of the catch from the northwest coast of Vancouver Island areas, some bias may have been introduced.

In the table below are shown the probable numbers of tags in the catches based on plant magnet recoveries, summarized by sub-district of tagging and sub-district of recovery. The results for the upper-east-coast taggings are more questionable than those for other sub-districts. The "certain" recoveries of tags put out in this sub-district were all made within the sub-district. However, a number of doubtful recoveries which could equally well have come from the middle-east-coast as from the upper-east-coast sub-district were all assigned to the latter.

Magnet recoveries

Sub-district of tagging	Sub-district of recovery							
	Queen Charlotte Islands	Northern	Central	Upper east coast	Middle east coast	Lower east coast	West coast	Total
Queen Charlotte Islands	17(12)	3(2)	4(4)	-	-	-	1(1)	25(19)
Northern	2(2)	928(798)	21(19)	3(3)	1(1)	-	-	955(823)
Central	-	83(71)	1,503(1,394)	6(6)	9(7)	-	1(1)	1,602(1,479)
Upper east coast	-	-	-	103(97)	-	-	-	103(97)
Middle east coast	-	-	-	-	215(202)	47(40)	13(11)	275(253)
Lower east coast	-	-	-	1(1)	36(32)	161(134)	31(30)	229(197)
West coast	-	3(2)	1(1)	2(2)	3(3)	56(49)	1,892(1,204)	1,958(1,261)
Total	19(14)	1,017(873)	1,529(1,418)	115(109)	264(245)	264(223)	1,938(1,247)	5,147(4,129)

The marked tendency for tags to be recovered in the sub-district of tagging, noted in previous years in the analysis of both detector and magnet returns, is again shown. The relative strength of the "homing" tendency in the various populations cannot readily be compared because of unknown differences in the exploitation rates in the various sub-districts. The tendency was more pronounced in the northern, central, upper-east-coast, and west-coast sub-districts and less so in the middle-east-coast, lower-east-coast, and Queen Charlotte Islands sub-districts.

Because of the small number of recoveries from Queen Charlotte Island taggings (Area 2B-E), only guarded statements can be made of the movements of the fish. There was apparently approximately equal emigration (12% and 16%) to the northern and central sub-district, with a small movement (4%) based on 1 tag return to the west coast of Vancouver Island. It is interesting to note that while there was a relatively heavy fishery in Area 2A-E, no Area 2B-E tags were recovered there. This suggests that the herring stocks in the northern and southern part of the Queen Charlottes are separate. The difference in age composition and spawning time lends support to this view.

The main movement of the northern sub-district fish (2%) was to the central sub-district. This is somewhat less than the 5.9% found in 1951-52. The main movement of central fish (5%) was to the northern sub-district and corresponds closely to that found in 1951-52. It is interesting to note that the movement (9%) of fish tagged in Area 5 to the central sub-district was greater than the movement (2%) of fish tagged in Area 4; on the other hand, the movement (20%) of fish tagged in Area 6 to the northern sub-district was greater than the movement (1%) of fish tagged in Area 7. Again, the movement (8%) of fish tagged in Area 10 to the upper-east-coast sub-district was greater than the movement (1%) of fish tagged in Area 6 or 7 to this sub-district. However, it should be pointed out that the movements of fish tagged in Areas 5 and 10 are based on a much smaller number of fish than those for Areas 4, 6 or 7.

Relatively great dispersal of middle-east-coast and lower-east-coast tags to other sub-districts was shown by magnet recoveries in 1953-54. Approximately 17% of the middle-east-coast tags recovered (23% on the basis of detectpr recoveries) were from the lower-east-coast, whereas 16% and 14% of the lower-east-coast tags were from the middle-east-coast and west-coast respectively. The movements indicated between the middle-east-coast and lower-east-coast are of approximately the same order as found in previous years. The movement to the lower-east-coast of fish tagged in Area 14 (22%) was greater than that for fish tagged in Area 15 (12%). Similarly the movement to the middle-east-coast of fish tagged in Area 17A (38%) was greater than that for fish tagged in Areas 17B (10%) or Area 18 (2%). On the other hand, the movement of lower-east-coast fish to the west-coast was greater for those tagged in Areas 17B and 18(14% and 16% respectively) than for those tagged in Area 17A (10%). The movement of west-coast fish to the lower-east-coast was greater from Area 23(5%) than from the other west-coast areas (1 to 2%).

The movement of fish in both directions between the west-coast and lower-east-coast (14% lower-east-coast to west-coast; 3% west-coast to lower-east-coast) was approximately the same as that in 1950-51, (10.5% and 4% respectively), and somewhat greater than that in 1951-52. The disparity in the movements in the two directions in these populations may partially result from differences in exploitation rates in the two populations.

In addition to the recoveries from the Canadian taggings discussed above, three recoveries were made from a group of tags put out by American investi-

gators in the Hood Canal, Washington, in April, 1953. One recovery was from the summer fishery off Swiftsure Bank (Area 21), another from Williams Head (Area 19) in the early fall, and the third from the regular winter fishery probably from Barkley Sound (Area 23).

In general, the analysis of tag returns in 1953-54 supports the findings of previous years on the discreteness of the populations in the various sub-districts and on the extent of intermingling between the various populations.

3. Magnet efficiency tests — F.H.C. Taylor

The purpose of the magnet efficiency tests carried out at various reduction plants is to determine the percentage efficiency of the magnets in recovering tags. This information is used in determining the probable numbers of tags in the catches. These tests also provide some information on the "time-lag" involved between the entry of tags into the plant and their recovery on the magnet.

In making these tests, 50 test tags are placed in fish and scattered randomly among the plant storage bins. Tags are later recovered from the magnets by plant crews and returned to the Pacific Biological Station with the date of recovery.

During the 1953-54 herring season, tests were carried out in 11 plants: 4 at Steveston, 1 in North Vancouver, 2 on the west-coast of Vancouver Island and 4 in northern British Columbia. In comparison with 1951-52, fewer tests were carried out; the coverage of plants on the west-coast of Vancouver Island was not as complete for no contact vessel was available to provide transportation to isolated plants. The tests at Steveston and on the west coast were carried out by investigational personnel, those in northern British Columbia by fisheries officers or investigational personnel.

In general, most plants tested showed an increase in efficiency of recovery. This was particularly noticeable in plants in Steveston and vicinity. This increase is no doubt related to the greater interest of plant crews arising from frequent contact with investigational personnel.

A summary of the tests, with comparative figures for 1951-52 in parentheses, is presented in the following table:

Locality	Plant	Number of tests	Average Efficiency
West coast	Kildonan	1 (-)	94 (-)
	Port Albion	1 (-)	90 (-)
		Average	92 (-)
Steveston and vicinity	Imperial	3 (7)	94 (86)
	Gulf of Georgia	2 (8)	97 (83)
	Colonial	2 (3)	92 (83)
	Phoenix	2 (5)	92 (94)
	North Shore	3 (3)	97 (97)
		Average	94 (89)
Northern British Columbia	Namu	3 (2)	86 (91)
	Butedale	2 (1)	96 (86)
	Seal Cove	1 (1)	68 (63)
	Port Edward	4 (3)	92 (94)
		Average	85 (82)
		Grand Average	91 (80)

In order to obtain more detailed information than provided by the routine tests on the "time-lag" between the entry of tags into the plant and their recovery, additional tests were carried out in 3 plants at Steveston during the 1953-54 season. In these tests, 10 tags were placed in fish and scattered randomly among the herring in the hold of the vessel unloading, in the fish-bins, or in the conveyors leading to the cookers. Plant magnets were examined at frequent intervals by investigational personnel and the time recorded when tags were found.

At each plant the percentage efficiency calculated on the basis of these tests was somewhat lower than that indicated by the routine test. This is probably explained by the smaller number of tags used in the special tests. While in some cases considerable differences apparently exist between plants in the time taken for tags to pass through the plant, it is not known whether these differences were real, as tests were not repeated at intervals throughout the season. In general, about one-third of the tags entering the plant are recovered within 6 hours, half within 12 hours, and two-thirds within 18 hours. After 18 hours, returns become sporadic and are spread over several days. These are probably tags that become lodged in plant machinery and are later worked free. The tests also showed that the delays and losses occur in plant machinery rather than in unloading lines or storage bins. The results of these tests are summarized below:

Plant	Percentage Recovery within 6 hours	within 12 hours	within 18 hours	Total Recovery
Imperial	34	52	63	84
Gulf of Georgia	75	-	-	90
Colonial	27	47	64	83

4. Tagging during the spring of 1954 G. T. Taylor

Two seine boats, Great Northern III and Bligh Island, were loaned by the fishing companies to assist in tagging herring in British Columbia this last season. The first vessel commenced operations on February 22 in the lower-east-coast of Vancouver Island and moved to the west-coast of Vancouver Island later in the week. After tagging on the west coast, it moved to the central sub-district and then on to the northern area. In the first week of April herring were tagged from this vessel in Burnaby Narrows in the Queen Charlotte Islands. The second vessel commenced operations on February 25 in the lower-east-coast and after completing tagging there moved to the central sub-district completing operations on April 1. An intensive fishery developed in Skidegate Inlet for the first time in 1953-54; to gain more information on the relationship of this population to other stocks in the Queen Charlotte Islands and northern British Columbia, three taggings were carried out in Skidegate Inlet during the second week in May, 1954.

The number of herring tagged in the various sub-districts in 1953 and 1954 are given in the following tabulation:

	Queen Charlotte Islands	Northern	Central	Upper east coast	Middle east coast	Lower east coast	West coast	Total
1953	4,111	6,244	15,610	1,342	6,008	13,216	34,859	81,390
1954	7,066	8,089	6,081	-	3,014	8,074	6,141	38,465

The intention was to reduce tagging in the more southerly sub-districts and increase tagging in the more northerly. By and large this object was achieved; however, less tags were inserted in the central and west coast of Vancouver Island sub-districts than intended because of delays occasioned by breakdowns in both tagging vessels.

C. Sampling of the fishing and spawning runs R. S. Isaacson

From the sampling program, information is provided on the age composition, growth, sexual maturity, and the proportion of each sex in the various populations. The age-composition data provide estimates of the relative strength of the various year-classes and some indication of the extent of future recruitment. Changes in growth may reflect variations in feeding conditions.

During the 1953-54 season, 386 herring samples (364 from the fishery and 22 from the spawning grounds) comprising 35,136 individual fish were collected. Care was taken to ensure that each sample was randomly selected and whenever possible consisted of 100 fish. In sampling, the length, weight, sex, and stage of maturity of each fish was recorded and a scale taken for age determination.

The distribution of the samples taken during the 1953-54 season by sub-district is given in the following tabulation with comparative figures for the previous season in parentheses. Twelve samples taken from the 1953 summer fishery in the lower-east-coast (5 samples) and west-coast (7 samples) sub-districts are included in this tabulation.

In 1952-53 the sampling program was somewhat curtailed due to the lack of a major fishery. The number and general distribution of the samples taken during the 1953-54 season is similar to that for the 1951-52 season.

Sub-district	Number of samples	
	Fishing samples	Spawning samples
Queen Charlotte Islands	36 (0)	6 (2)
Northern	31 (19)	4 (6)
North central	6 (3)	1 (2)
South central	53 (28)	2 (10)
Upper east coast	26 (1)	0 (1)
Middle east coast	*54 (20)	2 (6)
Lower east coast	80 (100)	4 (9)
West coast	*78 (43)	3 (32)
Total	364 (214)	22 (66)

* Includes samples from the 1953 summer fishery

1. Age composition of herring in 1953-54

The average percentage age composition of the herring comprising the winter runs (W) and spawning runs (S) to the various sub-districts in 1953-54 is given in the following tabulation:

Population	Winter or Spawning runs	Age						
		I	II	III	IV	V	VI	VII
Queen Charlotte Islands.	W	0.05	2.36	27.49	21.74	34.37	10.69	2.27
	S	-	0.84	51.08	11.91	24.17	9.94	1.54
Northern	W	-	1.96	28.35	29.37	23.80	13.33	2.54
	S	-	0.26	43.62	39.02	11.30	5.54	0.26
North central	W	0.42	5.12	74.47	14.11	4.93	0.94	-
	S	-	-	85.57	11.34	2.06	1.03	-
South central	W	0.18	5.52	70.41	18.00	4.39	1.32	0.13
	S	-	-	78.44	16.42	4.11	1.03	-
Upper east coast	W	0.16	9.31	65.87	15.20	6.61	2.32	0.45
	S	-	-	-	-	-	-	-
Middle east coast	W	-	2.48	28.59	40.98	18.82	6.77	1.91
	S	-	-	30.13	42.38	18.84	6.60	1.54
Lower east coast	W	-	0.79	57.98	34.23	6.18	0.62	0.14
	S	-	3.16	56.56	33.98	6.30	-	-
West coast	W	0.03	2.42	62.25	28.42	5.87	0.70	0.23
	S	-	3.44	67.14	24.97	3.76	0.69	-

The 1951 year-class (III-year fish) was the foremost contributor to both the fishing and spawning runs of most of the major herring populations of British Columbia. In 5 out of 8 of these populations it constituted more than half of the run.

In the west-coast sub-district the proportion of III-year fish in both the fishing and spawning runs was slightly higher than in the previous season. This increase was most noticeable in the samples from the south west-coast areas (Areas 23 and 24). In the north west-coast areas III- and IV-year fish made about equal contributions to the stocks. The 1951 year-class was more prominent in the spawning runs than in the fishing runs, particularly in the north west-coast areas.

In the lower-east-coast sub-district in 1953-54 there was a slight drop in the percentage of III-year fish (1951 year-class) offset by an almost corresponding increase in the representation of IV-year fish. The II-year (1952 year-class) fish were less numerous in the fishing runs but were more numerous in the spawning runs than in 1952-53. In recent years the age composition of the lower-east-coast population has, in general, shown little variation.

In the middle-east-coast sub-district indications are that the 1951 year-class (III-year fish) is of below-average strength. In spite of its large contributions as II-year fish in 1952-53, this year-class made the smallest contribution for III-year fish in the past eight seasons. The 1950 year-class (IV-year fish) dominated both the winter and spawning runs, and made up approximately the same proportion of the population as it did as III-year fish in 1952-53.

The herring stocks of the upper-east-coast sub-district consist of a number of fairly discrete local sub-populations. Three of these sub-populations (in Areas 12A, B, and E) were sampled in 1953-54. In each of these areas, III-year fish represented more than half of the run. Herring of age II were above-average in abundance in Areas 12A and 12B and about average in Area 12E. Limited sampling in this sub-district in 1952-53 precludes any comparison with 1953-54 data.

In 1953-54 both the fishing and spawning runs in the central sub-district contained over 70% III-year fish. This was the largest contribution made by the 1951 year-class to any of the major herring populations in British Columbia. In both the north central and south central populations this year-class comprised more than three-quarters of the spawning runs. The 1950 year-class (IV-year fish), although strongly recruited to the spawning stocks in 1952-53 made a below-average contribution for fish of this age-group in both the north and south central populations. The 1951 year-class is considered more abundant than the 1950 year-class.

The proportion of VI-year fish in the catch in the northern sub-district in 1953-54 was larger than normal. The indications have been that this year-class (the 1948) is not of above-average strength. Its relatively large contribution in 1953-54 would suggest that the younger year-classes are all of below-average strength. The 1950 year-class (IV-year fish) was dominant. In 1952-53, as III-year fish, it was better represented than was the 1951 year-class in 1953-54. The indications are, therefore, that the 1951 year-class, at least on the basis of its showing as III-year fish in the fishery, is probably of below-average strength and weaker in the northern than in other sub-districts. For the second season in succession III-, IV-, and V-year fish have been almost equally represented in the fishing runs. Samples from the spawning runs have contained almost double the percentage of III-year fish found in the samples from the winter runs. This suggests that, at least in the past two years, the recruitment of III-year fish was not

completed until after the close of the fishery. More older fish were found in the winter runs than in the spawning runs.

The age composition of fishing runs to the Queen Charlotte Islands sub-district in 1953-54 was roughly similar to that for the northern sub-district, with fish of Ages III, IV, and V being the largest contributors. The 1949 year-class (V-year fish) was dominant in the fishing runs but in the spawning runs was superceded by the 1951 year-class (III-year fish). The IV-year fish (1950 year-class) were poorly represented in both the fishing and spawning runs.

2. Growth of herring in 1953-54

The average length (in millimetres) and average weight (in grams) of herring of Ages II to VI in the winter runs (W) and spawning runs (S) for each population in 1953-54 are given in the following tabulation. Numbers in parentheses indicate averages which have been based on fewer than 10 fish. It should be noted that no weights are taken of fish in the spawning runs. Populations are disignated by initial letters, i.e., Q.C.I. - Queen Charlotte Islands, N. - Northern, N.C. - North central, S.C. - South central, U.E.C. - Upper east coast of Vancouver Island, M.E.C. - Middle east coast of Vancouver Island, L.E.C. - Lower east coast of Vancouver Island, and W.C. - West coast of Vancouver Island.

Population		Average length (mm.) II	III	IV	V	VI	Average weight (gms.) II	III	IV	V	VI
Q.C.I. Area 2A-E	W	133	160	176	197	208	25	51	67	95	111
	S	(150)	170	201	215	229					
Area 2B-E	W	-	179	197	205	221	-	68	93	105	151
	S	-	178	197	208	-					
N.	W	144	177	201	216	232	36	72	106	131	145
	S	(165)	181	197	213	220					
N.C.	W	147	165	183	198	(214)	42	60	86	108	(139)
	S	-	182	194	(208)	(227)					
S.C.	W	127	158	184	196	204	27	53	84	102	116
	S	-	178	195	(208)	(206)					
U.E.C	W	132	155	179	203	225	35	56	85	117	154
	S	-	-	-	-	-					
M.E.C.	W	148	174	196	214	224	43	71	104	143	167
	S	-	185	201	216	224					
L.E.C.	W	152	187	199	211	223	46	88	108	127	149
	S	157	182	199	211	-					
W.C.	W	161	185	200	211	223	54	86	105	126	147
	S	156	181	200	216	(234)					

The growth index for length (sum of the average lengths of the III- and IV-year fish) and the comparable index for weight for each of the major populations in 1953-54 are given in the following tabulation (comparative figures for the previous season in parentheses):

Population	Growth index-length		Growth index-weight	
Queen Charlotte Islands				
Area 2A-E	342(W),371(S)	(-)	118	(-)
Area 2B-E	376	(382)	161	(-)
Northern	378	(384)	178	(191)
North central	348	(-)	146	(-)
South central	342	(385)	137	(189)
Upper east coast of Vancouver Island	334	(455)	141	(299)
Middle east coast of Vancouver Island	370	(377)	175	(173)
Lower east coast of Vancouver Island	386	(380)	196	(171)
West coast of Vancouver Island	385	(383)	191	(180)

The herring populations of the west coast and lower east coast of Vancouver Island sub-districts were the only populations to record increases in growth in 1953-54. Although these increases were not great, they probably reflect an improvement in ecological conditions. In the middle-east-coast sub-district the growth appears to have been similar to that of the previous season.

Tremendous decreases in both length and weight were recorded for the upper-east-coast sub-district. However, these decreases appear to be due mainly to non-comparative sampling in the two seasons of the various sub-populations within this sub-district. Samples taken from the same locality, and presumably from the same population, had similar growth indices in both seasons.

The south central population consists of several sub-populations, some of which are apparently faster growing than others. The distribution of samples shows that both fast-and slow-growing sub-populations were sampled in 1953-54, whereas in 1952-53, only fast-growing populations were sampled. This probably accounts for the smaller growth indices for length and weight obtained in 1953-54. The runs to Areas 9 and 10, sampled for the first time in several seasons, showed growth rates very similar to those previously recorded. In general, little change was noted in the growth rates of any individual runs comprising the population.

In the north central population only the inshore runs were sampled. Two samples were taken from Meyers Pass (Area 6), a locality where mixing between the inshore and offshore runs appears to occur. Both had a growth rate similar to that of the inshore run.

The growth indices for the population in the northern sub-district in 1953-54 showed a decrease from the previous season. Herring of Age III were smaller and lighter and herring of Age IV, lighter. In contrast, herring in the older age-groups (Ages V to X) were all larger and heavier than in

1952-53. As recruitment occurs mainly at Ages III and IV, and if the recruited and unrecruited portions of the stocks occupy different areas, the differences in growth between the younger and older fish suggest that conditions for growth may not have been as favourable in 1953-54 in the areas occupied by the unrecruited portion.

In 1953-54, samples were obtained from the winter and spawning runs to both Areas 2A-E and 2B-E in the Queen Charlotte Islands sub-district. In 1952-53, samples were obtained only from spawning runs to Area 2B-E. In Area 2B-E in 1953-54, the size of fish in the winter and spawning runs was similar. However, the spawning fish were somewhat smaller than in 1952-53. In Area 2A-E in 1953-54, fish of each age-class in the spawning runs were considerably larger than in the winter runs, but slightly smaller than those in the winter and spawning runs to Area 2B-E. At present, no explanation can be offered for the difference in the size of fish in the winter and spawning runs in Area 2A-E. This population has not been sampled before, because until 1953-54 this area had not been fished for many years.

D. Spawn deposition

D. N. Outram

This phase of the adult herring studies provides estimates of the relative size of the spawning stocks from year to year. These estimates are based on the assumption that the extent and intensity of spawn deposition each spring are proportional to the number of fish that are left to spawn, after the preceding winter fishery has taken its toll. The spawn deposited each year also represents the start of a new year-class. A study of this early life-history stage gives basic data on the relationship between year-class recruitment and spawning.

Spawning ground surveys

Each year the spawning grounds in all major sub-districts are surveyed by officers of the Federal Department of Fisheries. Separate estimates of the amount of spawn deposited in the west coast of Vancouver Island sub-district are made by herring investigators.

For each area, from a survey of individual spawning grounds, data are obtained on: (1) the extent (in statutory miles) of spawn deposited along the intertidal zone, (2) the average intensity of spawn deposition calculated by weighting the intensity of each individual spawning classified as very light, light, medium, heavy, and very heavy according to the number of eggs per unit area in the ratio of 1, 2, 3, 4, and 5 respectively.

In the following tabulation the number of statutory miles of spawn and the average intensity of spawn deposition in 1954 are shown for each sub-district with comparable data for the previous year in parentheses:

Sub-district	Extent of spawning (miles)		Average intensity	
Queen Charlotte Islands	22.3	(13.7)	2.9	(2.9)
Northern	15.6	(17.2)	3.1	(3.6)
North central	4.9	(6.8)	2.9	(2.9)
South central	32.4	(39.9)	3.4	(3.3)
Upper east coast	15.3	(23.2)	2.8	(3.2)
Middle east coast	20.0	(30.0)	3.3	(3.6)
Lower east coast	55.8	(82.7)	3.5	(3.7)
West coast	46.3	(64.3)	2.8	(3.2)
All	212.6	(277.8)	3.2	(3.4)

In 1953-54 the extent of spawn deposition along the British Columbia coast, although showing a decrease of 23.5% from the previous year, was the second largest recorded in the past 10 years. A total of 212.6 miles of spawn was deposited, compared to 277.8 miles in 1953. The large spawning in 1953 was at least partly a result of greatly reduced fishing in 1952-53.

The average intensity of spawn deposition was less in 1954 than in the previous year. The south central area was the only region that showed an increase in intensity.

An increase in spawning was recorded in only one sub-district, the Queen Charlotte Islands. This increase was the result of greatly increased spawnings in Area 2B-E, attributable, probably, to the small fishery in this area resulting from the greater abundance and availability of fish in Area 2A-E. In all other sub-districts the extent of spawn deposition decreased from the 1953 levels, and generally, except in the lower-east-coast sub-district, to levels similar to or slightly below the average levels prior to 1953. The greatest decreases occurred in the upper east coast (33.9%), middle east coast (33.1%), and lower east coast (32.4%). However, in the latter sub-district, spawning was still almost double that for any year prior to 1953. The extent of spawning in the west-coast sub-district, while reduced by 30%, still remained well above a level at which future recruitment might be impaired.

E. The comparative study of two herring populations subjected to different methods of management

F. H. C. Taylor

Since 1946-47 no catch quota restrictions have been applied to herring populations in the west coast of Vancouver Island sub-district, while an annual quota of 40,000 tons has limited the catch in the lower east coast of Vancouver Island sub-district. A fixed closing date of February 5 has applied in both sub-districts. The results obtained from this study in 1953-54 will be discussed here. A full report is being published in the Report of the British Columbia Department of Fisheries for 1953.

1. West coast population in 1953-54

In 1953-54, population abundance on the west coast apparently increased from the low level of 1951-52. This was indicated by the size of the catch, the third largest since 1946-47, coupled with a spawn deposition of above-average extent. Area 23 provided the bulk of the catch, with above-average

contributions from Areas 24, 26, and 27. The Area 25 catch was below normal.

Evidence indicates that while population abundance in Area 23 in 1953-54 is considerably greater than in 1950-51 or 1951-52, it may not have attained the average level of abundance of 1947-50. The catch in Area 23 in 1953-54, while considerably larger than that of 1950-51 or 1951-52, was less than the average catch for the period 1946-47 to 1949-50. Spawn deposition in 1954 in Area 23 was greater than in 1951 or 1952, but less than the average deposition in the years 1947-50.

In Area 25, the other major west-coast fishing area, the 1953-54 catch was one of the smallest since 1946-47. Spawn deposition in Area 25 has progressively decreased since 1951, with the exception of 1953, when the increase in Area 25 was proportionately less than in other west-coast areas. Population abundance in Area 25 may, therefore, have declined.

The relative contributions of the various year-classes provide an explanation of the changes in abundance noted in the two major fishing areas. In the south west-coast areas, the decline in abundance in 1950-51 and 1951-52 was the result of the recruitment of two successive year-classes (the 1948 and 1949) of below-average strength, while the increase in abundance in 1952-53 and 1953-54 resulted from the recruitment of two average or above-average year-classes (the 1950 and 1591). In the north west-coast areas, the 1948 and 1949 year-classes were also weak, but because of the relatively great contribution made by the very strong 1947 year-class as IV- and V-year fish in 1950-51 and 1951-52, the decline in abundance was not as pronounced as in the south west-coast areas. However, the 1950 and especially the 1951 year-classes do not appear to have been as strong in the north west-coast as in the south west-coast areas. With no strong contribution by older year-classes, abundance has, therefore, declined.

2. Lower-east-coast population in 1953-54

In the lower-east-coast sub-district, abundance has continued at the high level that has existed since 1951-52. Following the record catch of 52,660 tons, spawn deposition in 1954, although showing an expected decrease from the exceedingly high level of 1953, was still the second highest recorded. The 1949 year-class was considerably stronger here than on the west coast, and the 1950 and 1951 year-classes have also been of above-average strength. Abundance was maintained in 1953-54 by the good recruitment of the 1951 year-class as III-year fish and the above-average contribution of the 1950 year-class as IV-year fish.

3. A review of the results of the comparative study

During the past eight years, the results of the comparative study have indicated that on the west coast during periods of high population abundance, the lack of quota restrictions has not affected abundance. The opportunity was lost in 1952-53 to assess the effect of unrestricted fishing during a period of low population abundance. The fluctuations in abundance that have occurred during the course of the study are explainable on the basis of variations in the success of the different year-classes. It has also appeared that fishing has not been entirely unrestricted. In certain areas, particularly Area 25, natural limitations have been imposed by late inshore migration after the close of the fishery.

On the lower east coast, the present fixed quota has not apparently been effective in stabilizing population abundance, and may have resulted in some

wastage of fish during periods of high abundance. Spawning escapements especially in the last three years, appears to have been much larger than necessary to maintain abundance. The 1947 to 1951 year-classes have all been of average or above-average size, yet these year-classes resulted from spawn depositions of one-third to one-half the size of the spawn deposition of the last three years. The fluctuations in population abundance that have occurred appear to be readily explained on the basis of variations in year-class strength.

There is, on the other hand, some evidence that may indicate that a form of restriction may be necessary to conserve this population. Tag returns have shown that this population follows a single migration route inshore passing progressively through or into each major area, in any of which the major fishery may develop. This single migration route, together with the early inshore time of migration, render this population vulnerable. There is a possibility that exploitation could readily be increased, but whether to an extent that would be detrimental has not been determined.

