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FISHERIES RESEARCH BOARD OF CANADA

ANNUAL REPORT

of the

BIOLOGICAL STATION

NANAIMO, B.C.

for

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(WITH INVESTIGATORS' SUMMARIES AS APPENDICES)

FISHERIES RESEARCH BOARD OF CANADA

Report for 1959-60 of the
Biological Station, Nanaimo, B. C.

The purpose of the Nanaimo Station is to provide the scientific basis for the development, exploitation and continuance of Canada's marine fisheries resources in the Pacific. In 1959-60 the demand for research from both the fisheries administration and the fishing industry continued to grow. It became increasingly difficult to make satisfactory progress towards the solution of urgent practical problems without neglecting the improvement of the fundamental scientific knowledge on which the best solutions depend.

In 1959 new facilities for holding and observing adult salmon, and new chemical and physiological laboratories were provided at the Station's headquarters at Nanaimo. Field camps and facilities for salmon research were maintained at a number of points on the Skeena River from Babine Lake to the sea. A small field station at Port John provided for studies on salmon in a small unspoiled watershed in the wet coastal zone. Port observers were maintained at Vancouver and Prince Rupert to obtain samples and data from the commercial fishery for various studies. The Station's research program took its personnel and vessels to many other parts of the coast and far to sea.

The same four Station vessels were again operated in 1959-60. The 78-foot general-purpose fishing vessel A.P. Knight was used mainly in herring research but also in investigations on salmon, pollution, shellfish, fur seals and oceanography. The 54-foot dragger Investigator No. 1 was used mainly in work on groundfish but also on salmon, dogfish, oceanography, shellfish and herring. The principal work of the 39-foot Alta was to transport personnel and supplies in connection with the extensive Fraser River pink salmon investigations but she was also used in work on herring and shellfish (predictions of settlement of oyster spat). The 30-foot Noctiluca was used to supply the Port John field station and the Fraser River pink salmon investigations.

Eight chartered vessels were also used in 1959-60 on special projects. The 114-foot packer Fort Ross and the 84-foot seiner Key West were again used in studies of the distribution of salmon on the high seas in connection with the research program of the International North Pacific Fisheries Commission. The 72-foot general-purpose steel fishing vessel Pacific Ocean was again chartered to collect fur seals in the open sea from Oregon to Alaska to meet Canada's commitments under the Interim Convention on Conservation of North Pacific Fur Seals. The seiners Cape Blanco and Wendy Belle were used in tagging of pink salmon in the Johnstone Strait area as part of a joint study of the movement of pink salmon in and out of the Fraser River convention area; the 16-foot cruiser Sea Wolf was used to supply field operations in the same program. Two chartered gill-net boats, the Shirley D. and the Lady Luck I, again fished salmon systematically just above the upper limit of commercial fishing on the Skeena River to get immediate information on the numbers of salmon getting through the fishery.

DISTRIBUTION OF SALMON STOCKS IN THE NORTH PACIFIC

The Convention between Canada, Japan and the United States which established the International North Pacific Fisheries Commission introduced, for the first time in an international fisheries agreement, the principle of abstention by any country from fishing stocks which are under scientific study, regulation and full use by one or more other countries. In accordance with this principle Japan agreed to abstain from fishing salmon stocks east of a provisional line which, for most of its length, is 175° W. Longitude. The Protocol to the Convention provided that the three countries discover as soon as possible whether salmon of North American and Asian origin intermingle on the high seas and, if so, whether another line could be shown to divide the salmon from the two continents more equitably. To answer these questions the Commission was faced with the problem of discovering the distribution of American and Asian salmon on the high seas of the North Pacific. To accomplish this urgent and difficult task it formulated a joint program of research in 1954 and active work by the three countries started in 1955.

The program included: (1) study of the distribution of salmon on the high seas through fishing by research vessels and statistics of the commercial fisheries, (2) study of samples of salmon from both high-seas and inshore waters in order to recognize stocks of various origins on the high seas, (3) tagging, and (4) study of the oceanographic background for salmon distribution and movements. Canada, through this Station, has participated in (1) by high-seas fishing with chartered vessels, in (2) by providing samples from British Columbia and the nearer high seas for the research program generally and by studying samples from all sources as to their parasites, scale patterns and osteology, and in (4) by taking a leading part in oceanographic research in the North Pacific.

The program as a whole has been one of the greatest cooperative fisheries investigations ever attempted. Having little background knowledge and being faced with some urgency, the Commission in 1954 adopted a program which included every method of recognizing salmon stocks which offered any prospect of success. Some of the lines of research proved ineffective and were discontinued; others were productive. After five years of active field work (1955 to 1959) the program has provided partial answers to the questions posed by the Protocol to the Convention. It is currently being reviewed to assess the value of continuing various lines of research with the resources available.

The research has shown the very broad distribution of salmon throughout the North Pacific and Bering Sea north of waters which are too warm (over about 58°F.). The first question posed by the Protocol has been answered by showing that salmon of Asian and North American origin intermingle over a broad area extending over at least 28 degrees of Longitude (168° E. to 164° W.) and probably farther. Stocks spawned in various areas occur together on the high seas but all or almost all leave the high seas to reappear as spawning runs in their areas of origin. The factors responsible for concentrations on the high seas and for seasonal and year-to-year variations in distribution remain largely unknown, as do the means by which such directed movements are carried out by the salmon. The facts of intermingling and of reappearance as spawners in the fresh waters where they originated are, however, now firmly established.

The second question posed by the Protocol is more difficult to answer. Although the distributions of particular stocks are emerging, the difficulties of obtaining reliable quantitative information over such a large area are obvious and perhaps insurmountable with available resources. Assessment of how equitable a division of Asian and American stocks is achieved by any line is thus not yet possible, although it is clear that salmon from both continents cross the present provisional line in large numbers.

Canada's interest in the high-seas life of salmon goes beyond that of the International North Pacific Fisheries Commission. In order to use the salmon runs efficiently and to regulate the fishery to let the best numbers of spawners through, it is important to know in advance how large the runs will be. This involves understanding and predicting the factors governing growth and survival of salmon in the ocean. Attention is being directed to the study not only of the distribution of Canadian stocks in the sea but also of the conditions which affect the sizes of the returning runs and the times and routes of their shoreward migrations. For this a broad study of conditions, circulation and productivity in the waters off our coast is required.

Research fishing for salmon on the high seas. In 1959 collection of salmon samples was carried out by a chartered vessel at seven stations in the middle and western parts of the Gulf of Alaska (Latitude 50° N. to 58° N., Longitude 145° W.

to 160° W.). As in 1957 and 1958, the gear consisted of gill-nets of mesh sizes 2 1/2", 3 1/4", 4 1/2" and 5 1/4" in the proportion 1:1:3:1.

The total numbers of salmon caught at these stations were sockeye 1,683, pinks 495, chums 763 and cohoes 11. While the proportions of the different species were similar to those found in 1958, the total catch of 1959 was considerably greater, due in part to weather conditions which play an important role in high-seas fishing.

Age determinations showed that the youngest sockeye caught (one winter in the sea) were mainly found in the southwestern part of the region examined (Latitude 50° N. to 53° N., Longitude 155° W. to 160° W.). Progressively higher proportions of older fish were taken with increasing distance north and east from this area. A similar general trend was observed for chum salmon. Other studies have shown that sockeye present in the southwestern part of the Gulf of Alaska include fish from Bristol Bay, Rivers Inlet and probably other parts of British Columbia.

More than 80% of the pink salmon obtained were caught at the westernmost stations (Longitude 160° W.). The possibility that many of these fish were of Asiatic origin is suggested by the fact that large numbers of pink salmon from East Kamchatka were shown by United States tagging to be present in 1959 at localities as far east as Longitude 168° W.

The vertical distribution of salmon was investigated by a second chartered vessel, using a gill-net of 4 1/2" mesh which could be set at various levels from the surface to a maximum depth of 160 to 200 feet. Operations were carried out at four stations in the Gulf of Alaska with different temperature conditions. During May, when the water within the depths fished was nearly isothermal, sockeye and chum salmon were caught within each depth interval fished, pinks not below 120 feet. Later in the season, sockeye and pink salmon were not taken below 40 feet and chums not below 80 feet. The change in distribution coincided with the development of a sharp temperature gradient below the levels occupied by the fish.

In evaluating the significance of salmon distribution in the ocean it is important to distinguish immature from maturing fish. A criterion for this purpose has been found for sockeye and chum salmon, in the ratio of gonad weight to total body weight. The use of these indices has permitted the satisfactory separation of salmon caught on the high seas into the two categories.

The high-seas fishing for salmon by Canadian research vessels has yielded information of possible value to the future development of fisheries for other species. Experimental fishing with long-lines and deep trolls in 1959 salmon fishing operations showed that pomfret could be caught readily on hooks baited with fresh fish at depths extending from near the surface to 150 fathoms.

Investigations of high-seas plankton, carried out in conjunction with the salmon fishing operations, showed the continued widespread occurrence, as in 1958, of the chaetognath Sagitta lyra, which is tentatively regarded as an indicator of the intrusion of warm water. Two kinds of tunicates, Doliolum and Salpa, which usually occur in limited quantities in summer only, were exceptionally abundant over a long season in the southeastern part of the Gulf of Alaska in 1959. There are thus biological indications of the continuance of the intrusion of warm water from the south. Oceanographic surveys show this intrusion to have reached a peak in 1958.

Oceanographic background for salmon distribution. The Fisheries Research Board's Pacific Oceanographic Group has continued to play a leading part in the study of the oceanographic conditions and circulation in the areas where salmon occur. The work of the Group is presented in greater detail elsewhere but certain points are worthy of note in this connection.

The Gulf of Alaska and the adjacent ocean were again surveyed in the winter (January-February) and summer (August) of 1959. The intrusion of warm water northward along the British Columbia coast was found to have declined from the peak reached in 1958.

In the "sub-arctic" waters inhabited by salmon in the North Pacific there is an upper layer about 50 fathoms deep of relatively homogeneous low-salinity water, a transition layer characterized by a marked salinity gradient or halocline, and a lower layer in which salinity increases gradually with depth. Seasonal changes in temperature do not extend below the upper layer, in which winter cooling establishes a uniform low temperature from the surface down to the top of the halocline. The water warms from the surface downwards in spring and summer but the low temperatures established in winter persist in the lower part of the upper layer - i.e. just above the halocline. The temperatures found there in summer can therefore be used as an indication of the temperatures which occurred at the end of the winter throughout the upper layer.

The application of this method in 1959 to all available data on the North Pacific indicated geographic and annual changes in the winter conditions in the upper layer of considerable importance to salmon distribution. Minimum winter temperatures below the known range for salmon abundance are widespread in the western North Pacific and Bering Sea but do not occur in the Gulf of Alaska. They may well be responsible for the long migrations of Asian salmon southward and eastward from their areas of origin and, consequently, for the concentration of salmon of mixed origins in the Aleutian area. Salmon from British Columbia, on the other hand, do not need to travel far to avoid low winter temperatures. Another important feature is the occurrence of much variation from year to year in the distribution of extreme low winter temperatures. These may be responsible for variations in salmon distribution or survival.

Parasites as a means of distinguishing salmon stocks. Efforts in this field in 1959 were concentrated on the use of two parasites acquired by sockeye salmon in fresh water. One of these, the cestode *Triaenophorus crassus* is characteristic of western Alaska (mainly Bristol Bay) sockeye and does not occur in other sockeye stocks; the other, the nematode *Dacnitis truttae*, is found only in sockeye originating in Kamchatka. In both cases the parasite is acquired in fresh water and carried by the salmon throughout its sea life. The samples examined in 1959 were collected from high-seas and inshore or fresh-water areas in 1958 and were the most extensive available since this work was started in 1955. They included 331 smolts and 614 adults from North American areas from the Columbia River to northwestern Alaska, and 2,378 in 76 collections from the high seas including some from close to Kamchatka. *Triaenophorus* was found in 130 specimens of sockeye, *Dacnitis* in 16.

Sockeye with *Triaenophorus* and therefore known to be of western Alaskan origin were found westward south of the Aleutian chain to 168°15' E. and eastward into the Gulf of Alaska to 145° W., a range of over 46 degrees of Longitude. Immature sockeye with *Triaenophorus* were found only from 170° E. to 165° W. and mainly south of the Aleutians. Mature sockeye with *Triaenophorus* were sampled on the high seas both north and south of the Aleutian chain and in the spawning runs of the Bristol Bay area.

The incidence of *Triaenophorus* in the catches and spawning runs of Bristol Bay was estimated to be 22%. The incidence was 22% to 24% in mature sockeye in the Bering Sea west to 170° W. and at 55° N., 155° W. in the Gulf of Alaska, suggesting that the sockeye sampled in these areas were mainly of Bristol Bay origin. In the Gulf of Alaska the incidence decreased to 9% at 55° N., 150° W. and to 4% at 55° N., 145° W., indicating a decreasing proportion of Bristol Bay sockeye. In samples taken south of the Aleutians between 173° E. and 168° E. only 3 mature sockeye out of 300 had *Triaenophorus*, indicating that few were of Bristol Bay origin; west of 168° E. no *Triaenophorus* were found.

Sockeye with *Dacnitis*, and therefore known to be of Asian origin, were found from the Sea of Okhotsk eastward to 175° W. Maturing sockeye with *Dacnitis* were caught from mid-May to the end of July, the early samples generally farther to the east but none farther than 173°19' E. Immature sockeye infected with <u>Dacnitis</u> were found from the east coast of Kamchatka to 175° W.

Since the initiation of this project in 1955 the occurrence of about fifty parasites in sockeye and pink salmon has been studied. No parasites of pink salmon were found which exhibited sufficiently large and consistent geographical differences in occurrence to be used to recognize stocks of pink salmon on the high seas. In sockeye the two parasites acquired in fresh water noted above and two which infect the salmon after they enter salt water were found to be valuable but firm reliance can be placed only on the former. The study of the occurrence of <u>Triaenophorus</u> in sockeye has proved to be one of the most effective means of recognizing the occurrence of Bristol Bay and other western Alaskan stocks on the high seas; <u>Dacnitis</u> indicates Asian origin of sockeye but its low incidence impairs its value. Samples of sockeye for parasitological examination were collected again in 1959 and are being examined. When this is completed it is planned to terminate this study in the belief that further work would add little to the results already obtained.

<u>Distribution of sockeye originating in Rivers and Smith Inlets</u>. Sockeye originating in Rivers and Smith Inlets in the central part of the British Columbia coast can be recognized by a combination of scale characters including a small fresh-water zone, numerous but small circuli laid down during their first year in the ocean, and a wider annual zone in their second than in their first ocean year. Examination of scale samples from more than 4,000 sockeye taken on the high seas by the three countries in the summers of 1957 and 1958 revealed 41 identifiable as originating in Rivers or Smith Inlets. The 11 immature individuals found were from about 153° W. to 170° W., and the 30 matures from the British Columbia coast west to only 155° W. This accords with the distribution of immature and mature sockeye of various origins - the former being abundant in catches west of 145° W. in the Gulf of Alaska and the latter being closer to the coast during the early

summer when the research fishing has been carried on. It is noteworthy that even the immature individuals from Rivers and Smith Inlets were found no farther westward than 170° W. - five degrees east of the provisional line.

Study of chum salmon scales to distinguish stocks. Continuing this study in 1959 the scales of 3,576 chum salmon collected in 1957 from 33 inlets or river systems in North America and in Japan and Siberia were examined.

Differences in the characteristics of scales from different areas were similar to those reported last year for 1956 samples. Scales of chum salmon from British Columbia and southeast Alaska had many closely packed circuli in the first-year zone, those from central, western and northwest Alaska fewer, those from Siberia fewest of all and those from Japan about as many as British Columbia. Chum salmon from British Columbia had the largest numbers of circuli in the second-year zone but Japanese chums had the lowest. Differences in the width of the annual zones tended to parallel those in the numbers of circuli.

From combinations of these characters it is possible to identify the continent of origin of a certain proportion of the chum salmon. Thus those with 30 or more circuli in the first-year zone but a difference of less than 0.45 mm. in the widths of the first- and second-year zones constituted over half of the British Columbia samples, about a quarter of those from southeast Alaska and less than 10% of those from more northern streams in North America; fish with this combination of scale characters were virtually absent from Asian samples. Chum salmon with first-year zones 1.05 mm. wide or less constituted about 35% of Siberian samples but less than 3% of samples from any other areas. Methods of analysis are still under development and scales collected in 1958 and 1959 remain to be examined but scale studies offer promise of contributing substantially to our knowledge of the high-seas distribution of chum salmon originating in various areas.

FRASER RIVER PINK SALMON

A Protocol to the Convention between Canada and the United States for the Protection, Preservation and Extension of the Sockeye Salmon Fisheries in the Fraser River System was ratified by the governments of the two countries in 1957. It made the International Pacific Salmon Fisheries Commission responsible for scientific investigation and regulation of the pink salmon fisheries in the convention area. The two countries also agreed that "a co-ordinated investigation of pink salmon stocks which enter convention waters for the purpose of determining the migratory movements of such stocks" should be carried out by the Commission within convention waters and by the agencies of the two countries outside them. The agreement was ratified too late to organize a large research project in 1957 and the first opportunity was in 1959, the next year with a substantial run of pink salmon to the Fraser system. A co-ordinating committee with representatives of the Washington State Department of Fisheries, the Commission, and the Canadian Department of Fisheries (the Area Director and the Director of this Station) was appointed to formulate a joint program and arrange for its execution and the interpretation of its results. On the basis of a review of the results of earlier investigations, a large-scale tagging and recovery program was proposed in 1958 and carried out in 1959.

The program was the largest of its kind ever undertaken on Pacific salmon. It involved extensive tagging in the approaches to the Fraser, recovery of tags in the fishery north, south and inside the convention area, and surveys of Canadian and United States streams to recover tags and estimate the abundance of spawners. Canada's part included tagging in the Johnstone Strait area and surveys of streams from there to the northern boundary of the convention area. It was carried out by this Station in co-operation with personnel of the Department of Fisheries.

Tagging. Using two chartered seiners, the Station tagged 21,743 pink salmon in upper Johnstone Strait between July 5 and September 30; the Commission tagged

28,458 in the southern approaches to the Fraser, and the State of Washington 3,155 at the entrance to Puget Sound. The numbers tagged in each area were varied in so far as possible in proportion to the seasonal changes in abundance. Tagging was concentrated in the part of each week when the commercial fishery was closed in order to keep local recaptures at a minimum.

Recoveries in the fishery. With excellent co-operation from fishermen and buyers over 32,000 tags (61% of the total applied) were recovered in the commercial fishery.

Surveys of spawning grounds. Intensive surveys were conducted of all major spawning grounds from Puget Sound to Johnstone Strait. In some cases counting fences were operated but more often pink salmon were tagged at the mouths of the streams which were then surveyed on foot to examine carcasses of spawned fish and recover both marine and stream tags. In all 53,152 tags were applied in streams to estimate escapements and 359,904 carcasses examined; of these, 29,520 tags and 217,150 carcasses were in the Canadian streams north of convention waters. In this area the Fish Culture Development Branch conducted the surveys on 6 river systems and the Station those on 15, many of them difficult of access. In all 1,328 (2.5%) of the tags applied in the sea were recovered in fresh water.

Preliminary results. The analysis of the data is still in progress and the following results are preliminary and approximate.

The tagging showed that, in spite of restrictive regulation, the 1959 fishery was quite intensive. It removed over 70% of the nearly 10,000,000 pink salmon entering the study area from Johnstone Strait to Puget Sound. About 2,400,000 were caught north of convention waters, about 4,700,000 in convention waters and about 150,000 south of them.

Spawning escapements in the study area totalled about 2,500,000 divided between Canadian streams north of the Fraser, the Fraser system itself and United States streams in the approximate proportion 2:2:1.

Runs entering from the north provided virtually all the escapements in the Johnstone Strait area, proportions decreasing from 98 to 40% of escapements to streams in the Strait of Georgia, about a quarter of both early and late spawning runs of the Fraser and about 2% of the spawners in United States streams. Runs entering from the south provided almost all of the spawners in United States streams, about three-quarters of those in the Fraser, about half of those in the Indian and Squamish Rivers just north of the Fraser and up to 15% of those in streams farther north in the Strait of Georgia.

ASSESSMENT OF THE CONDITION OF SALMON STOCKS

The British Columbia salmon stocks are subject to increasingly intensive and mobile fishing which makes effective regulation both urgent and difficult. The sockeye and pink salmon of the Fraser and the Skeena are the subjects of special studies which have demonstrated their value for management purposes. Information on the hundreds of other stocks is much less complete and often inadequate as a basis for regulating the fishery so as to obtain the maximum long-term yield. It is, of course, not possible to study the salmon runs of every river as intensively as those of the Fraser and the Skeena. It is, however, important to assemble and analyze information bearing on the condition of these stocks, on the trends in their abundance and on their management. The Station is making an increasing effort in this direction.

The information collected for management purposes is also valuable as evidence of the qualification of our salmon stocks for abstention by Japan under the International North Pacific Fisheries Commission. To qualify, stocks must be shown to be fully exploited, so that more intensive fishing would not increase the long-term yield. The qualification of our salmon stocks is still under consideration by the Commission and effort by the Station was still required in 1959 to assemble and present information on their status.

In our waters sockeye mature mainly in their fourth or fifth year but the proportions maturing at various ages vary greatly from year to year. At Rivers Inlet, for example, those returning at the end of their fourth and fifth years have been about equally abundant on the average, but over the past 50 years the percentage of 4-year-olds in the catch has varied from 3% to 84%. Chum salmon also mature at various ages, the proportions differing from year to year. It is, therefore, necessary to learn the age composition of the catches if we are to discover what returns have resulted from parent runs of various sizes, a basic reouirement for management.

Sockeye catches in the major fishing areas have been sampled annually by the Station since 1908; annual sampling of catches of chum salmon for age, size and sex was started only in 1957. Samples taken in 1959 included 10,976 sockeye from areas which yielded over 90% of the 1959 sockeye catch north of the Fraser River Convention area, and 9,710 chums from areas with 87% of the total British Columbia catch. Sampling of escapements is being organized but has not advanced so far.

The data thus obtained on the age composition of the runs is combined with statistics of catch, fishing effort and escapement, collected annually by the Department of Fisheries, to give information on the condition of the stocks and more particularly on trends in abundance and on the numbers of progeny produced by runs of various sizes.

<u>Sockeye catches in Rivers and Smith Inlets</u>. The recent trend in the catches in these two inlets is an example of the type of information emerging from this program. Even when the effects of the 1959 strike are taken into account, the catches of the progeny (both 4- and 5-year-olds) of the runs of 1950 to 1954 averaged only three-ouarters as large as the catches of the parent runs in Rivers Inlet. A similar average decline in the catch from one generation to the next occurred in Smith Inlet. The causes are not known.

Ages of chum salmon. The sampling of chum salmon catches has not continued long enough to indicate variations in the ratio of catch of the progeny to the catch of the parent run. It has already shown, however, that the age composition of the catch varies enough to make data on ages essential to an understanding of the returns from spawning runs and of trends in catches. Although the data suggest that most chum salmon return as 4-year-olds in all areas, the proportion of 3-year-olds in the catch may reach about 70% and that of 5-year-olds 20%.

SPRING AND COHO SALMON

The two-year study on coho salmon in the Strait of Juan de Fuca, in co-operation with the State of Washington Department of Fisheries, was completed by the submission of a joint report to the second International Conference on Co-ordination of Fisheries Regulations between Canada and the United States in April, 1959. The program of tagging, sampling and catch statistics had shown no differences between coho of commercial size outside the Bonilla-Tatoosh seaward boundary for net fishing and those in the Strait inside it. The great majority were bound for spawning areas inside the Strait; all were 3-year-olds which, as the season progressed, became more mature, fed less and delayed for shorter periods in the outer part of the Strait. The Conference did not agree on any change in the seaward boundary for net fishing in the Juan de Fuca area.

The same Conference reviewed the regulations regarding commercial trolling and ocean sports fishing for spring and coho along the Pacific coast but recommended no changes. Sampling showed that spring salmon caught in waters outside Vancouver Island were large in 1959 and that the 26-inch size limit reduced the numbers landed by only about 25,000, a number similar to that estimated for 1958 but much less than for 1957 when the fish were small.

In recent years the commercial catches of spring and coho salmon in British Columbia have been relatively constant and at the highest level on record.

In 1959, if allowance is made for the effects of a fishermen's strike, catches of spring salmon were about average, in contrast to low catches off Washington and record low catches off Oregon and in the Columbia River, where the "fall chinook" gill-net catch was, for the first time, smaller than the gill-net catch on the Fraser. Catches of coho in 1959 in British Columbia were below average.

Examination of spring salmon catches on the outer coast of Vancouver Island for fish marked when released from United States hatcheries was expanded in 1959 at the request of the Pacific Marine Fisheries Commission, an inter-state organization which has sponsored these studies. No marked spring salmon were found among 2,037 examined off the Queen Charlotte Islands, but among 37,524 off Vancouver Island 134 single-fin and 110 double-fin marks occurred. This was the highest proportion of marked fish yet found, but still much lower than the proportions off Washington and Oregon. Unfortunately the significance of the marks was seriously limited by duplication of marks used at various hatcheries.

Sampling of catches has shown that from 1952 to 1959 both spring and coho salmon are consistently larger off the west coast of Vancouver Island than in the Strait of Georgia. Both species in both areas were above average size in 1952 and below it in 1957; both species were particularly small in the Strait of Georgia in 1959.

Examination of scales has indicated that the smaller size of the coho caught in the Strait of Georgia persisted through all three years of the life of the fish, both the one year in fresh water and the two in the sea. In spring salmon the majority of the troll-caught fish went to sea in their first year and were caught in their third; more older fish were caught outside Vancouver Island than in the Strait of Georgia, and more younger fish in the Strait. The gill-net catch of spring salmon in the Fraser River consists about equally of individuals which went to sea in their first and in their second years. Most of the early-run, red-fleshed fish had spent their first year in fresh water; most of the late-run white-fleshed fish had gone to sea in their first year. These differences are being explored further as possible means of identifying races of both spring and coho.

SALMON MANAGEMENT IN THE SKEENA AREA

Among British Columbia salmon rivers the Skeena, with large runs of both sockeye and pinks, comes next to the Fraser in importance. In 1954 the Area Director of Fisheries and the Director of the Nanaimo Station of the Fisheries Research Board were named as a Committee responsible for the management of the Skeena salmon fisheries. The principal sockeye run, that to the Babine Lake system, had been badly damaged by a rock slide which greatly reduced its spawning potential in 1951 and 1952. Pink salmon were also much less abundant than they had been. Using the combined resources of the Department and the Board in research, development and regulation, it was the task of the Committee to restore the Skeena salmon production to its former higher levels and, indeed, to obtain the maximum long-term yield. At the end of the Committee's first five years the damage by the Babine slide has been overcome and prospects are bright for sockeye catches as high as they ever have been and at the same time for adequate spawning escapements. Runs of pink salmon have increased substantially and are expected to increase still further. The Skeena Salmon Management Committee has, thus, had a large measure of success.

Research by the Station for the Committee has attempted to answer the two key questions in the regulation of salmon fisheries: What spawning escapements will give the greatest return to the fishery? How may the fishery be regulated to provide such escapements? To answer the former requires knowledge of the relationship between the numbers of spawners and the numbers of returning adults produced in the next generation. To answer the latter requires knowledge of the routes and timing of the spawning runs and the proportions taken by the fishery. In so far as possible these questions must be answered for each of the many runs contributing substantially to Skeena salmon production as a whole. The important Babine sockeye run has been studied most intensively, but increasing attention has been paid in recent years to others, especially the principal runs of pink salmon.

The research program has included: tagging in the sea and in the river to discover the routes and timing of various components of the salmon runs; special statistics of the fishery to indicate its distribution, intensity and effectiveness; standardized gill-netting just above the up-river limit of commercial fishing to give early information on the numbers of spawners escaping the fishery; estimates of numbers of spawners and of resulting seaward migrants in important units of the sockeye and pink salmon stocks; and special studies of young sockeye in Babine Lake to discover how to use it as fully as possible as a nursery area.

Improvement of sockeye production in the Babine Lake system. The nursery areas of this system produce over 75% of the Skeena sockeye. Observations at the Babine River rock slide and on the spawning grounds showed that the slide prevented two-thirds of the spawning by the Babine run in 1951 and in 1952 before it could be removed by the prompt and effective action of the Department. It was, therefore, necessary to restrict the fishery severely in 1955, 1956 and 1957 when the progeny of the damaged spawning runs returned as 4- and 5-year-olds.

The Babine system is a composite series of basins. The large, southern basins of the main lake, comprising 90% of the total area, have relatively few and small spawning grounds; the smaller, northern basins near the outlet, with only 10% of the lake area, have large spawning grounds in the Babine River above and below Nilkitkwa Lake. Tagging in 1944-48 and again in 1956-58 showed that the sockeye runs to the spawning grounds tributary to the large, southern basins passed through the fishery earlier than those to the outlet areas. Observations of the distribution and growth of young sockeye in the Babine system, commencing in 1955, showed that they did not distribute themselves evenly throughout the lake area but remained close to the spawning grounds which produced them. The early spawning runs left the large, southern basins of the lake under-utilized as nursery areas; the later runs to the large spawning grounds at the outlet provided enough young in most years to use the smaller, northern basins nearly to their capacity. By restrictions at the beginning of the fishing season the Committee has, since 1956, given special protection to the early spawning runs in order to obtain fuller use of the large, southern nursery areas of the Babine system.

The number of sockeye (not including small, precocious males or "jacks") passing a counting fence at the entrance to the Babine system averaged about 450,000 in the years from 1946 to 1954 if we exclude 1951 and 1952 when the rock slide blocked the run. The number was 71,000 in 1955, 355,000 in 1956, 433,000 in 1957, 812,000 in 1958 and 783,000 in 1959. The Committee's policies in regulation of the fishery have resulted not only in increasing the spawning runs but also in distributing them better and making fuller use of the large, southern basins of the lake. The smolt run in 1957 (from the 1955 spawning) was 6,500,000, in 1958 22,500,000, and in 1959 38,500,000.

The escapements in 1958 and 1959 were the largest since the counting fence was installed in 1956 and are probably at about the optimum level. An analysis of information on the size of the spawning stock in each of the last fifty years and on the resulting numbers of sockeye returning in the next generation, has indicated that about 900,000 spawners in the Skeena system as a whole produced on the average the maximum surplus (1,400,000) for the fishery above replacement of the parents. It will be interesting to observe the results from the high escapements of 1958 and 1959.

<u>Skeena sockeye catches and escapements, 1959 to 1964</u>. The 1959 sockeye run was mainly 5-year-olds, the 4-year-olds being the progeny of the extremely poor run in 1955 which in turn was affected by the 1951 slide. The special

restrictions in the early part of the fishing season to protect the runs to the main southern basins of Babine Lake, coupled with a strike at the peak of sockeye abundance in the fishing area, kept the catch low (196,000). The escapement was large (854,000) and the total run (1,044,000) was close to the level predicted the previous autumn.

Prediction of Skeena sockeye runs is subject to great uncertainties. Survival in the ocean varies considerably and cannot be predicted; the proportions returning as 4- and 5-year-olds, although averaging about half and half, vary considerably from brood to brood. When we have enough determinations of the returns from smolt runs varying both in number and in average size, a more reliable prediction of the numbers of returning adults may be possible. For the time being we can estimate future runs only on the basis of the average returns which have resulted in the past from escapements of various sizes. The 1960 Skeena sockeye run will consist of 5-year-olds from the 1955 spawning which was the poorest on record and 4-year-olds from the moderate spawning in 1956. On this basis a run of somewhat less than a million is predicted; on a similar basis the size of succeeding runs will increase to about 2,000,000 in 1963 and 1964. Recent smolt runs have had a high proportion of large smolts from the good growing conditions in the southern basins of the Babine system. If this causes a better average survival in the sea than occurred in the past, these estimates are probably low but data are still lacking for a firm prediction on this basis. In any case we can expect runs in 1963 and 1964 approaching the largest runs of the past.

Abundance and growth of young sockeye in Babine Lake. During their one year in Babine Lake young sockeye attain most of their growth in the summer months. They weigh about 0.2 grams when they enter the lake as fry in mid-June; those that weigh 4.5 grams in mid-October gain only one more gram before emigrating as smolts in the following spring. Observations on the size, abundance and food of young sockeye in the various basins of Babine Lake in the years 1956 to 1959 have made it possible to compare the growth rates under a wide range of conditions. The results show that there is a general direct relationship between growth rate and zooplankton abundance but that the latter is itself influenced by the density of the population of young sockeye as well as by other factors. The growth of the young sockeye is not affected by crowding up to about 2,600 per acre but above that level growth decreases as the population density increases. In the Babine Lake system the young sockeye have never been found abundant enough in the large, southern basins for their growth to be affected but in the smaller, northern basins their average weight in mid-October may be as low as 1.4 grams when population density is high as compared with 3.5 to 4 grams at low densities.

When the effects of crowding on growth are combined with what little evidence is yet available on the effects of smolt size on survival to maturity, a late-summer density of about 4,000 young sockeye per acre is suggested as the level likely to give the maximum return of adults. At this density Babine Lake would produce about 200,000,000 smolts with a mean weight of about 3 grams. This suggested optimum density of young sockeye has been reached in some recent years in the small, northern basins of the system; it has never been approached in the large, southern basins. Spawning grounds rather than lake area appear to limit production there and the maximum capacity of the lake as a nursery area can be realized only if effective artificial means of increasing the supply of fry can be developed.

Basis for management of Skeena pink salmon. The history of the fishery for pink salmon in the Skeena area shows that pink salmon catches were formerly much greater than they are now and that large spawnings generally produced larger returns than did small spawnings. It is clear that the Skeena pink salmon stocks have recently been far below the levels at which they can make their greatest contribution to the fishery and that greater yields can come only with greater escapements. Efforts were started in 1956 to obtain a firmer basis for improving the Skeena pink salmon fishery by learning when and where the principal spawning runs occur and by discovering the relationship between numbers of spawners and numbers of fry produced.

Intensive surveys showed the pre-eminent importance of the spawning runs to three tributaries - the Kispiox, the Kitwanga and the Lakelse - and revealed other substantial spawnings, including that in the main stem of the river. Tagging in the sea showed that, while there is considerable overlap in timing, the major runs tend to pass through the fishery in a consistent order - the earliest being those which go farthest from the sea. Of the three principal runs the Kispiox and Kitwanga appear earlier than the Lakelse. It is thus possible to regulate the fishery for the early and late runs independently to some degree.

Estimates of the numbers of spawners reaching the principal areas and of the relative numbers of fry produced by runs of various sizes in any one area, show that fry production has been roughly proportional to the size of the spawning runs at recent levels. Observations on the spawning grounds, even in the most crowded of recent runs, show that densities are below the levels at which experiments elsewhere have indicated that crowding affects fry production. It is, thus, confirmed that spawning escapements should be increased. The Skeena Salmon Management Committee is, therefore, endeavouring to raise the pink salmon production to higher levels by increasing the spawning escapements without undue hardship to fishermen and industry.

Skeena pink salmon catches and escapements. As practically all pink salmon mature when two years old, the stocks spawning in the even- and odd-numbered years can be considered separately. In the Skeena both cycles are increasing.

A special closure to protect the very small sockeye run of 1955 also protected the early pink salmon runs and about 1,000,000 escaped of which over half went to the Kispiox. Exceptionally high survival from this escapement produced in 1957 the largest catch (about 3,000,000) for some years and another escapement close to 1,000,000. Fry production from this escapement in the spring of 1958 appeared to be excellent but ocean survival was apparently very poor and the 1959 run totalled just over 2,000,000, much less than expected. A two-week strike at the peak of the run kept the catch low (only about 600,000) but permitted the best escapement of the past 5 years (about 1,500,000). The increase in escapement was greatest in the early up-river runs which were best protected by the strike.

The even-year cycle has recently been smaller but has been increasing. The estimated escapement of 1956 was less than 300,000 but the 1958 run (like the 1957) benefitted from a high ocean survival and was twice as large as expected. The 1958 catch in the Skeena area was about 900,000 and the estimated escapement almost 700,000.

Variations in ocean survival prevent accurate predictions of pink salmon runs. On the basis of escapements and fry production the most probable level of the run in 1960 appears to be about 2,000,000 and that of the run 1961 4,000,000 or more.

STUDIES OF SALMON REPRODUCTION AND PROPAGATION

Permeability of gravels and development of salmon eggs. For the past two years detailed studies have been made of the relationship of permeability of gravel to salmon spawning and the development of salmon eggs. Using the "stand-pipe" instrument developed at the Station it has again been confirmed that permeability is an important factor in the survival of salmon eggs, low permeabilities leading to low survivals. The detailed variability of conditions in stream beds is under critical study to develop survey methods which will be reliable without being wasteful of effort and to improve the interpretation of past surveys.

Changes in permeability, whether of natural or artificial origin, are of particular interest. In one series of observations it has been found that flow of water through the gravel was rapid (800 to 1,200 feet per hour) when disturbed by salmon to deposit their eggs, but became ouite slow (40 to 200 feet per hour) as winter and spring progressed. In another it was shown that a flood reduced the permeability of the gravel, especially where the slope or change in direction of the stream was greatest, destroying about 6% of a stream's potential as a spawning ground. Gravels differ in their basic properties including their maximum and minimum permeabilities but it is obvious that short-term changes can be very important and must be taken into account in interpreting the results of surveys and in management.

A modification of the "stand-pipe" instrument described in earlier reports has been developed to measure the permeability of gravels at considerable depths. This permits a study of the conditions where important numbers of salmon sometimes deposit their eggs in lakes, especially in the alluvial fans at the mouths of streams.

Experimental transfer of pink salmon to Newfoundland. Of the 5,700 eggs from Vancouver Island, shipped by this Station in November, 1958, and planted in North Harbour River, Newfoundland by the Board's St. Johns Station, 10.7% emerged as fry in the spring of 1959. Emergence occurred from May 7 to June 5 about a month later than in southern British Columbia, presumably because of a longer winter period with water colder than 1°C. Such a delay is probably beneficial as it prevents fry from reaching salt water before a surface layer warm enough for their survival is developed.

With these indications of suitable conditions in fresh water, the experiment was carried further by the shipment of 250,000 eggs in 1959. Difficulties in collection, caused by disappointing spawning runs and by weather, prevented a larger shipment. The eggs were collected in Indian River, just north of Vancouver, and shipped by air express on November 16, 19 and 20 in special containers designed and supplied by the St. Johns Station. To reduce the danger of transferring diseases or parasites with the eggs, they were treated on the day of shipment by dipping for 10 minutes in a 1:5000 solution of sulfa merthiolate. The eggs suffered little mortality before being planted in prepared gravel in North Harbour River.

Further plans will depend on the success of this experiment.

Improvement of techniques for releasing hatchery fry. Modern salmon hatchery techniques can produce five to ten times as many apparently healthy fry as nature does from the same number of eggs, but this advantage is usually offset by failure of hatchery fry to survive as well as natural fry. Since 1957 an experimental hatchery has been operated at Kleanza Creek on the Skeena River in the hope of finding ways of overcoming the low survival and return of hatchery fry. Attempts are being made to rear and release fry so that they migrate to sea at the same time as in nature and conditions are controlled to upset natural behaviour as little as possible.

Pink salmon eggs are reared in darkness and transferred to light-proof boxes in which water wells up through screening in the bottom and overflows at the top. The larvae remain quiescent near the bottom until the yolk sac is nearly absorbed when they become active and escape through the overflow. Water for the hatchery is pumped from the creek into which the fry escape. The fry release themselves at a stage and time similar to nature and exhibit the natural migratory behaviour of hiding in the creek bed during the day and emigrating downstream at night. Whether or not fry produced in this manner return as adults in sufficient numbers to make the whole hatchery operation effective will be observed.

In 1957 adult pink salmon entering Kleanza Creek numbered only about 2,100 and only 570,000 eggs were taken. These were supplemented by 1,360,000 from the later run in Lakelse River. The Lakelse eggs did not develop rapidly enough in the cold Kleanza water and there were some equipment failures in the hatchery which had been completed barely in time for the 1957 run. Fry from the Kleanza eggs numbered 345,000 and released themselves satisfactorily although somewhat earlier than expected. Only 325,000 fry resulted from the Lakelse eggs; late and in poor condition they did not release themselves at a normal stage nor exhibit normal behaviour after release. A total of 1,200 adults returned to Kleanza Creek in 1959 - only .18% of all fry released or .35% of the Kleanza fry. This compares with an average natural survival from fry to adult of about 1.5%. These results are, however, not considered representative because of the very small run and the initial operating troubles in the hatchery.

In 1958, 340,000 eggs were taken from Kleanza Creek and 1,320,000 from Lakelse. This time the latter were incubated to the eyed stage at Lakelse and they developed to the migrant stage at the same time as the Kleanza eggs. Both survived the winter well and 1,400,000 fry released themselves satisfactorily at a normal stage and only slightly earlier than normal time.

The escape of these fry from the hatchery varied diurnally with the water temperature and was highest in late afternoon and low at night. Fry leaving the hatchery in daylight tended to hide in the gravel, although many were first displaced a short distance downstream. Traps 550 and 2,500 feet downstream showed that the fry migrated out of the creek mainly in the early hours of darkness as in nature.

In 1959 about 400,000 eggs were taken at Kleanza Creek and 7,300,000 from the Kitwanga River, one of the major Skeena pink salmon runs.

The results to date are encouraging although many problems remain to be solved before these new techniques of rearing and releasing fry under as natural conditions as possible prove themselves as valuable practical procedures.

EXPERIMENTAL STUDIES ON PHYSIOLOGY AND BEHAVIOUR OF SALMON

The advance of civilization carries in its wake serious threats to the fresh-water environment of salmon and consequently to the abundance of the fish on which the British Columbia industry chiefly depends. The threatened ill effects of population increase and industrialization can take many forms. One of the most serious and highly publicized is the construction of dams, for hydro-electric and other purposes, which prevent or delay the passage of salmon. Others are domestic or industrial pollution rendering waters unfit for salmon, and diversions of the fresh-water supply for irrigation, waste disposal and other purposes. In order to maintain the salmon stocks in the face of these developments we must know how much the salmon can stand, how much they can do and how they behave and react. Without such basic knowledge we cannot assess the stage at which pollution or some other environmental change becomes damaging and we cannot exploit the salmon's abilities and reactions to best advantage in guiding them past obstructions. Because of the urgency of these problems, basic research on the physiology and behaviour of salmon was greatly increased in 1957 and is gaining momentum. Although its first purpose is to meet the threats of population increase and industrialization, its potential value goes beyond these limits and may find important application in other fields such as the finding and catching of other species of fish in the sea.

Research in this field was provided in 1959 with important additional facilities, including chemical and physiological laboratories, additional space and equipment for culturing and holding young salmon, special tanks for holding and observing adult salmon and equipment for moving them with a minimum of damage, and a field station where behaviour can be observed in nature. The problems of capturing and holding adult salmon in good condition for observation and experimentation have largely been met.

Effort has first been concentrated on studying the normal sequence of changes which accompany growth and maturation, so that the effects of experimentally-imposed stresses can be measured and abnormal behaviour or performance recognized in the field. The principal subjects under study at this stage include: biochemical changes in blood plasma accompanying maturation, characteristics of blood cells, factors affecting respiratory metabolism and the energy requirements of swimming, social behaviour of adult salmon (especially when spawning), environmental cues in migrating young salmon, and individual activities observed in the field during entry into fresh water and upstream movement. A few results may be mentioned.

Biochemical changes in salmon blood. A quantitative study of the proteins in the blood plasma of coho salmon throughout their life cycle is nearing completion. Four protein fractions, one of which is a lipoprotein, are present in fry in fresh water and immature fish of both sexes in salt water. During transformation to the smolt stage at which they migrate to sea, one of these protein fractions disappears and remains absent until the fish are in salt water. In maturing females a second, the lipoprotein which is probably a yolk constituent in transit to the developing eggs, appears and remains in the plasma until the eggs are fully developed. Another is present in spawning and spawned-out fish of both sexes and in many instances is very concentrated immediately prior to death.

Silicic acid chromotography has demonstrated six neutral lipid and three phospholipid fractions in the plasma of maturing female coho. Cholesterol esters, free cholesterol and astacin (astaxanthin) have been tentatively identified in three of the neutral lipid fractions. Two neutral lipid fractions are present which correspond in elution behaviour to triglycerides and non-esterified fatty acids in mammalian plasma. Preliminary results suggest that during maturation the fraction corresponding to triglycerides decreases, and the fraction corresponding to free fatty acids increases.

Normally the cellular part of the volume of salmon blood is about 50%, but when maturing sockeye were caught by gill-net in the brackish water of Alberni Inlet, the values were as high as 80%. In these fish the plasma was very viscous and the concentration of plasma protein extremely high suggesting a loss of water. Previous workers have reported that dilution occurs as the fish migrate up-river to the spawning grounds. These results suggest that quantitative values for plasma constituents should be based on dry weight rather than unit volume. Experiments are being designed to determine the effects of fatigue and salinity on the plasma volumes of salmon under controlled laboratory conditions.

Physiological studies. The development of methods for the diagnosis of disorders in their incipient stages has been considered broadly by examining urine, blood cells, and the enzyme system related to transamination. The collection of undiluted urine required the investigation of the anatomy of the urino-genital system. By the use of radiopaque (contrast) media and X-ray plates, separate urinary and genital systems were clearly defined, opening separately in the urino-genital papilla. It was found possible to pass fine polyethylene tubes correctly into each system, thereby opening the way to direct collection of urine.

Because increased transaminase levels have been shown to be sensitive indicators of cardiac disturbances in man, and are known to be an important link between carbohydrate and protein metabolism, examination for glutamic-oxalacitic transaminase (GOT) and glutamic-pyruvic transaminase (GPT) in salmon and trout was undertaken. Preliminary results indicate the presence of both in the liver, heart and spleen.

Immature red blood cells have been readily identified in the blood using Wright's stain, and further examination of these is expected to assist in diagnosing the presence of stress from disease, for which refinements in colour photomicrography are being developed. The presence of small rod-like bacteria (*Corynebacterium* sp.?) associated with kidney disease has been found for the first time in pink salmon and is a serious impediment to the maintenance of this early maturing salmon for experimental purposes.

Tolerance of salmon to pulp-mill effluents. Young salmon, as they migrate downstream and first enter the estuary, are faced with a number of environmental changes, including salinity and temperature. The presence of one of the largest kraft pulp mills in British Columbia releasing effluent into one of these estuaries (Alberni) introduces the additional environmental factors of sulphate waste and reduced oxygen. The responses of young salmon to such complex environmental changes are being studied by factoral experiments in the laboratory in an endeavour to establish the nature of the interactions. While little can be said at the present time in regard to interaction, other than that definite optima occur, more can be reported in regard to the direct relation of the effluent.

Final, sewered "full-bleach" effluent was found less toxic to coho underyearling salmon than either of its two major components, the "bleach" and "unbleach" fractions.

Toxicity of the bleach fraction appears to be related almost entirely to its acid pH, a factor having little or no expression in dilutions of full-bleach effluent.

Toxicity of the unbleach fraction appears to be related principally to its content of black (cooking) liquor. Toxicity of the black liquor itself is reduced to some extent by oxidation processes involved in the procedure to which most liquor is recovered and burned for heat and chemical recovery.

Because of the complex nature of full-bleach effluent and its high variability, subsequent studies are being carried out using weak oxidized black liquor, the component apparently contributing mostly to toxicity of its full-bleach effluent while at the same time being more consistent in effect on fish, as measured by controlled bio-assay tests.

Behaviour studies. A comparative study of the normal social behaviour patterns of salmon (fry, smolts, and adults) is underway, making detailed recordings of behaviour seouences as observed under normal and artificial conditions, and grouping the stereotyped or instinctive activities into major behaviour systems. There are strong indications that measurable external features (body positions, fin erections, colour combinations) reveal particular relations between the behaviour systems (e.g. aggressive over escape) the occurrence of which can be predicted in advance. Motion pictures of chum and coho salmon spawning in a large glass-faced experimental tank have been obtained, providing the basis for a study of the factors influencing spawning success.

These studies also serve as a basis for examining and comparing those behaviour patterns which relate to migration. Consideration has been given to two potential points of reference which could provide cues for orientation - chemical (or olfactory) and visual stimuli. At present it seems likely that chemical stimuli (e.g. home-stream odours) act as <u>releasers</u>, the fish being then responsive to a second factor as a <u>directive</u> stimulus, such as water current.

Experiments on visual orientation, using a circular tank masked above to permit vision of the sky only, have revealed that sockeye smolts show a direction preference which is correlated with the compass direction of the main discharge axis of the lake through which they must migrate and that this direction is obtained in some way by celestial orientation. There are diurnal cycles of restlessness, one at dusk which is correlated with the peak period of migration and one at dawn which may be related to normal feeding activity. The tendency to select a given direction disappears experimentally when there is a slight current.

<u>Observations of migrating adult salmon</u>. This program is mainly concerned with describing movements of adult salmon migrating upriver and analysing environmental factors influencing river entry. Field work is being carried out in two small watersheds: the Somass River (discharge 1,000 to 10,000 cubic feet per second) and its tributaries, and Nanoose and Bonell Creeks (discharges 0 to 100 c.f.s.).

Salmon of all five species are rarely seen migrating steadily upriver. Normally they are seen performing other activities such as circling, wandering, darting, holding, and jumping, only some of which have a migratory function. They tend to migrate for only limited periods during the day; usually two to four hours in the morning, often near dawn. Migration in the investigated rivers appears to consist essentially of passing from pool to pool, each of which serves as a temporary place of refuge. The speed and timing appears to be influenced by many factors including a daily cycle of activity, the numbers of salmon moving together, the stage of maturity of the fish, the species concerned, and the topography of the river bottom. The last suggests that artificially contouring river bottoms to provide "guiding-lines" parallel to the current and "obstruction-lines" perpendicular to the current could be an effective method of diverting adult migrants in small rivers with good underwater visibility.

Entry of sockeye, coho and chum salmon into the two river systems from the sea appears to be related to weather changes, often, but not necessarily, including rain. Chum entry usually coincides with rain; sockeye entry usually follows a change from sunny to cloudy weather without rain. The association of weather changes with the initial day of entry of groups of salmon suggests that the responsible environmental factor is acting as a "releaser"; there is no indication that the rate of entry is proportional to the extent of any environmental change.

Techniques of diving and photography have been developed to the point where they are now useful tools in salmon observation. Salmon have been effectively observed and photographed under water in a variety of habitats. Conditions are most favourable where many salmon are crowded together in a limited space as in waterfall pools, and river eddies. Under these conditions salmon pay little attention to divers and can be approached within a few feet without causing disturbance.

POLLUTION

As population and industry grow pollution becomes a more and more serious threat to British Columbia's fishery resources, especially salmon and shellfish. To keep damage by pollution to a minimum the disposal of domestic and industrial wastes must be kept under close supervision and the best possible means of waste disposal must be devised and put into effect. Basic knowledge is needed in the nature and properties of pollutants and on their effects on fish or shellfish.

The Station carries out surveys of actual or potential cases of polluting and research on the chemistry of certain pollutants important in British Columbia waters. The surveys are carried out in close co-operation with the Area Director of Fisheries and recommendations are made to him regarding methods of waste disposal with minimum damage to fisheries. The purpose of the research on the chemistry of pollutants is to improve their recognition in the sea and, where possible, to recommend treatment to render them less harmful. The fundamental studies on salmon physiology and behaviour, reported in the preceding section, also apply to the pollution problem by helping to recognize and understand damage when it does occur. Biological investigations of particular cases of pollution have also been carried out as, for example, the effects of pulp-mill pollution in oysters at Crofton (see below).

Surveys relating to pulp-mill pollution. Surveys of Osborn Bay and Stuart Channel were carried out in April and July, 1959, in a continuing examination of waste disposal from the kraft (sulphate) pulp mill at Crofton. Dilution between the diffuser discharging at 10 fathoms depth and the "boil" at the surface continued to be about 20:1. A further dilution of about 10:1 occurred between the "boil" and the nearest oyster grounds giving an overall dilution of about 200:1 on the average. No accumulation of effluent was found and no adverse effect on dissolved oxygen or pH.

The efficacy of the diffuser in providing dilution and mixing was studied by water sampling and bathythermograph casts. The turbulent energy of the effluent discharging through jets in the diffuser mixes sea water with the effluent and carries the mixture to the surface, deep water flowing in to replace that mixed with the effluent. The excellent results suggest this as a means of obtaining dilution in inlets where there is insufficient inflow of fresh water for dilution and flushing.

Bi-monthly sampling indicated considerable variation in the concentration of kraft mill effluent in the area, related to variations in the effluent itself. There was also considerable local diurnal fluctuation associated with tidal action.

A survey in August, 1959, revealed lower concentrations of dissolved oxygen in the deep water of Alberni Harbour than were found in 1954 and 1957. Concentrations in the bottom water were less than 2.0 milligrams per litre in some parts of the harbour. Higher precipitation and lower temperatures in 1959 than in 1958 caused higher oxygen concentrations in the surface water.

A survey of Muchalat Inlet in Nootka Sound, where a new pulp mill is planned, revealed concentrations of dissolved oxygen as low as 0.2 mg/ℓ in the deep water of the inlet inside a sill at the entrance. Inflow of fresh water appears to be much lower than in Alberni Inlet. It is suggested that a diffuser might use salt water for dilution of the effluent as at Crofton.

A survey of Howe Sound showed that a sill 80 fathoms deep at the entrance prevents frequent flushing of the bottom water in the upper reach of the sound. At 100 fathoms dissolved oxygen was only 1.3 mg/ℓ as compared with 10.7 at the surface. The large volume of fresh water entering the sound is, however, believed to be sufficient to dilute the wastes expected in the near future from a new pulp mill and other industries.

Fraser River Estuary and Burrard Inlet. Because British Columbia's largest centre of population and industry is at the mouth of the most important salmon river, the Fraser, a special effort is made to follow conditions in this area.

In 1959 a third annual survey was conducted in August. Dissolved oxygen concentrations were high in all parts of the Fraser River estuary sampled, including Steveston Cannery Basin, where flushing had been improved by removal of the upstream rock wall. The pH was unusually high (8.1 to 8.3 as compared with 7.5 to 7.9 in 1950, 1957 and 1958). This was apparently a transient condition as lower values were observed later in the year by the International Pacific Salmon Fisheries Commission.

A survey in early October, 1959, showed higher concentrations of dissolved oxygen in Vancouver Harbour (6.0 mg/ℓ at all depths) than in 1958. On the other hand as much as 500 parts per billion of phenol were found in some parts of Port Moody Arm contrasting with a maximum of 15 p.p.b. in 1958. Distribution of phenol was patchy and was highest in oil films.

Benzene hexachloride (BHC) in sea water. This compound continues in favour as an insecticide to protect log booms from the ambrosia beetle, and research was continued on methods for its determination in sea water and on its decay in sea water and identification of the products. Tests were carried out on the interference with the current method of analysis for BHC by extraneous compounds in the water. Decay was more rapid in high-salinity than in brackish water. After more than seven days an increase in BHC was indicated but appears to be due to the effects of products of the decay on the analytical method. A unit for continuous extraction of these products was designed and constructed and identification of the products is proceeding. Water-soluble alicyclic compounds are believed to form a major portion.

Disposal of radio-active wastes in the sea. A considerable effort was spent in study of the problems of disposal of radio-active wastes in the sea, including participation in a committee of the United States National Research Council and National Academy of Sciences on the disposal of low-level wastes off the Pacific Coast and in the Scientific Conference on Disposal of Radio-active Wastes sponsored by agencies of the United Nations.

HERRING

In recent years the British Columbia herring fishery has developed steadily in intensity and in the efficiency of its catching methods. The catch is reduced to produce meal and oil, relatively small quantities being used for other purposes. Most of the catch is made by a well-organized purse-seine fishery when herring are concentrated inshore in the autumn and winter before spawning in the spring. Smaller quantities are caught by purse-seining in the summer and still smaller quantities with gill-nets for use as food or bait.

The catch has shown an upward trend. In the 1958-59 season it was over 230,680 tons, an amount exceeded only by the record catch of over 250,000 tons in 1955-56. In the autumn of 1959 catches were greater than in any previous autumn but the fishery was interrupted early in 1960 by low prices for its products on the world market. There appear to be supplies of herring available in British Columbia waters for maintenance, or even some increase, of the catch if and when the price and cost structure is again favourable.

During the growth of the herring fishery there has been much concern that over-fishing would result in a decline in abundance and in a reduction in the long-term catch, and a great deal of research on the herring stocks and fishery has been carried out by the Station over the last thirty years. Intensive tagging has shown that there are ten, perhaps eleven, major herring populations which occupy different areas and between which there is some exchange but which are sufficiently independent for separate study. A continuing program of catch statistics, sampling for age, size and maturity, and estimations of the amount of spawning has provided information on the changing abundance of each population, on the variations in the strength of successive broods, on growth and on the mortality rates from fishing and from natural causes. Other aspects of the life history have been studied.

Analysis of the great volume of data which has been accumulated gives no indication of overfishing. In general, the herring after they join the schools which are fished (are "recruited to the fishery") when they are three to five years old do not grow fast enough to offset the rate at which they die from natural causes (about 50%). Under these circumstances the poundage caught from any given number of young fish entering the fishery (the "yield per recruit") is increased by fishing harder and catching them before they die off. Restriction of the fishing effort could result in a greater long-term yield only if it were necessary to protect the spawning stock to maintain the supply of recruits. An examination of the data, even on the most heavily fished populations, fails, however, to show any relation between the amount of spawning in any one year and the abundance of the resulting fish when they are old enough to be caught. It is evident that at present fishing intensities the fishery has an insignificant effect on recruitment in comparison to the great mortalities which occur early in the herring's life from natural causes such as predation, lack of food or unfavourable physical conditions. The intensity of fishing need not be reduced either to keep up the supply of young fish or to get more poundage from those that are produced. On the contrary some increase in fishing intensity could take place without endangering the stock.

The fishery has, however, been intense. Recently it has caught each year, on the average, about 60% of the herring in the schools fished. The total annual mortality rate from both fishing and natural causes has been about 80% in all the principal populations except those of the Queen Charlotte Islands, where the fishery developed too recently to provide adeouate data to assess the situation. The intensive fishery and high total mortality rate has important effects. The number of herring available to the fishery in any year depends to a large degree on how many new recruits join the schools (mainly of maturing fish) which are fished. While the carry-over from the preceding year can be predicted, the abundance of the new recruits cannot. Predictions of abundance can only indicate in a general way the most probable level within a wide range; predictions cannot be accurate.

More important, the high mortality rate and intensive fishery mean that the stocks are already being exploited quite well and that more intensive fishing will not result in a substantial increase in the long-term yield. It is, moreover, not possible to know what further fishing intensity is possible without reducing the spawning stocks to levels where scarcity of spawners would eventually reduce the numbers of young entering the fishery. This can be discovered only by comparison of the numbers of young (the strengths of the broods or "year-classes") resulting from present levels of fishing intensity and from considerably greater levels. Light could be thrown on this question by a properly designed experiment if it could be arranged.

Results of the Station's intensive herring investigations were presented in 1950 to the International North Pacific Fisheries Commission as evidence that more intensive fishing would not in itself result in a substantial increase in the long-term yield, and that, consequently, the herring stocks qualify for abstention by Japan.

More recently, in 1959, the Area Director of Fisheries and the Director of this Station were appointed as the British Columbia Herring Management Committee, and as the first step in its work the Committee has initiated a review of the scientific knowledge on the British Columbia herring stocks with an advisory group representing all branches of the fishing industry. It is hoped that this review will result in a better general understanding of the basis for regulation of the fishery. It is planned to publish the review in bulletin form.

In 1959 a start was made in a program of exploratory fishing to discover the distribution of herring in offshore waters during the summer. Our present information concerns almost exclusively the distribution and abundance of the adult herring, which form the spawning schools on which the fishery depends. Our knowledge of the distribution even of these fish between the spawning in the spring and the inshore movement of pre-spawning schools in the following autumn is far from complete. Knowledge of where the herring are before they mature and join these schools is still poorer. By obtaining a more complete picture of the distribution and movements of herring throughout their lives it might be possible to lay the basis for development of a fishery for fat herring for food at some future date and, in the meantime, to improve our understanding of changes in abundance and of variations in the timing of the inshore migration which makes the herring available to the present autumn and winter fishery. Two test cruises were made off the west coast of Vancouver Island with drift-nets of various meshes designed for setting at various depths. These operations, hampered by bad weather and the problems associated with the first use of gear of a new type, were preliminary only. Modifications in the gear and methods are being made and it is planned to continue this project in 1960 using both drift-nets and mid-water trawls.

The increased use in 1959 of high-powered lights is believed to have enabled seiners to concentrate and catch more scattered herring than in the past. It has been feared that it also concentrates young salmon and increases the incidental catch of salmon with herring, in certain areas at least. Sampling of herring catches to study this problem was commenced in the autumn of 1959 too late to give adequate coverage of the fishery as a whole. Sampling will be resumed, when herring seining re-commences, to discover when, where and in what numbers salmon are caught.

GROUNDFISH

There is a year-round fishery for groundfish along the British Columbia coast, mainly on offshore banks during the spring and summer and in more protected waters during the autumn and winter. Although less valuable than the highly seasonal fisheries for salmon and herring, it plays an important role in the general fishery economy by providing relatively stable employment for hundreds of fishermen and shoreworkers. Close to thirty species of groundfish are landed by otter-trawlers and hook and line vessels, but only eight or nine of these are of sufficient importance to warrant detailed study.

The limited extent of the continental shelf adjacent to British Columbia affects the prospects for major expansion of the groundfish fishery there. Most of the fishing banks are now within the normal working range of Canadian vessels, and in waters beyond the three-mile limit there is active competition with trawlers from the United States. With the prospect of increasing market demand over the long term, pressure on currently exploited stocks can be expected to increase rather than decrease, and some relatively unexploited stocks will doubtless come into fuller use.

To provide information for management on a sustained yield basis, the present research on groundfish is aimed primarily at the measurement of changes in abundance and evaluation of the relative effects of the fishery and the environment in producing such changes. Measures of the change in abundance and availability of the major species are being obtained through a continuing program involving the collection and analysis of statistics of catch and fishing effort. This study is complemented by routine sampling of commercial landings to provide information on length and age composition, growth rates, mortality rates and changes in recruitment. Field work consists mainly of tagging to provide information on the geographical relations of important stocks and also information on growth and mortality rates. In 1959 particular attention was again given to the tagging of Pacific (grey) cod and rock sole in order to fill some of the remaining gaps in knowledge of these species.

Exchange of information with United States research agencies respecting the groundfish catch in international waters is being maintained through co-operation with the Pacific Marine Fisheries Commission. Recent formation of an international Trawl Fishery Committee holds promise of encouraging joint study of fisheries problems in offshore waters.

Trends in catch. In 1959, landings in British Columbia of groundfish other than halibut amounted to 29 million pounds, about the same as in 1958. In recent years the total Canadian and United States production from this general area has exceeded 70 million pounds, an amount which is roughly equivalent to the production of halibut from the entire northeastern Pacific.

Landings by Canadian otter-trawlers exceeded 22 million pounds in 1959 and 75% of this total consisted of species used for human consumption. As in the previous year, Pacific (grey) cod was the main item of production, amounting to 9.2 million pounds or 41% of the otter-trawl landings. Production of flatfish (principally rock sole, lemon sole and brill) was only 4.9 million pounds, the lowest yield since 1945 and far below the long-term average of 8.5 million pounds. Although landings of all flatfishes were below the long-term average, the main reason for the decline was the collapse of the rock sole fishery in northern Hecate Strait.

Landings of scrapfish (mainly arrow-tooth sole and whiting) were well above average in 1959 at 4.2 million pounds.

A federal government program of price support on dogfish liver was initiated on an experimental basis in 1959 as a means of combatting the growing interference of dogfish in the trawl fishery and in the fisheries for salmon and herring. As a consequence, liver landings reached one million pounds, substantially more than in any year since 1949. This is equivalent to about 6.7 million pounds of whole fish. In addition, 1.4 million pounds of whole dogfish were destroyed by government-chartered trawlers, which brought the total kill to approximately 8 million pounds.

Trends in abundance. Statistics of catch per unit of effort are of value in detecting trends in abundance of groundfish. In British Columbia waters two stocks of brill (petrale sole) have been distinguished by tagging. Both underwent a sharp decline in abundance between 1948 and 1956. Thereafter, precise measurement of stock size was made difficult by a scarcity of reliable data. Re-examination of available information coupled with observations of most recent (1959) events has yielded fairly strong evidence in support of the view that the southern-most of the two stocks is now undergoing at least a temporary increase in abundance. In company with an increase in catch, catch per effort has been rising and average size of fish in the catch has been declining. Recruitment of the 1951 to 1953 year-classes appears to be much stronger than that of five preceding year-classes. In 1959 the Canadian and United States catch from the southern stock was 2.5 million pounds, the greatest since 1952. In the northern stock of brill, average size in the catch is decreasing and catch per effort is increasing slowly, but there is no evidence of improved catch (only 1.3 million pounds as compared with 10.6 million pounds in the peak year of 1948).

The abundance of lemon sole in northern Hecate Strait has undergone moderate variations in the past decade but without sign of trend. However, catch has been declining gradually, apparently as a result of decreasing fishing effort.

As mentioned above, the fishery for rock sole in northern Hecate Strait declined abruptly in 1959. This occurred despite an apparent sharp increase in abundance. Direct observations on the fishing grounds revealed large concentrations of fish which were too small to meet market requirements. Exceptionally heavy recruitment appears to be in progress, and although it is currently detrimental to fishing it augurs well for the fishery several years hence.

The apparent abundance of Pacific (grey) cod undergoes pronounced variations from year to year, particularly in Hecate Strait, and this is reflected in the annual catch. For example, in 1956 the average catch per hour of trawling in northern Hecate Strait was 585 pounds and the combined Canadian and United States catch for that year amounted to 3.4 million pounds. In 1958 the catch per hour jumped to 1,560 pounds and the catch reached an unprecedented 11.2 million pounds. The cause of these large, short-term variations in fishing success is not as yet fully understood. Lack of a simple means of age determination hinders assessment of the effect of variations in recruitment and too little is known about the factors which control the concentration (availability) of cod on the fishing grounds.

Mortality rate of Pacific cod. Calculation of the total mortality rate of cod, using length-freouency curves and knowledge of growth rate determined from tagging, yields estimates which are in excess of 70% per year for certain inshore stocks. Preliminary indications are that a large share of this mortality is due to natural causes. If so, then there would be basis for believing that the sharp annual variations in fishing success are primarily the result of variations in recruitment.

Temperature relations of Pacific cod. On offshore banks, cod engage in seasonal movements between deep and shallow water. Greatest depths are attained during the early winter after which there is a gradual movement towards shallow water. After May or June the cod appear to move slowly towards deep water again. Comparison of these seasonal movements with information on the seasonal cycle of temperature in waters of the continental shelf suggests that cod remain more or less within the same band of temperatures throughout the year. In Hecate Strait and Queen Charlotte Sound, temperatures associated with the occurrence of cod range from 6° to 8°C, while off the Vancouver Island coast they range from 7° to 9°C. In comparison with other regions of the North Pacific which support stocks of cod, these temperatures are high, and no doubt account for the apparently high rates of growth and natural mortality among British Columbia cod.

CRAB

In 1959 field work was kept at a minimum and attention concentrated on analysis of the results of the investigation of the Queen Charlotte Islands crab fishery started in 1947. Review of the catches in Naden Harbour from 1933 to 1959 showed that their fluctuations depend mainly on changes in fishing effort. Tagging and experimental fishing from 1947 to 1956 revealed changes in abundance unrelated to commercial fishing and apparently due to variations in annual recruitment of crabs as they reach four years of age. A strong positive correlation was found between average catch of crabs per day's fishing in Naden Harbour in any year from 1944 to 1959 and the mean sea-water temperature at Langara Island lighthouse during April four years earlier. Warm water, or some associated factor, apparently favours the survival of the early larval stages. On this basis abundance will be high from 1960 to 1962 and it is planned to test this prediction by sampling surveys well in advance of the fishery.

SHRIMP

Explorations for shrimp were carried out in conjunction with groundfish investigations in June, 1959, in several inlets on the west coast of Vancouver Island and on ground off Nootka Sound. Indications of possible commercial fishing obtained in 1954 and 1955 were confirmed and successful fishing on one inshore ground started early in 1960. Prospects for a fishery off Nootka Sound seem good if shrimps of small, average size can be handled, perhaps by the use of peeling machines.

