E. R. Dowds

CONFIDENTIAL

FISHERIES RESEARCH BOARD OF CANADA

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of the

PACIFIC BIOLOGICAL STATION

by

J. L. HART, Director

(With Investigators' Summaries as Appendices)

NANAIMO, B.C. December, 1950

FISHERIES RESEARCH BOARD OF CANADA

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

by
J.L. Hart, Director

The effort of the Pacific Biological Station continues to be directed toward providing information bearing on the supply of fish. Some of the projects are intended to provide answers quickly to relatively simple problems related to the administration, conservation, or pursuit of the fisheries. However, more than half of the work concerns the principles involved in limiting the abundance of fish or controlling their availability to the fishermen and is included in long-term projects. It is fitting that the prestige of the Station and its familiarity with the techniques of investigation should be made available to supply information of special administrative significance. It must be constantly remembered, however, that the greatest contributions of the Station will be in the fundamental studies of the vital statistics of fishes, of the interactions of populations, of the causes of death and survival under various conditions and at different stages, and of the factors directing daily movements and full-scale migrations. These are and should be the chief objects of its endeavour.

The allocation of limited funds and personnel to the study of the various phases of numerous far-reaching problems involves difficult decisions. Grounds for the allocation of funds could be: (1) the desirability of knowing in broad terms the economic biology of all marine resources in the area, (2) the difficulties and costs involved in carrying out an investigation, (3) the apparent feasibility of translating the results of research into administrative or other conservational action, (4) the potential value of the resource, and (5) the present value of the resource.

The recent distribution of investigational funds at the Pacific Biological Station has given recognition to these considerations. The salmons provide the most valuable fisheries of British Columbia. In addition, because of their fresh-water spawning, the habitat during the early critical stages of life is not only within range of ready observation but is in many cases subject to manipulation and control. The percentages of investigational budgets assigned to salmon work in recent years have been: 1949-50 (expenditures), 39 per cent; 1950-51 (allotments), 46 per cent; and 1951-52 (estimates), 56 per cent. The herring fishery is currently the second most valuable in the province. The best policy for its exploitation turns upon fundamental studies of the relationship between spawning escapement and resulting recruitment. The percentages set aside for herring work in the three years were respectively 27, 26, and 20. The research on groundfish and the trawl fishery is important because of the variety of the species taken, the potential productivity of the more abundant species, and the conflicts of interest between different types of gear. The amounts set aside for the trawl and related investigations in each year have been respectively 27, 16, and 16 per cent of the total investigational budget.

REVIEW OF INVESTIGATIONS

Salmon

There are five species of salmon in British Columbia. Each has a characteristic life history, with its own growth and maturity pattern, its specific spawning habits, and characteristic reactions and tolerances. They must, accordingly, be investigated individually since conclusions reached for one cannot be applied to another except as useless generalizations.

At least four types of spawning areas can be recognized in British Columbia. They are the rain-fed coastal streams, the glacier-fed coastal streams, the coastal lakes, and the interior lakes (the latter two with their feeder streams). Whether the reactions of a single species of fish are identical in these different habitats remains to be seen. It is certain, however, that the limiting factors in the environment are entirely different so that each species must be studied in each habitat before comprehensive knowledge of the factors controlling its abundance can be gained. The salmon programme to investigate the factors limiting the survival of salmons throughout their juvenile life is accordingly carried out at widely separated stations.

Counting weirs and fences have been established at several places in order to provide information on the numbers of spawning fish and resulting fry. They also provide a means of getting the results from experimental attempts to increase fry production. A large fence at the outlet of Babine lake allows estimates of and critical examination of the escapements of all salmon species to the most important spawning area in the Skeena system. During 1950, 543,009 sockeye were counted but 35 per cent of these were small-sized III-year-old fish. Another fence has been installed in Six-mile creek on Babine lake, where 1,237 adult sockeye were passed up to the spawning grounds to deposit an estimated 1,800,000 eggs. The fence is designed to allow a count of the resulting fry to give an index of survival values for the streams around the lake.

A corresponding pair of fences has been established at Port John creek and in a tributary creek so that the effectiveness of reproduction for four species of salmon in a rain-fed system can be followed from year to year. An interesting similarity between the reproductive efficiencies of pink and chum salmon is already developing.

Other fences are operated at Lakelse lake and at Nile creek. At them, studies of predation on downstream migrants have been undertaken. In Scully creek at Lakelse, predation on sockeye fry was found to range from 3.0 to 29.5 per cent, depending on how far down stream the fry had to travel. At Nile creek, predation mortalities ranged from 16 to 86 per cent, depending on how many fry were present to carry the load of predation. Predation by birds and bears in the creeks and by game and coarse fish in the lake were studied at Lakelse lake. Experiments to test methods of reducing mortality are being undertaken at Port John and Nile creek. At Port John, experiments are being tried with the early transfer of sockeye fry to salt water in order to obtain accelerated growth and to escape fresh-water mortality. At Nile creek, natural spawning, eyed-egg planting, and green-egg planting under conditions of controlled water flow were compared. Indications are that control of the environment or of the eggs can materially increase the supply of downstream migrants. Experimental studies on the oxygen supply necessary to maintain chum salmon eggs have supplemented observational work, and surveys of Nile creek have shown that the oxygen available in the gravel beds is in some places below the limiting value.