The west-coast and lower-east-coast populations were chosen for the comparative study because they were considered to be the most closely related stocks with regard to geographical location and extent of intermixture. The past eight years of study have shown that certain fairly fundamental differences, however, exists between these stocks. While these differences would appear to throw some doubt on the usefulness of the lower east-coast population as a control, it is unlikely that they will materially affect the validity of the main conclusions to be drawn from the experiment or of their general applicability to other populations. The differences found were:

(1) A difference in migration pattern and times of migration. Tag returns have shown that the lower-east-coast stocks receive apparently quite substantial contributions from stocks in the middle-east-coast sub-district and that the stocks which spawn in the three major lower-east-coast areas (Areas 17A, 17B, and 18) are completely mixed and fail to show significantly less intermixture with increase in distance separating the spawning grounds. The lower-east-coast herring follow a single migration route in from the offshore feeding grounds. On the west coast, tag returns have shown that there are two relatively discrete sub-populations consisting of four main runs each. One sub-population comprises those runs to Areas 23 and 24, the other those to Areas 25 to 27. The runs to the various areas probably approach the coast separately. The times of the inshore migrations to the lower east coast, south west coast and north west coast are progressively later.

(2) On the lower east coast spawn survival is apparently higher and the factors which influence survival more constant that those on the west coast. On the west coast, an average spawn deposition of 43.1 miles was followed by an average catch of 33,500 tons, while on the lower east coast an average deposition of 16.7 miles was followed by an average catch of 43,700 tons.

(3) No statistically significant relationship has been found between the fluctuations in population abundance in the two sub-districts.

It is planned to investigate these apparent differences more closely and to obtain more information on the spawning stocks contributing to the lower-east-coast fishery. It is intended to intensify tagging in the middle and lower-east-coast sub-districts and also to institute a spawn survey by investigational personnel.

F. Forecast of the herring fishery in 1954-55 F. H. C. Taylor

The tenth in a series of annual forecasts of the prospects of the

herring fishery was prepared in September, 1954. The accuracy of the forecasts depends on knowledge of future population abundance and on the assumption that herring will be available to the fishing fleet in proportion to their abundance.

Relative abundance of herring in the previous fishing season and the quantities expected to enter the fishery before the next fishing season form the basis for the estimation of future population abundance. The size of the catch, the ease with which it is taken and the amount of fish left to spawn, provide information used in estimating previous abundance. An assessment of the relative strength of the various year-classes obtained from a study of the age composition of fishing and spawning runs, enables an estimation to be made of the amount of recruitment to be expected the following year.

The various assumptions made in estimating population abundance the previous year and for predicting recruitment have been discussed in Appendix 83 of the 1951 Report.

1. West-coast sub-district

It is considered unlikely that as good catches will be made on the west coast in 1954-55 as in 1953-54. The catch will be better in the south west-coast areas than in the north west-coast areas. Evidence has been presented in previous sections of this report which showed that, although abundance has increased in the south west-coast areas, it has not reached the general level attained prior to 1950-51. Abundance in the north west-coast areas has apparently declined. The 1951 year-class, which supported the fishery, was of average or above-average size, and was stronger in the south west-coast than in the north west-coast areas. Indications are that the 1952 year-class, upon which the 1954-55 fishery will depend, may not be as strong as the 1951 year-class, particularly in the north west-coast areas.

2. Lower-east-coast sub-district

Present indications are that the 1952 year-class may not be as strong as the 1950 and 1951 year-class, and hence abundance may decrease in 1954-55. However, the general level of abundance is expected to remain high and the quota should be readily taken.

3. Middle-east-coast sub-district

In the summer of 1954, a fishery again developed in Area 14 and a catch of 4,000 tons was taken by the end of July, probably largely from resident herring stocks. It seems likely that the main migratory stock was not exploited and for this reason it is expected that the balance of the quota will be taken from the migratory fish passing through Area 13 in the fall. In view of the indications that the recruitment of the 1952 year-class and the contribution of the 1951 year-class as IV-year fish will not be particularly large, greater fishing effort may be required to take the quota in 1954-55.

4. Upper-east-coast sub-district

It is unlikely that in 1954-55 any increased catch can be expected or that with the usual amount of fishing effort the quota will be taken. In

1953-54 the stock was sustained almost entirely by the strong contribution of the 1951 year-class as III-year fish. The contributions of the 1953 and 1952 year-classes as I- and II-year fish were the lowest recorded in recent years.

5. Central sub-district

It is considered that in 1954-55, the 1951 year-class will dominate the fishery as IV-year fish and that the contributions of the 1952 and 1950 year-classes may be less than average for III- and V-year fish respectively. Abundance is, therefore, expected to be about the same as in 1953-54. Fishing should be better in Area 7 than in Area 6. Catches in Area 9 will not be as good as in 1953-54.

6. Northern sub-district

The condition of the stocks in this sub-district is considered to be the poorest for some years. The quota was just reached in 1953-54; availability was down sharply and spawn deposition reduced somewhat from 1953. The 1950 year-class was dominant as IV's. Indications are that the 1951 year-class was not as strong in the north as in the other sub-districts. Therefore, it is considered that while the quota may be taken in 1954-55, it will be taken less readily than in previous years.

7. The Queen Charlotte Islands sub-district

Area 2B-E. The stock appears to be at a high level of abundance. The 1951 year-class entered the fishery strongly as III-year fish and should sustain the fishery as IV's in 1954-55. Spawn deposition showed a remarkable increase. Prospects are good for an intense fishery in 1954-55.

Area 2A-E. A good fishery should develop in this area in 1954-55. The 1951 year-class as III's was well recruited in 1953-54 and should sustain the fishery in 1954-55.

G. Special herring studies

1. Mortality and recruitment in herring — A. L. Tester

A study is being made of age composition and catch data collected over a period of about 40 years from the purse seine fishery of the lower east coast of Vancouver Island with the object of obtaining basic information on mortality and recruitment from "survival curves" (the plot of logarithm of number of fish against age).

Average total annual mortality rates were similar (0.80) in two periods (1925-26 to 1931-32; 1942-43 to 1951-52) of similar average catch (40,000 tons). The rate was less (0.70) in an early period (1909-10 to 1917-18) of lower average catch (about 20,000 tons).

The nature of recruitment of a year-class to the fishable stock appears to have changed throughout the years. In earlier years fish appear as new recruits at Ages II to V (or older); in recent years they appear as new recruits at Ages I to IV. This anomaly is not adequately explained by possible changes in gear selectivity, sampling technique or age interpretation. It may be related to a long term trend in ocean temperature and its influence

on food supply, growth, and maturity.

A formula has been developed which permits the direct calculation of natural mortality rate from data pertaining to two periods of equilibria, assuming the same absolute recruitment in each.

From changes in catch and mortality rate between the two periods of approximate equilibria, it has been possible to estimate natural mortality rate as about 50% per annum. This agrees with a rough estimate previously made from the age-composition of virgin or near-virgin herring populations.

Accepting the mortality estimates, calculations indicate that the lower-east-coast fishable stock has averaged 830 million fish (87 thousand tons) in recent years. This agrees well with estimates made by Stevenson and Outram from spawning ground surveys and catch which place the average population at about 607 million fish.

The investigation of mortality and recruitment will be extended to other herring populations as time permits.

2. Analysis of herring tagging data, 1936 to 1952 J.C. Stevenson

Herring tagging and recovery have been undertaken since 1936. The data have been analysed each year, and the results were published annually in the Reports of the British Columbia Fisheries Department. The desirability of having a general assessment of results accumulated during this long-term study has become apparent, and this summer the writer analysed the results from the point of view of their bearing on herring movement. The resulting paper was presented in Paris in October, 1954 to a Special Scientific Meeting of the International Council for the Exploration of the Sea, and it will appear shortly in the Rapports et Proces-Verbaux of that organization. A summary of the methods and problems of tag-recovery was also included in the paper.

From 1936 to 1951 the number of herring tagged in British Columbia waters amounted to 555,521 comprising 310 individual taggings.

The general method of studying the intermingling of herring stocks necessitated relating the actual numbers of tag recoveries to the estimated total number of tags in the catches. Certain assumptions were involved in this method of analysis. They pertained to rate of exploitation, recruitment, intensity of tagging, and random distribution of tagged fish in the stocks.

The total number of tags recovered in the fishing seasons from 1936-37 to 1951-52 was 20,328, or 3.7% of the number of fish tagged. The percentage recovery was considerably greater in the later years of the study than in the early years, due mainly to increased opportunity for plant recovery and generally increased exploitation of the herring stocks. All but 14 of the 310 individual taggings produced returns. Recovery of tags decreased with increase in time between tagging and recovery.

The recovery data revealed a strong tendency for tags to be recovered in or near the area of tagging, indicating that most herring return in the fall and winter to the inshore area in which they spawned the previous spring. It was concluded that British Columbia herring comprise a limited number of more or less distinct populations, a conclusion which is in general agreement with results from studies on meristic characters, age composition, and growth.

Migratory and resident herring populations were distinguished on the basis of population abundance, seasonal migration, growth and age composition, location of spawning grounds, and homogeneity of individual runs. Eight migratory populations were identified according to the general coastal regions in which they spawn and are fished -- (1) the east coast of the Queen Charlotte Islands, (2) northern mainland coast, (3) north central mainland

coast, (4) south central mainland coast, (5) middle east coast of Vancouver Island, (6) lower east coast of Vancouver Island, (7) south west coast of Vancouver Island, and (8) north west coast of Vancouver Island. There is a tendency for the main fishing and spawning grounds of each population to be located in the more southerly part of the region (or sub-district) of their inshore concentration, and for movement within each sub-district to be northerly. This has suggested that the route of migration from offshore feeding grounds to inshore waters is also northerly, and this indication is supported by the only tag-recovery taken from offshore waters. The migratory populations provide about 95% of the annual herring catch.

The numerous small resident populations are mostly concentrated in the long inlets of the north central, south central and upper-east-coast regions. Information on their movements is sparse since not all have been tagged. They show a considerable degree of isolation from neighboring migratory populations and from each other. Herring of resident populations are relatively slow-growing, suggesting that their summer feeding areas are less productive than the offshore feeding areas of the migratory stocks.

The recovery data indicated that about one-quarter of the fish of each major migratory population emigrates to other populations. Fish of the middle east coast of Vancouver Island showed the greatest emigration (45%), an indication that this population was the least independent stock. Least emigration occurred from the lower-east-coast population (16%).

The amount of emigration from one population to another varied with the distance separating the populations. It was concluded that the herring of British Columbia tend to form a series of intermingling populations.

The individual herring runs of the south west-coast and north west-coast of Vancouver Island showed a type of intergradation which resembled, on a smaller scale, the intergradation of the major migratory populations. There was evidence that the individual runs within the northern and north central populations also followed this pattern. In contrast, the runs within the population of the lower east coast of Vancouver Island appeared to be freely mixing and homogeneous showing no differential emigration outside the sub-district.

Emigration from individual herring runs of the middle east coast resembled that of the runs of the west-coast populations in certain respects. However, the presence within this sub-district of resident or partially resident stocks, as well as a migratory stocks, resulted in a relatively complicated situation.

EARLY LIFE-HISTORY STUDIES ON HERRING

The aim of the early life-history studies is to obtain information on survival during these stages which will permit an estimate to be made of the relative strength of a year-class before its recruitment to the fishery. No relationship has been found between the amount of spawn deposited and resulting number of recruits in the west-coast population or in other major herring populations. Good year-classes have at times arisen from relatively small amounts of spawn and poor year-classes from relatively large amounts. It would appear that in all populations the amount of spawn deposited has been greater than that needed to maintain the stocks, and that the fluctuations in year-class strength have been brought about by factors affecting survival between spawning and recruitment. Studies have, therefore, been undertaken on each major life-history stage. These were begun in 1947 and have been

carried out principally on the west coast of Vancouver Island. Survival of spawn during incubation and survival during the larval period were studied first, and in 1951 an investigation of survival during the juvenile stage (from metamorphosis to the end of the first year of life) was begun. Although data from these studies have not been completely analysed it is considered that abundance as juveniles will be more useful as an indication of relative year-class strength than abundance at an earlier stage of the life-history.

A. Spawn survival studies — D. N. Outram

Since the beginning of intensive spawn studies (1947) on the west coast of Vancouver Island, two major aspects of spawn mortality have been investigated. The first major aspect studied was the loss caused by sea-birds consuming herring eggs and eelgrass on the spawning beaches. Mortality from this source, while great (approximately 40%), appears to be fairly consistent from year to year. No additional data were obtained during the 1954 spawning season. The other major aspect studied was the determination of the amount of eggs lost as a result of other environmental factors, mainly physical and chemical. Further data relating to these were obtained during the spring of 1954, mainly for comparison with similar data to be obtained from the lower east coast of Vancouver Island.

As in 1953, numerous spawning grounds on the west coast of Vancouver Island were investigated by "spot" sampling to assess natural spawn losses. Particular attention was given to (a) the position of the spawning ground and its effect on spawn survival, (b) the effect of depth below zero tide level, and (c) factors responsible for the instances of unusually high or total spawn mortalities.

(a) Spawn mortality in relation to exposure and water circulation. The west-coast spawning grounds studied in 1954 were classified according to the following categories:

Category	Type
I	Grounds well protected from wave action, generally found at the head of sheltered bays and inlets. Very little exchange of saline waters.
II	Grounds protected from most wave action but greater exchange of more saline water occurs in these localities.
III	Semi-protected grounds, ocean swells occasionally reach these regions.
IV	Grounds with only slight protection from the ocean.
V	Grounds directly exposed to the open ocean, storm, winds, and heavy seas frequently occur in these localities.

In 1954, 12 west-coast spawning grounds were studied. The percentage of dead eggs found on each spawning ground is shown in the following

table:

Spawning ground	Area	Percent dead eggs found on spawning grounds classified according to geographic protection				
		I	II	III	IV	V
Little Whitepine Cove	24	60.0				
Big Whitepine Cove	24		27.0			
Bawden Bay	24		30.0			
Cypress Bay	24		5.0			
Malksope Inlet	26		7.0			
Nasparti Inlet	26			3.0		
Clanninick Cove	26			2.0		
Bunsby Islands	26			2.0		
Owasitsa Creek	25			1.0		
Ewin Inlet	25				7.0	
Catala Island	25				4.0	
Macoah Passage	23					20.0
Average percentage of dead eggs		60.0	17.2	2.5	5.5	20.0

The above table indicates that the least mortality of eggs (2.5%) was found on semi-protected spawning grounds (category III) where moderate water movements occur. Natural egg mortality was highest on grounds subject to extreme conditions (categories I and V), i.e., where the spawn is either exposed directly to open ocean or is so completely protected geographically that there is inadequate circulation. Eggs deposited on category I spawning grounds may have been affected by brackish water conditions, while eggs developing on category V grounds were subject to heavy wave action which destroys both the eelgrass and the attached eggs.

Approximately 20% of the 1954 west coast of Vancouver Island spawning grounds were of categories I and V. The percentage of grounds in these categories is probably fairly constant from year to year. Hence, it is unlikely that differential spawn mortality cuased by the degree of protection is an important factor in producing variations in year-class strength.

(b) Spawn mortality in relation to depth. Eelgrass beds were sampled at various positions above and below zero tide level to determine the effects of differential exposure of spawn at low tides. As shown in the table below, spawn that was covered at nearly all stages of the tide experienced the least mortality.

Spawning ground	Area	Percent dead eggs found at different depths		
		Below 0 ft.	0 ft to +4 ft.	+4 ft to +12 ft.
Ewin Inlet	25	3.0	7.0	9.0
Owasitsa Creek	25	2.0	1.0	2.0
Cypress Bay	24	4.0	5.0	6.0
Macoah Pass	23	6.0	4.0	10.0
Average percent of dead eggs		3.5	4.2	6.7

Spawn that was deposited high upon the beaches (+4 ft. to +12 ft.) experienced the greatest mortality. Eggs in this position on the spawning grounds would be subject to longer periods of frost or dessication during changes of the tide.

(c) Total losses caused by special conditions. During the 1954 survey there were several instances when spawning grounds showed almost a total egg mortality. It was noted that in the majority of these regions (Amai Inlet, McKay Passage, and Mosquito Harbour) recent logging operations had taken place. In previous surveys it had been noticed that eggs deposited on cedar branches soon die. The possibility exists that chemicals leached from fallen logs, particularly cedar logs, may pollute the water over the spawning beaches.

The results of the 1954 studies suggest again that, except in the cases where total mortality occurs, natural spawn mortality is not likely to be a major factor in the success of reproduction.

B. Juvenile herring studies

A. S. Hourston

A study of the juvenile stage of the Pacific herring was inaugurated in 1951 in an effort to determine year-class strength at this stage and its relationship to recruitment two and one-half years later. Prediction of year-class strength in itself is an important objective of the herring research; it also provides an early check on the effect of management procedures. Since the strength of a year-class does not appear in most cases, to be related to the amount of spawn producing it, and since the herring are extremely vulnerable to major mortalities during the egg and larvae stages, the stage immediately following metamorphosis (juvenile or first-year fish) presents the earliest practical opportunity for the assessment of year-class strength. For better interpretation of these assessments, studies are being made of size groups, growth rates, and environmental conditions. The relationship of the juvenile population to the adult spawning population in an area is being investigated by tagging the older juveniles and recovering the tags in the adult fishery. Tagging mortality experiments and tag-recovery tests provide the supplementary data necessary to interpret the results.

The lateness of the field season precluded even the preliminary analysis of the 1954 data in time for presentation for this report and the data will be presented as a unit in the 1955 report. Data on population estimates for the 1952 and 1953 studies were presented in the 1953 report, but the analysis of the sampling data was not completed at that time, and the

1953 tag-recovery program was still in progress. An analysis of these programs is presented below.

1. Size and growth

(a) Sampling. The sampling program provides data for the comparison of size and growth of juvenile herring from different localities and different years. Each sample consisted, where possible, of 100 fish. The standard length and the weight of each fish were recorded. Samples were obtained from a number of sources. In the following tabulation are shown the number of samples taken and the number of fish sampled in 1952 and 1953 from each source of samples.

Series	Number of samples 1952	Number of samples 1953	Number of fish 1952	Number of fish 1953
Barkley Sound	56	69	8,252	12,243
Barkley Sound - Recoveries of marked fish	9	22	24	63
Clayoquot Sound - Sydney Inlet	2	-	166	-
Nootka Sound - Esperanza Inlet	8	-	1,005	-
Lower east coast of Vancouver Island	-	9	-	1,685
Mortality experiments in live pond	6	53	877	1,359
Mortality experiments in laboratory tank	-	34	-	271
Adult fishery	9	-	510	-
Totals	90	192	10,834	15,621

(b) Growth of juvenile herring during the summer of 1952 and 1953. The juvenile growth of the 1952 and 1953 year-classes in Barkley Sound was expressed, as was the data on the 1951 year-class, in terms of age-length, age-weight, and length-weight relationships. Age is given as the number of days after the estimated average hatching date of March 26 in both years. Differences between samples in age-length and age-weight relationships represent differences in growth rate, whereas differences in the length-weight relationship indicate differences in body shape.

(1) Age-length relationship. The 1953 fish showed a distinct tendency to be shorter than the 1952 fish of the same age. This tendency was especially pronounced after the end of July. The 1951 fish tended to be intermediate in size between the 1952 and 1953 fish.

(2) Age-weight relationship. The 1953 fish showed a tendency to be lighter than the 1952 fish, but both groups were heavier than the 1951 juveniles.

The smaller size of the 1953 fish may reflect adverse feeding or environmental conditions during the summer of that year. It is noteworthy in this connection that spring and coho salmon were smaller in 1953 than in 1952 and that whales on the west coast of Vancouver Island were in comparatively poor condition in 1953.

(3) Length-weight relationship. The logarithmic length-weight relationship for 1952 and 1953 year-classes were virtually identical. This relationship appears to remain relatively constant over periods of good (1952) and poor (1953) growth. The slight difference in the length-weight relationship for the 1951 year-class, to be expected from the differences in the age-length (intermediate) and age-weight (lighter) relationships, may reflect poor local feeding conditions.

(c) Length groups within sub-populations. The wide variation in length and weight of juveniles of comparable "ages" and the wide variation in hatching dates of the various spawnings involved suggested the presence of more than one size-group within a population.

To detect the presence of size-groups a graphic analysis of polymodal frequency distributions was used. This method was tested in Departure Bay, a relatively isolated locality, where mixing with other sub-populations can be considered negligible. From analysis of the 1950, 1951, 1952, and 1953 data it was shown that size-groups are due to the age differential resulting from spawnings at different times and that the differences detected by the graphic analysis are probably real.

In Barkley Sound, because of the number of spawnings contributing to the juvenile stock, it was not possible to associate each size-group with a definite major spawning. A number of size-groups was found in different localities throughout the sound. A careful analysis showed that each locality would appear to contain a separate sub-population which differs from sub-populations in other localities in the number of size groups, sizes represented and/or growth rates. Separate sub-populations are considered to be present in Banfield Inlet, Sechart Channel, Useless Inlet, and off Effingham Island. The possibility remains of migration from Uchucklesit Inlet to San Mateo Bay, thus forming a single sub-population in this vicinity, a similar migration may occur from Pipestem Inlet to Ucluelet Inlet.

2. Tagging and tag-recovery

(a) Tagging. Juvenile herring are tagged late in the summer, shortly before they move out of the bays and inlets. A small metal body-cavity tag is used and the same technique employed as in adult herring. Taggings carried out in 1952 and 1953 are summarized below:

Locality	Number of tags 1952		1953	
Area 23				
Banfield Inlet	4,198		2,091	
Ecoole Cannery	2,064		-	
Effingham Island	2,056		-	
Pipestem Inlet	-		6,248	
San Mateo Bay	6,017		3,147	
Sarita Bay	-		5,157	
Uchucklesit Inlet	3,986		1,538	
Ucluelet Inlet	2,017		-	
		20,338		18,181
Area 24				
Dixon Bay	4,639		-	
Steamer Cove	1,016		-	
		5,655		
Area 25				
Nootka Cannery	1,940		-	
		1,940		
Area 17A				
Departure Bay	-		8,437	
				8,437
		27,933		26,618

(b) Tag-recovery. The 1953-54 fishery was the first one from which juvenile tags were recovered. Recoveries are tabulated below:

	Inserted			Recovered		
Code	Date	Place	Area	Date	Place	Area
C7	Aug 27/51	Banfield Inlet	23	Dec 3-4/53	Effingham Inlet	23
C18	Sep 5/51	Uchucklesit Inlet	23	Feb 23-25/54	Myers Pass	6
BBBB	Aug 13/52	San Mateo Bay	23	Dec 15-19/53	Effingham Inlet	23
CAAC	Sep 16/52	Dixon Bay	24	Dec 16-17/53	Sydney Inlet	24
				Dec 17/53	Smith Inlet	10*
CAAC	Sep 16/52	Dixon Bay	24	Dec 21/53	Sydney Inlet	24
				Dec 21/53	Uchucklesit In.	23*
CYYC	Oct 1/52	Ecoole Cannery	23	Dec 16-17/53	Trevor Channel	23
				Dec 15-17/53	Sydney Inlet	24*
				Dec 14/53	Imperial Eagle Channel	23*
HJJH	Oct 7/53	Departure Bay	17A	Oct 12/53	Nanoose Bay	17A*

* Possible alternate areas of recovery

Of the 7 recoveries, 2 had been out for over two years, 4 for a little over one year, and 1 for two weeks. With one exception (the C18 tag) all recoveries were from the area of tagging. The first CAAC tag might have been recovered in Smith Inlet, but the possibility is much greater that it was recovered in Sydney Inlet, the area of tagging. Since no major migrations were indicated by the recoveries of II-year fish (tagged in 1952) the migration of one of the III-year fish (tagged in 1951) to the central sub-district is considered exceptional. On the basis of these few tag-recoveries, it would appear that herring return as adults mainly to the area where they were reared.

(c) Tag-recovery tests. In 1953-54, 16 tests were carried out in 7 reduction plants to determine their efficiency in recovering juvenile tags. These tests were carried out simultaneously with tests with adult tags. The results are summarized in the table below. Figures in parentheses include special tests and tests where juvenile and adult data may not be strictly comparable.

Plant	Number of tests	Percent recovery of juvenile tags	Efficiency ratio of recovery (Juvenile tags to adult tags)
1. Colonial	2(3)	70(57)	.97 (.85)
2. Gulf of Georgia	1	90	.96
3. Imperial	3(4)	90(73)	.99 (.80)
4. Kildonan	1	84	.89
5. North Shore	3	87	.90
6. Phoenix	3	53	.76
7. Port Albion	1	84	.93
All plants	16	75(73)	.86 (.83)
Larger plants (1, 2, 3 above)	8(6)	85(73)	.93 (.83)

It would appear that plant magnets recover juvenile tags about 90% as well as adult tags, resulting in an average efficiency of about 80%. While there were considerable differences in efficiency between plants, the annual averages showed little variation. The loss of tags in plants is, therefore, a comparatively minor factor in the total loss of tags between the tagging and recovery stages.

3. Mortality experiments on marked and tagged fish

When fish are marked or tagged, mortality may result from the mark or tag and from handling the fish. This mortality reduces the effective number of marked or tagged fish at large. To determine the extent of this mortality, controlled experiments were carried out in 1952 and 1953 in which groups of marked or tagged fish were held in live ponds or laboratory tanks. The results of these experiments are tabulated below:

Experiment number	Locality	Duration days	Observed survival Controls	Marked	Tagged	Corrected survival Marked	Tagged
1952							
1	Live pond	28	100	81	-	81	-
2	Live pond	19	100	88	-	88	-
1953							
1	Live pond	16	91	44	16	53	25
2	Live pond	6	62	-	0	-	0
3	Live pond	16	92	89	0	97	0
4	Live pond	16	97	96	0	99	0
5	Lab. tank	51	49	65	0	100	0
6	Lab. tank	16	86	-	0	-	0
7	Lab. tank	16	84	-	0	-	0

The percentage mortality of the controls (unmarked fish handled in a similar manner to marked fish) is considered to represent the mortality due to causes other than marking. Ignoring the results of 1953 Experiment No. 1, whose conditions were not considered standard, the marking mortality experiments indicated that without taking the mortality of the controls into account, an average survival of marked fish of 84% is obtained over the period of the assessment. Survival of marked fish was 93% of that of the controls. This compares favourable with the value of 87% found in 1951.

In 7 tagging mortality experiments carried out in 1953, none of the tagged fish survived in the last 6. The first experiment was terminated while tagged fish were still dying. Juvenile tagging mortality must, thus, be extremely heavy, but it is evidently not complete as shown by the recovery of juvenile tags during the 1953-54 fishery. On the basis of the recovery of tags put out in 1951, survival from juvenile tagging is estimated to be less than 1%. This figure may possibly be unduly low, as an approximately similar estimate was obtained from the recovery of 1952 tags at a time when the 1952 year-class was not recruited to the fishable stocks to any extent.

4. Relationship of juvenile herring schools and their environment

In an effort to determine what factors have a direct bearing on the presence and abundance of juvenile herring, observations have been made of the conditions of the environment in which juvenile herring are found. Factors studied in the 1952 and 1953 surveys included geography, prevailing winds, and temperature and salinity.

(a) Geography. While virtually all the major spawnings occur on the northwest side of Barkley Sound, juveniles tended to concentrate on the southeast side in narrow inlets, and in bays to the southeast of some of the larger islands. The fish were usually found within 500 yards of shore. In both 1952 and 1953, inlets, channels etc., running in a northwest - southeast direction seemed to provide better rearing grounds than those running in a northeast - southwest direction.

(b) Wind. The concentration of juveniles on the southeast side of the sound and in inlets lying across rather than along the main axis of the sound, suggests that some factor tends to direct juveniles in a southeast direction

from the spawning grounds. It appeared that wind might be a factor. The prevailing winds in Barkley Sound in the summer are westerly and their average effect would presumably be to drive surface water toward the southeast shore. This transport could result in a direct displacement of the herring or it could cause a concentration of food supply on the southeast shore in inlets running in a southeast direction or in eddies on the lee of larger islands. However, the data on population abundance are extremely variable and patchy and fail to show any relationship to wind direction. This would not imply that no such relationship exists, but that other factors affecting observations, such as weather, run-off, phase of the tide etc., are exerting a stronger influence on observable abundance that is the wind.

(c) Temperature and salinity. In 1952 and 1953, attempts were made to gather sufficient data on temperature and salinity to permit examination of their relationship to juvenile herring abundance. The results obtained were not clear-cut.