Comparative fishing showed that, although catches were about the same, a 40-foot Gulf of Mexico otter trawl was preferable to the Station's special sampling trawl because it caught fewer fish and was easier to handle. Cod-ends made of 1 1/8-inch nylon and 1 1/4-inch cotton retained shrimps (Pandalus jordani) equally well but a 1 1/2-inch mesh cotton cod-end permitted smaller shrimps to escape and reduced the weight of catches by about one half.

OYSTERS

To better understand the drastic seasonal changes in condition which occur in the Pacific oyster, a gross histological study of changes in the gonads has been carried out. Spawning of Pacific oysters is usually complete and may occur any time from late June to early September but most often in late July or early August. After complete spawning, condition is at the lowest level of the year, the body almost transparent and the gonad collapsed. By November condition is greatly improved but gonad development is still small and undifferentiated as to sex. This condition lasts throughout the winter and not until April does gonad development become active and sex differentiation occur. Increase in follicular material proceeds rapidly and production of eggs and sperms is well under way in May. By the end of June the oysters are fully ripe with the follicles tightly packed with eggs and sperm, a condition which persists until spawning.

In 1959 forecasts of the settlement of oyster spat were made at Ladysmith Harbour and Pendrell Sound. In the former temperatures were marginal, few larvae were found in plankton tows, oyster growers were advised not to attempt spat collection and tests indicated a spatfall well below the minimum commercial level. In Pendrell Sound temperatures were higher, spawning occurred on June 25, a commercial set was forecast for July 14 or 15 and cultch exposed July 11 and removed July 16 had an average of 161 spat per shell. Later spawnings on July 12 and 19 produced heavy sets early in August which were also forecast. A commercial producer of oyster seed obtained a heavy set on 300,000 cement-coated veneer circles and about 3,000 strings of shells. The heavy set produced in the warm summer of 1958 has blanketed many areas in the Strait of Georgia. Its distribution will be studied in relation to the circulation of the surface water.

The Provincial Shellfish Laboratory at Ladysmith studied the condition of oysters in the Crofton area, in anticipation of possible effects of a proposed pulp mill there. Now the mill is in operation and these studies have been resumed by this Station. Monthly samples from commercial oyster beds at Crofton and in neighbouring areas showed, of course, the usual seasonal changes in the condition of the oysters. It was not good at Crofton, especially during the harvest season in January, February and March, but the magnitude of changes that have occurred so far, since the operation of the mill started, are within the range of those known to occur in non-polluted areas. Oysters held in these trays, within 25, 300 and 600 yards of the outfall from the mill, all showed the normal increase in condition from the low value in April; the oysters nearest and farthest from the outfall reached about the same condition by winter and the intermediate oysters did somewhat better. Heavy settlement of larvae of barnacles, shipworms and other animals occurred close to the outfall. Short-term effects of the pulp-mill pollution were not indicated by these observations, but neither can it be concluded with certainty that the condition of oysters was not affected. Further observations are in progress.

MARINE INVERTEBRATES GENERALLY

Studies of the distribution and ecology of marine bottom invertebrates in British Columbia were initiated in 1958 because of their importance to the marine resource as a whole. One major intertidal collecting trip was made in 1959 to the northwest coast of Vancouver Island and advantage was taken of field trips for other purposes. Study of the collections is proceeding.

The Station continued to co-operate with other agencies in the study of the toxicity of bivalves (paralytic shellfish poisoning) in the northern part of the Strait of Georgia. There has been a general downward trend in toxicity levels since the 1957 outbreak. No opportunity presented itself for study of the basic causes.

A study of the production of butter clams at Seal Island in the northern part of the Strait of Georgia was carried on by this Station from 1939 to 1948, by the Provincial Department of Fisheries from 1948 to 1958 and by this Station again since that time. A major feature of this clam population has been a generally low level of recruitment, but with infrequent occurrence of abundant year-classes which may be highly productive as long as they last.

WHALES

The whale fishery is kept under review in accordance with the requirements of the International Whaling Agreements. In 1959 the catch was higher than in any previous year comprising 28 blue, 369 fin, 27 humpback, 185 sei and 259 sperm whales - 868 in all. The proportion of sei whales was unusually large. There are, as yet, no signs of depletion of any species of whale in this area.

FUR SEALS

Investigations on fur seals, in co-operation with Japan, U.S.A. and U.S.S.R. under the Interim Convention on Conservation of North Pacific Fur Seals, entered their second year in 1959. Using the Station's vessel A.P. Knight for a fortnight in January and February and the chartered Pacific Ocean from March to July, 491 seals were collected of 1,372 seen. About 60% were taken off British Columbia, 15% off Oregon and Washington and 25% from the Gulf of Alaska. The main herd passed British Columbia 2 to 4 weeks earlier than in 1958.

Pregnant females 6 to 10 years old composed most of the catch in all areas. The scarcity of 2-year-olds in the 1958 catch and 3-year-olds in 1959 suggests that the 1956 year-class is weak.

Maximum volumes of food were found in the morning but 45% of all stomachs examined in 1959 contained food. Off British Columbia 45% of the food of migrating seals was salmon or herring, 25% whiting or sablefish, 10% rockfish. Yearlings fed mainly on sablefish and herring. Off Washington and Oregon rockfish predominated in food volume with squid second; off Alaska food consisted of sand lance, capelin, herring, squid and salmon in that order.

In all areas combined 89% of adult females were pregnant; the proportion was higher in each age group in 1959 than in 1958. The most important cause of reproductive failure appeared to be failure of the ovum to implant; other causes were miscarriage and failure to ovulate.

SEA LIONS

Because they are known to interfere with fishing and are believed by many to cause serious damage to stocks of commercial fish, sea-lions are under study to assess the need for control and suggest the means.

Surveys have indicated a population of about 12,000 in British Columbia waters, including pups of the year. Two major rookery areas, the Scott Islands and Cape St. James, have about two-thirds of the population during the breeding season and account for 90% of the annual recruitment of about 3,000 pups.

In 1959 169 sea-lions were collected from March to July for studies of age, growth, reproduction, and feeding. Food studies to date show that octopus and scrap-fish constitute most of the summer diet. Tagging, commenced at Sartine Island in 1958, is being continued in order to obtain specimens of known age and to study movements. In 1959 320 pups (about 95% of those on the Sartine Island rookery) were tagged. Efficacy of local control measures is being tested by keeping under observation a small rookery (North Danger Rocks) on which almost all the pups and as many adults as possible were killed in 1958 and again in 1959.

FISHING GEAR

The importance of research on fishing gear, both to reduce costs and maintain existing fisheries and to develop the means of exploiting new stocks, has been recognized. In 1958 the research on fishing gear formerly carried on at Vancouver was transferred to this Station and a broader program developed. A building with suitable laboratory and net-loft space was designed and is soon to be constructed.

The main project is to develop better means of catching pelagic fish, concentrating first on design, next on testing of research-scale gear and eventually on commercial nets. The use of lights and electricity in association with trawling will be explored. Work was commenced in 1959-60 on establishment of the hydrodynamic properties of netting, a prerequisite to design.

Research on materials was continued to co-operate in the development of international standards for testing gear under FAO auspices and to assist in development trade specifications. The properties of a new Japanese high-tenacity nylon twine were tested, the monofilament nylon gill-net situation surveyed and circulars issued on both subjects.

Information and advice were provided in answer to many requests from industry, and an important part was played in the development of gear for Station research projects. To make full use of developments elsewhere a considerable effort was spent on review of the literature.

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STAFF LIST BY INVESTIGATIONS

(for period April 1, 1959, to March 31, 1960 - casual help excluded)

Director	A.W.H. Needler, Ph.D.
Assistant Director	J.C. Stevenson, Ph.D. (to 31 May) F.C. Withler, M.A. (from 1 Jun)
Salmon Consultant	
Principal Scientist in charge	R. E. Foerster, Ph.D.
Marine Salmon Investigation	
Principal Scientist in charge	F. Neave, Ph.D.
Associate Scientist	J.I. Manzer, M.A.
Associate Scientist	H. Godfrey, M.A.
Assistant Scientist	R.J. LeBrasseur, M.A.
Technician 3	G.T. Taylor (to 19 Jun)
Technician 3	C.E. Turner (from 3 Aug)
Technician 2	W. Pinckard (to 31 Jul)
Student Assistant	G.I.M. Cowan (4 May to 6 Oct)
Student Assistant	H. Menkes (4 May to 18 Sep)
Student Assistant	G.P. Schroh (4 May to 30 Sep)
Student Assistant	L. Regan (2 Jul to 17 Sep)
Port John Field Station	
Technician 3	R.C. Wilson
Technician 1	P.W. Neave
Assistant Technician 3	P.R. Houlihan (16 Mar to 30 Jun)
Assistant Technician 3	R.G.M. Grubb (30 Mar to 30 Jun)
Assistant Technician 2	W.R. Filmer (31 Mar to 30 Jun)
Caretaker 3	Chandler, E.E. (12 Jun to 31 Mar)
Skeena Salmon Management	
Principal Scientist in charge	F.C. Withler, M.A.
Senior Scientist	W.E. Johnson, Ph.D.
Associate Scientist	J. McDonald, M.A.
Associate Scientist	K.V. Aro, B.A.
Technician 2	I. Miki
Technician 2	J. Martell
Technician 2	F.P. Jordan
Technician 2	J.R. Kolodychuk
Technician 1	J. Lucop
Assistant Technician 3	C.D. Murray (1 May to 5 Oct)
Assistant Technician 3	W.R. Harling (6 Jan to 30 Sep)
Assistant Technician 3	G.E. Johnston (1 Apr to 1 Aug)
Assistant Technician 3	R. Leahy (1 Apr to 22 Jan)
Assistant Technician 3	C.E. Twaites (1 Apr to 10 Nov)
Assistant Technician 3	P.R. Houlihan (1 Jul to 24 Nov)

Assistant Technician 2	W.L. Wiley (4 May to 31 Dec)
Assistant Technician 2	P.F. McLaughlan (13 Apr to 15 Sep)
Assistant Technician 2	W.D. Grinnell (9 Apr to 22 Oct)
Assistant Technician 2	W.R. Filmer (1 Jul to 27 Aug)
Assistant Technician 2	R.E. Hippislay (7 Aug to 9 Oct)
Assistant Technician 2	G.O. Mutschke (7 Aug to 7 Oct)
Assistant Technician 2	Hazel H. Turner (14 Dec to 31 Mar)
Assistant Technician 2	Elizabeth A. Thomson (14 Dec to 31 Mar)
Student Assistant	R.A. Hankin (4 May to 19 Sep)
Student Assistant	J.K-K Tang (4 May to 9 Sep)
Student Assistant	A.E. Aspinall (5 May to 15 Sep)
Student Assistant	R.L. Martin (5 May to 19 Sep)
Student Assistant	T. Miki (13 May to 19 Sep)
Stenographer 1	Hisami Nakanishi (29 Jun to 3 Sep)
Observer	May Henry (Part-time)
Spring and Coho Salmon	
Senior Scientist in charge	D.J. Milne, Ph.D.
Technician 1	E.A.R. Ball
Technician 1	K. Mueller (15 Apr to 11 Nov) (7 Dec to 31 Mar)
Salmon Stock Assessment	
Senior Scientist in charge	M.P. Shepard, Ph.D.
Associate Scientist	A.S. Hourston, Ph.D.
Associate Scientist	H.T. Bilton, B.A.
Technician 2	R.M. Humphreys
Technician 1	D.W. Jenkinson
Assistant Technician 3	Sigrid A.M. Ludwig
Assistant Technician 3	R.G.M. Grubb (1 Jul to 6 Nov)
Experimental Hatchery	
Technician 2	A.S. Coburn
Technician 1	E.M. Malmo (1 Apr to 20 May)
Assistant Technician 3	G.E. Johnston (from 3 Aug)
Assistant Technician 3	J.T.W. Dewar (15 Jun to 31 Mar)
Stream Salmon	
Associate Scientist in charge	W.P. Wickett, M.A.
Technician 2	W. Caulfield
Technician 1	H. Neate
Student Assistant	Verna I. Caunt (4 May to 19 Sep)
Experimental Biology	
Principal Scientist in charge	J.R. Brett, Ph.D.
Associate Scientist	D.F. Alderdice, M.A.
Associate Scientist	G.R. Bell, Ph.D.
Associate Scientist	D.V. Ellis, Ph.D.
Associate Scientist	W.E. Vanstone, Ph.D.
Associate Scientist	C. Groot, Phil. Drs.
Technician 2	D.B. Sutherland

Technician 2	C.T. Shoop
Technician 1	F.P.J. Velsen
Assistant Technician 3	D. Pozar
Student Assistant	F.C-W Ho (19 May to 15 Sep)
Student Assistant	R.J.F. Smith (4 May to 30 Sep)
Student Assistant	A.J. Wiggs (4 May to 15 Sep)

Pollution

Senior Scientist in charge	M. Waldichuk, Ph.D.
Technician 4	A.E. Werner
Student Assistant	J.G. Varsanyi (19 May to 4 Sep)

Parasitology

Senior Scientist in charge	L. Margolis, Ph.D.
Technician 2	Rosalie C. McAllister, B.A. (to 15 Oct)
Technician 2	N.P. Boyce, B.Sc. (from 14 Dec)
Student Assistant	Renata A.I.G. Brall (4 May to 15 Oct)
Student Assistant	Elsie von Rosen (19 May to 11 Sep)
Student Assistant	S.U. Qadri, M.Sc. (22 Apr to 31 Mar)

Marine Commercial Fisheries

Principal Scientist in charge	K.S. Ketchen, Ph.D.
Senior Scientist	F.H.C. Taylor, Ph.D.
Associate Scientist	W.E. Barraclough, M.A.
Associate Scientist	T.H. Butler, M.A.
Assistant Scientist	D.N. Outram, B.A.
Assistant Scientist	J.A.C. Thomson, M.Sc.
Technician 3	C.R. Forrester
Technician 2	R.M. Wilson
Technician 2	A.N. Yates
Technician 2	J.S. Rees
Technician 2	R.S.K. Isaacson
Technician 2	E.J.R. Lippa (from 1 Apr 59)
Technician 1	A. Rigby
Technician 1	E.W. Stolzenberg
Assistant Technician 3	B. Wildman
Student Assistant	M. Yesaki (4 May to 16 Sep)
Student Assistant	Katherine J. Casper (4 May to 19 Sep)

Marine Mammals

Associate Scientist in charge	G.C. Pike, M.A.
Assistant Scientist	D.J. Spalding, B.A. (on leave w/o pay 5 Oct to 15 May)
Technician 1	I.B. MacAskie
Assistant Technician 2	E. Binnersley (1 Mar to 9 Nov)
Student Assistant	A.M. Craig, B.Sc. (8 Jun to 31 Mar)

Marine Invertebrates

Senior Scientist in charge	D.B. Quayle, Ph.D.
Student Assistant	D.A. McCaughran (4 May to 15 Sep)

Fishing Gear Research	
Associate Scientist in charge	P.J.G. Carrothers, S.M.
Technical Services (responsible to Assistant Director)	
Technician 4 (Electronics Lab)	M.A. Pirart, A.M.I.R.E.
Technician 1 (Drafting)	G.D.G. Denbigh
Technician 1 (Photography)	C.J. Morley
Technician 1 (Statistics)	Dorothy P. Dzendolet
Clerk 3 (Library)	Evelyn M. Wardropper
Student Assistant (Library)	Lynn A. Curry (4 May to 11 Sep)
Secretarial Services	
Clerk 4 in charge	Ethel E. Robinson
Stenographer 3 (Files)	Margaret K. Philp
Stenographer 2	Ruth Cote
Stenographer 1	Rosaline Pullan (to 31 Mar)
Stenographer 1	Joan S. McWhinney (to 12 Jun)
Stenographer 1	Joan Wilson-Brown (to 8 Jan)
Stenographer 1	Audrey R. Barner (from 11 Jan)
Stenographer 1	Deanna M. Shuhart (from 2 Jul)
Administration and Maintenance	
Administrative Officer 3 in charge	G.F. Hart
Purchases, Accounts and Personnel	
Administrative Asst. (Purchases)	O.O. Morgan
Clerk 4 (Accounts and Personnel)	R.E.K. Lumley (to 10 Nov)
Clerk 4 (Accounts and Personnel)	L.A. Noon (from 14 Oct)
Clerk 3	S.C. Grando
Stenographer 2	Doris Braydic
Typist 1	A. Louise Muir
Typist 1	Mildred A. Hannah
Maintenance and Services (Nanaimo)	
Maintenance Supervisor 5 in charge	A.G. Paul
Caretaker 5	J.C. Wallace
Caretaker 3	J.R. Jardine
Caretaker 3	J.H. Merner
Watchman	O. Perrin (to 21 Sep)
Watchman	J.M. McArthur
Watchman	W.W. Thompson (from 1 Jan)
Watchman	S.E. Allan (30 Jun to 31 Oct)
Cleaning Service Man	W.J. Hogan (to 12 Sep)
Cleaning Service Man	L. Klobchar (from 13 Jul)
Cleaning Service Man	N.R. Marsh
Cleaning Service Man	W.W. Thompson (20 Aug to 13 Nov)
Maintenance (boats, gear, field stations, workshop)	
Technician 3 in charge	L.G. Quickenden
Technician 2 (Master Mechanic)	K. Sutherland

Technician 1 (Master Carpenter)	M. Ilich
Technician 1 (Technical Storekeeper)	R. Hancock
Vessels	
"A.P. Knight"	
Technician 4 (Captain)	H. Mahle
Chief Engineer	P.G. Squarebriggs
Mate	O.N. Fylling (to 30 Apr)
Mate and Second Engineer	H.T. Wetting (from 1 Apr)
Second Engineer	P.C. Bergseth (to 14 Apr)
Second Engineer	F.R. Read (to 22 Jul)
Second Engineer	A. Mollevik (from 7 Aug)
Cook-Deckhand	W. Cowan (to 19 Jun)
Cook-Deckhand	G. Moum (from 15 Jun)
Netman	W. Ryles
"Investigator No. 1"	
Technician 2 (Captain)	C. Watson
Engineer	W.P. Winstanley
Mate	R.A. Dean
Cook-Deckhand	E. Bateman
"Alta"	
Technician 1 (Captain-Engineer)	R.E. Hirst
Cook-Deckhand	J.L. Day
Pacific Oceanographic Group	
Oceanographer in charge	J.P. Tully, Ph.D.
Senior Scientist	J.D.H. Strickland, Ph.D.
Senior Scientist	N.P. Fofonoff, Ph.D.
Senior Scientist	M. Uda, Ph.D. (to 15 May)
Associate Scientist	F.G. Barber, B.A.
Associate Scientist	A.J. Dodimead, M.Sc.
Associate Scientist	L.F. Giovando, Ph.D. (from 3 Aug)
Associate Scientist	S. Tabata, M.A.
Associate Scientist	T.R. Parsons, Ph.D.
Associate Scientist	C.D. McAllister, M.A.
Assistant Scientist	Charlotte Froese, Ph.D. (15 May to 15 Jul)
Assistant Scientist	N.E.J. Boston, B.Sc.E. (from 4 May)
Assistant Scientist	R.K. Lane, B.Sc. (from 4 May)
Technician 4	H.J. Hollister
Technician 4	L.D.B. Terhune
Technician 4	R.H. Herlinveaux
Technician 2	J.A. Stickland
Technician 2	K.V.C. Stephens
Technician 2	R.L. Johnston
Technician 1	D.G. Robertson (leave w/o pay 29 Oct to 29 Apr)
Technician 1	N.F. Bdinka (from 4 Jan)
Technician 1	R. Cagna
Technician 1	J.D. Carswell
Technician 1	O.D. Kennedy (to 17 Feb)
Technician 1	K.B. Abbott-Smith (to 23 Feb)

Technician 1	J.H. Meikle (from 16 Mar)
Technician 1	R.B. Farquharson (to 9 Mar)
Technician 1	W.R. Harling (from 1 Oct)
Technician 1	K.S. Booth (8 May to 17 Jun)
Assistant Technician 2	Mary C. Cairns
Stenographer 3	M. Madeleine Smith
Student Assistant	F.M. Boyce (19 May to 23 Sep)
Student Assistant	N.K. Chippindale (4 May to 24 Sep)
Student Assistant	J.A. Gow (1 May to 16 Sep)
Student Assistant	J.D. Lewis (4 May to 17 Sep)
Student Assistant	M. Revzen (1 May to 8 Sep)
Student Assistant	T. Tabata (4 May to 22 Sep)
Student Assistant	G.S. Pond (13 Jul to 4 Sep)

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STUDIES OF SALMON IN THE OCEAN

F. Neave

In 1959 effort was again directed toward (1) obtaining information on the distribution, abundance and movements of salmon in the North Pacific, and (2) providing samples of salmon from the Gulf of Alaska for examination by various groups of investigators working under the International North Pacific Fisheries Commission program to determine the origin of stocks occurring in offshore waters.

The sampling was carried out in the central and western part of the Gulf of Alaska. Relatively good weather conditions contributed to a successful operation.

Additional data on the vertical distribution of salmon in the ocean were obtained. This information, which Canada alone is seeking at the present time, is needed for assessing the significance of all other gill-net operations on the high seas, in which only surface gear is used.

The development of a method for distinguishing between immature salmon and those which are nearing maturity is contributing to a better understanding of salmon distribution and the timing of migrations. There is accumulating evidence that the western part of the Gulf of Alaska is an important feeding area for young fish from British Columbia, as well as from other regions.

In conjunction with the fishing program, investigations of the biological environment of salmon were continued. These studies give promise of resulting in the recognition of organisms which can serve as indicators of physico-chemical conditions in the ocean, as well as being potentially useful in determining the locations and characteristics of the most favourable feeding grounds, and the basis of fluctuations in the size of salmon.

Further observations were made on the distribution of, and methods of fishing for, pomfret and jack mackerel - species which may provide future fisheries.

In accordance with the Canadian policy to make available as much data as possible to scientists charged with solution of the Protocol problem, the salmon catches, plankton and oceanographic data collected in 1958 were compiled and distributed in 1959 as a Data Record which appeared as FRBC Manuscript Report (Biological) No. 682.

1. Sampling salmon on the high seas

F. Neave and J. I. Manzer

The sampling operations in 1959 were carried out in the central and western parts of the Gulf of Alaska by the chartered vessel Key West II. The vessel left Nanaimo on May 7 and returned from her final cruise on July 27.

The fishing gear used consisted of surface gill-nets of mesh size 2 1/2", 3 1/4", 4 1/2" and 5 1/4", in the proportion 1:1:3:1, as in 1957 and 1958. The amount of gear set at one time was either 36 or 35 50-fathom shackles.

Collections of salmon for use in the morphometric, parasitological and scale studies of the INPFC program were made at seven stations, the localities of which are shown in Figure 1. From 1 to 3 night sets were made at each station between May 18 and June 30. After covering these stations a few sets of long-line and gill-net gear were made by the Key West II in waters adjacent to the southern end of the Queen Charlotte Islands.

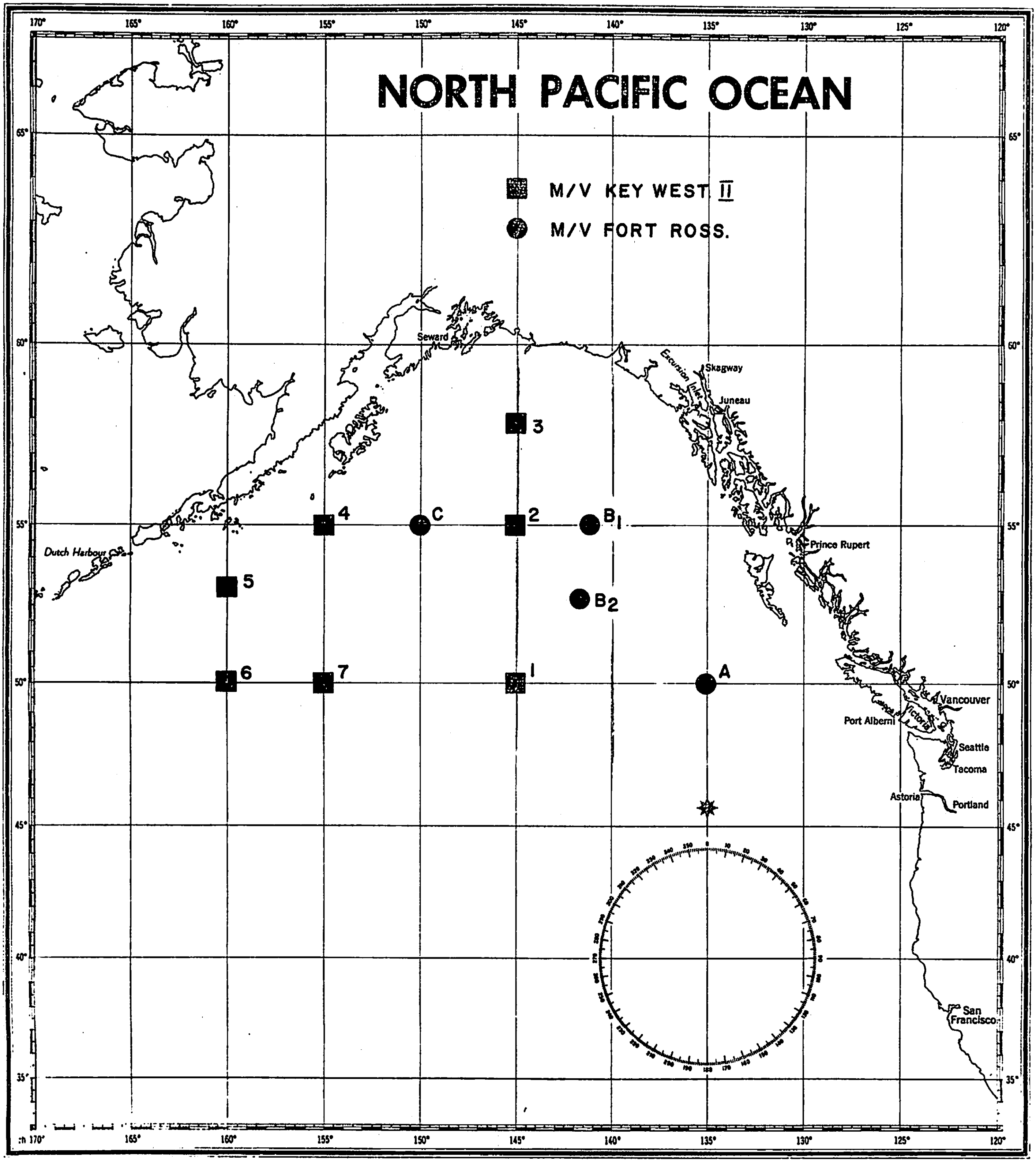

Figure 1. Sampling stations occupied by Canadian research vessels, 1959.

Taking the season as a whole, weather conditions were considerably more favourable than in 1958 and fishing operations were accordingly carried out more often and more successfully.

Other operations carried out in association with fishing, or between fishing stations, included: vertical plankton hauls from 150 meters to surface; horizontal plankton tows at fishing stations; hauls with mid-water trawl; collection of organisms by plankton net and dip-net with use of night light; bathythermograph casts.

Catches and accompanying data for surface gill-nets fished by the Key West II are shown in Table 1. The relative size of catches of sockeyes, pinks and chums at the seven sampling stations, after weighting for the amount of gear and the length of time the gear was fished, is given in Table 2.

Sockeye salmon were the most numerous species at all stations but were found most plentifully on Longitude 155° W, south of Kodiak Island. Chum salmon were also considerably more numerous on this meridian than farther east. Very few pink salmon were taken in the central part of the Gulf of Alaska. More than 80% of the total catch of this species were taken at the two westernmost stations (Longitude 160° W). The possibility that many of these fish were of Asiatic origin is suggested by the fact that United States investigators found numbers of pink salmon from East Kamchatka as far east as Longitude 168° W. Determinations of the ages of sockeye and chum salmon (made by T. H. Bilton) are recorded in Tables 3 and 4.

A main feature of the distribution picture in 1959 was the further evidence that the ocean region near Latitude 50° N and west of Longitude 145° W is an important feeding area for young sockeyes, pinks and chums originating in widely separated coastal areas.

Table 1. Salmon catches by the Key West II, 1959

Date	Position		No. of	Surf. temp.	Salmon				
	Lat. (°N)	Long. (°W)	shackles	(°C)	Sockeye	Pink	Chum	Coho	Total
May 18	50°00'	145°00'	36	7.9	46	9	19	..	74
19	50°00'	145°00'	36	7.9	58	29	6	8	101
21	55°00'	145°00'	36	7.0	130	7	30	..	167
22	55°00'	145°00'	36	6.5	26	..	6	..	32
23	55°00'	145°00'	36	6.8	156	2	9	..	167
25	58°00'	145°00'	36	7.9	190	..	27	..	217
26	58°00'	145°00'	?	8.6	13	..	3	..	16
June 10	54°56'	155°00'	36	8.1	105	5	26	..	136
12	55°11'	155°00'	36	8.9	363	14	163	..	540
14	53°00'	160°00'	36	8.1	14	76	27	..	117
24	53°00'	160°00'	35	9.6	41	46	11	..	98
25	53°00'	160°00'	35	9.4	104	148	60	..	312
27	50°00'	160°00'	35	9.9	91	54	239	..	384
28	50°00'	160°00'	35	10.0	129	89	..	..	218
29	50°00'	155°00'	35	10.4	217	16	137	3	373
July 17	51°00'	130°15'	35	13.8	11	..	..	..	11
18	51°00'	132°00'	35	13.5	4	..	..	..	4
19	52°10'	131°24'	35	12.9	8	16	..	..	24
24	52°00'	134°00'	35	13.1	3	..	..	..	3
25	51°00'	132°00'	35	13.1	40	2	1	..	43
Total					1749	513	764	11	3037
Percent					57.6	16.9	25.1	0.4	100.0

Table 2. Relative abundance of salmon. Catches are weighted to 900 fathoms of surface gill-net fishing 10 hours, each mesh size equally represented.

Station	Position		No. of sets	Weighted catch		
	Lat.(°N)	Long.(°W)		Sockeye	Pink	Chum
1	50	145	2	14	6	3
2	55	145	3	31	1	5
3	58	145	1	48	--	9
4	55	155	2	100	3	43
5	53	160	3	28	21	9
6	50	160	2	41	16	30
7	50	155	1	240	6	57

Table 3. Ages of sockeye salmon caught at sampling stations in the Northeast Pacific, 1959.

Date	Stn.	Age											Total
		3_2	4_2	4_3	5_2	5_3	5_4	6_2	6_3	6_4	7_4	Unknown	
May 18-19	1	11	47	1	18	15	-	1	5	-	-	6	104
21-23	2	8	44	2	43	23	-	-	22	2	3	20	167
25-26	3	1	68	-	61	39	-	1	20	4	3	6	203
Jun 10-12	4	16	108	3	22	56	1	-	16	4	2	35	263
14-25	5	42	30	8	18	34	-	-	13	4	-	10	159
27-28	6	69	21	24	3	11	1	-	1	1	-	10	141
29	7	126	10	7	-	5	-	-	-	-	-	13	161
Total		273	328	45	165	183	2	2	77	15	8	100	1198

Table 4. Ages of chum salmon caught at sampling stations in the Northeast Pacific, 1959.

Date	Stn.	Age					Total
		2	3	4	5	Unknown	
May 18-19	1	1	16	3	-	5	25
21-23	2	-	11	34	-	0	45
25-26	3	-	4	21	4	1	30
Jun 10-12	4	-	74	67	2	46	189
14-25	5	1	59	26	-	12	98
27-28	6	-	62	95	4	78	239
29	7	-	75	29	1	32	137
Total		2	301	275	11	174	763

2. Distribution of immature and maturing sockeye and chum salmon in the Northeast Pacific J. I. Manzer

The need to consider immature and maturing individuals separately in any study of the high-seas distribution and movements of salmon and the factors related thereto has been recognized for some time. Initially, these two groups were separated on the basis of age or, in the case of sockeyes, by duration of marine residence. While this method was useful for revealing gross features of salmon distribution, it could not measure the effect produced by fish maturing at different ages. This difficulty to a large extent has now been overcome by the application of the "Index of Maturity" method developed by Godfrey (see Summary Report 4).

Sockeye and chum salmon data collected during 1957, 1958 and 1959 have been re-examined and individual fish classified wherever possible as immature or maturing. The results of this are summarized in Tables 5 to 7.

Table 5. Percentages of immature and maturing individuals in sockeye and chum salmon catches in the Northeast Pacific, 1957.

Period	Position		Sockeye			Chum		
	°N	°W	No.	% Imm.	% Mat.	No.	% Imm.	% Mat.
Jun 8-Jul 12	55°	135°	55	1.8	98.2	347	8.0	92.0
	55°	145°	13	38.5	61.5	113	99.1	0.9
	55°	153°	39	48.7	51.3	54	92.6	7.4
	55°	155°	96	59.4	40.6	107	92.5	7.5
	58°	145°	116	19.8	80.2	186	91.9	8.1
	50°	135°	136	3.7	96.3	112	88.4	11.6
	50°	145°	46	63.0	37.0	48	97.9	2.1
	50°	155°	72	95.8	4.2	21	100.0	0.0
	50°	138°	32	6.3	93.7	2	100.0	0.0
July 20-Aug 22	55°	135°	34	0	100.0	4	0.0	100.0
	55°	143°	1	0	100.0	15	93.3	6.7
	55°	145°	2	100.0	0.0	21	76.2	23.8
	55°	152°	10	100.0	0.0	73	93.2	6.8
	55°	153°	15	100.0	0.0	127	97.6	2.4
	58°	145°	2	100.0	0.0	128	89.8	10.2
	51°	135°	118	0.0	100.0	-	-	-
	51°	155°	2	100.0	0.0	6	100.0	0.0
	52°	155°	30	93.3	6.7	32	100.0	0.0
	52°	145°	3	0.0	100.0	13	100.0	0.0
	52°	135°	-	-	-	5	80.0	20.0
	52°	134°	-	-	-	2	0.0	100.0

Table 6. Percentages of immature and maturing individuals in sockeye and chum salmon catches in the northeast Pacific, 1958.

Period	Position		Sockeye				Chum			
	°N	°W	No.	% Imm.	% Mat.	?	No.	% Imm.	% Mat.	?
May 11 -	51°	130°	5	40.0	60.0	-	6	16.6	83.4	-
June 25	50°	135°	13	0.0	84.5	15.5	74	88.0	12.0	0.0
	55°	145°	53	13.2	73.6	13.2	20	0.0	95.0	5.0
	58°	145°	262	2.7	97.0	0.3	49	4.1	93.6	2.3
	55°	135°	35	45.7	54.3	0.0	28	57.0	43.0	0.0
	50°	145°	164	69.0	27.4	3.6	87	23.0	77.0	0.0
	55°	150°	328	0.9	62.0	37.1	70	14.3	71.4	14.3
	55°	155°	181	5.0	95.0	0.0	16	0.0	93.7	6.3
	50°	155°	125	61.5	38.5	0.0	67	53.7	44.7	1.6
July 26 -	50°	145°	1	0.0	100.0	0.0	-	-	-	-
Aug. 24	50°	155°	1	100.0	0.0	0.0	48	96.0	2.0	2.0
	55°	155°	5	80.0	20.0	0.0	33	70.0	30.0	0.0
	55°	145°	-	-	-	-	2	50.0	50.0	0.0
	51°	130°	36	0.0	97.2	2.8	2	0.0	100.0	0.0
	55°	135°	15	0.0	100.0	0.0	3	33.3	66.7	0.0
	57°	144°	-	-	-	-	10	0.0	100.0	0.0

Table 7. Percentages of immature and maturing individuals in sockeye and chum salmon catches in the northeast Pacific, 1959.

Period	Position		Sockeye				Chum			
	°N	°W	No.	% Imm.	% Mat.	?	No.	% Imm.	% Mat.	?
May 17 -	50°	145°	106	58.5	33.0	8.5	25	28.0	48.0	24.0
June 29	55°	145°	165	6.1	83.0	10.9	45	2.2	91.1	6.7
	58°	145°	203	1.5	92.1	6.4	30	0.0	100.0	0.0
	55°	155°	260	13.1	83.5	3.4	148	2.0	93.2	4.8
	53°	160°	160	59.4	36.9	3.7	97	20.6	77.3	2.1
	50°	160°	143	90.2	9.1	0.7	169	91.7	5.3	3.0
	50°	155°	161	99.4	0.6	0.0	111	87.4	7.2	5.4
	55°	141°	76	13.2	85.5	0.3	29	13.8	86.2	0.0
	55°	150°	51	18.0	82.0	0.0	9	22.0	78.0	0.0
July 5-25	50°	135°	21	0.0	100.0	0.0	-	-	-	-
	52°30'	142°	21	0.0	100.0	0.0	21	76.2	23.8	0.0
	55°	150°	24	66.7	33.3	0.0	30	90.0	10.0	0.0

The distribution of immature and maturing fish showed a consistent pattern throughout the three years, insofar as changes in the locations and dates of sampling stations permitted comparison. During May and June both categories of sockeyes were present throughout the northeast Pacific but immature fish were especially prevalent along Latitude 50° N, west of Longitude 145° W, in some cases constituting up to 99% of the sockeyes caught. They constituted a much smaller proportion of the catches made at stations closer to land. In July and August maturing fish were virtually absent from catches made west of Longitude 145° W. Chum salmon showed a generally similar pattern but some maturing fish continued to occur in the western areas until a later date than in the case of sockeyes. The area near Latitude 50° N, west of Longitude 145° W appears to be an important feeding area for immature fish of both species.

3. Vertical distribution of salmon in the northeast Pacific — J. I. Manzer and R. J. LeBrasseur

The study of the vertical distribution of salmon in the northeast Pacific, initiated in 1957, was continued on an expanded scale in 1959, using a chartered vessel, M/V Fort Ross. Increased knowledge of this phase of salmon distribution is necessary in order to interpret the catches made by surface gill-nets.

Fishing was carried out between May 13 and August 2 at three stations in the Gulf of Alaska: 55° N, 150° W (Station C), 50° N, 135° W (Station A) and at an intermediate station (Stations B_1 and B_2) which changed in position during the season (Fig. 1).

The gear used consisted of one panel of regular INPFC surface gill-nets and a sunken net of 4 1/2-inch web, 400 fathoms long (initially) and 40 feet deep. The latter, by means of drop lines, could be set at 40-foot intervals to a maximum depth of 160-200 feet. Thus five sets were required to complete a series. Day and night sets were made during May in order to provide information on diurnal migrations. Day sets were later discontinued when more time was required for gear maintenance. A total of 8 day sets and 27 night sets were made.

As part of the normal fishing routine, surface temperature observations, a bathythermograph cast to 270 meters, and plankton collections were made.

The relative numbers of sockeye, pink and chum salmon caught at different depths, by time periods, are shown in Table 8 and Figure 2. The numbers of fish are based only on night catches with sunken net adjusted to 400 fathoms of gear.

In May, sockeye and chum salmon were caught at each of the five depth intervals but most of the sockeyes were taken in the top 40 feet and most chums below 80 feet. Later in the season all sockeyes and pinks and most of the chums were caught within 40 feet of the surface. The balance of the chums were taken between 40 and 80 feet. The apparent change in vertical distribution during the course of the season coincided with the development of a strong thermocline below the level at which fish were caught. This phenomenon is best shown at Station C.

Comparison of catches by day and night sets suggest that sockeye undertake diurnal vertical movements. It is not yet known whether pink and chum salmon do so. It must be emphasized that these findings are based on small catches and (because of the mesh size used) are applicable mainly to maturing fish. What effects size, maturity, and other factors may have on vertical distribution are still to be determined.

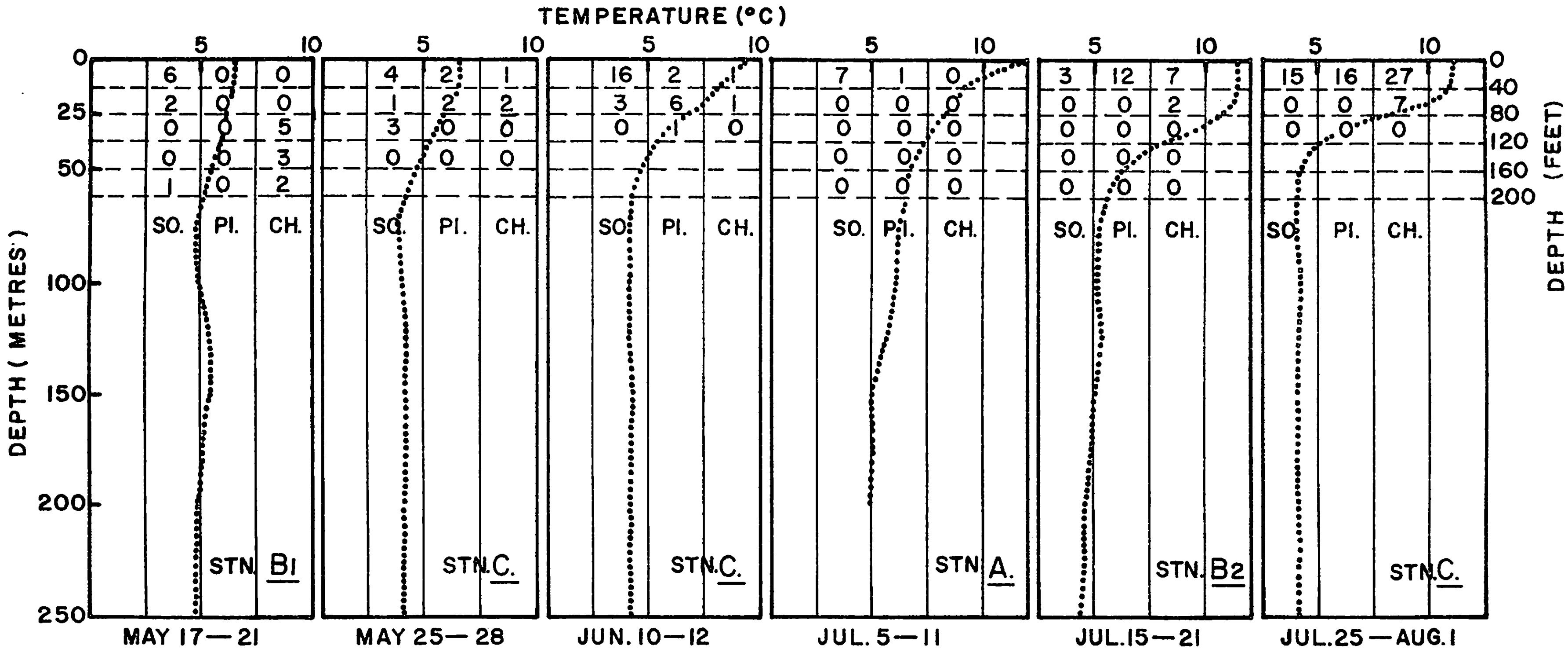

Figure 2. Average temperature profiles (dotted lines) at fishing stations with salmon catches (weighted) at various depths.

The results of this study are reported more fully in Report No. 689 of the Board's Manuscript Series.

Table 8. Relative numbers of sockeye, pink and chum salmon at various depth intervals to 200 feet. Data are based on sunken net catches at night, weighted to 400 fathoms of gear.

Date	No. sets	Depth (ft.)	Sockeye		Pink		Chum	
			Av. catch per set	%	Av. catch per set	%	Av. catch per set	%
May-June	3	0-40	8.7	68.4	1.3	30.3	0.7	10.1
	3	40-80	2.0	15.8	2.7	62.6	1.0	14.5
	3	80-120	1.0	7.9	0.3	7.1	1.7	24.6
	2	120-160	0.0	0.0	0.0	0.0	1.5	21.8
	1	160-200	1.0	7.9	0.0	0.0	2.0	29.0
Total			12.7	100.0	4.3	100.0	6.9	100.0
July-August	3	0-40	8.3	100.0	9.6	100.0	11.4	79.0
	3	40-80	0.0	0.0	0.0	0.0	3.0	21.0
	3	80-120	0.0	0.0	0.0	0.0	--	0.0
	2	120-160	0.0	0.0	0.0	0.0	--	0.0
	2	160-200	0.0	0.0	0.0	0.0	--	0.0
Total			8.3	100.0	9.6	100.0	14.4	100.0

4. Method for distinguishing between immature and maturing sockeye and chum salmon taken on the high seas

H. Godfrey

In the studies of salmon distribution on the high seas currently being carried out under the auspices of the International North Pacific Fisheries Commission, it is necessary to take into account the state of maturity or immaturity of the fish.

Salmon were taken in gill-nets, were frozen at sea, and were brought back for later examination. The greatest catches were of sockeye, chum and pink salmon. Pink salmon almost invariably mature in their second year of life, but sockeye and chum salmon spawn at various ages. Since, among these two species, the sizes of mature and immature fish overlap considerably, it became necessary to find a means of distinguishing between them.

Fish with well-developed gonads were obviously maturing, but there were numerous specimens in which it was not possible to determine directly whether or not the gonads were ripening. For this reason, the 1957 data were examined in order to develop an "Index of Maturity" which could be used to identify the immature and the maturing fish.

The Index used was the ratio of the gonad weight to the total body weight, expressed as a percentage. Index values were arranged (by species and age group, separately) according to period of capture. When this was done it became evident that two groups of fish were present - one in which the Index remained low and relatively constant over the whole season, and the other in which the average value of the Index increased progressively during the season. The first group identified the immature fish, and the second the maturing.

By this method, immature and maturing sockeye and chum salmon were separated as follows:

Fish	Immature (Index)	Mature (Index)
3_2 male sockeye -	<0.2	>0.2
3_2 female sockeye -	none would mature until one or more years older; the Index did not exceed 0.6.	
4_2 male sockeye -	<0.1	>0.1
4_2 female sockeye -	<1.0	>1.0
5_2 and 5_3 male and female sockeye -	The sample numbers were too small to observe seasonal changes adequately; limits appeared to be very similar to those of 4_2 fish.	
2-year male and female chums -	None would mature until one or more years older; the Index did not exceed 0.05 for males, and 0.3 for females.	
3-year male chums -	<0.1	>0.1
3-year female chums -	<1.0	>1.0
4-year male chums -	<0.1	>0.1
4-year female chums -	<1.0	>1.0

In addition to the Index, similar plots of absolute gonad weights and body weights were also made, and were useful in some instances. However, whereas the body weights and gonad weights of fish could be expected to vary considerably from year to year, because of annual changes in rates of growth, the Index should remain relatively constant, and should be indicative of the degree of maturity irrespective of the size of the fish.

The method outlined here is now being used in INPFC in describing the distribution of salmon in the North Pacific, and a paper defining it in greater detail has been submitted for publication by INPFC.

5. Ocean distribution of Rivers and Smith Inlets sockeye J. I. Manzer

Certain scale characters which appear to be peculiar to Rivers and Smith Inlets sockeye, and which were first noted by U.S. Fish and Wildlife Service scientists in Seattle, are being used to determine the high-seas distribution of fish originating from these areas. So prominent are these characters ((1) small freshwater zone, (2) circuli in first ocean year are numerous and concentrated,

(3) the second ocean annulus is wider than the first) when present together that fish originating in these water-sheds can be recognized during routine scale examinations.

Of over 4,000 sockeye sampled by Japan, United States and Canada on the high seas during 1957 and 1958, 42 were considered Rivers and Smith Inlets types. Information concerning their occurrence is given in Table 9 but because of differences in sampling times and areas these data can only indicate the minimal occurrence of these stocks offshore. In general, mature individuals were caught from near the British Columbia coast westward to Longitude 155° W; immature individuals from about 153° W to 170° W.

Table 9. High-seas catch data for Rivers and Smith Inlets-type sockeye.

Year	Date	Location		Maturity			Total
		Lat °N	Long °W	Imm.	Mat.	Unknown	
1957	Jun 7-10	50°	135°	-	9	-	9
	15	55°	135°	-	1	-	1
	Jul 1	55°	153°17'	1	-	-	1
	3	50°	135°	-	1	-	1
	24	53°	165°	1	-	-	1
	31	55°	135°	-	2	-	2
1958	May 17	50°	135°	-	1	-	1
	24	50°	145°	-	1	-	1
	Jun 2	55°	145°	-	1	-	1
	4	58°	145°	-	2	-	2
	7-8	55°	150°	-	5	-	5
	24-25	50°	155°	2	5	-	7
	Aug 8	51°	130°	-	2	-	2
	10	50°	170°	1	-	-	1
	11	51°	170°	3	-	-	3
	15	52°51'	166°	1	-	-	1
	17	52°	165°	1	-	-	1
	18	51°	165°	1	-	-	1
Total				11	30	-	41

6. Studies of plankton in the Gulf of Alaska in 1959

R. J. LeBrasseur

The plankton sampling in 1959 was similar to that of previous years. The standard haul from 150 meters to the surface continued to provide most of the samples. Horizontal tows made at the surface one hour after sunset have been included as part of the standard sampling procedure for all offshore vessels. The mid-water trawl was used to sample 3 depths (0, 25 and 60 m) at night. Day sampling was discontinued as the samples were too small to work with. In contrast to 1958, the 6-foot trawl was used throughout. Some comparative tows with the 3-foot trawl were made but these data have not yet been examined. However, data from the University of Washington indicate that the 6-foot trawl catches roughly 4 times as many fish and 3 times as much macroplankton as the 3-foot trawl.

Overall coverage of the Gulf of Alaska was not as complete as it has been in previous years due to changes in the INPFC sampling program and shorter charter periods for the research vessels. In all, some 1,029 samples were obtained. The breakdown of these samples into their respective types is given in Table 10. August was again the month in which plankton coverage of the Gulf of Alaska was most complete.

Table 10. Numbers of plankton samples collected in 1959.

	Vertical		Horizontal	Mid-water Trawl
	150 m.	1200 m.		
Weathership	100	5	45	--
P.O.G.	300	--	--	--
M/V Fort Ross	180	--	70	210
M/V Key West II	76	--	22	21
Total	656	5	137	231

Only preliminary examination has yet been made of the samples. Briefly, it seems that the biomass of edible zooplankton taken was similar to that in 1956 and 1958. It seems also that the intrusion of warm water into the Gulf has continued. Sagitta lyra, which has been tentatively assigned the role of an indicator of warm water intrusion, was found over about the same area it occupied in 1958. The abundance of small, immature specimens of S. lyra was noticeably less than in previous years.

The most striking feature of net plankton was the abundance and distribution of the pelagic tunicates (Doliolum sp. and Salpa sp.). While these species are a normal part of the summer plankton they generally occur in limited quantity, being more characteristic of the waters to the south of our area (50° N Lat.). In 1959 their occurrence was noted in the samples taken in January. Subsequent cruises along the coast and offshore indicated that they were becoming increasingly numerous over a wide area. By August (most recent of the processed observations) they occupied about one-third of the Gulf of Alaska and the B.C. coastal waters (Fig. 3). Doliolum occurs mainly at the surface whereas Salpa may occur at any depth from 150 m. to the surface.

Referring again to Figure 3, it is interesting to note that Doliolum shows a rather different distribution from Salpa, the latter being most abundant in the comparatively warm water off the B. C. coast. As these tunicates feed almost exclusively on the very small phytoplankton (nanoplankton), and since they do not appear to be normally abundant in this area, it is interesting to speculate on their possible role as competitors with the larval crustaceans and other juvenile zooplankton for food. Because of their abundance there should, presumably, be less food available to the normal juvenile forms common to the Gulf of Alaska. The effect of this competition, if it is real, will probably not be apparent until the spring of 1960 as it is these late summer forms which make up the wintering zooplankton which in turn gives rise to the new generations developing in 1960.

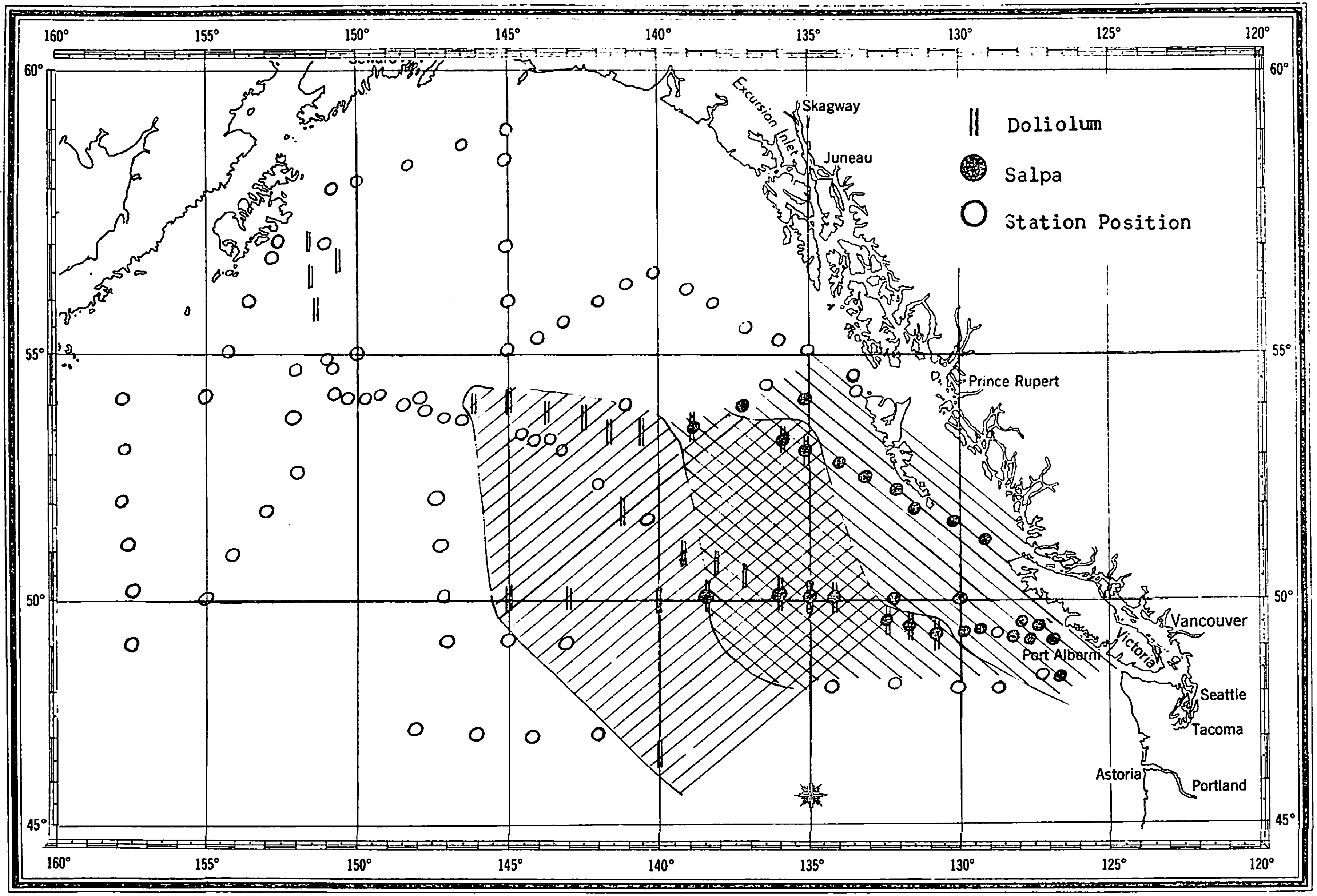

Figure 3. Distribution of <u>Doliolum</u> and <u>Salpa</u> in the northeast Pacific, August, 1959.

Another comparatively rare animal which occupied roughly the same area as the tunicates and is commonly considered a subtropical form was the pteropod, Pterotrachea sp. Other pteropods, such as Carinaria sp. and Atlanta sp. (also warm water forms), showed up along 50° N Latitude as far west as Station "P". Surface temperatures in the summer of 1959 were less than those noted for 1958 when there was a very pronounced intrusion of warm water. Biologically, it would seem that in the summer of 1959 there was at least as much warm water intrusion as in 1958. However, there is the possibility that the warm water forms were residuals and their progeny from the previous year.

7. Food of sockeye salmon at three high-seas localities R. J. LeBrasseur

Although the diet of salmon in the open ocean is known in a general way from the examination of many stomachs, comparatively little attention has been paid to the differences in the food supplies of different areas and their effect on salmon distribution, or to the effect of maturation on the feeding habits.

Comparisons have been made between sockeyes caught in 1958 at three widely separated localities in the Gulf of Alaska, viz. Station 2, southwest of Kodiak Island (55° N, 155° W); Station 8, at the weathership position (50° N, 145° W); and Station 7, situated between Station 8 and the British Columbia coast (50° N, 135° W) (see Annual Report for 1958-59).

Relative amounts of food present in the stomachs examined were expressed as:

$$\frac{\text{Volume of stomach contents (cc.)} \times 10^4}{\text{Weight of fish (grams)}}$$

Fish were segregated into "immature" and "maturing" categories.

The food components making up the food indices and their percent frequency are shown in Table 11. In general, two groups of zooplankton (pteropods and crustaceans), squid, and fish (capelin) were the main food constituents. Among the crustaceans, the euphausiids Euphausia pacifica and Thysanoessa sp. were the most important. They were followed by amphipods (Parathemisto sp.), decapods (Sergestes) and copepods. Only rarely did the latter two occur in significant quantities. The most important items at Station 7 were euphausiids and amphipods; at Station 8, squid; at Station 2, fish.

Sockeyes were caught most abundantly at Station 2. Station 7 showed the lowest catch per hour of fishing. At this station plankton hauls showed the presence of the chaetognath Sagitta lyra, which is regarded as an indicator of unfavourable conditions for salmon (see Annual Report for 1958-59).

The food index indicated that maturing fish fed relatively more heavily than immature fish whether or not they differed in age. At Station 8, maturing sockeye had an index of 69, as compared with 11 for immatures. The overall value of the food index for each station varied in conformity with the percentage of maturing fish in the catches. This was also true for chum salmon at these localities.

Comparisons between stomach contents and the catches of organisms made by plankton net and mid-water trawl (night and day) showed no quantitative agreement. It was noted that certain organisms such as Sergestes and chaetognaths, although

Table 11. Stomach contents and associated data for sockeye salmon caught at Stations 2, 7, and 8 in 1958.

Station	2		7		8	
Catch/hour	6.2		0.1		2.1	
Number caught	181		9		160	
Number examined	84		9		131	
Percent maturing	90		100		28	
Percent with food	71		55		32	
Mean food index	35		45		28	
Food item	A	B	A	B	A	B
Unidentifiable	0.4	2	1.7	22	0.9	9
Amphipod	2.8	49	11.8	67	1.4	65
Copepod	-	-	tr	22	0.2	35
Euphausiid	7.8	26	31.0	22	tr	2
Decapod	tr	2	0.4	11	1.2	7
Squid	1.7	13	-	-	24.5	20
Pteropod	1.7	15	-	-	tr	1
Fish	20.5	44	-	-	tr	1

A = food index
B = percent frequency

abundant in some hauls, were seldom taken in quantity by salmon. The composition and condition of stomach contents suggested that salmon do not feed much at night, although both fish and plankton organisms are present in numbers at the surface at that time. It is considered likely that salmon feed mainly during the rising and sinking of the food organisms in evening and early morning, or possibly during the day at a considerable depth.

8. Observations on pomfret, jack mackerel and albacore

F. Neave

Some additional data were obtained in 1959 on species of fish which can be regarded as potential resources but which are not exploited by Canadian fishermen at the present time or, in the case of the albacore, provide only a small, irregular fishery. All three species are seasonal immigrants to waters off the British Columbia coast from more southerly latitudes. Information in 1959 came from the following sources:

(a) Catches made in the course of salmon-fishing operations on the high seas.

(b) Line-fishing conducted during a large part of the year from the weathership at 50° N, 145° W (Station "P").

(c) A short exploratory cruise made in mid-August by the M/V Key West II after conclusion of the charter period for salmon fishing.

Pomfret. This species spreads throughout most of the Gulf of Alaska during the course of the summer. However, much of the fishing in 1959 was done in areas which are not populated by pomfret until about the time when operations were suspended. At the weathership the first pomfret were caught on July 3. Thereafter, they were caught regularly until December 7 by fishing with spoons at depths of between 15 and 100 meters. Surface temperatures at the beginning and end of this period were about 10° C and 8.2° C respectively. In July and early August, the Fort Ross, operating in the eastern part of the Gulf of Alaska between 50° and 53°30' N, took pomfret readily on lines baited with fresh fish. They were caught from the surface down to estimated depths of at least 300 meters.

In 4 sets made with surface gill-nets in early August at about 49° N and between 128° and 133° W, the Key West II took 563 pomfret. An additional number, perhaps 20%, dropped from the nets during hauling. Nets of 5 1/4-inch mesh were more effective than smaller sizes. Much larger concentrations of pomfret have been encountered from time to time in previous years.

As a commercial fish, pomfret are completely unutilized although the edible quality is considered excellent by most people who have tried them. There is little doubt that the species occurs in quantity each summer off the B. C. coast. Establishment of a fishery would depend on (a) developing a market, (b) adopting appropriate methods of transporting and processing the catch, (c) obtaining further information on the quantitative distribution of the species and the best way to fish it. Regarding the latter point, our experience in 1959 indicates that exploratory fishing could be carried out most rapidly and economically by the use of baited long-lines at various depths.

Jack mackerel. Quantitatively, this species now ranks among the most important fishes in the California catch. Salmon-fishing operations have shown that it is regularly present in July and August off the British Columbia coast. In 1959 it was taken occasionally at the weathership, at estimated depths down to 100 meters, until September 13. The surface temperature on this date was 11.7° C. Four sets of surface gill-nets made in August in the vicinity of 49° N (see above) yielded 807 jack mackerel.

Albacore. The catch statistics of the Department of Fisheries show that about 80 tons of "tuna" were taken by British Columbia fishermen in September and October, 1959, in offshore waters south of Cape Flattery, Washington. The capture of 24 albacore in the previously mentioned August gill-net operations of the Key West II shows that the northward distribution of the species in 1959 extended at least as far as the latitude of southern British Columbia.

STUDY OF SOCKEYE SALMON PARASITES TO DISTINGUISH STOCKS

L. Margolis

As in 1955, 1956, 1957 and 1958 the Station's parasitological work was almost all associated with the research program of the International North Pacific Fisheries Commission. Only minor attention was given to other problems.

During the past year the studies commenced in 1955 on the use of parasites of sockeye salmon (Oncorhynchus nerka) as a means of tracing the ocean distribution of North American and Asian stocks of these fish were continued and expanded. Progress in the research for the years 1955 to 1957 has been reported in the Annual Reports for 1956-57, 1957-58 and 1958-59. The last report contained a review of the pertinent data for the three years during which the studies had been in progress.

In the Annual Report for 1958-59 four parasites were reported as providing evidence of the origin of sockeye taken on the high seas. Two of these were Triaenophorus crassus, a cestode found only in some western Alaska (mainly Bristol Bay) sockeye stocks, and Dacnitis truttae, a nematode found in some sockeye of Asian origin, both of which are parasites acquired in fresh water before the young sockeye migrate to sea. Once the fish take up their ocean residence further acquisition of these parasites becomes impossible. Since these parasites have a restricted geographical distribution in sockeye stocks they serve to identify the geographical origin of ocean-caught sockeye infected with them.

The other two parasites, Tubulovesicula lindbergi and Hemiurus levinseni, are trematodes acquired in the sea. Tubulovesicula was considered to indicate North American origin of sockeye infected with this species because of the characteristics of the distribution of sockeye infected with it and because it never occurred together with Dacnitis or Hemiurus in the same fish but was present in some sockeye simultaneously infected with Triaenophorus. The occurrence of Hemiurus in high-seas samples of sockeye, other than from the Gulf of Alaska, was suggested as indicating the Asian origin of such fish because of the characteristics of the distribution of sockeye infected with it and because it never occurred along with Triaenophorus or Tubulovesicula in the same fish, but was found in some fish also parasitized with Dacnitis.

Although in 1958 the distribution of fish infected with Tubulovesicula or Hemiurus fitted the general pattern of previous years, one sockeye was encountered which was infected simultaneously with Hemiurus and Triaenophorus, and another carried both Hemiurus and Tubulovesicula. The sockeye infected with Triaenophorus and Hemiurus was a maturing female, age 4_2, taken in the Bering Sea at 56° N, 172°30' W, and the sockeye infected with Hemiurus and Tubulovesicula was an immature male, age 4_3, taken south of the Aleutians at 50° N, 180°.

Triaenophorus indicates western Alaskan origin of any sockeye infected with it and therefore the occurrence of Hemiurus along with Triaenophorus in a maturing sockeye demonstrates that Hemiurus may be found in sockeye which are migrating to western Alaska. Consequently it can no longer be stated that every high-seas sockeye carrying Hemiurus (exclusive of those in the Gulf of Alaska) is of Asiatic origin. However, since we have rarely observed Hemiurus in sockeye samples taken near the shores or the mouths of rivers of western Alaska it is probably true that most ocean-caught sockeye infected with Hemiurus (except those in the Gulf of Alaska) are of Asiatic origin.

The occurrence of Hemiurus and Tubulovesicula in the same fish also conflicts with the use of these parasites in identifying the continent of origin of individual sockeye taken on the high seas. Although Tubulovesicula generally is associated with sockeye of North American origin, the suggestion that it is never found in sockeye of Asiatic origin may be doubtful, since the origin of the fish harbouring both Hemiurus and Tubulovesicula is unknown.

Since the parasites were used to identify the origin of individual fish it is apparent from the foregoing that neither Hemiurus nor Tubulovesicula can be considered to be completely reliable indicators. Some revision of previously presented conclusions (see Annual Report for 1958) on the distribution of sockeye stocks from North America and Asia are therefore necessary. The ensuing discussion on ocean distribution of sockeye from North America and Asia will be based only on the distribution of sockeye infected with Triaenophorus and Dacnitis and is applicable only within the limits of time and locations of the sampling.

Of all North American sockeye stocks, the ocean distribution of those from some western Alaskan rivers only can be traced with certainty, since it is in this region alone that Triaenophorus occurs in sockeye.

The Asiatic rivers in which the sockeye are infected with Dacnitis are not well known because of the lack of samples from Asian rivers. However, A. K. Akhmerov, in papers published in 1954 and 1955, recorded Dacnitis from Kamchatka River sockeye, and since we have consistently found Dacnitis in some of the sockeye from the Sea of Okhotsk (off the southwest tip of Kamchatka) it would appear that Dacnitis also occurs in sockeye from one or more rivers on the west coast of Kamchatka. Dacnitis therefore gives evidence of ocean distribution of some sockeye originating from both east and west Kamchatka.

In the laboratory 3,323 sockeye were examined from collections made in 1958, compared to a combined total of 4,610 for the three previous years, 1955 to 1957, inclusive. The 1958 samples consisted of 331 seaward migrants (smolts) from North America, 614 adults from coastal North America and 2,378 sockeye from the high seas. The high-seas samples, collected from mid-May to the latter half of August, included immature (fish which would have spent at least one more year at sea before returning to spawn) and maturing fish (fish which would have spawned in the year they were caught). The localities from which samples were collected, the date of each collection and the number of sockeye examined from each collection site are given in Tables 12 to 14. Figure 4 also shows the distribution of coastal adult and high-seas sockeye samples.

A. High-seas distribution of North American and Asiatic sockeye in 1958 as determined by Triaenophorus and Dacnitis. In shore samples of adults from North America, Triaenophorus was most prevalent in the Wood River (Nushagak River system) and was also found, but to a much lesser extent, in the Naknek River, both of which empty into Bristol Bay. It was also found in the seaward migrants from these two systems. Triaenophorus was not found in any other North American samples listed in Tables 12 and 13. In addition to the above two rivers, Triaenophorus was observed in previous years in one smolt from the Ugashik River, Bristol Bay and in one adult returning to spawn in the Kuskokwim River, on the west coast of Alaska, north of Bristol Bay.

Shore samples from Asia were again unavailable but some samples taken close to the east coast of Kamchatka and some from the Sea of Okhotsk off the southwest coast of Kamchatka showed the presence of Dacnitis. It was not observed in any of the North American samples listed in Tables 12 and 13.

Table 12. Locality, date of catch, and size of sockeye smolt samples examined for parasites from 1958 collections from North America.

Locality	Date of catch	Number of sockeyes
Baker R., Washington	20-VI	13
Cultus Lake, Fraser R., British Columbia	20-IV	25
Seton Creek, Fraser R., British Columbia	5 to 12-V	25
Chilko R., Fraser R., British Columbia	1-V	25
Babine Lake, Skeena R., British Columbia	7-VI	25
Sockeye Creek, Ketchikan, southeast Alaska		40
Karluk R., Kodiak Is., Alaska	24-VI	25
Chignik R., Alaska Peninsula	11-VI	25
Ugashik R., Bristol Bay, Alaska	27,28-V	25
Brooks R., Bristol Bay, Alaska	25,26,27,29-VI and 3-VII	28
Naknek R., Bristol Bay, Alaska	29-V	25
Kvichak R., Bristol Bay, Alaska	21,22-V	25
Wood R., Bristol Bay, Alaska	31-V	25
Total		331

Table 13. Locality, date of catch, and size of adult sockeye samples examined for parasites from 1958 collections from coastal North America. (The letters preceding the locality refer to the lettered positions in Fig. 1).

	Locality	Date of catch	Number of sockeyes
A.	Columbia R. (Astoria, Oregon)	22 to 28-VI	23
B.	Fraser R., British Columbia	6-VIII	25
	Fraser R., British Columbia	8-IX	25
C.	Rivers Inlet, British Columbia	13,14-VII	25
D.	Skeena R., British Columbia	31-VII,1-VIII	25
E.	Nass R., British Columbia	8-VII	25
F.	Naha Bay (Ketchikan), southeast Alaska	17-VII	25
G.	Stikine R. (Petersburg), southeast Alaska	9-VII	25
H.	Situk-Ahrnklin R. (Yakutat), Alaska	21-VII	25
I.	Eyak R. (Cordova), central Alaska	21-VII	25
J.	Seldovia, Cook Inlet, Alaska	14-VII	25
K.	Karluk R., Kodiak Is., Alaska	26-VI	25
	Karluk R., Kodiak Is., Alaska	31-VIII	24
L.	Red R., Kodiak Is., Alaska	24-VI	25
M.	Chignik, Alaska Peninsula	1-VII	25
N.	Shumagin Is., Alaska Peninsula	10-VII	25
O.	Ugashik R., Bristol Bay, Alaska	16-VII	25
P.	Egegik R., Bristol Bay, Alaska	7-VII	25
Q.	Naknek R., Bristol Bay, Alaska	9-VII	25
	Naknek R., Bristol Bay, Alaska	19-VII	27
R.	Kvichak R., Bristol Bay, Alaska	10-VII	25
S.	Wood R., Bristol Bay, Alaska	4-VII	25
T.	Togiak R., Bristol Bay, Alaska	12,13-VII	25
U.	Kuskokwim R., northwestern Alaska	2,4-VII	15
V.	Salmon Lake, northwestern Alaska	27-VII	25
	Total		614

Table 14. Locality, date of catch and size of high-seas sockeye samples examined for parasites from 1958 collections. (The numbers preceding the locality refer to the numbered positions in Fig. 1).

Locality		Date of catch	Number of sockeyes
(1)	50°49' N, 153°07' E	5-VII	25
(2)	51°09' N, 153°40' E	25-VI	25
(3)	51°08' N, 153°45' E	15-VI	25
(4)	51°39' N, 154°10' E	15-VII	25
(5)	48°55' N, 156°28' E	5-VII	53
(6)	50°35' N, 159°50' E	19-VII	49
(7)	51°58' N, 159°51' E	26-VII	55
(8)	49°21' N, 160°27' E	16-VI	55
(9)	54° N, 163° E	2-VI	5
(10)	55°02' N, 164°02' E	4-VI	10
(11)	55° N, 164° E	7-VIII	50
(12)	55° N, 164° E	29-VII	50
(13)	56°01' N, 164°58' E	30-VI	5
(14)	58° N, 166° E	25-VI	6
	58° N, 166° E	26-VI	8
	58°02' N, 166°03' E	22-VI	4
(15)	49°35' N, 166°35' E	25-VI	54
(16)	59°01.5' N, 167° E	21-VI	18
(17)	50°41' N, 167°14' E	15-VI	51
(18)	50°10' N, 168°15' E	16-V	54
(19)	59°16.5'N, 169°03' E	17-VI	20
(20)	47°30' N, 169°41' E	26-V	55
(21)	59°18' N, 170°38' E	31-VII	95
(22)	59°20' N, 170°51' E	13-VI	5
	59°28' N, 170°54' E	12-VI	3
	59°27' N, 171°04' E	11-VI	5
(23)	51°05' N, 171°30' E	29-V	53
(24)	52°02' N, 171°35' E	5-VI	53
(25)	53° N, 172° E	2-VI	12
(26)	50°50' N, 172°30' E	7-VI	55
(27)	51°35' N, 173° E	8-VI	10
(28)	49°21' N, 173°19' E	16-V	54
(29)	54° N, 173° E	1-VI	17
(30)	55° N, 174° E	31-V	5
(31)	53°21' N, 174°58' E	22-VII	2
	54° N, 174°58' E	21-VII	3
	55°01' N, 174°58' E	20-VII	2
	55°59' N, 175°01' E	19-VII	5
(32)	49° N, 175° E	15-VII	10
(33)	50° N, 175° E	16-VII	14
(34)	52° N, 175° E	18-VII	49
	53° N, 175° E	19-VII	3
(35)	54° N, 175° E	17-VII	6
	55° N, 175° E	18-VII	16
	54°02' N, 176°28' E	16-VII	2
(36)	50°37' N, 175°02' E	8-VI	11
(37)	49°39' N, 176°11' E	14-VII	4
	50°18' N, 177°28' E	13-VII	8

Continued....

Table 14 (cont'd)

	Locality	Date of catch	Number of sockeyes
(38)	54° N, 178° E	15-VII	17
(39)	50° 59' N, 178° 50' E	12-VII	49
(40)	48° 33' N, 178° 29' E	1-VI	3
	49° N, 180°	31-V	7
	50° 03' N, 180°	29-V	8
	51° N, 180°	28-V	8
(41)	50° N, 180°	30-VI	42
(42)	53° N, 178° 15' E	29-V	5
	53° N, 180°	28-V	6
(43)	54° 43' N, 178° 14' E	22-VI	9
	53° N, 180°	17-VI	3
	54° N, 180°	18-VI	11
(44)	53° 31' N, 180°	14-VII	26
(45)	52° 04' N, 178° 38' W	12-VII	14
(46)	54° N, 178° W	10-VI	11
(47)	52° 58' N, 175° 13' W	27-VII	7
(48)	49° 30' N, 175° W	8-VII	4
	50° 30' N, 175° W	7-VII	15
	51° 17' N, 175° 53' W	6-VII	24
	50° 22' N, 177° 45' W	10-VII	5
(49)	53° 01' N, 175° W	2-VII	7
(50)	53° N, 174° 59' W	5-VIII	7
(51)	55° N, 175° W	7-VIII	13
(52)	51° 30' N, 175° W	5-VIII	53
(53)	50° N, 175° W	6-VIII	77
(54)	49° N, 175° W	7-VIII	27
(55)	56° N, 172° 30' W	18-VI	50
(56)	53° 30' N, 170° 02' W	17-VI	54
(57)	55° 58' N, 170° 04' W	26-VI	23
(58)	56° 57' N, 168° 58' W	27-VI	2
(59)	57° 59' N, 169° 59' W	28-VI	2
(60)	51° N, 170° W	11-VIII	52
(61)	50° N, 170° W	10-VIII	29
(62)	49° N, 170° W	9-VIII	11
(63)	55° 04' N, 169° 24' W	25-VI	79
(64)	52° 51' N, 166° W	15-VIII	24
(65)	52° N, 165° W	17-VIII	29
(66)	51° N, 165° W	18-VIII	27
(67)	50° N, 165° W	19-VIII	27
(68)	55° N, 155° W	15-VI	72
(69)	50° N, 155° W	25-VI	25
(70)	55° N, 150° W	7-VI	54
(71)	58° N, 145° W	4-VI	50
(72)	55° N, 145° W	1-VI	25
(73)	50° N, 145° W	24-V	25
(74)	55° N, 135° W	15-VI	16
(75)	55° N, 135° W	15-VIII	15
(76)	51° N, 130° W	8-VIII	25
	Total		2378

Figure 4 shows the distribution of sockeye (exclusive of seaward migrants) infected with Triaenophorus or Dacnitis. From this figure it is apparent that sockeye of western Alaskan origin (i.e. infected with Triaenophorus), mainly from Bristol Bay, were found as far west as 168°15' E and sockeye of Asiatic origin (i.e. infected with Dacnitis) were found as far east as 175° W. Since Triaenophorus and Dacnitis occur in only part of the sockeye originating in North America and Asia, respectively, and because of sampling limitations, the range of ocean distribution of sockeye from the two continents may be greater than indicated by these two parasites.

Table 15 lists the localities at which sockeye infected with Triaenophorus or Dacnitis were found, the date of catch, the number of fish examined at each locality, the number and percent of fish infected with Triaenophorus or Dacnitis, the age of these fish and whether they were maturing or immature. The determination of the state of maturity was based largely on the gonad development and utilized the gonad weight to body weight ratio, as proposed by Mr. H. Godfrey of the Fisheries Research Board's Biological Station at Nanaimo. In a few cases in which the gonad weight had not been recorded, the decision as to probable state of maturity was based on age, size of the fish, locality and date of catch.

Distribution of maturing sockeye. The upper chart in Figure 5 shows the distribution of maturing sockeye which harboured Triaenophorus or Dacnitis in 1958. Triaenophorus-infected maturing sockeye were found as far west as 168°15' E and eastward into the Gulf of Alaska to 145° W. Dacnitis-infected maturing sockeye were found from the Sea of Okhotsk eastward to 173°19' E.

The maturing sockeye infected with Dacnitis were caught from mid-May to the end of July, the earliest-caught fish generally having been taken farther to the east. The maturing sockeye infected with Triaenophorus (not including those taken in or near the estuaries of the home streams) were, with three exceptions, caught in May or June (see Table 15). The three exceptions were: (1) one fish taken on July 10 in the commercial fishery operating in the Shumagin Islands area, Alaska, (2) one fish taken on July 2 at 53°01' N, 175° W and (3) one fish taken on August 5 at 51°30' N, 175° W. The occurrence of a maturing western Alaska sockeye in mid-ocean as late as August 5 seems very unusual, because it is generally believed that the sockeye returning to spawn in western Alaska have entered the rivers by the end of July or early August, but on the basis of gonad weight this sockeye definitely seems to be maturing. The fish was a female, age 4_2, with a body weight of 2,140 grams and a gonad weight of 88 grams. All other sockeye taken in the latter half of July or throughout the month of August, not only in 1958 but in other years as well, which were identified as being of western Alaskan origin because of the presence of Triaenophorus, were immatures. It appears that most of the maturing western Alaska sockeye leave the open ocean by the end of June, but some may remain there until early August.

The majority of maturing Triaenophorus-infected sockeye captured west of their area of origin (western Alaska) were from the Bering Sea between 175° W and 169° W, and were taken almost exclusively in the second half of June. The three Triaenophorus-infected sockeye from the area bounded by 168° E and 173° E Longitude and 50° N and 52° N Latitude were captured in May or early June. The apparent absence of Triaenophorus-infected sockeye between 173° E and 175° W may well be due to the fact that few samples taken from this area in May or June were examined. In the Gulf of Alaska the maturing Triaenophorus-infected sockeye were all taken in the first half of June.

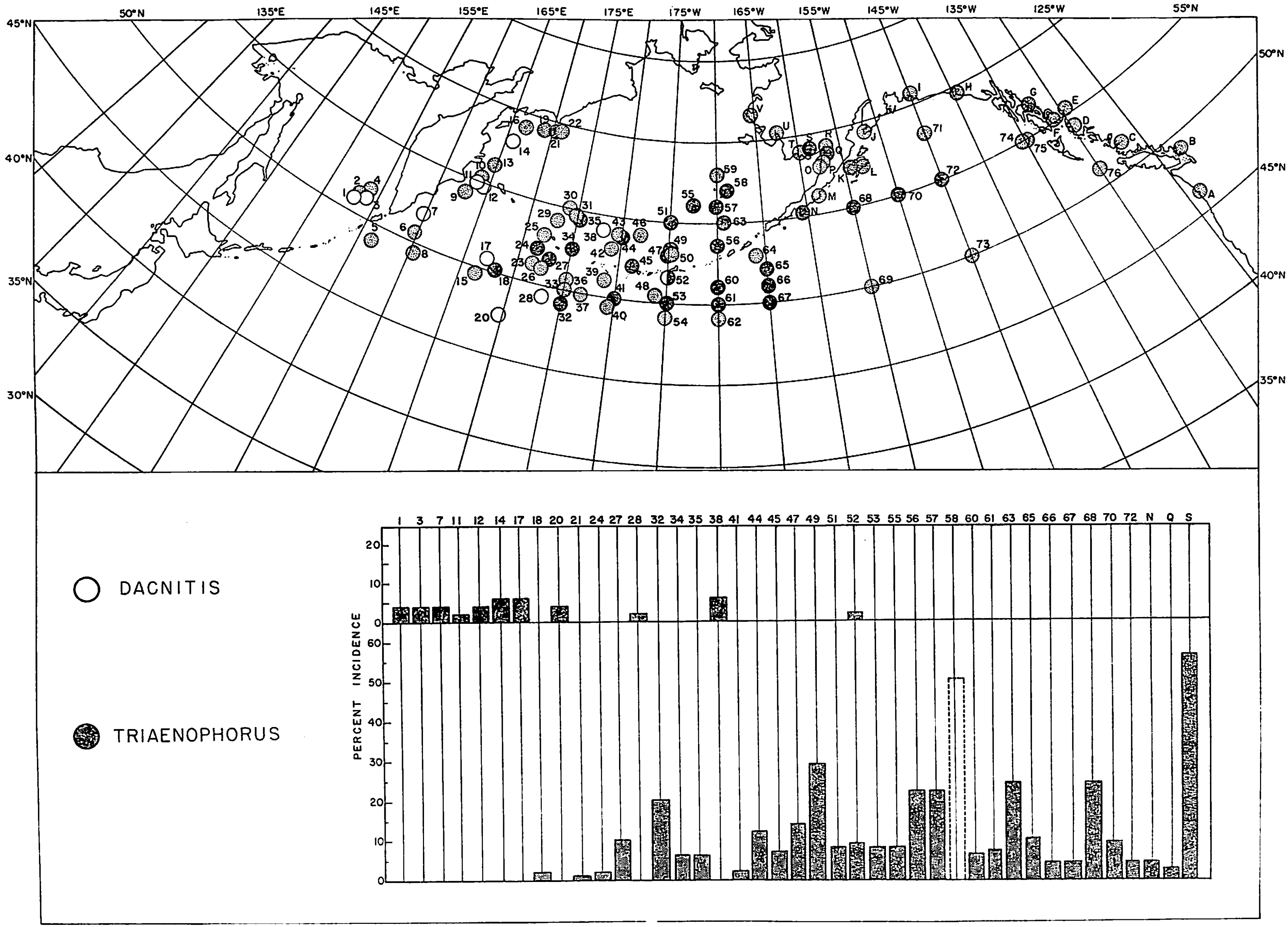

Figure 4. **Distribution of sockeye salmon samples examined in 1958 and the occurrence and incidence of _Triaenophorus_ and _Dacnitis_ in these samples.**

Table 15 Incidence of *Triaenophorus* and *Dacnitis* in 1958 sockeye samples, with age and stage of maturity of the infected fish.

Locality	Date	Number examined	Infected with *Triaenophorus* No.	Infected with *Triaenophorus* %	Infected with *Dacnitis* No.	Infected with *Dacnitis* %	Age[a]	Maturity[b]
Wood R., Bristol Bay	4-VII	25	14	56	-	-	4_2(10),5_3,5_2,?(2)	m
" " " "	31-V	25	9	36	-	-	-	smolts
Naknek R., Bristol Bay	9,19-VII	52	1	2	-	-	5_3	m
" " " "	29-V	25	1	4	-	-	-	smolts
55° N, 145° W	1-VI	25	1	4	-	-	4_2	m
55° N, 150° W	7-VI	54	5	9	-	-	4_2(4),5_3	m
55° N, 155° W	15-VI	72	17	24	-	-	4_2(15),5_3,5_2	m
Shumagin Is., Alaska	10-VII	25	1	4	-	-	5_3	m
50° N, 165° W	19-VIII	27	1	4	-	-	5_3	i
51° N, 165° W	18-VIII	27	1	4	-	-	4_2	i
52° N, 165° W	17-VIII	29	3	10	-	-	4_2(2),5_3	i
56°57' N, 168°58' W	27-VI	2	1	(50)	-	-	4_2	m
55°04' N, 169°24' W	25-VI	79	19	24	-	-	4_2(9),5_3(3),5_2 2 oc.(5),?(1)	m
50° N, 170° W	10-VIII	29	2	7	-	-	4_2,?(1)	i
51° N, 170° W	11-VIII	52	3	6	-	-	4_2,5_3,?(1)	i
53°30' N, 170°02' W	17-VI	54	12	22	-	-	4_2(4),5_3(2),5_2(5),6_3	m
55°58' N, 170°04' W	26-VI	23	5	22	-	-	4_2(3),5_3(2)	m
56° N, 172°30' W	18-VI	50	4	8	-	-	4_2,5_3,5_2,6_3	m
50° N, 175° W	6-VIII	77	6	8	-	-	3_2,4_3,5_4,4_2,5_3(2)	i
51°30' N, 175° W	5-VIII	53	5	9	1	2	Triaen. 3_2,4_2,2 oc.(2)	i
							Triaen. 4_2	m
							Dacnit. 3_2	i

Table 15 (cont'd)

53°01' N, 175° W	2-VII	7	2	29	-	-	5_3	m
							2 oc.	i
55° N, 175° W	7-VIII	13	1	8	-	-	4_2	i
52°58' N, 175°13' W	27-VII	7	1	14	-	-	4_2	i
52°04' N, 178°38' W	12-VII	14	1	7	-	-	1 oc.	i
50° N, 180°	30-VI	42	1	2	-	-	4_3	i
53°31' N, 180°	14-VII	26	3	12	-	-	$4_3, 5_4, 4_2$	i
54° N, 178° E	15-VII	17	-	-	1	6	3_2	i
49° N, 175° E	15-VII	10	2	20	-	-	$3_2, 4_3$	i
52° N, 175° E	18-VII	49	3	6	-	-	4_3(2), ?(1)	i
55° N, 175° E	18-VII	16	1	6	-	-	3_2	i
49°21' N, 173°19' E	16-V	54	-	-	1	2	5_2	m
51°35' N, 173° E	8-VI	10	1	10	-	-	7_3	m
52°02' N, 171°35' E	5-VI	53	1	2	-	-	6_3	m
59°18' N, 170°38' E	31-VII	95	1	1	-	-	5_3	i
47°30' N, 169°41' E	26-V	55	-	-	2	4	$5_2, 6_2$	m
50°10' N, 168°15' E	16-V	54	1	2	-	-	5_2	m
50°41' N, 167°14' E	15-VI	51	-	-	3	6	$5_2, 6_2$, ?(1)	m
58° N, 166° E	22,25,26-VI	18	-	-	1	6	6_2	m
55° N, 164° E	29-VII	50	-	-	2	4	4_2(2)	i
55° N, 164° E	7-VIII	50	-	-	1	2	4_2	i
51°58' N, 159°51' E	26-VII	55	-	-	2	4	5_2	m
51°08' N, 153°45' E	15-VI	25	-	-	1	4	6_3	m
50°49' N, 153°07' E	5-VII	25	-	-	1	4	6_3	m

a - Numbers in parentheses following the age indicate the number of fish of that age. Where there is no number following an age it signifies that only one fish of that age was encountered. Sockeyes for which the age could not be determined, either because of poor scales or lack of scales, are indicated by ?. Where the freshwater zone of a scale could not be interpreted the ocean growth is indicated by the number of years followed by oc.

b - Fish which would have matured in the year they were caught are indicated by "m" and those that would have remained in the ocean at least one more year, i.e. immatures, are indicated by "i".

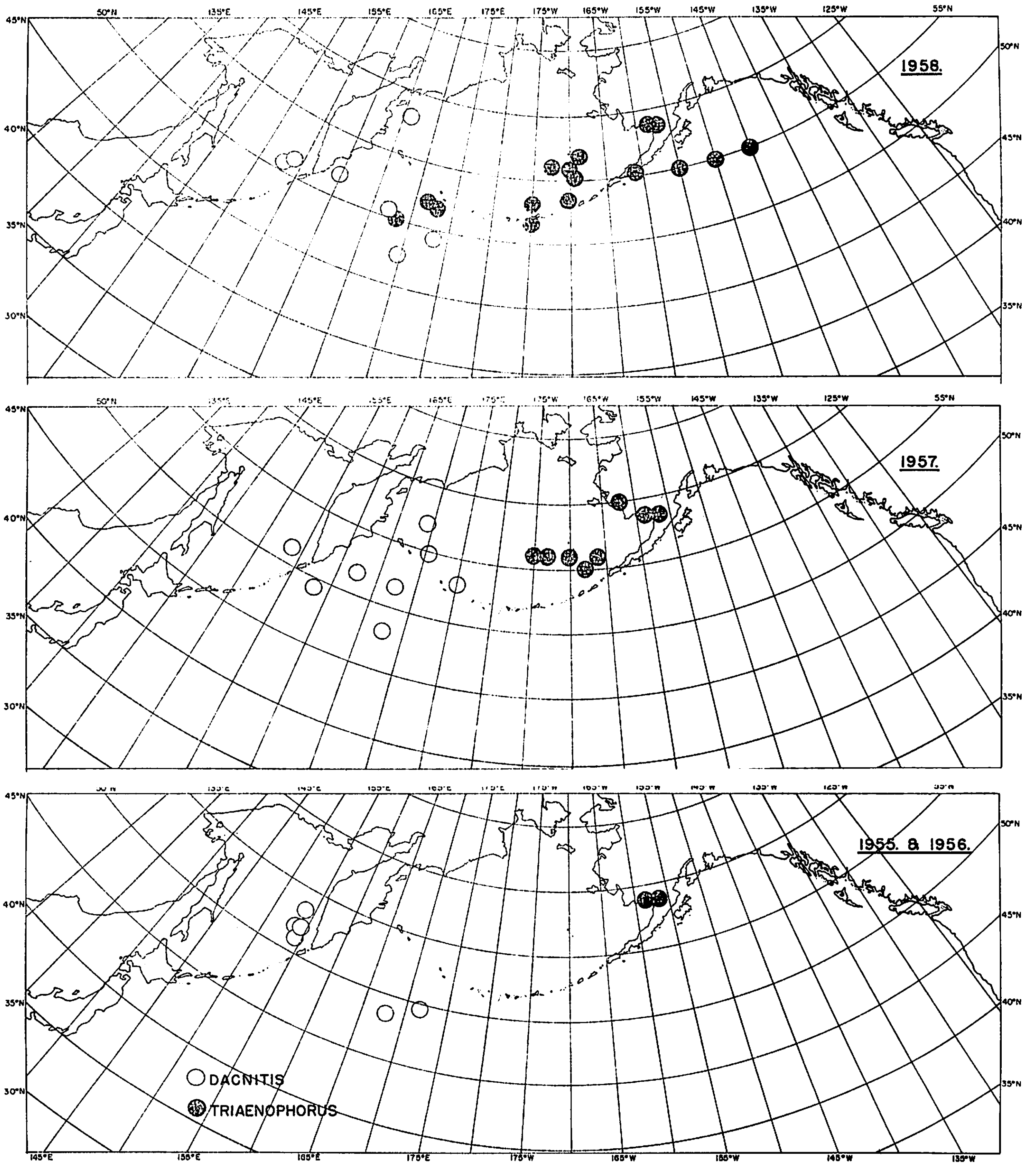

Figure 5 Distribution of maturing sockeye salmon infected with *Triaenophorus* or *Dacnitis* in the years 1955 to 1958.

Some features of the incidence of Triaenophorus in maturing sockeye were extremely interesting. On the basis of the small samples examined from the spawning runs to the rivers of Bristol Bay an overall incidence of Triaenophorus in all Bristol Bay sockeye (catch plus escapement) was calculated to be almost 22% (see Table 16). In the samples examined from 55°04' N, 169°24' W (79 sockeye), 53°30' N, 170°02' W (54 sockeye), 55°58' N, 170°02' W (23 sockeye) in the Bering Sea, and from 55° N, 155° W (72 sockeye) in the Gulf of Alaska, the incidence of Triaenophorus was either 22% or 24% (see Table 15), which is identical or almost identical with the calculated overall percent incidence for Bristol Bay. This suggests that the samples from these high-seas localities consisted wholly or largely of a mixture of Bristol Bay sockeye, the various stocks being present in proportion to the size of their respective spawning runs.

In the Gulf of Alaska at 55° N, 150° W and at 55° N, 145° W the incidence of Triaenophorus-infected sockeye decreased to 9% and 4% respectively, and at 55° N, 135° W none were found, indicating a progressive decrease towards the east in the number of Bristol Bay sockeye in the samples. In the samples from 58° N, 145° W, 50° N, 145° W, and 50° N, 155° W Triaenophorus was not found.

Only one good sample was obtained from 170° to 175° E and therefore no data are available on the trends of Triaenophorus infection of sockeye in this area. In the 50 sockeye from 56° N, 172°30' W, the incidence of Triaenophorus was 8%. This lower rate of Triaenophorus infection as compared to the samples taken at 169° W and 170° W could mean that the sample did not consist solely of Bristol Bay sockeye, or that the various Bristol Bay stocks were not represented in proportion to the size of their respective runs, or that a greater proportion of uninfected than infected sockeye were represented from the stocks in which Triaenophorus occurred.

In the samples from south of the Aleutians between 173° E and 168° E only 3 maturing sockeye out of approximately 300 examined were found infected with Triaenophorus, suggesting a much lower proportion of Bristol Bay sockeye than in the samples from near 169° W and 170° W in the Bering Sea. Since good samples were also available to the west of 168° E and Triaenophorus was not found, 168° E probably was close to the extreme western limit of Bristol Bay or western Alaska sockeye, at least for the period during which the samples were collected.

Distribution of immature sockeye. The upper chart in Figure 6 shows the distribution of immature sockeye infected with Dacnitis or Triaenophorus.

Few Dacnitis-infected immature sockeye were found in the samples. One was taken just south of the Aleutian Islands at 175° W on August 5 in a sample which also contained several sockeye infected with Triaenophorus. Another was taken in the Bering Sea at 54° N, 178° E on July 15 and three were taken off the east coast of Kamchatka at 55° N, 164° E on July 29 or August 7.

Immature sockeye infected with Triaenophorus were represented in many of the samples from 165° W to 175° E which were collected from June 30 to August 19. One was also encountered in a sample of 95 fish from 59°18' N, 170°38' E taken on July 31, 1959. Most of the immature Triaenophorus-infected sockeye were taken south of the Aleutians, but some were also found in samples from north of the Aleutians to 55° N between 175° W and 175° E.

Table 16. Incidence of Triaenophorus in adult sockeye runs to Bristol Bay in 1958, based on samples from each river

River	Size of "run" (catch + escapement)	Sample size	% infected with Triaenophorus	Estimated no. infected in total "run"
Nushagak (Wood)	2,000,000	25	56	1,120,000
Kvichak	1,200,000	25	0	0
Naknek	575,000	52	2	11,500
Egegik	750,000	25	0	0
Ugashik	700,000	25	0	0
Totals	5,225,000			1,131,500

Estimated incidence of Trianeophorus in total Bristol Bay run - 21.7%

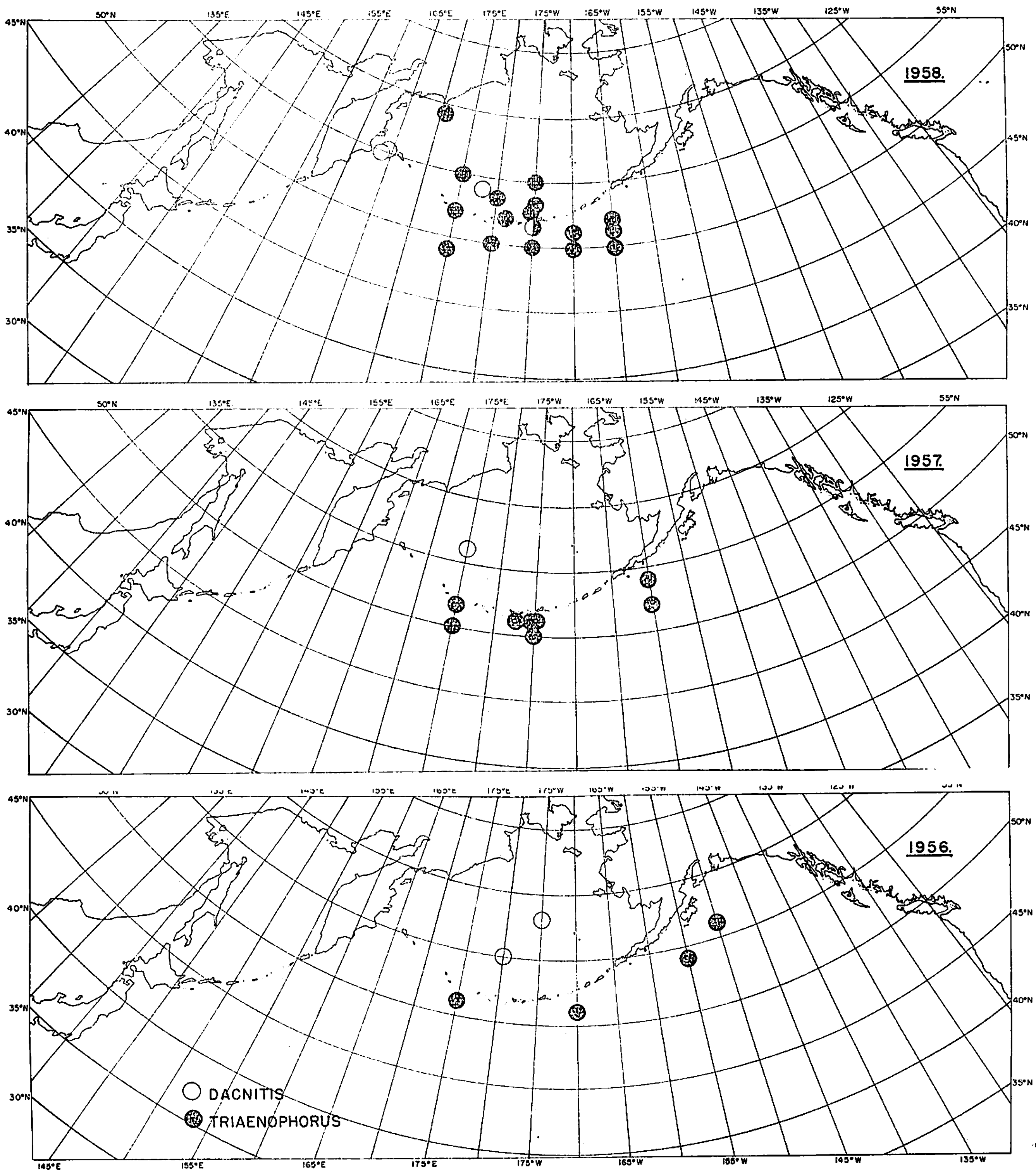

Figure 6 Distribution of immature sockeye salmon infected with _Triaenophorus_ or _Dacnitis_ in the years 1956 to 1958.

B. Comparison of high-seas distribution of sockeye in 1958 with earlier years (1955-1957). Figure 5 shows the distribution of maturing sockeye infected with *Dacnitis* or *Triaenophorus* for the years 1955 to 1958, inclusive.

One feature in the distribution of *Dacnitis*-infected maturing sockeye which is more or less similar from year to year is the most easterly point of capture, which is between 172° E and 175° E Longitude. It is impossible to determine if there was any change in the distribution of *Dacnitis*-infected sockeye from year to year because of their low incidence (never more than 11 in any one year and only 1.6% to 4% of all maturing sockeye taken from 175° E to the Sea of Okhotsk) and because the sampling locations, dates of sampling and the number of samples were not the same from year to year. For example, in the Bering Sea region in 1957 *Dacnitis* was found at 54°51' N, 170°24' E, and 57°02' N, 169°11' E. Samples from these locations were not examined in other years.

For between-year comparisons of the distribution of maturing *Triaenophorus*-infected sockeye, only 1957 and 1958 can be considered satisfactorily because of the lack or scarcity of samples in 1955 and 1956 from east of 175° E during the months of May and June.

In 1957 the qualitative distribution of *Triaenophorus*-infected maturing sockeye in the Bering Sea from 175° W and eastward was similar to that in 1958, but the incidence in this area was considerably less. Of the 263 fish examined from 166° W to 175° W, 3.4% were infected with *Triaenophorus* (incidence varying from 0% to 12% in individual samples) which is close to the calculated *Triaenophorus* incidence of 3.5% for all Bristol Bay runs combined, in 1957 (see Table 17). The much lower overall rate of *Triaenophorus* infection in the Bristol Bay stocks in 1957 as compared to 1958 is therefore reflected in the incidence in Bering Sea samples. This lower incidence was due to two factors: (1) The Wood River (Nushagak River system), which provides the majority of *Triaenophorus*-infected sockeye, comprised only about 10% of the 1957 Bristol Bay run, compared to about 40% in 1958, and (2) the incidence of *Triaenophorus* in the 1957 Wood River run was apparently lower than in 1958.

The samples from the Gulf of Alaska in 1957 were taken later in the season than those from comparable locations in 1958 (see 1958 Annual Report). If maturing Bristol Bay sockeye had been present in the Gulf of Alaska in 1957 they probably would have left the area on their homeward migration prior to commencement of the sampling. Therefore the absence of maturing sockeye infected with *Triaenophorus* from the Gulf of Alaska samples in 1957 may not indicate a real difference between 1957 and 1958.

Also, the failure to record any *Triaenophorus*-infected maturing sockeye in 1957 as far west as in 1958 cannot be interpreted as indicating that western Alaskan sockeye extended farther to the west in the latter year. In 1958, when the overall incidence of *Triaenophorus* in Bristol Bay sockeye was considerably higher (about 6 times) than in 1957, only 1% of the 300 sockeye examined in samples collected in May or early June between 168° E and 173° E were infected. This is about 1/20 of the overall incidence for Bristol Bay for that year. If the same relative representation of infected sockeye had prevailed in this area in 1957, then only about 0.17% would have been expected to be infected with *Triaenophorus*. Less than 100 maturing sockeye, taken in May or early June, from 175° E to 168° E were examined and the absence of *Triaenophorus* from these samples cannot lead to any conclusions regarding the presence or absence of Bristol Bay sockeye in this area in 1957.

Table 17. Incidence of *Triaenophorus* in adult sockeye runs to Bristol Bay in 1957, based on samples from each river

River	Size of "run" (catch + escapement)	Sample size	% infected with *Triaenophorus*	Estimated no. infected in total "run"
Nushagak (Wood)	1,000,000	25	20	200,000
Kvichak	6,500,000	20	0	0
Naknek	1,500,000	25	12	180,000
Egegik	1,150,000	20	0	0
Ugashik	575,000	20	0	0
Totals	10,725,000			380,000

Estimated incidence of *Triaenophorus* in total Bristol Bay run - 3.5%

Figure 6 shows the distribution of immature sockeye infected with Dacnitis or Triaenophorus in the samples examined in the years 1956 to 1958.

Since few Dacnitis-infected immature sockeye have been observed in the samples there are insufficient data for a comparison between years. The most easterly records have been at 175° W in 1956 and 1958.

A constant feature of the distribution of immature sockeye infected with Triaenophorus is their occurrence south of the Aleutians to 175° E. The increased number of these immature sockeye observed from 1956 to 1958 is attributable in part to the increase in numbers of fish examined, but there was also an increase in the incidence of Triaenophorus in the immatures examined from samples taken from 175° E to 160° W. In 1956, 1.5% of about 200 fish were infected, in 1957, 3.3% of about 400 fish and in 1958, 5% of about 600 fish.

Whether or not the occurrence of immature sockeye infected with Triaenophorus in the Bering Sea in 1958 indicates a real difference from other years cannot be determined because of differences in the number of fish examined and their localities and dates of capture.

SALMON STOCK ASSESSMENT INVESTIGATION

- M. P. Shepard

In recent years there has been an increasing need for more precise information on the status of British Columbia salmon stocks. This information is required for effective management of the stocks in the face of increasingly complicated and intensive fisheries at home and to meet the threat of increased international competition for British Columbia salmon.

Basic catch, effort and escapement statistics are provided annually by the Canadian Department of Fisheries. These data are used, along with estimates of the age, size and sex composition of the runs derived from sampling by the Board, to describe annual changes in production for the major sockeye and chum stocks.

In addition to these annual assessments, the investigation carries out projects to meet special needs. These include preparation of reports on the status of British Columbia salmon stocks in connection with International North Pacific Fisheries Commission, the United States-Canadian International Conference on the Co-ordination of Fishing Regulations, and the Fraser River Salmon Treaty. In 1959, the investigation's major effort was a co-operative tagging and recovery program for pink salmon in southern British Columbia required by the Pink Salmon Protocol of the Fraser River Treaty.

Studies of chum salmon scales to distinguish races on the high seas (as part of the INPFC research program) were continued in 1959.

1. <u>Studies of migratory movements of pink salmon stocks in connection with the Fraser River Salmon Treaty</u>

A. S. Hourston and M. P. Shepard

In 1957, Canada and the United States ratified a Protocol to the existing Fraser River Salmon Treaty to bring the management of the pink salmon fisheries in the Fraser Convention waters under international control. Under terms of this agreement, the International Pacific Salmon Fisheries Commission was charged with scientific investigations and promulgation of regulations for the pink salmon fisheries in the Convention area. In addition, the two countries agreed (Article VI of the Protocol) to conduct "a co-ordinated investigation of pink salmon stocks which enter Convention waters for the purpose of determining the migratory movements of such stocks".

Pink salmon which enter Fraser Convention waters approach either from the north through Queen Charlotte Strait or from the south through the Straits of Juan de Fuca (Fig. 7). In the coastal waters between Queen Charlotte and Juan de Fuca Straits, the runs destined for the Fraser system itself intermingle with runs bound for Canadian streams adjacent to Queen Charlotte and Johnstone Straits, Discovery Passage and the Strait of Georgia and with runs bound for streams in the State of Washington, mainly in the Puget Sound area. The problem posed by the Protocol involves determining the times of passage of the different populations through the various Canadian and American fishing areas, and estimating the contributions of the individual runs to the fisheries.

To implement Article VI of the Protocol, a Co-ordinating Committee was established in January, 1958, comprising representatives of the Canadian Department of Fisheries (the Area Director and the Director of the Board's Nanaimo Station), the Washington State Department of Fisheries and the International Pacific Salmon Fisheries Commission. As stated in last year's Annual Report, the Co-ordinating Committee first reviewed past data on the movements of pink salmon in the study area. On the basis of this review, a large-scale tagging and recovery program was planned, covering the waters of southern British Columbia and northern Washington. This program, the largest of its kind ever conducted on Pacific salmon, was carried out in 1959. It involved:

(a) <u>Tagging</u>. The Fisheries Research Board operated two chartered seiners, the <u>Cape Blanco</u> and the <u>Wendy Belle</u>, to tag pink salmon on the northern approach to the study area. Between July 5 and September 30, a total of 21,743 tags were applied mainly in the Upper Johnstone Strait area (see Fig. 8 and Table 18). The Salmon Commission tagged 28,458 pinks in the major United States fishing area on the southern approach (mainly in the Salmon Bank-West Beach and Point Roberts areas). The State of Washington tagged 3,155 pinks from traps operated at Admiralty Inlet at the entrance to Puget Sound. In all, the three agencies tagged a total of 53,356 pinks. As nearly as possible, tagging was conducted in proportion to seasonal changes in abundance of the pinks in the different areas. Within each week, tagging was concentrated on days when the fishery was closed so that as many tagged fish as possible could escape to the spawning grounds. The numbers of fish tagged at each of the tagging sites are given in Table 18.

(b) <u>Recovery of tags in commercial fisheries</u>. The assistance of the statistical branch of the Canadian and Washington State Departments of Fisheries and of the fishing industry generally were enlisted to recover tags from the commercial fisheries. Arrangements were made for buyers or tendermen to purchase tags at the same time as they purchased fish from the fishermen. In addition, tags were purchased by cannery offices , and personnel of the various research and management

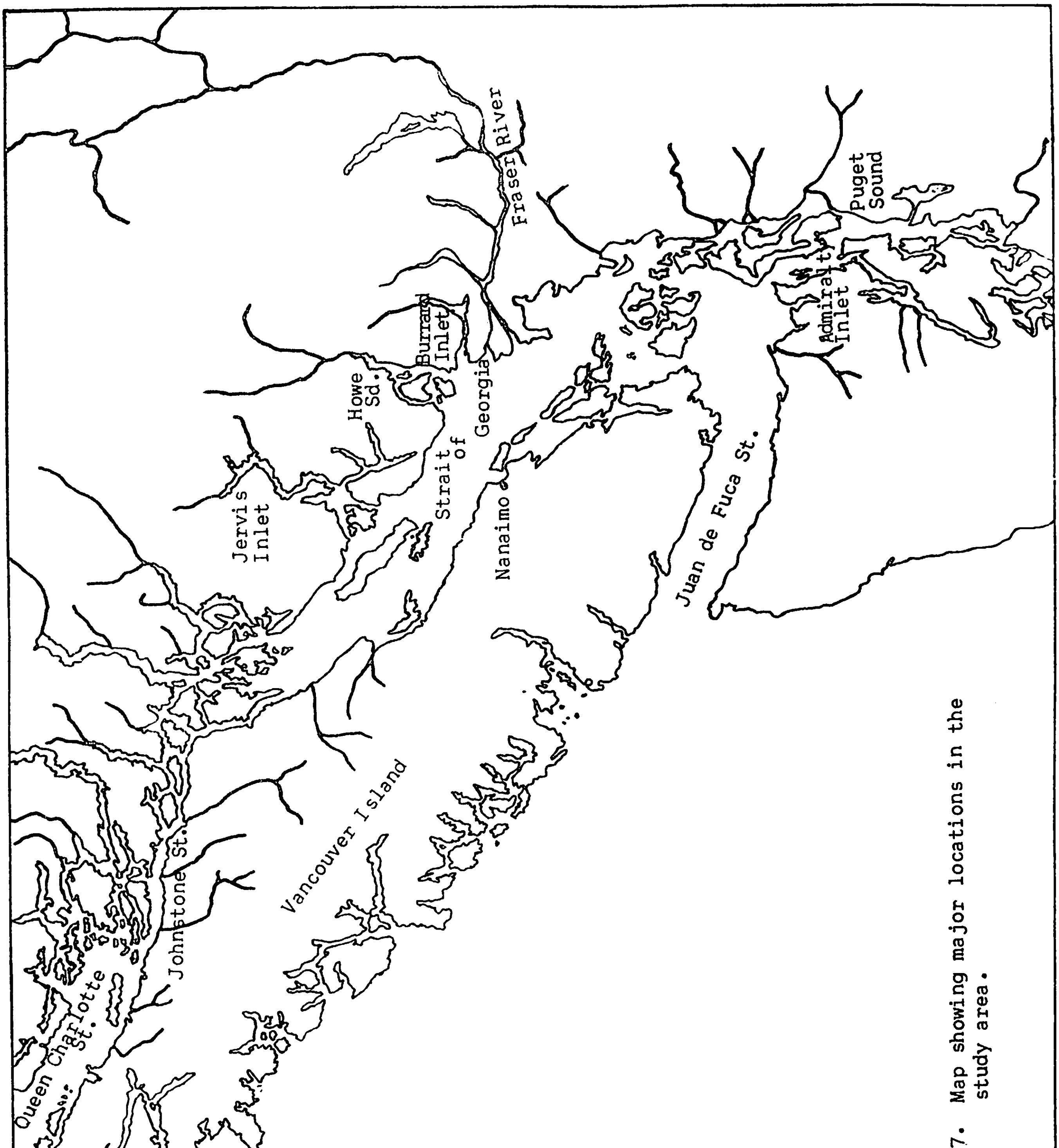

Fig. 7. Map showing major locations in the study area.

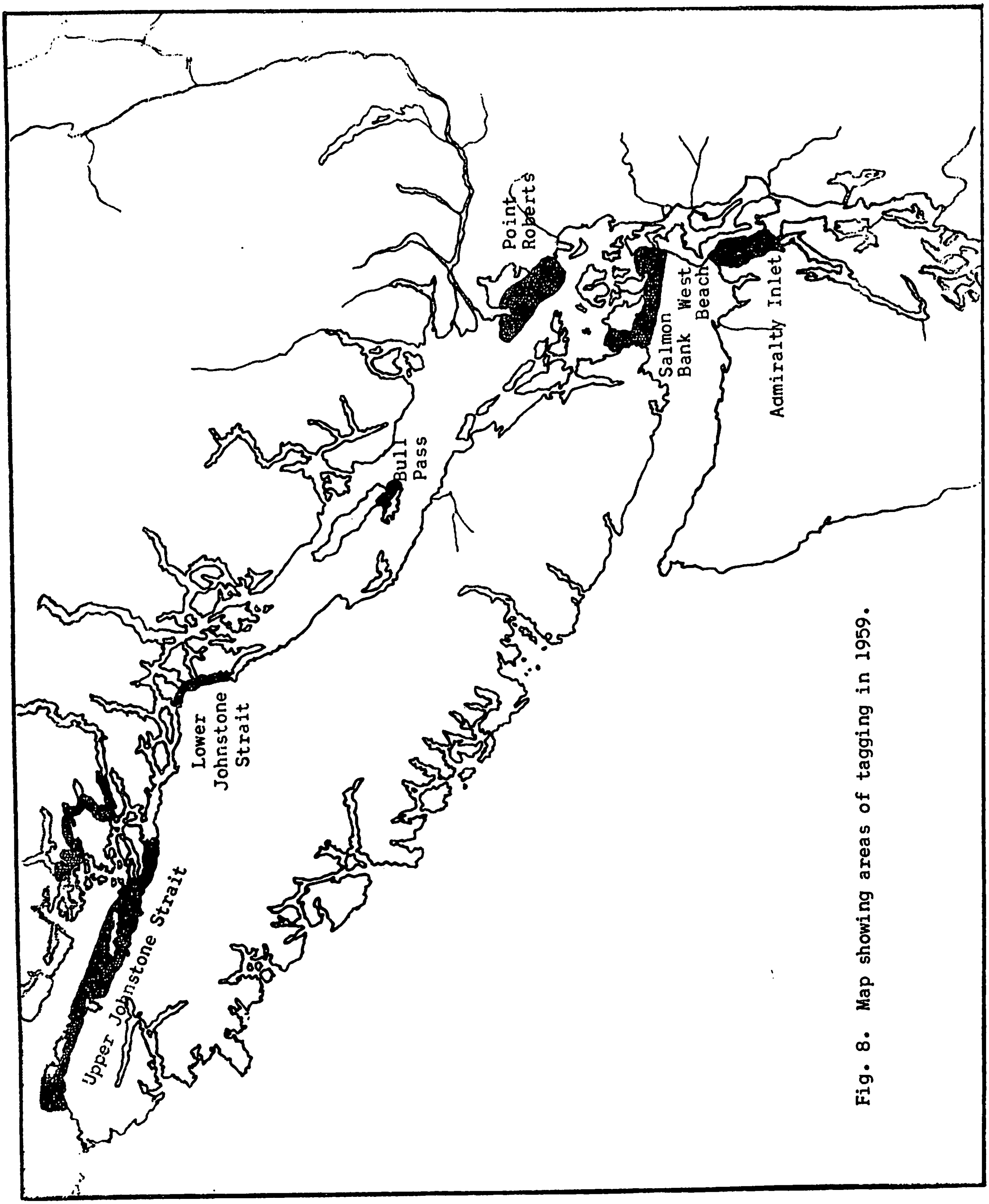

Fig. 8. Map showing areas of tagging in 1959.

Table 18. Marine tags applied by agency and area.

Agency	Area		Number tagged
FRBC	Upper Johnstone Strait		20,322
	Lower Johnstone Strait		1,359
	Bull Pass		62
		Total	21,743
IPSFC	Pt. Roberts		10,464
	Salmon Bank		13,868
	West Beach		4,126
		Total	28,458
WDF	Admiralty Inlet		3,155
		Total	3,155
All agencies			53,356

agencies involved. The response of the fishermen and companies was very good and a total of 32,398 tags (61% of the total applied) have been recovered to date from the commercial fisheries. Recovery data are summarized in Table 19. Breakdowns according to area of recovery are tentative pending final coding of the results.

(c) Surveys of spawning grounds. Throughout the study area, intensive surveys were conducted on all major spawning grounds to recover tags and to estimate the abundance of spawners. In most cases the stream programs involved additional taggings at the mouths of the streams and subsequent foot surveys to pitch carcasses and recover both "marine" and "stream" tags. On these surveys, the proportion of "stream" tags in the population was used to derive estimates of the number of spawners present.

In some cases, fences were operated to enumerate spawners and recover tags. In the Canadian area, the Fisheries Research Board conducted surveys on 15 river systems and the Department of Fisheries Fish Culture Development branch on 6. Most of the rivers covered by the Board personnel were located in remote areas and the crews had to be supplied by aircraft and boat. During the period August 15 to October 31, two chartered aircraft and the M/V Alta were engaged in transporting and supplying the 40 men involved in the survey operations.

Comparable coverage of the pink spawning streams of the Fraser system and Washington State was provided by the research staffs of the Salmon Commission and the Washington State Department of Fisheries respectively.

Table 19. Recoveries of marine tags by agency and area

Area	Number recovered FRBC	IPSFC	WDF	Per cent of total applied FRBC	IPSFC	WDF
Commercial Recoveries						
Canada outside Convention area	10,116	171	3	46.52	1.17	0.10
Canada Convention area	1,585	4,615	17	7.29	15.64	0.54
U.S. Convention area	311	11,434	370	1.43	40.18	11.73
U.S. outside Convention area	33	1,895	486	0.15	6.66	15.40
Miscellaneous[1]	666	531	166	3.06	1.87	5.26
Total commercial	12,710	18,646	1,042	58.46	65.52	33.03
Stream Recoveries[2]						
Canada outside Convention area	523	184	0	2.41	0.65	0
Fraser River system	113	308	0	0.52	1.18	0
U. S.	3	71	127	0.01	0.25	4.02
Total streams	639	563	127	2.94	1.98	4.02
Grand total	13,349	19,209	1,169	61.40	67.50	37.05

[1]Includes tags for which source of recapture not known, recaptures in Indian food fisheries, etc.

[2]Does not include recoveries made during stream tagging.

Data on the stream programs have not yet been fully analysed and estimates on the abundance of spawners in the various rivers are not yet available. However, data on the number of "stream" tags applied, the number of "marine" and "stream" tags recovered, the number of carcasses examined and/or the number of fish counted through fences are available for the major streams covered (Table 20). These streams supported about 90% of the pink salmon spawners of the study area.

Altogether, 1,328 marine tags were recovered in carcass counts (2.5% of the total applied). In addition, 383 marine tags were recovered in fence and stream tagging operations.

A total of 53,152 stream tags were applied, 29,520 in the Canadian area north of Convention waters. From a total carcass count of 359,904 (217,150 in the Canadian study area), 8,272 "stream" tags (15.6% of the total applied) were recovered (5,685 in the Canadian area).

(d) Catch statistics. Special catch statistics for Canadian areas outside the Convention area were collected and are now being compiled by the Canadian agencies. As in the past, the Washington State and the Salmon Commission compiled catch statistics for the areas under their jurisdiction. In Table 21, commercial catches for general areas are given for 1959 and the three preceding cycle years. It may be seen from the table that the 1959 catch was the lowest in the last 4 cycle years in spite of the relatively heavy rate of fishing indicated by the tag recoveries. Outside the Convention area it averaged about half that of the preceding 2 cycles. In Convention waters it was only slightly less than in 1957 but about half of that in 1955 and 1953. The overall trend for the past 4 cycles has been a continuous decrease averaging about 20 percent with each cycle.

(e) Collection of samples to determine sizes. In some years it has been noted that the average size of Fraser fish has been somewhat different from the size of pinks bound for streams north and south of the Fraser. Such size differences could be very useful for identifying the various runs as they passed through the fishing areas. To investigate this problem further, daily samples were obtained from the fisheries throughout the study area and representative samples were taken on most of the important spawning streams. A total of 48,426 pinks were sampled in the fisheries (almost all by the Salmon Commission) and 13,536 on the spawning streams (6,756 by Canadian agencies, 4,380 by the Salmon Commission and 2,400 by Washington State). The data, now being tabulated, are to be analysed by the Salmon Commission.

Summary of tagging results. Of the 21,743 pink salmon tagged in the northern approach (mainly Johnstone Strait) by the Board, 58 percent were recovered in the commercial fisheries. Over three-quarters of the returns came from Canadian fisheries north of the Convention area and most of the remainder came from Canadian Convention waters. Over 80 percent of the stream recoveries from these taggings were made in Canadian streams outside the Convention area, less than 1 percent in United States streams outside the Convention area and the remainder in the Fraser River system.

Of the 28,458 fish tagged by the International Pacific Salmon Fisheries Commission in the main United States fishing areas on the southern approach (Salmon Bank and Point Roberts), over 65% were recovered in the commercial fisheries. Well over three-quarters of these were recovered in the Fraser River Convention area (mostly in the United States section). Most of the remainder were taken in United States fisheries in the Puget Sound area immediately south of Convention waters.

Table 20. Summary of Stream Tags Applied, Carcasses Examined, Stream Tags Recovered, Marine Tags Recovered on Streams and Fence Counts for Major Runs in the Three Regions of the Study Area

Stream	No. Stream Tags Applied	Other Tags Recovered During Tagging				No. Carcasses Examined	Tags Recovered from Carcasses					Fence Count	No. Marine Tags Recovered at Fence	
							Stream Tags	Marine Tags						
		FRBC	IPSFC	WDF	GV			FRBC	IPSFC	WDF	GV		FRBC	IPSFC
Canada														
Adam R.	1,719	19	-	-	-	11,440	334	46	-	-	-	-	-	-
Apple R.	600	-	-	-	-	4,170	65	12	-	-	-	-	-	-
Cluxewe R.	163	1	-	-	-	203	2	1	-	-	-	-	-	-
Glendale R.	6,042	29	-	-	-	34,679	1,198	75	-	-	-	-	-	-
Indian R.	5,148	11	6	-	-	33,280	965	50	69	-	-	-	-	-
Kakweiken R.	455	2	-	-	-	1,760	58	9	-	-	-	-	-	-
Keogh R.	1,402	11	-	-	-	3,732	72	3	-	-	-	25,721	-	-
Phillips R.	1,073	10	-	-	-	8,447	240	81	2	-	-	-	-	-
Puntledge-Tsolum R.	1,264	8	3	-	-	2,356	234	7	4	-	-	(Tsolum) 12,064	36	9
Quatam R.	145	-	-	-	-	286	7	2	-	-	-	-	-	-
Quinsam R.	435	7	-	-	-	246	17	3	-	-	-	3,288	17	1
Salmon R.	2,244	3	-	-	-	1,795	170	5	-	-	-	-	-	-
Skwawka-Deserted R.	4,167	16	2	-	-	86,186	1,382	180	96	-	-	-	-	-
Squamish-Cheakamus R.	3,641	15	2	-	-	18,412	814	22	11	-	-	-	-	-
Toba-Klite R.	716	7	-	-	-	5,005	92	13	1	-	-	-	-	-
Other Streams - Total	306	3	-	-	-	5,153	33	13	1					
Total Canadian Waters	29,520	142	13	-	-	217,150	5,685	523	184	-	-	41,073	53	10
IPSFC														
Harrison R.	4,473	6	18	-	54	25,630	1,031	27	95	-	206	-	-	-
Chilliwack-Vedder R.	1,494	3	8	-	17	11,072	178	13	39	-	151	-	-	-
Coquihalla R.	452	3	2	-	12	3,421	104	6	23	-	33	-	-	-
Seton Creek	486	-	3	-	-	7,562	248	6	13	-	56	-	-	-
Fraser R.	-	-	-	-	-	25,516	-	36	96	-	215	-	-	-
Thompson R.	-	-	-	-	-	6,996	-	2	10	-	29	-	-	-
Stave R.	-	-	-	-	-	81	-	-	1	-	-	-	-	-
Chehalis R.	-	-	-	-	-	1,734	-	1	6	-	22	-	-	-
Other Streams - Total	-	-	-	-	-	4,028	-	22	25	-	45			
Total Convention Waters	6,905	12	31	-	83	86,040	1,561	113	308	-	757	-	-	-
Glen Valley Tags (GV)	10,356	25	71	-	-	-								
Grand Total - IPSFC	17,261	37	102	-	83	86,040	1,561	113	308	-	757	-	-	-
United States														
Nooksack R.	351	-	-	-	-	4,127	37	1	-	-	-	-	-	-
Skagit R.	1,212	-	7	4	-	11,741	94	1	67	26	-	-	-	-
Stillaguamish R.	1,458	-	-	7	-	12,124	137	-	2	39	-	-	-	-
Snohomish R.	849	-	1	5	-	7,435	64	-	-	32	-	-	-	-
Puyallup R.	742	-	-	1	-	4,084	222	-	-	5	-	-	-	-
Dosewallips R.	951	-	-	-	-	6,524	323	1	1	20	-	-	-	-
Dungeness R.	808	1	-	-	-	7,532	151	-	-	2	-	-	-	-
Other Streams - Total	-	-	-	-	-	3,147	-	-	1	3	-	-	-	-
Total United States Waters	6,371	1	8	17	-	56,714	1,028	3	71	127	-	-	-	-
Grand Total - All Agencies	53,152	180	123	17	83	359,904	8,272	639	563	127	757	Can. Waters (41,073)	(53)	(10)

Table 21. Numbers of pink salmon caught in the major fisheries of the study area in 1959, 1957, 1955 and 1953

Area	1959	1957	1955	1953
<u>Canadian Fisheries outside Convention Waters</u>				
Area 12 (Upper Johnstone Strait, Knight Inlet, etc.)	1,743,074	3,191,374	2,542,905	3,469,247
Area 13 (Lower Johnstone Strait, Bute Inlet, etc.)	543,952	1,163,889	500,866	1,403,762
Area 14 (Upper west coast of Strait of Georgia)	6,210	10,179	7,158	2,127
Area 15 (Toba Inlet region)	19,168	20,891	18,907	12,315
Area 16 (Jervis Inlet, Malaspina Strait)	132,029	32,874	68,712	192,059
Area 28 (Howe Sound)	27	874	44,302	52,205
Total:	2,444,460	4,420,081	3,182,850	5,131,715
<u>Canadian Fisheries inside Convention Waters</u>				
Areas 17-18	64,774	7,574	6,294	24,105
Area 29 (Fraser River region)	472,896	914,703	799,897	1,016,488
Sooke	232,475)			
San Juan and outside Troll	1,542,761)	1,681,519	3,255,869	2,921,991
Total:	2,312,906	2,603,796	4,062,060	3,962,584
<u>Washington Fisheries inside Convention Waters</u>				
Strait of Juan de Fuca and outside Troll	237,519	290,247	1,360,262	666,247
San Juan Islands (Salmon Banks, Stuart Island, Rosario Strait, San Juan Channel)	1,338,059	1,198,069	1,941,610	2,470,011
West Beach	78,062	102,865	227,389	395,885
Point Roberts (includes Bellingham Bay)	773,853	1,189,789	1,167,797	1,425,045
Total:	2,427,493	2,780,970	4,697,058	4,957,188
<u>Washington Fisheries outside Convention Waters</u>				
Admiralty Inlet	293	11,242	86,533	267,388
Other Inside "77" Line Areas (Skagit Bay, Port Susan, Port Gardner, southern Puget Sound)	154,975	345,553	429,439	769,436
Total:	155,268	356,795	515,972	1,036,824
Grand Total:	7,340,127	10,161,642	12,457,940	15,088,311

Slightly over half (55%) of the stream recoveries from this tagging were made in the Fraser system, about one-third in other Canadian streams and the remaining 12% in United States streams. Most of the stream recoveries of IPSFC tags in the Canadian area came from the Indian (Burrard Inlet), Squamish (Howe Sound) and Skwawka (Jervis Inlet) Rivers which are the most southern of the principal mainland streams in the Canadian area. IPSFC tags were recovered in decreasing numbers in Canadian streams northward as far as Johnstone Strait.

Of the 3,155 pinks tagged by the Washington State Department of Fisheries in the Admiralty Inlet area, about one-third were recovered in commercial fisheries. Of these about one-half (46%) were taken in United States fisheries south of Convention waters. Almost all the remainder were taken in United States Convention waters. All of the stream recoveries from this tagging were made in United States streams.

Conclusions. Although co-operative analysis of the results of this program is still in a preliminary stage, some conclusions may be drawn at this time:

(a) In spite of fairly restrictive regulation, the 1959 fishery on this run of pink salmon was highly effective. In 1959 it removed over 70 percent of the nearly 10,000,000 fish entering the study area, catching about 2,400,000 north of Convention waters, about 4,700,000 in Convention waters and about 150,000 south of Convention waters.

(b) Spawning escapements in the study area in 1959 totalled about one-quarter of the run (i.e. 2.5 million fish). It was divided in a ratio of 2:2:1 between Canadian streams north of the Fraser, the Fraser River system itself and United States streams respectively.

(c) Runs entering the study area from the north provided virtually all the escapements to streams in the Johnstone Strait area, and, moving southward, proportions decreasing from 98 percent to 40 percent of the escapements to streams in the Strait of Georgia area. They also provided about a quarter of the escapement to both the early and late segments of the spawning runs to the Fraser River system and about 2 percent of the spawners in United States streams.

(d) Runs entering the study area from the south provided almost all of the spawners in United States streams, about three-quarters of both the early and late segments of the Fraser River escapements, about half the spawners in the Indian and Squamish Rivers on the Canadian mainland just north of the Fraser, and up to 15 percent of the spawners in the Gulf of Georgia streams north of the Squamish River.

(e) Fish bound for the Fraser River tend to enter the study area, both from the north and from the south, later than those bound for other streams.

2. Sampling of salmon catches for age, size and sex composition

T. H. Bilton, M. P. Shepard and D. W. Jenkinson

For sockeye and chum salmon, knowledge of the age composition of the stocks is essential to understand year-to-year fluctuations in abundance. In Canadian waters sockeye mature mainly in their fourth or fifth year and chums mainly in their third, fourth or fifth year. In an individual population, the proportions of the stock that return at the different ages vary greatly from year to year. For example, over the past 50 years at Rivers Inlet 4- and 5-year-olds have, on the average, been about equally abundant. In any one year, however, the 4-year-olds have formed as few as 3% of the catch and as many as 84% of the catch. Because of these wide year-to-year fluctuations, the age of return is one of the most important factors influencing the number of fish available to the fishery in any one year.

Since 1908, annual samples have been obtained from all major sockeye fishing areas throughout British Columbia. Sampling for chum salmon on an annual basis began only in 1957. In 1959, 10,976 sockeye were sampled from areas which provided over 90% of the 1959 sockeye catch.[1] A total of 9,710 chums were sampled, providing good coverage for areas which yielded 87% of the total chum catch in 1959.

(a) Sockeye catches

Data on the abundance and age composition of sockeye catches in the various areas are summarized in Table 22.

i) Nass River (Area 3). In 1959 the Area 3 sockeye catch totalled 224,735, very close to the average annual catch for the past 10 years (229,000). The catch would have been somewhat higher had a strike not resulted in a 2-week cessation of fishing toward the end of the run (Fig. 9). In 1959, as in most years, 5_3 fish predominated in the Nass sockeye catch (Table 22); 5_2's were also abundant in 1959 but 4_2's and 6_3's formed only a small part of the catch. As shown in Figure 9, the "sub-3" fish (i.e. 5_3 and 6_3 fish) appear most abundantly at the beginning of the season. The numbers of 4_2 and 5_2 fish were low at the beginning of the season but increased steadily so that by late July they formed over half the weekly catch.

The increase in 4_2's and 5_2's in the latter part of the season is in part attributable to the passage of predominantly "sub-2" Skeena-bound fish through the Nass area. Tagging has shown that a substantial number of sockeye caught in Area 3 are bound for the adjacent Skeena River. These Skeena River fish are taken late in the Nass season mainly in the offshore regions of Area 3 between Dundas Island and the mainland.

ii) Skeena River (Area 4). On the Skeena River samples were obtained from both the commercial fishery and from the escapement immediately above the upstream fishing boundary (from catches of the test-fishing boats). Combination of the data from both sources provides an estimate of the composition of the Skeena stock as a whole.

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[1] Exclusive of the Fraser River Convention area where sampling is carried out by the International Pacific Salmon Fisheries Commission.

Table 22. Percentage age composition of 1959 sockeye catches

Statistical Area	Location	Catch	2_1	3_1	4_1	5_1	3_2	4_2	5_2	6_2	4_3	5_3	6_3	6_4	Total Samples	% Females
		1,000's														
3	Nass River	225	.07	.3	.4	.07	.1	5.6	25.8		.46	63.5	3.7		1,264	55.5
4	a) Skeena River catch	191					.05	13.8	65.4		.05	18.2	2.5		943	58.7
	b) Skeena River escapement[1]	870					2.4	25.35	62.1	.05	.5	8.2	1.4		1,634	51.8
	Skeena, catch + escapement	1,061					2.0	23.27	62.69	.04	.4	10.0	1.6		-	-
5	Ogden-Principe	84		.06			1.0	28.9	40.2		.3	23.5	5.8	.24	1,137	51.7
6	Whales Channel	27					.1	23.3	42.7		.3	23.5	10.1		361	52.6
8	Bella Coola	76		.1	.55		.9	53.7	26.3		.05	16.4	2.0		496	60.2
9	Rivers Inlet	404		.06	.1		.2	18.7	76.4	.4		2.9	1.24	.002	1,289	52.5
10	Smith Inlet	107			1.0		.1	15.9	77.9	.2	.1	3.7	1.1		593	48.5
12	Upper Johnstone Strait	294					.5	86.99	6.6	.1	.01	5.3	.5		1,214	58.0
13	Lower Johnstone Strait	85					.9	84.38	8.4		.02	5.9	.4		657	54.9
Total catch in areas covered		1,493													9,588	
Total catch Fraser Convention Area		1,527													100	
Total catch other areas		139													1,288	
Total B. C. catch		3,159													10,976	

[1] Derived from test-fishing catches above the fishing boundary

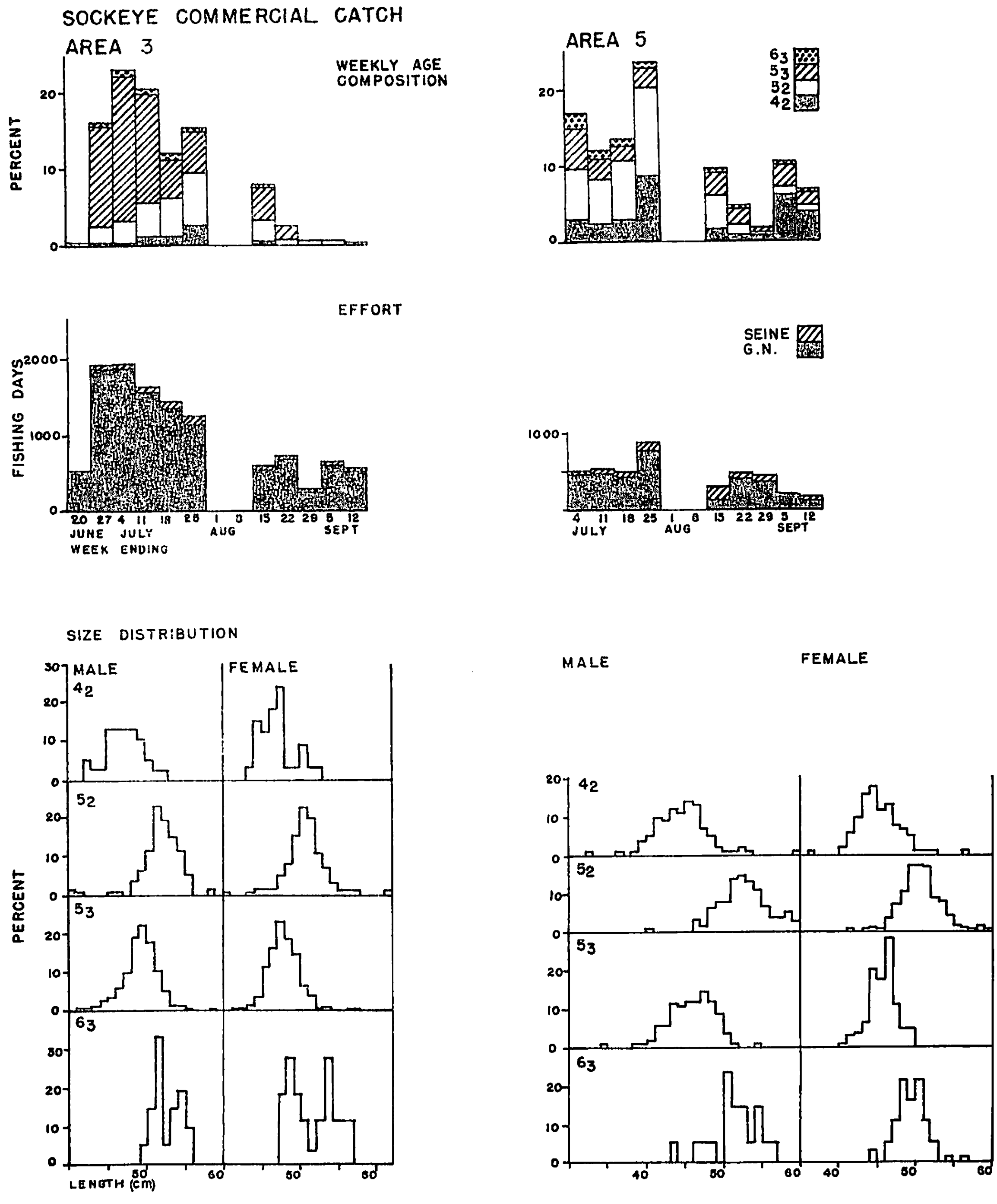


Figure 9. The weekly effort, age composition and size distribution of of sockeye in catches from areas 3 (Nass River) and 5 (Ogden-Principe) in 1959.