In 1952, a very significant relationship was noted between temperature and abundance of herring on the surface water. Juveniles appeared to show a preference for colder surface water. No significant relationship to salinity was noted. In 1953, no significant relationship was noted between juvenile abundance and surface water temperatures. However, significant relationships to both temperature and salinity were found at depths of 40 to 60 feet. Waters at these depths where herring were abundant were warmer and less saline than where they were absent.

A consideration of the relationship between herring abundance and temperature in the two years would appear to indicate that juvenile herring are most abundant in waters whose temperatures for the first 20 feet are relatively low (64-53°F) but whose deeper temperatures (40-60 feet) are relatively high (50°F). The juveniles may thuse be associated with a minimum temperature gradient rather than with a specific temperature.

5. The 1954 field program

Field surveys were continued in 1954, with a greater emphasis on the relationship of juvenile abundance to ecological conditions. Systematic observations of plankton abundance, current, temperature, and salinity were made in relation to juvenile abundance. However, the delineation and assessment of stocks remained the primary objective, with one boat working exclusively on this aspect (July 26 to September 18) and the other boat devoting about one-third of its time to this field in the period July 28 to September 28. This resulted in a more complete coverage of this aspect than in previous years. In order to accomplish this, the tagging program and mortality experiments were dropped in 1954. It is anticipated that the programs in the previous will provide adequate data in these fields. The 1954 program began approximately two weeks later than in the previous years.

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G R O U N D F I S H - K. S. Ketchen

The main objective of the groundfish investigation is to establish the means of describing and predicting fluctuations in the availability of bottom-fish which contribute to the trawl and line fisheries of British Columbia. About 20 species are involved in these fisheries, but only 6 or 7 are in sufficiently consistent demand to warrant detailed study.

Year-to-year changes in availability may result from fluctuations in the vulnerability of fish to capture and (or) from changes in abundance. The latter may in turn be the result of fishing or of factors in the natural environment which govern survival. Thus, in order to understand changes in availability it is essential that the forces of nature be properly distinguished from those of exploitation. Various phases of the work are geared to provide this understanding: (1) the collection of accurate catch statistics is perhaps the most important part of the work, for it provides the records of catch and effort necessary for computing measures of availability; (2) tagging experiments are being conducted not only to define the limits of various populations but also to assess rates of fishing and natural mortality; (3) age and growth studies provide important information on the extent of variations in the strengths of year-classes and at the same time reveal the effects of fishing on both mortality and growth rates; (4) surveys of important fishing banks are being conducted to determine the geographical relationships of the nursery grounds to the adult grounds and to determine quantitatively the year-to-year fluctuations in the strengths of year-classes at the juvenile stage; (5) attempts to associate biological changes with changes in the physical environment are being made through the study of oceanographic and meteorological data.

In the year ending September 30, 1954 there were no major changes in the conduct of the investigation. However, some of the field work was reduced to provide more time for analysis of data already on hand. The Investigator No. 1 was employed during the winter of 1953-54 in numerous tagging projects in the Strait of Georgia, and during the summer months in the survey of north coast banks.

Considerable attention was again given to the trawl fishery in the Strait of Georgia which is being re-established on a limited basis on a number of grounds along the east coast of Vancouver Island. The catch from these grounds in the winter of 1953-54 amounted to 1,190,000 pounds of food fish and represented 49% of the total for the entire strait.

During 1954 a project for the development of a mid-water trawl for herring was undertaken with funds from the Industrial Development Vote.

CATCH AND AVAILABILITY

During the year ending September 30, port observers at Vancouver and Prince Rupert obtained 832 reports from otter-trawlers, 350 from salmon trollers, 200 from shrimp and crab boats and 60 from long-line vessels. The number of trawler reports was down by 21% from that of the previous year, while the number of long-line reports was down by 50%. The decline in landings is a reflection of a poor market condition which has been keenly felt for the past two years, particularly in the frozen fish trade.

Although the United States trawler market has been very active in response to the demand for "fish sticks", no similar reaction is yet evident on the west coast of Canada. However, as in the previous year, considerable quantities of fish landed at Vancouver have been shipped in load lots to the State of Washington. This has kept the Vancouver market fairly active.

Regarding the compilation of catch records, considerable effort was expended during the summer of 1954 in bringing the statistics of the past five or six years into final form.

It is the custom to include in these summary reports the catch statistics of United States vessels which operate off the British Columbia coast. However, no opportunity arose during 1954 to obtain these records. They will be presented in the 1955 report.

A. Tabulation of 1953-54 trawl landings in British Columbia

C.R. Forrester

The summary of trawl landings for British Columbia is again presented according to three major fishing divisions: (1) Hecate Strait and Queen Charlotte Sound, (2) west coast of Vancouver Island, and (3) the Strait of Georgia. More detailed accounts of catch and effort appear in other appendices. The weights shown in the following tables are in thousands of pounds.

Hecate Strait and Queen Charlotte Sound

	Lemon sole	Rock sole	Brill	Rex sole	Butter sole	Dover sole	Fldr.	Gray cod	Ling cod	Rock fish	Mink feed
1953											
Oct	6		17	1				19	1		26
Nov	22		18					31	3		182
Dec	39		8					30	1		106
1954											
Jan	28		2		40		2	54	2	5	63
Feb	60				141			134	6		13
Mar	141	11	1		30			413	4	2	21
Apr	155	30	2				2	315	13	12	78
May	128	116	19	2	5	24		349	26	4	138
Jun	69	306	30	4		41		93	23	153	235
Jul	36	528	17	4		81		77	18	170	123
Aug	14	632	4	2		31		1	1	100	58
Sep	6	487	6			3		15	12	1	107
Totals	704	2,110	124	13	216	180	4	1,531	110	447	1,150

Reduced activity by the Prince Rupert fleet of trawlers in Hecate Strait during the season did not result in any serious drop in total production. The spring fishery for lemon sole was considerably lighter than usual, but landings of rock sole for all 1954 will be somewhat heavier than in 1953. Gray cod landings increased sharply in March, April and May and were possibly the result of increased demand for the "fish stick" market. The increase in

rockfish landings is mainly due to the utilization of ocean perch (Sebastodes alutus) from the mid-Hecate Strait grounds. Landings of scrap species for mink feed continue to increase.

West coast of Vancouver Island

	Lemon sole	Rock sole	Brill	Dover sole	Fldr.	Gray cod	Ling cod	Rock fish	Skate	Black cod	Dog Liver	Mink feed
1953												
Oct	3	1	13	11		48	5	11	1		1	98
Nov	1	6			1	3		1	2			28
Dec	1	5				1	1	2				19
1954												
Jan		7			19	1		2				9
Feb		5			8	12		4				
Mar	2	10	6	1	10	107	1	1				
Apr	6	14	18		8	182	8	2	4		6	11
May	11	52	118	5		409	113	72	5		27	84
Jun	12	14	163	1		692	223	8	2		7	45
Jul	6	3	129	34		291	172	7	3		1	53
Aug	7	33	161	34		119	160	15	3		6	250
Sep	3	89	99	1		64	68	6	1	29	5	164
Totals	52	239	707	87	46	1,929	751	131	21	29	53	761

Off the west coast of Vancouver Island the catch of brill was lower than in 1953. This is in line with the general decline which has been occurring over the past few years and is apparently the result of declining availability. Gray cod production from this area was considerably higher than that for the same period last year. Here again landings may have been influenced to some extent by the "fish stick" development. Landings for most other food species are lower with the exception of rock sole and lingcod. Unusual quantities of rock sole were landed in September from the fishing grounds off Long Beach and seem to have been a reaction to the scarcity of brill. Landings of scrap species for the fur breeders remained at the same level as last year.

	Strait of Georgia										
	Lemon sole	Rock sole	Brill	Fldr.	Gray cod	Ling cod	Rock fish	Skate	Dog liver	Crab	Mink feed
1953											
Oct	55	6	2	13	84	17	7	4	8	5	53
Nov	49	37		27	190	8	12	5	15	6	78
Dec	68	9		9	148	1	7	5	33	3	94
1954											
Jan	63	24		27	361		8	7	26	5	20
Feb	102	16		79	428		9	9	47	6	51
Mar	63	26		35	365	16	11	12	12	2	69
Apr	18	8		2	77	4	7	7	2	1	25
May	25	3		1	102	2	2	5	11	8	50
Jun	26	4			92	6		4	14	37	37
Jul	12	2		4	50	1		3	1	6	25
Aug	9	1		2	12	2		3	3	3	6
Sep	8	1		1	17	2	1	3	2	2	19
Totals	498	137	2	200	1,926	59	64	67	174	84	527

In the Strait of Georgia, landings of flatfish species were lower than in the same period last year. The main reason for this decline was a drop in production in the October fishery for lemon sole in Union Bay. Weather conditions coupled with lower availability were responsible for this decreased production. As in other fishing areas, gray cod landings were heavier for this period.

B. Trawl landings in British Columbia in recent years

W.E. Barraclough and C.R. Forrester

As a result of the introduction of the multiple sales slip system by the Department of Fisheries, it is now possible to rectify some ommissions in past trawl landing records. With the help of a summer assistant, Miss Lois Tuck, microfilm records of sales slips were examined for 1951 and 1952. The following table gives corrected totals for the trawl fishery during the past six years.

Thousands of pounds

Lemon sole	Rock sole	Brill	Butter sole	Dover sole	Rex sole	Fldr.	Gray cod	Ling cod	Rock fish	Dog liver	Mink feed
1948											
2,045	2,135	7,721	651	157	119	149	1,033	1,027	85	667	35
1949											
1,689	1,678	3,215	29	171	160	183	1,889	1,901	134	587	59
1950											
5,271	2,177	2,039	8	694	235	326	3,041	1,348	236	126	37
1951											
2,162	3,548	1,585	1,824	974	234	461	5,678	1,876	449	204	414
1952											
2,537	5,955	1,828	3,716	941	180	495	4,913	1,113	589	229	1,392
1953											
2,241	1,851	1,040	160	416	81	138	3,196	585	456	245	2,298

The total landing of food fish in 1953 was less than half of that recorded in 1952. The catch of lingcod and most species of flatfish reflected poor market conditions; gray cod, however, continued to be in fairly heavy demand. The most interesting feature of the past six years has been the phenomenal growth of the mink feed fishery. Production for this market in 1953 was over two million pounds.

C. The controlled trawl fishery in the Strait of Georgia

K. S. Ketchen

In the fall of 1953 and the early part of 1954, certain areas along the east coast of Vancouver Island were again opened to otter-trawlers. To obtain a better understanding of the capabilities of the trawlers, the open periods for certain areas were extended considerably beyond those of the previous year. In addition, a new area was opened to fishing after a closure of almost seven years.

The accompanying table is a summary of the catch in these various areas during the fall and winter of 1953-54. Reference to the fishing areas may be found on the accompanying map.

	Catch in pounds							
	Cape Lazo	Union Bay	Deep Bay	Yellow Rock	Qualicum-Parksville	Nanoose Bay	Satellite	Total
Hours of fishing	257	99	738	1,083	282	555	510	3,524
Lemon sole	26,700	44,400	80,300	40,600	12,800		58,000	262,800
Rock sole	9,400	100	4,100	79,000	3,600	1,800	800	98,800
Flounder		16,900	73,800	53,100	500			144,300
Other flatfish					2,000			2,000
Gray cod	63,900	6,400	113,300	160,800	55,300	166,000	58,300	624,000
Lingcod	700	800	1,200	7,700	6,400	2,700	1,600	21,100
Rockfish	1,900	3,300	14,200	8,300	3,600	4,900	700	36,900
Others*	1,700	500	8,800	8,400	1,400	300	1,600	22,700
Dogfish (liver)	(5,495)		(1,480)	(30,340)	(2,930)	(2,730)	(29,610)	(72,585)
Total food fish	99,300	72,400	295,700	357,900	85,600	175,700	121,000	1,212,600

* Mainly skate, perch, devilfish. Not included are 27,000 pounds of mink feed and 45,000 pounds of dogfish carcasses.

About 1,210,000 pounds of food fish were removed from the experimental areas in the winter of 1953-54, as compared with 850,000 pounds in the previous year. Over half of this catch was composed of gray cod (624,000 pounds), while 22% was of lemon sole. The largest total catch was made at Yellow Rock 29% and Deep Bay was next with 24%. This is in contrast to the previous year, when Nanoose Bay and Union Bay were the main centres of activity.

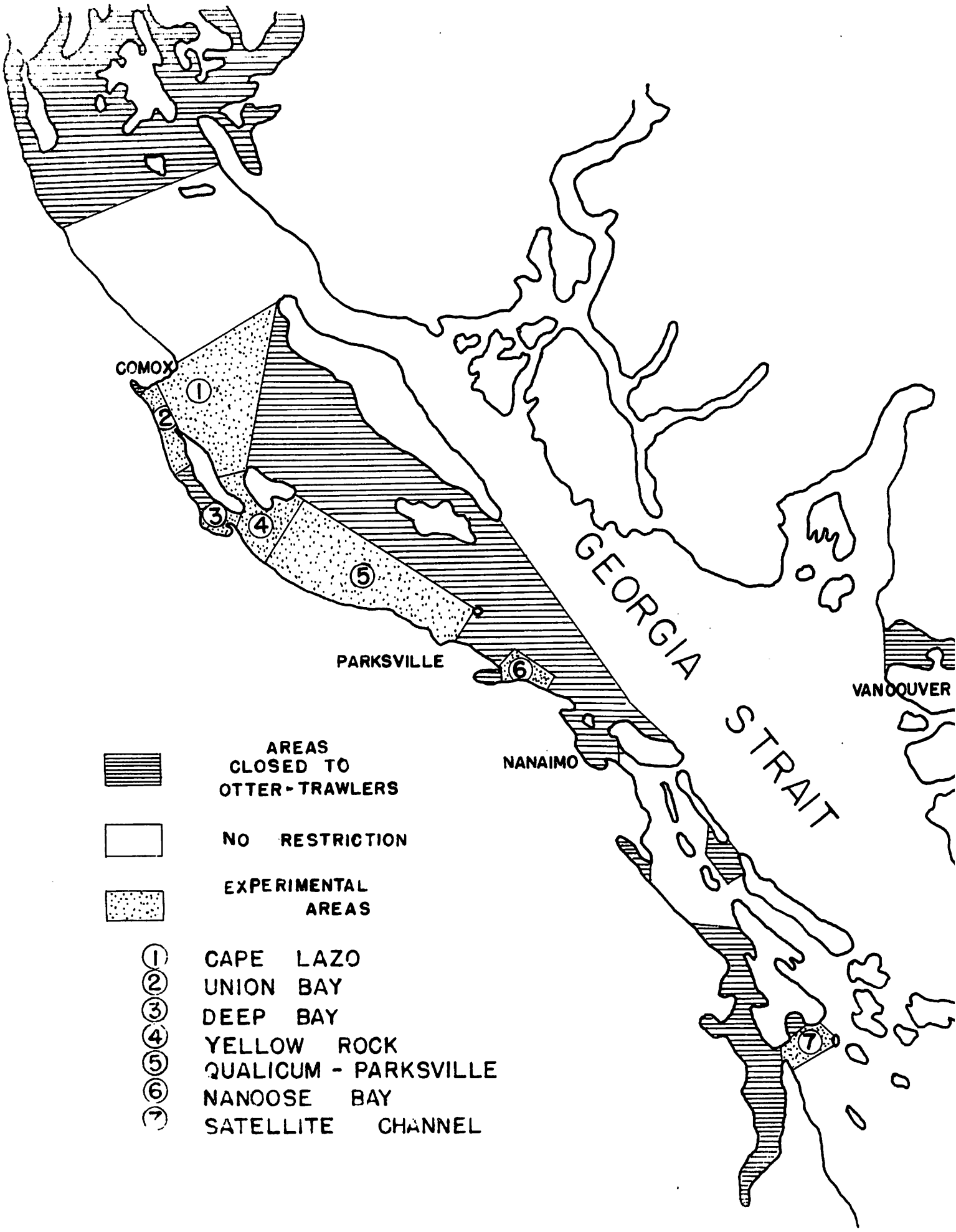
A more detailed account of the various fisheries is given in the following sections.

1. Cape Lazo

This area was open for a 16-week period from October 15, 1953 to February 14, 1954. The catch of lemon sole was less than half of that in the previous year, which was in turn half of that in the winter of 1951-52. This is attributed not to a decline in abundance but to a lack of fishing effort. Other areas nearby were more attractive to the fishing fleet. Actually, the availability of lemon sole was higher than in previous years (170 pounds per hour as compared with 140 pounds per hour for each of the preceding four years).

2. Union Bay

Because of the undesirably heavy concentration of effort in the 3-day open period in the fall of 1952, it was recommended that the 1953 fishery be conducted on one day each week for a period of 6 hours (between October 17 and November 14). The total catch for the 5 days of fishing was


COMOX
PARKSVILLE
NANAIMO
VANCOUVER
GEORGIA STRAIT
AREAS CLOSED TO OTTER-TRAWLERS
NO RESTRICTION
EXPERIMENTAL AREAS
① CAPE LAZO
② UNION BAY
③ DEEP BAY
④ YELLOW ROCK
⑤ QUALICUM - PARKSVILLE
⑥ NANOOSE BAY
⑦ SATELLITE CHANNEL

kept low by this restriction on fishing effort and also by the reduced concentration of fish in the Bay. In the previous year the catch was 252,000 pounds and the catch per hour was 700 pounds. In 1953 the catch was 44,000 pounds and the catch per hour was only 440 pounds.

There has been a remarkable increase in the abundance of starry flounder in Union Bay and this is believed to be associated with the decreased abundance of lemon sole.

3. Deep Bay, Yellow Rock and Qualicum

These areas were open to fishing from October 15 to March 20. Because of the longer open period the boats were able to exploit the gray cod stock which makes its appearance in these regions in the early part of the year. Over half of the gray cod catch from the experimental areas was taken in these areas.

Tag recoveries indicate that a small percentage of lemon soles which inhabit Union Bay in the fall of the year, enter Deep Bay during the winter.

4. Nanoose Bay

As in previous years this fishing ground was open from February 1 to March 20, 1954. The main interest is in gray cod, which were less available this year than last. It has been pointed out in the summary report on availability of gray cod that the decrease in catch per hour does not seem to be the result of a decrease in actual abundance, but rather the result of lower catchability. The Nanoose Bay fishery accounted for 26% of the gray cod catch from all experimental areas, whereas in the previous years it accounted for 82%.

5. Satellite Channel

This area was closed to trawlers for nearly seven years prior to the winter of 1953-54. An open period was permitted from December 1, 1953 to March 20, 1954. The main interest was in dogfish and the catch of this species amounted to almost half of the total from all the experimental areas. Tagging has shown that the lemon soles present in this area do not mix with those in other areas in the Strait and apparently do not participate in the spawning migration to Boat Harbour.

D. Availability of lemon sole and rock sole in Hecate Strait — C.R. Forrester and K.S. Ketchen

Through the use of log records and trip reports a long series of availability records is now on hand for the two most important flatfish species of Hecate Strait. A summary of the average seasonal catch per hour (in thousands of pounds) is contained in the following table.

	Catch per hour									
	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954
Lemon sole	1.22	0.82	0.93	0.66	0.60	0.96	0.75	0.64	0.72	0.79
Rock sole		0.81	1.02	0.81	1.34	1.39	1.84	1.72	1.62	2.55

Regarding the lemon sole, the 1954 catch per hour was close to the 1945-54 mean (0.81 thousand pounds). Two factors may have accounted for the recent increase in availability, namely, the lower annual catch and (or) the appearance of fairly strong year-classes. However, time has not permitted a thorough investigation of this trend. The situation is complicated by the fact that, in previous years, variations in catchability have had as much effect on availability as have variations in year-class strength and yield.

The availability of rock soles has undergone remarkable changes over the past nine years, and reached an all-time high of 2.55 thousand pounds per hour in 1954. This is well above the 1946-54 mean (1.37 thousand pounds). The general increase in availability has occurred in the presence of a general increase in annual yield.

The high availability within recent years seems to be closely associated with the recruitment of strong year-classes (1947 and 1948).

E. Availability of brill off the west coast of Vancouver Island

W.E. Barraclough

A report on the decline in availability of brill off the west coast of Vancouver Island as associated with a decline in recruitment appeared in Pacific Prog. Rept., No. 98, pp. 17-21, April, 1954. A summary of the report is given below.

The availability of brill along the west coast of Vancouver Island has declined during the years 1948 to 1953. It has been shown that although the total brill catch from this area has not changed appreciably during this period, the catch per unit of effort has shown a definite decline. The catch per trip dropped from 9,700 pounds in 1948 to 5,500 pounds in 1953. During the same period, the catch per hour dropped from 350 pounds to 210 pounds. Although the decline in availability may be partly due to heavy exploitation over the past decade, an analysis of length data from samples of the commercial catch has indicated a failure in recruitment during recent years. The average size of female brill in the fishery has been on the increase ever since 1948 and has been the result of a decrease in the number of young fish entering the fishery. This decline in recruitment appears to be associated with the drop in the catch per unit of effort. If the decline had resulted mainly from over-fishing of the stocks the average size would have decreased rather than increased. Heavy fishing would be expected to reduce the numbers of larger and older fish in relation to the number of new recruits and hence the average size would be expected to decline.

In 1954 it was found that further decline in availability of brill occurred off the west coast of Vancouver Island. The catch per trip was only 4,600 pounds and the catch per hour declined to 135 pounds.

It is becoming more difficult to determine the actual amount of time being spent in search of brill and hence more difficult to assess availability. The expanding market for gray cod and mink feed has resulted in profitable trips to the west coast area even though the catches of brill have been small. The very noticeable increase in abundance of dogfish on most of the trawling grounds has reduced the time spent on the grounds where the brill fishery normally occurs. In spite of these factors the evidence at hand suggests that unless there is a heavy recruitment of young fish in the immediate future, further increases in fishing effort cannot be expected to maintain the catch at its present level.

F. Availability of gray cod — K.S. Ketchen

Pronounced fluctuations in market demand for gray cod can make it almost impossible to gain a true picture of the year-to-year trend in availability on most of the important fishing grounds. Only in the restricted area of Nanoose Bay, where fishing effort is known to be directed almost entirely on that species, has such a study been possible. The following table shows the statistics of catch and effort over the course of six years as computed for the February-March fishing season.

Year	Total catch (pounds)	Total fishing hours	Catch per hour
1948	42,450	223	190
1950	145,900	509	285
1951	155,500	964	160
1952	457,200	999	455
1953	289,200	879	330
1954	166,000	555	300

There has been a noticeable fluctuation in catch, effort and catch per unit of effort. The smallest catch was made in 1948 when both fishing effort and catch per hour were lowest. The largest catch was achieved with the highest effort and in the presence of the highest seasonal average catch per hour. There is nothing to suggest in these records that catch per unit of effort is influenced by the number of units of effort, which is surprising in view of the smallness of the Nanoose ground.

The fluctuations in catch per hour seem to be the result of changes in catchability and not of abundance. Fluctuations in the strength of year-classes are evident from the annual changes in size composition, but these do not correlate with the changes in catch per unit of effort.

Attempts to relate the fluctuations in catch per hour to (1) water temperature, (2) abundance of herring (as implied by spawn deposition), and (3) wind conditions, have been unsuccessful.

G. Availability of blackcod — K.S. Ketchen and C.R. Forrester

A paper dealing with the blackcod fishery of British Columbia has been submitted for publication in a bulletin of the Pacific Marine Fisheries Commission. Availability of the blackcod has been dealt with in that paper and a summary of the findings is given below.

A change in availability has been evident within the past two decades on the southern fishing grounds (Queen Charlotte Sound and the west coast of Vancouver Island) and also on the northern grounds (west coast of the Charlottes and southeastern Alaska). The catches per unit of effort on these grounds are now two-thirds of their values during the thirties.

Over the past 35-year period there has been a steady increase in the importance of the northern grounds. Whereas the majority of the landings were made at the southern British Columbia ports prior to 1930, these have declined to 30 to 40% of the total in more recent times. During World War II, the fishery off southern British Columbia did not expand to the same extent as did that in the north, which suggests that it is producing to or beyond its capacity.

On the majority of fishing grounds along the coast, the period of most pronounced decline in catch per skate was between 1944 and 1947. From 1947 to the present a condition of relatively stable availability has occurred. The level at which each fishery has stabilized seems to be related to the history and intensity of the fishery and probably to the cost of production as affected by the distance from major railhead markets. The catch per skate on grounds off southeastern Alaska is now at a level 40% higher than that off the west coast of the Queen Charlottes and in Queen Charlotte Sound, and 100% higher than that off Cape Flattery.

TAGGING EXPERIMENTS

In the year ending September 30, 1954, approximately 5,000 groundfish were tagged aboard the Investigator No. 1. The bulk of these were flatfish (4,550). The remainder were lingcod and gray cod.

Early in April, 1954, tagging was conducted on the brill off the west coast of Vancouver Island in cooperation with the Washington State Department of Fisheries aboard a chartered American trawler.

The results of comparative tests with various types of tagging pins have shown the distinct superiority of stainless steel over other metals. This type is now being used in all tagging experiments. Because of the high rate of corrosion in nickel wire which was used extensively in earlier investigations, the recovery results are of little value quantitatively. Many of these projects must be repeated in order to obtain more accurate estimates of fishing and natural mortality rates.

With the exception of the lingcod, the roundfishes have received little attention until recently because of unsatisfactory tags. However, preliminary tests on gray cod with tags attached with nylon cord have shown promise of success; and full-scale experiments are planned for the winter of 1954-55.

A. Lemon sole tagging — C.R. Forrester

The lemon sole tagging experiments conducted in 1954 and returns for earlier experiments have been summarized in the following sections.

1. Satellite Channel

Approximately 350 lemon sole were tagged in the Satellite Channel area in December, 1953. This ground had been closed to trawling for several years and the tagging was conducted to determine migration patterns and exploitation rate of the stock of lemon sole present. Forty-nine recoveries (14%) have been made to date, only one from outside the region of tagging. This fish had travelled approximately 25 miles northward towards the Boat Harbour area.

2. Sechelt

Three small-scale taggings were conducted on the east side of the Strait of Georgia. Fish were released in the vicinity of Selma Park (50), Sargent Bay (235) and Buccaneer Bay (75) in March, 1954. The lack of returns suggests that the fish in these regions belong to discrete populations which do not contribute to the year-round fishery further south in the Strait off the mouth of the Fraser River.

3. Point Atkinson

Early in March, 1954, a tagging experiment took place in the closed area of Burrard Inlet on spawning stocks of lemon sole which congregate off Point Atkinson.

Seventy-two tags have been recovered from approximately 1,000 released; all recoveries were made to the south of the tagging area. Canadian fishermen returned 60 of the tags while American trawlers accounted for the balance. It appears that Point Atkinson is one of the major spawning grounds for the stocks of lemon sole which contribute to the fisheries off the Fraser River in Canadian waters and Point Roberts in American waters. The possibility of other spawning areas to the south is suggested from tags released off the Fraser Estuary in the fall and recovered from American waters in the early spring months. Such examples are few however, and difficult to interpret because the amount of effort involved in the recoveries is not known.

4. Fraser River Estuary

Recoveries continue to be made from the 1952 lemon sole tagging off the Fraser River. Twenty-nine returns have been received during the past year, bringing total recoveries to 21% from the August tagging and 27% from the October releases. The continuation of American returns from south of the tagging area shows that the Fraser River stock is decidedly international in its outlook.

5. Controlled fishery - middle east coast of Vancouver Island

Eight hundred lemon sole were tagged in the Union Bay experimental area just prior to the opening of the fishing season in October, 1953. Of the 128 tags subsequently returned (i.e., 16%), 61 or 7.6% were recaptured in Union Bay itself during the course of the fishery. The remaining 67 tags (8.4%), with one exception, were recovered in adjoining experimental areas between October, 1953 and March, 1954. The distribution was as follows: 40 in Deep Bay, 9 at Yellow Rock, 5 at Cape Lazo, and 12 of uncertain origin (presumed to be Deep Bay or Yellow Rock). The one exception was a recovery off the Fraser River in June, 1954.

It is apparent that this dispersal out of Union Bay (most of which seems to occur during January and February) must be reckoned with in any attempt to control the amount of fish removed from the Union Bay grounds.

The population present at the start of the 1953 fishing season was estimated at 439,000 fish with limits of 350,000 and 590,000. This estimate is less than half of that obtained at the commencement of fishing in 1951, namely 1,130,000 fish.