In 1959, restrictions to protect the early runs to the south end of the Babine Lake system and the two-week tie-up of the fleet during price negotiations (the two weeks ending August 1 and August 8) resulted in a small catch of only 190,700 (37% of the average for the past 10 years) and a relatively large escapement of 870,000 (see Table 22 and Fig. 10). Five-year-olds formed the bulk of the catch and escapement. The lack of 4-year-olds reflects the small production from the very poor spawning in the parent year, 1955 (see Table 23).

Comparison of the age, size and sex composition of the Skeena catches and escapements (Fig. 10) indicates that the fishery exerted a selective effect on the stock, removing a higher proportion of 5-year-old fish than of 4-year-olds. Data on the size composition of the catch (Fig. 10) suggest that this apparent selectivity was caused by the failure of the commercial nets to remove small 4-year-olds as effectively as large ones.

iii) Grenville-Principe (Area 5). The catch of 84,000 sockeye from this area in 1959 was slightly above the average annual catch of 76,000 over the previous 7 years. Undoubtedly many of the fish taken in this area were bound for the adjacent Skeena River area. Although they did not represent the majority of the catch 5_2's were the most abundant age class.

iv) Whales Channel (Area 6). The catch of sockeye in this area in 1959 was 27,000 which is much below the average annual catch of 78,000 for the previous 7 years. In 1959, 5_2 fish appeared as the predominant age group in the catch, although over half of the catch was made up from 4_2, 5_3 and 6_3 fish.

v) Bella Coola (Area 8). In 1959, the total catch of sockeye from Area 8 was 76,000, which is approximately half the average annual catch of 140,000 for the previous 8 years. Unlike the catches of sockeye from all the other areas in 1959, which were predominantly 5_2 fish (excepting Johnstone Straits), over half the sockeye in the catch from this area were 4_2's.

vi) Rivers Inlet (Area 9). The 1959 sockeye catch at Rivers Inlet was 404,300, less than half the average annual catch over the past 8 years (811,000). A major reason for the low yield was the two-week tie-up of the fleet just following the normal peak period of the Rivers Inlet fishery. As in other important producing areas 5_2 fish formed the bulk of the catch (76%).

Examination of age and catch data for recent years reveals that the returns in the last 5 years have, on the average, been somewhat smaller than in the parent years (Table 24). Returns from spawnings in 1950, 1952 and 1953 have yielded catches much smaller than the catches in parent years and returns from 1951 and 1954 were only slightly greater than in the parent years. Whereas the catch in 1950 was very good, the total resultant return of 4-year-olds in 1954 and 5-year-olds in 1955 yielded only 0.66 million fish to the fishery, 44% of the catch in the parent year (1.51 million). Similarly, the returns from the 1952 and 1953 broods were only 25% and 64% respectively of the catches in the parent year. Returns in the other 2 years (1951 and 1954) have yielded catches barely equal to those in the parent years; the total return from the 1951 brood was 1.23 million compared to a catch in the parent year of 1.02 million; the return from the 1954 brood (which produced the 5's of 1959) was 0.61 million compared to the brood-year catch of 0.58 million. However, as pointed out above, had the strike not limited fishing in 1959 the yield of 5's from the 1954 brood might have been substantially larger and in this case the total return would have been in the order of 1.2 times that in the parent year instead of only 1.06 times as indicated in Table 24. Even taking into account the effects of the 1959 strike, the total returns to Rivers

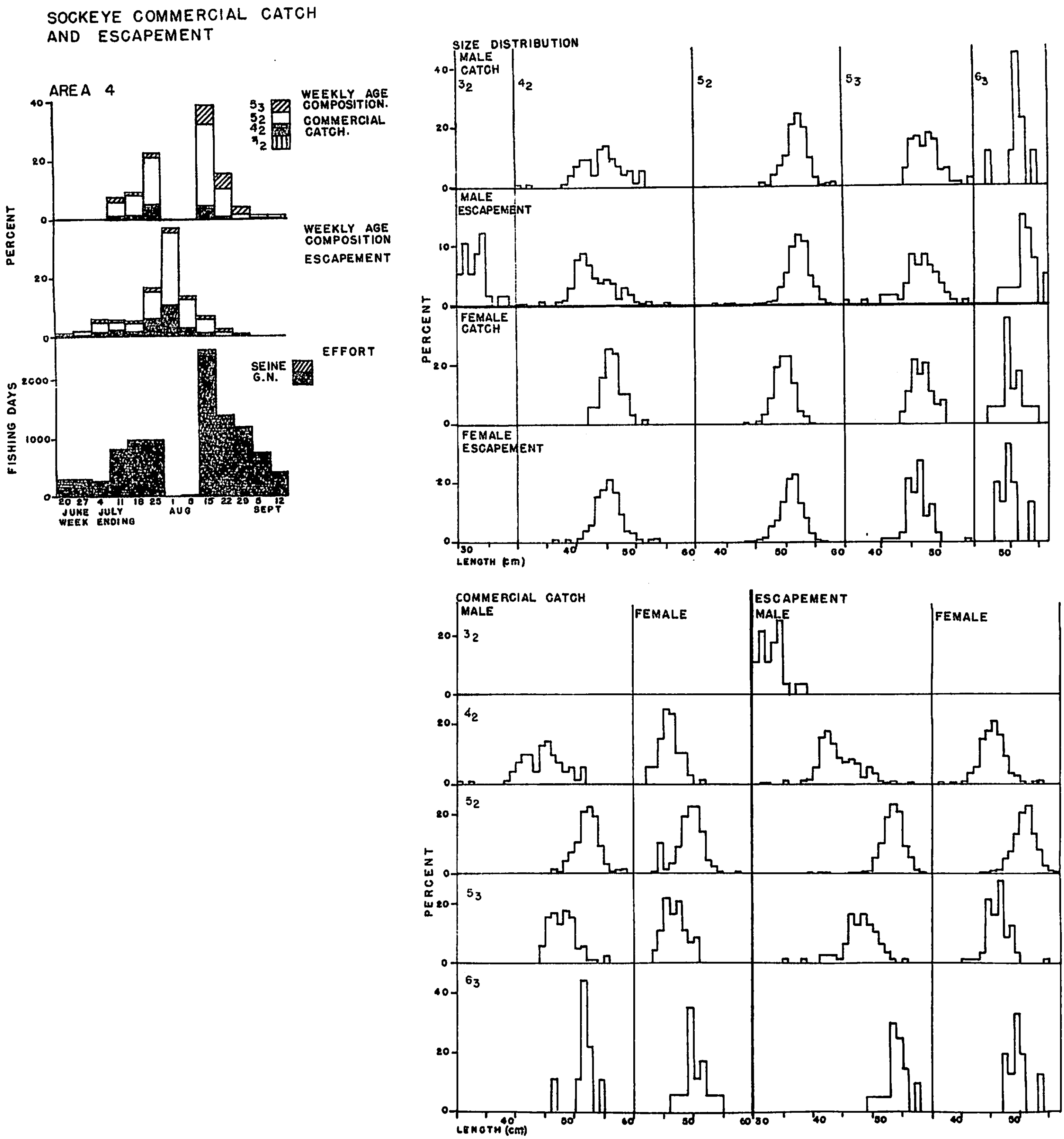


Figure 10. The weekly effort and age composition, and size distribution of sockeye in the catch and escapement on the Skeena River in 1959.

Table 23. Skeena River sockeye

Brood year	Brood year esc.	Resultant stock							% 4's	% 5's
		1954	1955	1956	1957	1958	1959	Total		
		thousands of fish								
1950	449	394	193	16	-	-	-	603	65.3	32.0
1951	248	-	55	140	7	-	-	202	27.3	70.0
1952	237	-	8	438	255	8	-	709	61.8	35.9
1953	752	-	-	2	525	919	17	1463	35.9	62.8
1954	580	-	-	-	42	596	771	1409	42.3	54.7
1955	110	-	-	-	-	14	251	-	-	-
Total	-	-	256	596	829	1537	1039	-	-	-

Table 24. Rivers Inlet sockeye

Brood year	Brood year catch	Resultant catch							% 4's	% 5's
		1954	1955	1956	1957	1958	1959	Total		
		thousands of fish								
1950	1510	345	315	-	-	-	-	660	52.3	47.7
1951	1016	-	263	965	2	-	-	1230	21.4	78.4
1952	939	-	-	107	129	3	-	239	44.8	53.9
1953	1522	-	-	-	242	723	7	972	24.9	74.4
1954	575	-	-	-	1	287	320	608	47.2	52.6
1955	584	-	-	-	-	4	76	-	-	-
Total		-	578	1072	374	1017	403	-	-	-

Smith Inlet sockeye

Brood year	Brood year catch	Resultant catch							% 4's	% 5's
		1954	1955	1956	1957	1958	1959	Total		
		thousands of fish								
1950	474	118	188	-	-	-	-	306	38.6	61.4
1951	439	-	137	424	-	-	-	561	24.4	75.6
1952	342	-	-	18	27	-	-	45	40.0	60.0
1953	367	-	-	-	37	166	1	204	18.1	81.4
1954	191	-	-	-	-	57	87	144	39.6	60.4
1955	325	-	-	-	-	-	18	-	-	-
Total		-	325	442	64	223	106	-	-	-

Inlet in the past 5 years have yielded average catches of only three-quarters of those provided by the parent years.

vii) Smith Inlet (Area 10). The catch of 107,100 sockeye in Area 10 in 1959 was far below the average annual catch over the previous ten years of 297,000. As was the case for Rivers Inlet, the catch would have been substantially higher had the strike not restricted fishing in the period immediately after the normal peak of the Smith Inlet run. The catch was composed mainly of 5_2 fish. As indicated in Table 24, returns in the past 5 years have averaged much smaller (67%) than the catches made in the parent years of 1950-54; in only one year (the brood year 1951) was the resultant catch greater than the catch in the parent year.

viii) Johnstone Strait (Areas 12 and 13). The 1959 sockeye catch in the Johnstone Strait area (379,000) was composed almost entirely of 4-year-olds, reflecting the presence of a very high proportion of fish bound for the Fraser River area.

Thus, in 1959, sockeye catches in most areas were substantially less than the average for recent years. The occurrence of a two-week strike in late July and early August was a contributing cause of the low catches but did not entirely account for the apparently low stock levels. For the second consecutive year 5-year-olds predominated in the catches in almost all areas, reflecting first, the tendency for the progeny of the 1954 brood to return predominantly as 5-year-olds and second, the relatively poor production of 4-year-olds from the 1955 brood.

(b) Chum catches

Data on the age composition of chum catches are available for most areas only since 1958. Because of this, only the most general appraisal can be made of the data. In Table 25, the percentage age composition of chum catches for 1957 to 1959 are listed. In 1959 thorough sampling was conducted in areas providing about 87% of the total British Columbia chum catch.

In northern British Columbia (Areas 3 and 4) the 1959 chum salmon catch was about the same as in the past 3 years. In both Areas 3 and 4, 4-year-olds predominated. In the Central Coast region (Areas 5 to 9), however, the 1959 catches were very small. Associated with this, the proportion of 4-year-olds was also much lower than in 1958, possibly reflecting the very poor production from the 1955 brood. Catches in southern areas (Areas 12 to 29) were, in general, much better than in the last two years. In most southern areas 4-year-olds from the 1955 brood formed more than 50% of the catches.

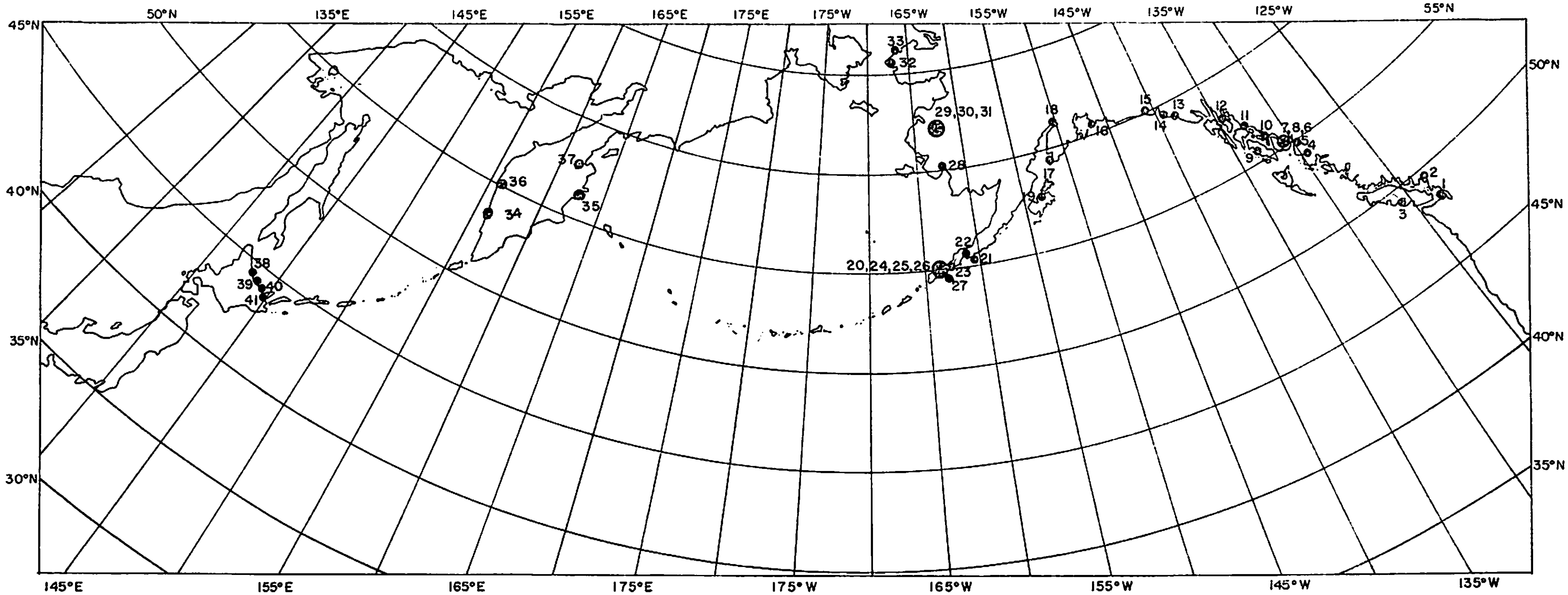
3. Study of chum salmon scales to distinguish stocks

T.H. Bilton, M.P. Shepard and D.W. Jenkinson

As part of Canada's contribution to the International North Pacific Fisheries Commission research program, studies on scale characteristics of chums taken from spawning grounds and coastal areas throughout the North Pacific area and on the high seas were continued in 1959-60. Scales from 3,576 chums collected from 33 inlets or river systems in North America and from 8 Asian river systems in Siberia and Japan in 1957 were examined. The sampling areas and numbers of specimens examined from each are shown in Figure 11.

Table 25. Percentage age composition of chum catches 1957-1959.

Statistical area	Main sampling location	Year	Catch	Age composition (per cent) 2_1	3_1	4_1	5_1	6_1	Total samples	% females
			(1,000)							
3	Nass River	1957	226		10.8	77.7	11.5		1,176	45.9
		1958	178		12.5	73.4	14.1		1,627	41.8
		1959	159		16.9	62.4	20.7		805	46.7
4	Skeena River	1957	36		3.9	92.6	3.5		744	35.2
		1958	43		6.8	82.9	10.3		1,000	39.9
5	Wright Sound	1957	72		17.7	73.4	8.9		192	36.4
	" "	1958	54		5.3	91.0	3.7		301	52.7
	Ogden Channel	1959	14		33.0	52.6	14.4		333	40.0
6	Whales Channel	1958	313		2.8	94.2	3.0		201	49.1
		1959	23		55.7	24.3	20.0		235	52.9
7	Bella Bella	1958	268		9.1	88.4	2.5		1,768	49.2
		1959	69		35.3	52.1	12.6		394	46.0
8	Namu	1958	302		10.2	85.59	4.2	.01	2,695	48.8
		1959	69		27.9	66.3	5.8		492	57.7
9	Rivers Inlet	1958	60		11.5	86.9	1.6		341	45.6
10	Smith Inlet	1959	9		40.7	51.7	7.6		194	45.7
12	Upper Johnstone Strait	1959	461		31.6	66.1	2.3		1,230	48.7
13	Lower Johnstone Strait (early run)	1958	126		38.1	61.7	.2		368	43.9
		1959	311		35.5	62.7	1.8		1,241	50.6
16	Sabine Channel	1959	104		34.4	64.6	1.0		474	55.2
20	San Juan	1958	29	.2	69.6	28.3	1.9		352	49.1
		1959	36	.4	29.2	69.9	.5		828	49.1
23	Barkley Sound	1959	76		41.4	56.4	2.2		276	43.6
25	Nootka Sound	1959	76		59.8	39.6	.6		394	35.3
26	Kyuquot Sound	1959	94	.2	56.9	40.8	2.1		363	49.3
29	Fraser River	1957	119		15.8	78.1	6.1		329	42.8
		1958	195		56.1	43.4	.5		452	44.1
		1959	219		40.8	58.7	.5		1,576	51.8



Map No.	Location	No. in sample	Map No.	Location	No. in sample	Map No.	Location	No. in sample
1	Puget Sound	52	16	Cordova, Prince William Sound	58	30	Yukon River, Alakanuk	40
2	Fraser River	161	17	Seldovia, Rocky Bay	101	31	Yukon River, Far North	244
3	W. Coast Vanc. Isl.	100	18	Cook Inlet, Kalgen Island	102	32	Teller, Pt. Clarence	87
4	Skeena River	146	19	Uyak Bay	71	33	Kotzebue Sound	38
5	Nass River	114	20	Larsen Bay	150	34	Bolshaya River	49
6	Portland Canal	44	21	Shumigan Island	249	35	Kamchatka River	49
7	Boca de Quadra	12	22	Pavlof Bay	105	36	Icha River	47
8	Boca de Quadra, Anan Bay	76	23	Cold Bay	267	37	Uka River	25
9	Noyes Island	11	24	False Pass	51	38	Yubetsu River	33
10	Anan Bay	37	25	Unimak Island	7	39	Tokoro River	59
11	Farragut Bay	25	26	Alitak	167	40	Abashiri River	162
12	Seymour Canal	73	27	King Cove	150	41	Shari River	92
13	Pt. Eaton	19	28	Kuskokwim River	73			
14	Yakutat, East River	82	29	Yukon River, Old Andreafsky	104			
15	Taku River	44						

Figure 11. Sampling locations for chum salmon utilized for 1957 scale studies.

Age composition (Table 26). In 1957, chum salmon from the inshore waters of North America were again predominantly 4-year-olds, but the proportion of 3- and 5-year-olds was somewhat higher than in 1956. Siberian chums were also mainly 4-year-olds (70%). This is in contrast with data for 1956 when samples of chums taken off the Siberian coast contained roughly equal proportions of 4- and 5-year-old fish as well as a substantial number of 3-year-olds. Chums sampled in Japanese streams in 1957 were also mainly 4-year-olds but 3-year-olds were also well represented.

Table 26. Percent age composition of chum salmon sampled in 1957 from 6 general areas.

Area	Age				
	3_1	4_1	5_1	6_1	7_1
British Columbia	18.2	75.7	6.1	-	-
Southeast Alaska	10.6	75.7	13.7	-	-
Central and Western Alaska	6.2	68.1	25.6	.1	-
Northwest Alaska	19.3	55.7	24.2	.8	-
Siberia	1.7	71.8	23.6	2.3	.6
Japan	51.7	45.4	2.9	-	-

Circulus counts (Fig. 12). The 1956 data indicated a geographical cline in the number of circuli in the first-year band, fish from the southern extremes of the range tending to have more circuli than those from the more northern areas. The 1957 data show essentially the same trend. As seen in Figure 12, British Columbia (including State of Washington) and southeast Alaska chums had many closely packed circuli, more or less evenly distributed throughout the first-year band. Chums from the northwest part of North America (central, western and northwest Alaska) had fewer circuli, especially in the last half of the first-year band. Chums from Siberia had the fewest circuli of all. Japanese chums again exhibited a higher first-year circulus count, quite similar in magnitude to chums from British Columbia.

There was also a cline in the number of circuli in the second-year band, with a number of second-year circuli decreasing from East to West. Chums from British Columbia had the highest second-year circuli counts, whereas Japanese chums had the lowest (see Fig. 12).

Circulus counts for the first year for each area were quite similar for all age groups. Second-year counts, however, tended to vary with age, with the younger fish tending to have higher counts than the older ones (this tendency was evident for all stocks except the Japanese ones).

Annulus measurements (Fig. 13). Differences in annulus measurements between stocks tended to parallel the observed differences in circulus counts. First-year annuli in the southern-most extremes of the chum salmon's range (i.e. British Columbia and Japan) tended to be larger than those in the northern areas. For second-year annuli, however, there was an East-West cline in annulus widths; scales from British Columbia chums had the largest second-year widths, while those from Japanese chums had the smallest.

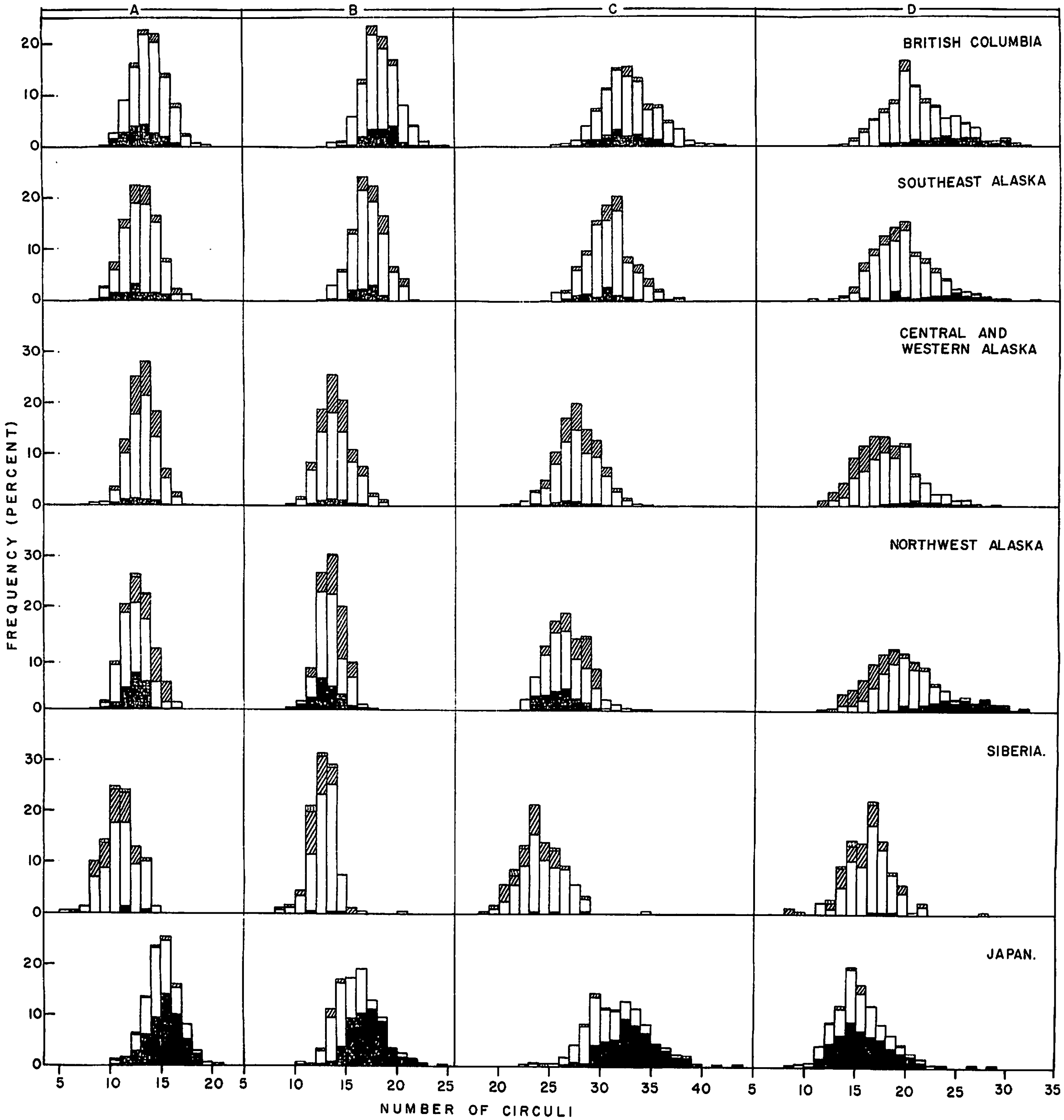


Figure 12 Distribution of circulus counts for scales of chum salmon from different areas of the North Pacific in 1957.

Column A - Circuli in first half of first-year band.
Column B - Circuli in last half of first-year band.
Column C - Total first-year circuli.
Column D - Total second-year circuli.

Black bars indicate frequencies for 3_1 fish, white for 4_1's and cross-hatched for 5_1's.

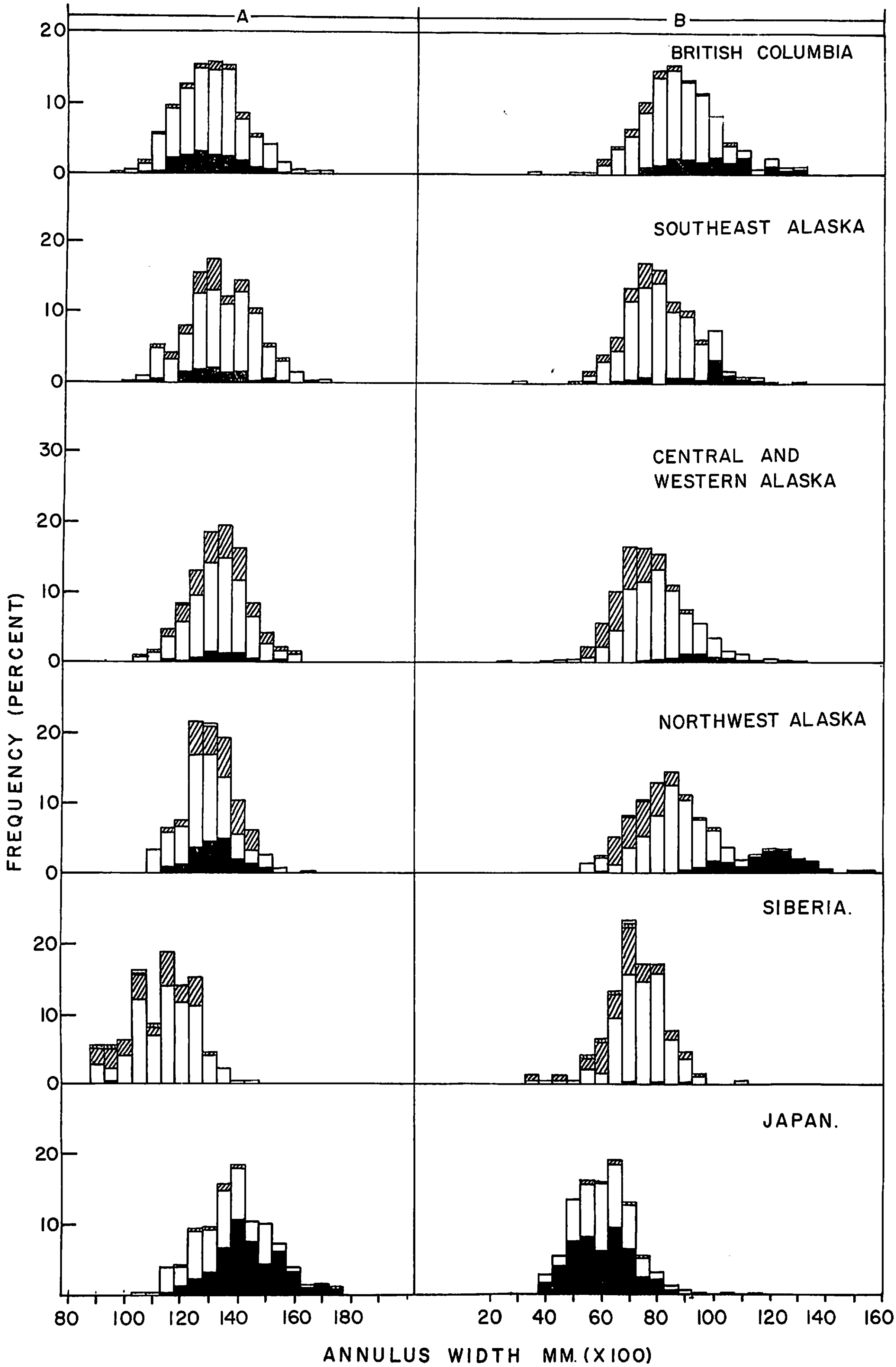


Figure 13 Widths of first- and second-year bands of scales of chum salmon from different areas of the North Pacific in 1957.

Column A - First-year annulus widths
Column B - Second-year annulus widths

Some distinguishing characteristics of Asian and North American chums. As seen in Figure 13, Siberian chum salmon tended to have narrower first-year annuli than did chums from other areas. Fish with first-year annuli measuring 1.05 mm and less composed 35% of the samples collected from Siberian streams, whereas they formed less than 3% of the fish sampled in other areas. The percentage of fish having first-year annulus measurements of 1.05 mm and less for each of the six general areas of study are listed in Table 27.

As noted in Figure 12, fish having first-year circulus counts of 30 and more formed the major proportion of samples from British Columbian, southeast Alaskan and Japanese coastal areas. Only one fish of the 170 sampled from Siberia exhibited a circulus count as high as 30 (Table 28). It can also be seen from Figure 12 that although fish from Japan had high first-year circulus counts similar to those for British Columbian and southeast Alaskan fish, they had considerably lower second-year circulus counts and annulus widths. On the basis of these observations, for fish from each of the six general areas, a comparison was made of the difference between the first-year and second-year annulus widths for fish with 30 and more circuli in the first year. It was found (Table 29) that chums having 30 and more first-year circuli and differences between the widths of the first and second annuli of 0.45 mm and less formed over half of the fish sampled in British Columbia, approximately one-quarter of the southeast Alaskan fish, less than 10% of the fish sampled in the more northern North American streams and virtually none of the fish from the Asian samples (only 2 out of 516 fish examined).

Table 27. Percentage of chums from 6 general areas having first-year annulus widths of 1.05 mm or less.

Area	Percentage
British Columbia	2.61
Southeast Alaska	1.19
Central and Western Alaska	1.09
Northwest Alaska	0
Siberia	34.70
Japan	.58

Table 28. Percentage of chums from 6 general areas having total first-year circulus counts of 30 and more.

Area	Percentage
British Columbia	92.85
Southeast Alaska	78.72
Central and Western Alaska	26.89
Northwest Alaska	12.67
Siberia	.59
Japan	84.39

Table 29. Proportion of chums from 6 general areas having first-year circulus counts of 30 and more and a difference of 0.45 mm or less between first- and second-year annulus widths.

Area	Percentage of sample
British Columbia	57.6
Southeast Alaska	27.2
Central and Western Alaska	5.7
Northwest Alaska	1.9
Siberia	0
Japan	0.6

SPRING AND COHO SALMON

D. J. Milne

Last year recent catches of spring and coho salmon were reviewed. For the past decade the commercial catches of these species have remained relatively constant and are apparently at the highest level in their history. The spring salmon catch has been about 14,000,000 pounds or 1,000,000 fish and the coho salmon catch has been about 24,000,000 pounds or 3,000,000 fish. They usually constitute about one-quarter of the total landings and value of all salmon caught in British Columbia. As reviewed in this report, the 1959 catches were below average, particularly for coho, but owing to low catches in the other species and high prices in the fresh-fish market, spring and coho salmon accounted for 30% by weight and 40% by value of the total salmon landings. The rapidly growing ocean sport fishery made another large catch of these two species.

The two-year study on coho salmon in the Strait of Juan de Fuca, which was carried out in co-operation with Washington State, was completed by the submission of a joint report to the second International Conference on Co-ordination of Fisheries Regulations between Canada and the United States in April 1959. No agreement was reached on re-locating the seaward limit of net fishing now at a line from Bonilla Point to Tatoosh Island but it was agreed that further consideration would be given to the coho salmon problem if additional scientific evidence was presented in the future. No work was done in this area by either agency in 1959 but the commercial catches are reviewed below.

At the same conference the commercial troll and the tidal sport fishing regulations along the Pacific Coast were reviewed but no changes were recommended. The effects of the new minimum size limit and winter closed period for spring salmon (adopted after the first conference in 1957) were reviewed last year. Results of 1959 sampling are given below.

No new field work was undertaken in 1959 but sampling of the commercial catches for size and age was continued and the examination of spring salmon catches in outside waters for United States hatchery marks was expanded. By liaison with the Pacific Marine Fisheries Commission, a watching brief was maintained on the commercial and sport fisheries, especially for those stocks which are fished jointly by Canadian and United States fishermen. Much back data on catches and sampling were summarized and some of the results will be given in the following reports, which show promise of being useful in designating stocks for regulation and management purposes.

1. Catches of spring and coho salmon in 1959

In 1959 the total catches were below average or 13,510,000 pounds for spring salmon and 19,570,000 pounds for coho salmon. Of these the trollers caught 8,650,000 pounds or 64% of the spring salmon (an average catch) and 11,680,000 pounds or 60% of the coho salmon (the lowest in the last nine years). Both catches were affected by the fishermen's strike from July 25 to August 9. During this two-week period at the peak of the troll fishery about 10% of the spring salmon catch and 15% of the coho salmon catch are usually taken. Accordingly the troll catches were probably reduced by over one million pounds of spring salmon and over two million pounds of coho salmon. This exceptional closure of the British Columbia troll fishery had no apparent effect on American catches to the south. The Washington spring troll catch was low, particularly off Westport, and the coho catch was low, particularly off Neah Bay. The Oregon troll catches were record lows in both species.

The British Columbian trollers also caught 4,320,000 pounds of pink salmon which is over twice as many as were taken in the cycle year 1957 when the pink salmon stocks were larger. (In contrast the Washington trollers caught fewer pinks in 1959 than in 1957.) The Canadian sport fishermen also caught more pinks (37,000) in 1959 than in 1957 (10,000).

Spring salmon. The 1959 troll catch off the west coast of Vancouver Island of 334,000 spring salmon was the lowest in the last eight years but the fish averaged large while in the Strait of Georgia the catch of 139,000 fish was the second largest during this period but they were small. The troll catch of 34,000 springs off the Queen Charlotte Islands was the highest since 1953.

The Fraser River catch of spring salmon in 1959 (2,800,000 pounds) was the best since 1954 and the fish were of average size (16.5 pounds). This is the first time that the Fraser gill-net catch has been higher than the gill-net catch of fall chinooks in the Columbia River which was a record low of 1,900,000 pounds, with fishing heavily restricted by closures. It is quite likely that at the present time the stocks of Fraser River spring salmon and Columbia River fall chinooks are of equal importance to the Canadian trollers who fish in outside waters.

Coho salmon. The 1959 troll catch of coho salmon off the west coast of Vancouver Island was exceptionally good after the season opened on June 15 but was poor later in August and September and the fish were small in average size. In the Strait of Georgia the coho catch was the second lowest in the last eight years and the fish were also small. The gill-net catch in the Fraser River was below average and the fish were small, averaging 6.5 pounds.

The 1959 total Canadian coho salmon catch in the Strait of Juan de Fuca (Area 20) was 417,191 fish compared to 266,000 in 1958 and 462,000 in 1957. The United States catch in the outer straits (89,000) was higher than either 1958 (44,000 fish) or 1957 (81,000 fish). In both 1957 and 1959 fishing started at about the same time (July 22 and July 20, respectively) and was dominated by the abundance of pink salmon. However, in 1959 the Canadian strike from July 25 to August 9 affected both the effort and the catch. In 1959 the purse-seiners fished

1,982 boat-days and caught 196,000 fish compared to 2,378 boat-days and 238,000 fish in 1957. The gill-netters fished 5,678 boat-days and caught 205,000 cohos in 1959 compared to 6,458 boat-days and 199,000 fish in 1957. Thus the gill-netters caught a large proportion of coho salmon in this region for the fourth consecutive season, while the purse-seine catch was below average for a pink salmon year. The trollers caught 16,424 fish and the Sooke traps did not operate. The coho salmon caught by nets in the Strait of Juan de Fuca in 1959 were exceptionally small (av. 6.1 lbs) compared to the large fish taken in 1958 (8.3 lbs) but similar to the small fish in 1957 (6.2 lbs).

In summary, the spring salmon catches were about average in 1959, when the effect of the two-week strike is taken into account, but the coho salmon catches were below average, especially in poundage as the fish were small in average size.

The ocean sport fishery relies on spring and coho salmon and has expanded greatly in recent years from a total catch of about 200,000 fish in 1953 to over 400,000 fish in 1958. In 1959 the catch is estimated at 396,000 fish made up of 65,000 springs, 90,000 cohos over three pounds in weight and 37,000 pinks. The remainder are small spring and coho salmon, popularly called "grilse". In 1959, for the first time, these small fish were separated into species by the colour of the gums - black for springs and white for cohos - but the final estimates for each species are not available yet. The sport catch by species is essential for sound discussions of minimum size regulations and the management of stocks of spring and coho salmon that are caught in the Strait of Georgia where most of the sport fishing occurs.

2. <u>Sampling of spring and coho salmon catches for marks and growth of fish</u>

(a) <u>1959 mark returns in spring salmon</u>. In recent years the troll catches have been sampled for fish which have been fin-clipped in United States hatcheries. In 1957 and 1958 this sampling was reduced but in 1959, at the special request of the Pacific Marine Fisheries Commission, it was expanded for spring salmon caught in outside waters. Over 10 million chinooks had been marked from the brood years 1954 to 1956 in many experiments at Columbia River and Puget Sound hatcheries.

No marks were found in 2,037 springs caught off the Queen Charlotte Islands but in 37,524 fish examined from the west coast of Vancouver Island, 134 single-fin and 110 double-fin marks were found. This is the highest number and the largest proportion (one double-fin mark in 341 fish) that has been found off British Columbia since sampling started in 1952.

The results in United States waters were similar. In southeastern Alaska only 39 single-fin and 4 double-fin marks (1 in 987 fish) were found in 39,480 fish. In Washington 335 single-fin and 317 double-fin marks (1 in 205 fish) were found in 65,105 fish. In Oregon 26 single-fin and 36 double-fin marks (1 in 171 fish) were found in 6,158 fish examined. Many marks were also found at hatcheries and in the gill-net fishery of the Columbia River. Although more marks were found in 1959 along the entire Pacific coast than in previous years, unfortunately most of the ocean recoveries cannot be assigned to the river of origin because all of the double-fin marks were duplicated in several experiments in both the Columbia River and Puget Sound, except for the experiments at Spring Creek hatchery on the Columbia River. In these experiments more recoveries were made from fry marked adipose and right-pectoral and released at 90 days (6 off B.C.) than from those marked adipose and left-pectoral and released as unfed fry (none off B.C.).

Because of the confusion in duplicated marks there is apparently little value in the marking agencies analysing the ocean recoveries from the recent experiments to estimate the contribution of the hatcheries on the lower Columbia River to the various ocean troll fisheries. For this reason it is not planned to sample the troll catches off British Columbia for United States marked fish in 1960.

(b) Variations in the size of coho salmon. Since 1952 coho salmon caught by trollers on each side of Vancouver Island have been measured for fork length. Virtually all coho mature and are caught in their third year of life after spending the first year in fresh water. In previous reports, the rapid growth during the last summer in the ocean has been noted but it is of interest to compare the size at capture in both regions for a series of years. Because fishing has started at different times in June and the sampling has varied in August, only the sampling results for July are presented in Table 30.

Table 30. Average fork length of coho salmon sampled in July from troll catches off each side of Vancouver Island, 1952-59.

	1952	1953	1954	1955	1956	1957	1958	1959
West Coast								
Length (cm)	64.1	60.1	60.9	62.9	60.5	58.6	62.5	60.4
Number	3402	1464	896	2150	2340	1749	1026	1615
East Coast								
Length (cm)	55.1	53.1	53.4	51.8	58.0	52.0	54.5	52.1
Number	1443	2523	2035	2418	1522	1121	1135	1293

It has been known for years that coho salmon taken "outside" (off the west coast of Vancouver Island) are consistently larger than those taken "inside" (off the east coast). During the last 8 years the outside fish were largest in 1952 and smallest in 1957. The inside fish were also large in 1952 and small in 1957 but were exceptionally large in 1956, when the catch was the lowest in this period, and were small in 1955 and 1957. In six of the last eight years the size has varied similarly in the two regions but not in 1955 and 1956.

In order to determine whether or not the difference in size between the two regions was consistent throughout the life of the fish, the circuli were counted and the scales were measured for all 3_2 coho sampled during August 1958, the first time that one scale had been taken at the same place on each fish. From the average fork length at time of capture and the average scale radius from the centre to each annulus, the average fork length of fish in each year was calculated (Table 31).

From the 1958 scales it appears that the coho salmon caught in each region have different growth rates throughout life. Both the number of circuli and the width of the scale radii are greater in fish caught in outside waters than in those caught inside. Scales collected in 1959 reouire similar analysis. If the

Table 31. The average number of circuli (C), scale radius in mm. (R), and fork length in cm. (FL) in each year for coho salmon sampled in August, 1958.

	Outside Van. Is. (118 fish)			Inside Van. Is. (120 fish)		
	C	R	FL	C	R	FL
First year (fresh water annulus)	17.8	.51	9.6	16.6	.47	8.5
Second year (ocean annulus)	56.7	2.18	41.0	53.8	1.95	35.2
Third year (at capture in August)	81.8	3.54	66.6	77.5	2.97	53.5

same conclusion holds it is hoped that scales from yearling migrants and adult spawners can be collected and compared for various streams to determine where and when the fish, with the two observed types of growth, actually spawn. Do the fish which spend their ocean phase in the Strait of Georgia spawn in different streams than those spending their ocean phase in outside waters or in the same streams at different times and places.

(c) Variations in the size of spring salmon. Last year a review was presented of the lengths of spring salmon with reference to the 26-inch total length size limit adopted in 1957 for outside waters. In 1959 a total of 7,877 fish were measured from the west coast of Vancouver Island. Of these, 12.3% were under 26 inches which is similar to the 12.4% obtained in 1958 but less than the 20.3% in 1957 when the fish were small in size. The average fork length in 1959 was 74.2 cm. compared to 74.3 cm. in 1958 and 70.2 cm. in 1957. As the 1959 catch was 334,000 fish it is estimated that about 40,000 small fish were caught and retained and about 25,000 small fish were either released or avoided in outside waters. This is similar to 1958 but much less than in 1957.

From the Strait of Georgia 3,119 fish were measured in 1959 and 39.6% were less than 26 inches. This compares with 21.6% in 1958, 51.7% in 1957 and 34.7% for the previous 5-year average. As the 1959 catch was again high (139,000 fish) it is estimated that about 55,000 small fish were caught and retained. This is between the estimates for 1958 and 1957 but almost twice as many as the average for the years 1952 to 1956.

In contrast to coho salmon, the average lengths of spring salmon cannot be used to show with precision the annual variation in size of fish caught on each side of Vancouver Island because several age groups are involved and because since 1957 there has been a minimum size limit in outside waters. Consequently the lengths of the dominant age group of 3_1 fish are compared for each region in Table 32.

Table 32. Average fork length of spring salmon of 3_1 age-group sampled from troll catches off each side of Vancouver Island, 1952-59.

	1952	1953	1954	1955	1956	1957	1958	1959
West Coast								
Length (cm)	70.5	66.0	70.7	69.1	67.8	66.8	67.4	66.2
Number	62	151	92	234	189	228	263	164
East Coast								
Length (cm)	69.4	64.6	67.6	65.4	64.7	64.1	67.3	64.7
Number	97	51	144	196	107	116	170	170

There is a consistent difference in size between fish caught in the two regions but it is not as marked as that for coho salmon. The outside fish were large in 1952 and 1954 and were small in 1953, 1957 and 1959. The inside fish were largest in 1952 and smallest in 1957. These variations also show some similarities to those for coho salmon.

When the average weights of fish, obtained from the total catch statistics, are considered in conjunction with the conclusions from the length samples it is apparent that both spring and coho salmon were large in 1952 and small in 1957 and that fish caught outside of Vancouver Island were consistently larger than those taken inside. How changes in oceanographic conditions affect the growth of salmon remains to be investigated but it is evident that different minimum size regulations should be considered for fish caught in outside and inside waters.

(d) Spring salmon age determinations. In 1959 scales were again sampled from spring salmon caught by troll off each side of Vancouver Island and from fish caught by gill-nets in the Fraser River. Previous reports have given age determinations for similar samples taken from 1952 to 1956. In Table 33 the percentage age composition is given for samples collected in the last three years. The Fraser River fish have been separated into red- and white-fleshed types. Because of the complexity of obtaining consistent age determinations in spring salmon these results should be considered as preliminary and subject to revision when more is known about the early life in fresh and brackish water.

It is known from tagging and marking experiments that spring salmon taken by troll off the west coast of Vancouver Island are a mixture of fish from many rivers along the Pacific coast and that some are fished as immatures during more than one season. The age readings indicate that 80 to 90% are of the "ocean type", i.e. go to sea in their first year and that the majority are caught in their third and fourth years. Fish caught by troll off the east coast of Vancouver Island are also a mixture of stocks of which about 90% are of the ocean type. They are caught at younger ages, mostly 3's with 2's and 4's of about eoual importance. It is surprising that so few are of the stream type for many must spawn in the Fraser River.

The fish caught by gill-nets in the Fraser River are all maturing fish on their spawning migration. Approximately one-half are of the "stream type" - i.e. spend the first winter in fresh water. For the early run of red-fleshed fish

Table 33. Percentage age composition of spring salmon samples 1957-59.

Area	Number of scales			Ocean type							Stream type					
	Years	Read	Not readable	1	2	3	4	5	6	Total	2	3	4	5	6	Total
West coast of Van. Is. (troll)	1957	648	46	.5	3.5	57.7	28.2	3.2	.2	93.3	-	1.5	4.7	.5	-	6.7
	1958	700	140	-	1.6	47.0	27.7	3.0	-	79.3	.2	5.0	10.8	4.5	.2	20.7
	1959	625	186	-	.9	37.4	42.4	3.2	-	83.9	-	.9	10.7	3.6	.9	16.1
East coast of Van. Is. (troll)	1957	294	19	-	15.3	49.1	22.2	.7	-	87.3	-	8.4	3.6	.7	-	12.7
	1958	325	32	-	13.0	57.6	15.0	1.4	-	87.0	-	5.1	7.2	.7	-	13.0
	1959	375	100	-	4.0	61.8	22.2	1.1	-	89.1	.7	5.1	3.6	1.5	-	10.9
Fraser River Reds (gill-net)	1957	182	13	-	10.1	17.8	29.0	1.2	-	58.1	.6	24.2	14.2	2.9	-	41.9
	1958	252	68	-	-	8.7	19.0	2.7	-	30.4	-	9.2	32.1	27.2	1.1	69.6
	1959	311	119	-	-	5.7	30.3	3.1	-	39.1	-	.5	26.0	32.8	1.6	60.9
Fraser River Whites (gill-net)	1957	157	8	.7	15.4	20.1	38.3	2.0	-	76.5	-	10.1	7.4	6.0	-	23.5
	1958	289	105	-	1.6	26.1	41.8	4.3	-	73.8	-	1.6	13.1	10.4	1.1	26.2
	1959	164	63	-	-	4.0	63.4	10.9	-	78.3	-	1.0	7.8	12.9	-	21.7

about two-thirds were of the stream type, mainly 4 and 5 years of age except in 1957 when more 3-year fish were present. Most of the ocean type fish mature at 4 years of age. In contrast, for the late run of white-fleshed fish about three-quarters are of the ocean type, mainly 4 years of age. The stream type fish are mainly 4 and 5 years of age. In each group the males mature at younger ages (2, 3, 4) than the females (3, 4, 5). Fraser River spring salmon mature at various ages from 1 to 6 but the dominant age is 4 years.

Prior to August 1958, several scales were taken from each fish, of which one was later selected for age reading. This usually resulted in less than 10% of non-readable scale samples (those with regenerated centres after the original scale had been lost). Since then only one scale has been taken from each fish at the same location on the left side. This has resulted in about 4 times as many non-readable scale samples. In 1959 the proportion of regenerated scales was so high that in the future the procedure will have to be changed to ensure that more scales can be read. It is not clear why spring salmon should lose so many scales in early life, especially in the Fraser River where there are no major dams at present.

There are many variations in the growth pattern of spring salmon during early life with all intergrades between fish that go to sea shortly after hatching and those that remain for more than a year in fresh water. Some also appear to spend variable periods in brackish water. Because of these complexities it is difficult for different investigators to obtain consistent age determinations. In order to resolve these debatable scales, scale types will have to be established by means of circulus counts and scale measurements which have been checked against scales collected from young fish in fresh water. In the coming year it is hoped that such collections can be made and that all scales from the more important fishing areas can be re-checked and final age determinations made in a more objective manner than heretofore. In addition, larger and more representative samples will be taken of maturing springs caught in the Fraser River gill-nets and of mature fish found on the spawning grounds. It will then be possible to calculate the different growth rates for each sex and age group of fish for both red- and white-fleshed varieties and to attempt a separation of the main racial stocks of fish in this most important spring salmon river system.

SKEENA SALMON INVESTIGATIONS

- F. C. Withler

The purpose of the Skeena salmon investigation is to provide the biological information needed to manage the Skeena River stocks to provide the maximum yield to the fishery over the long term. Most attention is given to sockeye and pinks which are the two most abundant species.

Knowledge gained by investigation of the stocks about the requirements for maximum sustained production is readily applied through the Skeena Salmon Management Committee, which represents the administrative and fish cultural arms of the Department of Fisheries, as well as that of research. The Committee, which was formed in the fall of 1954, has now completed five seasons during which it has been responsible for recommendation of appropriate fishing regulations, of fish cultural aid to the stock, and of research to provide information for management. Reports of progress in research during 1959-60 follow this section; only a general review of progress of studies and application is given here.

Pacific salmon reproduce in fresh water and do most of their growing in the sea. Although annual variations in the sea environment exert important effects on their survival and growth, their wide distribution in the ocean suggests that space and food available there are not factors limiting abundance. Such being the case, achieving maximum production depends upon making the fullest use of the freshwater environments. Regulation of salmon fisheries is therefore mainly concerned with providing spawning escapements which will, as nearly as possible, provide the greatest return to the fishery.

In this perspective, the Skeena salmon investigation has been concerned chiefly with two questions: What escapements are required to provide the greatest return to the fishery? How may the fishery be regulated to provide such escapements?

Sockeye stocks. In realizing its objective of providing optimum spawning escapements, the Committee immediately faced the problem of greatly reduced returns from the slide-blocked Babine sockeye escapements of 1951 and 1952, parents of sockeye runs of 1955, 1956, and 1957. Observations at the slide and on the spawning grounds in 1951 and 1952 had demonstrated the seriousness of the block - the escapements had been reduced to one-third their effectiveness. Stringent restriction of the fishery in 1955, 1956, and 1957 was enforced to restore the damaged runs.

Meanwhile, observations had begun on the distribution and growth of young sockeye in Babine Lake by collection with high speed townets, which had been developed in 1953 and 1954 at Lakelse Lake. These collections showed that, for the young from the substantial 1954 spawning, the distribution within the lake was markedly uneven due to the concentration of over one-half of the spawners in the outlet region of the lake coupled with the inability of the young to move far from their natal stream whilst in the lake. The result was that the large southern basins of the lake (comprising 90% of the total area) were sparsely populated, and the fish were large; the restricted North Arm-Nilkitkwa region (10% of the area) adjacent to the large outlet spawning grounds was densely populated, and the young fish markedly smaller than in the southern basins. Further study of the young sockeye in subsequent years confirmed the opinion that, in the restricted northern area, the escapements were large enough in most years to provide enough young to use the nursery area to nearly its capacity. In the large southern basins, where the amount of spawning area available was a factor limiting production, escapements were less than those needed to fully use the streams let alone the lake area.

Tagging of sockeye in the sea from 1944-48, and later from 1956-58, showed that sockeye runs to streams tributary to the main southern basins passed through the fishing area in the early and middle portions of the sockeye fishing season. Hence a means of adjusting the distribution of escapements to the Babine spawning grounds was available through regulation of the fishery. Since 1956 stringent restriction of the early sockeye fishery has been applied.

Studies of the performance of Skeena salmon stocks in the past also shed light on the optimum sockeye escapements required for maximum sustained production. Information on catches and escapements of Skeena sockeye since 1908 was examined to determine the relationship between the abundance of spawners and the size of the resulting stock. By comparing recent relatively complete records of effort, catch, and escapement with catch and effort data for the earlier years, it was possible to compare escapement and resultant return for the period 1908 to 1952. In general, the return and the number of spawners tended to vary together - small spawnings tended to provide small returns, the largest returns were obtained from large - though not the largest - escapements. Spawnings below 500,000 never produced better than moderate resultant stocks, spawnings between 500,000 and 900,000 produced larger returns on the average and resulted in the really big returns. With spawnings of over 900,000 the average return diminished.

Since 1955, the Skeena sockeye escapement has been increased each year closer to the apparent optimum required for best use of the spawning and nursery areas; regulation of the fishery has provided better distribution of the spawners over the Babine spawning grounds where the major portion of the sockeye stock is produced. In 1958 and 1959, the total sockeye escapements were 885,000 and 854,000. The effects of near-optimum escapement and better distribution will be demonstrated in the smolt production of 1960 and 1961. Encouraging signs are already apparent in the number and size of underyearlings present in Babine in 1959.

Pink stocks. Since young pinks go to sea directly, the problem of fresh-water capacity is restricted to consideration of the available spawning ground only. Intensive study of Skeena pinks began only in 1956, and little was known of escapements prior to that time. Intensive survey methods showed that the bulk of spawners used three major spawning streams - Kispiox, Kitwanga, and Lakelse Rivers. More recently, extensive spawning has also been observed in the main stem of the river. Tagging in the sea showed that, while there is considerable overlap in time, the major pink runs tended to pass the fishery earlier or later in accordance with the distance to be travelled in fresh water; the Kispiox and Kitwanga runs appeared first, the Lakelse run last.

Analysis of past pink catch statistics has shown that spawnings in years of abundance more often resulted in large returns than did spawnings in years of scarcity. This evidence, plus the fact that direct observation of even the largest recent spawning densities does not suggest them to be excessive, strongly indicates that spawning populations need to be larger before pink production can be returned to former high levels. In four years of observation, indices of fry production have been roughly proportional to the size of spawning escapement, further suggesting that the densities so far observed have not taxed the capacities of the spawning grounds to produce young pinks.

With this background, regulation of the fishery has been directed toward increasing pink escapements generally, but particularly in the even-numbered years in which the spawning stock has recently been only about one-quarter to one-half as abundant as in the odd years. Escapements in both cycles are increasing; in 1959, as a consequence of a tie-up of the fishing fleet, the escapement was greater than any in the past five years - almost 1,500,000. A total return of over 4,000,000 is expected in 1961.

1. <u>The 1959 Skeena salmon catch and escapement</u> F.C. Withler and K.V. Aro

Regulation of the Skeena salmon fishery since 1955 has been directed toward providing those escapements of sockeye and pinks which will return the production of these species to their former levels, and ultimately provide the maximum sustained return to the fishery. The facts that the fishery is extremely effective in catching the fish at any time, that it occurs over a wide area through which the fish must pass, and that each year's run is composed of several major stocks each of which has its especial escapement need, makes precise regulation to meet escapement needs a challenging task. The success of regulation can be assessed by observing the annual catch and escapements to major systems.

In presenting recommendations for regulation of the 1959 Skeena sockeye and pink fisheries, the Skeena Salmon Management Committee had the following considerations in mind:

(a) The need to increase the sockeye escapement to the underused spawning streams tributary to the large nursery area of the southern portion of Babine Lake was still evident. Sockeye which spawn in these streams pass through the fishing areas from mid-June to mid-July.

(b) The total Skeena sockeye run was expected to be substantially less than in 1958 (when the total run amounted to about 1,600,000). The 5-year-old sockeye would follow the poor return of 4's in 1958. With knowledge available it could not be known whether the poor run of 4's preceded a proportionately greater run of 5's in 1959, or whether the ocean survival of the 1954 brood had been generally poor and would provide only a small run of 5's in 1959. It was estimated that the return of 5's would not exceed 1,100,000 and would probably be lower. The 4's of 1959 would return from the poorest sockeye escapement on record, and very few could be expected.

(c) The 1959 Skeena pink run was expected to be large, in the order of 4,000,000. While the 1957 escapement was slightly smaller than that of 1955 (which had returned 3,700,000 after an exceptionally high-seas survival), the fry output from the 1957 run had been almost twice that from the 1955 escapement. Consequently, assuming that sea survival of the 1957 brood would be only average, the 1959 run was expected to be about equal in number to that of 1957.

Bearing the above considerations in mind the Committee recommended the following regulations for the 1959 Skeena salmon fishery:

(a) That fishing for sockeye commence on July 5, by which time a good number of early-run sockeye would have passed the fishing area.

(b) That for the 3 weeks from July 5 to July 26, 2 1/2 days per week fishing be permitted to harvest the middle season sockeye.

(c) That from July 26 to August 30, 3 days per week fishing be permitted to harvest the expected large run of pinks. It was borne in mind that heavy fishing to harvest early-run pinks might jeopardize the late-season sockeye escapement which would be passing during the last week of July and the first week of August.

As fishing progressed, it became apparent that the sockeye run was moderate in abundance, and was especially small in the early and middle portions of the season. Figure 14 shows, for the Skeena Gill-net Area, the numbers of days fishing recommended by the Committee prior to the season, the actual number of days fishing allowed each week, the weekly number of gill-net boat deliveries, and the estimated weekly total abundance of sockeye and pinks (catch plus escapement estimates derived from test fishing above the upriver commercial fishing boundary). It will be seen from the diagram that the abundance of sockeye prior to the commencement of sockeye fishing on July 5 provided only a relatively small escapement. During the first two weeks of sockeye fishing ending July 12 and 19, the run remained small, and about 25% of sockeye entering the Skeena Gillnet Area were caught. During the week ending July 26, when the fishing time was decreased to 1 1/2 days to permit more middle-run sockeye to escape, the run increased somewhat in number, and again about 25% of the total present were caught. During the weeks ending August 2 and 9, when the fleet was tied up pending settlement of negotiations on fish prices, the run was most abundant and about 435,000 sockeye escaped upriver. During the week ending August 16, when fishing time was extended to 4 days to permit fishermen to make up for fishing lost during the tie-up, 55% of the sockeye were taken from the last part of the run. Thus, as a consequence of only a moderate-sized run being present, and of the fleet being tied up during the period when sockeye were most abundant, the catch was small - only 196,000 fish.

Conversely, the escapement was good, amounting to some 854,000. Of these, 783,000 entered the Babine-Nilkitkwa watershed, providing the second largest run to Babine since counts began in 1946. The spawners were well distributed over the Babine spawning grounds, with slightly over half entering streams tributary to the underused southern basins. Three large, stable streams in this region - Fulton, Morrison, and 15-Mile Rivers - carried over 220,000 spawners. In contrast to the low-water spawning conditions attending the larger 1958 run when 75,000 died unspawned, conditions in 1959 were very favourable and no losses due to low water occurred. Because of this more favourable condition, the 1959 Babine spawning run actually exceeded the 1958 run in terms of eggs available for seeding. Other Skeena sockeye spawning areas were moderately to well seeded, with the exception of the Morice Lake watershed. Here, for the sixth year in a row the escapement to the main spawning area was about 1,000, approximately 2% of its abundance in the years up to 1951.

The 1959 Skeena pink run was only one-half as abundant as expected, due to a poorer than average survival of the 1957 brood in the sea. The total run amounted to slightly over 2,000,000. Figure 14 illustrates the weekly abundance of pinks in the Skeena Gillnet Area and the division of the stock by week into catch and remaining escapement upriver. Pinks appeared in relatively small numbers during the week ending July 26, when fishing was reduced to 1 1/2 days to permit more middle-season sockeye to escape. About 25% of the pinks present were caught. The early and middle pink run appeared in the next two weeks, ending August 2 and 9, while the fleet was tied up pending settlement of price negotiations. During this time 965,000 pinks escaped upriver. During the week ending August 16, when fishing was extended to 4 days to permit fishermen to make up for fishing lost during the tie-up, the pinks were still abundant and 70% of those present were caught. The pink run declined rapidly during the weeks ending August 23 and 30 when about 60% were caught. The effect of the tie-up was to reduce markedly the proportion of the moderate pink run taken, so that the season's catch amounted to 572,000.

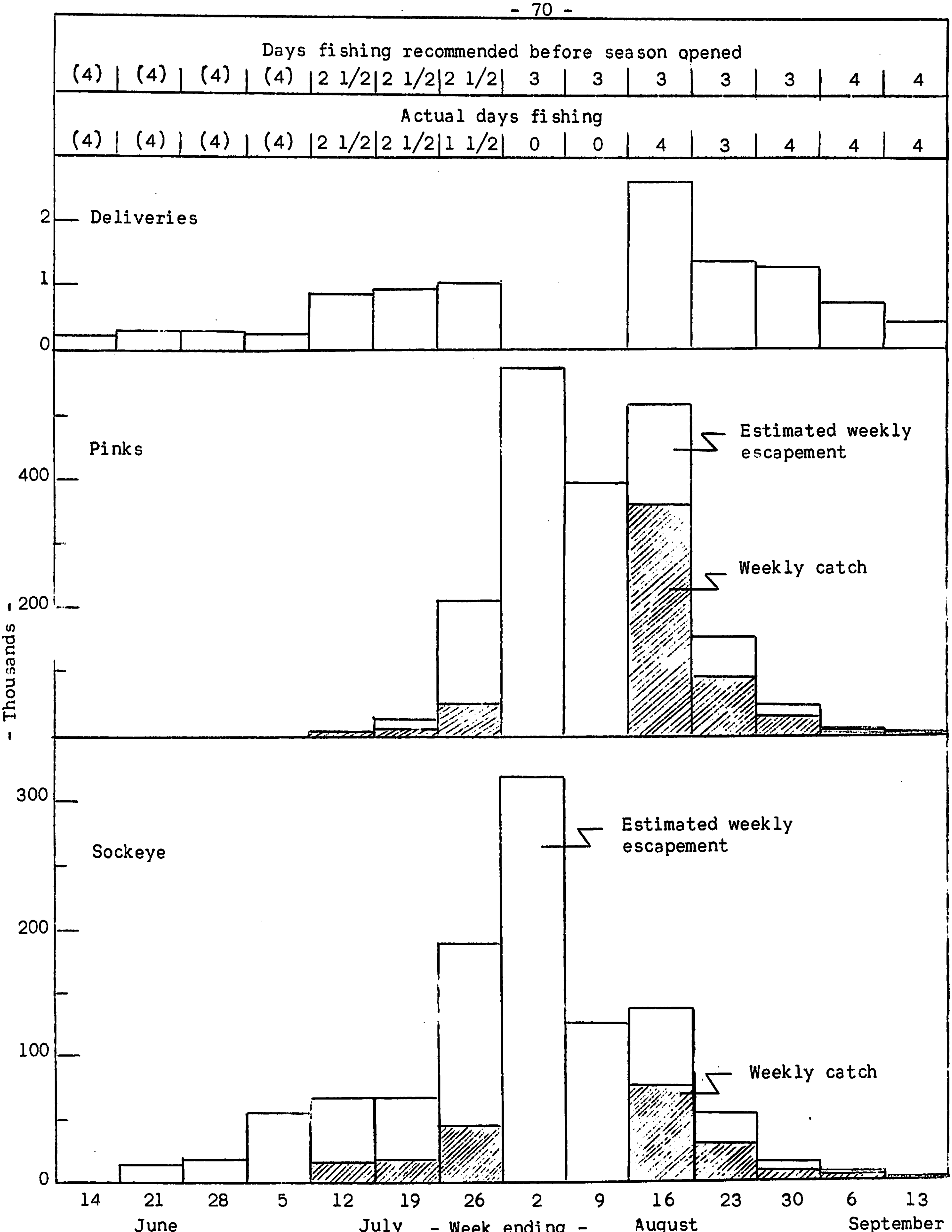


Fig. 14. Catch, escapement (based on test fishing catches), and fishing effort (boat deliveries) by week, Skeena sockeye and pinks, 1958. Days fishing in brackets refer to days when spring salmon nets only were permitted.

The escapement was 1,478,000, the largest recorded in recent years and 1 1/2 times as great as that of the brood year 1957. Some 1,383,000 spawned in tributaries of the Skeena River or in the river itself, while 95,000 spawned in coastal streams adjacent to the Skeena Gillnet Area. The tie-up in late July and early August permitted a high proportion of early-run fish to escape. The effects were reflected in substantially increased spawnings on the Kispiox, Kitwanga, Bear, and Babine Rivers over those in 1957. The increase to the Lakelse River was not so marked because fishing resumed during the week ending August 16 when the pinks in the fishing area were preponderantly bound for Lakelse. The spawning in the main stem of the Skeena, while difficult to assess accurately, appeared to be about 3 times heavier than in 1957.

The 1959 Skeena gill-net catch of spring salmon was about 18,000, which is below average for the period since 1950. The escapement to the Bulkley River was reported by Departmental officers to be small, to the Ecstall and Khyex Rivers, and to Johnson Creek to be fair, to the Morice, Kitsumgalum, and Kitwanga Rivers to be moderate, to the Lower Babine River to be above average, and to the Bear and Kispiox Rivers, heavy.

The 1959 gill-net catch of coho salmon in the Skeena area was approximately 47,000, which is less than the 1950-58 average. The escapements to the Bulkley, Bear, and Kispiox Rivers, to the streams in the Skeena-Lakelse area, and to the streams tributary to the Skeena estuary were reported to be light, to the Morice River to be of medium intensity, and to the Babine system, slightly above average. The low catch of coho can be attributed partly to the reduced fishing for the season caused by the tie-up.

The 1958 Skeena gill-net area catch of chums was about 32,000, which is below the average of the preceding 9 years. The escapement to the streams in the Skeena-Lakelse area was reported to be above average; to the streams tributary to the Skeena estuary, very light. The tie-up affected the chum catch adversely.

2. Escapement indices from test fishing

F. C. Withler

Catches of salmon in standard test drifts of gill-nets above the upriver commercial fishing boundary have been used to provide information about the weekly escapement of sockeye and pinks from the commercial fishery. These estimates, when used with catch statistics, permit assessment of seasonal changes in rate of exploitation.