6. Goose Island grounds

Tagging of lemon sole was continued on the Goose Island grounds in May of 1954. Six recoveries have been made from a tagging of 500 fish on the northeast corner of the grounds. Two of three Canadian returns were from regions north of the tagging area on the Two Peaks and Butterworth grounds.

During the past year, 17 tags were returned from the 1953 taggings on the same grounds. The higher percentage of American recoveries during this period (approximately 65%) is the result of more intense fishing by the

American boats. In other years Canadian recoveries have been greater than American recoveries. However, this year market conditions discouraged most Canadian boats from fishing on the Goose Island grounds.

B. Brill tagging

1. Winter recaptures of tagged brill from deep water off the west coast of Vancouver Island — W.E. Barraclough

A report has been submitted for publication in Pacific Progress Reports which deals with the winter recaptures of tagged brill from deep water off the west coast of Vancouver Island. The following is a summary of that report:

An important winter trawl fishery for brill has developed in the deep water off Esteban Point within the past two years. The grounds, now referred to as the "Esteban Deep", are centered in an area little more than 6 miles long by 1/2 mile wide, about 24 miles S.S.W. of Esteban Point between the depths of 160 and 210 fathoms. The grounds were discovered by United States trawlers in search of ocean perch (Sebastodes alutus) late in the winter of 1953. As yet the fishery is exploited only by United States trawlers which landed about 250,000 pounds between March and April in 1953, and about 1 million pounds between February and April in 1954.

The high productivity of this fishery and the fact that the brill were in a spawning condition have aroused concern of fishermen and biologists alike. It is important to know whether or not this winter fishery is concentrating on an aggregation of brill which contribute to the inshore fishery along the west coast of Vancouver Island during the summer months. Already a decline in availability of brill has been demonstrated for this stock between the years 1948-1954 (see summary report on brill availability).

Tagging experiments conducted within recent years have shed some light on the relation of the winter stock in the "Esteban Deep" to the summer stock in the inshore region. Of the 15 Canadian brill tags recovered in the "Esteban Deep" in the past three winters, 12 had been released during the summer months in Hecate Strait and Queen Charlotte Sound. Only 2 of the 15 marked fish had been released off the west coast of Vancouver Island. This is surprising in view of the fact that over the past few years far more brill have been tagged and liberated in that area than in the northern waters of British Columbia. In 1950 alone over 1,000 tagged brill were released on different sections of the La Perouse Bank (off Barkley Sound) and yet none of these showed up in the fishery in the "Esteban Deep". Instead, a number of recoveries was made in the winter fishery off Washington and Oregon.

On the basis of these returns there is a strong suggestion that the brill which appear off the west coast of Vancouver Island during the summer months are not the major contributors to the spawning stock in the "Esteban Deep". Rather, the stock seems to be an aggregation of at least some runs or stocks of fish from the waters in Hecate Strait and Queen Charlotte Sound. Other tag recoveries support the view that brill which contribute to the summer fishery off the west coast of Vancouver Island move southward off the coasts of Washington and Oregon during the winter.

2. A report on the joint American and Canadian brill tagging project off the west coast of Vancouver Island in 1954 W.E. Barraclough and B.M. Chatwin

This tagging project was undertaken at the invitation of and in cooperation with the Washington State Department of Fisheries as a result of the extensive brill fishery which has occurred in the past two years during the months of March and April in the deep offshore waters 25 to 30 miles S.S.W. of Esteban point. The purpose of the tagging was to ascertain where the brill move after spawning.

During a period from April 9 to 12 a total of 1,796 tagged brill was liberated, of which total 922 were Canadian and 874 American. The brill which were tagged were caught at a depth of 205 fathoms. A file report on the details of this tagging project has been prepared.

A total of 13 tag recoveries from this tagging have been reported to time of writing, of which 8 were Canadian and 5 American tags. Some of the tags have been recovered north of the tagging area closer inshore and along the west coast of Vancouver Island. Two have been recovered from Hecate Strait during the late summer.

It is not possible to give a comprehensive report of the results of the tag returns until the complete data on the American tags are reported. It is hoped that this tagging and future experiments will help clarify the patterns of migrations along the coast.

C. Rock sole tagging W.E. Barraclough

1. Tags released on the Goose Island grounds

During May, 1954, 300 rock soles were tagged on the northeast corner of the Goose Island grounds. These were caught in depths from 30 to 50 fathoms.

Of the 13 recoveries this year, 10 were made by Canadian trawlers during the summer months in the area of tagging between 32 and 50 fathoms. United States trawlers recovered two on the southeast edge of the Goose Island bank and one on the Cape Scott grounds, all at depths from 60 to 70 fathoms.

In addition, 34 tags were recovered in 1954 from the 755 rock soles tagged on the Goose Island grounds in 1953. Canadian trawlers reported 15 tags and United States trawlers reported 19. All of the 113 tags recovered in 1953 from this tagging were made by Canadian vessels. During that year a far greater emphasis was placed upon the rock sole fishery by Canadian vessels than by United States trawlers.

It was noticeable that the American tag recoveries were made in deeper water than those recovered by Canadian vessels. This is to be expected in view of the fact that the efforts of the United States fleet are directed primarily on deep water species (brill and ocean perch). Increased numbers of recoveries of tagged rock sole by the Americans suggests that the hitherto dormant market for that species is now improving.

The tag returns in 1953 and 1954 strongly suggest that the rock soles on the Goose Islands belong to a stock which intermingles only to a light extent with the stocks off Cape Scott and are distinct from the stocks in Hecate Strait bank to the north.

2. Tags released on the Cape Scott grounds in 1954

During June, 150 rock soles were tagged on the Cape Scott grounds north of Cox Island at the northern end of Vancouver Island. This represents the first tagging of rock soles in that area. The tagging was undertaken in order to help determine the amount of intermingling of the stock of rock soles on the Cape Scott grounds and the Goose Island grounds.

Three recoveries were reported by United States trawlers during the summer months, all from the area of tagging.

3. Tags released in experimental areas in Georgia Strait

Just prior to the opening of the experimental areas in the Strait of Georgia in October 1952, small-scale rock sole taggings were conducted at Yellow Rock (198 fish), Cape Lazo (104 fish) and the grounds off Qualicum Beach (205 fish). Recovery in the ensuing fishery was highest at Yellow Rock (24%), where most effort was concentrated, and negligible in the other tagging areas.

All recoveries were made in the areas of tagging. Recoveries after two years' experimental fishing now total 2%, 10% and 28% for the Cape Lazo, Qualicum and Yellow Rock grounds, respectively.

D. Lingcod tagging B.M. Chatwin

Since October 23, 1953 a total of 221 lingcod have been tagged and from this number 15 were subsequently returned. A summary of the tagging and recovery is shown below.

Area	Number tagged	Number recovered
(1) Goose Islands-Cape Scott	14	1
(2) Cape Lazo-Union Bay-Yellow Rock	57	3
(3) French Creek-Qualicum	73	5
(4) Boat Harbour-Swanson Channel	47	5
(5) Point Grey	30	1
Totals	221	15

During the year some of the tagging effort has been directed toward liberating tags in areas known to be productive in lingcod for trawlers as in Area 3 above. To date, recoveries from French Creek-Qualicum taggings total 5 in number: 4 were returned by trawlers and 1 by a line fisherman.

Line fishing on board the Investigator No. 1 was also undertaken in order to obtain lingcod for tagging purposes. Lack of live herring bait during recent months has restricted this effort somewhat. However, good results in line fishing were obtained on two separate occasions and are included in the tabulation above (Area 2 -- 12 released at Lambert Channel; Area 4 -- 16 released at Ben Mohr and 4 at Governor Rock). Four of the 16 fish tagged and liberated at Ben Mohr Rock were recaptured in the same area some three weeks later by a line fisherman.

Two of the 15 lingcod tag recoveries show a considerable migration. One 6 3/4-pound male tagged at French Creek on October 23, 1953 was caught by a trawler at Nanoose Bay on March 17, 1954. One 5-pound male tagged at Cape Lazo on February 18, 1954 was returned from Shelter Point on May 7, 1954.

Both were small fish which supports evidence from earlier taggings that the smaller fish tend to migrate more than those of larger size.

Four recoveries were made during the year from taggings conducted in previous years. Two were recaptured from the 1951 tagging in Sydney Inlet; 1 from the 1950 tagging in Baynes Sound; 1 from the Lasqueti Island tagging in 1942. The last mentioned is a record for tagged lingcod, having been at large for 12 years. These four recoveries were all made in the area of tagging.

E. Tagging experiments on gray cod — C.R. Forrester

The clincher-type jaw tag originally used in tagging of gray cod has been discarded in favour of a nylon attachment through the flesh between the first and second dorsal fins. To date, the method has been found to be moderately successful, and further taggings are planned for the winter months. A description of the method and preliminary results of an experiment conducted in the lower Strait of Georgia were published in Pacific Prog. Rept., No. 99, July, 1954. Approximately 260 fish were tagged in Satellite Channel in February, 1954. All but 2 of 21 recoveries were from the area of tagging. The 2 exceptions were recaptured off the Fraser River and in United States waters of the Strait of Georgia.

F. Pin corrosion — C.R. Forrester and K.S. Ketchen

Returns for a two-year period are complete in a pin corrosion experiment conducted in the lower Strait of Georgia. A paper dealing with the results has been submitted for publication in the Board's Journal. The following is a summary of that paper:

It is apparent from the high rate of corrosion in nickel tagging pins that they are worthless for long-term quantitative studies of marine fish populations. In flatfish tagging experiments off the British Columbia coast, severe corrosion and weakness was found in more than 40% of the tag recoveries by the end of the first year.

In a comparative experiment in which nickel, silver, and stainless steel pins were tested, recaptures at the end of the first year were highest for tags attached with stainless steel. The ratio of recaptures of manufactured nickel pins to stainless steel at the end of the first year was 0.61:1.00 and at the end of the second year 0.38:1.00.

Silver wire showed little corrosion, but considerable thinning where contact was made with the tagging discs. Losses from the effects of wearing were indicated at the end of the first year in a silver:stainless steel ratio of 0.66:1.00. At the end of the second year the ratio to stainless steel was the same as that for nickel (0.38:1.00).

That the source of weakness (vulnerability to corrosion) in the manufactured nickel pin lies at or near the head, was demonstrated in tests where the head was removed and replaced by a loop. Recoveries of the nickel-loop pin at the end of the first and second years were not significantly different from those of stainless steel.

Tagging wounds at the time of recapture were classified according to the type of wire used. Wounds were least severe where stainless steel had been used and most severe where nickel had been used.

On the basis of the ratio between the recaptures of nickel and stainless steel pins, at various intervals after tagging, correction factors have been computed to account for losses of nickel pins through corrosion.

AGE AND GROWTH STUDIES

In the year ending September 30, 1954, collections of flatfish otoliths amounted to 28,640. These were almost entirely from commercial catch samples of the three most important flatfish species, brill, lemon sole and rock sole.

At Prince Rupert the sampling was carried out by the port observer, W.G. St.Clair, while at Vancouver several people were involved. During the winter of 1953-54 members of the Station staff travelled to Vancouver whenever sampling prospects were good. Throughout the summer of 1954, a student assistant, Mr. A.V. Beach, provided excellent service.

For the first time satisfactory methods have been evolved for the sampling of commercial catches of lingcod and blackcod. Approximately 3,600 of the former and 8,500 of the latter were measured during the past summer.

Sampling of gray cod has been increased substantially. Over 10,500 fish were measured during the past year. The problem of age determination from the otoliths has not been resolved satisfactorily. Until the time can be found for thorough study of this matter, reliance will be placed on length data to provide indications of changes in stock composition.

Another important species which has given considerable difficulty in age determination is the lingcod. However, the study of vertebral rings together with the seasonal trends in modal lengths is showing much promise of providing reasonable estimates of age and growth.

A. Age and growth of lemon sole in Union Bay — C.R. Forrester

Approximately 2,850 lemon sole otoliths were examined from samples of the 1952 and 1953 controlled fishery in Union Bay. The age composition is given below.

		Age composition - %										
		IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	Total
Female												
Percent frequency	1952	0.3	6.9	22.3	41.4	21.8	5.4	1.4	0.2	0.1		900
	1953	6.6	12.7	14.0	18.1	30.4	13.3	3.4	0.7	0.6	0.3	701
Male												
Percent frequency	1952	0.6	13.8	30.4	38.3	15.2	1.8					494
	1953	3.5	8.7	15.9	30.4	29.5	10.4	1.3	0.3	0.1		761

Samples from the 1951 fishery which took place after four and a half years of closure were characterized by a high percentage of fish belonging to the 1944 and 1945 year-classes (VI- and VII-year-old fish). These fish had undergone no exploitation prior to 1951 and constituted over 80% of the fish sampled in that year. They have continued to show strength as VII's and VIII's in 1952 and again as VIII's and IX's in 1953.

The average length of male and female lemon sole in Union Bay has been calculated from samples taken by the Investigator No. 1 and by commercial vessels. These are compared with average ages in the following table.

	Male		Female	
Year	Average length	Average age	Average length	Average age
1949	308	5.3	383	5.8
1950	318	5.7	392	6.1
1951	331	6.3	399	6.5
1952	346	6.6	424	7.0
1953	354	7.1	427	7.2

Both male and female fish have shown a noticeable increase in average size and age between 1949 and 1953. Because of variations in the annual recruitment, it has been difficult to detect the effects of fishing on growth rate. Following four years of closure the Union Bay area was opened in the fall of 1951. At that time 165,000 pounds of lemon sole were removed; and again in 1952 approximately 250,000 pounds were removed. Changes in catch per unit of effort show that these removals had a marked effect on the density of the stock. However, the sharp increase in average size in 1952 (particularly in female fish) seems to be attributable more to an absence of young fish than to an increase in growth rate. This conclusion is supported by length-weight data which show no radical variations from year to year.

The decrease in density has had a noticeable effect on the incidence of disease in the Union Bay stock. A condition known as "milkiness" was very troublesome in the first landings of fish in 1951. Milkiness is caused by a spore that requires no intermediate host, and hence it may be presumed that its incidence would be highest under conditions of high density. Fish handlers reported milkiness in up to 21% of fish in 1951, whereas the highest incidence of the same condition in 1952 involved no more than 12% of the fish handled, with the bulk showing considerably less (8%). In 1953 the occurrence of milkiness was negligible.

B. Growth rate of 0-group lemon sole — K.S. Ketchen

In order to determine the time of setting of the 0-group lemon sole and also the growth rate during the spring and summer months, the Departure Bay beach was sampled periodically with a model trawl. Drags were made over a fixed distance, at approximately the same stage of tide, at 14-day intervals from April 22 to August 13, 1954.

Although small fish ranging in size from 20 to 100 millimeters (mode: 30-40 millimeters) were present on the first day of sampling, it was apparent from subsequent events that they did not represent the main set from the 1954 spawning. This main set was first observed on May 7 as fish of about 20 millimeters in length. By May 21 these fish were four times as abundant as they were on May 7. Since the average catch per tow did not increase appreciably in the weeks following May 21, it is presumed that the set was completed sometime between May 7 and 21.

The average lengths of 0-group lemon sole at 2-week intervals are shown in the following table.

Date	May 21	June 4	June 18	July 2	July 16	July 30	August 13
Average length (mm.)	24.6	35.3	46.9	54.7	63.7	67.9	80.3
Increment (mm.)		10.7	11.6	7.8	9.0	4.2	12.4

The rates of growth from May to July are very similar to those computed for samples taken in 1946. Late in July the larger 0-group fish begin to move away from shore and hence out of range of the model trawl. This makes the apparent growth rate less than the actual.

The fact that it is possible to detect fairly accurately the time of arrival of the young lemon sole on the beaches in the spring, is of considerable aid in the study of factors affecting abundance. Knowing the peak time of spawning, it should be possible to place firm limits on the time of the "critical stage".

C. Fluctuations in the length composition of brill in Hecate Strait — W.E. Barraclough

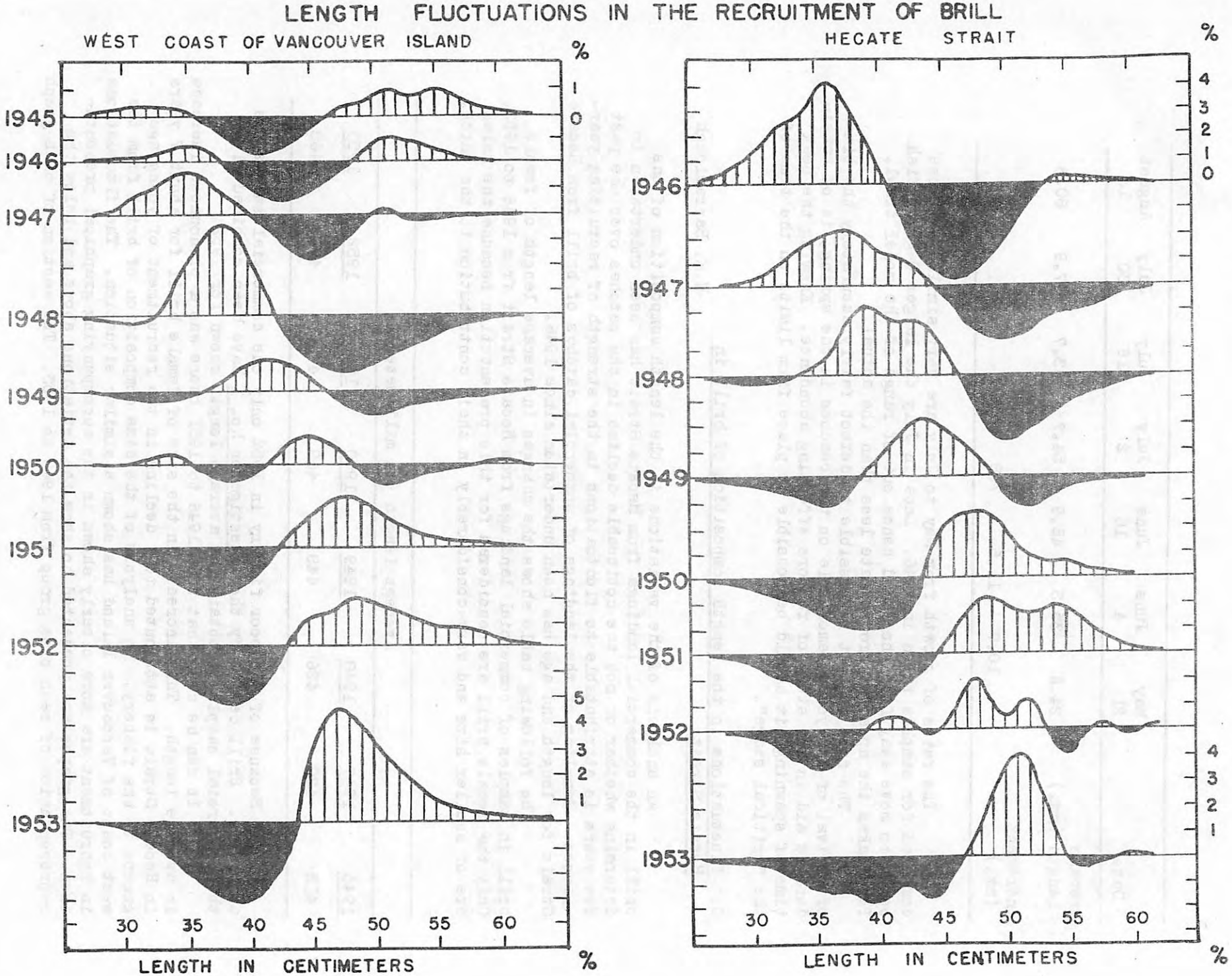
An analysis of the variations in the length composition of the brill in the commercial landings from Hecate Strait has been undertaken to determine whether or not the noticeable decline in the catches over the past few years is attributable to fluctuations in the strength of recruiting year-classes. Sampling of the landings of commercial catches of brill from Hecate Strait for length and age has been undertaken since 1946.

The following table shows the changes in average length of female brill in samples of commercial landings from Hecate Strait from 1946 to 1953. Only the female brill are considered for this presentation because the males are of smaller size and vary considerably in their contribution to the catch.

Average length (in millimeters)							
1946	1947	1948	1949	1950	1951	1952	1953
413	420	426	448	469	479	474	468

Because of the poor fishery in 1952 only one commercial sample was available. Brill caught by the Investigator No. 1 have been combined with the commercial sample to obtain the average length shown for 1952.

It can be seen that from 1946 to 1951 there was a pronounced increase in average length. This increase in the size of female brill for about 7 years in Hecate Strait is attributed to a decline in the recruitment of young age-groups to the fishery. An analysis of the size composition of brill from the west coast of Vancouver Island has shown a similar situation. The fluctuations in recruitment are more clearly shown in the accompanying graphical presentation. The graphs are presented to show the deviations above and below the representation of each size group from 1946 to 1953. The section of each graph


LENGTH FLUCTUATIONS IN THE RECRUITMENT OF BRILL
WEST COAST OF VANCOUVER ISLAND
HECATE STRAIT
%
1945
1946
1947
1948
1949
1950
1951
1952
1953
1
0
4
3
2
1
0
5
4
3
2
1
30
35
40
45
50
55
60
LENGTH IN CENTIMETERS
%

above the line (notched) indicates the size-group of brill which occurred in the catches in numbers greater than the average for the 7 years 1946 to 1953 (1952 was excluded from the average because only one commercial sample was available). The sections of the curves below the line (in black) show the size-groups of brill which were present in numbers less than the average for the 7-year mean. For purposes of comparison, the west coast data are presented along with those for Hecate Strait.

The shift in mode of the positive deviations in Hecate Strait samples has paralleled the situation observed in west coast samples. However, the actual modes are not strictly comparable, being at slightly larger sizes in the Hecate Strait sample. In the absence of age-composition data for Hecate Strait it is difficult to say whether or not different year-classes are responsible for the deviations observed in the two areas.

The length fluctuations show no evidence of a new wave of recruitment appearing in the fishery. The fact that the smaller size-groups of brill appear to be very scarce and that there has been an increase in the average length of the brill since 1946 shows that the fishery is becoming more and more dependent upon the remaining stocks represented by the large size-groups. Unless heavy recruitment occurs not only in Hecate Strait but also off the west coast of Vancouver Island, it is very unlikely that a productive brill fishery can be maintained off the coast of British Columbia.

D. Age composition of butter sole — B.M. Chatwin

A winter trawl fishery for butter sole (Isopsetta isolepsis) in the Skidegate Inlet area on the Queen Charlotte Islands was first carried out in 1943. The production since then has been very irregular, with catches varying from almost nothing to over 3 million pounds annually. Much of this irregularity has been a result of market requirements. However, poor production in 1949 and 1950 (15,000 pounds and 1,000 pounds, respectively) resulted from a real scarcity of fish in Skidegate Inlet. A survey of the spawning stock in 1953 (Summary Reports 1953; Circular No. 30, Pacific Biological Station) indicated that the year-classes of 1949 and 1950 were not in low abundance. A further check on the age composition of the stock in 1954 was obtained from 3 otolith samples taken from the commercial catch. A summary of these data and the 1951 commercial catch age analysis are shown in the accompanying table.

	Age-group frequency (%)											
	II	III	IV	V	VI	VII	VIII	IX	X	XI	No. fish	Average length (cm.)
1951												
Male	-	0.1	1.3	11.0	37.1	36.5	11.8	1.9	0.3	-	899	33.5
Female	-	0.1	0.7	7.0	24.7	39.4	20.2	6.5	1.0	0.4	1,234	37.6
1954												
Male	-	-	0.5	26.4	43.2	25.1	3.8	0.7	-	-	386	33.2
Female	-	-	0.6	9.1	46.4	25.1	15.6	2.9	-	-	338	35.5

Butter sole from the 1949 and 1950 spawnings are present as V- and IV-year-olds in the 1954 catch. Although the 1949 year-class is well represented in male fish, it is too early to assess the strengths of these year-classes. However, sampling on the summer feeding grounds in 1954 showed that the 1949 and 1950 year-classes were present in at least moderate strength. This is in agreement with observations in the summer of 1953.

E. Age composition of Hecate Strait rock sole — C.R. Forrester

Otolith samples from the 1953 fishery have been examined. Males and females continue to be heavily represented by young age-groups. The 1947 and 1948 year-classes appearing in 1953 as V- and VI-year-olds accounted for more than 70% of the fish sampled. There is some divergence from 1952 in average length of age-groups of older fish that has not yet been satisfactorily explained. A re-reading of the samples for 1953 may prove necessary.

F. Age and growth of the lingcod — B.M. Chatwin

1. Growth of young lingcod

The lingcod spawns during the winter months each year and recognizable size-groups of fish can be observed up to approximately the third year of life. Investigations have shown that lingcod scales and otoliths are unsuitable age indicators. There are, however, growth marks on the vertebrae which are evident as concentric rings on the face of each centrum. Annual growth patterns during the first years of life have been difficult to interpret. Accordingly, a study of the young fish seemed desirable in order to relate the observed growth rates to vertebral ring counts. The results of this work, "Growth of Young Lingcod", are contained in Pacific Prog. Rept., No. 99.

It is shown therein that young lingcod grow very rapidly, and on the average attain a length of 27 centimeters at the end of the first year and 47 centimeters at the end of the second year. Indications are that the average length is approximately 55 centimeters at the end of the third year. It is at about this age that the lingcod reaches commercial size.

2. Sampling of commercial lingcod landings

During the summer of 1954 (May to September) length-weight data were obtained for the first time from dressed lingcod landed on the Vancouver waterfront. Although the line fishery accounts for the greater part of the total lingcod catch, sampling of line-boat landings is difficult since the fish are usually retained alive for varying periods of time before being marketed, with the result that catches are almost always mixed. Therefore, for the first stage in the lingcod sampling program, trawl-caught lingcod were used exclusively and the samples contain a total of 3,610 fish. Most of the samples are from fish caught off the west coast of Vancouver Island in Areas 21 and 23. Dorsal-fork lengths and weight to the nearest pound were recorded from dressed fish. The results obtained are shown in the tables below.

	May	June	July	August
Number of fish	615	632	803	857
Average total length (cm.*)	71.94	80.58	75.69	73.73
Range of sample length (cm.*)	50-113	56-114	54-110	55-110

* (Converted from dorsal-fork measurements)

	Dorsal-weight groups (pounds)							
	3-5	6-8	9-11	12-14	15-17	18-20	21+	Total
July								
Number	98	107	83	38	17	1	3	(347)
Total average length cm.*	64.8	74.5	84.7	93.8	100.2	109.2	112.5	
% frequency	28.2	30.8	23.9	10.9	4.8	0.2	0.8	
August								
Number	88	170	65	11	4	-	-	(338)
Total average length cm.*	63.6	76.7	83.7	90.6	100.9	-	-	
% frequency	25.9	50.1	19.1	3.2	1.1	-	-	

* (Converted from dorsal-fork measurements)

Samples from other trawling areas (1 -- Cape Scott, 1 -- Cape Lazo, 1 -- Mexicana Point and 1 -- Fraser Lightship) were also taken and in general are comparable to those of the west coast. The data above show that the trawl fishery removes fish covering a wide range of sizes. It is particularly interesting to note that fish of the smaller sizes form the bulk of the catch. At least 25% of the fish caught are just above the minimum size of 3 pounds. This 3-5 pound group is believed to represent Age III and IV fish. As mentioned above, it has not been possible so far to obtain comparable data on line-caught lingcod. However, it is believed that the line fishery selects more of the larger fish. Tagging has shown that smaller lingcod migrate more extensively than larger fish and any movement of the smaller fish into areas which would make them available to the trawl might easily be reflected in the trawl catches.

Figures for catch of lingcod for the years since 1951 are now available through the Department of Fisheries sales slip statistics. A study of all previous catch records is being undertaken and will be reported on at a later date.

3. Length conversion factor for lingcod

Lingcod are generally landed for market dressed with heads off. Length samples of the commercial catch are therefore taken by means of a proportionate measurement. Special measuring boards have been placed in use at the port sampling stations whereby a straight line measurement along the

lateral cephalo-caudal axis from the origin of the dorsal fin to the fork of the tail can be obtained. Because the fish are dressed, samples contain both sexes combined. In order to convert dressed length to total length, a conversion factor must be used. This has been computed from field data on measurements of 204 trawl-caught lingcod taken in the Strait of Georgia during October and November, 1953 and February and March 1954. The equation for the relationship between total length and carcass length (both in centimeters) is $Y = 0.558 - 1.228\ X$, where X is the carcass length and Y the total length. As data become available, additional factors will be computed if necessary to account for sex, area and season differences.