Comparison of the seasonal patterns of test fishing catches with those of escapements on the spawning grounds has shown that test fishing catches within each season were roughly proportional to the daily escapements. Thus, it is possible to derive indices converting catch/hour to escapement for each year by summing the daily catch/hour figures and dividing this number into the total escapement to areas upstream from the test fishing site. The indices so derived for the years 1955 to 1959 are shown in the following table.

Year	Sum daily catch/hour		Total escapement (1,000's fish)		Escapement per daily catch of 1 fish/hour	
	Sockeye	Pink	Sockeye	Pink	Sockeye	Pink
1955	377	1,672	125	987	333	584
1956	834*	522	441	202	530	387
1957	769*	1,929	485	868	632	451
1958	1,203*	1,149	884	556	735	484
1959	1,111*	1,909	854	1,383	769	724

*Adjusted to correct for differences in efficiency of boat skippers.

There was a relatively large difference between escapement indices derived from the years 1955 and 1956, and this discrepancy has been attributed largely to differences between nets used in the two years. The large difference between the indices for pink escapement in 1959 and those in 1956 to 1958 cannot be accounted for in this way. It is now believed that when the salmon at the test fishing site are very abundant, as was the case during the two-week tie-up of the fleet in 1959, the nets catch a smaller proportion of the fish because the presence of large numbers already in the net tends to discourage others in the vicinity from approaching. The data are being re-examined to determine the changes in proportions caught with extreme changes in abundance.

3. <u>Babine fence counts in 1959</u>

F. P. Jordan

Since the sockeye escapement to Babine Lake constitutes about 75% of the total escapement to the Skeena River, the Babine fence count, which was carried out in 1959 as in all other years since 1946 (except in 1948 when floods damaged the fence), provides the best single measure of sockeye escapement to the Skeena River. The fence data have been of especial importance since 1951 in assessing the effect on the salmon runs of the partial block by the Babine River rockslide. In conjunction with estimates of smolts, they also give information on the relationship between the number of spawners in the Babine area and the resulting smolt production.

The numbers of the five species of Pacific salmon which were counted in 1959 are compared in Table 34 with counts made in the other years of operation.

The sockeye run in 1959 was the second largest recorded to Babine Lake since fence operation began in 1946. The count began on July 19 and by July 30 the daily count rose to a peak of 19,613 sockeye. This early peak which has been characteristic of most years is composed of early running fish to smaller streams of the south end of the lake. Following the early peak the run declined and rose again to a peak of 37,140 sockeye on August 15. This second peak was larger than usual. The daily count stood at over 30,000 sockeye for 9 days. On August 22 the run dropped below 30,000 and declined further until on October 2 the daily count was 250 sockeye. Fence operations were discontinued on October 3.

Table 34. Counts of salmon passing the Babine fence.

Year	Sockeye		Spring	Pink	Coho	Chum
	Large	Jack				
1946	444,551	31,154	10,528	28,161	12,489	18
1947	261,460	261,101	15,614	55,421	10,252	7
1948*	650,000					
1949	461,139	47,993	7,433	13,663	11,938	5
1950	364,356	179,302	6,838	38,728	11,654	7
1951	141,415	11,042	2,778	50	2,122	0
1952	349,011	27,936	5,915	2,706	10,554	1
1953	686,586	28,028	8,353	1,108	7,648	17
1954	493,677	9,745	5,925	4,604	3,094	66
1955	71,352	30,624	3,528	2,151	8,947	3
1956	355,345	18,164	4,345	2,691	9,250	3
1957	433,149	50,162	7,509	25,865	4,421	15
1958	812,043	30,769	8,274	6,600	7,606	8
1959	782,868	31,920	9,597	56,766	10,947	20

*Total sockeye estimated from comparison with stream surveys and fence counts of other years.

The run of spring salmon was above average. During the early part of the season it consisted mainly of "jacks" while later the run consisted mainly of large fish. Since spring salmon spawn below as well as above the fence, the count is only an index of the total Babine River run. The pink salmon run was the largest since weir operations began in 1946. As with springs, some pinks spawn below the fence. The coho salmon run was slightly above average. A few chum salmon again reached the Babine fence.

4. Sockeye sampling at the Babine fence in 1959 F. P. Jordan

To examine the composition of the 1959 Babine sockeye run, 1% of the previous half-day's fence count was sampled twice daily for length and sex. In addition sampling was carried out to determine the proportion of the large sockeye which were normal, net marked or injured.

Female sockeye in the 1959 Babine run outnumbered the large male sockeye as in all other years with the exception of 1951 and 1952. The 1% sample indicated that 39.6% of the large sockeye were males and 60.4% were females. A comparison of percentages in other years of the Babine fence operation is made in Table 35.

The sampling indicated that the "jacks" were of average size, while the males and females were slightly larger than average. Length-frequency plots suggest that the age composition of the large sockeye was about 73% 5-year-olds and 27% 4-year-olds. Almost identical proportions of 4- and 5-year-old sockeye were present at the test fishing site in the mouth of the Skeena River.

Table 35. Percentages of male and female sockeye passing the Babine fence.

Year	% male sockeye	% female sockeye
1946	43.52	56.48
1947	45.56	54.44
1948	--	--
1949	40.99	59.01
1950	43.74	56.26
1951	51.88	48.12
1952	58.90	41.10
1953	44.15	55.85
1954	39.72	60.28
1955	47.16	52.84
1956	48.62	51.38
1957	49.00	51.00
1958	39.38	60.62
1959	39.56	60.44

Sampling to determine the condition of the large sockeye showed that 14% had net marks, 2.4% had other injuries and 83.6% had no injuries or net marks. Comparison with comparable sampling in previous years of fence operation are shown in Table 36.

Table 36. Condition of sockeye passing the Babine fence.

Year	Normal	Net-marked	Injured
1946	--	--	--
1947	84.5	11.35	4.2
1948	--	--	--
1949	86.9	6.22	6.8
1950	84.2	12.34	3.5
1951	51.6	18.33	31.1
1952	69.2	1.00	29.9
1953	93.0	4.27	2.7
1954	89.3	8.26	2.5
1955	87.2	6.12	6.7
1956	94.2	4.27	1.5
1957	90.2	8.26	1.5
1958	83.5	13.91	2.6
1959	91.5	4.17	4.3
1960	83.6	--	2.4

The average egg content in 1959 was estimated to be 3,343 eggs per female. Since the number of female sockeye surviving the Indian fishery above the weir was estimated to be 464,906, the potential egg deposition was approximately 1,554,000,000. This figure constitutes the highest deposition since 1946 when Babine weir operations began.

5. Babine sockeye smolt run J. McDonald

The number of smolts emigrating from Babine Lake has been estimated annually since 1951 by means of a marking and recovery technique. Smolts are captured, marked by the removal of one or more fins, then released near the lake outlet. The proportion of marked fish in the run is determined from samples taken 10 miles downstream near the outlet of Nilkitkwa Lake.

The estimated abundance of the annual smolt run since 1951 is shown in Table 37.

Table 37. Babine smolt runs.

Year	Estimated size of run (millions)	95% confidence limits (millions)
1951	4.2	3.7 to 4.8
1952	4.5	4.2 to 4.9
1953	3.1	3.0 to 3.2
1954	2.8	2.7 to 3.0
1955	30.9	28.6 to 32.6
1956	21.1	18.5 to 22.9
1957	6.4	6.0 to 6.8
1958	15.9 + 6.3 = 22.2	13.8 to 18.9
1959	28.5 + 10.0 = 38.5	26.9 to 30.3

In 1958 and again in 1959 considerable numbers of smolts migrated prior to the time that the mark and recovery program was underway. Fyke net catches and school counts in 1958 indicated that this "early" migration amounted to 6,300,000 smolts. Observation made in 1959 indicated that this "early" run was about 1 1/2 times that of the previous year and probably amounted to 10,000,000 smolts. The total number of smolts emigrating from the Babine area in 1959 is, therefore, estimated to be 28,500,000 plus 10,000,000 "early" smolts or a total of 38.5 million.

Since almost all Babine smolts migrate after one year in the lake estimates of survival from egg to smolt for each brood year from 1949 to 1957 are shown in Table 38.

Table 38. Sockeye survival from egg to smolt in the Babine area.

Brood year	Eggs potentially available (millions)	Year smolts emigrate	Estimated number of smolts (millions)	Survival egg to smolt (%)
1949	853	1951	4.2	0.49
1950	591	1952	4.5	0.76
1951	194	1953	3.1	1.60
1952*	409	1954	2.8	0.68
1953	1,241	1955	30.9	2.49
1954	1,020	1956	21.1	2.07
1955	105	1957	6.4	6.10
1956	523	1958	22.2	4.24
1957	653	1959	38.5	5.90

*Only about one-third of this run spawned successfully due to adverse effects of the Babine slide. An adjusted estimate of the survival to smolts would be about 2%.

6. Studies of young sockeye salmon in the Babine Lake system

W. E. Johnson

Distribution throughout the lake system. Study of the distribution of underyearling sockeye throughout the many basins of Babine and Nilkitkwa Lakes has shown that they travel only limited distances from their natal streams. Thus, the overall distribution of young sockeye in Babine is controlled largely by the distribution of the parent spawners to the various tributary spawning streams. On this basis the Babine-Nilkitkwa Lake nursery area can be divided into two general regions: (1) the areas north of Halifax Narrows (Nilkitkwa Lake and the North Arm of Babine) which serve the young sockeye produced by late-running fish which spawn on the outlet Babine River spawning grounds, and (2) the lake areas south of Halifax Narrows (about 90% of the total area) which accommodate the young sockeye from the earlier-running fish which spawn on grounds tributary to these areas.

In the years prior to 1955 for which we have escapement records, more than half (and up to 80%) of the Babine sockeye escapements were later-running fish which spawned in the outlet Babine River - above and below Nilkitkwa Lake. The majority of the resulting young sockeye were therefore contained in the small lake area (about 10% of the total) north of Halifax Narrows. Because of this restricted nursery area, the smolts produced in many of these years must have been quite small.

Regulation of the fishery since 1956 has been directed toward distribution of spawners in such a way as to achieve a better distribution of young sockeye throughout the entire Babine Lake nursery area. The better distribution of spawners has been achieved by restricting the fishery for the earlier-running sockeye which spawn in streams tributary to the lake regions south of Halifax Narrows. As shown in Table 39 this policy has been successful in achieving better distribution of the young sockeye throughout the lake system. With an increasing proportion of spawners to regions south of Halifax Narrows there has been a corresponding change in distribution of the young sockeye toward greater numbers south of Halifax Narrows. Also, as a result of this change in distribution of the

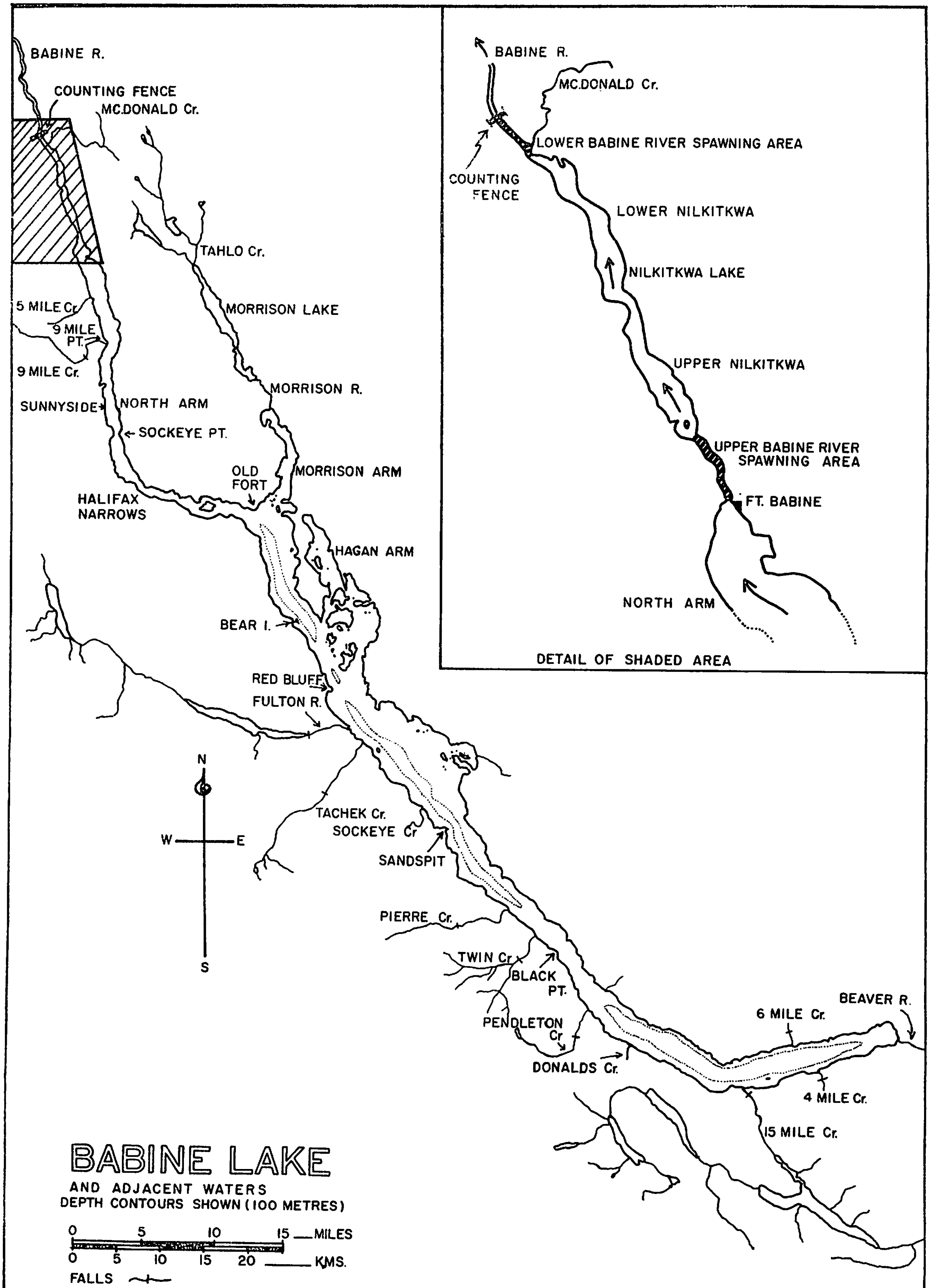

BABINE R.
COUNTING FENCE
MC.DONALD Cr.
TAHLO Cr.
MORRISON LAKE
5 MILE Cr.
9 MILE PT.
9 MILE Cr.
MORRISON R.
SUNNYSIDE
NORTH ARM
SOCKEYE PT.
OLD FORT
MORRISON ARM
HALIFAX NARROWS
HAGAN ARM
BEAR I.
RED BLUFF
FULTON R.
N
W
E
S
TACHEK Cr.
SOCKEYE Cr.
SANDSPIT
PIERRE Cr.
TWIN Cr.
BLACK PT.
PENDLETON Cr.
DONALDS Cr.
6 MILE Cr.
BEAVER R.
4 MILE Cr.
15 MILE Cr.
BABINE R.
MC.DONALD Cr.
LOWER BABINE RIVER SPAWNING AREA
COUNTING FENCE
LOWER NILKITKWA
NILKITKWA LAKE
UPPER NILKITKWA
UPPER BABINE RIVER SPAWNING AREA
FT. BABINE
NORTH ARM
DETAIL OF SHADED AREA
BABINE LAKE
AND ADJACENT WATERS
DEPTH CONTOURS SHOWN (100 METRES)
0 5 10 15 MILES
0 5 10 15 20 KMS.
FALLS

Table 39. Distribution and size of young sockeye in the Babine Lake system.

Lake Region	Number of adult sockeye spawning excluding "jacks" (thousands)	Estimated number of age-0 sockeye in late August (millions)	Approximate mean weight of age-0 sockeye in mid-Oct. (grams)
	1954	1955[b]	
North of Halifax Narrows	256.3	38.2 to 52.9	1.5
South of Halifax Narrows	185.6	7.1 to 19.3	4.0+
Total	441.9	45.3 to 72.2	
	1955	1956	
North of Halifax Narrows	19.2	2.0	3.8
South of Halifax Narrows	27.8	3.1 + (7.4)[a]	4.0+
Total	47.0	5.1 + (7.4)[a]	
	1956	1957	
North of Halifax Narrows	119.5	26.5	3.3
South of Halifax Narrows	148.9	34.8 + (22.3)[a]	4.0+
Total	268.4	61.3 + (22.3)[a]	
	1957	1958	
North of Halifax Narrows	188.2	45.0	2.4
South of Halifax Narrows	202.8	46.5 + (20.0)[a]	4.0+
Total	391.0	91.5 + (20.0)[a]	
	1958	1959	
North of Halifax Narrows	270.0+	66.0	2.7
South of Halifax Narrows	290.0+	85.1 + (20.0)[a]	4.0+
Total	560.0+	151.1 + (20.0)[a]	

[a]Additional millions of age-0 sockeye believed progeny of "kokanee".

[b]1955 data from very limited sampling, so estimates are only roughly approximate.

young sockeye, their growth rates have been increased and smolts of larger mean size are being produced.

Growth rate of young sockeye salmon. During their one year of lake residence in the Babine system young sockeye attain most growth in the first few months, that is, during the period of summer thermal stratification. For example, fish weighing 0.2 grams when entering the lake as fry in mid-June attain 4.5 grams by mid-October, but weigh only about 5.5 grams when emigrating from the lake as smolts the following spring. Observations of the growth rate of underyearling sockeye, their abundance, and the abundance of their zooplankton food in the various lake basins of this system in the years 1956 to 1959 provide a basis for comparing mid-June to mid-October growth rates under a wide range of conditions. Near-surface water temperatures for this period have been roughly comparable throughout, and there are no known genetic differences involved; thus, growth rate is believed to have been largely determined by intraspecific competition and food abundance. The results strongly support this belief.

Using logarithmic scales throughout, Figure 15 presents graphically the relationship of growth rate to food abundance and intraspecific competition. Figure 15a implies a general direct relationship between growth rate and zooplankton abundance over the range shown, Figure 15b shows the growth rate is increasingly depressed by intraspecific competition after population densities exceed approximately 6,500 fish per hectare (2,600 per acre).

At a glance it appears that there is a simple explanation of the relationship between growth rate, competition and food abundance, i.e. that with an increasing number of young sockeye present an increasing reduction of the food supply is brought about resulting in an increasing reduction of the growth rate. Although cropping of the zooplankton by large populations of young sockeye is obvious in much of these data, critical examination (beyond the scope of this brief report) does not verify such a simple explanation of growth-competition-food relations based on food abundance alone. Detailed examination suggests there is an effect of competition on growth rate which is expressed independently of absolute food abundance. In spite of the complexities of the mechanisms involved, the rather well-defined relation between growth rate and population density as shown by the solid line in Figure 15b will serve to evaluate the potentials of this lake nursery area.

The 4 points to the right of the descending part of the solid line in Figure 15 b are of special interest. These 4 points represent 1959 observations in the 2 basins of Nilkitkwa Lake and the 2 basins of the North Arm of Babine nearest the outlet. In spite of the high densities of young sockeye present in these basins in 1959, the zooplankton maintained itself at much higher levels than in some former years when the young sockeye were even less abundant. This greater abundance of food is believed responsible for the higher than expected growth rates observed. The maintenance of greater mean zooplankton abundance in the presence of large populations of young sockeye in these basins (during mid-June to mid-October) than in previous years may indicate a greater production of zooplankton during 1959. On the other hand, it may be only a result of the fact that the spring pulse of crustacean zooplankton appeared considerably later than in previous years. Whichever the case, this one year of greater food abundance in the four years of observation to date will be of interest in examining production in future years - especially in evaluation of its possible contribution toward a dominant year class.

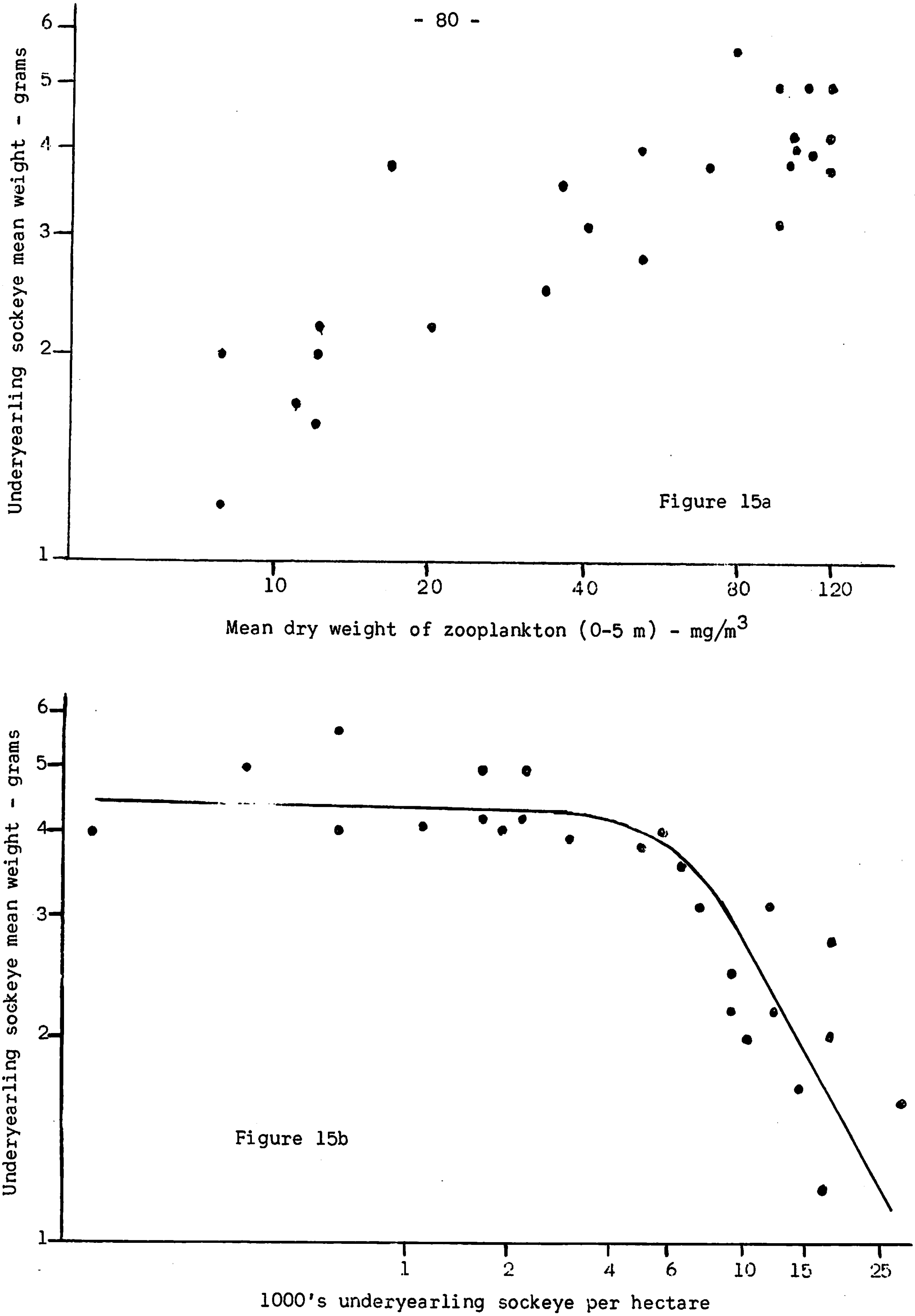


Figure 15. Density and size of young sockeye in the Babine Lake system.

The combination of great numbers of young sockeye and relatively high growth rate during 1959 gives promise not only of an extremely large smolt output in 1960 (probably of the order of 60 million) but of a larger mean size than expected.

Capacity of the Babine system as a sockeye producer. The curve in Figure 15b demonstrates the growth rate of young sockeye which may be expected at various levels of population density. In an earlier study at Cultus Lake, Foerster has shown that there is a direct relationship between smolt size and subsequent survival rate to maturity. Evidence that this relationship might hold generally is available from recent research on sockeye in Alaska. Combining the curve of Figure 15b and Foerster's relationship between smolt size and survival rate, Figure 16 describes the relationship between lake population density per unit area and the likely numbers of returning adults per unit area. No units are given for the likely number of returning adults as we cannot reasonably apply the same survival rates found by Foerster for Cultus Lake sockeye. However, for consideration of this general relationship we need only assume that there is a direct relation between smolt size and survival.

The relationship shown by Figure 16 follows the law of diminishing returns. With the progressive addition of more units of production (young sockeye) there is an increase in total production (returning adults) up to a point where the addition of further units of production results in a decrease in total production. The critical point (where production is at a maximum) corresponds to a late-August lake population of approximately 10,000 young sockeye per hectare (4,050 per acre). At this population density young sockeye would attain a size of about 2.5 grams by mid-October and emigrate as smolts of about 3 grams mean weight. For such optimum or maximum production, then, the Babine Lake system would require an evenly distributed late-August young sockeye population of 4,050 per acre or a total of the order of 500,000,000 - which would give a smolt output of roughly 200,000,000.

This estimation of the maximum potential is based only on the potential of the lake nursery area for rearing of smolts. In the Babine system there are insufficient spawning grounds to produce naturally the numbers of fry required, and achievement of such a maximum production would of course require large-scale fish culture techniques as yet unproven.

In considering the practicable potential of this sockeye-producing area, we must again make the broad separation into those regions located north and south of Halifax Narrows.

The region north of Halifax Narrows is characterized by having large-capacity spawning grounds (the Babine River above and below Nilkitkwa Lake) in relation to the lake nursery area available. With this situation the ultimate potential of the lake area can be realized and the problem becomes one of providing an escapement of the proper size to these outlet spawning grounds. Escapements of the order of 250,000 to 300,000, as provided in 1958 and 1959, appear to be of the proper magnitude.

The region south of Halifax Narrows is characterized by the opposite situation. An extremely large lake nursery area is available in proportion to the capacity of the tributary spawning grounds. The problem of attaining the highest natural production of sockeye from this region is then one of providing escapements which will make fullest possible use of the available spawning grounds. Such has been the aim of recent regulations and the large escapements of 1958 and 1959 have approximated this ideal.

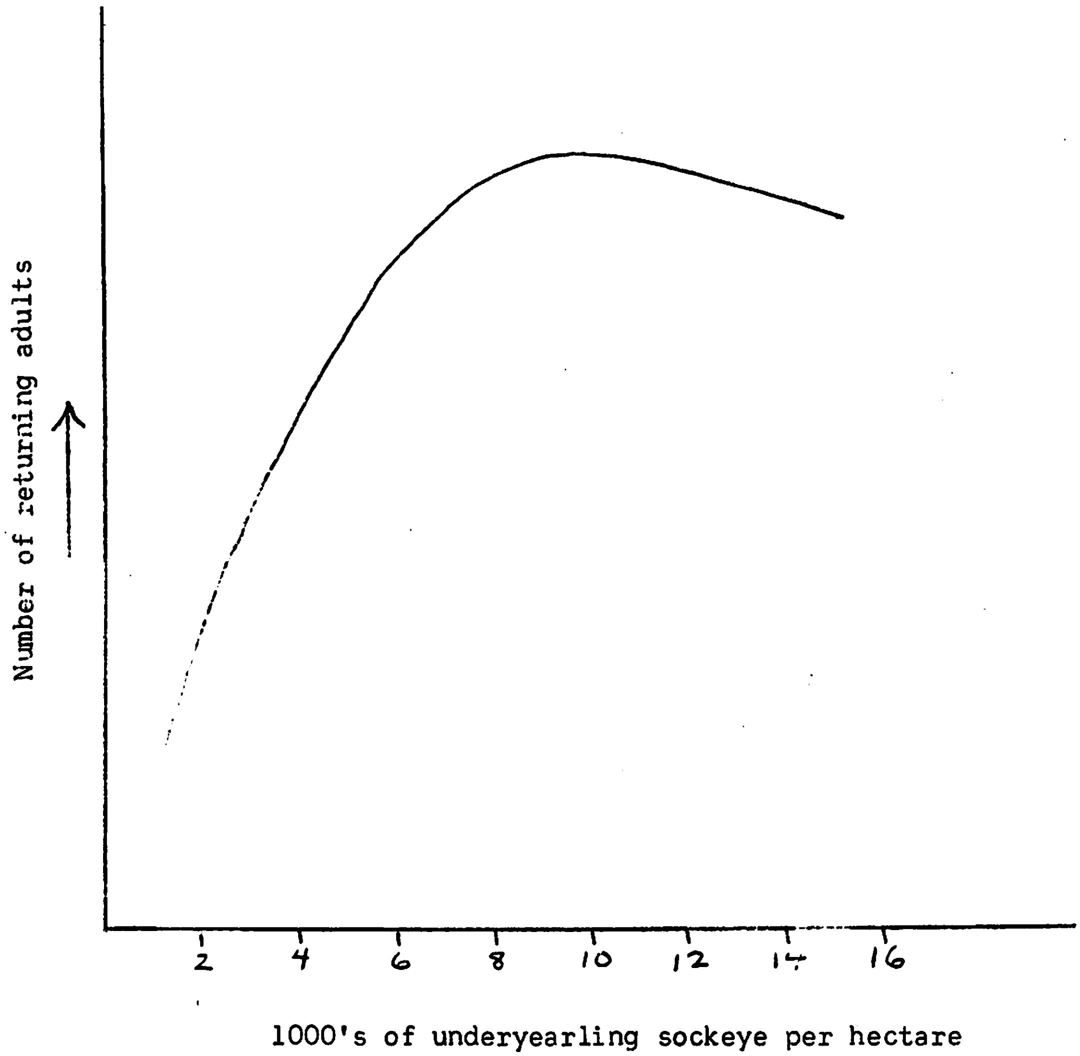


Figure 16. Density of young sockeye and probable numbers of returning adults per unit area.

7. The 1959 Skeena pink salmon escapement J. McDonald

Estimates of the number of spawning pink salmon are based in part on surveys carried out annually by the officers of the Department of Fisheries. In 1959, as in other recent years, Fisheries Research Board personnel have been employed to supplement these surveys and to carry out tagging and recovery programs and fence counts in order to obtain more precise information on escapement size.

In 1959 the abundance of escapements to most large pink salmon-producing areas were estimated by tag and recovery procedures (Lakelse and Kispiox Rivers) and by fence counts (Babine and Kitwanga Rivers). The escapements to other areas were estimated by direct counts or estimates of the number of fish observed on the spawning grounds.

Table 40 gives the total estimated escapement in 1959 and other recent years.

Table 40. Estimated escapements of Skeena pink salmon.

Place	1955	1956	1957	1958	1959
Kispiox River	540,000	75,000	360,000	66,000	650,000
Kitwanga River	125,000	35,000	160,000	158,000	250,000
Lakelse River	175,000	75,000	140,000	262,000	185,000
Babine River	5,000	3,000	27,000	10,000	77,000
Bear River	6,000	Nil	15,000	Nil	20,000
Skeena River	10,000	5,000	50,000	50,000	150,000
Others	119,000	10,000	113,000	10,400	54,000
Coastal Rivers	78,000	75,000	105,000	116,000	95,000
Total	1,058,000	278,000	970,000	672,000	1,478,000
Total upstream of test fishing site	987,000	202,000	868,000	558,000	1,383,000

The 1959 escapement was the largest recorded in recent years and was 1 1/2 times that observed in the parent year. This was a direct result of the commercial fishing tie-up during the last week of July and the first week of August. The tie-up resulted in a considerable increase in the number of spawners in the Kispiox, Kitwanga, Babine, and Bear Rivers as compared to the parent year. The run to the Babine River was the largest recorded since 1946. The escapement to the Lakelse River was only slightly larger than in 1957; a large proportion of this run was in the fishery after the fishing tie-up ended.

For the third consecutive year pink salmon were observed to spawn in the main stem of the Skeena River. Most spawning took place in a 40-mile stretch downstream of Terrace, B. C. The number of pinks which spawned there was estimated to be between 100,000 and 200,000. This estimate was based on the number of spawned-out fish recovered as compared to other spawning grounds where more precise information could be obtained.

8. The timing of Skeena pink salmon runs in 1959 J. McDonald

Tagging programs carried out in 1957 and 1958 provided information on the timing of the major pink salmon runs through the commercial fishing area. In 1959 another tagging program was carried out to supplement the earlier information, particularly to indicate the period when pinks which spawn in the main stem of the Skeena River are present in the fishing area.

The salmon were captured in beach seines at McLean Point, situated on the Skeena River about 20 miles upstream of the up-river fishing boundary. A total of 6,845 pinks were tagged with Petersen disc tags between July 24 and August 21. Spawned out fish were examined for tags in most large spawning areas. The number and place of tags recovered on specific spawning grounds was as follows:

Kispiox R.	Kitwanga R.	Lakelse R.	Skeena R.	Babine R.	Bulkley R.	Total
72	59	70	25	54	11	291

The date that fish proceeding to the various spawning grounds were present at the river boundary can be shown by adjusting the date on which they were tagged by the time required for the fish to travel from the boundary to the tagging site. This "time out" has been estimated by comparing daily catches at the test fishing site at Tyee, which is adjacent to the boundary, to the daily catches at McLean Point. Throughout most of the season extreme fluctuation in the catch at test fishing was reflected in the McLean Point catch approximately 3 days later. In Figure 17 the date of tagging has been predated three days to adjust for "time out". The bars in the figure indicate the relative abundance of fish proceeding to specific spawning grounds present at the up-river fishing boundary each day. The daily average catch per hour at the test fishing site is also shown to describe the relative abundance of the total escapement throughout the season.

The timing of the various runs in 1959 was similar to that observed in 1957 and 1958. The runs to the Kispiox and Babine Rivers were amongst the earliest. The Lakelse run was again the last major run to enter the fishery. There appeared to be considerably more overlap of the runs in 1959 than in other years. This may have resulted from the fishing tie-up which lasted throughout the peak of the migration period.

The first peak in the escapement was recorded on July 28 and tag recoveries indicate that fish going to all major spawning grounds were present at that time. This was also the case during the period of the second peak of August 3 although Lakelse River fish began to predominate. After fishing resumed on August 9, the Lakelse run was the only one present in abundance in the fishing area.

Fish proceeding to spawn in the main stem of the river were present in the fishing area throughout most of the season. Tag recoveries suggest they were in greatest abundance in the last days of July and fewer in number from then until the middle of August.

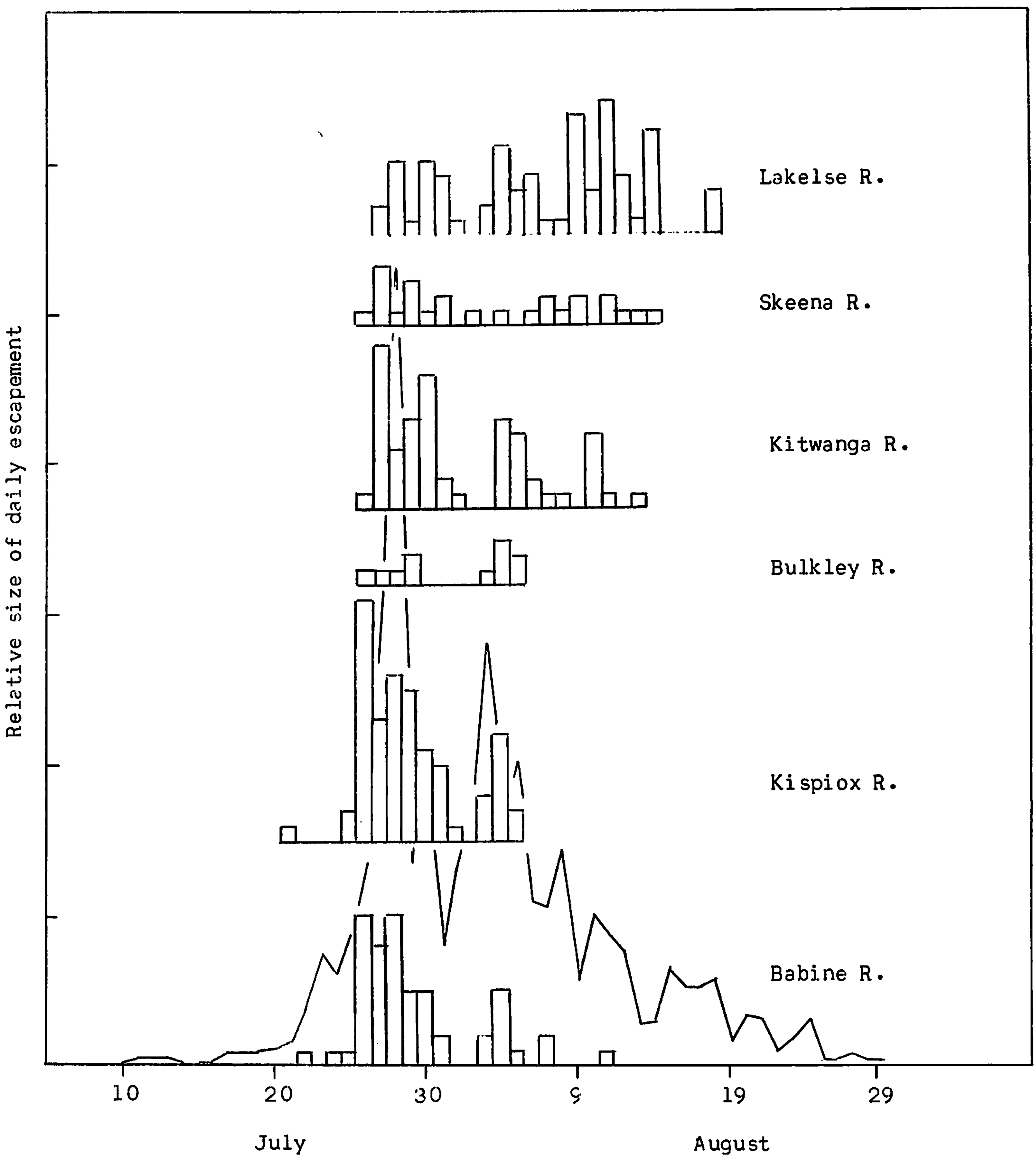


Figure 17. Timing of Skeena pink salmon runs in 1959.

9. Fry output from the 1958 Skeena pink salmon run

J. McDonald

Trap-netting for pink fry has been carried out annually since 1956 to indicate the number of fry produced from the spawning run of the previous fall on the Lakelse, Kispiox and Kitwanga Rivers, three of the largest spawning areas in the Skeena drainage. The object of the work is to determine the escapement size which will efficiently produce the greatest number of fry and hence the greatest number of adult salmon. Since the fry output from the three tributaries mentioned above would constitute a major part of the total output from the whole of the Skeena system, the information is also used to indicate very generally the magnitude of the total Skeena output and the most likely number of returning adults.

The same method of fry trapping has been used each year. A small meshed net, which strains the water to a depth of one foot, is fished at a number of stations across each river mouth, usually two or three times each week of the migration. The average catch per hour is used to calculate an index which is a relative measure of the total number of migrants. The degree of accuracy obtained has not been fully determined. Special netting was carried out in 1958 and 1959 and has shown that the proportion of the fry present in the top foot of water (and thereby captured in the standard net), may vary with changes in the total depth of the river at the trapping site. Error in comparing each year's run arising from these changes in the vertical distribution of the fry has been minimized by using the same trap site whenever possible. Any variation in water depth was therefore due only to seasonal changes in the runoff, which tend to follow a similar annual pattern.

In 1957 and again in 1959 it was necessary to change the location of the Lakelse River trapping site. The sites used from 1956 to 1958 were comparable in depth and other physical characteristics. However, the depth of water at the 1959 site was about twice that at the sites used previously. The 1959 index is therefore not comparable to that obtained in other years and on the basis of information now at hand the 1959 index would be relatively very low.

The indices of fry output and the best estimates of the escapement size in the parent year are given below:

Table 41. Pink salmon escapement size and fry output in Skeena tributaries.

Place	Parent year	Estimated escapement	Index of fry output
Lakelse River	1955	175,000	3.2
	1956	75,000	1.9
	1957	140,000	13.5
	1958	262,000	3.3+
Kispiox River	1955	540,000	8.6
	1956	75,000	1.4
	1957	360,000	13.2
	1958	66,000	5.4
Kitwanga River	1955	125,000	--
	1956	35,000	3.7
	1957	160,000	7.6
	1958	158,000	7.3

Kispiox River. Since the brood year of 1955 the index of fry output has varied from 1.4 to 13.2 or about 9 times while the escapement has varied from 75,000 to 540,000 or about 7 times. The largest numbers of fry have resulted from the largest spawning runs. The smallest spawning escapement (1956) produced the smallest fry output. However, the second largest escapement resulted in the highest fry index. The index of 5.0 from the small escapement of 1958 indicates an above-average survival of fry from this deposition.

Kitwanga River. Three years' data indicate a twofold increase in the number of fry resulting from an increase in the brood stock of over four times. The 1957 and 1958 brood stocks were of comparable size and produced a comparable number of fry.

Lakelse River. As was mentioned previously, the index of the output from the 1958 escapement cannot be compared to the indices obtained previously. Special netting carried out in addition to the routine netting has indicated that this index is relatively low and that the number of fry from the 1958 spawning was large.

STUDIES ON SALMON REPRODUCTION AND PROPAGATION

W. P. Wickett

A transplant of 6,000 pink salmon eggs in 1958 to the Atlantic coast showed that the downstream migration time of the fry in the new area (south-eastern Newfoundland) was delayed one month. This delay was advantageous as the sea temperature had risen above the lethal level by this time, the latter half of May. A second shipment of 250,000 eggs was made in 1960. The eggs were successfully gathered, eyed, shipped and planted. An estimate of freshwater survival will be made early in 1960 and future plans made at that time.

The propagation of salmon in spawning areas with controlled water flow has been accepted as a management tool. Jones Creek has shown a build-up of the natural population over three cycles. A large installation has been made by the Fish Culture Branch at Robertson Creek and an even larger proposal has been engineered and proposed for the Qualicum River. A period of assessment is indicated before further research on controlled-water installation used for fry production is undertaken.

Studies have been confined to the assessment of past gravel-condition sampling methods and the development of a new deep-water standpipe. Spawning fish raised the permeability of gravel in November from 1000-5000 cm/hr permeability to 20,000-50,000 cm/hr. By March, all stations had reverted to the original low values. A general relationship between looser gravel, water flow in the gravel and survival was evident. Sampling is best done when gravels have been undisturbed for four months. A detailed study of an area using a three-foot grid is underway. This will give information on the type of statistical control required in survey work.

The deep-water standpipe is for use in the first instance by the Fish Culture Branch in their study of the lake spawning of sockeye salmon. Design, building and field testing led to redesign, building and calibration of a second model. The field testing should be completed early in 1960.

A major study project covering the survival from egg to fry is nearly complete. The mechanism whereby water-flow affects the size of salmon populations, i.e., flow in the gravel past the eggs, has been identified and experimentally verified. Instruments have been developed to assess the differing capacities of streams to incubate eggs. Optimum spawning densities can be predicted.

Studies of Salmon Reproduction and Propagation

1. Transplant of Pacific salmon to Atlantic streams.

All Canadian Atlantic fishing areas would benefit greatly by a new, valuable and easily-sold fish resource. This is especially true of Newfoundland. Establishing one or more species of Pacific salmon in commercial quantities offers a possibility of major assistance to the Atlantic fishing economy. Available information suggests that this can be done without harm to any existing fish or fishery. The study of such an undertaking was seen to have three phases: exploratory, experimental, pilot-plant.

Exploratory phase. Problems in this phase included a choice of collecting and planting sites, shipping boxes, and observation of temperatures of stream and sea and of migration time in the new area.

Several items were reported on last year. The Avalon Peninsula in Newfoundland was chosen as the planting area and pink salmon for initial experimental transfer. The Tsolum River on the southeast coast of Vancouver Island was selected as the donor stream. The Board's St. John's Station designed and supplied strong, light, insulated shipping cases. Six thousand eyed pink eggs were planted in the selected Newfoundland stream in the fall of 1958.

The fall stream temperature was only slightly cooler in Newfoundland than in Nile Creek, B. C. Hatching would be expected in early December rather than in November. Winter temperatures were low (1°C or less) for a much longer time than in southern B. C. The fry emerged from the gravel about a month later than in Nile Creek. The peak of the Newfoundland migration was May 15-30. The peak of the Nile Creek pink run in 1958 was April 15. The transplanted fry emerged after the stream temperature reached 5°C. This is normal behaviour and enhances the fry's chances of survival in the sea. The sea which had been around 0°C in April had warmed up enough not to be lethal by May. The survival of fry appeared sufficiently assured to proceed with the next phase of the study. The problems here were to check on freshwater survival more fully and to familiarize personnel with shipping, planting and incubation problems.

A progress report dated December 3, 1959, from Newfoundland indicates that the shipping and planting has been successful. The shipping box designed and supplied by the Newfoundland Station is excellent with the small modifications of an air hole and added handles. Seventeen boxes are on hand, which will hold a total of one million eggs. With tight planning, a future large-scale transplant can be handled by shipping empty cases back for refilling.

In 1959 the Fish Culture Branch built a large collecting fence and pen on the Tsolum River for a local tranplanting project. Only 400,000 eggs could be spared from the small run that appeared there. With some difficulty, Station and Fish Culture personnel collected 1,700,000 eggs from the Indian River on Burrard Inlet. The total take was well below the 3 to 4 million eggs the Department required so that we were asked to use only the minimum number of 250,000 eggs that had been agreed as needed for this project.

Eggs from the Indian River only were used for the transplant to Newfoundland. They were collected from September 16 to 27 and incubated at temperatures ranging from 54°F down to 32°F until November 16 to 20 at the Puntledge hatchery at Courtenay, Vancouver Island. The eggs were fertilized on the river, placed in new 5-gallon paint or grease cans and taken by boat and truck to the hatchery. The journey took six hours. The eggs were stirred gently by hand every two hours. The cans of water were three-quarters filled with eggs. The overall loss until shipping was less than 3%.

Dr. L. Margolis investigated methods of sterilizing the eggs to avoid introducing disease inadvertently to the new area. The method of Snieszko and Friddle was used. A test of a 1:5000 sulfa merthiolate dip was carried out November 9 to 12. Four thousand eggs were dipped for 0, 10, 20 minutes and then placed in an iced shipping box. After four days there was no apparent mortality and only minor mortality a week after the eggs were returned to hatchery baskets.

On the day of shipping, the eggs were dipped, 20,000 at a time in a small wooden trough holding 40 litres in which 8 grams of sulfa merthiolate were dissolved. The eggs were stirred for ten minutes and at this time, the few dead eggs among them were picked off. Two men packed the eggs in the trays. The eggs were poured dry into a plastic household strainer used as a measuring device and then transferred to the moss-lined, gauze-covered trays. The packing was done between 0800 and 0930 hrs and the cases trucked to Victoria and shipped by air 1445. On November 16, 63,000 were shipped, on November 19, 84,000 and on November 20, 104,000, making a total of 251,000.

2. Controlled-flow spawning grounds.

The use of spawning grounds with the water flow over them under control is now accepted as a management tool. The large-scale use of such facilities will depend on the success of present and projected installations. As this Station has played a leading part in their development, it is opportune to review our progress to date.

The studies started at Nile Creek in 1947. Higher production of fry from eggs of pink and chum salmon was recorded in a section of stream protected from winter floods than in the natural stream. Laboratory and field studies with specially developed equipment showed that, in addition to the destructive power of floods, stream flow had a direct effect on the survival of eggs through its influence on the rate of flow of water past the eggs in the gravel. Fluctuations in chum and pink salmon populations were associated with flow conditions during early incubation. Further studies indicated that the spawning density that gave the maximum fry output in various streams was related to the average permeability of the gravel. Permeability is one factor controlling the flow of water past the eggs in the gravel that could be considered a constant from year to year. Thus, factors were recognized that could impose year-to-year fluctuations in population size while at the same time certain populations varied over different ranges.

During the year, Manuscript Report #676 "The Biological Potential of the Qualicum River" was issued which formed the basis for extensive engineering studies by the Fish Culture Branch and reports by biological and engineering consultants. A large-scale controlled-flow spawning stream is now planned.

3. Natural conditions of stream gravel.

The constancy of the permeability of stream gravel under both natural conditions and under the influence of man-made changes is of some concern. The validity of past surveys of gravels and the assessment of present conditions are both of concern to the investigator and to those charged with management. Therefore, for the past two years, detailed studies have been made in small areas.

At McNaughton Creek, the permeability of the gravel and the velocity of the water flowing in the gravel was found to be high (20,000 to 50,000 cm/hr) while salmon were digging the gravel during the deposition of their eggs. As winter and spring progressed, the permeability and the water velocity dropped to quite low levels (1,000 to 5,000 cm/hr). Of the nine positions studied, the lowest survival of eggs was associated with the lowest permeabilities. It is fairly obvious that the gravel with the highest natural permeability is more likely to revert to a higher permeability after digging than the gravel with the lowest natural permeability.

During the past year, the validity of our sampling for determination of an average permeability value of a stream has been examined. We are dealing with a non-normal distribution. Statistical analysis indicates a distribution similar to that of Chi-square. To make certain, we are at present surveying an area at three-foot intervals both transversely and longitudinally.

A progress report was issued on the effect of a flood on the permeability of gravel. The portions of a stream with the greatest slope and change of direction had their permeability reduced most. Six per cent of the spawning area was lost.

4. Deepwater standpipe for lake spawning studies.

A new instrument to measure the velocity of water flowing out of alluvial fans has been made and calibrated. The Fish Culture Branch is studying the spawning success of sockeye at depths as great as seventy feet in Great Central Lake on Vancouver Island. The Mark VI instrument was used as the basis for the new one.

The standpipe, driven into the gravel to be studied, is connected by 200 feet of two-inch plastic tubing to a well set on a tripod at the lake surface. Through this tube and well, water is pumped and the rate of discharge under a one-inch head is determined. Two quarter-inch (outside diameter) copper tubes are led from the point of the standpipe to the tripod where they are joined to separate wells. One tube enters the standpipe itself; the other is open to the lake at the standpipe.

The design was arrived at after a preliminary model, which used two 2-inch plastic tubes to connect to the lake and the standpipe, was found to be subject to various surges in the lake. The copper tubes are manometers that largely eliminate surges of up to 20 minute periods but will allow differences in water pressure inside and outside the gravel to show up in the wells on the tripod.

The water level in the wells is measured by means of a modified depth micrometer. The insulated tip of the gauge is connected to a 22-volt battery and to a milliammeter. The ammeter deflects when the probe touches the water surface. Differences of .0005 inches can be detected. A special levelling table with an accurate surface fastens on the tripod to provide an exact reference height.

The calibration for permeability required, firstly, the determination of head-loss at various flows through the 200-foot tube. The Hecate Model was used as a large constant head tank. Secondly, the rate of discharge from the Mark VI standpipe was determined in gravels of various permeability for heads of 0.5, 0.6, 0.7, 0.8, 0.9, 1.0 inches. Thirdly, a graph of discharge versus head for the standpipe combined with a graph of discharge versus one minus head for the tube, gave corrected values for discharge to be used in drawing a calibration curve. The curve allows for the fact that there is not a one-inch head being applied at the end of the 200-foot tube when the normal procedure for the Mark VI standpipe is used. Values to be applied to the Mark VI calibration curve, in milliliters per second, are as follows:

Observed: 67, 53, 43.7, 36.5, 26.5, 19.5, 15.5
Corrected: 83, 62.5, 50, 40.5, 28.5, 20.5, 16.

STUDIES ON SALMON PRODUCTION AT PORT JOHN

R. C. Wilson and F. Neave

The main purpose of the investigations at Port John has been to obtain information on the incidence and causes of fluctuations in the pink and chum salmon populations of a small stream. Collectively, watercourses of this type are important in the over-all production of these species and are relatively immune to the hazards created by hydroelectric development. Special attention has been given to the manner in which the varying density of the spawning population affects salmon production. With optimum escapements, under natural conditions, Hooknose Creek alone seems capable of providing a surplus of 60,000 or 70,000 fish for the industry.

In addition, a small run of sockeye salmon has provided opportunity for recording the fluctuations of fry production in this species and for gathering data on the smolt-producing capacity of a small lake. Comparisons with other sockeye-producing areas have been instructive. Data on the natural reproduction of coho salmon are also obtained at this field station.

Output of pink and chum fry in 1959

The potential deposition of eggs in 1958 and the resulting fry output in 1959 were as follows:

Species	Potential deposition	Number of fry	Percent survival
Pink	5,897,000	745,000	12.63
Chum	5,749,000	881,000	15.33

On the basis of previous experience, the combined deposition of 11,646,000 eggs was considered to be close to the optimum for this stream at the present time. This view was supported by the output of 1,626,000 fry, the largest number recorded in the 12 years of operation of this field station.

Production and disposal of sockeye fry in 1959

The estimated potential deposition of sockeye eggs above Tally Creek weir in 1958 was 1,067,000. These produced a count of 140,563 fry at the weir in the spring of 1959. The percentage survival (13.17) was above the long-term average. Nearly all these fry (135,180) were transported and released at the stream mouth in continuation of tests to determine the ability of the fish to survive in the marine environment at an early stage.

Sockeye smolt production in 1959

The run of seaward-migrating smolts trapped at the Hooknose Creek weir was 8,380, of which 7,867 were released after removal of adipose and right ventral fins and 168 were used for sampling purposes. The age composition of these was:

1 year residence in lake	0.64%
2 years residence in lake	98.10%
3 years residence in lake	1.26%

Coho smolt production in 1959

Coho smolts migrating to sea in the spring of 1959 numbered 5,291. These resulted from an estimated deposition of 391,200 eggs in the Hooknose Creek watershed in 1957, showing a survival of 1.35%. Both the number of smolts and the survival rate have been relatively constant in recent years.

Adult runs in 1959

The operation of the weirs in the autumn of 1959 was unavoidably suspended. A visit to the area during the spawning period by an experienced observer showed that pink, chum and sockeye escapements were small. It was considered that not more than 1,500 pinks, 600 chums and 1,000 sockeyes entered the stream.

EXPERIMENTAL HATCHERY INVESTIGATION

M. P. Shepard and A. S. Coburn

Modern salmon hatchery techniques can provide egg to fry survival rates from 5 to 10 times greater than that in nature. In the past, however, this increased survival has been offset by an apparent failure of hatchery-reared fry to survive to the returning adult stage as well as natural fry. Before the full potential of hatcheries as a tool for increasing salmon production can be realized, the problem of why hatchery fry survive so poorly must be solved and suitable techniques to overcome this deficiency must be developed.

To study this problem, an experimental hatchery for pink salmon has been operated at Kleanza Creek (a tributary of the Skeena River) since 1957. In this hatchery, attempts are being made to rear and release fry so that they develop at the same rate and emigrate from the creek at the same time as natural fry. In addition, environmental conditions at the time of release are controlled in such a manner as to distort the normal migratory behaviour patterns of the fish as little as possible.

The program has involved rearing pink salmon eggs (obtained from the native Kleanza run and from the runs of nearby Lakelse and Kitwanga Rivers) in darkness throughout the winter. Near the end of larval development, the young salmon are transferred to light-proof "release troughs", consisting of boxes in which the water wells up through a screen partition in the bottom and overflows at the top. The larvae remain quiescent at the bottom of these troughs until the yolk sac is almost completely absorbed when they begin to swim actively and escape from the trough through the overflow pipe to the creek. By following these procedures, the fry release themselves from the hatchery at a stage of development similar to that of natural fry escaping from the gravel. By incubating the eggs in water pumped directly from the creek, the rate of development of the hatchery fish is very close to that of natural ones and as a result the time of release from the hatchery is similar to that which would occur under natural conditions. Once released from the hatchery, the young fish exhibit migratory behaviour similar to that observed among natural fry; i.e., they hide in the gravel during the day, and move up off the creek bed during the night to emigrate from the stream.

The success or failure of these techniques will be assessed by counting the adults returning to Kleanza Creek in the next two years.

a) The 1957 brood. From the natural 1957 spawning run to Kleanza Creek of about 2,100 adult pinks (including approximately 1,000 females), 0.57 million eggs were taken for the hatchery (about 40% of the eggs available). About half the females laid their eggs in the delta region of the creek below the egg-collecting weir. In construction of the fence the delta area later used by the spawners had been raised to about 2 feet over the normal creek level. During fall and spring freshets, flooding restored the creek to its original level, washing the naturally deposited eggs out of the creek and presumably killing them. The 0.57 million Kleanza eggs were supplemented by 1.36 million eggs obtained from later-running pinks from the Lakelse River.

Breakdowns in the new pumping system and failure of the transported Lakelse eggs to develop rapidly enough in the relatively cold Kleanza water, resulted in severe losses during the early incubation period. As shown in Table 42, from the 0.57 million Kleanza eggs, 0.345 million survived to the fry stage. Only 0.325 million of the 1.36 million Lakelse fry survived. The Kleanza fry, although they emigrated from the hatchery somewhat earlier than expected, released themselves satisfactorily. The Lakelse fry, however, approached the migrant stage more than a month later than the Kleanza fry and emigrated from the hatchery long after the normal stream migration time of natural Kleanza fry. Their behaviour in the release troughs was quite dissimilar to that of the hatchery-reared Kleanza fry; the alevins failed to settle to the bottom and most of the fish escaped to the creek with prominent yolk sacs still attached. As a result, subsequent survival of these Lakelse fry would probably be very low.

Table 42. Summary of experimental hatchery operations at Kleanza Creek.

Year of egg take	Number of eggs taken				Number of fry released			Number of adults returned
	Kleanza	Lakelse	Kitwanga	Total	Kleanza	Lakelse	Total	
	(1,000's)				(1,000's)			
1957	570	1,360	0	1,930	345	325	670	1,200
1958	340	1,320	0	1,660	300	1,100	1,400	...
1959	400	0	7,300	7,700	...	...	...	...

In 1959, a total of 1,200 adults returned to Kleanza Creek. This represents a survival rate from fry to returning adult of only 0.18% (or, if the abnormal Lakelse fry are omitted from the calculation, 0.35%) compared to an approximate average in nature of 1.5%. On the basis of these data, the survival of hatchery-reared fry would be only about one-tenth to one-fifth of that in nature. However, because of the small numbers of fish involved in both the release and return, these results cannot be considered indicative of the average situation. A more dependable assessment of the relative success of the techniques must await the returns from the much larger releases from the 1958 and 1959 broods.

b) The 1958 brood. From the small 1958 pink run to Kleanza, 0.34 million eggs were taken for the hatchery. These were supplemented with 1.32 million Lakelse eggs. This time, however, the development of the Lakelse eggs was accelerated by eyeing them at Lakelse before transporting them to Kleanza. In this way, the Lakelse fry reached the migrant stage at approximately the same time as the Kleanza. Both the Kleanza and Lakelse fish survived the winter relatively well,

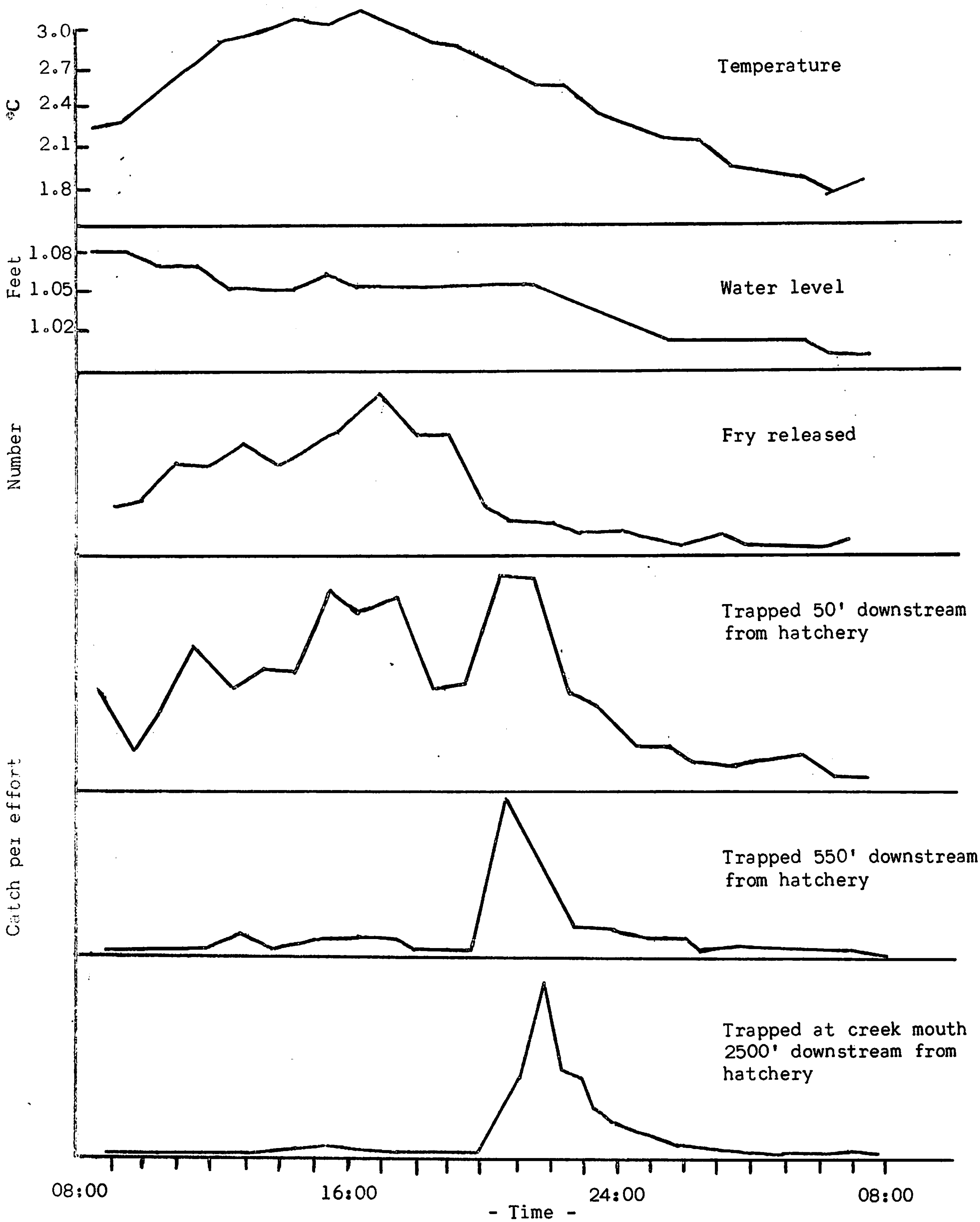


Figure 18. Diurnal variations in water temperature and level and in numbers of fry released and trapped at various points on Kleanza Creek.

and a total of 1.4 million fry released themselves during early April of 1959 (see Table 42). Although these fish released themselves slightly earlier than was anticipated, their behaviour pattern before and after release was very satisfactory. Alevins placed in the release troughs remained on the bottom until their yolk sacs were almost absorbed at which time they escaped from the trough into the creek.

In Figure 18, observations on the release and downstream movement of fry over a typical 24-hour period are illustrated. The escape of fry from the hatchery tended to follow the diurnal change in creek temperature, the numbers releasing themselves tending to increase steadily from early morning to late afternoon and then dropping to a low level at night. When they reached the creek, the fry tended to burrow in the gravel. However, many were washed a short distance downstream before managing to escape from the current to burrow in the gravel. A trap operated 50 feet downstream from the point of release caught substantial numbers of fry all day whereas a trap located 550 feet downstream and a series of traps at the creek mouth (2,500 feet downstream) caught essentially none during daylight hours. As darkness approached (20:30 to 21:00 hrs) the fry moved off the stream bottom and emigrated from the creek. As illustrated in the figure, from about 21:00 hrs to midnight, all 3 sets of traps made large catches; there tended to be a lag of about one-half hour between the trap catches at 550 feet downstream from hatchery and at the creek mouth.

Thus the 1958 brood of fry escaped from the hatchery mainly during the day and the fry hid in the gravel during daylight hours and moved rapidly downstream and out of Kleanza Creek during the early hours of darkness. This behaviour pattern is similar to that exhibited by fry reared under natural conditions.

c) <u>The 1959 brood</u>. Approximately 0.40 million eggs were obtained from the small 1959 Kleanza run. An additional 7.30 million were obtained from the Kitwanga run and transported to the Kleanza hatchery. The first eggs obtained at Kitwanga were very sensitive to handling; as a result, about 1.5 million were lost in the transport operation. Additional losses occurred over the winter and it is expected that about five million fry will be released during April and May of 1960.

As suggested above, the 1957 and 1958 releases tended to be somewhat earlier than the fry runs from nearby rivers such as the Lakelse and Kitwanga. This early emigration was probably the result of a small increase in the rate of development caused by a slight warming of the creek water as it was pumped through the hatchery supply system (from 1°C for a week or two in the late summer to 0.1-0.2°C throughout the winter). In 1959, the volume of water pumped was greatly increased and this heating effect greatly reduced. Consequently, it is expected that the majority of the hatchery fry will emigrate at about the same time as the fry from the neighbouring river systems. Control of the time of fry migration may be an important factor in further attempts to improve survival and return.

EXPERIMENTAL STUDIES ON PHYSIOLOGY AND BEHAVIOUR OF SALMON J. R. Brett

This investigation had its inception in 1951, with two scientists and one technician (to 1956). The main theme of research concerned methods for safeguarding downstream migrating young salmon by developing techniques for guiding, supplemented by appropriate laboratory investigations (e.g., determining swimming speeds, temperature tolerance, light sensitivity). Some experiments on the resistance to toxic materials were undertaken (e.g., sodium arsenite, pulp-mill effluent). A repellent odour affecting adult salmon was discovered, and isolation experiments conducted co-operatively with the Vancouver Technological Station. Guiding of salmon remained the chief objective up to 1956. In that year experiments using charged moving cables were demonstrated to be 95% successful in guiding sockeye and coho fingerlings but not fry.

With the 1955 announcement of the feasibility of diverting the upper Columbia River into the Fraser and obtaining hydro-electric power by building ten dams on the Fraser and Thompson Rivers, attention swung to the acute problem which this would create for safeguarding adult salmon, as well as downstream migrants. An increased program of research was requested in 1956.

Because of the complex nature and multitude of salmon problems created by industrialization (power, irrigation, pollution), a fundamental study of the fish was considered necessary first to be followed by and integrated with applied studies. The following broad lines of research were selected as basic and common to the overall problem:

(1) Factors governing maturation.
(2) Energy release and conservation during migration.
(3) Capacity to meet cumulative stress and remain active.
(4) Mechanics of migration and associated behavior patterns, including spawning.

The current research approach is subdivided as follows:

1. <u>Biochemistry</u> - <u>Maturation processes</u> W. E. Vanstone

The biochemical questions which command attention are:

(1) What are the related biochemical changes occurring in the blood and gonads of salmon during maturation?

(2) What induces and/or determines the sequence of these changes?

(3) How is the sequence modified by environmental change?

Blood has been obtained from sockeye and coho at various stages of maturation by sampling at different times from salt water to spawning grounds. Physical measurements of body and gonads have been correlated with plasma protein and lipid (fat) fractions. Problems of blood collecting, separation, fractioning, and biochemical determination are apparent and progress is being made. Considerable changes in blood cell volume (haemoconcentration) occur which require investigation before relative measures of constituent concentrations can be made.

Males and immature females have been found to contain four protein fractions including one lipoprotein. A second lipoprotein fraction was discovered in the plasma of maturing females. It appears to be an egg-yolk constituent probably formed in the liver and transported via the plasma to the developing ovary.

Preliminary experiments on induced maturation by synthetic hormone injection (estradiol benzoate) in immature sockeye and coho have yielded variable results. In one sample, however, the "yolk lipoprotein" was induced in a laboratory stock of sockeye just over 2 years old.

Outlook. It is apparent that the development of procedures, the variability within and between stocks, and the necessity of controlled experiments will make quantitative determinations slow in developing. Qualitative results will accrue in this relatively virgin field more rapidly. Once the normal variability is defined, emphasis will be placed on determining the effects of such factors as exercise, fatigue, salinity, temperature, and light.

2. Physiology J. R. Brett and G. R. Bell

a) Respiratory metabolism and energy demand. Since there is no food intake in the upstream migration, adult salmon must be equipped with enough fuel in the form of stored fat and convertible protein to meet all demands of maintenance and activity. The extent of these stores at any one time can be measured by analyses on dead fish; the instantaneous demand can be obtained by determining metabolic rates in a respirometer. The former requires proximate analysis and calorimetry; the latter requires frequent measures of the O_2, CO_2 and NH_3 exchange, relating the respiratory nitrogenous fraction (NH_3) to urinary nitrogen excretion. In addition, metabolic rates reflect the overall functional status of an animal, and constitute an excellent measure of stress.