4. Age studies

For reasons explained previously, effort has been directed towards the use of vertebrae for determining age of lingcod. Although the practical application of this method does not appear likely, the results from such a study should yield information which is currently lacking on: (1) total age attained; (2) the approximate size of the fish at each age; and (3) the range of age-classes utilized by the fishery.

The abdominal vertebrae used are boiled and air-dried, sectioned dorso-ventrally and examined with the aid of a low-power microscope. Using an ocular micrometer, radial measurements of each year's growth are made. Preliminary results to date indicate that ages up to 15 years can be determined but beyond the age of 8 to 10 years the annuli are difficult to measure separately.

5. Lingcod spawn survey

In Districts 1 and 3 a closed season for lingcod is in effect from the first of December until the first of March, during which time spawning occurs. It is known that some lingcod deposit their spawn on rocks and ledges of the intertidal zone. In order to learn more of the spawning lingcod, surveys were commenced the night of December 22, 1953, in Departure Bay and covered the intertidal zones adjacent to the northern side of Jessie Island and Inskip Rock. The purpose was to determine the time of first appearance of lingcod egg masses and hence to obtain a closer approximation of the time of spawning and time of hatching. The accompanying tabulation lists the observations made.

Date	Tide	No. of egg masses observed	No. of lingcod observed	Weather and water conditions (visibility)
22 Dec 53	1.1'	-	-	Good
4 Jan 54	1.6'	-	-	Poor
7 Jan 54	1.7'	-	3	Good
18 Jan 54	1.8'	-	-	Fair
2 Feb 54	2.0'	5 exposed	1	Good
2 Mar 54	3.2'	3 submerged	-	Good

The first appearance of lingcod egg masses was noted February 2 and these were all found attached to the rocks above the water level, some at least 6 feet above the lowest stage of the tide. The mid-February survey was cancelled because of bad weather. On March 2, 3 different egg clusters were seen. From these results it is reasonable to believe that the Departure Bay "beach" spawning commenced during the last 2 weeks of January.

Remarks from lingcod fishermen concerning the state of maturity of lingcod suggests that on December 1 when the season closes the fish are at least a month or more from spawning.

These observations are preliminary however, and further lingcod maturity studies are anticipated.

G. Length composition of gray cod — K.S. Ketchen

A preliminary examination has been made of length-frequency distribution in samples of gray cod taken during the past 4 or 5 years along the southern coast of British Columbia. The presence of dominant year-classes is suggested by year-to-year trends in modal length.

In the Strait of Georgia there are two important gray cod grounds one in Swanson Channel and the other at Nanoose Bay. Fish taken in the latter area average much larger in size than those in the former. It is apparent from this size difference that the two stocks do not undergo extensive intermingling within one season.

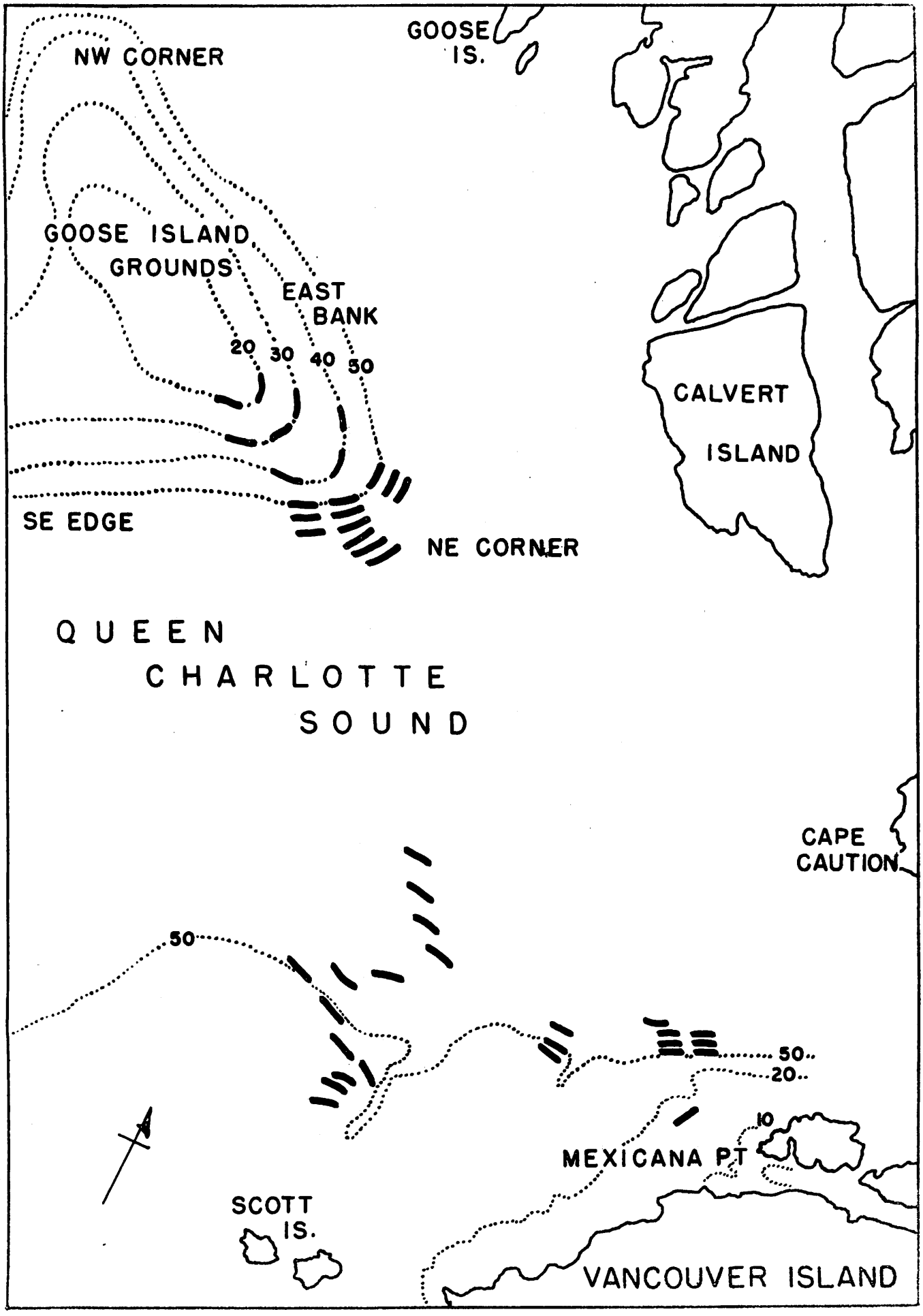
The Nanoose Bay fish (winter spawning stock) are very similar in size composition to those which occur off the west coast of Vancouver Island during the summer months. The two groups seem to be subject to the same fluctuations in year-class strength. Whether or not they are components of a single stock will have to be determined from tagging. The fact that the gray cod appear in the Strait at the same time of year as the herring which move in from the open coast, lends support to the suggestion of a single stock.

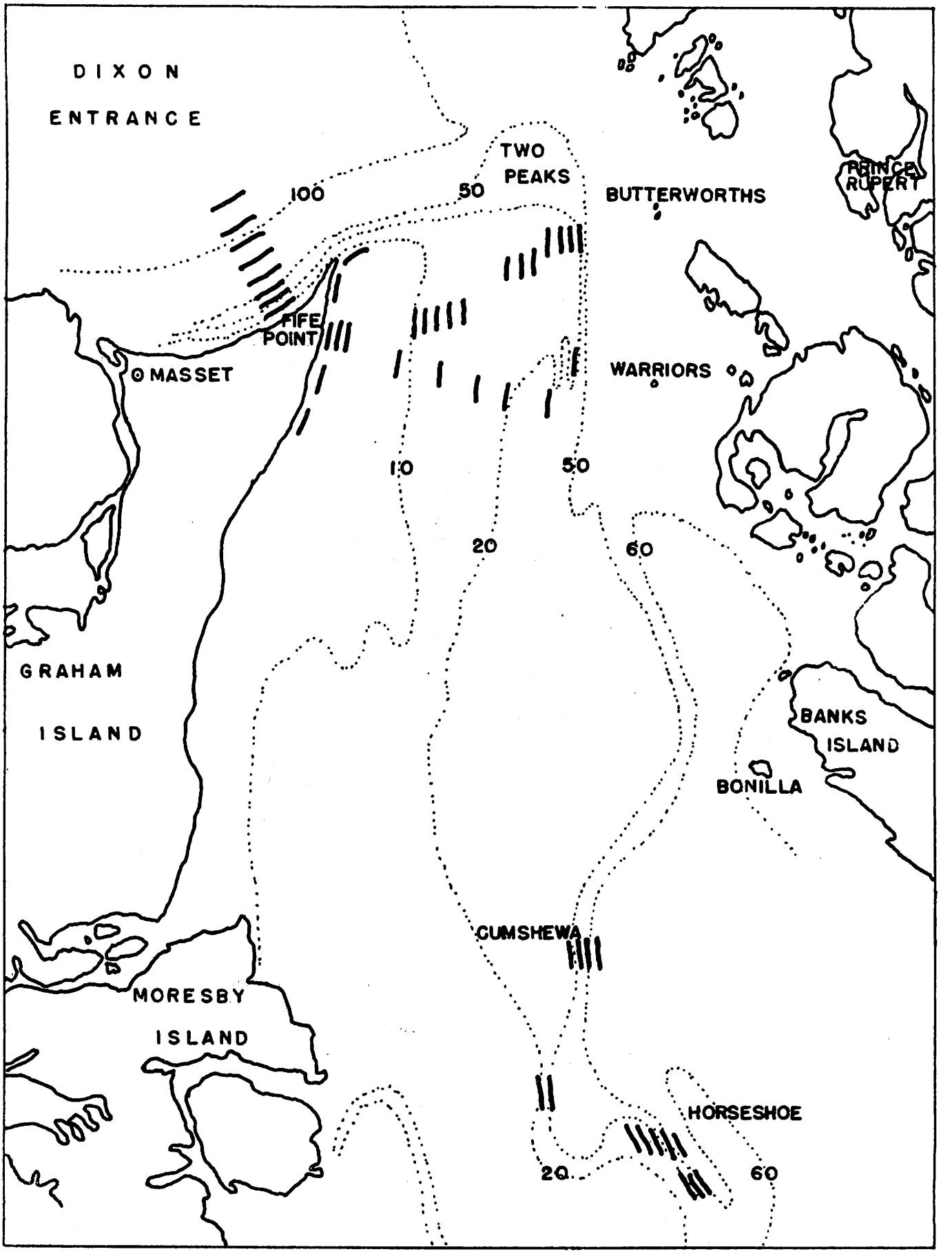
Samples from other areas in the Strait of Georgia (e.g., Yellow Rock and Cape Lazo) are similar in composition to those at Nanoose. Hence there may be considerable intermingling.

The tagging program which is to be conducted in the winter of 1954-55 will be designed to throw light on these various relationships.

SYSTEMATIC EXPLORATION OF NORTH COAST BANKS

The surveying of north coast banks (Cape Scott, Goose Island and Hecate Strait) in a reasonably systematic manner was initiated in 1953 and continued in the summer of 1954. The main purpose is to define the composition of fish on these banks according to species and size. Particular attention is being paid to the geographical relationships of the juvenile segments of various populations to the adult segments. An enquiry is also being made into the possibility of obtaining indices of relative abundance of various age-groups, so that they may be compared from year to year. Such estimates have definite value for prediction purposes and in investigations of the factors governing abundance.


NW CORNER
GOOSE IS.
GOOSE ISLAND GROUNDS
EAST BANK
20
30
40
50
SE EDGE
NE CORNER
CALVERT ISLAND
QUEEN CHARLOTTE SOUND
CAPE CAUTION
50
50
20
10
MEXICANA PT
SCOTT IS.
VANCOUVER ISLAND


DIXON
ENTRANCE
TWO
PEAKS
100
50
BUTTERWORTHS
PRINCE
RUPERT
FIFE
POINT
MASSET
WARRIORS
10
50
20
60
GRAHAM
ISLAND
BANKS
ISLAND
BONILLA
CUMSHEWA
MORESBY
ISLAND
HORSESHOE
20
60

A. Survey No. 1 - Goose Island Grounds

W.E. Barraclough

1. Description of stations

The Goose Island trawling grounds which are situated in the middle of Queen Charlotte Sound are becoming increasingly important to British Columbia trawlers. The grounds afford an extensive fishery for rock soles, brill, ocean perch and scrapfish.

In 1953 the "N.W. corner" and the "East Bank" of the grounds were surveyed with a small-meshed otter trawl to determine the extent to which the grounds serve as a nursery area for the important groundfish species. In May 1954, a survey of the "N.E. corner" was undertaken between the depths of 22 and 100 fathoms. A comprehensive file report has been prepared. A summary of the results is given below.

2. Species encountered

(a) Rock soles. Immature rock soles were encountered at 22 fathoms. It was not possible to give a satisfactory estimate of the relative amount or numbers of young rock soles at this depth. The extremely rough bottom gave them good protection from commercial gear and the sample trawl.

The best indications of sizeable quantities of rock soles were found at 30 fathoms. However, age groups I, II and III were not present on the "N.E. corner" at this depth. This is in contrast with the relatively large numbers of the same age groups found in June 1953, northward along the "East Bank". A larger size-group of rock soles was found at 30 fathoms on the "N.E. corner" when compared to the size groups found at the same depths on the "N.W. corner" and "East Bank" in 1953. The results of the survey suggest that as the rock soles grow toward maturity they tend to move southward along the bank to the "N.E. corner" and at the same time to deeper water. This seems to be reasonable because the heaviest commercial rock sole fishery exists in the region of the "N.E. corner" at depths greater than 40 fathoms. Further evidence is shown by the fact that the dominant age-group IV rock soles which appeared in 1953 at 40 fathoms appeared as age-group V on the "N.E. corner" in 1954. The results from the surveys at present have shown that the nursery area for rock soles is limited to depths less than 35 fathoms.

(b) Dover soles. Very few immature dover soles were encountered. It was concluded from the survey that the nursery ground for dover soles is not extensive on the "N.E. corner", rather a nursery area occurs farther northward along the "East Bank". The largest numbers of dover soles were encountered at 60 fathoms and 74% of the catch was of commercial size. The average length of the dover soles was found to increase with increasing depth to 90 fathoms. It was found that the dover soles of commercial size occur more extensively on the N.E. bank than to the northward on the East bank or "N.W. corner".

(c) Brill. Particular attention was given to the distribution of immature brill, but so few were captured in all the tows between the depths of 22 and 100 fathoms that the "N.E. corner" of the grounds cannot be considered as a nursery area to any extent for that species.

(d) Lemon sole. The results of the survey on the "N.E. corner" are in agreement with the findings of the survey in 1953 on the "N.W. corner" and the "East Bank". The lack of any sizeable quantity of immature lemon soles on all these banks at the different depths shows that the Goose Island grounds

from the "N.W. corner" to the "N.E. corner" is not an important nursery area for the lemon sole. However, the area does support a commercial fishery for the larger members of this species.

(e) Rex sole. The distribution of rex soles was found to be confined between the depths of 50 and 90 fathoms. Immature rex soles of the age groups I, II and III were taken between 50 and 70 fathoms. Rex soles of commercial size were most abundant between the depths of 60 and 70 fathoms.

B. Survey No. 2 - Cape Scott B.M. Chatwin

1. Description of stations

The major commercial trawling grounds adjacent to the northern end of Vancouver Island are at depths greater than 40 fathoms and extend from the area northwest of Mexicana Point, Hope Island, to north of the Scott Island group. Two "tongues" or gullies along the 50-fathom contour divide the bank into 3 grounds, namely: the Mexicana ground (northwest of Hope Island), the "middle ground" (lying between the 50-fathom gullies) and the Cape Scott grounds (north of the Scott Islands).

This survey consisted of 3 cross-sections of these grounds using the small mesh sampling trawl. Eight drags were made on the Mexicana grounds, 3 on the "middle bank", and 13 across the Cape Scott bank, a total of 24 in all. The nature of the bottom does not permit trawling at depths less than 40 fathoms, consequently the depths surveyed ranged from 40 to 95 fathoms.

2. Species encountered

All flatfish captured were measured with the exception of long-jaw flounders which were, in some cases, the dominant species in the catch. In these instances sub-sampling was necessary.

For all species encountered a comprehensive report has been filed, with a complete analysis of the results. This summary presents the salient features.

(a) On the Mexicana ground lemon, rex and dover sole were the commercially important species present. Long-jaw flounder were equally abundant and consisted of medium-sized fish (30 centimeters). These 4 species were encountered in each of the 8 tows and none was particularly dominant. This ground is relatively narrow and a nursery area for immature flatfish is not indicated.

(b) On the middle ground similar species were encountered, lemon, rex, dover sole and large-sized long-jaw flounder (average length = 50 centimeters). The majority of each species were of commercial size or larger and the long-jaw flounder were dominant. In addition, 12 brill ranging in size from 18 to 44 centimeters (average = 20 centimeters) were taken.

(c) The Cape Scott ground is of larger size and appears to support a greater variety of species. The long-jaw flounder was the dominant species and occurred at all depths (40 to 95 fathoms). Age-groups I, II and III were strongly represented to depths of 60 fathoms. Rock sole were present at 40 to 45 fathoms only and their average size was 34.9 centimeters. Immature rock sole were relatively few in number since only 70 fish of a total of 267 were less than 30 centimeters in size. Lemon sole were present from 40 to 60 fathoms. In all catches a total of 51 of this species was taken, of which 15 were larger than 30 centimeters in length and the remain-

der from 16 to 25 centimeters. Rex and dover sole occurred from 45 to 95 fathoms but not in abundance. Average lengths increased with increasing depth of capture. Immature rex sole (14 centimeters) and dover sole (11.6 centimeters) were strongly represented at 45 fathoms. Brill were found from 40 to 70 fathoms and ranged in length between 16 and 40 centimeters.

Small numbers of other species were captured, these included gray cod, tom cod, whiting, slender sole, flat head sole, mottled sand dab and butter sole. Data on sex and size have been recorded and are on file.

C. Survey No. 3 - Hecate Strait K.S. Ketchen

1. Description of stations

The survey in this area can be divided roughly into three sections, the first dealing with the northern Hecate Strait flats, the second with Dixon Entrance and the third with southern Hecate Strait. The first consisted of two cross-sections of the shallow grounds between the Queen Charlotte Islands and the Butterworth-Warrior area and covered depths from 2 fathoms to 20 fathoms. Most of the stations sampled were repititions of work carried out in 1953. The Dixon Entrance survey was carried out parallel to but 20 miles to the west of the Two Peaks survey of 1953. The investigation of the southern Hecate Strait grounds (Horseshoe and Cumshewa banks) was an extension of previous work designed mainly to locate brill for tagging. Detailed description of the species composition on these grounds was of secondary importance.

2. Species encountered

(a) Lemon sole. Members of the 0-group were restricted in their distribution (as in previous years) to the shallow water around the Queen Charlotte Islands. Greatest numbers were caught at depths less than 9 fathoms, while none were caught at depths over 14 fathoms.

Attempts to sample the shore-line stations down the east coast of Graham Island were frustrated by large quantities of algae which had been concentrated in that region by persistent southeast weather. Thus, it was impossible to execute the system inaugurated in 1952 for obtaining an index of relative abundance of the 0-group.

Group I and II fish were found in almost all drags across the Hecate Strait flats, but none occurred in the Dixon Entrance drags. On the Hecate Strait flats the catch of group I fish per drag was 47, as compared with 35 in 1953. The catch of group II fish per drag was 9, as compared with 23 in 1953.

On the Cumshewa and Horseshoe grounds the catches of lemon sole were composed mainly of groups II and III.

To summarize: Group 0 fish are confined to shallow water (less than 14 fathoms) along the western side of Hecate Strait. Group I fish are dispersed over the flats and mixed to a certain extent with groups II and III. The latter groups are however, in greater abundance in the central and southern region of the bank and concentrated more along the "drop off". The older (mature) elements of the stock lie in deep water (25 to 60 fathoms) around the northern perimeter of the bank from Warrior Rocks to Dixon Entrance. These conclusions are supported by observations made during 1952 and 1953.

(b) Rock sole. In contrast to the lemon sole, the young of the rock sole appear to inhabit the same regions as the adults. Group 0, I and II are concentrated most heavily along the edge of the Hecate Strait bank between the Butterworths and Warriors. These young fish were absent on the Dixon Entrance grounds and scarce on the Horseshoe and Cumshewa grounds. Present indications are that the main nursery area in Hecate Strait lies on the northern part of the flats.

Young rock sole caught in the series of drags between Butterworth Rocks and Fife Point were noticeably smaller at each age than those caught between Warrior Rocks and Fife Point. This difference may be a reflection of different growth conditions in the two regions, but the possibility of segregation of schools according to size cannot be neglected.

(c) Butter sole. This species was distributed unevenly across the Hecate Strait flats, but heaviest concentrations were found in the central region. As in the case of the rock sole, immature fish inhabit much the same regions as the adults.

The species was scarce in Dixon Entrance and in southern Hecate Strait. In the latter region, nearly all fish caught belonged to group III (1951 year-class).

On the northern flats group IV fish (1950 year-class) were better represented than either groups III or V. In Chatwin's report on the 1953 sampling (Circular No. 30), group III fish were more abundant than either groups II or IV. Thus it appears that the 1950 year-class was stronger than those of 1949 and 1951. This is rather surprising in view of the fact that spawning, which in most years has occurred in Skidegate Inlet, failed to take place in that region in 1950.

(d) Brill. This species was not encountered in great numbers on any of the Hecate Strait grounds in the summer of 1954. In MacIntyre Bay small numbers of adult fish were found at depths of 20 and 22 fathoms. None were found on the Hecate Strait flats. In southern Hecate Strait, they were found only on the Cumshewa ground. The commercial-sized fish were considerably larger than those in Dixon Entrance, but small immature fish were also present. The latter were about 23 centimeters in length and were 2 years of age.

(e) Gray cod. In contrast to the results obtained in 1953, large numbers of 0-group gray cod were encountered on the northern part of the bank and in MacIntyre Bay. No representatives of this group were found in 1953.

(f) Other species. Group I dover sole were found only along the eastern side of the Hecate Strait bank and in shallow water in Dixon Entrance. Mature fish were found in deep water (50 to 100 fathoms) on the Horseshoe and in Dixon Entrance.

Long-jaw flounder, believed to be group I, were found in moderately deep water (30 to 40 fathoms) both on the Cumshewa ground and in Dixon Entrance.

OCEANOGRAPHIC STUDIES

Long-term temperature trends — K.S. Ketchen

During the past three years, long-term records of air and water temperatures have been assembled from various regions of the British Columbia coast. Interest in this subject has been prompted by the belief that climatic changes are occurring in the North Pacific and that these changes are affecting the abundance and distribution of various species of groundfish.

A discussion of the long-term temperature trend appeared in manuscript form (Manuscript Report No. 575) during 1954. The following is a summary of that report.

Mean annual air temperatures for the southern British Columbia coast shows an upward trend from 1910 to 1940 while those for the north coast follow the same course from 1920 to 1940. Between 1940 and 1950 in both regions, temperatures have declined markedly.

The trend from the turn of the century to 1940 corresponds well with the trend in the North Atlantic. However, after 1940 there was a divergence. North Atlantic temperatures continued to rise while those in the Pacific went into a sharp decline.

The significance of the changes in the northeast Pacific in respect to the fisheries is not immediately apparent. This may be due to inadequate statistics or simply that there have been no long-term fisheries for species which are sensitive to the changes. There are, however, several indications that these changes are affecting the distribution of groundfish. The gray cod, which was the object of a large fishery in Alaska earlier in this century, is now noticeably absent from that region. The fact that gray cod are currently very abundant on British Columbia grounds suggests that the range of distribution is undergoing some changes.

The brill, which is undergoing a decline in abundance as a result of poor recruitment over a number of years, may be responding to the marked changes in temperature which have occurred over the past decade.

MISCELLANEOUS PROJECTS

Mid-water trawl development program — W.E. Barraclough

The mid-water trawl development project was undertaken to test and adapt to British Columbia conditions an efficient mid-water trawl for herring. The project was requested by certain segments of the trawling industry because they were unable financially to continue independent or private experimentation. The project has been carried out under the Industrial Development Vote.

Through the cooperation of the Department of Fisheries, trawl net fishermen met with representatives from this Station and the Department of Fisheries and formed a committee composed of experienced fishermen to advise on the design of gear and the program of experimentation. Most sections of the trawl fleet were represented in order to take maximum advantage of the knowledge already gained on the problems of herring trawling. One member of the committee, Mr. W. Johnson, has been assigned part-time employment to design and construct the necessary gear for a mid-water trawl.

Mr. Johnson and K.S. Ketchen consulted representatives of the U. S. Fish and Wildlife Service and sections of the fishing industry in Seattle about various net and kite designs of mid-water trawls. In Prince Rupert Mr. Johnson and W.E. Barraclough met with trawl fishermen who had fished with bottom trawls for herring and experimented independently with mid-water trawls in the herring

fishery. In meetings with these fishermen Mr. Johnson demonstrated models of an otter-board with a hydrofoil section and horizontal stabilizer, which he considered would be suitable for mid-water trawling. The fishermen demonstrated general agreement on net designs of nylon webbing and expressed approval of the proposed type of otter-board. A full-scale set of boards of this new design has been built and trials conducted aboard the Investigator No. 1. Mr. Johnson stated that the performance of these boards in the preliminary experiments was satisfactory.

Experimentation with a type of mine-sweeping gear used as a spreading device to keep the mouth of the trawl net open was conducted aboard the Investigator No. 1 by W.E. Barraclough with the assistance of Lt. Comdr. R.P.R. Saunders, R.C.N. and his staff. This equipment was loaned by the Department of National Defence, H.M.C. Dockyard, Esquimalt, B. C. in cooperation with the Pacific Naval Laboratory at Esquimalt, B. C. The gear shows some promise for adaptation to trawling in surface layers.

Considerable time has been spent in gathering information on the webbing required for a mid-water trawl net. In keeping with the almost unanimous opinion of fishermen and the committee that nylon web is the most suitable for this type of fishing, a special study was made of the various types of nylon twine currently available in Canada and the United States. Designs of mid-water trawls developed in other countries have been studied with the view of adapting them to British Columbia trawlers and the conditions which exist in the British Columbia herring fishery.

The advice of Mr. P.J.G. Carrothers, who is now on the staff of the Pacific Experimental Station, is acknowledged in the selection of the most suitable type of nylon twine for the mid-water trawl. The nylon web of the required mesh and twine size has been delivered by a Canadian manufacturer and construction was commenced in November.

Although there is no assurance of a successful outcome, it is hoped that a type of mid-water trawl will be developed which will catch herring in commercial quantities. It is believed that development of a successful mid-water trawl could lead to a more orderly system of processing herring than that which currently exists and open a new field of operation for trawl fishermen in British Columbia.

W H A L E - G.C. Pike

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WHALE

G.C. Pike

THE 1954 WHALE FISHERY

The whaling station at Coal Harbour on Vancouver Island completed its seventh whaling season during 1954. This was a record year, considering the length of the season (from March 15 to September 15) the number of catchers operating (6 as compared to 4 or 5 in previous years) and the total catch, which has continued to increase each year since the operation began in 1948. Although the 1954 catch of 630 whales was the largest on record, the season was not the most successful.

The species composition of whales taken at the Coal Harbour Whaling Station during the years 1948 to 1954 was as follows:

Year	Fin	Hump	Blue	Sei	Sperm	Grey	Beradius	Right Whale	Total
1948	37	115	0	2	28	0	0	0	182
1949	105	76	2	3	69	0	0	0	255
1950	150	95	4	24	40	0	1	0	314
1951	216	51	9	5	153	1	1	1	437
1952	240	61	16	22	126	0	0	0	465
1953	181	47	8	14	275	10	4	0	539
1954	150	106	11	134	226	0	3	0	630
Total	1,079	551	50	204	917	11	9	1	2,822

The "catch per catcher's day's work" is used as a measure to gauge the the success of a whaling season. This unit gives consideration to the size of the fleet, the length of the season and time lost due to bad weather, repairs, refueling, etc. The whaling effort in 1954 was 750 "catcher's day's work" as compared to 611 in 1953 and 444 in 1952. Catcher's day's work lost as a result of poor weather, including fog, were 272 in 1954 as compared to 216 in 1953 and 201 in 1952. The number of whales taken per catcher's day's work was 0.84 in 1954 as compared to 1.05 in 1952 and 0.88 in 1953.