The prime task to meet the above has been developing appropriate methodology, apparatus and instrumentation. A special cage coupled with a large flume (Robertson Creek) is now available for studying energy drain in adults swimming at prescribed rates; techniques for urinary collection are progressing; a new respirometer of advanced design is under construction; facilities for capture and handling large fish without injury have proven successful; and appropriate instrumentation for rapid gas analysis has been found to be available commercially.

Outlook. The development of apparatus which will allow experiments on fish comparable with physiological studies on mammals will open up a large horizon. Bridging the gap between original designs and successful experiments will take time. New criteria and formerly unappreciated consequences of stress can be anticipated. First results are expected to reveal the separate consequences of energy drain from swimming and that from temperature elevation, a distinction never possible in nature and necessary for forecasting the effects of decreased velocity but increased temperature of reservoirs and rivers.

b) Tissue metabolism and haemotology. The consequences of changed environment of toxic substances, of maturation, and of disease are reflected by changes in cellular function and, in the case of blood, by changes in cell types and ratios. Gill and brain tissues are reported to be sensitive indicators of different stresses. In addition vital links (transaminases) between carbohydrate and protein metabolism can be traced through serum analysis, indicating shunts in metabolism (important in energy transformation studies) and the unsuspected presence of disease.

Progress has been made in the development of photomicrographic techniques which will provide permanent records of cell shape and staining characteristics.

Outlook. A strong feeler is being made in this direction because of the obvious returns which medicine has achieved in identifying stress by tissue studies (including blood). Tissues can be removed from salmon at any point, frozen, and examined later with a facility which is impossible for the intact animal. In addition, the detection and control of disease is vital in the laboratory.

As in the maturation studies, qualitative returns can be expected much earlier than quantitative assessment. The normal range of variability in the blood requires first attention. Various stresses will be applied to help select those characteristics which are most likely to be diagnostic.

3. Tolerance studies (Bioassay). D. F. Alderdice

Normal and foreign environmental factors singly and collectively impose an overall stress. Extremes result in death; intermediate levels can impose limitations of small or large magnitude, of subtle or obvious consequences. It is short-sighted to examine the effects of toxic materials without regard to the sum total of environmental factors (e.g., temperature, salinity, oxygen, etc.) and the necessary functions of the fish (respiring, digesting, maturing, etc.). Normal environments are complex; some toxic materials are complex (pulp-mill effluents, insecticide formulations). So far attention has been directed mainly to determining lethal levels on small fish, supplementing the forecast of consequences or "safe levels" by observations on respiration and behaviour. Some pertinent findings are: young coho cannot tolerate normal sea water until nearly one year old; the principal toxic components of pulp-mill black liquor (sulphate) appear to be either oxidizable or volatile - in the oxidized state the toxicity is reduced; the toxicity of the unbleached fraction appears directly related to its content of oxidized black liquor; coho and Atlantic salmon have roughly similar resistances to a variety of insecticides - of the four studied, none was less harmful than DDT.

Outlook. The need for adequate criteria in determining safe levels (more truly ranges, in relation to expected temperature and salinity ranges) of toxic materials must be explored. There is potential danger in making judgment from data which uses mortality as its main criterion. In addition the consequences of interaction (toxic concentration × temperature × salinity × oxygen concentration, etc.) require investigation. These are the aspects which will receive increasing attention in the future, and will be integrated with the physiological developments.

4. Behaviour - Migration and spawning. C. Groot

Successful migration and reproduction is not just a matter of enough fuel to make the course, enough resistance to meet the stresses and enough time to complete maturation. It involves a series of perception-response activities which carry the fish from point to point (no matter how devious the course) arriving at and depositing fertilized eggs in appropriate spawning grounds. Alterations in the normal environment can affect the behaviour in numerous ways, e.g., by providing false cues or no cues, by changing the internal state of the fish, or by masking the natural environment. What are the environmental requirements which satisfy the internal drives of migration and spawning? The two basic questions which must be answered first are (1) what are the normal social patterns within the species? and (2) what are the stimuli used in orientation and navigation during migration?

These have been approached by making detailed recordings of behaviour sequences as seen under natural and artificial conditions, and grouping the stereotype (or instinctive) activities into major systems - aggressive, escape, feeding, courting and nest-building - which can then be tested for correlation. There are strong indications that measurable external features (body positions, fin erection, colour combinations) reveal particular relations between systems (e.g., aggressive over escape), the occurrence of which can be predicted before the actual activities. The act of spawning has been predicted on a number of occasions 15 to 20 minutes in advance. Excellent movies of chum and coho salmon spawning in a large glass-faced experimental tank have been obtained.

Outlook. Accurate, detailed behaviour descriptions are needed before the study of orientation can be considered adequately. However, it has been possible to demonstrate in young salmon that odour of like species is readily detected, also that the possibility of celestial orientation exists. The development of methods and overcoming the technical problems is challenging. Accent will be placed on descriptions of normal social behaviour to be followed by studies on the behavioural sequence of migration, primarily by laboratory studies and subsequently by field investigations.

5. Ecology - Field description and mechanics of migration. D. V. Ellis

A great deal is known about the numerical sequence and timing of many salmon runs. Basically, these hinge on what individual fish are doing, about which relatively little is known. Forecasting the consequences of changed environments is consequently perilous. This program, therefore, has as its objective the description of how salmon move through different river environments, the selections which are made in nature, and what properties of the environment correlate with salmon movements - first in natural environments and then in industrially developed areas. The runs of salmon in the clear waters of the Stamp and Sproat Rivers (average seasonal discharge 300-1000 cfs) have received most attention. Fish tracking, underwater viewing techniques, photography, and diving are under almost constant development. A field guide based on distinctive characteristics of form, colour and movement, serviceable from above and below the water is required and being developed.

In the above river system salmon are rarely seen swimming steadily upstream; normally they are seen performing other activities such as circling, wandering, darting, holding, jumping, etc., only some of which have migratory function. They tend to move upstream for limited periods daily, occasionally as little as 2-3 hours in the morning often near dawn. Other observations suggest that sockeye are stimulated to enter the river by a change from sunny to cloudy weather, that rain and increased river discharge are not necessary for sockeye entry but often are correlated with it, and that entrance in large numbers occurs during high-tide slack near dawn.

Outlook. The individual study of fish in nature is subject to many vicissitudes, in which being on hand for those more rare but revealing glimpses is paramount. It is apparent that movements of salmon upstream comprise a limited number of co-ordinated patterns. Greatest effort will be devoted to documenting these and correlating frequency of occurrence with environmental characteristics and change. In addition, there will be a means of checking laboratory observations against what actually happens in nature - a highly necessary control.

P O L L U T I O N

M. Waldichuk

Oceanographic surveys were carried out extensively during the course of the year to study further the existing pollution problems and to investigate areas threatened by new pollution. The Osborn Bay-Stuart Channel area continued to be a major problem with two surveys, one in April and one in July, supplemented by monthly samples taken at strategic points for monitoring the presence of KME (Kraft mill effluent) from the Kraft pulp mill at Crofton. Alberni Inlet was surveyed during late August to note the year-to-year changes as a result of waste discharge from the Kraft pulp mill at Port Alberni. Weekly monitoring data on Somass River discharge, pulp mill effluent characteristics and Alberni Harbour conditions continue to be received from the pulp mill company. These have been analyzed to note any changes in dissolved oxygen of the inlet water in relation to pulp mill production and river discharge during the year.

Areas, where new industrial developments are anticipated to create pollution problems, include Muchalat Inlet and Howe Sound. New pulp mills for sites on these inlets are either in the planning stages or are actually under construction. Preliminary oceanographic surveys were conducted to note the characteristics of the water with a view toward predicting possible pollution from waste discharge.

A monitoring survey was carried out during the early autumn in the important and highly vulnerable fishery area of the Fraser River estuary and Burrard Inlet. The increase in disposal of domestic and industrial wastes into these waters supporting British Columbia's largest salmon fishery makes an annual study of conditions in the water very important.

Chemical research on the nature of pollutants, their identification, and techniques to render them less harmful has been continued. The decomposition rate of the insecticide, benzene hexachloride, in sea water has been further explored. A technique was developed for extraction of reaction products of BHC - sea water mixtures for analysis by gas chromatography and infra-red spectroscopy. Work has been continued on improvement of methods of identification and quantitative determination of KME and SSL (spent sulphite liquor).

Assistance has been given to the Fish Culture and Development Branch of the Department of Fisheries in setting up recommendations concerning various insecticidal spray programs and projected pulp mill developments. Other incidental work has included the study of low-level radioactive waste disposal into the marine environment.

1. Field studies.

a) Osborn Bay-Stuart Channel. Studies of the oceanographic conditions in Osborn Bay and Stuart Channel, as they are related to the effluent disposal from the Kraft pulp mill in Crofton, were continued with a spring survey in April and a summer survey in July. From the distribution of KME, it was noted that a dilution of about 1 part of effluent to 10 parts of sea water occurs, on the average, between the "boil" at the outfall and the nearest oyster leases. A total dilution of 200:1 between the diffuser at the end of the pipeline and the nearest shores can be expected at any time. The KME concentration in surface water at stations more than 200 yards from the outfall seldom varied by a factor of more than 2 during any one survey. Although some patchiness in effluent distribution occurred, there was no evidence, except at the outfall, of abrupt changes in KME concentration such as that observed in the vicinity of pulp mills where wastes are discharged at the surface. Deep water at all stations appeared to be rarely contaminated by mill wastes, and there was no indication that deterioration had occurred in the other water qualities measured.

The efficacy of the diffuser, through which the pulp mill effluent discharges, was investigated by a program temperature observation (bathythermograph) and water sampling. Samples were analyzed for salinity, DO (dissolved oxygen), pH, alkalinity and lignin. Data from these observations showed that excellent mixing was occurring and that a dilution of about 1 part of effluent to 20 parts of sea water was regularly achieved. Judging from the high salinity and low temperature in the area of the "boil", the diffusion process carried a considerable quantity of cold, high-salinity bottom water to the surface.

The results of this study suggest that properly installed, a diffuser might serve to provide dilution water from the deep zone of an inlet. This might be used to supply part of the need for dilution water, which is normally derived from fresh-water river discharge and any sea water entrained therewith in the upper zone. Such a technique might relieve the costly requirement of dams for storage to provide dilution water during low river flow of late summer, which is the present practice in Alberni Inlet. However, a danger exists in applying this mechanism, if insufficient energy is provided to drive the effluent to the surface. Improperly installed, a deep-water diffuser may cause pollution in the deep zone with serious consequences at some later date. A zone of pollution could conceivably be also created near the surface just above the pycnocline, if the mixture of effluent and cold, saline sea water is much denser than the surface sea water. Under such circumstances, even if the effluent-sea water mixture diffuses to the surface satisfactorily, an unstable situation would result and the mixture would sink, unless rapidly mixed into the surface layer. Extensive research with a model (flume), in which different characteristics found in nature can be varied, is needed to determine the feasibility of using the diffuser mechanism for providing dilution water.

In a cooperative study with the Marine Invertebrates unit on the effects of Kraft mill effluent on oysters in the Crofton area, water samples have been collected at strategic points in Osborn Bay and Stuart Channel concurrently with oyster samples for condition factor studies. The water samples have been analyzed for KME using the Pearl and Benson nitrosolignin test. Except for those samples taken above the diffuser or in the immediate vicinity of the "boil", concentrations of KME were small. Based on standards made up from "black liquor" from the pulp mill containing about 15% solids, the KME concentrations in water on the oyster leases showed monthly variations of from 5 to 20 ppm. Water from the nearest oyster leases (Lots 81 and 277, shown in Fig. 19) gave the highest concentrations of KME, while those from distant leases, such as Lot 320, usually gave concentrations slightly above "background". As an index of background values for naturally-occurring lignin, water was analyzed from the Biological Station wharf. This sea water generally gave an apparent KME value of about 5 ppm, although it sometimes reached 10 ppm, depending on time of year, run-off conditions, plankton concentration, and stage of the tide when the sample was taken.

There was found to be considerable day-to-day variability in makeup of the mill effluent, the concentration of lignin, as reflected in KME values, showing wide fluctuations. This was manifested in a variability of the KME concentration found in the water above the outfall and ultimately on the oyster leases. While KME concentration at the outfall was usually about 80 ppm, sometimes dropping as low as 40 ppm, it has been found to go as high as 240 ppm. The amount of dilution between the outfall and oyster leases remains fairly constant with about a ten-fold reduction in concentration.

In order to determine some of the tidal effects on concentrations of KME found in the water, samples were taken through part (20 hours) of a tidal day above oyster trays (see Figure 19) set up in an experiment to determine effects of the effluent on oysters at different distances from the outfall. There were

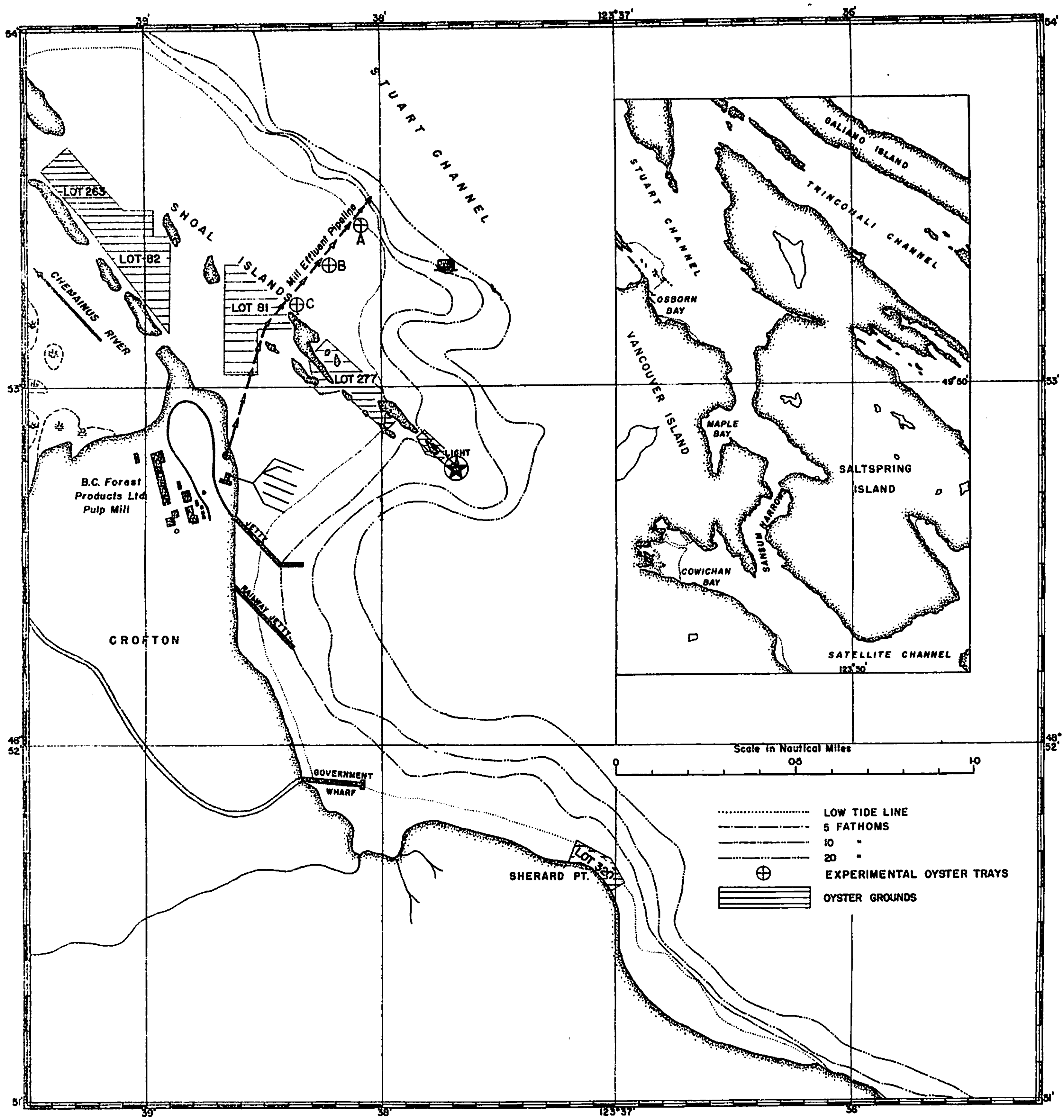


Fig. 19. Chart of Osborn Bay and contiguous waters showing locations of commercial oyster grounds and experimental oyster trays in relation to the pulp-mill effluent outfall.

quite significant variations of KME through a tidal cycle, especially in those areas near the outfall. If the mixture of effluent and sea water in the "boil" area mixes with just enough warm, surface water to give it buoyancy while still retaining a high effluent concentration, it can be noted to drift in a dark cloud in various directions, depending on wind and tide. As a result of these movements, a slight patchiness was noted in KME distribution, and the gradient was not always in the expected direction, i.e., with high KME concentration near the outfall decreasing toward the nearby oyster leases. With an appropriate wind and tide, the KME above the oyster tray A nearest the outfall was sometimes lower than that found above the oyster trays B and C further away. However, during very calm and warm weather, there was evidence that the effluent-sea water mixture was sinking near the outfall inasmuch as a sharp demarkation separated the dark mixture from the clear sea water at the surface on the periphery of the boil.

b) Alberni Inlet. In a survey of Alberni Inet during August, concentrations of DO in the deep water of Alberni Harbour were lower and the thickness of this oxygen-poor layer was perceptibly greater than that observed during other years (1954, 1957). The effect of the organic material on the bottom appears to be reducing the oxygen content of the near-bottom layer of water. Less than 5 mg/ℓ of DO (dissolved oxygen) were found at depths from 10 meters to the bottom. Concentrations of DO in the bottom layer during August 1959 were less than 2.0 mg/ℓ in some parts of Alberni Harbour compared to a minimum greater than 3.0 mg/ℓ in August 1957 and early September 1954. While DO concentrations had already dropped off to less than 5 mg/ℓ below 10 m in 1954 and 1957, they had not yet reached the low levels observed in 1959.

Weekly sampling of water in Alberni Harbour and in the Somass River was continued in 1959 by personnel of MacMillan and Bloedel Ltd. As in the previous year, copies of the data have been sent to this Station for analysis. Concentrations of DO were considerably higher, on the average, during 1959 than in 1958 in both surface water and at 10-foot depth. This can be attributed in part to the higher precipitation and larger run-off and partly to lower temperatures in 1959. Bottom water at the station near Hohm Island (35-foot depth) did not exhibit the low DO in 1959 that was observed in 1958. Near-bottom samples were taken only once per month so that the period of oxygen deficiency in the bottom water may have been missed.

As during 1958, there seemed to be little seasonal fluctuation in BOD (biochemical oxygen demand) in the surface water of Alberni Harbour. Any seasonal fluctuations in the content of natural decomposable organic materials were masked by the predominance of pulp mill effluent. There appeared to be a rough relationship between BOD of the raw pulp mill effluent and BOD of surface water.

Judging from the weekly data on Somass River discharge, the flow of fresh water was maintained well above 1000 cfs (cubic feet per second) at all times, although it fell to about 1150 cfs on one or two occasions. A flow of 1000 cfs was calculated in 1956 as the minimum safe discharge of the Somass River, which would provide sufficient dilution water to supply the oxygen demand of the pulp mill wastes from the expanded pulp production and still retain sufficient dissolved oxygen for the needs of fish.

There were no known reports of fish kills occurring in Alberni Harbour during 1959. Nevertheless, the danger does exist that if a warm, dry summer, such as that of 1958 should recur, there may be fish kills resulting from the presence of the oxygen-deficient layer near bottom. This could happen especially if the deep water is disturbed by some mechanical action, such as a dredging operation. (It was in the course of such an operation that there was a kill of a large number of sticklebacks and some shiners during September 1956.)

c) Muchalat Inlet. A survey was conducted in Muchalat Inlet of the Nootka Sound system during August, 1959, to assess the capability of the inlet to receive wastes from a proposed pulp mill at Gold River. This inlet is one of the few along the coast where dissolved oxygen concentrations are at the near-zero level in deep water. Concentrations as low as 0.2 mg/ℓ were found below the 500-foot depth, and less than 2 mg/ℓ at 150 feet in the waters of the upper part of the inlet. The amount of fresh water in the system, as deduced from salinity distribution, suggests that it receives a much smaller run-off than Alberni Inlet.

In a preliminary assessment of Muchalat Inlet for receiving wastes from the projected pulp mill operation, it has been proposed that, in view of the small fresh-water inflow, consideration should be given to use of a diffuser as a means of utilizing deep, saline water for dilution purposes. Taken from about the 60-foot depth, this sub-surface water would have an adequate dissolved oxygen supply to support the oxygen demand of the pulp mill wastes. The mixture of effluent and sea water would diffuse to the surface and flow seaward in the upper layer. Care must be taken, however, to insure that the effluent-sea water mixture is all carried into the surface layer and does not remain at some subsurface depth because of its relatively high density (see Section 1(a)).

d) Fraser River estuary. A Fraser River estuary survey was conducted during the last week in September and early part of October in order to observe conditions during low river flow. Dissolved oxygen (DO) concentrations were high in all parts of the river surveyed. Even near Steveston, where low oxygen concentrations had been observed during the 1957 and 1958 surveys, the deep water showed DO levels higher than 5 mg/ℓ. The removal of the rock wall at the east end of the Steveston Cannery Basin has apparently provided improved flushing, with bottom water being replaced regularly. An unusually high pH was noted in all Fraser River water samples, ranging generally between 8.1 and 8.3. This is considerably higher than that noted during previous years, 1950, 1957, and 1958, when pH rarely exceeded 8.0 and was usually in the range 7.5 to 7.9. Total and carbonate alkalinities were also somewhat higher in 1959 than during previous years. This relatively alkaline condition was apparently a transient feature, inasmuch as Fraser River water samples collected by personnel of the International Pacific Salmon Commission some weeks later exhibited pH values within the normal range.

e) Burrard Inlet. An annual survey of Burrard Inlet was conducted during early October. The vertical distribution of dissolved oxygen in Vancouver Harbour showed that there was less oxygen stratification in 1959 than in 1958. Concentrations in deep water were greater than 6 mg/ℓ at most stations in 1959 compared to levels between 4.5 and 6.0 mg/ℓ between the 20-foot depth and the bottom in 1958. This condition may have been created by the relatively cool summer of 1959 and the stirring by wind action during early autumn.

Phenol concentrations in certain areas of the Port Moody Arm of Burrard Inlet were found to be much higher (500 parts per billion) in the 1959 survey than observed in 1958 (14 ppb). Whether this was a result of an increased volume of refinery wastes or a change in sampling technique is unknown. An additional refinery (B. A. Oil Co. Ltd.) commenced discharging wastes in late 1958, making a total of two refineries in the Port Moody Arm and a total of four in the whole Burrard Inlet.

Water samples taken in areas where oil films were present gave particularly high phenol concentrations. During a period when the survey vessel was anchored at the entrance to Port Moody, samples were taken on various stages of the tide. Oil films were noted to drift past the ship during the greater part of the ebb tide. On the last stage of the ebb, just before the change to flood, the incidence of oil slicks became particularly high. Samples taken at this time gave the highest phenol concentrations observed at this station, 90 to 120 parts per billion. Following the change to a flood tide, the concentration of phenol reached a low value (15 to 20 ppb) within minutes.

A water sample taken at one of the large oil refinery docks (Imperial Oil Co.) gave a phenol value near 500 ppb; while 200 yards toward mid-channel, the concentration was only 20 ppb. At points 200 yards on either side of the wharf along the inlet, phenol concentrations were down to 2 ppb on the up-inlet side and 5 ppb on the down-inlet side. This suggests that phenol concentrations in waters receiving refinery wastes are very patchy and occur in high concentrations at the surface in the oil films.

f) Howe Sound. A survey was conducted during October in Howe Sound to obtain further data on oceanographic conditions in this area in preparation for further industrial expansion (Kraft pulp mill under construction at Woodfibre and possible future pulp mill developments at Squamish at the head of Howe Sound).

Howe Sound is unlike most inlets in its waste-assimilating characteristics. It is a funnel-shaped system with a broad section opening into the Strait of Georgia somewhat protected by numerous large and small islands. Only the upper reach of Howe Sound, from Montagu Channel to Squamish, is narrow and constricted like a typical British Columbia inlet. It is in this upper reach that industries have been established in the past (sulphite pulp mill at Woodfibre; copper mine and mill at Britannia Beach), and new industries are proposed for the future.

A sill, which is about 80 fathoms deep at the entrance to the upper reach, prevents frequent complete flushing of the water. At the 200-meter depth, a DO (dissolved oxygen) concentration of only 1.3 mg/l and pH of 7.4 were found. Compared to a DO of 10.7 mg/l and pH of 8.1 at the surface, the deep water exhibits a poverty in oxygen and a relatively acid state.

The large volume of fresh water entering Howe Sound, as deduced from salinity distribution, originates primarily from the Squamish River and its tributaries. This run-off has always been a good source of dilution and flushing water for any wastes entering Howe Sound. It is not anticipated that serious pollution will occur too easily from any additional small industries located in Howe Sound.

2. Chemical research on pollutants.

a) Benzene hexachloride (BHC). A. E. Werner

This insecticide continues to find favour in the forest industry for spraying log booms as a protective measure against infestation by the ambrosia beetle. Research has been continued on the analytical method for the determination of BHC in sea water, its decay rate in sea water, and identification of the products formed.

(i) Analytical method for gamma BHC. A number of substances were tested for their effect on the analytical method for BHC in water, developed by Hancock and Laws. They were chosen from various groups of compounds likely to arise in the reaction of the gamma isomer of BHC with sea water. About half of them (Table 43) interfered with the analytical procedure.

Table 43. Interference with Hancock and Laws' Test

Compounds	
Interfering	Non-Interfering
1:2 dichlorocyclohexane	cyclohexanol
2 chlorocyclohexanol	meso inositol
0 - dichlorobenzene	phenol
asym. trichlorobenzene	pyrogallol
0 - chlorophenol	

(ii) Rate of decay of gamma BHC. A preliminary study of the decay rate of gamma BHC in coastal sea water was extended to include offshore ocean water and brackish water (i.e., diluted sea water). The results were substantially as expected, ocean water giving the higher decay rate (see Table 44).

Table 44. Effect of Water Type on decay of gamma BHC

Reaction Time in Days	Relative gamma BHC Concentration	
	Ocean Water	Brackish Water
0	100	100
1	74	97
3	62	94
7	43	90
15	98	87
31	96	100

There was a regular decrease in BHC concentration during the first week of contact with sea water. However, an apparent increase occurred again during the following week. Analysis of a mixture of sea water and gamma BHC which had been standing approximately 12 months indicated the apparent existence of a significant amount of BHC. The interpretation of these findings can be given only when the study of the reaction products has progressed further; but it is presumed that reaction products are formed which give a positive test with the analytical method used.

Comparative experiments of storing the mixtures in glass and polyethylene containers showed an apparently higher decomposition rate in the latter. This may be due to adsorption effects.

(iii) Solvent extraction of sea water. A unit for continuous extraction was designed and constructed. It served to extract and concentrate minute traces of reaction products from large amounts of sea water. The products of a 7-day-old mixture of sea water and gamma BHC were isolated with it. Their examination by gas chromatography showed the absence of a number of compounds known to interfere with Hancock and Laws' method. Infra-red spectroscopy revealed nothing more than the starting material of which a large excess had been added. Further tests with prolonged reaction time are underway.

(iv) Reaction products. Aromatic compounds, presumably phenols, were extracted from aged mixtures of coastal sea water and gamma BHC. They were investigated by ultraviolet spectroscopy and paper chromatography. A strong background of natural phenolic substances present in the sea water hampered the detection and identification of the reaction products. This difficulty is being overcome by the use of offshore ocean water which is relatively free from phenolic substances. Polyhydroxy phenols cannot be easily extracted. However, they can be determined directly by means of the Folin reagent, which does not react with polyhydroxy cyclohexanes. The 4-aminoantipyrine method for phenol traces was tested for interference by cyclitols, e.g., inositol. These substances were found to be non-interfering with the method.

Water-soluble alicyclic compounds may be a major portion of the reaction products. The determination of inositol, as the best known representative of this group, was studied in detail. Methods of concentrating inositol and separating it from the relatively large amounts of associated sea salts were investigated. Inositol was discovered to be noticeably volatile with water vapour. Due to this behaviour, serious losses can occur when dealing with the low concentrations and small quantities considered here.

Currently known methods of analysis are suitable only for milligram quantities of inositol (in dilutions 1:1000), while our work requires methods for the microgram range and dilutions of the order of 1:1,000,000. The method of Balatre and Traisnel and many variations of it were studied and were found to be unsatisfactory for extension to these ranges. Similar, if somewhat better, results were obtained with the nitric acid method developed here. The periodic acid oxidation method of Platt and Glock offers greater possibilities of extension to smaller inositol quantities.

Analysis by paper chromatography proved more sensitive and reliable than other methods, but its disadvantages are: (1) the sea salts interfere seriously, and (2) the sample must be applied in the form of a relatively concentrated solution. New de-salting and concentration methods for overcoming these limitations are currently being studied.

A new spot test for inositol was developed, consisting basically of forming a lead complex of inositol and subsequently converting it to a dark-coloured lead sulphide. Nagaij and Kimura's spot test was investigated and found so satisfactory that it was used to investigate quantitatively the above-mentioned volatility of inositol with steam.

b) Further evaluation of the nitrosolignin test for pulp mill effluent.

M. Waldichuk

(i) Standards. The "P-B" (Pearl and Benson) nitrosolignin test appears to give a good, simple approximation of the amount of KME (Kraft mill effluent) in sea water. A problem has been encountered in establishing a reliable standard for the colorimetric determination. The composite effluent from the sewer of a Kraft pulp mill varies from one pulp mill to another and even undergoes considerable variation within the same pulp mill from day to day. The technique of adjusting the effluent to a given percentage concentration of solids does not solve the problem, because the proportion of solids - lignin, non-lignin, organics, and inorganics - varies. The use of weak "black liquor" from the digestor has met with considerable success, but it suffers from the same shortcomings as the total effluent, if to a lesser degree. The lignin in black liquor can be readily precipitated by acidification and heating. By a series of resolutions and reprecipitations this material can be purified. Dissolved in alkaline solution, the purified lignin seems to offer the best answer so far to the problem of a reliable standard.

(ii) Interference by naturally-occurring phenolic substances. Background values of lignin concentration in near-shore sea water continue to pose a problem. Naturally-occurring phenolic compounds present in sea water respond quite readily to the P-B test. Under average conditions, they give a background value of the order of 5 ppm in terms of black liquor. There appears to be little constancy of this background from area to area or even in the same area over a period of time. Concentration of the brown-coloured humic acids contained in run-off waters varies widely according to the nature of the drainage basin. Marsh, muskeg and low-lying agricultural areas yield run-off which is highly discoloured giving high P-B values. Substances leached from drift wood, bark extracts, and even certain constituents in domestic sewage, e.g., urine, will give interference in the P-B test for pulp mill effluents.

Some index of the variability of these naturally-occurring organic substances is needed. Offshore oceanic water (Station Papa; 50°N, 145°W) gives a spectrophotometric absorption equivalent to that of distilled water. Brown-coloured water from streams passing through marshes and agricultural land (e.g., Bonsall Creek near Crofton) gives a large absorption equivalent to that of 100 ppm KME. Between these two extremes, there are the small daily variations in a particular area, which are caused by variations in precipitation and run-off, by log storage, and by introduction of other foreign substances. Values for the P-B background in various waters along the British Columbia coast are being determined and catalogued for reference.

(iii) Spent sulphite liquor determinations. This Station cooperated with the University of Washington Department of Chemical Engineering as one of the 20 laboratories using a revised and improved P-B test on samples of known concentrations of SSL (spent sulphite liquor). The analyses were part of an attempt to check reproducibility of results at different laboratories with the revised test.

Research is obviously needed on a new specific test for pulp mill wastes in sea water. This need is strongly indicated by the fact that the constituents which respond to the P-B test or are concentrated by ion exchange bear little relationship to the toxic or oxygen-consuming constituents of either SSL or KME.

3. Sea disposal of radioactive waste. M. Waldichuk

While no direct experimental work was carried out on the radioactivity problem, a considerable amount of time was spent reviewing the literature and attending meetings on radioactive waste disposal. The Fisheries Research Board was represented by the writer on the Pacific Coast Subcommittee of the U. S.

National Academy of Sciences - National Research Council on the disposal of low-level radioactive wastes off the Pacific coast. Two working meetings of this committee were attended during the course of the year. The committee's report is now being completed and will be published. Recommendations have been made for uniform regulations in low-level radioactive waste disposal along the Pacific coast from Mexico to Alaska.

The Fisheries Research Board was also represented by the writer at the Scientific Conference on Disposal of Radioactive Wastes co-sponsored by UNESCO and the IAEA (International Atomic Energy Agency) held in Monaco, November 16-21, 1959. A paper was presented there on the problem of containment of low-level radioactive waste for sea disposal and possible effects on the bottom fisheries off the British Columbia coast.

MARINE COMMERCIAL FISHERIES – HERRING

K. S. Ketchen and F. H. C. Taylor

In British Columbia, a well-equipped purse-seine fleet fishes extensively for herring during the winter months. In some years, a small summer purse-seine fishery occurs. The main fishery, however, takes place when the pre-spawning fish concentrate in late fall and early winter in the sheltered bays and inlets along the coast.

The object of herring research is to provide the scientific basis for a management program that will permit the greatest catch possible from all stocks under conditions which will promote maximum recruitment. In the continuing research program, emphasis is placed both on the assessment of the level of abundance in each population from data on catch, spawn deposition, and the strength of the contributing year-classes, and also on the determination of the relationship between the size of the spawning stock (measured by the amount of spawn deposited) and the resulting number of recruits to the fishable stocks (year-class strength). The data collected also provide some information pertinent to prediction. Various ecological and life history studies have been made or are being made in an effort to determine the factors causing variations in year-class strength, with the aim mainly of improving prediction.

Little information exists on herring between the time they leave the bays and inlets toward the end of their first year of life and the time they return again two years later as maturing three-year-old fish. A program to study the distribution and abundance of herring during a part of this period was initiated during the summer of 1959 in waters off the west coast of Vancouver Island.

The herring investigation group is also responsible for the preparation both of the additional material required to support the Canadian case for abstention by Japan from fishing British Columbian herring under the International North Pacific Fisheries Commission.

During the winter of 1959-60, a comprehensive review of the investigation and management of the British Columbia herring fishery was prepared for presentation to the British Columbia Herring Management Committee.

The data presented in the following reports are mainly for the 1958-59 herring fishing season covering the period from April, 1958, to March 1959, with certain information on the 1959 summer fishery, and on the results of experimental fishing in offshore waters in 1959.

1. The 1958-59 fishery. J. S. Rees

The successful negotiations early in 1958, of prices for both summer and winter herring fisheries, resulted in an almost continuous herring fishery from May, 1958 to March, 1959. The total catch in this period was 230,682 tons which is second only to the highest recorded catch of 250,962 tons made in the 1955-56 season. Of this figure the summer fishery contributed 22,062 tons and the winter fishery, 208,620 tons. Table 45 shows the catch and catch per unit of effort by sub-districts for the summer and winter fisheries in 1958-59 and in 1957-58, together with the average catch from 1951-52 to 1957-58.

The summer fishery, never as substantial or widespread as the regular winter fishery, was affected in 1958 by a heavy salmon run to which the efforts of many of the herring seiners were diverted. The 1958 summer catch was the lowest in three seasons and only half the 1957 summer catch. The largest catches were made in Area 12 where 8,349 tons, representing 38% of the total summer catch, were taken, and in Area 1 where 5,793 tons were caught, mainly off Shag Rock. The fish were caught mainly in June (29%) and July (63%).

The winter catch of 208,620 tons is five times greater than last year's and is the second highest winter catch on record. All sub-districts except the lower Queen Charlotte Islands yielded higher tonnages.

In the upper east coast of the Queen Charlotte Islands, 11,842 tons were caught entirely from Skidegate Inlet (Area 2AE). The lower east coast of the Queen Charlotte Islands yielded 7,527 tons, below last year's figure of 12,288 tons. Availability was, however, high at 113 tons/seine/day.

The northern sub-district accounted for 10,587 tons which represents 5% of the total winter catch. Area 5 contributed mainly to this total with a yield of 7,392 tons.

In the central sub-district the catch of 38,016 tons was over three times greater than the catch the previous year. Area 7 with a total of 30,866 tons was the main producer in this sub-district. The quota of 40,000 tons (including summer and winter catches) was taken by March 2 following which an extension was requested by the fishing industry but not granted.

The quota of 10,000 tons for the upper east coast sub-district was filled by November 9 and a quota extension of 5,000 tons was granted and taken in just over one week. Only 6,622 tons of this extended quota was taken during the winter fishery.

The middle east coast quota of 10,000 tons was taken by November 5. Deepwater Bay (Area 13) was the main fishing region accounting for 6,622 tons of this sub-district's total.

In the lower east coast the quota of 40,000 tons was taken by October 28, one of the earliest dates on record for this sub-district. An extension of 10,000 tons was taken in two days and a further extension of 3,000 tons was granted

Table 45. Catch and catch per unit of effort by sub-district for the 1958-59 summer and winter fisheries with comparative figures from the previous years.

Sub-district		Season	Catch 1958-59	Catch 1957-58	Average catch 1951-52 to 1958-59[1]	Catch per unit of effort[4] 1958-59	Catch per unit of effort[4] 1957-58
West coast Queen Charlotte Islands			(tons)	(tons)	(tons)		
	Area 1	summer[2]	5,793	254	-	50	-
	Area 2AW	winter[3]	-	-	-	-	-
	Area 2BW	winter	-	-	-	-	-
Upper east coast Queen Charlotte Islands	Area 2AE	summer	-	20	11,349	-	-
		winter	11,842	-		50	-
Lower east coast Queen Charlotte Islands	Area 2BE	winter	7,527	12,288	20,679	113	25
Northern	Areas 3-5	summer	1,208	10,775	24,866	14	27
		winter	10,587	1,550		29	45
Upper Central	Area 6	summer	578	1,142	7,418	29	13
		winter	1,525	5,677		20	60
Lower Central	Areas 7-10	summer	2,855	1,351	26,786	22	10
		winter	36,490	6,202		47	46
Upper east coast of Vancouver Is.		summer	8,349	3,523	8,316	27	26
		winter	6,428	-		55	-
Middle east coast of Vancouver Is.		summer	46	3,995	17,649	-	24
		winter	10,411	6,075		25	67
Lower east coast of Vancouver Is.		summer	3,232	8,472	43,421	17	19
		winter	46,478	8,879		51	35
Lower west coast of Vancouver Is.		summer	-	12,390	18,381	-	36
		winter	41,649	533		38	35
Upper west coast of Vancouver Is.		summer	-	48	10,282	-	36
		winter	35,684	-		108	-
Total (tons)		summer	22,061	41,970	188,514	-	-
		winter	208,621	41,204		-	-
Grand Total			230,682	83,174	188,514	-	-

1) Catches in 1952-53 ommitted because of fishermen's strikes.

2) Summer fishery - June 1 to August 16, except in the lower east coast where the opening date is May 1.

3) Winter fishery affected by strike - season closes in District 3 on February 5 and in District 2 on March 10.

4) Catch per unit of effort is in tons per seine per day.

for food purposes. Only 692 tons of this later extension were taken. A large fishery in the vicinity of Nanoose Bay and Nanaimo inside Area 17A was the main producer with 30,063 tons. The total winter catch for this sub-district was 46,478 tons with an availability of 51.4 tons/seine/day.

In the lower west coast the catch was 41,649 tons, the highest on record for this sub-district. Barkley Sound, after several years of low production, accounted for 39,635 tons of this total.

The upper west coast sub-district also produced the highest catch on record of 35,684 tons, caught mainly in Area 25. Availability was high, 107.9 tons/seine/day.

2. Tag recovery. F. H. C. Taylor

In the 1958-59 season, 223 herring tags were recovered by magnets from nine reduction plants. An additional 18 were recovered which appeared to be hold-overs from the preceding season. Six recoveries were from the summer fishery in the lower east coast, and one from the Alaskan summer fishery - the first record of a return from Alaska. The remaining 216 were from the regular winter fishery.

Because of differences among plants in equipment, in the location of the magnets, and in the diligence of plant crews, the efficiency of the plants in recovering tags varies. Tests to determine the efficiency were carried out in 10 plants with the results shown below (efficiencies in 1956-57 are shown in parentheses).

Plant	No. of Tests	Efficiency or Average Efficiency
Southern B. C.		
Imperial	2	79 (84)
Colonial	3	82 (76)
Gulf of Georgia	1	84 (94)
Phoenix	1	96 (97)
North Shore	1	88 (89)
Shingle Bay	1	32 (--)
Central B. C.		
Namu	1	96 (96)
Butedale	1	94 (--)
Northern B. C.		
Port Edward	2	80 (68)
Fairview	2	84 (90)

In 1957-58 only one reduction plant operated because of an industrial dispute. The results obtained in 1958-59 compare reasonably well with those obtained in 1956-57. Some plants decreased in efficiency, while others increased. The small Shingle Bay plant was very inefficient. No recoveries of tagged fish were made in this plant.

Movement between populations can be estimated from the probable numbers of tags in the catches, calculated from the actual plant magnet returns adjusted for the varying efficiencies of the magnets in different plants and the varying proportion of the catches in the different sub-districts searched by magnets. Table 46 shows the probable numbers of tags by sub-district of tagging and recovery; actual numbers of recoveries are shown in parentheses.

As in 1957-58, the small numbers of recoveries make estimates of movement between populations unreliable. Since it has been demonstrated that the degree of dispersal from the area of tagging varies with the number of years at liberty, comparisons cannot be made with recoveries in previous years. The middle and lower east coast populations were tagged up to 1956, other populations only up to 1954; except for five taggings in the summer of 1957, two each in Hecate Strait (Area 5) and Caamano Sound (Area 5) and one in Bate Pass (Area 12).

Because of the longer period of liberty, the degree of dispersion indicated from each sub-district is somewhat greater than in previous years. However, the majority of recoveries were still from the sub-district of tagging.

Recoveries from the northern and upper west coast sub-districts are of interest. In the former, all except 2 of the 106 recoveries were from tags put out in the summer of 1957. These recoveries can be divided into two distinct groups. Of the fish tagged in Hecate Strait, 65% of the recoveries were from the upper Queen Charlotte Island sub-district, and 12% each from the northern and lower central sub-districts. Of the fish tagged in Caamano Sound, on the other hand, 57% were recovered within the northern sub-district, 26% from the lower central and 6% each from the upper and lower Queen Charlotte Islands sub-districts.

The heavy fishery in the upper west coast of Vancouver Island sub-district produced 23 tags, 20 from fish originally tagged there in 1952, 1953 and 1954. On the other hand, the equally large fishery in the lower west coast produced only 5 tags. This disparity in number of recoveries, considering that as many or more herring were tagged in the lower west coast as in the upper west coast from 1952 to 1954, suggests that the upper west coast population has not been as heavily exploited in recent years as the lower west coast population.

Thirty-six recoveries were made of fish tagged in the State of Washington; one from a tagging in Holmes Harbour in 1956, four from taggings in the Hood Canal in 1957, seven from taggings in Bellingham Bay and 24 from taggings in Boundary Bay in 1958. Twenty-eight, including six in June and July, were from the lower east coast of Vancouver Island sub-district, five were from the lower west coast, one from the upper west coast and two could not be assigned to any definite area. It would appear that movement of herring tagged in the State of Washington into British Columbia stocks is probably no greater than between adjacent stocks of similar size in British Columbia.

The first recorded recovery from Alaska of a herring tagged in British Columbia occurred in the summer of 1958. A herring tagged in Hecate Strait 10 to 15 miles west of Seal Rocks on July 10, 1957, was recovered at the Big Port Walter reduction plant between August 3 and 9, 1958, from fish caught in the lower Chatham Sound region.

Six recoveries were made from herring tagged as juveniles. Five were from fish tagged in Area 15 and one from a tagging in Area 17B. Of the herring tagged in Area 15, two recoveries were definitely from the lower east coast of

Table 46. Probable numbers of tags in the catches, by sub-district of tagging and of recovery, with actual numbers of recoveries in parentheses.

Sub-district of Tagging	Sub-district of Recovery: Upper Q.C.I.	Lower Q.C.I.	Northern	Upper Central	Lower Central	Upper east coast	Middle east coast	Lower east coast	Lower west coast	Upper west coast	?	Total
Upper Q.C.I.	16(13)											16(13)
Lower Q.C.I.									1(1)			1(1)
Northern	37(30)	8(6)	48(42)		27(25)					1(1)	2(2)	123(106)
Upper Central			1(1)									1(1)
Lower Central					5(4)							5(4)
Upper East Coast					1(1)	2(2)						3(3)
Middle East Coast					1(1)			8(7)	1(1)		5(4)	15(13)
Lower East Coast								5(4)	4(3)	1(1)	4(3)	14(11)
Lower West Coast										5(5)		5(5)
Upper West Coast									2(2)	23(20)	1(1)	26(23)
Juvenile Tags								4(3)	1(1)		2(2)	7(6)
Washington State												
Holmes Harbour								1(1)				1(1)
Hood Canal								5(4)				5(4)
Bellingham Bay								8(6)	1(1)			9(7)
Boundary Bay								19(17)	5(4)	1(1)	2(2)	27(24)
Total	53(43)	8(6)	49(43)		34(31)	2(2)		50(42)	15(13)	31(28)	16(14)	258(222)

Northern Sub-district. 1957 summer taggings (also included above)

Sub-district of Tagging	Upper Q.C.I.	Lower Q.C.I.	Northern	Upper Central	Lower Central	Upper east coast	Middle east coast	Lower east coast	Lower west coast	Upper west coast	?	Total
Hecate Strait	34(28)	3(2)	7(6)		7(6)						1(1)	52(43)
Caamano Sound	4(3)	5(4)	39(34)		19(18)					1(1)	1(1)	69(61)

Vancouver Island and one from the lower west coast. The remaining two were recovered in either the middle or lower east coast. The Area 17B tag was recovered from the lower east coast.

3. Sampling of the commercial catches. R. S. Isaacson

Samples were obtained from the 1958 summer and 1958-59 winter herring fisheries. Information on the age composition, average length and weight, sex ratio and state of sexual maturity of the various populations of herring which contributed to the fishery was obtained from these samples. The unselected samples were taken from the hold of the packer prior to unloading. Fifty fish were considered to provide an adequate and practical sample. Personnel at various processing plants along the coast assisted in the collection of these samples.

A total of 576 samples totalling 27,321 herring were collected. Of this total, 80 samples (3,101 fish) were taken during the summer fishery and 496 (24,220 fish) from the winter. The ratio in 1958-59 of one sample for every 400 tons of fish caught is about average, although considerably lower than in the previous season (1:198 tons) when the fishery was curtailed by a strike. (See Table 47).

The average percentage age composition, the average length and average weight of herring at each age and the sex ratio are obtained for each area. On the assumption that abundance of herring in each area is proportional to the catch there, the percentage age composition (Table 49), sex ratio (Table 52), average length (Table 50) and average weight (Table 51) for each sub-district are calculated from the averages for the areas included within the sub-district, weighted in the case of the two former by the total numbers of fish caught in each area; in the two latter by the number of fish of each age caught in each area (Table 48).

a) Age composition. Fish of Age III from the 1956 year-class were the largest contributors to the fishery. This age group was dominant in the catches from nine of ten populations fished during the winter and in six of seven fished during the summer. In the winter fishery in the upper west coast sub-district, Age IV fish were dominant and in the summer fishery in the upper Queen Charlotte Islands, Age VI fish were dominant.

In terms of numbers of fish, the 1956 year-class made the largest recorded annual contribution by one year-class in both the lower east coast and lower west coast sub-districts. This year-class was certainly of above-average strength in these two populations and also probably in the major lower central population. Three year-classes contributed almost equally to the record upper west coast catch, the 1956 as Age III fish, the 1955 as IV and the 1954 as V. The large catch with a high proportion of IV- and V-year-old fish tends to support the hypothesis that abundance in the upper west coast population has been at a high level for several seasons but that the stock has not been fully exploited because of late inshore migration. In the northern and Queen Charlotte Islands populations, the 1956 year-class, although dominant, may not be as strong as in the more southerly populations.

Two-year-old fish (the 1957 year-class) were well represented in both the middle and lower east coast populations suggesting that this year-class may also be relatively strong in these populations.

b) Length and weight. In the winter fishery, fish of Ages II and III were generally larger and heavier than in the previous season. There was a tendency

Table 47. Herring catch and number of samples obtained during the 1958 summer and 1958-59 winter fishing season.

Population	Season	Catch (tons) Summer	Catch (tons) Winter	Catch (tons) Total	Samples taken Summer	Samples taken Winter	Samples taken Total
Upper Queen Charlotte Islands	summer	5,793			21		
	winter		11,842			24	
	Total			17,635			45
Lower Queen Charlotte Islands	summer	-			-		
	winter		7,527			2	
	Total			7,527			2
Northern	summer	1,208			8		
	winter		10,587			37	
	Total			11,795			45
Upper Central	summer	578			4		
	winter		1,525			8	
	Total			2,103			12
Lower Central	summer	2,856			25		
	winter		36,490			103	
	Total			39,346			128
Upper East Coast	summer	8,349			13		
	winter		6,428			25	
	Total			14,777			38
Middle East Coast	summer	46			-		
	winter		10,411			48	
	Total			10,457			48
Lower East Coast	summer	3,232			9		
	winter		46,478			171	
	Total			49,710			180
Lower West Coast	summer	-			-		
	winter		41,649			44	
	Total			41,649			44
Upper West Coast	summer	-			-		
	winter		35,684			34	
	Total			35,684			34
Total		22,062	208,621	230,683	80	496	576

Table 48. Number of herring (in millions) caught at each age during the 1958 summer and 1958-59 winter fishing seasons. (Asterisk - No samples obtained - based on 1958-59 samples)

Population	Season	I	II	III	IV	V	VI	VII	VIII+	Total
		In year of age								
Upper Queen Charlotte Is. (Areas 1, 2A east)	summer	-	-	2.78	4.92	10.06	16.42	5.73	2.24	42.15
	winter	-	9.64	79.92	17.05	8.47	2.72	3.51	6.81	128.12
	Total	-	9.64	82.70	21.97	18.53	19.14	9.24	9.05	170.27
Lower Queen Charlotte Is. (Area 2B east)	winter	-	0.80	47.51	20.18	5.30	-	-	-	73.79
Northern (Areas 3-5)	summer	-	1.05	3.70	1.92	1.32	1.68	0.75	0.09	10.51
	winter	-	2.60	58.77	20.64	5.78	7.47	1.36	1.49	98.11
	Total	-	3.65	62.47	22.56	7.10	9.15	2.11	1.58	108.62
Upper Central (Area 6)	summer	-	0.41	6.36	1.61	0.23	0.23	0.05	-	8.89
	winter	1.42	2.67	11.52	4.98	0.90	0.11	0.05	0.11	21.76
	Total	1.42	3.08	17.88	6.59	1.13	0.34	0.10	0.11	30.65
Lower Central										
Major population	winter	-	8.39	156.39	122.10	29.42	2.87	1.71	1.71	322.59
Minor population	summer	-	2.49	16.93	12.53	3.98	1.55	1.55	1.52	39.00
	winter	-	5.23	30.14	31.62	6.90	1.20	1.09	0.13	76.31
	Total	-	7.72	47.07	44.15	10.88	2.75	2.64	1.65	115.31
Upper East Coast (Areas 11, 12)	summer	-	3.95	56.57	32.00	8.98	0.90	2.48	0.22	105.10
	winter	0.08	8.27	47.98	25.80	6.83	2.49	3.55	1.96	96.96
	Total	0.08	12.22	104.55	57.80	15.81	3.39	6.03	2.18	202.06
Middle East Coast (Areas 13-16)	summer*	0.01	0.15	0.32	0.08	0.01	-	+	+	0.57
	winter	1.04	23.55	68.39	21.03	3.09	0.44	0.57	0.13	118.24
	Total	1.05	23.70	68.71	21.11	3.10	0.44	0.57	0.13	118.81
Lower East Coast (Areas 17A-20)	summer	-	0.98	19.66	7.01	3.06	1.17	0.22	0.60	32.70
	winter	3.77	79.19	342.15	74.28	11.56	2.33	0.77	0.89	514.94
	Total	3.77	80.17	361.81	81.29	14.62	3.50	0.99	1.49	546.64
Lower West Coast (Areas 21-24)	winter	-	20.04	264.46	109.04	26.90	4.29	0.83	1.22	434.78
Upper West Coast (Areas 25-27)	winter	-	3.95	77.48	96.98	80.74	24.05	17.20	18.61	319.01

Table 49. Age composition based on number of fish caught during the 1958 summer and 1958-59 winter fishing seasons.

Population	Season	In year of age I	II	III	IV	V	VI	VII	VIII+
Upper Queen Charlotte Islands (Areas 1, 2A east)	summer	-	-	6.59	11.68	23.86	38.95	13.59	5.33
	winter	-	7.52	62.37	13.31	6.61	2.12	2.74	5.32
Lower Queen Charlotte Islands (Area 2B east)	winter	-	1.08	64.39	27.35	7.18	-	-	-
Northern (Areas 3-5)	summer	-	-	40.06	20.74	10.66	18.27	9.13	1.14
	winter	-	2.65	59.90	21.04	5.89	7.61	1.39	1.52
Upper Central (Area 6)	summer	-	4.61	71.59	18.08	2.59	2.61	0.52	-
	winter	6.53	12.26	52.94	22.87	4.12	0.52	0.25	0.51
Lower Central (Areas 7-10)									
Major population	winter	-	2.60	48.48	37.85	9.12	0.89	0.53	0.53
Minor population	summer	-	6.38	43.42	32.12	10.20	3.97	3.44	0.47
	winter	-	6.85	39.50	41.44	9.04	1.57	1.43	0.17
Upper East Coast (Areas 11, 12)	summer	-	3.76	53.82	30.44	8.54	0.86	2.36	0.21
	winter	0.08	8.53	49.48	26.61	7.04	2.57	3.66	2.03
Middle East Coast (Areas 13-16)	summer*	no samples obtained							
	winter	0.88	19.92	57.84	17.78	2.61	0.37	0.48	0.11
Lower East Coast (Areas 17A-20)	summer	-	3.00	60.12	21.44	9.36	3.58	0.67	1.83
	winter	0.73	15.38	66.44	14.42	2.25	0.45	0.15	0.18
Lower West Coast (Areas 21-24)	winter	-	6.45	60.83	25.08	6.19	0.99	0.19	0.28
Upper West Coast (Areas 25-27)	winter	-	1.24	24.29	30.40	25.31	7.54	5.39	5.83

* No samples obtained - based on 1958-59 samples

Table 50. Average length (mm) of herring by population caught during the 1958 summer and 1958-59 winter fishing seasons.

Population	Season	I	II	III	IV	V	VI	VII	VIII	Mean
		In year of age								
Upper Queen Charlotte Islands (Areas 1, 2A east)	summer	-	-	179.0	184.5	205.6	208.0	218.9	223.0	205.4
	winter	-	149.9	175.2	179.8	186.3	205.6	224.7	231.7	179.7
Lower Queen Charlotte Islands (Area 2B east)	winter	-	173.0*	189.8	193.3	205.6	-	-	-	192.0
Northern (Areas 3-5)	summer	-	-	175.5	186.0	205.4	212.5	221.2	220.9	193.7
	winter	-	148.8	185.8	194.4	202.8	215.3	220.2	222.8	190.9
Upper Central (Area 6)	summer	-	138.1	156.9	175.1	187.8	183.8	188.0	-	160.7
	winter	115.0	147.3	161.2	185.6	198.1	194.5	190.0	212.0	163.6
Lower Central (Areas 7-10)										
Major population	winter	-	144.1	180.2	189.6	198.5	197.1	210.4	209.3	185.0
Minor population	summer	-	140.6	161.6	172.8	184.4	192.5	195.8	206.2	168.4
	winter	-	140.7	162.6	170.9	180.8	189.9	189.6	203.0	167.0
Upper East Coast (Areas 11, 12)	summer	-	136.6	166.9	181.2	189.9	192.5	203.6	200.0	172.7
	winter	108.0	141.6	155.7	169.5	171.6	175.5	183.0	184.9	161.7
Middle East Coast (Areas 13-16)						no samples obtained				
	winter	121.6	150.4	177.5	192.1	209.6	223.4	224.2	234.0	176.0
Lower East Coast (Areas 17A-20)	summer	-	139.8	176.3	193.8	208.9	212.4	233.5	227.2	184.2
	winter	118.1	153.6	183.1	192.8	202.0	214.0	209.2	216.4	180.4
Lower West Coast (Areas 21-24)	winter	-	158.4	182.1	192.7	202.2	212.4	217.2	203.2	184.9
Upper West Coast (Areas 25-27)	winter	-	158.8	181.1	192.5	203.5	193.9	215.5	218.9	195.2

* One fish only

Table 51. Average weights (gms) of herring caught during the 1958 summer and 1958-59 winter fishing seasons.

Population	Season	In year of age I	II	III	IV	V	VI	VII	VIII	Mean
Upper Queen Charlotte Islands (Areas 1, 2A east)	summer	-	-	78.0	86.9	124.4	129.7	149.1	164.2	125.4
	winter	-	43.6	72.8	81.3	93.9	131.0	171.9	189.4	83.5
Lower Queen Charlotte Islands (Area 2B east)	winter	-	62.0	88.2	98.4	117.1				92.9
Northern (Areas 3-5)	summer	-	-	74.0	89.4	128.7	140.3	164.5	148.7	106.9
	winter	-	42.1	86.7	102.1	120.1	149.6	155.5	165.0	97.6
Upper Central (Area 6)	summer	-	38.1	54.4	74.7	98.4	81.2	84.0	-	59.2
	winter	15.9	42.9	59.2	87.6	108.8	99.5	102.0	133.0	63.1
Lower Central (Areas 7-10) Major population	winter	-	38.8	78.5	93.6	109.6	108.0	134.2	134.6	86.8
Minor population	summer	-	36.4	57.1	71.0	86.6	93.4	100.0	124.0	65.9
	winter	-	35.2	59.3	72.1	86.9	96.4	103.8	136.0	66.6
Upper East Coast (Areas 11, 12)	summer	-	33.4	63.5	81.6	92.2	84.0	111.4	102.0	71.0
	winter	15.9	37.0	53.0	70.2	73.8	76.8	85.1	89.3	60.6
Middle East Coast (Areas 13-16)	winter	24.0	48.4	79.6	103.3	145.6	177.4	192.0	193.0	80.5
Lower East Coast (Areas 17A-20)	summer	-	37.6	80.0	112.0	138.4	140.4	180.0	187.5	95.0
	winter	21.0	49.7	83.8	98.0	123.3	154.8	144.8	161.1	81.8
Lower West Coast (Areas 21-24)	winter	-	50.9	81.8	98.7	113.2	136.4	126.5	103.8	86.7
Upper West Coast (Areas 25-27)	winter	-	48.8	77.1	95.0	112.9	122.4	133.7	139.3	101.6

Table 52. Sex ratio (females/males) in the herring catches during the 1958 summer and 1958-59 winter fishing seasons.

Population	Sex ratio Summer	Sex ratio Winter	Percent mature Winter only
Upper Queen Charlotte Islands (Areas 1, 2A east)	1.98	1.18	98.0
Lower Queen Charlotte Islands (Area 2B east)	-	1.27	100.0
Northern (Areas 3-5)	1.81	1.07	99.4
Upper Central (Area 6)	3.63	1.43	80.5
Lower Central (Areas 7-10)			
Major population	-	1.05	98.0
Minor population	2.56	1.03	96.0
Upper East Coast (Areas 11, 12)	2.74	1.21	88.9
Middle East Coast (Areas 13-16)	-	1.06	78.4
Lower East Coast (Areas 17A-20)	1.72	0.87	89.1
Lower West Coast (Areas 21-24)	-	1.20	98.0
Upper West Coast (Areas 25-27)	-	0.97	99.8

for the fish from the lower east and upper and lower west coasts of Vancouver Island to be smaller but heavier than in the 1957-58 season. In the northern British Columbia stocks, fish of Age IV and older tended to be slightly larger than in the previous season.

c) Sex ratio and maturity. There was a slightly higher proportion of males in the 1958-59 catch than in the previous season, due largely to the decrease in the numbers of Age II fish in the catches.

Approximately 90% of the fish sampled were mature. The middle east coast catch contained the lowest proportion (78.4%) of mature fish and attributed to the large proportion of immature II-year-old fish in the catch here.

4. Spawn deposition. D. N. Outram

One of the major aspects of adult herring studies involves annual estimates of the extent and intensity of the herring spawnings which take place in the coastal waters of British Columbia each spring. Since the amount of spawn deposited in any region is related to the number of spawners, annual estimates of spawning not only forms a basis for a quantitative index of the size of the spawning escapements but also will provide an indication of the number of survivors forming the carry-over to next year's fishery.

a) The 1959 spawn census. Annual spawn surveys are carried out by officers of the Federal Department of Fisheries. The length and width of over 180 spawnings were recorded in 1959 and the intensity of each expressed as one of five broad categories (very light, light, medium, heavy or very heavy) depending on the number of eggs deposited per unit area of vegetation.

Since Pacific herring deposit eggs primarily on vegetation growing within and just below the intertidal zone, the boundaries of the spawning zones can be readily determined. The extent is measured in yards and later converted to an equivalent length in statutory miles, after adjusting for differences in intensity. For example, 3,520 yards or 2.0 statutory miles at a reported light (2) intensity is equivalent to 1.3 miles at a medium (3) or standard intensity ($2/3 \times 2.0 = 1.3$ miles). By summing the equivalent lengths, an annual spawning index is obtained for each statistical area and by adding the area indices, the relative amounts of spawn deposited in a sub-district and on the coast as a whole are obtained.

The number of statutory miles of herring spawn, adjusted to a standard intensity by area and sub-district, recorded in British Columbia in 1959 are given in Table 53. The results of previous years' surveys and a 20-year average (1937-56) are also included for comparison. Figures in parentheses are estimates of the extent of spawn derived from combined fishery officers' and biological station surveys. All other figures are based on fishery officers' reports.

b) Coastwide summary of spawning success. A total of 154.7 miles of herring spawn was surveyed in British Columbia coastal waters in 1959, an increase of 35% from the record low level of the previous year but still far below the 20-year average (1937-56) of 205 miles.

The extent of spawning showed an increase in seven sub-districts from the 1958 level. Large increases took place along the east and west coasts of the Queen Charlotte Islands and the upper central sub-districts where, however, spawning has averaged only about one mile for the past two years. Spawning also

Table 53. Statutory miles of herring spawn, adjusted to a standard intensity by statistical area and sub-district, deposited in British Columbia and adjacent coastal waters of Washington State in 1959. For comparison, 1957 and 1958 results are also shown, together with 20-year averages (1937-1956).

Sub-district	Area	Statutory miles of spawn at a standard intensity of medium			
		20-year average 1937-56	1957	1958	1959
Upper east coast Q.C.I.	2A-E	3.3	...	0.2	1.1
Lower east coast Q.C.I.	2B-E	14.7	2.8	1.5	12.5
West coast Q.C.I.	2A-W	...	0.1	0.4	10.0
	2B-W	...	...	...	2.0
		...	0.1	0.4	12.0
Northern	3	0.7	11.1	0.4	0.4
	4	12.3	9.8	7.9	16.3
	5	4.4	10.8	3.9	4.9
		17.4	31.7	12.2	21.6
Upper Central	6	24.1	0.9	1.2	8.4
Lower Central	7	21.6	11.4	6.3	4.5
	8	7.0	1.6	5.2	3.1
	9	2.8	0.1	2.8	0.2
	10	3.4	1.7	5.7	1.2
		34.9	14.8	20.0	9.0
Upper east coast Van. Is.	11	0.1	0.1	0.1	4.4
	12	16.6	9.8	9.8	8.1
		16.7	9.9	9.9	12.5
Middle east coast Van. Is.	13	4.1 (4.5)	2.8 (2.0)	6.2	7.5
	14	16.8 (17.0)	6.1 (6.1)	3.2	20.3
	15	2.2 (2.2)	2.8 (3.2)	...	1.0
	16	3.1 (2.0)	1.1 (1.1)	2.5	2.6
		26.4 (26.8)	12.8 (12.4)	11.9	31.4
Lower east coast Van. Is.	17A	7.7 (7.8)	16.9	2.2 (4.7)	2.6
	17B	18.7 (19.7)	0.5	6.3 (7.3)	15.7
	18	1.9 (2.4)	4.9	3.8 (11.7)	6.7
	19	0.2	...	...	0.2
		28.5 (29.9)	22.3	12.3 (23.7)	25.2
Lower west coast Van. Is.	23	8.7 (11.4)	7.9	10.2	3.4
	24	5.8 (5.2)	1.8	6.5	6.0
		14.5 (16.6)	9.7	16.7	9.4
Upper west coast Van. Is.	25	7.1 (13.6)	22.0	9.9	5.9
	26	2.1 (2.6)	1.6	1.4	0.8
	27	3.3 (3.6)	0.8	0.2	0.2
		12.5 (19.8)	24.4	11.5	6.9
Lower Mainland (Dist. 1)	28	...	...	2.3	...
	U.S.A.	...	2.1 (2.1)	2.8	4.7
		...	2.1 (2.1)	5.1	4.7
Grand total	All areas	192.9 (205.0)	131.5 (131.1)	102.9 (114.3)	154.7

increased but to a lesser extent in the upper east coast of Vancouver Island sub-district (by 26%), in the northern (by 77%) and in the middle east coast of Vancouver Island (by 164%).

The 1959 spawning was markedly below the 1958 level in three sub-districts: the lower central (by 55%), the lower west coast of Vancouver Island (by 44%) and the upper west coast of Vancouver Island (by 40%). Amounts of spawn comparable to those found in 1958 were reported in 1959 from two sub-districts: the lower east coast of Vancouver Island and the lower mainland.

In spite of the second-largest winter catch on record, the size of the 1959 spawning escapements showed an increase from the previous year in all but three sub-districts. This terminated a steady, downward trend apparent during the past six years in the total amount of spawn deposited along the British Columbia coast.

It is encouraging to note also that twelve new spawning grounds were discovered in 1959, principally on the west coast of the Queen Charlotte Islands and in the lower central sub-district.

c) Summary of spawning by sub-districts.

Upper east coast of the Queen Charlotte Islands sub-district (Area 2A-E). As in the past four years, spawning was almost negligible along the upper east coast of the Queen Charlotte Islands. About one mile of spawn was located in 1959.

Lower east coast of the Queen Charlotte Islands sub-district (Area 2B-E). Along the lower east coast of the Queen Charlotte Islands, the amount of spawn (12.5 miles) recorded in 1959 was comparable to the 20-year average (1937-56) for the first time since 1955. About 8 times as much spawn was found in 1959 as in 1958. Extensive spawnings in the Burnaby Straits region (5.4 miles) and the discovery of a new spawning ground at Fowrivco Bay (4.1 miles) were primarily responsible for the increased spawn deposition in this region in 1959. The sizes of the spawning stocks in the lower east coast have been decreasing consistently for the past few years. In 1959, however, the spawning escapement increased, due possibly to the reduced winter fishery in this area.

West coast of the Queen Charlotte Islands (Areas 2A-W, 2B-W). Attempts to survey the exposed regions along the west coast of the Queen Charlotte Islands in 1959 indicated that as much, if not more, spawn may be deposited in this region as along the east coast. New and extensive spawning grounds were found in Area 2A-W at Newcombe Inlet (3.0 miles), Port Chanal (2.0 miles) and Inskip Channel (1.9 miles). The recurrence of a large spawning in Louscoone Inlet (2.0 miles) in Area 2B-W should be noted. A total of 12.0 miles of spawn was located in 1959, about 30 times as much as in 1958 and almost comparable to the 13.6 miles found along the upper and lower east coasts of the Queen Charlotte Islands. It would appear that unexpectedly large spawning stocks move inshore annually to spawn along the rugged west coast of the Queen Charlotte Islands.

Northern sub-district (Areas 3, 4 and 5). Spawn deposition in this region in 1959 was 21.6 miles, slightly above the 20-year average (1937-56) and 77% greater than in 1958. The largest spawning on the coast, 9.4 miles at Big Bay (Area 4), was primarily responsible for the increase in this sub-district. It would appear that late inshore spawning migrations to the regions north and south of Big Bay have built up the spawn deposition to a high level in Area 4 in recent years.