The species must also be considered when judging the success of a whaling season, as the species differ in value. Whale equivalents estimated according to oil yield are: 1 blue whale = 2 finbacks = 2 1/2 humpbacks = 6 seis. The 1954 catch consisted of a large proportion of sei and humpback whales. These species are economically less valuable than the blue or finback. In 1952, a good whaling year, about 75% of the catch of baleen whales consisted of blue and finback whales. In 1954, only about 44% of the catch of baleen whales consisted of these species and the value was consequently less. The outstanding features of the 1954 catch composition are the small proportion of finbacks, which during 5 previous years constituted the largest proportion of the catch, and the large proportion of sei whales, which during previous years were rarely taken.

The reason for the decline in the numbers of finbacks and in the proportion of finbacks in the catch is believed to be that the finbacks are becoming wary of this whaling area and are tending to avoid it. There is no evidence to suggest that the stock is being depleted. There has been no decline in the average lengths or in the proportion of mature animals in the

annual catches of this species. Catches at this station have always consisted mostly of young finbacks, immature or recently matured.

The biological study of the whales from this locality has been continued during 1954 but there has been a relaxation of field work in order to provide more time for analysing back data. A period of four weeks was spent at the whaling station in March and in August. During the remaining part of the season the statistical data on species, length, sex and foetuses required by the International Whaling Convention, were collected by company employees.

COLLECTION OF DATA

A routine system of data collection in examining the carcasses of each whale as it is processed has been followed since 1948. That season was one of familiarization and 1948 data have been excluded from the final analysis. Additional data from less than 50 whales were collected during the 1954 season. The following tabulation summarizes the collection of data for the years 1949-1953, inclusive. Analysis is directed towards an understanding of the life-history features of each species. These features relate to age, growth and maturity, and are fundamental to an understanding of the dynamics of the population.

	Finback	Humpback	Sei	Blue	Spern	Total
Ovary weight	391	109	23	18	24	565
Count of corpora lutea	219	67	26	16	23	351
Size of largest follicle	356	108	20	16	23	523
Width of uterine cornua	207	58	7	10	15	297
Mammary glands	445	128	30	20	22	645
Testis weight	376	167	30	15	526	1,114
Blubber thickness	778	282	57	34	577	1,728
Baleen recordings	798	292	61	35	-	1,186
Proportional measurements	474	221	56	34	415	1,200
Foetuses measured	129	38	20	5	12	204

Various other supplementary data are recorded for each whale. Stomach contents have been studied to show that finbacks, humpbacks and blue whales feed almost exclusively on euphausiids, chiefly the species Thysanoessa spinifera. Sei whales show a preference for copepods. Sperm whale stomachs contain mostly squid, of which at least 4 species occur, chiefly Moroteuthis robusta. Sperms feed secondarily on the ragfish, Acrotus willoughbyi. Rockfish, dogfish and skate occur in lesser quantities. Notes are recorded on the extent of diatom infestation and on the prevalence of scars caused by parasites. This gives information on migration. Parasites are recorded and specimens collected. A first report dealing with the helminth parasites of whales from this locality is at present in the hands of the publisher. A collection of pathological specimens has been set aside for future study.

An attempt to encourage the reporting of whales sighted along this coast is being fostered by the circulation of a whale identification booklet among fishermen and lighthouse attendants. Log books for reporting whales sighted have been placed aboard three U.S. Coastguard Lightships stationed at the mouth of the Columbia River, at Umatilla Reef and at Swiftsure Bank.

Log books have also been placed aboard the Canadian weatherships at Station "Papa" which is located about 1,000 miles west of Victoria.

RESULTS OF MATURITY STUDIES

Study of the reproductive organs permits the division of the catch into components according to sexual condition as shown in the following tabulation. Columns showing figures for the numbers of whales caught and the number examined will indicate the reliability of the percentage figures and the degree to which each is representative of the catch.

	Finback	Humpback	Sei	Blue	Sperm
Females					
Number caught	457	140	33	23	28
Number examined	439	128	32	20	25
Immature %	45.8	43.8	9.4	15.0	0
Pregnant %	29.8	26.6	62.5	25.0	48.0
Resting %	12.7	15.6	21.9	40.0	20.0
Lactating %	9.1	10.9	3.1	20.0	16.0
Ovulation %	2.5	0.8	3.1	0	12.0
Both preg. and lactating %	0	2.3	0	0	4.0
Males					
Number caught	435	189	35	16	634
Number examined	384	169	27	16	0
Immature %	52.1	45.5	4.0	37.5	-
Mature %	48.9	54.5	96.0	62.5	Almost 100%

Approximately one-half of the mature finback and humpback whales have been pregnant. The other half have been in a resting or lactating condition. Females which have ovulated preparatory to a new pregnancy were few. This suggests pregnancies in alternate years following first maturity. Foetus measurements show that breeding in these species is at a maximum during the winter months and that the duration of pregnancy is between 11 and 12 months. Finback whales conform closely to this schedule. Humpbacks, by reason of the occurrence of a few females which are simultaneously pregnant and lactating, and of a wider range of foetus lengths in any given period during the summer season, may occasionally breed out of season and may bear two young in a three-year period.

Male baleen whales are classified as mature or immature on the basis of testis weights. Finbacks, humpbacks, sei whales and blue whales, with testes weighing 5 kg., 7 kg., 1 kg. and 10 kg. respectively, are recorded as immature. Smears of seminal fluid from finbacks and humpbacks taken during the summer whaling season usually show an absence of spermatozoa, indicating a breeding season generally restricted to the winter months.

Male sperm whales in the catch consist mainly of small and medium-sized bachelor bulls. All but a few are sexually mature. Smears of seminal fluid from 100 sperm whales showed the presence of spermatazoa in all but one individual--a 34-foot whale. Spermatogenesis connences in this species at lengths of 36 feet or less and, unlike the baleen whales, continues unabated

throughout the summer months. Female sperm whales, which are uncommon in catches from temperate latitudes, were all sexually mature. The length of female sperm whales seldom exceeds 38 feet. Consequently, the 35-foot length limit precludes the capture of all but a few of the largest females.

Catches of baleen whales at the Coal Harbour station, in keeping with other shore station catches in temperate latitudes, show a large proportion of immature and young whales. The information provided by data described in the preceding appendix allow estimates to be made of the average lengths at which sexual maturity is attained. For finbacks the average length is 58 feet for the males and 60 feet for the females. Averages for humpbacks are 38 feet for the males and 40 feet for the females. Averages for blue and sei whales, because of the limited data available, are less clear. They are about 40 feet for sei whales and 68 feet for blue whales--the females attaining sexual maturity at lengths slightly greater than males.

AGE AND GROWTH STUDIES

The approach to the problem of age in baleen whales is being made by means of recording the surface sculptures on the baleen plates, counting numbers of corpora lutea in the ovaries of the females and by reference to length frequencies, which do not in themselves permit age classification. Corpora lutea counts give relative ages for mature females. Baleen plate recordings are most reliable for younger whales. As growth proceeds, the tips of the growing plates are worn away, thereby erasing early growth periods. A combination of the two methods is expected to yield the best age determinations.

Growth studies relate chiefly to the measurement of body proportions and the changes in body form which occur as growth proceeds. Body form of British Columbia whales is compared, according to sex and length, with the body form of their specific counterparts in other localities. Finback, sei and blue whales from British Columbia are found to differ in their relative body proportions from whales of corresponding lengths caught in the Antarctic. This difference demonstrates a faster growth rate in Antarctic whales of these species, but no specific or subspecific differences. The opposite condition seems to apply for humpback whales--their growth being faster in British Columbia waters. The body proportions of sperm whales are similar wherever this species has been studied.

M A R I N E C R U S T A C E A (C R A B A N D S H R I M P) - T.H. Butler

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MARINE CRUSTACEA (CRAB AND SHRIMP) - T.H. Butler

CRAB — T.H. Butler

The main part of the work on marine crustacea is concerned with the crab fishery of the Queen Charlotte Islands. The objective is to determine the cause of fluctuations in the fishery, and to recommend a management policy to ensure the maintenance of a stable fishery. To achieve this, the research program is divided into three phases: tagging, sampling and life-history studies.

The present status of the crab fisheries in Hecate Strait and McIntyre Bay is considered in a later portion of this report. It is believed that the intense exploitation by Canadian and American vessels in Hecate Strait has removed the greater part of the accumulated stock, and that the fishery is now dependent upon the recruitment of younger crabs. The situation is of economic importance since the crabs which moult to become commercial size in the summer months are inferior in quality.

A. Tagging.

The extensive tagging program conducted from 1947 to 1953 in these regions was discontinued during 1954. Only 10 tags were released southwest of Butterworth Rocks; to date no recovery has been reported.

During 1953, 261 crabs were tagged in Naden Harbour. In the 1953 fall fishery, 85 tags or 32.6% were recovered. The total catch was 58,916 crabs. The size of the population before the fishery is estimated at 149,700 crabs (fiducial limits at 95% confidence level = 127,400 and 172,200). The 1952 population estimate was 117,600 crabs. A spring fishery in Naden Harbour, March and April 1954, resulted in the recovery of 37 additional tags.

Analysis of the 1953 and 1954 recoveries from the 1953 tagging program in Hecate Strait and McIntyre Bay is not yet completed.

B. Sampling of undersized crabs.

Experimental fishing to determine the distribution and abundance of juvenile crabs was continued. Most of the work has been concerned with establishing the distribution; it has, however, been possible to compare the abundance in 1953 and 1954 at a number of stations.

Small-meshed trawls were used for sampling in 1954. Sampling data were also obtained incidentally in Hecate Strait in July, 1954 during the third groundfish survey by the Investigator No. 1.

Sampling was carried out as follows:

Area	Date	Total tows	Tows with crabs	Total crabs
Naden Harbour	Autust	28	18	201
McIntyre Bay	September	25	5	11
Hecate Strait	July	36	15	562

In Naden Harbour, tows taken in 10 localities were repeated in 1954. In 1954, post-larval or 0-group crabs were found to be less abundant than in the previous year: 1953--149 per 10-minute tow, 1954--15 per 10-minute tow. I-group were more abundant and more widely distributed in 1954 than in 1953: 1953--3 per 10-minute tow, 1954-- 5 per 10-minute tow.

In McIntyre Bay, the 0-group crabs were considerably less abundant in 1954: 1953--202 per 10-minute tow, 1954--4 per 10-minute tow. It is possible that more post-larval crabs would have been taken with later sampling in 1954, but the trawling was conducted at approximately the same dates in the two years. It was also found that the megalops larvae, the last larval stage before metamorphosis, were not abundant in 1954; this would suggest that the 1954 brood was less abundant than that of the previous year.

Sampling in Hecate Strait was not very successful. The presence of large quantities of detached algae restricted shallow trawling along the east coast of Graham Island by the Investigator No.1. Therefore, a valid comparison of the 1954 sampling with 1953 results does not seem possible.

The young stages of the crab are found most abundantly in shallow water (2 fathoms or shallower). In Naden Harbour they occur in the inshore regions associated with eelgrass. The eelgrass is not present along the exposed beaches of McIntyre Bay; here the post-larvae are found amongst the debris of detached algae. The I-group crabs in McIntyre Bay seem to be found in the region between Tow Hill and the entrance to Masset Inlet; the presence of many rocks and boulders makes trawling very difficult in this area and it is planned to carry out further sampling in this region with specially adapted traps.

C. Life-History studies.

1. Mating of male crabs.

As reported in the 1953 Annual Report, an attempt has been made to determine the size range of male crabs by the presence of mating marks. These marks on the claws of the male are the result of contact between the exoskeletons of the two sexes during the mating embrace.

During the 1953 season all males larger than about 12 centimetres were examined for the presence of mating marks. In Naden Harbour, of 181 males examined, 237 or 27.6% had mating marks. Of the 237 males with marks, 137 or 58.8% were legal size or over (17.5 cm., greatest width of carapace). It seems then that the legal-sized males formed a slightly larger part of the breeding population than smaller males. Mating marks were found less frequently on newly-moulted males of the legal size group. However, it is likely that these crabs mated before moulting or would mate after the shell became harder.

In Hecate Strait, of a total of 1,102 male crabs used for tagging, 179 or 16.2% bore mating marks. This value is considerably lower than the percentage found in Naden Harbour, but the Hecate Strait sample was taken earlier in the summer, probably before the peak of the breeding season. Samples of undersized males in Hecate Strait have not been available.

The study in Naden Harbour has indicated that the smaller males form an important part of the breeding population. It is possible that they would form an even higher proportion of the breeding stock if the abundance of males of commercial size were reduced by an intense fishery. There is an indication from the 1954 sampling in Hecate Strait that the undersized males are important in breeding there also.

2. Food of the crab.

The contents of 170 crab stomachs collected in trawls and on the beach during 1952 and 1953 were examined. Crustaceans were the most important

group in the crab's diet: in order of importance, amphipods, commercial crabs, mysids, barnacles, other crabs, cragonid shrimps, unidentified crustacea, and isopods. Clams were also important generally. Several different organisms were found in one stomach. Cannibalism was most evident in the crabs from Naden Harbour, where the small post-larval stages were eaten.

Since the main food organisms live either completely or partly buried in the sand, the crab obtains these by probing partly opened claws into the sand. The claw of the commercial crab is well adapted anatomically for this type of hunting.

Further samples were collected during the 1954 season. A progress report has been published (No. 99, July 1954) based on the samples collected during 1952 and 1953.

D. Status of the crab fishery in Hecate Strait and McIntyre Bay.

Hecate Strait. The region was first fished by a Canadian vessel in 1946. An American fleet appeared in 1950, and has continued to fish to the present. American vessels took from 69% to 76% of the total Hecate Strait catch during the period 1950 to 1952.

A feature of the 1954 fishery was the occurrence of many newly-moulted or soft male crabs. Sampling on two occasions in late July revealed that the catch was composed of up to 86% of newly-moulted crabs. These crabs are not of the best quality. The recovery of meat is lower than from hard crabs, and generally the crabs are not suitable for the valuable frozen product.

The occurrence of soft crabs is indicative of an intensive fishery removing the older hard crabs. As a result the fishery is now dependent upon the recruitment of younger crabs during the summer season.

Tagging conducted in Hecate Strait between 1947 and 1953 has shown increasing recoveries from 3.8% in 1948 to 31.3% in 1952, and to over 60% in 1953. The number of tags carried over into the second and third seasons had decreased, indicating a removal of accumulated stock.

The course of the fishery during 1954 indicates the dependence of the fishery on newly-moulted stocks. In the spring, Canadian boats had average catches of about 10 crabs per trap. These were hard crabs of the carry-over from 1953. Early in June the rate of fishing dropped off and remained low until about the third week in July; then fishing improved with the appearance of the newly-moulted crabs. These are believed to have moulted near the end of May, and for about six weeks had remained inactive, not entering the traps because of their soft condition.

To reduce the catching of these soft crabs a summer closed season of three months from June 1 to August 31 is suggested. Such a regulation would have to be applicable to American vessels to be effective.

McIntyre Bay. This region was first fished about 1939. After the development of the Hecate Strait fishery in 1946, McIntyre Bay was not heavily exploited. The Hecate Strait region was fished during the summer, and McIntyre Bay was reserved for a fall fishery. In 1953, however, the heavy concentration of American boats in Hecate Strait forced Canadian boats into McIntyre Bay earlier in the season than usual.

Tag recoveries in 1953 went to over 50% from 4.8% to 14.8% in earlier years. Soft crabs were reported to constitute most of the catch in the fall fishery in 1953. In July, 1954, a sample showed that 68.1% of the crabs were soft. By the end of August, the situation was so acute that

a closed season from September 1 to September 15 was instituted voluntarily by Canadian fishermen.

It is recommended that a closed season be established in McIntyre Bay. The moulting season is later here, probably due to lower water temperatures. Therefore, it is suggested that the dates of the closure extend from July 1 to September 30. Since the McIntyre Bay fishing grounds are almost completely in Canadian waters, a regulation applicable to Canadian boats only would be effective.

SHRIMP

The shrimp resource of the British Columbia coast is largely unexplored and undeveloped. Practically the entire shrimp production of the province comes from a small number of long-established grounds. Difficulties in the transporting and marketing of shrimps have hampered expansion of the industry. Within the last year, because of favourable market conditions and the need of off-season fisheries for many vessels, there has been increased interest in shrimp fishing.

Commencing in 1953, the Station carried out exploratory fishing for the purpose of locating new shrimp grounds, and also to study shrimp fishing gear. An experiment to test the holding of shrimps in refrigerated sea water was planned in cooperation with the Pacific Fisheries Experimental Station. The above objectives were achieved during the winter months of 1953-54. An extended program of shrimp prospecting is being conducted during 1954.

A. Results of the 1953-54 program. T.H. Butler and H.E.J. Legare

The program was carried out during the period November 10, 1953 to March 10, 1954. Two vessels were used for prospecting: the Station trawler Investigator No. 1 and a chartered vessel, the Yuri M.

One hundred and fourteen tows were completed in the Strait of Georgia, in Chatham Sound, and in Queen Charlotte Sound and adjacent inlets. Shrimps were taken in commercial quantities in 36 tows.

The most promising grounds were found near Cape Lazo in the Strait of Georgia. The average rate of fishing was 352 pounds per hour, with the best catch of 1,293 pounds per hour at 40 fathams. The region was fished commercially soon after the prospecting, and proved to be very productive. In Chatham Sound the results indicated that the region surveyed would support a moderate shrimp fishery. The best fishing was encountered near the Kinahan Islands with catches up to 258 pounds per hour.

An experiment was conducted to compare the efficiency of the shrimp otter-trawl and beam trawls. It was concluded that the otter trawl was more efficient for catching shrimps on a time basis since it could be towed faster. In the course of a fishing day the otter trawl will catch more shrimps. The otter trawl was also found to catch more fish than the beam trawl. This is a disadvantage in that the larger loads of fish may damage shrimp by crushing in the net and increase the work of sorting.

Refrigeration equipment was installed and tested aboard the Investigator No. 1. Shrimps were held on the vessel in the refrigerated sea water on two occasions, for periods of 4 and 8 days without loss of quality. A separage report describing the equipment and results of the experiment has been issued by the Pacific Fisheries Experimental Station.

A miscellaneous collection of fishes, invertebrates, and parasites was taken during the survey and given to interested specialists.

A mimeographed circular (No. 31) on the results of the prospecting program has been prepared and distributed widely.

B. The 1954 prospecting program. T.H. Butler and G.V. Dubokovic

The aim of the current program is to extend the shrimp prospecting into regions of the British Columbia coast previously unexplored. In addition to the shrimp trawling which comprises most of the program, a certain amount of prawn trapping is being conducted. The program commenced on May 31, and will continue until the middle of December, 1954, using the chartered vessel Yuri M.

During June and July, regions on the west coast of Vancouver Island were prospected. One hundred and eleven otter trawl tows and 26 prawn trap sets were completed. One small shrimp trawling ground was located in Berkley Sound, where one tow yielded shrimps at the rate of 358 pounds per hour. No prawn trapping ground of commercial importance was located.

In the Strait of Georgia during August, 41 prawn trap sets were completed. Prawns were taken in commercial quantities in two localities: off Galiano Island in 42-52 fathoms, and off Gabriola Reef in 35-43 fathoms. In both regions, average catches of about 3 pounds of prawn per trap were recorded.

At the request of the Department of Fisheries a short prawn survey was conducted in Saanich Inlet, which is an area closed to all commercial fishing. Ten trap sets with 80 traps were completed, yielding an average catch of 0.44 pounds of prawn per trap. Reasonably good coverage of the inlet was obtained. Other regions in the Strait of Georgia with similar or better prawn abundance are open to trap fishing.

During September, prospecting was continued in Chatham Sound and in localities in the vicinity of Portland Canal and Observatory Inlet.

P A T H O L O G Y - L. Margolis

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PATHOLOGY - L. Margolis

The aims of the pathology investigation are to survey and assess the incidence and economic importance of parasites and pathological conditions in marine animals and to select appropriate economic problems for further detailed study.

The presence of parasites or diseases in fish may be of economic importance because they reduce the availability or interfere with the marketability of fishery products.

The main problem selected for study dealt with a nematode infection in herring. The research on this problem followed two distinct lines: (1) an analysis of the incidence and intensity of the infection in herring of different regions, and (2) attempts to elucidate the life history of the parasite.

A general survey of the parasitic fauna of marine fishes and mammals is continually in progress.

THE INCIDENCE AND INTENSITY OF ANISAKIS INFECTION IN HERRING - L. Margolis and Yvonne Bishop

The results of a preliminary analysis of the data obtained by the herring investigation in 1950-51 and 1951-52 were previously reported (1951 Annual Report of the Pacific Biological Station). The raw data have since been transformed, logarithmically, using the formula $Y = 100 \log_{10}(x + 1)$. The values obtained by this transformation had a near normal frequency distribution and hence could be analysed by use of established statistical methods. The analysis has been completed and a paper will shortly be presented for publication. The main conclusions, which are as follows, generally support the results of the preliminary analysis. For a map showing the location of areas referred to in this report see page 74.

A. Incidence.

In 1950-51, of 2,261 fish sampled, throughout the herring fishery, 91.9% were infected, and in 1951-52, 86.4% of 3,047 fish were infected. Fish in Area 7 in Hecate Strait and on the west coast of Vancouver Island showed an incidence of 90-100%, whereas the incidence in fish from the Strait of Georgia was 80-90%.

B. Intensity.

(1) The level of infection was highest in Area 7, and decreased north and south of this area. On the west coast of Vancouver Island the intensity decreased from Area 25 to Area 23. Throughout the Strait of Georgia the level of infection appeared to be constant and was lower than on the west coast of Vancouver Island.

(2) In all areas the level of infection noticeably increased with the age of the herring. The increment between successive age-groups was greatest in the most heavily infected areas. One-year fish were not infected.

(3) The level of infection was not influenced by the sex of the fish.

(4) There was no indication of a change in the degree of infection with progression of the fishery.

(5) In most areas the infection was a little lighter in 1951-52 than in 1950-51, but the same general trends were noted.

The incidence of infection (in percentage) and the mean level of infection (in actual number of worms) according to area of capture were as follows (all ages combined):

Area number	Number of fish examined		Incidence of infection		Mean level of infection	
	1950-51	1951-52	1950-51	1951-52	1950-51	1951-52
2B(E)	152	229	97.4	93.4	14.8	11.1
5	451	638	93.8	96.1	12.8	15.5
6	-	290	-	94.8	--	17.9
7	552	258	98.3	96.2	27.3	24.4
9	-	20	-	45.0	--	0.8
12	-	253	-	39.0	--	3.4
13	169	154	76.9	59.7	9.5	5.0
17A	173	337	86.7	87.2	5.7	5.5
17B	187	-	85.0	--	7.0	--
18	210	385	83.8	81.8	6.1	5.2
23	368	160	96.2	94.4	12.9	8.3
24	-	10	-	100	--	14.3
25	-	361	-	100	--	24.6

The incidence of infection (in percentage) and the mean level of infection (in actual number of worms) according to the age of herring, were as follows (all areas combined).

Age	Number of fish examined		Incidence of infection		Mean level of infection	
	1950-51	1951-52	1950-51	1951-52	1950-51	1951-52
I	--	97	--	0.0	--	0.0
II	81	259	62.1	38.9	2.2	1.5
III	799	896	92.7	85.9	6.1	6.2
IV	1002	858	93.3	96.6	16.1	13.5
V	220	826	92.7	98.9	23.4	20.8
VI	95	130	100	98.5	32.3	27.7
VII+	37	29	97.3	100	31.1	49.2

LIFE-HISTORY STUDIES OF ANISAKIS SIMPLEX — L. Margolis

In last year's report it was indicated that a survey of marine animals demonstrated that the definitive hosts of Anisakis were cetaceans. As, so far, it has been considered impossible to obtain living young, uninfected cetaceans for use in feeding experiments, an alternative method of elucidating the life-history has been followed. This involved obtaining eggs from adult worms, hatching them and attempting to follow the larvae through to the stage found in herring.

A. Attempts to find first intermediate hosts.

1. Experimental.

Living adult Anisakis simplex were obtained this year from a harbour porpoise, Phocoena vomerina. Eggs were dissected from the uteri of worms and hatched in sea water at room temperature. Previously, it was determined that the hatched larvae (apparently 2nd stage larvae) would not directly infect young herring and that Euphausia pacifica was a likely intermediate host. Attempts to infect E. pacifica again failed, as these crustaceans survived for no more than 3 or 4 days in the laboratory. Moreover, there was no evidence that they had fed during this time. An apparent scarcity or inability to capture E. pacifica this year hampered possibilities of extensive experiments in culturing these animals.

Three other crustacea, the humpback shrimp (Pandalus hypsenotus), a prawn (Pandalus platyceros) and the gray shrimp (Crago nigricauda) were also used in attempted infection experiments, since it was discovered that they could be kept indefinitely in the laboratory. Although they fed voraciously on food heavily contaminated with A. simplex 2nd stage larvae, there was no evidence that the larvae survived in these crustacea.

2. Examination for natural infection.

Examination of 200 to 300 E. pacifica, caught near Nanoose, Vancouver Island, did not reveal a natural nematode infection.

PARASITE SURVEYS

A. Marine mammal parasite surveys. L. Margolis

Large collections of whale parasites have been obtained by Mr. G.C. Pike. These have partly been studied and several publications have appeared in print or have been submitted for publication. Among the parasites recorded are three new species, viz., Cyamus catodontis, an external amphipod parasite of the sperm whale; Lecithodesmus spinosus, a new species of liver fluke from the sei whale; and Crassicauda pacifica, a new species of nematode from the kidneys of the fin whale.

B. Fish parasite surveys. L. Margolis and Deena Wakhroucheff

About 200 fish representing about 30 species have been examined for parasites, of which approximately 90% were infected. Forty-five percent were infected with trematodes, 40% with ectoparasitic copepods and isopods, 2% with cestodes and less than 1% with Acanthocephala. The most common parasites were the body cavity nematodes, all of which belong to the family Anisakidae. Detailed taxonomic studies are at present being carried out.

C. Invertebrate parasite studies. L. Margolis

An unusual and extremely heavy nematode infection of a shrimp has been studied. The parasite, Contracaecum aduncum, has been described in a paper submitted to the Journal of Parasitology.

MISCELLANEOUS

L. Margolis

During the course of the year, a number of specimens of diseased fish has been submitted from various sources for diagnosis. Some of these were samples from mass mortalities. Among the diagnosed cases were different types of tumorous fish and bacterial infections. One bacterial infection, a hemmorhagic septicemia of herring caused by a *Vibrio* organism, appears to have possible economic significance.

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EXPERIMENTAL BIOLOGY

J.R. Brett

The main theme of research in Experimental Biology involves contributing to a solution for safeguarding the passage of migrating salmon around obstructions, particularly those created by the use of water for power. Examination of the problem indicated that a fruitful path of investigation lay in determining how salmon could be effectively directed in their freshwater migrations, such that their safe passage could be ensured. Basic information of this nature is scant.

Investigations on young salmon have been conducted in a large experimental trough in which a variety of guiding techniques could be readily tested. From this study has emerged a possible system of directing sockeye migrants by the use of a curtain of hanging chain. Efforts have been concentrated on defining the most effective conditions of operation by further testing within the trough, and a major effort has been made to translate the trough findings to actual field conditions. This latter has been attempted by the construction of a prototype chain deflector in the Lakelse River. Work om the adult migration has involved investigating the effect of odours on the upstream movement of coho and chinook salmon. The discovery that some odour emanating from the skin of mammals had a repellent effect, even at extreme dilutions, was of considerable significance. The possible use of a concentrated repellent to disperse salmon away from potentially dangerous areas is evident. In conjunction with the Fisheries Experimental Station at Vancouver, attempts to isolate the active ingredient and to test it for sustained activity have currently been undertaken. This olfactory response has pointed up the need for more generalized studies on sensory perception in salmon. It is most desirable to obtain information on attractive odours.

The second theme of research is concerned with defining the significance of the physical and chemical elements of the environment to survival and distribution of fish. Laboratory experiments on the minimum oxygen requirements of chum salmon eggs, on the salinity tolerance of young sockeye, and on the toxicity of various pollutants have been undertaken.

EXPERIMENTS ON GUIDING DOWNSTREAM MIGRATING SOCKEYE YEARLINGS - J.R. Brett and D.F. Alderdice

The investigation of how to guide young sockeye during their downstream migration was commenced at Lakelse Lake in 1953. By the use of a large experimental trough and by testing a variety of potential deflectors, it was discovered that chain hung vertically in the form of a "curtain" was an effective deflector when the interval between strands of chain did not exceed 4 inches. These tests were conducted at an angle of 45° to the flow.

An expanded program of investigating this means of guiding young sockeye was conducted during the 1954 sockeye migration. Questions concerning the type of chain, the angle of deflection, the cause of deflection, possible benefits resulting from vibrating the chain, and the effect of rate of flow, needed to be investigated. Most important of all was the question of whether the method would work under actual field conditions with normal-run migrants, unhandled and unconfined within a trough. To test this latter relation a hanging chain deflector, 56 feet long, was built at a 45° angle to the upstream face of the Lakelse River counting weir. A hand-driven vibrator was designed and coupled to the aluminum tubing which carried the suspended chain. This deflector was located in such a manner as to influence the fish which would normally move into Pen I of the weir and guide them into Pen II.

A. Results of the trough experiments.

(1) Complete confirmation of the 1953 trough results was obtained. Experimentally, a schooling species of young salmon (e.g., sockeye) can be guided by a row of hanging chain. A non-schooling species (e.g., coho) does not respond in the same manner.

(2) The angle of deflection was found to be very important. The maximum angle which still results in high deflection (for flows of 0.5 ft. per sec. and less) appears to be about 57° to the direction of flow. Beyond this angle, effectiveness is progressively reduced for unvibrated chain.

(3) The type of chain is not important.

(4) The response is dependent mainly upon vision. Light sufficient for vision appears to be possible for these fish at very low levels of intensity (considerably below an incident intensity of 0.001 foot candles).

(5) The effectiveness of a given interval of chain is increased when vibrated (144 r.p.m., 3-4 inch stroke). The sight of a moving object is apparently a greater stimulus in causing deflection.

B. Results of the river deflector experiments.

The results from these experiments were quite clear in some instances and conflicting in others. The possibility of such confliction became apparent before any experiments were conducted. Despite the fact that the deflector was built at a 45° angle to the face of the weir, the presence of a new abutment built in the river bank to carry the vibrator, and a natural upstream constriction in the river flow, resulted in a current flow almost at right angles to the line of deflection. This placed the new deflector in the position of a face-on block, not, as intended, as a guiding influence, causing the fish to angle off downstream in a manner comparable with the 1953 trough experiments. Trough tests conducted immediately placed us in the uneviable position of correctly predicting that such a combination would not work. This rather surprising angle of flow had its more fortunate aspects. If it were possible under these adverse conditions to achieve a measure of deflection, and to relate this to the trough experiments, clarity of the field problem would result.

Limited consideration of the data collected supports these conclusions:

(1) Unvibrated, illuminated chain placed directly in the path of migrants has nothing but momentary influence on their continued progress downstream.

(2) Good deflection can be achieved with sockeye if the chain is vibrated (4-inch interval between strands, 4-inch stroke, 144 r.p.m.) and the flow does not exceed 0.5 feet per second.

(3) Much of the initial deflection can be lost if attractive, alternative downstream paths are not presented to the fish. Repeated experiences along the deflector resulted in the breakdown of clost schooling and penetration through the curtain of chain.

(4) As flow increases above 0.5 feet per second the effectiveness of such a block is reduced. The constant "pressure" of the current results in the fish moving into direct contact with the chain and, despite being actually struck by the moving links, they pass through the interval between strands.

The results of these direct field tests have been most beneficial in providing experience in the real problem - directing natural-run migrants, free from the relative simplicities and oddities presented in an experimental trough. The latter provides the ideas and possible techniques, but not the answers. It is now apparent that deflection in the trough is readily achieved because the alternative path, away from chain and into the other half of the trough, is both attractive and within the visual range of the fish. No such relation exists where 56 feet of hanging chain is faced and that much less if it were 560 feet.

In the field the presence of many other fish, steelhead, dolly varden and suckers, sometimes sent the young salmon darting in all directions, oblivious of any deflector.

It is only possible to speculate on the success of a similar type deflector operating under the specified conditions now set forth, namely, illuminated, vibrated, not more than an angle of 57° to flow when that does not exceed 0.5 feet per second, and coupled with an attractive alternative route. It is our opinion that these conditions are not particularly difficult to meet. Research on attractive openings must be commenced.

ISOLATION OF THE REPELLENT FACTOR IN MAMMALIAN SKINS DETERRENT TO ADULT SALMON

D.F. Alderdice and
J.R. Brett

In the course of investigation sensory perception in salmon it has been established that salmon exhibit an olfactory sensitivity to a substance produced by the skin of certain mammals. When introduced into the water, the repellent substance causes an interruption in the upstream migration of coho and spring salmon. The response to the repellent has recently been confirmed for sockeye and chum salmon.

In 1953 a knowledge of many of the physical properties of the repellent was developed with a view toward isolation of the active material and identification of its structure. It is considered that such a substance may find an application in the manipulation of salmon runs, particularly with reference to the increasing utilization of water resources by industry.

Gross separation techniques are now known. The second stage of isolation now in progress requires the use of more sensitive techniques which will differentiate between substances whose physical and chemical properties are too similar to allow successful separation by gross procedures. Continuous electrophoretic techniques have allowed collection of the active principle separated both from materials carrying strongly negative and from others with strongly positive charges. Since the active principle carries a small charge, adjustments are now being made to expand the neutral range to effect separation of the repellent from other molecules occurring within this range.

It is considered that the knowledge of physical properties of the repellent already gained and the employment of sensitive isolation procedures currently being tested will allow extraction, isolation and concentration of the repellent substance.

Further information may be obtained from the Annual Report of the Pacific Fisheries Experimental Station where these extraction procedures are being carried out. Field testing of the extractions has been the continued responsibility of the Pacific Biological Station.

POLLUTION STUDIES - D.F. Alderdice and J.R. Brett

A. Toxicity of kraft mill effluent.

Kraft mills discharge large volumes of effluent into waters inhabited at various times of the year by migratory stages of salmon. Recent indications of increases in the production of pulp and paper have made it necessary to examine what levels of effluent concentration are tolerable to young Pacific salmon. No information on the effect of the particular combination of present-day sulphate effluents discharged into saltwater estuaries inhabited by young salmon was previously available. If the downstream migrant may be assumed to be the more vulnerable stage in the cycle, the conclusions from this stage of development may then set the level of effluent concentration tolerable to Pacific salmon.

The problem is quite complex. The influence of varying temperatures, salinities, oxygen concentrations, time of exposure and developmental stage of the fish precludes any simple treatment.

As a representative study, the relations recorded at the head of Alberni Inlet were taken as likely type conditions. Sockeye salmon underyearlings averaging 5.04 cm. fork length and cultured at 18°C. were exposed to various concentrations of kraft effluent at 18°C. and a salinity of 20 o/oo. Solutions were made up from 24-hour composite samples of kraft effluent usually from 24 to 36 hours old. Tests were conducted in static volumes of these solutions and changed every 12 hours. Some trouble was experienced with low oxygen conditions at the end of several 12-hour periods but, in general, these tended to point up an increased oxygen requirement for fish held in the higher concentrations. Toxicity of the several concentrations of effluent tested are listed in the following table.

Test solution per-cent effluent	Median effective dose in minutes	"Safe exposure" in minutes*
18	1,190	---
10	1,300	300
8.5	2,550	450
7	2,700	1,000
6	5,400	1,550
5	11,000	3,400

* Semi-graphic estimation, pending analysis

If it may be assumed that migrants remain in the estuary of a river for a period of between 1 to 4 weeks, effluent concentrations in that region should allow safe exposure for an appropriate time period. Estimated safe exposure concentrations of kraft effluent* for sockeye underyearlings exposed for periods of 1 to 4 weeks at 18°C., salinity 20 o/oo, are as follows:

Exposure, weeks	Concentration, % effluent
1	4.0
2	3.6
3	3.5
4	3.3

* Semi-graphic estimation, pending analysis

Observations of hypoxial behaviour and the oxygen levels at which they occurred in the test solutions suggested that critical oxygen requirements rise from a minimum level of about 2 p.p.m. in the lowest effluent concentrations to about 5.4 p.p.m. in the 18% effluent test solution. In view of these results, it may be ventured that in situations where oxygen depletion of a water mass by the oxygen demand of the effluent is insufficiently counterbalanced by dilution and exchange, the synergistic action of toxicity and low oxygen conditions may lower the minimum acceptable dilution of effluent or, conversely, raise the minimum acceptable concnetration of oxygen required for safe exposure.

B. Toxicity of sodium arsenite.

Methods of treating flat rafts and Davis rafts against teredo infection while in salt water are being investigated in British Columbia. Sodium arsenite solutions have been demonstrated as effective agents for teredo control. In line with this developmental work the Department of Fisheries asked the Fisheries Research Board for information on the toxicity of sodium arsenite to fish.

Of the two types of raft which are treated, it would appear that the greater potential danger to marine organisms would occur in the locations for treatment of Davis rafts. Consequently, a species of economic importance which may be expected to frequent such treatment sites was selected as the test animal. Young chum salmon averaging 4.71 cm. fork length were cultured at 14 to 15°C. and tested at three concentrations of sodium arsenite at a mean temperature of 14.6°C. and a salinity of 18.1 o/oo. These concentrations were selected to cover a range in which it is considered exposure under field conditions would occur. The sodium aresenite vehicle used in the tests was "Penite 6X", a commercial preparation used in some of the raft treatment studies. Test solutions used in the bioassays were analysed by the B.C. Research Council for sodium aresnite content.

Results of the toxicity tests are given in the following tabulation.

Sodium arsenite as p.p.m. As_2O_3	Median lethal exposure, in minutes	"Safe exposure", in hours
410	88	1
85	398	3
12.2	2,600	11.6

The median lethal exposure at the three concentrations tested are hyperbolic functions of sodium arsenite concentration. Safe exposure at each concentration represents the extension of the provisional probit curve to zero mortality. Safe exposure limits (shown in the previous table) therefore, may be estimated from a double log plot of safe exposure time against concentration, within the concentration limits indicated.

Under field conditions, high concentrations probably would be applied to rafts to ensure complete teredo kill before dilution by seawater rendered the diminishing concentration of sodium arsenite ineffective. Since the effects of exposure are probably additive in a series of concentrations diminishing with time, total sublethal experience would depend on the rate of diminution in toxicity of the area in which treatment occurs. Dilution may be expected to be rapid. Under conditions approaching the characteristics of this series of tests, the safe exposure times listed may be regarded as a good approximation of the limits of sublethal experience.

ENVIRONMENTAL FACTORS

A. Minimum oxygen requirements for chum salmon eggs.

D.F. Alderdice, J.R. Brett and W.P. Wickett

To determine the minimum suitable conditions for successful development of salmon eggs, or the cause of death when mortality has occurred, experiments on oxygen requirements have commenced (see Pink and Chum Salmon Report, page 50).

The oxygen uptake of incubating salmon eggs is dependent on three main environmental variables. Temperature of the water medium influences the rate of uptake, while oxygen content and the velocity of the water perfusing the egg mass determine the availability of oxygen for respiration.

Chum salmon eggs collected at the Nile Creek field station were transported to the laboratory and cultured at 5°C. prior to experimentation. Oxygen requirements for eggs in the first series completed were determined at 5°C. at a developmental stage just prior to and during hatching.

Respiratory requirements were evaluated in a series of solutions varying in degree of oxygen saturation. Continuous flows of water at selected levels of oxygen saturation were introduced into the egg chambers by adjustment of the rates of flow to each chamber of saturated and desaturated water supplies. Desaturated water was produced by equilibrating water in a stripping column to an atmosphere of nitrogen.

The first series of tests was carried out at maximum flow rates to each chamber so that oxygen availability would be dependent only on the level of oxygen in the perfusing media. Mortality in the samples was followed for one week. The eggs were transferred to normal oxygen conditions in order to follow any post-experimental mortality until hatching was completed.

Results are illustrated in the following table:

	Mean oxygen concentration, p.p.m.					
	0.255	0.292	1.41	1.97	4.20	12.47
Survival in test period (%)	0	10	90	100	100	100
Survival in total hatch (%)	0	10	70	100	100	100
Hatch in test period (%)	30*	20*	70	60	30	20

*Including alevins which hatched and subsequently died.

The results suggest that at 5°C. chum salmon eggs at the developmental stage considered are tolerant of low oxygen concentrations to a minimum between 1.41 to 1.97 p.p.m. when velocity of the perfusing system does not limit oxygen availability. The level of oxygen concentration at which 50% of a sample would survive in a period of one week is about 0.65 p.p.m.

The data suggest a dependence of hatching rate on the level of oxygen concentration of the perfusing medium. Rate of hatching in the experimental period is minimal in the sample near saturation. Increases in the hatching rate progress to a maximum in the region of transition from tolerance to resistance against low oxygen. Further decreases in oxygen

level below the zone of resistance produce a stress on the organism inhibiting further development. It would appear that the increased rate of hatching provides a compensatory mechanism which allows eggs more quickly to become independent of the limiting effects on respiration imposed by the egg capsule.

B. Salinity tolerance in young sockeye — J.G. Hunter

Experiments to determine the tolerance of young sockeye salmon to sea water have been made. Analysis of this work is not yet complete but facts point to a total survival in sea water of concentrations up to approximately 20 $^{o}/_{oo}$. Repetition of this work on sockeye of increasing sizes shows tolerance to increased salinities, suggesting tolerance is related to the volume/oral surface area ratio.

It was not possible to show acclimation to sea water by prolonged immersion in sub-lethal concentrations of sea water.

CRUISING SPEEDS OF YOUNG SALMON

J.R. Brett and Mary Lennox

Cruising speeds of fish were measured by determining the maximum sustained steady-rate of swimming maintained for at least one hour. They constitute a measure of two fundamental aspects of fish performance: (1) the actual physical ability to swim, and (2) the capacity of the animal to do sustained work, i.e., metabolic performance (which may or may not be directed into the act of swimming).

These measurements are of value in determining what rate of flow of water does not exceed the capacity of a fish to stem the flow. In cases where water is screened for irrigation or for turbine use, or any other use which is potentially destructive to fish, that rate of intake must not exceed the cruising speed of the fish. Information of this nature is almost entirely lacking.

Present experiments demonstrate that for salmon underyearlings the rates are less than 1 foot per second (0.68 m.p.h.) in almost all instances. At temperatures of 5° C. and less, the cruising speeds average about 0.5 feet per second. Systematic cataloguing of the cruising speeds of all underyearlings and yearlings of Pacific salmon at temperatures ranging from 1° C. to the upper lethal levels of 24-25° C. is in progress. Work on coho and sockeye is reaching completion.

As a measure of metabolic performance, the highest cruising speeds have provided an index of the temperatures at which the fish are most likely to succeed, and consequently the temperatures at which they are most likely to be found. This has been borne out by the studies on coho and sockeye. Coho show an optimum performance in the vicinity of 20° C. and maintain a high level of performance even approaching the lethal level. They are found in streams and inshore shallows of lakes in mid-summer. Their activity is greatly reduced by low temperatures.

In contrast, young sockeye display their optimum at about 15° to 16° C., and have a greater ability to perform at low temperatures than do the coho. The fact that sockeye tend to be offshore in deeper waters of the lake and only move into the streams during the early spring supports the proposition that the swimming speeds are a profitable laboratory measure of ecological temperature relations. Measurement of lethal temperatures and preferred temperatures have not distinguished so clearly the fundamental differences between these species.

P O L L U T I O N - M. Waldichuk

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P O L L U T I O N - M. Waldichuk

Problems on pollution had been conducted heretofore by Dr. J.P. Tully and staff of the Pacific Oceanographic Group. The work on pollution under the writer's charge commenced in July, 1954, and will concern problems affecting the fisheries. Where solutions can be obtained only through research it is planned to conduct field surveys supplemented by any necessary laboratory work. It is anticipated that there will be numerous ad hoc problems presented by industries which plan waste disposal into natural waters. When possible, these problems will be dealt with from known characteristics of the wastes, the nature of the waterways into which the wastes are to be discharged, and information available in the literature.

KRAFT PULP MILL POLLUTION IN ALBERNI INLET

This study was undertaken by Alderdice and Brett on the toxicity of kraft mill effluent (see page 158). Application of the laboratory results to conditions in Alberni Inlet was made on the basis of early work reported by Dr. J.P. Tully. From data supplied by Dr. P.C. Trussell of the B.C. Research Council on the biochemical oxygen demand of kraft wastes, the limits of waste effluent discharge were defined under present conditions of river flow. The curves of oxygen supply at varying river discharges and oxygen demand at varying dilutions of the waste effluent were used to determine the necessary Somass River discharge for a particular volume of waste.

SURVEY OF EXISTING CONDITIONS IN ALBERNI INLET

During early September, 1954, an oceanographic survey was conducted in Alberni Inlet. Its purpose was to determine the dissolved oxygen and mill effluent concentrations in the inlet under conditions of late summer.

Results show that existing dissolved oxygen concentration meet the maximum requirements established in biological assay studies. Oxygen concentrations were low in the deep water due to intrusion of low-oxygen water from the sea. In the surface water, low-oxygen values were found only in the immediate vicinity of the sewer outfall as a result of effluent oxidation. Concentration of effluent was quite high (about 5%) in the surface water at the Somass River mouth during the flood tide. This condition is probably very transient and occurs only during calm weather so that it is not considered serious from a fishery viewpoint.

MISCELLANEOUS PROBLEMS

As part of a program of consultation on ad hoc problems two items have been dealt with on the basis of available information: (1) Some data were provided on the character of the bottom of the Strait of Georgia at the request of the company which is to supply the underwater cable for power transmission from the mainland of British Columbia to Vancouver Island, (2) Another request came from a firm concerned with corrosion of equipment used in pumping cooling water from the Gorge, near Victoria, B.C.

W E S T E R N A R C T I C - F. Neave

W E S T E R N A R C T I C - F. Neave

The joint Canadian-United States Beaufort Sea Expedition of 1954 included a biological observer who travelled on the U.S.C.G.C. Northwind, one of two ice-breakers which left Esquimalt on July 17 and returned on September 28.

His objectives were: (a) to make observations and collections relating to the fields of marine mammalogy and fisheries, and (b) to formulate impressions and suggestions regarding the desirability or direction of future biological work in the Western Arctic, having in mind particularly the possibility of increasing the availability of food supplies to the native human populations.

The route travelled included the crossing of the Beaufort Sea, the circumnavigation of Banks Island and the brief exploration of the southern size of Viscount Melville Sound.

Opportunities for collections were limited by the necessity of conforming to the major objectives of the expedition which were primarily non-biological, and by the difficulty of operating gear successfully in areas subject to the vicissitudes of moving ice.

Records were kept of mammals and birds sighted during the course of the expedition. Plankton hauls were made in conjunction with the various stations established for obtaining oceanographic data. The bottom fauna (previously almost unknown) was sampled by grab dredge and (on two occasions) by the use of a small beam trawl. Fishing was attempted by traps, gill nets and explosives as opportunity permitted. The fathometer tracings of the ship were examined for indications of schools of fish or concentrations of other organisms.

While the collected material has not yet been examined, certain findings may be summarized as follows:

1. A sparse population of ringed seals was observed throughout the areas visited. The bearded seal was only seen in Prince of Wales Strait.

2. No walrus were sighted during the Canadian portion of the cruise.

3. Bowhead whales and white whales were each sighted on only one occasion in the Banks Island area.

4. Despite considerable quantities of amphipods and other bottom and plankton organisms in some areas, no evidence was disclosed of significant stocks of marine fish around the coasts of Banks Island.

5. Whitefish and char were found in the fresh water of the Thomson River at the north end of Banks Island.

Most of the areas examined in 1954 are relatively remote from the main existing native settlements. Because of this and in view of the lack of evidence of any considerable unexploited stocks, it is thought that work in the near future could more profitably be devoted to waters near the mainland coast. Although the 1954 expedition provided no opportunity for the collection of first-hand data in these latter areas, existing reports indicate the presence at times of fish and mammals in greater numbers than

were observed in localities further north and north-east. It is by no means certain that these more readily accessible stocks are being fully utilized. It is suggested that assessment of biological resources and examination of opportunities for additional exploitation should begin at a point where the need is immediate and some local knowledge is available. Extension of operations to other areas might follow as a logical development from the information gained.

It is thought that such work could best be started by a small team working from or near shore and operating over a longer season than is possible for a ship which must travel from and to a southern port in the course of a single season. A small vessel of landing craft type, which would combine working facilities with living quarters and which could be left in the area between seasons is considered to be especially suited to the operations of such a team.

M I S C E L L A N E O U S S T U D I E S

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MISCELLANEOUS STUDIES

RECORDS OF FUR SEAL IN INSIDE COASTAL WATERS OF BRITISH COLUMBIA - J.I. Manzer

As far as it can be determined, no published records of northern fur seal (Callorhinus ursinus) in inside coastal waters of British Columbia exist in the literature dealing with migration and distribution of this species. However, records based on sight or actual examination of dead or dying individuals provide positive evidence that occasionally they do occur in limited numbers in these waters. During the past two years 20 authentic observations reporting on more than 30 individuals have been collected, the earliest being made in 1930. These records are now being prepared for publication.

POLYCHAETE STUDIES — E. and C. Berkeley

Work on Micronereis nanaimoensis has made little progress since the last report. No jelly-masses could be found at the low tides in early April this year. Stormy weather conditions made search difficult and the eel-grass on which they are usually found in greatest quantity had made very little growth. At the low tides in early May the eel-grass had made considerable growth and jelly-masses were more plentiful on it than we have ever known them to be. The development of the contained eggs was quite advanced in many cases. A heavy swarming must have taken place during April in spite of the fact that the weather was almost continuously stormy and the temperature of the water low.

A good many swarmers were still to be found in May, but almost exclusively males. Only two ripe swarming females were secured. These were mated and in due course produced fertile eggs, but the onset of egg laying was missed in both cases so that we still are without direct observational information as to the method of extrusion of the eggs. Confirmation of the opinion expressed in our 1952 paper that the eggs are passed out through openings at the base of the lobes of the parapodia has, however, been obtained indirectly by examining the feet of the swarming females secured in May fixed in Bouin immediately after laying. We found well defined openings at the base of both lobes (not the notopodia only, as originally thought) which are not present before the eggs are laid and we have confirmed this by re-examination of old similar material.

Renewed attempts were made to rear larvae beyond the 3-segmented stage. A series of experiments utilizing bolting-silk cages, both in aquaria and in the open sea, were unsuccessful. We have set up an aquarium, containing a bed of sterilized sand with circulating water, into which a large number of larvae in the 3-segmented stage have been placed. This will be maintained throughout the winter in the hope that sexually mature specimens will emerge from the sand in the spring.

The study of Dodecaceria fewkesi has also progressed very little during the year. Fertile eggs were obtained from colonies collected at the May low tides in the manner described in our paper of this year and larvae were reared to a slightly later stage of development than that of the latest one described in that paper. At the stage reached the larvae are attached by a terminal sucker to the containing vessel, segmentation is fairly clear, and rudimentary branchia or tentacular cirri, appear to be developing. The conditions of rearing beyond this stage have yet to be determined. Unfortunately, our supply of material derived from the May hatch was exhausted

before this could be done and all attempts later in the year (which were made at every low tide period until August, after which colonies were no longer accessible) to obtain fertile eggs in the manner used previously failed. This was doubtless due in some measure to difficulties in obtaining a pure water supply with adequate temperature control in the aquaria in which the attempts were made, difficulties which it is hoped will be overcome next year.

A correction in our 1954 paper on Dodecaceria fewkesi has to be made. In that paper we say that the species occurs only in the intertidal area. This is apparently not the case. In May of this year, Mr. E. Barraclough secured a large mass of tubes in a trawl off Goose Is., Queen Charlotte Sound, in 22 fathoms, and we overlooked two earlier records in 9 and 11 fathoms respectively off Santa Cruz Is., California.

A good deal of work has been done during the year on the classification of material collected by Mr. K.L. Klawe in Nova Scotia. The species new to Canada from that region were reported, together with records of others from the west coast, in a paper recently published in the Journal of the Fisheries Research Board.

Smaller collections, made both by ourselves and various members of the Station staff, have been examined from time to time and classification, and cataloguing of the collection in the Station museum have now been completed.

ANNUAL REPORT
PACIFIC OCEANOGRAPHIC GROUP - J.P. Tully

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ANNUAL REPORT
PACIFIC OCEANOGRAPHIC GROUP* - J.P. Tully

INTRODUCTION

1. Oceanographic information was sparse or non-existent in the Pacific and Arctic approaches to Canada. Therefore, the first requirement of this Group has been, and still is, to provide a basic description of the general oceanographic features of these regions. The continued program of exploration during the past six years has provided data for most of the areas and there is considerable progress towards making this information available. Oceanographic exploration will continue to be the principal directive until there is sufficient information in all areas to ensure an over-all appreciation of the properties and structure of the water and the currents and mechanism of their movement.

2. It is also a function of this Group to foster and provide opportunity for the development of other sciences in the sea, and to train scientists of any discipline in the philosophy and techniques of research in the sea. As these auxiliary undertakings grow and become important in their own right, they are detached to form independent groups. The Institute of Oceanography at the University of British Columbia is an outgrowth of this Group to teach the philosophy of oceanography. The Pacific Naval Laboratory is a continuation and expansion of the studies of underwater sound established here during the War. This year the pollution studies have been detached to an independent group in the Pacific Biological Station under Mr. M. Waldichuk.

3. Along with these general programs, the Group also undertakes specific researches of particular interest to the members of the Joint Committee, or the community. In the past these have included examinations of fishing areas, sewerage surveys, studies of pollution and underwater sound. This year they included establishing a method of measuring the dissolved oxygen supply to salmon redds, and the intrusion of sea water into the Fraser River. These projects are generally regarded as incidental studies and are undertaken on an ad hoc basis.

4. Co-operative undertakings and information exchange are major features of the program, contributing materially to accomplishment of the directives. The auxiliary information concerning meteorology, runoff, tides, hydrographic data, etc., are obtained from the departments concerned, and oceanographic information is supplied to them, or any other group requiring it. In addition, joint programs are carried out with private interests, and domestic and foreign government services. Resources, personnel and experience are pooled for common objectives in these undertakings.

5. The complement of the Group is thirteen full-time and three seasonal workers. However, only eleven full-time workers have been incumbent during most of the year, and the complement has been made up with seasonal or term workers of various grades and periods. Mr. R. W. Trites has been on transfer from the Atlantic Oceanographic Group for administration and pay while studying at the Institute of Oceanography. For details see the staff lists earlier in the report of the Pacific Biological Station.