<u>Upper central sub-district (Area 6)</u>. In the upper central sub-district (Area 6) spawn deposition averaged 35.3 miles from 1937 to 1948, then decreased abruptly to an average of 13.0 miles from 1949 to 1951 and decreased further to an average of 3.7 miles from 1952 to 1958. The 1959 deposition of 8.4 miles is 7 times greater than that of 1958 and is most encouraging since it represents the largest spawning since 1951. Large spawnings in Gardner Canal (1.7 miles) and at the head of Kitimat Arm (2.4 miles) were primarily responsible for the increased spawning in this sub-district in 1959.

<u>Lower central sub-district (Areas 7-10)</u>. In the lower central sub-district (Areas 7, 8, 9, 10) the amount of spawn located in 1959 was the lowest on record (9.0 miles), far below the 20-year average of 34.9 miles and only half the 1958 level. An above-average winter catch of 36,500 tons may have reduced the size of the spawning escapement.

<u>Upper east coast of Vancouver Island sub-district (Areas 11 and 12)</u>. Although spawning (12.5 miles) increased by 26% in 1959 from the previous year, it remained below the 20-year average for the third successive year. Two large spawnings (4.4 miles) in the usually non-productive Area 11 at Nugent Sound were responsible for the increased spawn deposition in this sub-district in 1959. A greater-than-average catch may have kept the size of the spawning stocks at a below-average level.

<u>Middle east coast of Vancouver Island sub-district (Areas 13, 14, 15, 16)</u>. The 1959 spawn deposition of 31.4 miles was 2 1/2 times greater than that of the previous year and above the 20-year average of 26.8 miles. Spawning increased in all four areas, particularly in Area 14, where extensive spawnings occurred in the vicinity of Cape Lazo (8.0 miles) and Qualicum Beach (5.7 miles). After an absence of spawning in Area 15 in 1958, one mile was reported this year, including a new spawning ground at Squirrel Cove. The above-average 1959 spawn deposition, coupled with the fact that the 10,000 ton quota was readily taken, suggests that the abundance of the herring stocks in this sub-district may have increased from the 1958 level.

<u>Lower east coast of Vancouver Island sub-district (Areas 17A, 17B, 18, 19)</u>. Spawning increased by 6% in 1959 from the previous year; 25.2 miles of spawn were reported, slightly below the 20-year average of 30 miles for this sub-district. Marked reductions in the amount of spawn deposited in Area 17A and 18 were more than offset by an increase in the number and size of spawnings in Area 17B, particularly those along the west shore of Valdes Island and south of Dodd Narrows. It would appear that sufficient spawners escaped the heavy winter fishery (6,000 tons over the 40,000 ton quota) to realize an adequate spawning population.

An unusual feature of the 1959 spawning along the lower east coast of Vancouver Island was the increased use of japweed (<u>Sargassum</u>) as the main spawning substrate in preference to eel grass (<u>Zostera</u>). The change-over from eel grass to japweed may be attributed to (1) a change in preference for substrate or (2) the increasing and widespread abundance of japweed in this region. Japweed was introduced incidentally to this coast in the early 1940's with oyster spat from Japan. This brown algae has subsequently become well established in the lower intertidal zone and is gradually supplanting eel grass as the major type of marine vegetation on the lower east coast of Vancouver Island spawning grounds.

Lower west coast of Vancouver Island sub-district (Areas 20, 21, 22, 23, 24). The 1959 spawning of 9.4 miles was about half that of the previous year and one of the lowest on record. A reduction in both the number and size of spawnings at Toquart Bay and along Macoah Passage (Area 23) produced a smaller spawning in Area 23 than in Area 24 for the first time since 1946. The below-average 1959 spawning followed an all-time record catch of 41,000 tons.

Preliminary surveys of the southwest coast of Vancouver Island from Sooke Harbour to Clo-oose (Areas 20, 21, 22) were carried out by Biological Station personnel. This portion of the coastline has never been thoroughly searched for herring spawnings. Indications were obtained that herring spawn in Nitinat Lake and Sooke Harbour.

Upper west coast of Vancouver Island sub-district (Areas 25, 26, 27). The size of the spawning stocks in this region continued to decrease in 1959 from the exceptionally high levels of previous years. Only 6.9 miles of spawn were located, a 40% reduction from the 1958 level and the smallest amount recorded since 1945. Less than one mile of spawn was found in Areas 26 and 27. It is difficult to say whether the decrease in Areas 26 and 27 represents an actual reduction in the size of the spawning stocks or stems from decreased coverage by fishery officers due to lack of suitable vessels. A record winter catch of 35,000 tons taken primarily in Area 25 may have been followed by a reduced spawning escapement.

Lower mainland (Area 28). This region, although not recognized as supporting a major herring population, produced about 5 miles of spawn in 1959, about the same as in 1958. A large spawning of 4.7 miles was found in Boundary Bay in late February.

5. Status of the stocks in 1958-59.

F. H. C. Taylor

In 1957-58 abundance in each of the major populations decreased and was below average in all except possibly the middle east coast (Areas 13 to 16) and lower east coast (Areas 17 to 19) populations. In 1958-59 catch and spawn deposition (Table 54) indicated that moderate increases in abundance over the 1957-58 levels had occurred in the upper Queen Charlotte Islands (Area 2AE), lower Queen Charlotte Islands (Area 2BE), northern (Areas 3 to 5), upper central (Area 6) and lower central (Areas 7 to 10) populations and that sharp increases in abundance had occurred in the middle east coast, lower east coast, lower west coast (Areas 23 and 24) and upper west coast (Areas 25 to 27) populations. In the latter two populations, record catches were followed by reduced spawnings.

The level of abundance is determined mainly by the numbers of III-, IV- and V-year-old fish in the population. In southern populations (those in District 3) the level of abundance is determined principally by the numbers of III-year-olds present; the contributions of IV- and V-year-old fish are less important than they are in the north. The relative strengths of the year-classes contributing fish of Ages III to V explain the low level of abundance in 1957-58 and the increase in most populations in 1958-59. Thus, in 1957-58, the year-classes contributing the III- and IV-year-old fish (1955 and 1954 year-classes respectively) were weak or below average in strength in all populations except the upper central where they were of above average strength. The 1953 year-class contributing V-year-olds was also weak in most populations, except the northern where it was of above average strength and the lower east coast and lower west coast populations where it was probably average.

Table 54. Spawn deposition and catch in 1957-58, and 1958-59 together with the averages, by major populations.

Population or sub-district	Area	Spawn in miles at standard intensity			Catch in tons		
		20-year average 1937-56	1958	1959	Average*	1957-58	1958-59
Upper Queen Charlotte Islands	1 + 2AE	3.3	0.2	1.1	9,530	274	17,635
	2AW	-	0.4	10.0	-	-	-
Lower Queen Charlotte Islands	2BE	14.7	1.5	12.5	13,430	12,288	7,527
	2BW	-	-	2.0	-	-	-
Northern	3-5	17.4	12.2	21.6	21,460	12,185	11,795
Upper Central	6	24.1	1.2	8.4	11,270	6,819	2,103
Lower Central	7-10	34.9	20.0	9.0	21,520	7,553	39,345
Upper East Coast	11 + 12	16.7	9.9	12.5	7,550	3,523	14,777
Middle East Coast	13-16	26.8	11.9	31.3	12,690	10,069	10,458
Lower East Coast	17-19	29.9	23.7	25.2	40,310	17,311	49,711
Lower West Coast	23 + 24	16.6	16.7	(3.4)	16,050	12,923	41,649
Upper West Coast	25-27	19.8	11.5	6.9	11,440	48	35,684

* Average for 1937-8 to 1956-57, omitting 1952-53.

Not all areas were fished each year.

In 1958-59, III-year-old fish (the 1956 year-class) were dominant in all populations, contributing mainly to the increased or record catches made. This year-class was obviously very strong particularly in the southern populations.

There are no data which provide a reliable indication in any population of the strength of the 1957 year-class which will contribute III-year-old fish in the 1959-60 season.

6. The offshore distribution of herring.

F. H. C. Taylor and
W. E. Barraclough

A program to determine the offshore distribution and abundance of herring during the summer was initiated in 1959. There is little information on herring from the time they leave the bays and inlets toward the end of their first year of life until the time they reappear in inside waters on their pre-spawning migration as maturing III-year-old fish. Information on abundance during this phase of their life history would be valuable in predicting the size of the year-classes on recruitment (as III-year-olds) to the fishable stocks.

Two herring drift-net cruises were carried out off the west coast of Vancouver Island by the Biological Station vessel A. P. Knight. The first extended from June 4 to 25, the second from August 21 to September 8. These cruises were mainly trial trips to test and develop methods of handling the gear at sea, to train both the ship's crew and investigational personnel in the operation of an unfamiliar type of equipment and to develop sampling methods.

a) Fishing gear. The experimental drift nets were made from synthetic twines in five different mesh sizes. Nylon was used for the three largest mesh sizes (2 1/4", 1 3/4" and 1 1/2" stretched mesh) and terylene for the two smallest (1 1/4" and 3/4"). All were dyed a medium green. Each net was 15 fathoms long and hung to fish 10 fathoms. The depth of each net was 10 fathoms, rigged to fish about 6 1/2 fathoms. Each net was guarded for 8 meshes top and bottom with a size heavier synthetic twine and selvedged all around one-half mesh depth with heavy twine (No. 60). Hemp gables were used to eliminate strain on the mesh when hauling the gear. Nylon ossels were fitted at the headrope. Special diagonal roping was used at the footrope to prevent the net "rolling-up" through the wave action (sometimes referred to as the "yo-yo effect").

Each net was roped top and bottom with one right and one left lay sisal rope. Small, 3-inch-diameter, plastic floats were placed 18" apart on the head rope. On the footrope, small leads were placed 12" apart. Table 55 summarizes the types and sizes of synthetic twine for each of the mesh sizes.

Table 55. Twine and mesh characteristics of the experimental gear

Mesh size	3/4"	1 1/4"	1 1/2"	1 3/4"	2 1/4"
Type of synthetic twine	Terylene	Terylene	Nylon	Nylon	Nylon
Twine (size number)	6	14	24	24	24
Meshes deep	930	560	465	400	310
Guardings, twine size	14	21	48	48	48

b) Operation of gear. Five nets of different mesh size were joined end to end to form a panel or gang. A series of 5 or 10 panels, each separated by a distance of 9 fathoms, were fished at different depths from the sea surface to 40 fathoms. The method of hauling and setting the gear was similar to the method used in the Iceland herring drift-net fishery. The panels of nets were attached below a separate hauling or setting cable (sometimes called a bush-rope, messenger rope or hauling warp).

On the first cruise, the hauling cable was made of three lengths of manilla rope of different sizes - 30 fathoms of 2" diameter, 350 fathoms of 1 5/8" diameter and 150 fathoms of 1 1/2" diameter. This rope proved to be very bulky and far too difficult to handle. It was replaced by a 3/4" diameter braided nylon rope of approximately the same breaking strain. This change made a large increase in handling efficiency.

Straps, of 7/8" diameter manilla rope, 7 fathoms long with a galvanized snap hook at one end, were used to attach the end of each net to galvanized rings lashed to the hauling cable at 9-fathom intervals. By hanging in each net 1 fathom on the cable, the strain on the nets was kept to a minimum when hauling the gear.

Each panel of 5 nets was buoyed at each end by canvas floats. Buoylines of 9/16" diameter manilla rope were made in lengths of 5 and 10 fathoms for ease in rigging the panels to fish at different depths.

On the first cruise, techniques of setting and hauling different numbers of nets were developed under varying weather conditions. A program of echo-sounding for herring schools was developed between drift-net stations. On the second cruise, the position of the drift-net stations at night was determined partly from the results of the echo-sounder recordings made during the day. To a large extent weather conditions governed both the possibility of drift-net sets at night and the number of nets set out. A gang of salmon drift-nets each 50 fathoms long was set out with the herring nets. The salmon nets were of 2 1/2, 3 1/4, 4 1/2 and 5 1/4 inches stretched mesh.

The locations of stations occupied during both cruises off the west coast of Vancouver Island are given in Table 56.

The hauling cable was pulled by the anchor winch over a bow roller. The canvas floats were detached as they came to this roller. A Puretic power block was used to haul the drift-nets aboard.

Table 56. The positions of 1959 herring drift-net stations

Station Number	Date	Area	Latitude North	Longitude West	Number nets fished
H59-1-1	June 15	outside edge LaPerouse Bank	48°41'	125°50'	30
H59-1-2	June 16	off LaPerouse Bank	48°22'	126°20'	45
H59-1-3	June 17	90 miles off Amphitrite Point	48°12'	127°35'	25
H59-1-4	June 18	21 miles off Esteban Point	49°12'	127°00'	25

(continued)

Table 56 (continued)

Station Number	Date	Area	Latitude North	Longitude West	Number nets fished
H59-2-1	August 25	shallow spot on LaPerouse Bank	48°37'	125°42'	10
H59-2-2	August 28	S.W. corner of LaPerouse Bank	48°46'	125°53'	15
H59-2-3	August 29	Firing Range off Long Beach	48°56'	125°47'	15
H59-2-4	August 31	8 1/2 miles SW x W 1/2 W of Cape Beale	48°46'	125°27'	25

No herring were caught in June. The capture of other species such as dogfish, hake, small blackcod, saury, lantern fish, squid, rockfish, and salmon showed that the nets were fishing.

The numbers and size composition of herring caught in each of the mesh sizes at the different stations during the second cruise is shown in Table 57.

Table 57. The number and size of herring caught off the west coast of Vancouver Island by drift-nets in 1959.

Mesh size	3/4"	1 1/4"	1 1/2"	1 3/4"	2 1/4"
Station No. H59-2-1	Depth of Nets at Corkline	(Surface-5 nets, 5 fathoms-5 nets)			
Number fish	10	9	590	705	123
Range Length mm.	92	135-154	135-214	165-219	160-224
Average Length mm.	92	145	165	188	203
Station No. H59-2-2	Depth of Nets at Corkline	(Surface-5 nets, 5 fm-5 nets, 15 fm-5 nets)			
Number fish	17	17	98	1,286	126
Range Length mm.	75-99	135-159	145-194	145-219	165-239
Average Length mm.	93	141	168	186	201
Station No. H59-2-3	Depth of Nets at Corkline	(Surface-5 nets, 5 fm-5 nets, 15 fm-5 nets)			
Number fish	166	2	33	10	-
Range Length mm.	75-94	85-139	140-204	155-199	-
Average Length mm.	87	112	154	181	-
Station No. H59-2-4	Depth of Nets at Corkline	(Surface-10 nets, 5 fm-10 nets, 15 fm-5 nets)			
Number fish	2	5	-	232	12
Range Length mm.	80-89	150-164	-	145-214	175-224
Average Length mm.	85	155	-	178	188

It was found that the different mesh sizes were very selective in capturing herring of particular length frequencies. There was no significant difference in the length of herring caught by a particular mesh size at different depths. The numbers of herring caught at each depth were, therefore, combined in Table 57 according to mesh size. The overlap in length frequency from one mesh size to another is attributed to the tendency of herring to be caught by the tip of the lower jaw or by the operculum as well to be properly gilled.

In spite of bad weather and mechanical breakdowns which hampered both cruises, the gear was tested successfully and major modifications made to improve handling efficiency. Extensive echo-sounding during the day and on runs between stations, together with the capture of small numbers of herring at some stations, showed that herring were in small widely-scattered schools. These two cruises further demonstrated the need for a method of sampling schools of fish located by echo-sounder. The mid-water trawl was not entirely satisfactory even when used with a depth telemeter. The latter instrument provided information on the depth of the otter boards and not necessarily of the net. A method of "aimed" mid-water trawling where the depth of the trawl is known at all times is required. To this end the experiments described in the next report were undertaken.

7. Improvements in experimental fishing methods. F. H. C. Taylor

In 1959 a program was started to determine the distribution and abundance of herring in the open ocean off the British Columbia coast during the summer. Two methods of fishing were tested: (1) drift-nets of five mesh sizes fished at various depths and (2) the mid-water trawl. The former proved more successful than the latter which was hindered by a lack of information on the precise depth at which the trawl was operating in relation to the depths of herring schools.

In the fall of 1959, preliminary experiments were carried out which indicated that "aimed" mid-water trawling, where the exact depth of the net in relation to the depth of the fish is known, is quite feasible. The method evolved followed that originated in England and developed in Germany of attaching an echo-sounder transducer to the mid-water trawl. In extensive experiments carried out in Germany a transducer, allowed to sound both upward toward the surface and downward toward the bottom, was attached to the headrope of the trawl. This transducer showed, in relation to the headrope, the depth of the footrope of the trawl, the surface and the bottom. Information was thus provided not only on the exact depth but also on the vertical opening of the trawl. Fish entering the trawl could be observed.

In our tests it was found better to attach the transducer to the footrope sounding only upwards. Information was provided on the mouth opening of the net and the depth of the net below the surface. The operation of the transducer in only one direction was found preferable to simultaneous operation upwards and downwards since it is then impossible to tell whether an object is above or below the headline of the net (the reference point). If the transducer sounds only downwards, it becomes difficult to determine the depth of the net over rough bottom since it will not always be known, for example, whether the net has moved downwards or the water become shallower. It was, therefore, found most satisfactory to attach the transducer to the footrope and to sound upwards. Since the water surface is flat, there is then no difficulty in following the depth and direction of movement of the net. Attachment to the footrope rather than the headrope is preferred since information is then obtained on the mouth opening of the net and of objects between the head and footropes.

The preliminary tests carried out showed that the mouth openings of the trawls used were much less than expected - about 2 instead of 5 fathoms. The size of the mouth opening and depth of the net varied with trawling speed. Further tests are planned to develop methods of opening the net to its maximum at trawling speeds of 3 to 5 knots.

The equipment used consisted of a Kelvin-Hughes MS 29 echo-sounder and extra transducer. The equipment was wired so that the same pulse generating and receiving equipment could be used with either the transducer in the ship or that fastened to the net. Switching from one transducer to the other required only one switch and was almost instantaneous. In the preliminary tests, a separate electrical wire was used to the net transducer. However, in future tests it is intended to use conductors in the 6-conductor 5/8-inch steel trawl cable used with the depth telemeter.

8. The number of salmon in herring catches. F. H. C. Taylor and W. E. Barraclough

The 1959-60 season saw the adoption by the majority of the herring seiners of bright lights to attract herring to the vessel. Nearly all seiners and some packers were equipped with 4 mercury-vapour street lights fitted to the upper deck. At dusk, the seiner anchored and turned on these lights. When enough fish were attracted to the boat, the lights were turned off and the net set rapidly around the accumulated fish. This system of fishing leads to complaints that large quantities of other fish, especially salmon, both immature and mature, were also attracted by the lights and taken in the catches.

The Biological Station was asked to undertake a study of this problem of salmon in herring catches and to outline methods whereby the numbers of such salmon could be estimated.

The reduction plants at Steveston were carefully examined to determine if there was any possibility of making direct counts of the numbers of salmon in the herring landings. The layout of the machinery in two plants (Gulf of Georgia and Phoenix) offered no facilities for making counts. At a third plant, Colonial, facilities were considered inadequate. The Imperial plant, however, had two possible sites where observations could be made.

One site was on the roof where the fish could be observed coming toward the observer along a conveyor. It was estimated that two observers could check about 50% of the fish unloaded and identify and remove salmon of any size, and that three observers could check about 75% of the load. The second site was at the machine where the large herring were graded out by thickness for kippering. This grader would also separate out salmon, which are probably as big as large herring by late autumn and also somewhat thicker than herring of comparable length. While only one observer would be required here, the grader is only operated at infrequent intervals and then only receives about 25% of the herring being unloaded.

Observations, mainly at the first site, were made during the week of November 18-26, 1959. During this period the number of salmon of all sizes observed in the landings from four areas in the upper and middle east coast and lower west coast sub-districts were insignificant (Table 58). However, most of the complaints regarding the number of salmon in herring catches were made in October, especially in Area 19, the lower east coast sub-district. This fishery was over before a system of observation could be organized. It may be that more salmon are captured earlier in the season than later and more in some areas than others.

Table 58. Observations made at Steveston on salmon and other fishes in herring purse seine catches, November 18-26, 1959.

Area	Day or night (with lights) fishing	Tons	Number of catches (seine loads)	Salmon more than 18" (460 mm)	Grilse - salmon less than 18" (460 mm)	other fish
12 Bones Bay	night	206	4	...	...	dogfish
14 Cape Lazo	night	1,079	27	18 (15 spring) (2 coho) (1 unident.)	21 (16 jack spring) (4 coho) (1 unident.)	greycod, dogfish, hake, rockfish, anchovy (2), shad (1), many small blackcod 9-14 inches many small whiting 11-14 inches.
16 Pender Harbour	night	40	1	19 (chums)	2 (grilse)	hake (1 ton)
23 Barkley Sound	night	70	1	...	...	...
	day	633	8	...	...	rockfish, (few) less 6 inches hake (40) less 12 inches.
Totals	night and day	2,028	41	37	23	

It is planned to make a detailed study of this problem of salmon in herring catches. Observations, both in the reduction plants and during actual fishery operations, will be made throughout the season to determine the numbers of salmon of all sizes in the herring catches from different areas and different parts of the seasons, and also to determine the extent to which the use of lights affects these numbers. It is hoped that the actual concentration of fish under the lights can be followed by echo-sounding and horizontal ranging with the Sea Scanar.

MARINE COMMERCIAL FISHERIES

GROUNDFISH

- K.S. Ketchen

Adjacent to the British Columbia coast there is a relatively small fishery for groundfish which is active on a year-round basis. The bulk of the Canadian catch comes from international waters where the fleet operates in competition with vessels from United States ports. During the winter months, when weather limits fishing on these offshore grounds, attention shifts to the more sheltered, territorial waters.

In both 1957 and 1958 the Canadian and United States production of groundfish (exclusive of halibut) on fishing banks adjacent to British Columbia amounted to more than 70 million pounds. Otter-trawling, which is the principal method of fishing, accounts for virtually all Canadian landings of flatfish (rock sole, lemon sole, brill and others) and Pacific (grey) cod. Various other species such as lingcod, blackcod, rockfish and dogfish are taken by hook and line as well as by trawling.

Although the fishery is small in comparison with the salmon and herring fisheries, it is very complex. Effective study depends on a continuing programme of investigation. This programme is designed to provide (1) a "watching brief" on changes in size of the numerous stocks contributing to the fishery, (2) an understanding of the factors responsible for such changes, and (3) definition of the reouirements for management of the fishery on a maximum sustained yield basis.

A. Main projects

Background information reouired for analysis of the groundfish fishery is derived from three continuing projects:

(1) Compilation and analysis of statistics. Accurate description of changes in stock size depends on the collection of reliable statistics of catch and fishing effort. Such statistics are obtained mainly by a system of interviewing vessel skippers at the principal ports of landing (Vancouver and Prince Rupert). This procedure, supplemented by log-book records and sales slip records collected by the Department of Fisheries, provides a complete picture of the Canadian catch by species from each statistical area and a representative sample of fishing effort exerted by various classes of vessel.

To complete the coverage of the catch statistics for international waters, co-operation is being maintained with the State of Washington through the auspices of the Pacific Marine Fisheries Commission.

(2) Age and growth studies. Routine sampling of the catches of important commercial species is conducted at the main ports of landing, for the purpose of obtaining data on changes in size and age composition. Such data provide valuable information on growth and mortality rates and on changes in recruitment.

(3) Tagging. Tagging is the most direct method of differentiating between stocks or populations of a particular species. It provides information which is of great importance in the interpretation of catch statistics. Tagging also provides information on growth and mortality rates and therefore is useful as a check on conclusions drawn from age determinations.

B. Review of immediate interests

The main work of the investigation is being advanced on a rather broad front in order to cope with the ever-changing and unpredictable nature of the fishery. However, there are subjects of particular concern or interest which require special mention. The following is a synopsis of recent developments and progress towards solution of immediate problems.

(1) International Trawl Fishery Committee. During 1959, the International Conference on Co-ordination of Fisheries Regulations established a Trawl Fishery Committee to deal with international problems pertaining to the investigation and regulation of trawl fisheries which are of mutual interest to Canada and the United States. This Committee established a technical sub-committee consisting of scientific representatives of various agencies to review the current status of regulations and knowledge of the trawl fishery in international waters. The first meeting of the sub-committee was held in January 1960 and a report is now in preparation. This report will form at least part of the basis for future deliberations of the parent Committee.

(2) Groundfish statistics. Final revision of the Canadian groundfish statistics for the years 1945 to 1959 is now virtually complete and publication in convenient manuscript report form is planned for sometime during 1960. This data record will contain detailed information on the catch by species, month and year for Departmental statistical areas as well as larger, internationally recognized statistical divisions of the open coast. In addition to the data on the Canadian fishery, records as compiled by P.M.F.C. for the United States fishery adjacent to the British Columbia coast will be included and will cover the period 1954 to 1959. Form of the data record will be such that it can be used as a convenient reference by biologists of both countries.

The method of handling Canadian catch records is now being changed from key-sort to IBM cards. A back-log of no more than five years of data will be converted to the machine system. This will enable much more intricate analyses than have heretofore been possible, particularly in respect to statistics of fishing effort. Development of a method for standardizing effort statistics will be required before a data record can be assembled to accompany the data record of catch.

(3) Regulation of the Strait of Georgia fishery. A proposal, emanating from the Groundfish Investigation for adoption of a 4 1/2-inch minimum mesh size in the Strait of Georgia is now in the hands of the Department of Fisheries. Results of investigation suggest that in areas which support a fishery for mink-food, the food-fish fishery for lemon sole has declined to the point where it is virtually non-existent. Even in areas where fishing for mink-food is unattractive and where seasonal closures are in effect, production of lemon sole is barely being maintained. Further increases in fishing pressure on the inshore stocks can be expected over the long term. Introduction of a larger mesh size to minimize the destruction of sub-commercial sizes of desirable species is one way of maintaining the stocks at such levels that exploitation remains economically practical.

(4) Research on grey cod and brill. Of the many species of groundfish under investigation, the grey cod and brill (petrale sole) have required special attention. The annual catch of grey cod in waters adjacent to British Columbia now exceeds 20 million pounds - almost one-third of the total groundfish landing. Lack of very precise information on growth and mortality rates has spurred field and laboratory work, as such information is vital for assessment of the effects of the current fishery. The brill is the only groundfish species in Canadian waters which is

obviously at a much lower level of abundance than it was a decade ago. While special effort has been made to determine the cause of this decline, the analyses are still incomplete. Nevertheless, the results of a large section of the work are now in manuscript form.

Catch Statistics

In 1959, the port observers stationed at Vancouver and Prince Rupert conducted over 900 interviews with vessel skippers. Data on catch, fishing effort, and related general information were collected on 705 dragger landings, 160 crab- and shrimp-boat landings, and 68 long-line, hand-line, cod-boat, and smelt-seine landings. During the absence of the port observer in Prince Rupert from September through December, coverage was maintained through the close co-operation of the vessel skippers who kindly provided copies of their log-book records.

The total Canadian landing of groundfish in 1959 (exclusive of halibut) was 29 million pounds, just about the same as last year. Of this total, 75% was food fish for human consumption. Grey cod again was the largest single contributor (9.2 million pounds). Flatfish landings were about 2.5 million pounds below the 1958 total.

Line vessels accounted for almost 6 million pounds, mostly lingcod and rockfish.

A. Trends in British Columbia landings of trawl fish

A. N. Yates and
J. A. Thomson

Table 59 provides a general summary of trends in the total catch by species over the past 15 years.

Table 59. Trends in British Columbia landings of trawl fish.

Year	Thousands of pounds											
	Lemon sole	Rock sole	Brill	Butter sole	Dover sole	Rex sole	Fldr.	Grey cod	Ling-cod	Rock fish	Dogfish liver	Mink food
1945	2,196	414	810	1,451	514	91	246	2,149	1,918	1,312	856	114
1946	2,210	1,085	2,398	1,540	1,008	159	630	3,834	2,005	569	519	27
1947	950	2,766	1,762	252	417	64	187	1,246	736	87	399	41
1948	2,045	2,135	7,721	651	157	119	149	1,380	1,417	85	667	35
1949	1,689	1,678	3,215	29	171	160	183	2,531	2,623	134	587	59
1950	5,271	2,177	2,039	8	694	235	326	4,075	1,860	236	126	37
1951	2,162	3,548	1,585	1,824	974	234	461	7,609	2,589	449	204	414
1952	2,537	5,955	1,828	3,716	941	180	495	6,583	1,536	589	229	1,392
1953	2,241	1,851	1,040	160	416	81	138	4,283	807	456	245	2,298
1954	1,470	2,588	941	216	402	23	277	7,638	1,358	866	326	2,843
1955	1,551	3,589	626	622	494	130	269	4,642	1,655	368	275	6,242
1956	1,968	4,428	608	736	417	58	242	5,218	2,509	544	58	11,023
1957	1,072	4,185	1,069	1,288	449	35	174	8,701	2,174	503	168	4,244
1958	1,330	4,617	926	477	264	30	127	9,929	2,113	815	159	2,950
1959	1,664	1,905	841	212	170	9	106	9,193	2,469	1,164	295	4,174
15-yr mean	2,024	2,862	1,828	879	499	107	267	5,265	1,784	546	340	2,373

Landings of lemon sole continued to increase during the past three years, but are still well below the mean value. Rock sole, partly as a result of market conditions, dropped to less than half the previous year's landing. The catch of brill remained at a low level because of reduced abundance. The grey cod catch for the first time in five years showed a slight decrease. The rise in rockfish landings was due to increased market demand, but the landings of "ocean perch" (included in the rockfish total) remained about the same as last year at 510,000 pounds.

Because of incomplete coverage, the total landings of dogfish liver, shown above, for the last few years are low. In 1959, according to Department of Fisheries sales slips, 384,000 pounds were landed by trawlers. This was about 30% of the total landed under the Federal Government Subsidy Program.

Mink food landings returned to the 1957 level after last year's decline but were still well below the peak of 11 million pounds established in 1956.

B. Tabulation of 1959 trawl landings in British Columbia

J. A. Thomson and A. N. Yates

Continued close co-operation with the statistical section of the Department of Fisheries and the use of a punch-card system for handling data from trip reports and Department sales slips allows an accurate and up-to-date account of groundfish fisheries to be made as they take place during the year.

The summary of monthly trawl landings for British Columbia in 1959 is presented according to four major divisions: (1) Hecate Strait, (2) Queen Charlotte Sound, (3) west coast of Vancouver Island, and (4) Strait of Georgia. Weights are given in thousands of pounds.

Table 60. Groundfish catches in Hecate Strait in 1959. (P.M.F.C. Areas 5C and 5D)

Month	Lemon sole	Rock sole	Brill	Butter sole	Dover sole	Rex sole	Fldr.	Grey cod	Ling-cod	Rock fish	Mink feed
Jan	27	-	-x-	-	-	-	-	447	2	-x-	23
Feb	111	2	1	89	-	-	-	1,291	10	2	173
Mar	246	8	2	123	-	-x-	6	559	5	3	184
Apr	265	51	1	-	-	-x-	8	317	3	9	79
May	78	156	13	-	-	-	1	180	11	7	4
Jun	9	351	15	-	-	1	-	202	26	1	12
Jul	84	83	6	-	7	-x-	-	773	25	16	2
Aug	116	45	19	-	2	1	-	198	5	-x-	88
Sep	59	38	18	-	-x-	-	-	56	7	1	16
Oct	149	9	117	-	9	2	2	447	27	1	510
Nov	70	1	45	-	-x-	-	-	181	8	3	108
Dec	52	-x-	14	-	-	-	-x-	102	2	1	77
Total	1,266	714	251	212	18	4	17	4,753	131	44	1,278

-x- = less than 500 pounds

Groundfish catches in Hecate Strait were 3,500,000 pounds lower than in 1958. The decline, due mainly to market conditions, was most noticeable among the flatfishes. Rock sole dropped to 33% of the 1958 total. Dover sole and rex sole each dropped by 80%. Brill landings decreased by 15%, and butter sole landings always variable, were less than half the 1958 total. Lemon sole alone showed an increase which amounted to 38% of the 1958 landing or 353,000 pounds. Landings of grey cod also declined, being 1,625,000 pounds lighter than in 1958, but this was, in part, balanced by rises in lingcod, rockfish, and mink food landings. Landings of rockfish in 1959 almost doubled the 1958 total.

Table 61. Groundfish catches in Queen Charlotte Sound in 1959. (P.M.F.C. Areas 5A and 5B)

Month	Lemon sole	Rock sole	Brill	Dover sole	Grey cod	Ling cod	Black cod	Rock fish	Ocean perch	Mink feed
Jan	-	-	-	-	-	-	-	-	-	-
Feb	3	-x-	-	-	6	-	-	-x-	-	2
Mar	-	16	1	-	60	2	-	2	-	-
Apr	9	153	18	-	462	26	1	206	-	64
May	6	245	19	-	267	108	-x-	153	27	84
Jun	7	199	35	3	202	326	-	58	204	107
Jul	6	279	42	-	333	314	-	60	101	170
Aug	8	127	10	-	19	60	2	5	-	97
Sep	8	27	2	-	22	4	1	6	50	35
Oct	-	-	2	1	1	2	-	6	128	-
Nov	-	-	-	-	-	-	-	-	-	-
Dec	-	-	-	-	-	-	-	-	-	-
Total	47	1,046	129	4	1,372	842	4	496	510	559

-x- = less than 500 pounds

Total landings from Queen Charlotte Sound showed an increase of 282,000 pounds over 1958. Production of rockfish, grey cod and mink food increased by 336,000 pounds, 470,000 pounds and 416,000 pounds, respectively, and this offset a sharp decline in the landing of rock sole which amounted to only 60% of that in 1958.

Table 62. Groundfish catches off west coast of Vancouver Island in 1959. (P.M.F.C. Areas 3D and 3C)

Month	Lemon sole	Rock sole	Brill	Dover sole	Fldr.	Grey cod	Ling-cod	Black cod	Rock fish	Skate	Dogfish liver	Mink feed
Jan	-	-	-	-	-	-	-	-	-	-	-	-
Feb	-x-	-	-	-	1	2	-	-	-	-	-	8
Mar	-x-	1	-x-	-	-x-	26	-x-	-	-x-	-x-	-x-	-
Apr	4	19	13	-x-	11	114	5	-	4	2	5	15
May	4	18	15	-x-	8	407	54	-x-	1	3	-x-	44
Jun	1	9	23	2	3	64	90	2	1	3	2	27
Jul	2	3	68	2	-	79	160	11	3	1	-x-	83
Aug	2	5	49	-	-	36	124	2	-x-	1	26	18
Sep	1	2	149	1	-	81	289	96*	1	-x-	15	143
Oct	1	-x-	100	1	-	70	91	33	3	-x-	9	112
Nov	-	-x-	4	3	-	7	-x-	22	16	-	1	68
Dec	-	-	-	-	-	-x-	-x-	-	-	-	-	-
Total	15	57	421	9	23	886	813	166*	29	10	58	518

-x- = less than 500 pounds
* includes 1,273 pounds from south of Cape Flattery (Area 3B)

Total landings of food fish from grounds off the west coast of Vancouver Island decreased by 500,000 pounds in 1959. Increased landings of blackcod (180,000 pounds) and rockfish (29,000 pounds) failed to offset a general decline. Lemon and rock sole landings were half those in 1958 while grey cod and lingcod landings decreased by 23% and 34% respectively. Mink feed production remained about the same as in the preceding year.

Table 63. Groundfish catches in the Strait of Georgia in 1959. (P.M.F.C. Area 4A)

Month	Lemon sole	Rock sole	Brill	Fldr.	Grey cod	Ling-cod	Rock fish	Skate	Dogfish liver	Crab	Mink feed
Jan	36	19	-	7	275	-x-	3	5	79	3	269
Feb	83	19	-	25	470	-	13	8	11	5	313
Mar	16	15	-	12	638	13	8	5	3	-x-	227
Apr	17	8	-	2	67	9	4	4	4	-x-	151
May	17	5	-x-	-x-	46	8	1	4	6	3	62
Jun	16	1	4	-x-	31	12	5	2	-	-	133
Jul	13	1	2	-	60	13	4	2	4	-x-	112
Aug	-x-	-	-x-	-	2	-x-	-x-	-	-	-	46
Sep	11	1	9	-	65	13	5	4	2	-x-	209
Oct	38	-x-	18	-x-	128	224	23	6	42	1	154
Nov	46	14	6	7	312	390	12	11	27	4	79
Dec	43	5	-x-	12	88	2	8	9	20	15	66
Total	336	88	39	65	2,182	684	86	60	198	31	1,821

-x- = less than 500 pounds

Food-fish landings from the Strait of Georgia showed an increase of 1,459,000 pounds (60%). Landings of fish for mink food also showed an increase, jumping from 1,173,000 to 1,821,000 pounds (49%). Much of this increase was due to the discovery of a highly productive ground near the entrance to Victoria harbour in the autumn of 1959. This ground produced approximately 470,000 pounds of lingcod and 210,000 pounds of grey cod during October and November alone.

C. The controlled trawl fishery of the Strait of Georgia C. R. Forrester

(1) General. The total catch of food-fish from the "experimental" fishing areas in the Strait of Georgia was almost 850,000 pounds in the 1958-59 season. This total is very slightly higher than the average catch over the past seven years. Table 64 shows total catch, total effort and average catch/effort for the years since 1952-53.

Table 64. Catch and effort in experimental areas in the Strait of Georgia.

Winter season	Total catch of foodfish	Total effort	Average catch per hour
	(pounds)	(hours)	(pounds)
1952-53	859,650	2,303	370
1953-54	1,091,600	3,014	340
1954-55	848,900	3,013	280
1955-56	570,900	2,254	250
1956-57	768,600	2,377	320
1957-58	913,400	2,816	324
1958-59	849,032	1,485	572
Mean	843,154	2,466	351

This catch was maintained despite the closure of the Deep Bay area to all trawling and despite a sharp drop in total effort expended. In large measure, maintenance of the catch was due to the successful grey-cod fishery at Nanoose Bay where approximately 360,000 pounds of grey cod were taken during the open period. The high availability of these particular grey cod is reflected in the substantial increase in catch per hour of all food-fish noted in the above table.

Catch according to individual areas in the 1958-59 season is given in Table 65.

(2) Union Bay fishery. The summary reports for 1958-59 give some of the background details which prompted the setting of a lemon sole catch quota on the Union Bay fishery. In the 1959 open period of four fishing days, a total of 24,400 pounds of lemon sole were caught. There was a substantial reduction in fishing effort in the Bay - little more than 50 percent of that spent the previous year. The average catch of lemon sole per hour of fishing was 316 pounds in 1959 as compared with 178 pounds in 1958. It is too early to say whether this increase was the result of an increased accumulation of fish on the grounds or simply the consequence of reduced effort which failed to break up and scatter the schools into less accessible parts of the Bay.

Table 65. Otter-trawl landings from experimental areas in the Strait of Georgia, October 1958 to March 1959.

	Cape Lazo	Union Bay	Deep Bay	Yellow Rock	Qualicum Parksville	Nanoose Bay	Total
Hours of fishing	448	102		257	171	507	1485
Lemon sole	60,761	32,288	Area closed	21,519	11,320	6,326	132,214
Rock sole	12,230	--		17,017	11,329	3,983	44,559
Flounder	1,200	1,788		23,049	2,669	275	28,981
Grey cod	81,200	5,053		103,768	33,881	359,705	583,607
Lingcod	476	941		6,395	10,253	1,057	19,122
Rockfish	7,938	2,015		300	6,510	6,110	22,873
Other fish	7,081	702		5,475	1,814	2,604	17,676
Dogfish liver*	119,044	--		21,776	12,405	26,994	180,219
Mink feed	--	89		4,511	--	4,214	8,814
Total food-fish	170,886	42,787		177,523	77,776	380,060	849,032

* Dogfish liver converted (× 6.67) to pounds of round dogfish.

(3) Deep Bay fishery. With the exception of sporadic appearances of grey cod, the species of most consistent importance in the Deep Bay area is the lemon sole. Chiefly because of the belief that there was undue destruction of small lemon sole in this area the trawler operators suggested that the area be closed. Experimental drags had shown that male lemon soles in the area were of little value commercially because of small size, and that female fish were substantially smaller than those in regions of Baynes Sound to the north.

Tagging of grey cod in the Deep Bay area suggested that these fish are highly mobile and available at other times in other areas (Yellow Rock, Cape Lazo, etc.). Accordingly, it was decided to close the Deep Bay grounds at the beginning of the 1958-59 season. This closure had no appreciable effect on total production from the experimental areas.

D. Co-ordination of catch statistics for the Pacific coast

J. A. Thomson

In 1956 a system was developed in co-operation with the Pacific Marine Fisheries Commission for co-ordination in compiling otter-trawl statistics for the Pacific coast of Canada and the United States. Six primary statistical areas were established which covered the region from southern California to southeastern Alaska. Three of these areas lie adjacent to the Canadian coast and each is subdivided into a number of secondary areas in order to distinguish catches from major fishing banks.

In 1958 the total otter-trawl production from Area 3 (Willapa Bay, Washington to the northern end of Vancouver Island) was 23.5 million pounds, as compared with 28.7 and 33.2 million pounds in 1957 and 1956, respectively). Production from Area 4 (Canadian and United States territorial waters - Juan de Fuca Strait, Georgia Strait and Puget Sound) was 16.1 million pounds, as compared with 10.6 and 14.4 million pounds in 1957 and 1956, respectively. In Area 5, which includes the various banks from Cape Scott to northern Hecate Strait, the catch was 28.9 million pounds in 1958, as compared with 27.8 and 28.8 million pounds in 1957 and 1956, respectively.

Table 66 summarizes the United States and Canadian catch by species in the various sub-areas adjacent to the Canadian coast. In 1958 the United States fleet accounted for the major part of the catch from all international sub-areas except those of Hecate Strait (Areas 5C and 5D) and Goose Island (Area 5B). This was the first year that the Canadian catch on the Goose Island bank has exceeded that of the United States. It is partly a reflection of increased interest on the part of the Vancouver fleet, which for many years has tended to fish mainly off the lower west coast of Vancouver Island (Area 3C).

Much of the difference in weight of landings made by the two countries is due to a difference in market demand. In the United States, rockfish (Sebastodes) are much more in demand than in Canada. On the other hand, Canadian vessels are apparently capable of making greater use of the rock sole resource on the northern grounds.

Table 66. Otter trawl landings by Canadian and United States vessels operating in waters adjacent to the British Columbia coast in 1958. United States data provided by the Pacific Marine Fisheries Commission.

Fishing areas:	Cape Elizabeth to Cape Flattery		Vancouver Island Lower west coast		Vancouver Island Upper west coast		Strait of Georgia	Puget Sound	Cape Scott		Goose Island		Lower Hecate Strait		Upper Hecate Strait	
P.M.F.C. area:	3B		3C		3D		4A	4B	5A		5B		5C		5D	
Country:	Can.	U.S.A.	Can.	U.S.A.	Can.	U.S.A.	Can.	U.S.A.	Can.	U.S.A.	Can.	U.S.A.	Can.	U.S.A.	Can.	U.S.A.
Sable fish	69	171	64	82	-x-	5	3	—	1	7	12	15	—	—	1	1
True (grey cod)	10	2,774	1,126	527	28	191	1,315	2,389	304	1,258	768	297	2,160	1,584	4,240	3,348
Lingcod	-x-	710	1,144	1,152	101	133	104	69	176	495	502	85	36	24	48	61
Ocean perch	—	1,176	-x-	264	—	105	—	—	132	467	562	880	9	25	1	12
Other rockfish	—	2,399	14	635	2	652	55	74	50	918	109	429	10	—	5	63
Petrale (brill) sole	-x-	593	414	750	32	331	26	1	55	249	104	100	17	44	250	69
English (lemon) sole	6	2,248	23	21	1	20	365	1,517	9	68	14	45	14	39	898	526
Dover sole	—	903	51	607	1	64	111	76	—	30	1	223	-x-	—	99	53
Rex sole	—	16	3	5	—	—	6	—	—	—	—	2	-x-	—	21	—
Rock sole	3	—	50	2	62	9	144	73	1,002	72	710	132	715	65	1,932	127
Starry flounder	—	228	9	—	—	8	92	470	-x-	—	—	2	—	—	26	177
Other flatfish	—	7	9	—	—	—	5	—	1	—	—	—	—	—	480	—
Dogfish	—	—	73	—	4	—	973	1,325	14	13	1	—	—	—	11	—
Misc. species	3	40	11	7	7	—	67	5,076	21	12	14	—	52	—	79	10
Sub-total	91	11,265	2,991	4,052	238	1,518	3,266	11,070	1,765	3,589	2,797	2,210	3,013	1,781	8,091	4,447
Animal food	33	177	482	1,603	1	—	1,172	580	113	11	30	—	113	2	1,060	2[illegible]
Total	124	11,442	3,473	5,655	239	1,518	4,438	11,650	1,878	3,600	2,827	2,210	3,126	1,783	9,151	4,472

x = less than 500 lbs.

E. Catch of dogfish in British Columbia in recent years

C. R. Forrester

Landings of dogfish liver by British Columbia fishermen dropped from a peak of 7,770,000 pounds in 1944 to less than 300,000 pounds in 1956. The decline, which began as a result of decreased abundance, was hastened after 1949 by collapse of the market for liver. Between 1950 and 1956 dogfish were only lightly exploited and during this period they appeared to increase in abundance and become a serious nuisance in fisheries for other species (herring, salmon, groundfish).

In response to representations from the fishing industry the Department, in May 1956, established a bounty of $10 per ton on whole dogfish landed at reduction plants. However, this move proved ineffective. Continued protests from the fishermen resulted in the initiation of an experimental killing programme by government-chartered vessels and institution of a subsidy of 10¢ per pound on liver. This came into effect in January 1959 and had immediate results. During that year 750,000 pounds of liver were landed from Strait of Georgia grounds alone, as compared with 246,000 pounds in the preceding year. Landings from all areas amounted to just over one million pounds, the highest since 1949.

In addition to liver landed, which represented approximately 6.7 million pounds of whole dogfish, the government-chartered vessels succeeded in destroying 1.4 million pounds. This brought the total catch to about 8 million pounds.

The subsidy on liver continued to the end of the 1959-60 fiscal year. The 1960 landings (to March 30) amounted to 476,873 pounds which is equivalent to about 3 million pounds of round dogfish. This brings the total since January 1959 to roughly 11 million pounds.

It is the view of fishermen that the abundance of dogfish has been reduced considerably in the Strait of Georgia. However, it is quite unlikely that the subsidized fishery has had any appreciable effect on the abundance of dogfish on nearby banks in international waters.

F. Trends in catch per unit of effort

K. S. Ketchen

Accurate statistics of catch per unit of effort are vital to the research on groundfish. They provide the basis for determining in a quantitative though relative way, the changes in size of fish stocks, and the basis for interpreting age composition. In complex fisheries like the otter-trawl fishery such statistics can be very misleading if proper allowance is not made for a number of factors. Among these are the complicating effects of fishing for more than one species of fish at one time, which necessitates the sorting out of fishing effort directed to particular species. The efficiency of capture may vary from year to year because of variations in the availability (vulnerability) of the fish, or it may follow a trend because of a subtle but progressive change in the efficiency of the fisherman and his gear. Some factors can be measured in a quantitative way but others cannot.

All that we can hope to do with the facilities available is to eliminate some of the more obvious factors which tend to distort the true relationship between catch/effort and relative abundance.

Results of studies on some of the important species are given in the sections which follow.

(1) Changes in the relative abundance of brill K. S. Ketchen

(a) The southern "stock". For several years now it has been very difficult to determine what is happening to the brill which inhabit waters off the lower west coast of Vancouver Island (the southern stock). The fishery has descended to such a low level that measures of abundance which formerly appeared to be satisfactory now yield erratic and confusing results. Formerly, estimates of seasonal average catch/effort were based only on those landings in which there was a significant quantity of brill in the total fare. This procedure was adopted in order to remove the effects of fishing effort directed to the capture of species other than brill. Since 1955, however, the numbers of "significant" landings of brill have become so small that there are simply not enough data to provide a reliable average of catch/effort. As a last resort, therefore, we have re-examined the data in terms of all effort expended in the lower west coast area, whether directed to the capture of brill or not. The underlying assumption here is that a fisherman would fish for brill if they were available, but if not he would turn to less valuable species. Generally speaking, this assumption is valid, but it is recognized that in certain years and seasons (i.e. in periods of high availability of grey cod or high demand for mink food) the assumption did not hold.

Table 67 shows the estimated seasonal (May-August) catch/effort for Class III (single gear) trawlers - derived by dividing the total effort of that class into its total catch of brill.

Table 67. Catch per effort of brill in the southern area.

Year	Pounds per hour	Year	Pounds per hour	Year	Pounds per hour
1945	41	1950	220	1955	73
1946	73	1951	108	1956	34
1947	113	1952	182	1957	87
1948	242	1953	175	1958	96
1949	232	1954	108	1959	140

This analysis suggests that the brill has been increasing in abundance since 1956. It exhibits much greater consistency than analyses attempted previously (cf. Summary Reports 1958-59, p. 146) and is perhaps a more accurate description of actual events. The recent increase in catch/effort is reflected to some extent in the total United States and Canadian catch which, from 1955 (the year of lowest catch) to 1959, has increased from 1.2 million pounds to 2.5 million pounds.

In company with the upward trend in catch and catch/effort there has been a downward trend in average size of fish in the catch, which suggests an increase in the strengths of incoming year-classes (those subsequent to 1949).

(b) The northern "stock". Heretofore little attention has been given to the changes in abundance of brill which inhabit Queen Charlotte Sound and Hecate Strait because the fishery has been very erratic during the past decade. Description is made difficult by the fact that the so-called northern stock is apparently distributed over a wide area during the summer months. Tagging shows that brill on the Cape Scott, Goose Island, Horseshoe and White Rocks ground intermingle to a certain extent and that many of them move southward to the Esteban deep at spawning time.

In order to obtain a single picture of the trend in catch/effort on the four "summer" grounds, the following procedure was adopted: (1) average catch/effort was calculated for each of the grounds for those periods of the year when a fishery for brill occurs (Mar.-Dec. at Cape Scott, Apr.-Oct. at Goose Island, May-Sept. at the Horseshoe, Apr.-Dec. at the White Rocks); (2) all records of catch and effort were used (so long as brill was reported) and no restriction was placed on the type of gear or size of vessel; (3) the average catch/effort for the entire northern area was obtained by weighting the average for each area by the total United States-Canadian catch on each ground.

The results of this gross and preliminary analysis are shown in Table 68. An alternative procedure involving the weighting of catch/effort for each ground by the total Canadian effort on each ground yields essentially the same results, namely a rise in catch/effort between 1945 and 1948, a rapid decline between 1948 and 1954, instability at a low level between 1954 and 1959. The pattern of events parallels fairly closely that of the southern stock, despite the fact that the history of fishing on the two stocks was quite different. On the northern grounds the rate of decline after 1948 was about twice as fast as on the southern grounds which was to be expected as the effect of fishing a virgin stock. On the southern grounds the removal of the accumulated stock occurred prior to 1945.

Table 68. Catch per effort of brill in the northern area.

Year	Pounds per hour	Year	Pounds per hour	Year	Pounds per hour
1945	360	1950	339	1955	112
1946	403	1951	482	1956	60
1947	554	1952	167	1957	146
1948	869	1953	226	1958	92
1949	591	1954	116	1959	117

In both stocks the lowest catch/effort occurred in 1956. Evidence of a subsequent recovery is not as yet apparent in the northern stock.

(2) <u>The rock sole of Hecate Strait and Queen Charlotte Sound</u> J.A. Thomson

During 1959 the catch and catch per unit of effort statistics of the Canadian rock sole fishery in waters north of Cape Scott were reviewed. Previously, catch per unit of effort had been expressed as pounds per day of fishing, irrespective of the efficiency of vessels involved. In Table 69 it is expressed as pounds per hour for a standard class of Canadian trawlers (Class III double gear; 25-49 gross tons). Prior to 1949 there were no double gear vessels of this class in operation, only single gear vessels. Accordingly, the figures given in Table 69 for the years 1945 to 1948 were obtained by extrapolation based on knowledge of the relative fishing power of double and single gear trawlers in more recent years. The catch/effort for Hecate Strait is expressed as a seasonal average (May-August), and is based only on those landing records in which rock sole amounted to 50% or more of the total landed weight. In Queen Charlotte Sound (Goose Island and Cape Scott grounds) where the fishery starts earlier and in general is more diverse, the season adopted was April through September, and the qualifying level of catch was 40%.

At the present stage of the analysis it is impossible to discuss the catch/effort data with intelligence. There have been pronounced year-to-year variations on all grounds, and these may or may not be reliable indications of variations in abundance. At least in northern Hecate Strait (site of the main trawl fishery for rock sole) there is no clear relationship between annual catch and average catch/effort. The next step is to collate catch/effort and age composition and thus determine whether observed fluctuations in the former are due to changes in recruitment, or to changes in availability.

Table 69. Total landings (thousands of pounds) and pounds per hour for Class III (double gear) trawlers.

Year	Upper Hecate Strait		Lower Hecate Strait		Goose Island grounds		Cape Scott grounds	
	Catch	Lbs/hr	Catch	Lbs/hr	Catch	Lbs/hr	Catch	Lbs/hr
1945	264	1,423	16	no data	32	No data	11	No data
1946	849	1,243	54	"	Nil	"	Nil	"
1947	2,312	2,262	292	"	80	"	38	"
1948	1,905	2,719	82	"	26	"	51	"
1949	1,275	1,246	174	"	53	"	19	"
1950	1,454	1,275	17	"	87	1,224	360	597
1951	2,495	1,487	371	1,434	241	624	122	643
1952	4,909	1,480	193	1,484	235	775	352	629
1953	1,067	1,108	445	1,605	86	333	116	746
1954	1,910	2,935	52	924	207	1,167	62	400
1955	2,670	1,341	235	1,933	287	1,621	140	944
1956	1,461	1,784	841	1,386	592	964	934	1,010
1957	937	1,532	1,496	1,033	389	612	1,063	503
1958	1,981	2,208	714	985	736	488	1,002	488
1959	365	6,995	508	904	676	471	366	699

(3) The lemon sole of northern Hecate Strait — K. S. Ketchen

During 1959, the basis for estimating changes in abundance of lemon sole on the principal fishing ground of northern Hecate Strait was completely revised and the data were placed in final form. In Table 70 catch/effort is expressed in terms of the performance of Class III (double gear) trawlers operating during the period March to July. The analysis was restricted to only those landing records in which the catch of lemon sole was 20% or more by weight of the total landing of each vessel. These various restrictions have eliminated as far as possible the effect of the fleet's transition from single to double gear, and the effect of fisheries for other species on the northern Hecate Strait grounds.

Table 70. Catch per effort of lemon sole in northern Hecate Strait.

Year	Pounds per hour	Year	Pounds per hour	Year	Pounds per hour
1945	1,367	1950	932	1955	677
1946	988	1951	639	1956	868
1947	1,093	1952	731	1957	534
1948	632	1953	745	1958	633
1949	553	1954	563	1959	632

After an initial decline during the early years of the fishery (1945-49), catch/effort has undergone short-term variations with little or no evidence of an over-all decline. In contrast, catch has followed a slow downward trend ever since the "bonanza" year of 1950. Calculated total fishing effort has followed a similar trend and this is in accord with general information on the history of the fishery. The number of vessels engaged in the trawl fishery of northern Hecate Strait has diminished greatly during the past 8 to 10 years and this appears to be primarily the conseouence of high and increasing cost of operation.

(4) <u>Grey cod catch per unit of effort</u> K. S. Ketchen

In offshore waters there are three major fishing areas for grey cod, each with a particular season of productivity: northern Hecate Strait (January to April), Queen Charlotte Sound (April to August), lower west coast of Vancouver Island (May to July). Although grey cod have been of importance to the inshore fishery for many years, they were of only incidental value to the offshore fishery until about 1951 when a market developed for "fish sticks". From that time onward they have been the main object of fishing at certain times of the year in northern Hecate Strait and off the coast of Vancouver Island. Canadian interest in a fishery for grey cod in Queen Charlotte Sound did not develop fully until 1957.

For Hecate Strait and Queen Charlotte Sound, the analysis of catch/effort has been based on the performance of Class III (double gear) trawlers and on catch and effort records which oualify at the 25% level of selection. The same level of oualification has been applied to the records for the lower west coast of Vancouver Island, but it has been necessary (for want of sufficient data) to use single gear rather than double gear vessels of the Class III category. Average catch/effort for the three major areas is shown in Table 71.

Catch/effort has varied sharply on northern Hecate Strait grounds during the period of study and this is reflected in eoually large variations in annual catch. As yet it is difficult to say whether these changes are due to variations in availability or to changes in the strengths of incoming year-classes. Off the west coast of Vancouver Island catch/effort is less variable. Annual catch is less variable, but it appears to bear little relation to the changes in catch/effort.

An important problem facing the investigation is that of distinguishing between the effects of variations in recruitment and availability. This is no easy task, in view of the lack of adeouate means of sampling catches for age.

Table 71. Catch per effort of grey cod.

Year	Pounds per hour			Year	Pounds per hour		
	N. Hecate Strait	Q. C. Sound	West coast		N. Hecate Strait	Q. C. Sound	West coast
1951	1,960	--	435	1956	585	(380)	480
1952	1,000	--	640	1957	885	1,140	900
1953	690	--	685	1958	1,560	930	440
1954	940	--	805	1959	1,105	760	855
1955	765	--	640				

Tagging Studies

A review of results of recent tagging projects — J. A. Thomson

I. Recoveries in 1959 from previous taggings

(a) Grey cod. After two years at large, three spaghetti-type tags were returned from the Porlier Pass tagging of February 1957 (388 released; 76 recaptured in the first year, 5 in the second year). These were from the Gulf Islands area. The maximum time at liberty for this type of tag in any area is 750 days.

From 654 grey cod tagged with spaghetti-type tags in March 1958 at Porlier Pass, 37 or 5.6% were recovered in the first year. Six more tags were recovered in the second year at liberty. Three of these were from United States waters of the Strait of Georgia, 2 were from the Canadian Gulf Islands area, and one was from the Fraser River.

From 714 spaghetti-tagged grey cod liberated in Nanoose Bay in March 1958, 45 or 6.3% were recaptured in the first year. Three additional tags were returned the second year. One was caught in the Cape Lazo area, one came from grounds off Albert and William Head near Victoria and the third returned to Nanoose Bay.

(b) Rock sole. In August 1958, 1,300 rock sole were tagged with Petersen disc tags along the Butterworth-Warrior edge. Only 15 tags have been recovered to date (March 1, 1960) and all were from the general area of tagging. There have been no recoveries from the 187 tagged rock sole liberated at the same time 27 miles west of Bonilla Island, nor from the 600 rock sole tagged and released 8 1/2 miles west of White Rocks buoy.

II. Tagging in 1959

(a) Grey cod. In 1959 a plastic "dart" tag was used for the first time on grey cod. This tag has a hard plastic head with a 1/2-inch barb. The head is bonded to a clear plastic tube 6 inches long, containing a yellow plastic insert bearing, a legend and number. The dart tag is inserted in the body musculature between the first and second dorsal fins by means of a hollow, sharpened needle. In order to test the suitability of this new type of tag, comparisons have been run with the spaghetti-type tag in various regions of the coast. In March of 1959, 605 dart tags and 611 spaghetti-type tags were used on grey cod in the Porlier Pass area. By March 1, 1960, 69 darts (11%) and 59 spaghetti (10%) had been recovered. There was no significant difference between the two types. The percent of spaghetti tags recovered was twice as large as that obtained from the 1958 tagging in the same area over a similar 11 month period. Recoveries by area are broken down as follows: 103 from the Gulf Islands area south of the area of tagging, 8 from areas just north of Porlier Pass, 13 from United States waters of the Strait of Georgia, 2 from the area around Victoria, and 2 from the "40-Mile Bank" off the west coast of Vancouver Island.

Also in March 1959, 325 of both types of tags were placed on grey cod in Nanoose Bay. In 11 months, 28 dart tags (9%) and 40 spaghetti tags (12%) had been recovered. The difference here is statistically significant but the reason is obscure. As in Porlier Pass fish the percentage recovered (spaghetti only) was higher than that from the previous year's tagging when it was 5.8% for a comparable period. Twenty-eight of the 52 tags recovered came from United States waters in the Strait of Georgia, 10 came from the Canadian Gulf Islands area, 5 from the waters off Victoria, 3 from Cape Lazo north of the tagging area, 19 returned to Nanoose, 2 came from the west coast of Vancouver Island, and one was recovered from Umatilla Reef, south of Cape Flattery.

In May and June of 1959, 104 dart and 98 spaghetti tags were applied to grey cod caught on the "Firing Range", a small ground off Ucluelet on the west coast of Vancouver Island. Considering the time and effort spent, this tagging was not a success. By March 1960, 1 dart and 16 spaghetti tags had been recovered. Spaghetti tags alone show a 16% recovery rate in 6 months. All recoveries were from the area of tagging, except one from off Port Renfrew in the Strait of Juan de Fuca.

In February of 1960, further tagging of grey cod was conducted on the grounds lying 8 miles southwest of White Rocks buoy in Hecate Strait. For this tagging, the standard spaghetti-type tag was modified by inserting a length of 15-pound test nylon inside the Temflex tubing. This was to strengthen the tubing and was initiated following reports from fishermen that some grey cod were being recaptured with broken tags. The Temflex appears to be subject to wear in the region of the knot; the cord frays through and the numbered plastic marker is then lost.

Between February 1 and 10, 1960, 610 dart and 618 spaghetti-type tags were placed on grey cod on the above ground. By March 1, 1960, 27 darts and 29 spaghetti tags had been recovered. There was evidence of a northward movement towards Freeman Pass during the 3 weeks immediately following tagging.

(b) <u>Rock sole</u>. In July 1959, 1,300 rock sole were tagged with Petersen disc tags. These fish were caught and liberated along the Butterworth-Warrior edge in Hecate Strait. There have been no recoveries to date.

Age and Growth Studies

During 1959, approximately 20,700 otoliths and measurements were taken of various species of flatfish (mainly lemon sole, rock sole and brill) and 30,900 length measurements were taken of roundfish (grey cod, lingcod, ocean perch and others). These collections were made from commercial landings at the ports of Vancouver and Prince Rupert.

Results of the examination of some of this material and previous collections appear in the sections which follow.

A. Age composition of brill from the lower west coast of Vancouver Island

- C. R. Forrester

Sampling of catches of brill from the fishery off the lower west coast of Vancouver Island continues to be of paramount importance. Table 72 shows results of age determination from otoliths taken during the 1959 fishery. Approximately 1,900 female and 1,000 male fish were sampled during the season.

Table 72. Age composition in brill off the lower west coast of Vancouver Island, 1959.

Age	% Frequency		Age	% Frequency		Age	% Frequency	
	Male	Female		Male	Female		Male	Female
IV	2.7	1.1	X	2.1	3.8	XVI	0.3	1.8
V	21.4	10.8	XI	2.2	1.7	XVII	0.2	0.6
VI	30.1	25.2	XII	2.9	2.4	XVIII	-	0.4
VII	20.8	26.6	XIII	0.9	2.3	XIX	-	0.4
VIII	8.9	13.2	XIV	0.7	1.5	XX	-	-
IX	5.4	6.3	XV	1.4	1.8	XXI	-	0.1

Three age groups consisting of 5-, 6- and 7-year-old fish (1954, 1953, and 1952 year-classes) accounted for more than 70 percent of the female fish sampled and more than 60 percent of the males. Average size and age in the commercial catch has been decreasing in recent years. This evidence, in company with an upward trend in catch and catch/effort, clearly demonstrates that improvement in recruitment is now in progress. The combined United States and Canadian catch from the southern stock in 1959 was higher than in any year since 1952.

B. Age composition of brill from northern Hecate Strait

- C. R. Forrester

Until recently, effort on age determination of brill has been directed mainly towards samples taken from the grounds off the lower west coast of Vancouver Island (southern stock). These readings are up to date and work has now resumed on fish belonging to the northern stock, i.e. Queen Charlotte Sound and Hecate Strait.

Table 73 summarizes age composition of the catch made in northern Hecate Strait in 1947 and 1948. (The 1947 readings were done by W. E. Barraclough.)

Table 73. Age composition of brill from northern Hecate Strait.

Age	Percent frequency			
	1947		1948	
	Male	Female	Male	Female
3	0.4	0.2	--	0.1
4	10.8	5.2	1.5	0.6
5	27.3	16.6	1.2	6.1
6	31.2	23.7	23.1	16.2
7	19.2	22.0	23.7	18.4
8	4.4	14.3	14.7	20.9
9	2.1	5.4	5.3	11.9
10	2.6	4.3	4.4	7.7
11	1.3	4.8	4.0	4.5
12	0.5	3.0	4.7	4.5
13	0.1	0.4	3.4	2.5
14	--	0.1	1.7	1.9
15	--	--	1.0	2.8
16	--	0.1	0.2	1.1
17	--	--	0.2	0.2
18	--	--	--	0.2
19	--	--	--	0.2
20	--	--	--	0.2
Number	816	987	1,001	883
Av. lgth. (mm)	373	419	396	435
Av. age (yrs)	6.1	7.0	7.0	8.5

Exceptionally good catches of brill were made in northern Hecate Strait in 1948. The combined American and Canadian catch amounted to 6.62 million pounds. It can be seen in the table that a high percentage of these fish were representatives of the year-classes 1940, 1941 and 1942. These year-classes were also strongly represented in the 1947 catch.

Using average lengths and length-weight data, it is possible to calculate contributions of year-classes in actual numbers of fish in the catch. Comparative year-class contributions calculated from the 1948 data are as follows:

	1937	1938	1939	1940	1941	1942
Numbers of fish (thousands)	128	178	249	529	648	609

The exceptional strength of the year-classes 1940-42 may be compared with strengths of brill year-classes from the lower west coast of Vancouver Island. The summary reports for 1956-57 (page 140) show exceptionally strong representation of the year-classes 1940 to 1943 inclusive, and very poor representation for later years.

Despite the fact that age determinations for years more recent than 1948 are not yet available for the northern grounds, it can be concluded quite safely (from the history of catch per unit of effort) that year-classes subsequent to 1943, like those on the southern grounds, were relatively weak.

C. Age composition of the lemon sole in northern Hecate Strait C. R. Forrester

Otolith samples of approximately 2,100 fish have been examined from the catch of lemon sole taken in 1958 and 1959 (Table 74).

Table 74. Age composition of lemon sole in northern Hecate Strait.

	Age (percent frequency)												Number sampled
	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	
Female													
1958	0.6	11.2	25.1	21.1	21.7	10.0	5.1	3.5	1.1	0.3	--	0.3	720
1959	0.5	16.3	29.4	22.6	13.9	8.7	4.6	2.1	1.4	0.4	--	0.1	722
Male													
1958	0.3	8.3	16.4	24.4	27.0	14.9	5.5	1.7	1.4	--	--	--	348
1959	--	6.3	19.6	25.2	22.4	15.4	4.9	4.2	1.4	0.3	0.3	--	286

The 1951 year-class which dominated the catch of male fish in 1956 and 1957 remained dominant as 7-year-olds in 1958. In 1959, however, it had been relegated to secondary importance by the year-classes of 1952 to 1954. Among female fish, the 1951 year-class had a shorter period of dominance (1956 and 1957 only) and was overshadowed by the year-classes of 1952 to 1955 in 1958 and 1959.

The percentage age frequency of female fish is almost identical with the mean frequency for the years 1954-58 inclusive. It appears that recruitment has been average for some years. Fluctuations in catch in recent years are probably just a reflection of changing availability of the species to the trawlers.

D. Age composition of rock sole in northern Hecate Strait C. R. Forrester

Age determinations from otolith samples of rock sole collected during the 1958 and 1959 fishery are summarized in Table 75.

Table 75. Age composition of rock sole in northern Hecate Strait.

	Age (percent frequency)										Number sampled
	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	
Female											
1958	4.1	67.4	13.5	6.2	3.0	3.7	0.9	0.8	0.2	0.2	1,009
1959	0.8	51.7	39.3	5.9	1.3	0.8	0.1	--	--	--	746
Male											
1958	11.1	40.7	16.3	15.6	10.4	5.2	0.7	--	--	--	270
1959	4.5	73.2	16.1	4.5	1.8	--	--	--	--	--	112

Both the 1958 and 1959 samples are characterized by unusually strong representation of 5-year-old fish. Average age and average length, which had been increasing during the 1954-57 period, showed a decrease. There is little doubt that there has been a marked increase in the level of recruitment to the stocks exploited in this area. This was indicated in the 1958 fishery when total catch was approximately 50% higher than the average for the previous 13 years. Catch per unit of effort was double that which had prevailed in previous years.