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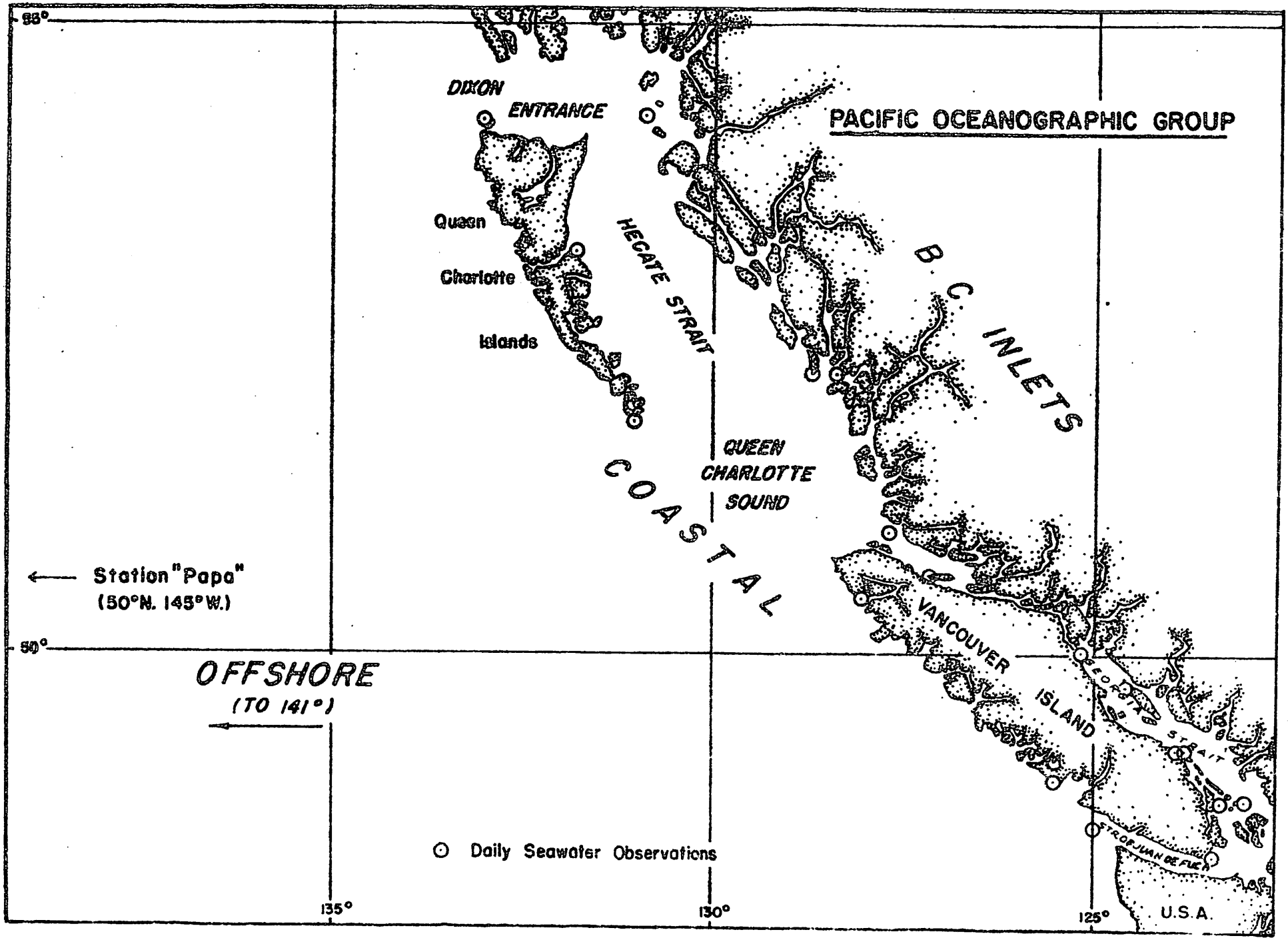
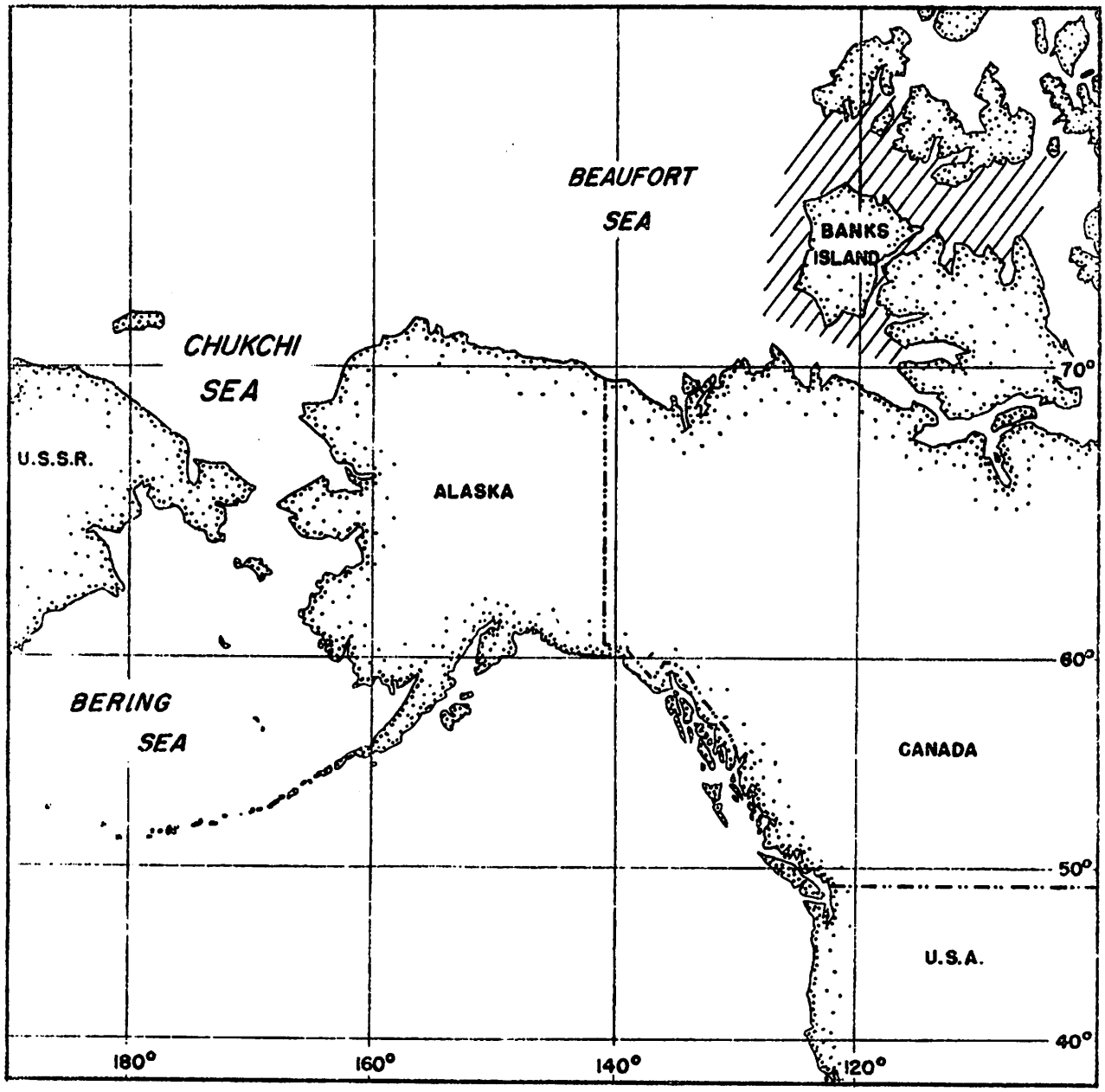
* Slightly abbreviated and re-arranged by the Director.


55°
DIXON
ENTRANCE
PACIFIC OCEANOGRAPHIC GROUP
Queen
Charlotte
Islands
HECATE STRAIT
B.C. INLETS
COASTAL
QUEEN
CHARLOTTE
SOUND
Station "Papa"
(50°N. 145°W.)
50°
OFFSHORE
(TO 141°)
VANCOUVER
ISLAND
JUAN DE FUCA
STRAIT OF
U.S.A.
Daily Seawater Observations
135°
130°
125°



PACIFIC OCEANOGRAPHIC GROUP

Western Arctic Program

GENERAL PROGRAM - 1954

6. The program is stipulated by the directives and the resources. At present the primary task is to collect data in an orderly manner and make it available as data records and progress reports. This keeps the ships operating continuously and requires most of the energy of the personnel. Appreciation and discussion of the data are secondary and must await relief from operational commitments, or sufficient increase of staff to allow both phases to proceed together.

7. The resources of this Group have never been adequate to undertake to study the areas as a whole, therefore they have been divided into natural regions such as the inlets and bays, larger straits, the coastal seas, and the ocean offshore. Each region is studied separately in some detail; generally oceanographic surveys are made at frequent intervals through one or more years to define the stages in the annual cycle of oceanographic conditions, and relate the sequence to daily observations of temperature and salinity at a point in the region. These data, together with a general appreciation of the oceanography of each region are being made available.

8. Thus there are five phases in this primary program: exploration by means of surveys, through limited periods, to determine the principal oceanographic features in each region; daily seawater observations to monitor the sequence of events and provide long-term continuity; study of the data to evaluate the oceanographic features; reporting of these general conclusions; and reporting of the data per se so that it is readily available for specific studies by ourselves and other groups.

9. The organization of the Pacific Oceanographic Group is based on the five phases of the General Program. The scientists plan the scope and detail of each project. The technicians, under supervision of the scientists, make the observations, analyse the water samples, process the data, and prepare data records. Then the scientists interpret the data and prepare reports.

10. Data have been collected in Georgia Strait, Juan de Fuca Strait, Alberni and Bute Inlets, Barkley and Chatham Sounds, the Offshore Pacific Ocean, and the Bering, Chukchi and Beaufort Seas. Some preliminary surveys have been made in most of the remaining regions. This year surveys were made in Queen Charlotte Strait, Hecate Strait, Dixon Entrance, the Beaufort Sea, McClure and Prince of Wales Straits, and Viscount Melville Sound. Daily seawater observations have been, and are being made in all Pacific Coast regions. All the data are catalogued, some have been published, some have been studied, and some studies have been reported.

11. In order to conclude this phase of research we must complete the surveys in the Queen Charlotte-Hecate-Dixon Entrance region, undertake studies of the ocean coastal region, maintain the daily seawater observations, complete the analyses and study of the data, and report the data and our appreciation of it.

PARTICULAR PROGRAM

12. Until April most of the energy was devoted to the analyses of data, and preparation of data records and reports. Since April attention has been devoted to operations, principally in the Hecate area.

13. Mr. F. G. Barber, assisted by Mr. S. Tabata and the technical staff, has initiated the oceanographic surveys in Queen Charlotte Sound, Hecate Strait and Dixon Entrance. Three cruises of one month's duration were undertaken in May, June, and September. In each cruise, two weeks were spent making

synoptic surveys of the temperature, salinity and dissolved oxygen, to define the water masses, structure and properties of the water. The remaining two weeks were spent making current measurements to define the tidal and non-tidal currents in the area. This program will continue at suitable intervals until the Autumn of 1955, or until the seasonal cycles of oceanographic conditions have been defined. These data are currently being processed and published as data records.

14. Resolution of the observed currents has proven to be a greater task than originally anticipated, and considerable theoretical study has been undertaken by Dr. N. P. Fofonoff to provide a means of solving the current system in a reasonable time and with reasonable investment.

15. Mr. Waldichuk has returned from the University of Washington where he continued his analyses of the very extensive Strait of Georgia data which was collected in 1949, 1950 and 1951. These studies are being prepared in thesis form as partial fulfilment of the requirements for his Ph.D. Degree.

16. Mr. R. H. Herlinveaux has completed the study of tidal currents in Juan de Fuca Strait and published two papers on the subject. He has completed the analyses of water masses and structure which is being studied by Dr. J. P. Tully preparatory to description.

ASSOCIATED PROGRAMS

17. Dr. W. M. Cameron of Defence Research Board, with assistance from this Group, led a joint United States - Canadian scientific expedition into the Western Canadian Arctic region in two icebreakers, the U.S.S. Burton Island and the U.S.C.G.C. Northwind. The Pacific Oceanographic Group provided oceanographic instruments and supplies to both ships, and Messrs. R. H. Herlinveaux and J. A. Stickland served as oceanographic technicians. These data are currently being processed and will be published as data records. Description of the region will be undertaken by Dr. Cameron.

18. Mr. R. A. Pollard, working in the Model Laboratory with Mr. W. P. Wickett of the Pacific Biological Station, has devised a field method for measuring the oxygen supply and flow through the gravel in stream beds. This amounts to a method of assessing the suitability of stream beds as salmon redds. A complete report is being published.

19. In conjunction with the Department of Transport the daily seawater observations at the coastal lightstations have continued under the management of Mr. H. J. Hollister. Regular observations have been initiated at Pulteney Point in Queen Charlotte Strait. Observations at Ivory Island are to be replaced by observations at McInnes Island. Both stations are operating during 1954 to provide a correlating link in the data.

20. Semi-daily bathythermograph observations and daily seawater samples have been initiated at Swiftsure Lightship in the approaches to Juan de Fuca Strait by co-operation with the United States Coast Guard.

21. In September, Mr. Hollister made the trip out to Station "Papa" in the Weathership C.G.S. Stonetown and returned in the C.G.S. St. Catharines, in order to monitor the observation procedure and familiarize himself with the operating conditions.

22. In June the pollution studies, with Mr. Waldichuk in charge, were transferred to the Pacific Biological Station. A study of the probable pollution from a proposed pulp mill extension at Port Alberni was commenced before the transfer, and completed afterwards, with assistance of the Pacific Oceanographic Group staff and C.N.A.V. Ehkoli.

23. Dr. M. Kirsch, working at the Institute of Oceanography, is making studies of the rates of standard reactions in sea water as compared to sodium chloride solutions. This is part of his general study of the physical chemistry of sea water. He is also conducting studies of the form of occurrence, and methods of precise determination of the trace elements in sea water. This is prerequisite to appreciating their role in the nutrition of sea life.

24. Mr. Trites (temporarily attached from the Atlantic Oceanographic Group) is studying turbulent exchange coefficients and mixing in British Columbia Inlets under the direction of Dr. G. L. Pickard at the Institute of Oceanography. It is hoped that these phenomena may be expressed and solved in a diffusion equation, which is prerequisite to a mathematical description of these processes in the sea.

25. The Port Meteorological Officer (Vancouver, B. C.) is collecting seawater temperature observations from coastal steamships. A form was prepared, and the data are being catalogued by the Pacific Oceanographic Group, and are being incorporated into the present programs.

26. Mr. G. W. LaCroix in C.G.S. Wm. J. Stewart (of the Canadian Hydrographic Service) made oceanographic observations and tidal and current measurements in Hecate Strait as time and opportunity permitted. The data collected fit well into the Hecate Strait Project and this co-operation is a useful and valued service.

27. The Hydrographic Service undertook, for the B. C. Electric Company, a detailed hydrographic and bottom current survey in the area of the proposed power-cable crossings from the mainland to Vancouver Island. The Pacific Oceanographic Group provided current-measuring equipment, and the services of Dr. Pickard to demonstrate its use and analyse the data. In addition, Dr. Pickard made an analysis of storm frequency, and Dr. Tully made an analysis of the bottom temperatures. An estimate of the depth of mud in one area, and some other minor requirements are also being provided.

28. The Department of Public Works has made an artificial harbour at Steveston, B. C., in the Fraser River by putting a rock fill from the shore to an island in mid-channel, and then parallel to the shore along a line of mid-channel banks. The quadrangle thus enclosed on three sides is virtually stagnant. The Department requested the Pacific Oceanographic Group to determine if there was sufficient sea water intrusion to enable teredo infestation to occur in the pilings. Mr. Tabata has directed a weekly observation program and analysed the data. Sea water intrudes the area in sufficient quantities to form a suitable habitat for teredos, although it appears that this intrusion may vary with river flow. Some further investigation is planned to evaluate this variation and determine if teredos are present.

GENERAL LIAISON

29. Liaison has been maintained with all institutions, services, and groups having an interest in oceanography in the Pacific and Western Arctic.

30. Co-operation with the Pacific Biological Station has continued, particularly in efforts to relate oceanographic conditions to fisheries. The records of daily seawater observations continue to be a primary reference for fisheries research. Close co-operation exists between the groundfish investigators and the oceanographers on the Hecate Project.

31. Oceanographic equipment, chemicals, and laboratory services have been provided to various fisheries investigations at Port John, Lakelse Lake, Barkley Sound and other locations. Engineering assistance was provided to Dr. J. R. Brett's experiments in deflecting downstream salmon migrants. Designs were prepared for the additions to the Station's Workshop and the Model Laboratory, as well as consultation and advice on similar engineering projects.

32. The association with the Pacific Naval Laboratory has continued on the usual friendly level throughout the year. Equipment, personnel, and services have been freely exchanged. In general the Pacific Oceanographic Group takes all responsibility for observing and processing oceanographic data, while the Pacific Naval Laboratory manages the ships, and provides a headquarters at H. M. C. Dockyard. From time to time, personnel of the Pacific Oceanographic Group have accompanied expeditions of the Pacific Naval Laboratory to record oceanographic conditions.

33. Through the Pacific Oceanographic Group as intermediary, the Pacific Naval Laboratory has provided underwater sound equipment, and use of naval trawl equipment to the Pacific Biological Station. The Pacific Naval Laboratory has also undertaken reconstruction of the recording current meter in their new shops. This liaison is valuable for the work accomplished, but is even more valuable for the indoctrination of personnel and exchange of ideas in the problems of the two Groups.

34. There is a free exchange of data, resources and personnel between the Pacific Oceanographic Group and the Institute of Oceanography at the University of British Columbia. In general, the Institute is more concerned with academic studies and training, but in the present stage of development some attention is given to geographic problems. Summer appointments were provided to support Drs. Kirsch and Pickard in projects of interest to the Joint Committee. The Institute loaned equipment and instruments for the Arctic expeditions, and has continually been most co-operative in providing consultation and advice to members of this Group. This is a most valued service.

35. Close liaison is maintained with the Hydrographic Service at all levels, in co-operative projects, and exchange of equipment.

36. The Department of Transport makes the daily seawater observations at the coastal stations for which the personnel are paid an honorarium. They also make the daily bathythermograph observations from the Ocean Weathership on Station "Papa" gratis. This program is sustained by good-will between the local officers of the Department of Transport, the ships' companies, and the Pacific Oceanographic Group staff.

37. International liaison is maintained with the Department of Oceanography at the University of Washington whose work is concerned primarily with teaching, chemistry of sea water and instrumentation. Liaison is also maintained with the United States Navy Electronics Laboratory at San Diego in respect to the joint project in the Western Arctic.

TECHNICAL SERVICES

38. Technical services include the collection of data, analyses of seawater samples, processing and cataloguing data, preparation of data records, preparation of reports, administration and clerical services, and conduct of daily seawater observations. Such service is prerequisite to the many activities of this Group.

39. Mr. Hollister is general manager of the technical services, and personally looks after financial administration (bookkeeping, ordering, and stock) as well as the reprint library, data and data records. In addition, he is in charge of the Daily Seawater Observations at shore stations and on Weatherships.

40. Mr. L. H. McCracken is in charge of the seawater analyses laboratory, and the provision of supplies to expeditions. He also assists with processing data.

41. Miss B. M. Berisford is general secretary in charge of administration files and correspondence. She is assisted by Mrs. M. A. Smith in preparation of manuscripts, manuscript reports, and data records.

42. The seagoing technicians include Messrs. Herlinveaux and Stickland who were allocated to the Arctic Project, Mr. A. W. Groll, and the Summer employees. These people assist at sea, in the seawater analyses laboratory, and the processing of data as required.

FACILITIES

43. The two ships, H.M.C.S. Cedarwood and C.N.A.V. Ehkoli were operated by the Navy. These ships were jointly used by the Pacific Oceanographic Group, the Pacific Naval Laboratory, and the Institute of Oceanography. The ships were used by the Pacific Oceanographic Group as follows:

Hecate Strait	May 3rd - 28th	Cedarwood
Hecate Strait	June 29th - July 22nd	Ehkoli
Alberni Inlet	September 7th - 11th	Ehkoli
Hecate Strait	August 16th - September 9th	Cedarwood

44. On the Weatern Arctic Project the two icebreakers, U.S.S. Burton Island (Navy) and U.S.C.G.C. Northwind (Coast Guard) were used from July 20th to September 28th.

45. The accommodation at the Pacific Biological Station continues to be excellent in the space provided on the main floor of the Annex Building. Proposals have been made to the Director for increased space to accommodate chemical programs from the Pacific Oceanographic Group and the Pollution Group of the Pacific Biological Station. An addition has been made to the Ocean Model Laboratory to meet the added requirements. Liaison remains on the traditionally high and friendly level, and the administrative and consultative services are deeply appreciated.

APPLICATIONS OF SOME RESEARCHES

46. The recent research on tidal currents should be of particular interest to the Hydrographic Service, although it was undertaken because it was a necessary prerequisite to appreciation of the general current systems in coastal waters.

47. The currents in British Columbia waters ebb and flow as tidal functions. Due to land drainage the surface ebb is generally greater than the flood, and the converse is true in the bottom water. Consequently the circulation is strongly influenced by land drainage but the currents are essentially tidal. Earlier studies directed toward pollution control required knowledge of the circulation systems, wherefore the behaviour of fresh water

entering the sea required and received first attention. More recently, the tidal currents have become important considerations and some advance has been made in their study.

48. Tidal currents in passes and narrows are generally hydraulic, and the velocity varies as the square root of the difference of sea level from one end of the channel to the other. In seaways where the tide occurs as a wave, the velocity varies linearly as the difference of sea level between the ocean and the inner end of the seaway. Thus tidal currents are always related to differences of sea level from place to place, but the form of the relation depends on the mechanism causing the difference.

49. The tidal rise along the ocean coast sweeps around both ends of Vancouver Island approaching the Strait of Georgia from the south and north. A tidal wave progresses through Juan de Fuca Strait, where Herlinveaux has shown that the tidal currents are linear functions of the difference of tidal height between the ocean and Georgia Strait. The current is hydraulic through the San Juan Archipelago at the southern end of the Strait of Georgia and it may be anticipated that the current velocities in each passage will vary as the square root of the difference of sea level from one end to the other. The northern tides are progressive waves from the ocean to Seymour and Yuculta Rapids where they change to hydraulic tides. Thus the Strait of Georgia is completely separated from the ocean tidal wave, and its tide is due solely to the influx and efflux of water through the hydraulic approaches, and is only indirectly a planetary function.

50. The classical method of predicting tidal currents is to make harmonic analyses of a long series of observations in terms of planetary functions, and extrapolate the components into the future. Recent researches have related the currents to the differences of sea level which are already predicted in the Tide Tables with considerably more accuracy than is possible in direct-current measurements. This approach is theoretically sound where suitable tidal reference stations are available. It permits more efficient use of the data and current predictions may be based on short series of observations. This has been demonstrated in the case of hydraulic currents by the study of the remarkable data observed by the Hydrographic Service in Seymour Narrows, and Herlinveaux' observations of progressive wave currents in Juan de Fuca Strait. The method failed in Hecate Strait because of the lack of tidal reference stations in the area.

51. The exploration of this method of current prediction, its accuracy and applicability, and the evaluation of tidal currents in unexplored seaways may be classified as research, and is properly a function of this Group. However, the application of the method to making tidal current tables is a function of the Hydrographic Service.

52. In the strategic area of Juan de Fuca Strait a general prediction of oceanographic conditions has been attained, and a means of quickly assessing the exact conditions has been provided. This is of particular interest to the Navy because the physical properties and structure of sea water limit the performance of Asdic Gear, and the knowledge is prerequisite to the design and strategy of seaward defences.

53. Determination of temperature structure by means of bathythermograph observations is simple and rapid. A corresponding instrument for salinity determinations has not been devised. However, Herlinveaux found that the salinity in Juan de Fuca Strait bears a constant relation to the temperature over the whole area at any one time. In consequence, the salinity structure may be evaluated from the bathythermograph observations alone. Once a day the relation is established by a surface and bottom

temperature and salinity observation. Thereafter bathythermograph observations provide all the necessary data because the salinity may be evaluated by direct correlation with the temperature. Sound velocities may be interpreted from these data by simple graphical means. This procedure allows rapid survey of the sound-ranging conditions which can be accomplished under operational conditions.

54. Herlinveaux also observed that there is a seasonal cycle in the temperature-salinity ratio, however the recurrence of the ratio appears to be no more precise than the cycles of local air temperature and rainfall to which it can be related. This cycle allows the prediction of approximate physical structure of the sea water, and the general sound-ranging conditions suitable for strategic planning. However this prediction does not provide the specific information provided by bathythermograph observations which are required for day-to-day naval operations.

55. The total area of salmon spawning redds in British Columbia is estimated to be less than 1,000 acres. The whole of this major fisheries resource depends primarily on the suitability of conditions in these fabulously valuable acres, which are so few as to constitute a virtual limitation of the fishery. It is evident that every effort to maintain, improve, or increase the redds is well justified economically.

56. Spawning salmon migrate into a stream having a gravel bed, there they dig holes and deposit their eggs. The eggs remain in the gravel for three to six months until the young fish wriggle out into the stream and commence their life. While the eggs are in the gravel they require oxygen which can only be supplied by a continuous flow of aerated water. In nature the salmon will spawn in any bed where the gravel and stream flow are suitable. However these redds may later go dry, they may become covered with fine silt which stops the flow of water through the gravel, or the water in the gravel may be devoid of oxygen. In each case the eggs die for lack of oxygen, and the potential salmon are stillborn.

57. Wickett (Pacific Biological Station) has established the oxygen requirement of the eggs, and Pollard, working with Wickett in the Model Laboratory, has devised field methods for classifying the stream gravel and measuring the flow and oxygen content of the water in the gravel. As a result the redds can be assessed.

58. A pointed iron pipe, having a ring of small holes near the point, is driven into the gravel to the depth which the eggs are usually laid. Some dye is added to the water in the pipe and the rate at which it fades is a measure of the force driving the water through the gravel. Then water is pumped out of the pipe and the rate of inflow is a measure of the permeability of the gravel. These define the flow of water through the gravel. Finally a sample of water is withdrawn and tested for dissolved oxygen. From these data the rate of supply of dissolved oxygen is determined.

59. Because of this research, the conditions in the redds can be readily assessed. If they are deteriorating corrective measures can be applied, and many of the eggs can be saved. Furthermore, the qualities of successful redds can be determined, new spawning grounds can be built to specification, and the productivity of the streams increased. This research is prerequisite to maintenance, improvement, and construction of salmon redds, hence it is a fundamental research of far-reaching consequence.

60. The Offshore Program of a few years ago yielded the first complete picture of the oceanic circulation off the Canadian Coast. The North Pacific Drift, moving eastward between Latitudes 47° and 50°, divides

into two parts about 800 miles West of the Canadian Coast between Longitudes 140° and 150° West. Part turns north past the Queen Charlotte Islands to circle around the Gulf of Alaska - forming the Alaska Gyral; part turns south to form the California Current flowing towards the Tropics. The approaches to Canada lie in the triangle between the coast and the divergent branches of these currents. It is one of the largest regions of divergence in the World. There are no definite currents, rather there are huge eddies - some of them 200 miles in diameter - which rotate slowly and wander aimlessly in the region. Even the weather is indeterminate, the winds vary all around the compass but blow principally from the southwest and northwest with eight to twelve major wind changes a month. The division of the North Pacific Current advances and retreats, and the relative strength of the northern and southern branches varies from time to time. Only the general picture is consistent, the detail is continually changing.

61. There are two layers of water; the upper zone, about 100 to 150 meters deep, varies with the seasons. It is warmed in the Spring and Summer, and cooled in Autumn and Winter. Its salinity varies with the annual and seasonal precipitation in the north-east Pacific area. The deep zone below 200 meters is nearly constant the year round. The salinity increases with depth and the temperature decreases, and there are small changes from time to time. However these changes appear to be secular rather than seasonal.

62. The bathythermograph observations daily at Ocean Weather Station "Papa" (Latitude 50° N, Longitude 145° W) and monthly along the 750 mile route from Vancouver Island are fitting sequence to the surveys. These data show the annual cycle of heating and cooling, the changing depth of the upper zone and the difference of these conditions from year to year. Even though all the sequences are not understood, it is already evident that the oceanographic conditions in the area are primarily seasonal, but are also affected by variations in the great currents which allow intrusion of warm water one year and cold water the next.

63. It is apparent even now that the northward migrations of pelagic fish such as tuna and pilchard must be affected by the oceanographic conditions in this area of divergence. It may be supposed that the salmon are also affected.

64. At present there are no fisheries or fisheries investigations in the offshore area. The studies were undertaken so that we would know the general conditions to seaward of the coastal regions where attention is now focused. The daily seawater observations are being maintained to monitor the oceanographic conditions and determine the nature and magnitude of variation, in the confidence that this area will be exploited in the not too distant future, and the information will be required.

PUBLICATIONS

Papers and Manuscript Reports from the Group are included in the general list of publications earlier in this report.

SUMMARY REPORTS

The following summary reports have been distributed by the Group in its separate Annual Report:

(a) Hecate Strait. F. G. Barber and S. Tabata.
(b) Strait of Georgia. M. Waldichuk.
(c) Juan de Fuca Strait. R. H. Herlinveaux.
(d) Western Arctic. W. M. Cameron.
(e) Flow Through Salmon Redds. R. A. Pollard.
(f) Daily Seawater Observations. H. J. Hollister.
(g) Bathythermograph Observations at Ocean Weather Station "Papa". H. J. Hollister.
(h) Chemical Oceanography. M. Kirsch.
(i) Mixing and Stability in Stratified Flows. R. W. Trites.
(j) B. C. Electric Company Project. G. L. Pickard.
(k) Sea Water Intrusion in Steveston Cannery Channel. S. Tabata.
(l) Data Records. H. J. Hollister.
(m) Laboratory Services. L. H. McCracken.