In 1959, however, the catch dropped sharply to the lowest point since 1945. This was despite the fact that catch/effort was even higher than in 1958. It appears that the rock sole trawling grounds in 1959 were crowded with small fish, and fishermen turned their attention elsewhere. Average size of female fish in catches which were made in the northern Hecate Strait area was only 35 cm. - or about 2 cm. over the minimum market size at Prince Rupert.

Observations made on the grounds during the summer of 1959 showed that a very high percentage of fish were well below commercial size. It is likely that by the summer of 1960 these fish will still be too small to attract a fishery.

E. Sampling of Bering Sea cod C. R. Forrester

In 1959, otolith and scale samples from 212 Bering Sea grey cod were obtained through the courtesy of Mr. R. J. Myhre of the International Pacific Halibut Commission. The samples were taken during the period April to August inclusive and included specimens from both shallow and deep water. The samples taken in shallow water (10 to 32 fathoms and 34 to 100 fathoms) were from grounds off Cape Mordvinof on Unimah Island and off Makushin Bay on Unalaska Island. The balance of the fish were taken in depths of 75 to 240 fathoms on the edge of the continental shelf which runs west from Cape Sarichef. Some of these fish were caught south and east of the Pribilof Islands while others were caught 160 miles W × N of St. Paul Island (largest of the Pribilof Islands) in the central Bering Sea.

Both scales and otoliths are being used in age determination. There appears to be some agreement in ages greater than 5, but there is considerable overlap in lengths at ages 4 and 5. Errors in age determination are not unlikely, but examination, which is continuing, may show differential growth between deep and shallow water cod.

A preliminary study has been made of both scales and otoliths for age determination. As yet discrepancies in the results obtained by the two methods have not been resolved. Greater agreement has been found for fish above Age V than for younger fish. Nevertheless, it is apparent that growth rate is much slower than in British Columbia waters and there is some suggestion of a differential growth rate between cod caught in deep and shallow water.

F. Total mortality rate of British Columbia grey cod — K. S. Ketchen

Lack of a technique for routine age determination of grey cod prevents the use of age-frequency distributions for estimation of total mortality rates. However, if there is information available on growth rate and length composition of the catch, this problem can be circumvented. Beverton and Holt (1956) have derived the following expression for instantaneous total mortality rate:

$$Z = \frac{K(L_\infty - \bar{\ell})}{\bar{\ell} - \ell'}$$

where K and L_∞ are the coefficient of growth and asymptotic length, respectively, as derived from the von Bertalanffy growth equation; ℓ' is the smallest length of fish which are fully represented in the catch sample and $\bar{\ell}$ is the average length in the sample as computed from ℓ' upwards.

For Strait of Georgia grey cod, values of K and L_∞ have been obtained by three methods. The first (Method I), which is independent of the other two, makes use of Swanson Channel growth data obtained by plotting length frequencies on probability paper. Method II is based on growth rates determined from one-year tag returns from <u>all</u> taggings conducted in the Strait of Georgia during the period 1955-59. Method III is also based on tagging results, but involves only those obtained from Nanoose Bay and Porlier Pass taggings.

The resulting values of K and L_∞ are given in the accompanying table. These have been applied to the length frequency distribution of commercial catch samples at Nanoose Bay (the average distribution for the years 1956-59). The length at full recruitment (ℓ') was estimated roughly as 580 mm. and the average length of fish from ℓ' upwards (i.e. $\bar{\ell}$) was 631 mm.

Method	K	L_∞	l'	$\bar{l}$	i	a
I	0.51	780	580	631	1.49	77.5%
II	0.53	756	580	631	1.30	72.8%
III	0.55	765	580	631	1.46	76.8%

As shown in the table, the three methods yield estimates which suggest that total mortality rate is relatively high - much higher than anything recorded for other groundfishes in British Columbia waters and of about the same order of magnitude as that observed in herring.

The low rate of return from taggings conducted in the Strait of Georgia (usually less than 10% after one year at large and zero after 2 1/2 years) has been mentioned in previous reports. Although this could be regarded as evidence of a high rate of tag loss (by shedding), this is not likely to be a major factor, for it would be apparent in the condition of those tags which are recovered. There is no evidence of an initial high rate of tagging mortality. Taggings which have been conducted in the presence of a fishing operation have yielded substantial numbers of returns during the succeeding two or three months.

These observations in company with the results drawn from analysis of catch samples support the view that death due to natural causes accounts for a large share of the observed total mortality rate. Current efforts to develop a tag which will lead to a minimum of loss due to shedding will help to reduce the disparity between tagging and length frequency estimates of total mortality. It will then be possible to consider methods for partitioning natural and fishing mortality rates.

Special Studies

A. Maturity of grey cod

C. R. Forrester

Maturity studies on grey cod were conducted during a tagging cruise to the White Rocks ground of Hecate Strait in February 1960. Sampling showed that the length-maturity relationship is very similar to that observed 400 miles to the south in the Strait of Georgia. Fifty percent of male fish are mature at 48 to 49 cm. in the Strait of Georgia and at 49 to 50 cm. in Hecate Strait. The 50% level of maturity in female fish is reached at a length of approximately 55 cm. in both localities.

Although much more work is required, there is some indication that growth rate in Hecate Strait is slower than in the Strait of Georgia - and that few fish are mature by the end of their second year. In the southern area, 50% of the females and all males are mature by that age.

B. The seasonal bathymetric distribution of grey cod in relation to temperature

- K. S. Ketchen

During 1959 an attempt was made to relate seasonal changes in the bathymetric distribution of grey cod (as indicated in trip report data) to seasonal changes in temperature structure on various banks along the open coast of British Columbia. If some relationship to temperature does exist, it may be possible to shed some light on the question of whether or not the large annual variations in catch/effort are due to variations in availability. Existing oceanographic information is however very sparse, and any hope for success in the study of year-to-year variations in cod distribution as related to the environment would depend on a greatly intensified programme of coastal oceanographic survey.

(1) Seasonal migrations. Table 76 gives a generalized (1954-58 average) picture of the depths at which cod are caught during various months throughout the year. Underlined figures mark the months of greatest activity by the Canadian fleet in the search for cod.

Table 76. Bathymetric distribution of grey cod in British Columbia waters.

Area	Average depth (fathoms)											
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Two Peaks	52	--	--	--	55	--	46	43	42	--	39	--
Warrior	--	--	46	42	44	50	43	33	32	31	--	--
White Rocks	--	--	65	62	57	57	55	47	37	--	--	--
Horseshoe	--	38	--	--	--	--	25	31	31	41	45	44
Goose Island	--	--	--	--	--	--	72	60	56	57	61	60
Cape Scott	64	56	83	--	--	--	44	52	46	51	62	63
Lower West Coast	37	43	43	--	--	--	--	35	37	35	36	38

In no one area does the fishery occur throughout the year because of either low availability, unfavourable weather, or both. Fishing on the White Rocks grounds takes place mainly during the winter months at which time the cod are in spawning condition and generally at depths greater than 50 fathoms. With the approach of spring the fishery shifts to adjacent areas and in shallower water (Warrior, Two Peaks and Horseshoe). This is probably a reflection of a migration away from the White Rocks spawning ground. As a rule, by June the fishery for cod in Hecate Strait comes to an end. The May-June period appears to mark the end of the spring-time advance to shallow water. Thereafter, what records are available suggest a gradual return to deeper water.

On the Goose Island and Cape Scott banks and off the lower west coast of Vancouver Island, the cod occurs mainly during the May-June period, again at the time when the cod reach the shallowest depth in their seasonal cycle. During the summer and fall there is evidence of a return to deeper water. Records on the United States fishery show that the cod in these general areas reach their greatest depth (50-70 fathoms) during the early winter months.

(2) The seasonal cycle of temperature. Data on the seasonal movements of cod for the years 1954-55 and 1957-58 have been compared with information on the seasonal change in temperature structure of water overlying the main banks (data from P.O.G. coastal surveys). There appears to be a general conformity between cod movements and seasonal changes in temperature. The cod move downwards during the summer and fall as temperature rises in the shallower levels. The warming progresses into deeper water (25-100 fathoms) and continues until mid-winter, at which time the cod reach the lower limit of their seasonal bathymetric range. They then advance to shallower water with the rapid cooling which takes place in late winter. As summer approaches, the upper regions begin to heat up again and the cod begin their descent to deeper water.

Throughout the seasonal bathymetric cycle, the temperature of the water occupied by cod was very much the same: 6°-7°C on the Two Peaks ground; 6°-8°C in the region of the Warrior, White Rocks and Horseshoe grounds; 6°-8°C on the Cape Scott and Goose Island grounds and 7°-9°C on grounds off the west coast of Vancouver Island.

Generally, cod of the North Pacific occur within the range of 0°-10°C. In Bering Sea and northwestern Pacific they are encountered most freouently between 0° and 4°C, while towards the southern limit of their range along the Asian shore, they appear to occur mainly in water of about 2°-6°C.

It is apparent from the preliminary studies in British Columbia waters that the cod occur in much warmer water than elsewhere and well within the upper half of the general temperature range for that species.

C. Studies related to the mesh selection problem

C. R. Forrester

(1) Length-girth relationship in rock sole of Hecate Strait. Length-girth studies for rock sole taken from Hecate Strait in July 1959 have yielded the following eouation:

$$Y = 1.07X + 2.00$$

where X is the girth (cm.) and Y the total length (cm.).

If we assume that the rock sole utilizes the available mesh dimension to the same extent as the lemon sole (Summary Reports 1958-59, p.165), the mesh size which would release 50 percent of rock sole at 33 cm. in length (minimum market size at Prince Rupert) measures 32.2 cm. in internal circumference. This measurement, when taken with the Scottish pressure-gauge using 8-pound tension on wet mesh, corresponds to a mesh size of 15.7 cm. or 6.18 inches. This measurement is in excellent agreement with the mesh size calculated from length-breadth measurements (6.19 inches).

(2) Length-girth relationship in grey cod. Data on the relationship between the length of a grey cod and its girth are being accumulated for the purpose of determining what size of mesh is reouired to liberate fish which are too small for marketing. During the February trip of 1960 to the White Rocks grounds girth measurements were taken for both the head and body. The relationship between total length (Y) and head girth (X) in centimetres is expressed as

$$Y = 2.18X + 0.26 \qquad (1)$$

and between total length and body girth it is

$$Y = 1.88X + 1.57 \qquad (2).$$

In the Swanson Channel area (Strait of Georgia), for the same time of year, the relationship corresponding to (2) above is

$$Y = 1.73X + 2.17$$

which shows that for a given fish length, body girth is about 6.5% greater than in fish from the Hecate Strait area. The length-maturity relationship in the two areas is more or less identical, so the observed difference is not likely to be due to differential development of the gonads. Further sampling is necessary to determine whether the greater girth of Swanson Channel grey cod is due to fatness or to the amount of food in the gut.

MARINE COMMERCIAL FISHERIES - CRAB AND SHRIMP

T.H. Butler

The crab fishery of the Queen Charlotte Islands has been under investigation since 1947 to discover and explain fluctuations and assess the need for regulation.

During 1959 all data pertaining to the fishery were reviewed in detail. At present, study of the Naden Harbour area is complete and work is well advanced on the Hecate Strait and McIntyre Bay fisheries. A limited amount of field work was carried out during the 1959 season.

The shrimp program of this Station since 1953 has been confined largely to exploratory fishing. Active investigation from 1953 to 1955 led to discovery of a number of promising shrimp grounds, three of which are fished commercially now. A limited program of exploration and gear testing was conducted in 1959.

Crab

A. 1959 Queen Charlotte Islands crab fishery

The total crab catch from the British Columbia coast was 4,322,700 pounds; 74.8% of this total was taken around the Queen Charlotte Islands. In the following summary the success of fishing is given for each area separately.

(1) Naden Harbour. During the spring fishery, from March 16 to April 28, 51,027 pounds of crabs were caught, an average catch of 615 pounds per day. In the 1958 spring fishery 25,935 pounds were taken at an average rate of 695 pounds per day. The 1959 fall fishery yielded 48,799 pounds and the average daily catch was 270 pounds. There was no fall fishery in 1958. The total catch in 1959 was 99,826 pounds, the highest since 1954.

(2) McIntyre Bay. The total catch of the 1959 season was 340,689 pounds compared with the 1958 catch of 534,702 pounds. In both years vessels from Masset accounted for the entire catch. During the years just before 1958 (1955 to 1957) the total annual catch averaged about 1.1 million pounds. The reason for the recent abrupt drop in production from this area was the establishment in 1958 of a closure extending from July 10 to September 20.

Four vessels started to fish in March, and late in April were joined by another; by mutual agreement each vessel was restricted to 350 traps. Catches were low until late in April and then fishermen began to move their traps to the Hecate Strait ground. No crabs were caught in McIntyre Bay from the first week in May until late in September when the fishery resumed and continued until the middle of October.

(3) Hecate Strait. In 1959, fishing extended from late March until early November. The total catch in 1959 was 2,771,368 pounds; 1,428,358 pounds were caught by five boats based at Masset, and the rest (1,343,010 pounds) were taken by four boats from Port Edward. In 1958 the record catch of 2,949,892 pounds was shared as follows: five boats from Masset caught 1,273,257 pounds and four Port Edward boats caught 1,676,635 pounds.

Generally, boats from Port Edward confine their operations to the eastern part of Hecate Strait, and those from Masset fish along the east coast of Graham Island. No American vessel has fished in the region since 1955. Canadian fishermen have been able to catch what was taken formerly by American vessels, and in 1958 and 1959 total Canadian catches of crab in Hecate Strait far exceeded the combined catches of both countries in earlier years.

B. Experimental fishing, 1959

During July, crab fishing was conducted by the Investigator No. 1. In McIntyre Bay six tows with a small-meshed trawl were made between 4 and 10 fathoms; and in Hecate Strait four tows were completed between 3 1/2 and 6 fathoms.

These ten tows were repeats of tows made in 1956. In Hecate Strait, both males and females were more abundant in all 1959 tows. In McIntyre Bay, males were found more abundantly in 1956 and the females were generally more abundant in 1959.

As mentioned in another section, a summer closure is now in effect in McIntyre Bay. The purpose of the regulation is to protect soft-shelled crabs. In general, the industry is satisfied with the closure, but there has been some representation to have one of the boundary lines of the closed area moved. It is contended that crabs in the western sector of the closed area, the so-called "Masset Bar" region, moult earlier and harden sooner than crabs on the ground off Rose Spit.

Limited trap fishing early in July 1956 had shown that 27% of legal-size males taken on Masset Bar were soft-shelled; and 62.5% of those caught at Rose Spit were soft-shelled. Further testing in July 1959, although fishing locations and times were not entirely comparable, showed that 30.8% of legal-size males on Masset Bar were soft-shelled, compared with 87.8% which were soft-shelled at Rose Spit.

Thus, there seems to be reason to suspect that moulting times and soft-shelled seasons differ in the two sectors of McIntyre Bay, although tagging has indicated a single population throughout the area. It is planned to conduct further experimental trapping in 1960 to determine moulting times more exactly.

C. Review of Naden Harbour fishery

Commercial fishing started in 1917 but catch records do not exist before 1933. Fairly complete statistics, including total fishing effort, are available for the period following 1938. Total catches from 1933 to 1959 in number of crabs are shown in Table 77; in some years fishing was carried out both in spring and fall.

Table 77. Numbers of crabs caught in Naden Harbour, 1933 to 1959.

Year	Catch	Year	Catch	Year	Catch
1933	13,000	1942	5,829	1951	43,835
1934	56,000	1943	--	1952	26,890
1935	68,000	1944	12,366	1953	77,446
1936	132,000	1945	--	1954	65,658
1937	124,000	1946	18,179	1955	25,412
1938	143,534	1947	76,214	1956	10,230
1939	124,037	1948	79,418	1957	19,434
1940	40,235	1949	51,920	1958	15,256
1941	24,301	1950	54,197	1959	58,721

In most years total catch is related directly to fishing effort. Until 1939 the crab cannery operated at Naden Harbour and it was possible for maximum effort to be exerted. In subsequent years the cannery was located at Masset, about twenty miles away. During the war years effort was low and in 1943 and 1945 fishing was suspended. Following the war, production rose again, but much fishing time was lost because fishermen had to pack their crabs to Masset, sometimes impeded by bad weather. Then during most of the last decade a closure further reduced fishing time, and also demand for Naden Harbour crabs declined in favour of those from "outside" fishing grounds which were more suitable for the developing "whole-frozen" trade.

Population estimates from tagging experiments and rates of commercial fishing show clearly that size of stock fluctuates. From 1947 to 1953, total number of marketable crabs varied from about 75,000 to 278,000; and the fishery took at the most about 35% of these. There is no evidence that fishing has brought about changes in abundance or that overfishing has occurred. Sampling showed that size composition changed from year to year and that the fishery is dependent largely upon crabs which each year reach legal-size (6 1/2 inches, or 165 mm.) and slightly larger. These crabs apparently represent an incoming year-class which is estimated to be four years old. The strength of this recruitment determines success of fishing.

In an attempt to explain fluctuations in crab year-class strength, effect of environmental factors during larval life was considered. Experimental fishing of early post-larval crabs showed annual variations in abundance, suggesting that year-class strength may be decided during pelagic larval life which extends from

April to September. Continuous observations of conditions in the sea around Naden Harbour are limited to daily readings of surface temperature and salinity at the lighthouse at Langara Island. Temperature data only were considered. Tests of correlation were made between catch of crabs per boat day (Table 78) for 14 years from 1944 to 1959 and mean seawater temperatures at Langara Island for April, March-April, and August four years earlier (1940 to 1955).

Table 78. Catch of crabs per boat day at Naden Harbour, 1944 to 1959.

Year	Catch per boat day	Year	Catch per boat day
1944	1,031	1952	94
1946	466	1953	293
1947	468	1954	187
1948	421	1955	110
1949	249	1956	166
1950	252	1957	420
1951	237	1959	159

Direct relationship was shown and the following correlation coefficients are statistically significant (at 1% level).

Mean monthly seawater temperature at Langara Island	Correlation coefficient (r)
April	.778
March-April	.753
August	.679

Thus warm water temperatures in April (and March) and August apparently promote better hatching and survival of larvae. Temperature during April may be a controlling factor since moulting of the first zoea which occurs within several days after hatching is a critical stage, at least in captivity. During August warm seawater is likely to be associated with prevailing onshore winds which would tend to keep larvae in Naden Harbour.

Using the relationship between relative abundance and the April mean seawater temperature at Langara Island ($Y = -8{,}350 + 194.5X$), an attempt has been made to predict success of fishing in 1960, 1961 and 1962, based upon temperature observations in 1956, 1957 and 1958 respectively. Predictions are that the Naden Harbour fall fishery in 1960 will be one of the poorest on record; in 1961 it will be slightly below average; and in 1962 the fishery should be very successful. It is planned to check the validity of these predictions well in advance of fisheries by surveys of abundance of crabs.

Shrimp

A. Survey of shrimp grounds

During 1959 several areas were re-surveyed by the Investigator No. 1.

(1) West coast of Vancouver Island. Twenty-one tows were completed during June in several inlets and in the open water adjacent to Nootka Sound. Localities in the inlets were fished first by the chartered trawler Yuri M. in 1954. Generally in 1959 catches of "smooth pink" shrimps, *Pandalus jordani*, were greater than in 1954. This was especially apparent in Imperial Eagle Channel, Barkley Sound, where tows indicated that a moderate fishery could be developed. Late in January 1960, commercial fishing on this ground started.

An area about 15 miles off the entrance to Nootka Sound was surveyed first during June 1955 by the chartered trawler Glendale V. Catches indicated that shrimps were not present in quantities sufficient to support a profitable offshore fishery by large trawlers. Also, because shrimps were small, it was considered that a hand-peeling operation would be uneconomical. The 1959 survey was limited to five tows which were not repeats of any made in 1955. Thus, it has been possible to determine the boundaries of this ground which is about 16 miles long and from one to two miles wide. Prospects for development of a commercial operation appear to be favourable, but would depend heavily on the availability of peeling machines nearby.

(2) Chatham Sound. To determine seasonal differences in abundance, five trawl tows, which were completed originally in January 1954 and repeated during September of the same year, were repeated again on 27 July 1959. In 1959, pink shrimps (*Pandalus borealis*) were more abundant than in January 1954 at depths from 47 to 59 fathoms and less so at 30 fathoms; but less abundant than in September 1954. Side-stripe shrimps (*Pandalopsis dispar*) at all depths were more abundant in July than in September; and more abundant at 30 and 47 fathoms than in January, but less so at 51 and 59 fathoms.

These five tows were made again by the A.P. Knight on 12 February 1960. In all but one tow pink shrimps were more abundant than previously, but side-stripe shrimp catches were generally less than at other times. It is suggested that the apparent differences in abundance indicated by the recent experimental fishing are annual fluctuations rather than seasonal variations.

B. Testing of shrimp trawls

Experimental fishing was conducted on the Cape Lazo ground from January 4 to 14 with the Investigator No. 1 to compare the fishing ability of the 40-foot "Gulf of Mexico" trawl with that of the Station shrimp otter-trawl, and to determine the effect of mesh size and length of extension lines on the amount and size of shrimps, and amount of fish taken.

Comparable tows showed that shrimp catches by the Gulf trawl and Station trawl did not differ significantly, but fish catches were higher in the Station trawl. Also, handling of the Gulf trawl proved easier. Thus, although performance of the trawls in catching shrimps is much the same, the Gulf trawl seems preferable to the Station trawl for exploratory fishing, especially in the open ocean.

Using the Gulf trawl, sixteen tows were carried out to test three cod-ends of 1 1/4- and 1 1/2-inch cotton, and 1 1/8-inch nylon. Catches were weighed and samples taken to determine number of shrimps per pound and for measurement. Results are shown below.

Type of cod end	Average catch of shrimps per 15 min. tow (lbs)	Counts of whole shrimps per lb
1 1/8-inch nylon	60.3	147
1 1/4-inch cotton	62	168
1 1/2-inch cotton	28.9	104

Catches of shrimps in the 1 1/4-inch cotton and 1 1/8-inch nylon cod-ends did not differ significantly, but weight of shrimps in the 1 1/2-inch cod-end was less than half that in the other cod-ends. Counts of whole shrimps from 1 1/4- and 1 1/8-inch cod-ends did not differ significantly, but the count of shrimps in the 1 1/2-inch cod-end differed significantly from counts of shrimps found in the other two. Carapace lengths of shrimps measured were from 8 to 22 millimeters. In a sample of 174 from the 1 1/8-inch nylon cod-end, those having carapace lengths from 8 to 13 mm. comprise 37.4% of the total, but from the 1 1/2-inch cod-end 12.1% of a sample were in this smaller group.

The apparent lack of difference in catches from cod-ends of 1 1/4-inch cotton and 1 1/8-inch nylon is to be expected since when wet the mesh sizes would be almost identical (nylon stretches and cotton shrinks). The reported change from 1 1/4-inch cotton netting to nylon netting by some commercial shrimpers then, apparently, will not occasion any adjustment in catch statistics. Escapement of small shrimps from the 1 1/2-inch cod-end reduces weight of shrimps taken and increases average size. Use of this mesh size in offshore fishing would yield larger shrimps which possibly could be peeled economically by hand.

The Gulf trawl normally is fished with 2-foot extension lines, i.e. lines between otter boards and wings of net. Tests were conducted to compare fish catches of this trawl with those of a trawl having 5- and 10-fathom extension lines. A trawl fitted with 10-fathom lines caught significantly more fish than the control trawl, but a trawl with 5-fathom lines did not. It is suspected that fish are "herded" or guided by long extension lines into the trawl, while shrimps apparently are unaffected because catches did not vary according to length of lines. The finding has some application to design and rigging of shrimp otter trawls since it is advantageous to keep incidental fish catches at a minimum.

MARINE INVERTEBRATES

D. B. Quayle

While the major objective is the study of the distribution and ecology of marine bottom invertebrates, a number of other problems dealing with this group come within the scope of the investigation. Subjects of study include: distribution and ecology of marine bottom invertebrates, Pacific oyster spatfall forecasting, advisory service to oyster growers, shellfish pollution problems, shellfish toxicity, commercial clam and abalone problems, invertebrate identification and information. Preparations were also made in 1959 for deep-water clam explorations in co-operation with the Industrial Development Service of the Department of Fisheries.

Distribution of Marine Invertebrates

So far the effort has been directed mainly toward gathering equipment. Bottom samplers such as the Peterson, Van Veen and Knudsen types have been obtained and a sorting device is being fabricated in the Station machine shop.

One major intertidal collecting trip was made to the northwest coast of Vancouver Island between Esperanza Inlet and Cape Scott. Little of the material has been studied so far but the first extensive population of Enteropneusta in British Columbia was located at Louie Creek. Found in the same habitat was the lamellibranch Bornia retifera, thus establishing a northward range extension of about 13 degrees of latitude for this species.

Field trips for other specific purposes provided some opportunity for additional collecting and life history study.

Some time was devoted to the identification of specimens for Station personnel and others.

Seasonal Gonad Changes in the Pacific Oyster

The Pacific oyster is well known for the occurrence of drastic changes in condition from season to season and from year to year. For better understanding at a cellular level of the processes which are associated with these changes, a gross histological study of the seasonal gonad changes has been partially completed. The next step will be concerned with the distribution of glycogen in oyster tissues by histochemical methods.

Spawning in the Pacific oyster is usually complete and may occur any time between late June and early September but most often in Late July and early August. After complete spawning the body of the oyster is nearly transparent and the gonad follicles are collapsed and contain only a few relict gametes and tissue fragments. The condition is then at the lowest level of the year.

By November the level of winter condition has been established. The follicles have shrunken to small compact islands of germinal tissue scattered throughout the mass of vesicular connective tissue which has filled in the interfollicular spaces as well as the area between the gonad proper and the body epithelium. The relative amount of this connective tissue particularly in the latter area determines the condition of the oyster. The main outer gonaduct separates the gonadal area from the outer connective tissue area where no germinal material occurs. At this stage some of the follicles that have not completely closed up may contain a few relict eggs or sperms. In a few cases of partial spawning only the outer follicles had been involved.

The gonad is generally undifferentiated as to sex at this time (November) and the condition exists throughout the winter. It was not until the April sample that early stages of gonad proliferation and differentiation could be noted. The maximum stage of development observed late in April was a female with about 25% of the gonad area occupied by follicular material. By mid-May gametogenesis was well under way and on the average about 50% of the potential gonadal area was filled with expanding follicles.

By the end of June all animals were fully ripe with the follicles tightly packed with eggs and sperm and only a very thin layer of vesicular connective tissue covering the gonad. This condition persists until spawning with an occasional partly spawned individual already showing proliferation of connective tissue between the spent follicles.

Material is now available for an histological study of the gonad in the case where spawning did not occur and where the animals entered winter in a fully ripe condition.

Pacific Oyster Breeding

Since there is active interest by oyster growers in obtaining local seed, assistance is provided in the form of spatfall forecasts. The two areas of interest are Ladysmith Harbour and Pendrell Sound.

Ladysmith Harbour. The water temperature in this area during the summer of 1959 was generally marginal for successful oyster breeding. At no time did the plankton show any evidence of a major spawning and only a few larvae were ever present. The growers were advised not to expose cultch. Test cultch indicated an average spatfall of one spat per shell, well below the minimum commercial level.

Pendrell Sound. The water temperature here reached 20°C as early as June 20 and remained relatively high throughout the summer. For some time in mid-July the mean daily temperature at a depth of 3 feet remained at about 23°C and at times reached a maximum daily mean of 24.5°C.

The first spawning occurred on June 25 and by July 7 the plankton contained an average of 4 umboned larvae per gallon. A commercial set was forecast for July 14 or 15. Cultch exposed at the thermograph station on July 11 and removed July 16 caught an average of 161 spat per shell, somewhat higher than expected from the small number (less than one per gallon) of advanced umbo larvae in the plankton of July 11.

Further spawnings were observed on July 12 and on July 19. Plankton taken July 23 indicated a heavy set would occur during the first few days of August. On cultch exposed between July 11 and August 4 the spatfall from this set averaged 156 spat per shell at 3 stations. Cultch exposed throughout the summer caught a set so heavy it was impossible to count, as it amounted to several hundred spat per shell.

The commercial seed producer who is the main and sometimes the only operator in Pendrell Sound exposed 300,000 cemented veneer circles and about 3,000 shell strings.

The extensive 1958 Pacific oyster set virtually blanketed a considerable portion of Brandon Island in front of the Biological Station. This situation is typical of many areas throughout Georgia Strait. Further study of the distribution of this set is planned to discover how well it fits the known surface circulation pattern.

Shellfish Toxicity

There has been little activity in this field during 1959.

The southern boundary of the closed area in Georgia Strait was moved about 15 miles northward to form a Departure Bay-Texada-Nelson Island line.

A modified method of obtaining routine samples of shellfish for toxicity determinations, involving the use of paid samplers, was suggested by a sampling sub-committee of the Pacific Coast Shellfish Committee. The purpose of this move was to attempt to make the sampling more regular than it has been in the past.

There has been a general downward trend in toxicity levels in butter clams (Saxidomus) in the Campbell River-Comox district of Northern Georgia Strait and most recent values are very near the accepted quarantine level. The erratic short term departures from the main well-established trend may be due to sampling variation, the range of which has not been established for British Columbia.

It is therefore possible the toxicity now being recorded is the slowly dissipating residual from the 1957 outbreak in the northern Georgia Strait.

This investigation supplies samples for routine toxicity determinations from the Departure Bay area.

Oyster Pollution at Crofton

In anticipation of probable difficulties with oysters following the kraft pulp-mill development at Crofton, the British Columbia Department of Fisheries through the Shellfish Laboratory at Ladysmith initiated a program to determine the pre-pulp-mill situation relative to spat survival, growth and condition of Pacific oysters in the vicinity of the proposed mill. This survey covered a period of about 2 years before the mill began operations.

As a result of claims by oyster growers that oysters were being deleteriously affected by the mill effluent, the study has been taken up again by this investigation after a hiatus of two years. Since growth and mortality of oysters do not appear to be affected, the effort was placed on the problem of condition. As far as the commercial beds were concerned it was realized that condition factor data would be unlikely to provide conclusive proof of pollution one way or another, but if the condition of the oysters was very significantly lower than they were prior to the advent of the mill it would be an indication upon which to base further study.

In view of this situation a field experiment was also designed to compare the effects of the effluent on the conditions of oysters held at varying distances from the outfall. The oysters would be held on trays so that variables such as tidal height and type of bottom might be controlled.

Condition of Commercial Oysters

Monthly condition factor determinations were made for the most part on composite samples of 25 oysters. The data from Ladysmith in the early years represent means of 10 oysters whose condition had been found on an individual basis. Samples in later years were taken from each of three commercial beds at Crofton, from one at Chemainus, two at Ladysmith and one from North Thetis Island.

Condition factor data treated on the basis of means must be used with caution. From the industry view-point the summer values are of little concern for it is usually a non-operating season, though this is when some of the highest values for condition occur. Where the overall situation is being studied, as in the present case, means are of value provided all seasons are equally represented. This is not so for the available data which is therefore presented in its entirety in Tables 79, 80 and 81.

As noted in Table 81 the condition of the Crofton oysters (see map for specific areas) in 1959 was not good, particularly during the harvest season in January, February and March. This was equally true for November and December of 1958 although no quantitative data are available. The conditions during the harvest period in late 1959 were similar for the Limberis (Lot 81) and Barnes (Lot 320) oysters but considerably better for those of Biscoe (Lot 277) which are approximately equivalent in condition, during this period, to those at Chemainus, Ladysmith and Thetis. The Biscoe and Limberis beds are approximately equi-distant from the outfall while those of Barnes are about four times as distant (2 miles). The distribution of the effluent is described in the reports of the Pollution investigation. Approximately the same relationship in condition between the three beds existed before the mill as after. The 1956 data for these three beds show some relatively low values which on the whole are not very different from those of 1959.

About the only conclusion that may be reached is that the magnitude of the changes that have occurred so far at Crofton are within the range of those known to occur in non-polluted areas. The data do not indicate whether the mill effluent is or is not a factor in causing the observed changes.

Field experiment. A randomised block design was chosen and arranged to provide 6 replicates at each of three stations (see map), allowing the following analysis:

Analysis of variance

Sources of variation	Degrees of freedom
Replications	5
Treatments	2
Error	10
Total	17

Station A was within 25 yards of the outfall; Station B was 300 yards further towards the shore and Station C was another 300 yards farther than Station B. All trays were placed at the 3.5-foot tide level. To each of the 13 trays, 200 oysters were allotted and samples of 25 were taken from each tray for 18 independent condition factor determinations each month.

Table 79. Condition factor of Pacific oysters, Ladysmith, 1952 to 1959.

	1952	1953	1954	1955	1956	1959 (A)	1959 (B)
January	106	68	95	92	99	--	--
February	100	--	63	91	--	105	80
March	91	--	77	93	91	82	87
April	128	--	73	--	75	123	127
May	160	99	110	119	92	--	--
June	149	103	99	134	108	139	107
July	160	93	114	140	74	--	--
August	90	56	93	91	107	--	98
September	96	--	114	92	--	--	76
October	109	76	128	98	82	93	77
November	102	78	96	70	91	--	--
December	109	62	93	96	77	94	68
Mean	117	80	96	101	90	106	90

Table 80. Condition factor of Pacific oysters, Crofton-Chemainus-Ladysmith, 1955 to 1957.

1955	Crofton			Chemainus	Ladysmith
	Limberis	Biscoe	Barnes	Betts	
January	--	--	--	--	92
February	--	--	--	--	91
March	--	--	--	--	93
April	--	--	--	--	--
May	137	125	103	115	119
June	--	--	--	--	134
July	152	136	--	156	140
August	68	108	91	97	91
September	70	157	52	109	92
October	70	144	67	101	98
November	70	122	57	109	70
December	--	111	40	105	96
Mean	94	129	68	113	101

continued.....

Table 80 continued

1956	Crofton			Chemainus	Ladysmith
	Limberis	Biscoe	Barnes	Betts	
January	64	82	68	98	99
February	67	--	49	--	--
March	58	93	56	102	91
April	--	--	--	--	75
May	46	96	70	96	92
June	70	98	82	128	108
July	62	108	70	89	74
August	98	129	123	130	107
September	--	--	--	--	--
October	--	--	--	--	82
November	53	86	--	133	91
December	51	81	98	84	77
Mean	63	97	77	107	90
1957					
February	52	76	74	71	

Table 81. Condition factor of Pacific oysters from four areas in Stuart Channel, 1959.

1959	Crofton			Chemainus	Ladysmith		North Thetis
	Limberis	Biscoe	Barnes	Betts	Paton (A)	Eugene (B)	Limberis
January	41	60	40	63	--	--	--
February	39	64	59	--	105	80	49
March	55	67	60	--	82	87	110
April	83	121	77	--	123	127	121
May	--	--	--	117	139	--	--
June	90	107	87	--	--	107	--
July	71	103	102	125	--	--	130
August	59	102	76	--	--	98	--
September	60	114	61	--	--	76	132
October	56	104	60	83	93	77	106
November	--	--	--	--	--	--	--
December	48	90	60	95	94	68	85
Mean	60	93	68	96	106	90	105

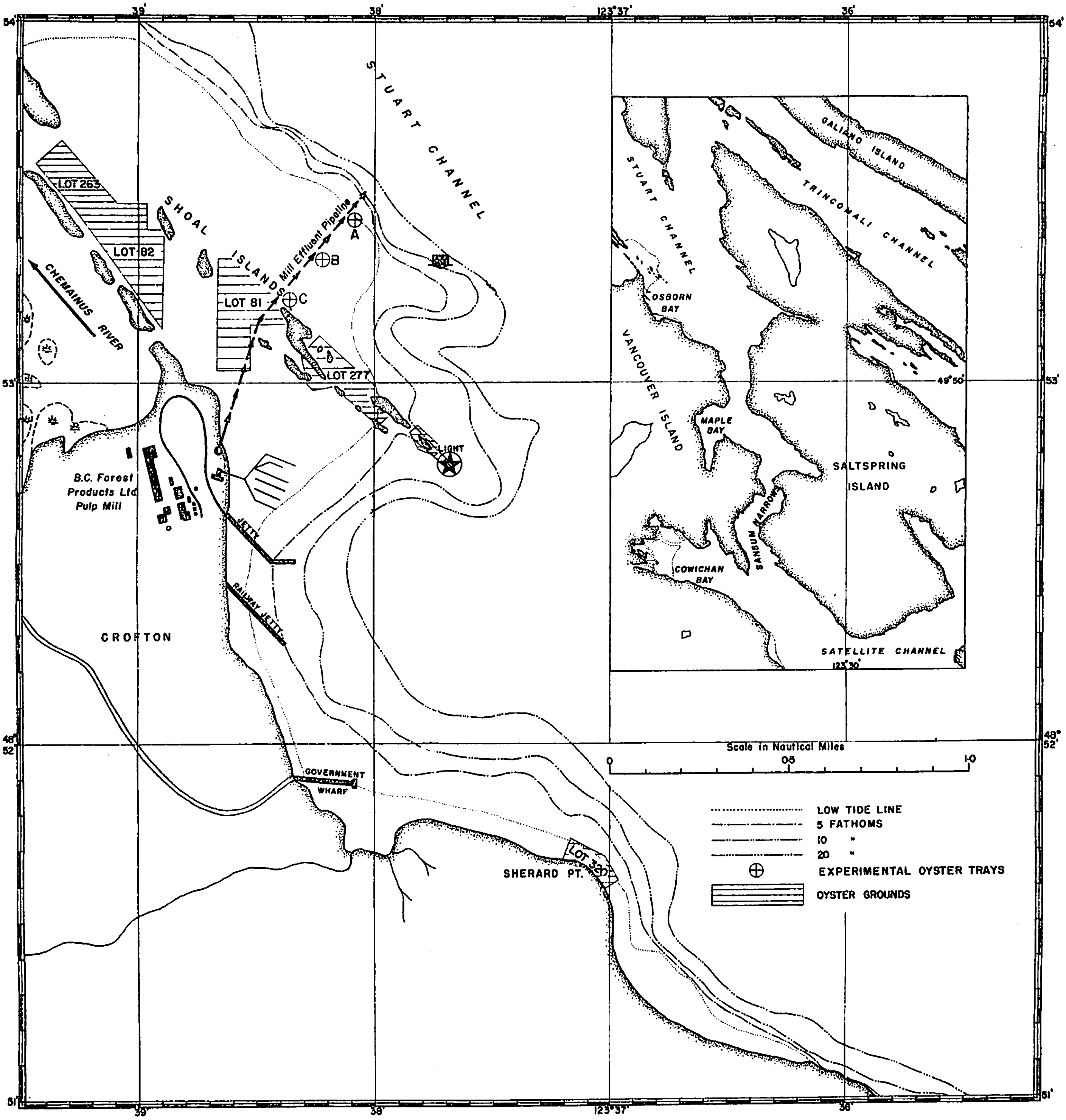


Chart of Osborn Bay and contiguous waters showing locations of commercial oyster grounds and experimental oyster trays in relation to the pulp-mill effluent outfall.

The results are given in Table 82. Analysis of the May data indicates the condition factor at Station B is significantly higher than at Stations A and C which are obviously little different. As shown by the means this relationship was largely maintained throughout the period of the experiment.

Table 82. Condition factor of Pacific oysters held on trays at varying distances from kraft effluent, Crofton, 1959.

Date 1959	A (outfall 25 yds)	B (outfall 300 yds)	C (outfall 600 yds)	Mean
April	77	77	77	77
May	85	99	89	91
June	101	120	108	110
July	102	117	93	104
August	128	124	102	118
September	78	128	98	101
October	100	131	93	108
Mean	97	114	94	

Several points may be noted. One is the quite normal increase in condition at all stations from the low inital value in April. Another is the equality of Stations A and C. It may be that under conditions of no effluent, there may have been a decreasing fertility gradient from A to C, for the latter station is in the general area of the Limberis beds on which the oysters have been consistently poor from September of 1955. Thus the difference between A and B may indeed be due to the effect of the effluent on the oysters at Station A.

Considering this station (A) is practically exposed to the full concentration of the effluent as it reaches the surface from the diffuser, maximum depressive effect on the oysters would be expected. Yet the oysters here were able to increase in condition and to enter the winter season at an average condition level.

Oysters on trays normally have a higher condition than those on nearby bottom and therefore no comparison may be made between the two. The fact remains, however, that the tray oysters, particularly those at Station A, are under the stress of the effluent and under the conditions of this experiment the short-term effect of the effluent appears to be minimal and not apparent.

While no detailed ecological studies have been made it may be noted the wooden framework for the trays at Station A collected a set of barnacles (Balanus glandula) with a mean density of 70 per square inch. There has been a heavy attack by the shipworm Bankia setacea on the same structure.

During the summer extensive populations of the bubble shell Haminoea vesicula were breeding in the eelgrass on the adjacent flats.

Pacific oyster spatting occurred in 1958 about 300 yards from the outfall where the nearest cultch was located.

It appears there has been no apparent change in the general ecology of the area.

Clam Investigations - Seal Island

Butter clam productivity studies were carried on by this Station between 1939 and 1948. Responsibility for this work was then transferred to the Provincial Department of Fisheries and in 1958 it reverted to the Fisheries Research Board.

The Seal Island clam beach near Comox was closed to digging in 1938 because of the depleted condition of the stocks of legal-sized clams. However, a considerable potential existed because of the existence of the dominant year-class of 1934 which formed in 1940 about 70% of the stock of an estimated 5 million clams in an area of 15 acres.

The controlled digging studies between 1942 and 1948 have been reported in this series. Commercial digging was permitted in 1949 and 1951. Thereafter the low return made the area unattractive to diggers and since then general closure has been maintained for control purposes.

Assessment of the stocks present on the beach have been made at intervals of approximately two years.

The total commercial production in the nine years between 1942 and 1950 inclusive (maximum quota about 100 tons in one year) was 854 tons, the main part of which was formed by the 1934 year-class. Since 1934 recruitment has been at a very low level. The largest single group appeared in 1949 and in 1955 this formed about 20% of the population.

In 1942 just less than 15% of the population was below the minimum legal size limit of 2 1/2 inches and this proportion has fluctuated relatively little since, although in 1955 the proportion was 28% and in 1959 about 8%.

In 1955 about 40% of the population were of the 1934 year-class and in 1959 (aging is difficult after 10 years) about 63% of the population were 10 years of age or more.

The significant features of the situation at Seal Island are the low level of recruitment and the infrequent dominant year-classes which, when present, may be highly productive. Search has been made in a number of years for seasonal gonad changes but none has ever been detected, indicating a low level of spawning activity. It appears whatever recruitment has occurred may be from an origin outside Seal Island.

With the background of information available and the relative ease with which it may be reached, this population of clams merits further detailed study.

MARINE MAMMALS

G. C. Pike

Introduction

Three groups of marine mammals - whales, fur seals, and sea lions - are currently being studied because of their intrinsic commercial or potential value, or because of their effect on other marine resources.

Whales and fur seals are regulated by international commissions, which attempt to promote maximum sustainable productivity with due regard to their relation to other marine resources. An essential part of the work is directed towards fulfillment of commitments to these international commissions. Studies of all three groups are coordinated in a unified marine mammal program because of similarities in research methods and techniques.

A biological study of fur seals was started in the fall of 1957 in accordance with provisions of the Interim Convention on Conservation of North Pacific Fur Seals. Under the terms of this convention, Canada agrees to take from 500 to 750 fur seals, pelagically, for research purposes, each year for a period of six years. The objective of this four-nation cooperative fur seal research program is to obtain essential knowledge on the size and population dynamics, the migration routes, and the extent to which food habits affect commercial fisheries.

Large commercial species of whales have been studied in accordance with requirements of the International Whaling Convention since 1948, when a whaling station at Coal Harbour began operations. Annual collections of routine data are designed to provide knowledge on age, growth, reproduction, feeding habits, migration, and racial identity. Seasonal and annual changes in the catch composition are followed in order to assess the effects of whaling on the stocks.

The ultimate goal of the sea-lion study is to assess the damage done to commercially valuable fish and gear, and to suggest methods for control. This requires a knowledge of life history features of the species which relate to mortality, reproduction, dispersion, and feeding. Preliminary work requires a knowledge of abundance and distribution, and of the nature, extent, and location of damage to fish and gear.

Information on all marine mammals in local waters is obtained through the distribution of special log-books for recording observations. Important contributions to this project include the weathership located at Station Papa; Swiftsure; Umatilla, and Columbia River lightships; research vessels; several strategically-located lighthouses, and Department of Fisheries patrol vessels.

1. Whales.

During 1959, the Coal Harbour whaling station processed 868 whales, comprising 28 blue, 369 fin, 27 humpback, 185 sei, and 259 sperm whales. The total catch is the best yet obtained during any operational year at Coal Harbour (Table 83).

The 1959 catch differs from the previous year's catch in the unusually large proportion of sei whales, composing 21 per cent of the total catch as compared to 4 per cent of the total in 1958. The catch of sperm whales increased appreciably, and the catch of fin whales decreased from that of 1958 (Table 84).

Table 83. Catch of whales in British Columbia in 1959.

Date	Sex	Blue	Fin	Hump	Sei	Sperm	Other	Totals
April	♂		8	1		18		27
	♀		9	1	2	1		13
May	♂	2	27	1	25	45		100
	♀	1	22		6	38		67
June	♂	1	32	5	85	28		151
	♀	4	23	1	59	4		91
July	♂		71	6	7	41		125
	♀	1	54	2	1			58
August	♂		41	3		50		94
	♀	1	40	4		2		47
September	♂	8	16			32		56
	♀	10	26	3				39
Totals		28	369	27	185	259		868

Table 84. Whaling days and catch per effort, 1958 and 1959.

Year	F	H	B	Sei	Sp	Total
1958	573	40	8	39	112	772
1959	369	27	28	185	260	869

Year	Total effort days	Catch per unit effort F	H	B	Sei	Sp	Total
1958	849	0.67	0.05	0.01	0.05	0.13	0.91
1959	775	0.48	0.04	0.04	0.24	0.34	1.12

There are, as yet, no signs of depletion of any whale species in this locality. The total catch of whales per catcher's day's work for 1959 was 1.12 as compared to 0.91 in 1958.

No field work was carried out at the Coal Harbour whaling station during the 1959 season.

2. Fur seals.

The 1959 pelagic fur seal research program was conducted during the months of January through July, inclusive. The "A. P. Knight" was used for a two-week period in January and February; the "M. V. Pacific Ocean" hunted in waters from the mouth of the Columbia River to Kodiak, Alaska, from March through July. Most hunting was done within 60 miles of shore. Thirteen hundred and seventy-four seals were seen, and 491 collected to the end of July. Eighty-three per cent of the total catch consisted of females. Sixty per cent of the total catch was taken from British Columbia waters, 15 per cent from Oregon and Washington, and 25 per cent from the Gulf of Alaska. Thirty per cent of the catch in British Columbia waters were yearlings, but these comprised less than 4 per cent of the catch in other areas. Pregnant females 6-10 years of age composed most of the catch in all areas. The scarcity of 2-year-olds in the 1958 catch and 3-year-olds in the 1959 catch suggests a weakness in the 1956 year-class.

The main herd, migrating northward, and consisting mostly of pregnant females, passed the British Columbia coast two to four weeks earlier in 1959 than in 1958. The peak seal concentration, comprising mostly pregnant females, was encountered in June in the Gulf of Alaska at a density estimated at 50 per square mile. Other concentrations were found just north of the Columbia River mouth in March and April, and off Cape Flattery in April. A small concentration found in upper Hecate Straits during early March had probably wintered in British Columbia and Alaska waters. Yearling seals from 1958 appeared to be widely dispersed offshore during the winter of 1958-59 and the summer of 1959. Storms in 1958 concentrated yearlings in inside waters of British Columbia.

Forty-five per cent of all stomachs examined in 1959 contained food. Maximum food volumes occurred during the morning hours. Migrating seals taken in British Columbia waters were feeding mainly on salmon and herring, which together comprised 45 per cent of the total volume. Whiting and sablefish together constituted 25 per cent; rockfish constituted 10 per cent. Yearling seals fed mostly on sablefish and herring. Rockfish predominated in food volume from stomachs taken off Washington and Oregon in March and April. Squid was second in importance and eulachon relatively unimportant. Stomach contents taken from seals in the Gulf of Alaska in June consisted of sandlance, capelin, herring, squid, and salmon (in order of decreasing volume). Sandlance were absent in stomachs sampled in this area in July, 1958.

The pregnancy rate among females 4 years and older is 81 per cent for all areas combined; that of adult females is 89 per cent. In each age group the rate is higher in 1959 than in 1958. Three causes of reproductive failure are apparent in the 1959 data: failure of the ovum to implant; miscarriage of a fetus; and failure to ovulate. The first of these appears to be the most important cause of reproductive failure.

Seven tags were recovered pelagically. All of these originated on the Pribilof Islands.

Pelagic fur seal research in 1960 will be based primarily on the collection of 500-750 specimens. All teeth, stomachs, and reproductive organs will be returned to the laboratory for study.

3. Sea lions.

Results of the 1956-1957 field studies relate chiefly to abundance and distribution. Surveys by vessel and air show that approximately 12,000 sea lions inhabit the British Columbia coast immediately after recruitment. During the summer breeding and pupping season, 60 to 70 per cent of this population concentrates in two major rookery areas: the Scott Islands and Cape St. James. These areas account for 90 per cent of the annual recruitment of about 3,000 pups. Near the end of August, sea lions other than mothers and their pups disperse widely throughout coastal waters of the province.

The 1958-59 sea-lion research program was conducted in conjunction with fur seal work during May through July. The "M. V. Pacific Ocean" was used almost exclusively for sea lions during July. One hundred and sixty-one specimens, comprising 69 males and 92 females, were taken from March through July for studies of age, growth, reproduction and feeding habits.

Of a total 150 stomachs examined during May-July from the Scott Islands and Cape St. James, 54 per cent (81) were empty or contained only rocks. Thirty-five of the remaining 69 stomachs contained octopus or squid; 13 contained hake or whiting; 6 contained rockfish; and 5 contained dogfish. Lamprey, clam shell, mussel shell, and shrimp were each found once; flatfish and salmon were each found twice; and unidentified fish remains were found in 10 stomachs. During the breeding season in the rookery areas, the incidence of empty stomachs is greater for females than for males, since pupping and nursing preclude any extensive feeding at sea. At the height of the breeding season in June, only one-third of the adult females have food in their stomachs. The incidence of food increases during July when most of the pups have been born. More food is taken near hauling grounds which are populated by non-breeding animals. Food studies to date show that octopus and scrapfish constitute the largest part of the summer diet. Commercially valuable fish are of little importance in the diet at this time.

The tagging program, begun on Sartine Island in June, 1958, was continued in June, 1959. An enlarged and modified cattle ear tag was used to mark 320 pups in this locality. This number included at least 95 per cent of the entire year-class on this rookery. Tagging in this locality is to be continued each June for the next four to five years, the purpose being to obtain specimens of known age for comparison with subjective growth and maturity estimates, and to trace the extent of emigration and immigration.

Investigation of the commercial value of sea-lion carcasses was carried out in 1959 with the delivery of 41 bodies to mink farmers and pet food producers after 11 to 24 days' storage in refrigerated sea-water tanks aboard the vessel. Seventeen hides were retained in salt with the intention of obtaining information on their potential value or use. Three of these hides have been sent to a leather manufacturer for experimental processing.

Most pupping occurs from the last week in May to the end of August, each female bearing one pup every year and occasionally every two years. Of the 92 females studied, 83, or 92 per cent, were pregnant; of the remainder, 8 were nulliparous, and one which was multiparous carried no fetus.

Biological studies will be continued in 1960-61 in conjunction with the fur seal program. All pups will be marked on Sartine Island in 1960, and destruction of sea lions on North Danger Rocks will be continued. Attempts will also be made to obtain specimens for food studies during the winter months.

FISHING GEAR RESEARCH

P. J. G. Carrothers

In the period following the recommendation that fishing gear research be transferred from the Technological Station in Vancouver to this Biological Station, considerable time and effort has been devoted to the development of the new research program. The initial concept was of a group of scientists and technicians, trained in different disciplines, combining their efforts in a fundamental approach to the problems in the relatively untouched field of fishing gear research. The first step was to draw up a list of projects which, from the technological point of view, required attention, gave promise of results, and would provide interesting work for inquiring minds. The list, in modified form, has become Appendix VI to the "Report of meeting of working group to develop a fishing gear and vessel research and development program", held in November, 1959. A study of these projects reveals how much fishing gear research needs to be done and a survey of our resources shows what a small percentage of this research we can undertake.

Following the directive that the fishing gear research program at this Station should be first devoted to the means for capturing pelagic species, a basic study of the mid-water trawl is being undertaken. At present, the mid-water trawl is the most promising means for capturing pelagic species but its development to date has been largely by trial-and-error methods and further major development is unlikely without an understanding of the principles of its operation. It is proposed first to establish the hydrodynamics of the netting, as determined by the type and size of the twine, mesh length, net taper, and closeness of hanging, by testing relatively small-scale prototypes of the trawl on rigid-mouth frames in Departure Bay. Scaling problems limit the value of model studies. It is further proposed to study the mechanics and the hydrodynamics of the rigging and the boards, depressors, floats, kites, etc. After this information has been obtained, the design of larger prototypes will be an engineering rather than research problem.

The technology of the mid-water trawl will then have advanced to the point where the co-operation of biologists will be needed to conduct experimental operations on pelagic stocks and to extend the study to include the acoustic relation between the gear and the fish and the attracting effect of light and the guiding and stunning effect of electrical fields used in conjunction with the trawl.

To effect a reasonable rate of progress, assistance of a full-time technician is required and is being obtained in 1960-61. Further assistance by a seasonal assistant technician or student assistant is required to perform laboratory tests on gear materials, to classify and file existing information on fishing gear, and to collect further pertinent information from outside sources. A most pressing need is for space in which to conduct the work. Present accommodations are such as to virtually preclude experimental work. A building has been designed, suited to house the above program and any other fishing gear research project now in view. Every effort is being made towards its early completion. The services of a relatively small, powered vessel, such as a small trawler or a seine skiff, will also be required on a part-time basis for trial runs with the experimental gear.

The above program satisfies important basic requirements. Technologically, it fills a large void in our knowledge of fishing gear and provides a most interesting challenge to the investigators. Biologically, it provides a valuable tool with which to explore for pelagic species off-shore and with which to sample migratory species in the lakes, at the river mouths, and in marine inlets. Economically, it could lead to a commercial off-shore fishery if existing stocks warrant. It could be valuable to the Canadian industry in the event of international competition for pelagic species off-shore or on the high seas.

There are, however, two other important phases of fishing gear research. At the meeting of the working party to develop a fishing gear research program, held in Halifax in November, 1959, and at the annual meeting of the Board in January, 1960, it was stated that research was required into the behaviour of fish relative to fishing gear. If this recommendation is to be followed, it will be necessary to include a biologist in the fishing gear research team, with special interest and training in sensory physiology. This should be included in long-term plans in this field.

The second additional phase is that associated with the materials used to construct fishing gear. At the FAO Fishing Gear Congress held in Hamburg in 1957, a working group was appointed to study the methods used at present for evaluating fishing gear materials and to recommend a single set of procedures for official recognition. The methods for measuring thirty-one different materials' properties pertinent to fishing gear are being assembled by Dr. A. v. Brandt of Germany, and a summary will be published in the near future. The next step will be to develop a single, generally acceptable method for measuring each property. Canada is represented in this working group and should take an active part in the development of these methods. Even the critical examination of the methods will require considerable time and effort.

The repeated request from fishing companies and fishermen for trade specifications for the sale and purchase of fishing twines and netting also involves materials research. The Canadian Fishing Company and British Columbia Packers Limited are jointly attempting to draw up trade specifications and have personally requested assistance, and during the Fisheries Short Course at the University of British Columbia, requests were received from fishermen for trade specifications. During the 1959 Halifax meeting of the fishing gear research program working group, Mr. J. B. Rutherford of the Fisheries Department's Economic Service stated that, even in an intensive and regulated fishery, one economic requirement for fishing gear research is to improve gear in such a way as to reduce costs and over-capitalization within the terms of reference established by the regulation. The development of trade specifications through adequate materials research would help answer this economic requirement and would fill a real need in the fishing industry.

It is clear that there is a real need for research on materials, and that this should continue to be included in the fishing gear program.

Other activities include answering requests for information, assisting in the solution of the gear problems of other investigations of the Station, and the very considerable effort necessary to keep aware of the world-wide developments in the gear research field.

1. <u>Classification system for filing information on fishing gear</u>.

It is becoming increasingly difficult to find existing information as required, so that when a watching brief on gear work elsewhere was undertaken, it was necessary to file the information according to subject matter. Two major systems are widely used for this. The U. S. Fish and Wildlife Service (FWS) system, described in their Fishery Leaflet 232, is used in the United States, and the

Universal Decimal Classification (UDC) system, described in British Standard 1000 and in the Handbook for World Fisheries Abstracts, is widely used in the rest of the world.

The FWS system is restricted to fishery science with emphasis on technology, and does not provide general classifications as for bibliographies nor for other sciences which could contribute toward the fishing industry. Further, within the fishing section, gear is divorced from the method by which the gear is used and each is subdivided according the the type of gear. Also, all gear materials are grouped without subdivision, making a large and unwieldy section.

The UDC system is more comprehensive, purporting to embrace the whole of human knowledge. Theoretically there is a place for everything. Perhaps because the system was originally drafted in French, many of the English headings do not follow a consistent pattern and many are ambiguous as to content. However, it was decided to use this system because it is broad in its concept and already in wide use, and to reword and amplify certain headings better to reveal the basis for classification and to eliminate ambiguities. The revised version of the classification of "Fishing Methods and Gear" is quoted below for the benefit of others using or desiring to use this system. Our use of this system differs from that for World Fisheries Abstracts in two ways. First, all information or special equipment for handling the gear from the vessel is included with the vessel, e.g., seine table data are classified with seiners rather than with seines, and only gear component data are classified with the gear. Second, all information on materials used to make fishing gear has been removed from the "general" heading under Fishing Methods and Gear and has been reclassified according to the type of material, e.g., data on netting, twine, and cordage are filed under Textiles, and preservative data are filed under Textiles: Defects and Deterioration: Protection against Rot.

Revised and amplified version of UDC subject division

639.2.081 Fishing methods and gear - classified according to the mechanical nature of capture and claiming.

.0 General - methods for observing gear behaviour (by divers, photography, television), testing complete structures, etc.

.1 Structures for imprisoning fish.

.11 Nets and other water-permeable structures made of textiles, wires, wood, etc.

.110 General - care, maintenance, and repair.

.111 Fixed nets - barriers, fixed (fish corrals and fences which block route of fish, entrance may be closable, water may filter through or enclosure may be flooded and drained); barriers, set (e.g., net set to encircle a tidal reef); filter nets, flat (stream) or bag (fish held in the net by the force of the current); fyke and hoop nets (cylindrical or conical, supported on hoops, with several "no return" funnels - the fyke net has wings); pouch nets, closing, including snap nets (bag closed after fish entry, may be set on bottom or suspended from a boat or raft, fish may enter naturally or be driven in); pound nets (similar to fixed traps, but the final chamber is a complete enclosure); screens (physically divert the fish into a container, may be fixed or suspended from a boat or raft); stake nets (structural maze which detains the fish long enough to be claimed); traps, aerial (fish jump over barrier into container); traps, fixed or permanent (multi-chamber structure with external guide fence and "no return" entrance); traps, floating (similar to fixed traps but floated at surface,not necessarily anchored); traps, mechanical (entrance closed by fish); traps, set (anchored trap made of netting, e.g., Japanese "set net"); traps, tubular (same girth as fish); weirs (similar to fixed traps).

.112 Drag nets (actively pursue and forcibly move catch).
- beach seine; Danish seine; dredges (oyster, scallop); plankton drags; rakes; scare line; trawl, beam (demersal fish and shrimp); trawl, otter (demersal fish, pelagic fish, prawn, shrimp); trawl, pair or pareja (demersal fish and pelagic fish).

.113 Entangling nets (these may be used as drift, encircling, or set nets).
- gill nets; tangle nets; trammel nets.

.114 Lift nets for fishing (catch not secured until the gear is lifted, haul by hand or power).
- clam digger (mechanical); dip (and scoop) nets; flue nets; lift nets (horizontal sheet of netting that may have a frame, may be baited, and may entangle, enclose or merely support the catch); push (or thrust) nets; tongs, oyster.

.115 Dip nets for landing (usually bagged).
- brailers; scoop nets.

.116 Cast and drag nets (placed or thrown over the catch to restrain it until claimed, may be rigid or flexible, usually conical or bell-shaped, may have pull string).
- cast nets (hand thrown); cover pots; plunge baskets.

.117 Round-haul nets (set around catch and closed in situ, usually operated from vessel(s), may be set at surface or on bottom).
- drum seine (bunt at one end and purse line on bunt half only); lampara seine (bag bunt at centre, no purse line, usually surface operated); purse seine (bunt at one end, full purse line); ring net (bag or bunt usually at centre and purse line sometimes only on the wings).

.118 Auxiliary fishing gear equipment.
- boards, depressors, hydrofoils, and kites; buoys; floats; hardware (rings, shackles, etc.); rollers; sinkers (chain, leads, etc.).

.119 Other nets.

.16 Traps (require moving to claim the catch).
- line traps; loop fishing (usually baited); snares; tassel fishing; traps (crab) and pots (lobster and fish).

.2 Weapons, used to disable but not restrain (hence includes harpoons and spears).
- arrows; darts; guns; knives.

.3 Animals for fishing.
- dogs; otters.

.323 Birds - cormorants.

.324 Fish - suckerfish.

.4 Hook fishing and line fishing.

.42 Rods (angling).

.43 Lines - drag line (several hooks strung from a bar); dropline or jig (no bait and no reel, and may or may not use a pole); handline (with bait, lures, or gorge, and with or without pole and/or float); longline or line trawl (usually baited and set on bottom, mid-water or surface, or drifted); trolling and surf whiffing (with bait or lures towed behind vessel, may use pole); trot line (collector moves along the set line claiming catch which has been attracted to bait, may or may not include hooks).

.433 Reels and gurdies, line haulers.

.434 Casting equipment, e.g., long-line horn, tubs, etc.

.44 Hooks.

.45 Auxiliary equipment - alarms; anchors; buoys; clips; floats; sheaves and fair leads; sinkers; springs; swivels.

.46 Bait.

.462 Preparation.

.463 Artificial flies and lures.

.466 Containers (bait tanks are classified under the appropriate vessel).

.5 Weapons which disable and restrain (cf. .2 above).
- forked spears (e.g., eel spears); gaffs; harpoons (with detachable, barbed head); lances (no barb); spears (fixed barb).

.53 Firing equipment.

.6 Poisons for fishing (including suffocation and poisoned projectiles).

.62 Administered in food.

.63 Administered in water.

.7 Detecting apparatus and locating methods.

.71 Aerial spotting.

.72 Echo sounding (fish finder).

.73 Echo ranging (e.g., Asdic).

.79 Miscellaneous (e.g., acoustic sensing).

.8 Explosives for fishing - indiscriminate (e.g., dynamite); specific (e.g., explosive harpoon heads).

.9 Miscellaneous methods and gear.

.93 Electrical fishing.

.98 Attracting, guiding, repelling - air bubbles; artificial reefs; chemicals (smell, taste, touch); electromagnetic radiations including heat (as distinct from temperature) and light (intensity and colour); pressure waves and acoustics.

2. <u>Consulting and information service and materials research and testing</u>.

Many requests for advice, information, and for tests of fishing gear materials have been received from members of the Board staff, from industry, and from other government agencies, both native and foreign. In keeping with Board policy, these requests have been answered as fully as time and facilities permit.

The one project that involved more time than any other was consulting with members of the Marine Salmon Investigation in the design of their sunken gill net for high seas exploration. The time was justified because this project falls within the broad terms of reference for fishing gear research, viz., to develop gear for catching pelagic species off-shore. This work involved joining the first 1959 cruise of M. V. "Fort Ross" across the Gulf of Alaska to examine the gear then in use and to observe fishing conditions. The net was then redesigned, physical tests were applied to evaluate certain floats, and assistance was rendered in the specification of materials for the 1960 gear. Preliminary trials indicate that the improvement of the new gear over the old is well worth the effort expended.

Considerable "fraying" of the continuous filament nylon selvedge twines occurred in the Marine Salmon gill nets. Closer examination revealed that the "fraying" consisted of individual filaments of nylon in the twine being pulled into loops. The filaments were not broken. This change in twine structure caused a shortening in length by about 6.5% and a weakening of the straight, wet twine by about 40%. However, the knot strength of the wet twine was virtually unchanged. This means that, although the twine itself is weakened by this change in structure, the twine at the "fray" is still as strong as the knot next to the fray so the netting is still usable.

Consulting services were also extended to the Marine Salmon Investigation re nylon purse seine and surface long line gear materials, to the Skeena Salmon Management re the design of a stream sampling ladder, to Experimental Biology re the gate lift frame for their large tank, to the Pacific Oceanographic Group re the plastic sea bag for productivity studies, and to the Marine Mammal Investigation re the strength of used nylon netting.

During the past year, 25 requests for information concerning fishing gear have been answered, some from information on file and others after a bit of digging. It would be tedious to treat these individually here; suffice it that the requests were from Burma, India, South Africa, France, Germany, Greece, Netherlands, Norway, four from U. S. A. and Hawaii, six from eastern Canada and seven from B. C. In addition to the above, three requests to test specific pieces of fishing gear material were answered, considerably fewer than were handled when the Fishing Gear Research Investigation was based at the Vancouver Station. Also in the nature of information service is the instruction given in fishing gear technology. Two lectures on the fibres used to make commercial fishing gear were delivered to the Youth Training School in 1959 and to the Fisheries Short Course both in 1959 and in 1960, and several days were spent with Mr. Park of Korea. Obviously, this information and testing service is providing good public relations for the Board.

Three short-term fishing gear materials research projects were undertaken this year. Chronologically, the first of these was a critical examination of the Japanese, Type 6, high-tenacity, multi-filament nylon gill-net twines introduced just over a year ago. The results of this investigation were reported in Circular No. 51 of this Station. Generally speaking, the new Japanese product is noticeably stronger than the previous Japanese product and is nearly as strong as corresponding Canadian and British nylon salmon twines. In Canada, Type 707 nylon is gradually replacing the Type 300 nylon previously used, and this newer Canadian nylon will undoubtedly give stronger netting than did the previous nylon, probably restoring the differential between the Canadian and Japanese products. This investigation also confirmed that nylon netting made today is as strong as. if not stronger than, nylon netting made in Canada and the United Kingdom years ago, and substantiated the test data provided in Industrial Memorandum No. 19 of the Vancouver Station.

The second materials research project was a study of the use of monofilament nylon in salmon gill nets. The results of this study were published in Circular No. 54 of this Station, and the significance of the study is attested by the fact that most of the text was reprinted verbatim in Pacific Fisherman (p. 35, February, 1960). Monofilament nylon is less visible in the water than is the multifilament nylon used at present, which is an advantage in all but muddy river water. However, because it is so springy, it cannot yet be made into netting heavy enough and strong enough for salmon. Also, because it lacks the "clinging" quality of multifilament nylon, very few fish tangle in the web. Most fish must become properly gilled in monofilament nylon web before they are securely caught. There are still technical problems associated with the use of monofilament nylon salmon gill nets, but as these are solved one by one, this material will probably take its place beside the others. However, it is doubtful if monofilament nylon netting will be the "murderous" weapon some think it will.

The third materials research project, still underway on a part-time basis, concerns the possible use of glass fibres in fishing gear. These fibres are relatively heavy in the water, are very strong, have very little stretch under load, and are highly resistant to attack by chemicals and organisms, but they have very poor wear resistance and relatively low knot strength. The smooth surface and small diameter for a given strength of glass fibres make them hydrodynamically attractive for towed gear.

In addition to the above, and in co-operation with other staff members, the requirements for a technical services building to house machine, welding, carpenter, paint, electronics, drafting and photography were established and preliminary plans were drawn.