Other work is more closely associated with the commercial fisheries. The main commercial runs of sockeye have been thoroughly sampled, and pertinent data on growth rates, age-classes, and sex ratios reported. Systematic search in canneries and on the spawning grounds for sockeye marked as migrant young at Babine and Lakelse lakes has yielded convincing evidence of the homing tendency within the river system and has shown when the fish originating in the two lakes are in the commercial catches. At the request of the Department of Fisheries, a tagging programme on the chum and pink salmon passing through Johnstone strait was undertaken. Still another tagging programme was carried out on the troll-caught spring and coho salmon in two areas on the west coast of Vancouver island. For spring salmon it was shown that the fishing grounds off Ucluelet are feeding grounds on which the fish stay for some time, whereas the springs tagged on the Kyuquot grounds were evidently migrating through. In general, spring salmon were migrating south with long-distance tag recoveries nearly equally divided between the Fraser and the Columbia. In cohos, recoveries were rather generally distributed between Puget sound and Milbanke sound.

Dr. R.E. Foerster is the senior scientist responsible for planning the salmon work in association with Mr. F. Neave and Dr. D.J. Milne. Six other full-time scientists, four part-time scientists, eight full-time and eight part-time technicians and clerks, and fifteen seasonal assistants have been engaged in salmon work. In addition, eleven casuals were engaged for a total of 36 months.

Herring

The main effort of the herring investigation is still directed toward "the west-coast experiment". This experiment originated some five years ago when the observation, there, that excellent year-broods of herring originated from very poor spawnings suggested that the restrictions on fishing imposed by the quota system might be detracting from effective use of the resource. Quotas have now been removed so that the only restriction remaining on the fishery is the closure date of February 5. The course of the fishery is being followed in comparison with that on the east coast of Vancouver island where quotas are retained. Since the tests were begun a succession of good year-broods have supplied a successful fishery. The trial should be continued until one or more poor year-classes have passed through the fishery.

The work on herring is by no means limited to observations on the tonnages landed by pursuing different policies of exploitation. The herring populations are being carefully followed to discover the mechanics by which changes in abundance occur and to study the principles involved in developing a basis for long-range prediction.

As had been forecast on the basis of the large proportion of II-year-old fish revealed in the intensive sampling of the 1948-49 catch, in 1949-50 the III-year-old herring were very abundant in the west-coast fishery, comprising 69 per cent of the large total catch. Barkley sound produced a record catch. Farther north the catch was disappointing, although the spawning surveys made after the close of the fishing season showed that an average amount of fish was available to spawn in March.

An extensive tagging programme has been in effect in southern British Columbia for some years and during the spring of 1950 was extended into northern British Columbia. The results are used to assess in each year the varying degrees of isolation of the different populations of herring throughout the province and in recent years have been employed to show the

relative changes in exploitation rates from year to year. In 1949-50, 10.9 per cent of the recoveries of west-coast tags were from fish taken on the east coast as compared with 3.3 per cent in 1948-49 and 5.8 per cent in 1947-48. Movement in the reverse direction was indicated as 12.9 per cent in 1949-50 and 2.9 per cent in 1947-48.

Although the most intensive work has been carried out around Vancouver island, much information is being collected from the northern part of the province. Detailed catch records compiled from pilot house log-books allow a quantitative measure of the extremely productive fishery in northern British Columbia as 189 tons per-seine-per-fishing-day, and other studies show that the III-year-old herring constituted 61 per cent of the catch. This is in contrast to the previous year in the same area in which the V-year-olds were dominant, constituting 49 per cent of the fish landed, and the III-year-olds constituted only 22 per cent.

Quantitative studies of herring spawning are an important part of the work and are carried out to a large extent through the co-operation of fisheries officers. Considerable effort is devoted to standardizing methods of estimation. No significant change was found in the amount of spawning between 1949 and 1950 on the west coast of Vancouver island. Causes of mortality in spawn from natural causes which may include non-fertilization, dessication, wave action, temperature, etc., have been assessed and found to be as high as 12.6 per cent. A special study of the mortality brought about by predation by birds (chiefly gulls) indicated that mortalities up to 92.8 per cent in the inter-tidal zone were induced and that the worst damage occurred during the first half of the incubation period.

Another phase of the herring programme deals with the studies on the young herring at various stages. The studies of the very young larvae have been going on for some years and are directed toward explaining differences in their survival rates in different years. Studies of the juveniles have been begun more recently in the hope of establishing accurately the relation between spawning grounds and fishing grounds, and providing accurate bases for prediction of year-class strength.

The herring work is planned by Mr. J.C. Stevenson. In his absence on educational leave, it is being expedited by Messrs. A.S. Hourston and J.A. Lanigan. Three junior biologists and seven other full-time assistants and eight part-time assistants are also employed in the herring work. The herring investigation calls for much work at sea calling for the use of large vessels of the seine-boat type. The vessels have been loaned by the fishing companies, and their crews should be regarded as part-time workers in the herring investigation.

Groundfish

The groundfish programme is closely associated with the trawl fishery. Partly because of the versatility of the gear in taking many species and all sizes of fish, and, partly because the fishery is new and not yet completely stabilized, the investigation continues to devote some attention to a general survey.

It is already apparent that some species and fishing grounds are going to be important in the stabilized fishery and more detailed studies have been begun on them. Tagging programmes have been employed to investigate the interchange of fish between different fishing grounds. In the case of the lemon sole fishery of cape Lazo in the strait of Georgia, it was shown that during the fishing season there was comparatively little recruitment of fish from the closed grounds of Baynes sound but that more general movement took place after the fishery was closed. In the case of

brill tagged at cape Scott, 88 per cent were returned from the same grounds but six per cent were recovered from the Swiftsure - cape Flattery area some 250 miles away. Estimates of population size and the intensity of fishing by tagging and marking by fin clipping have been made in the cape Lazo fishery and have given maximum population estimates of nearly 400,000 lemon soles with fishing intensity between 20 and 25 per cent. Tagging experiments also provide a method for determining mortality rates, assigning the parts played by fishing and natural mortality. For the lemon sole in north Hecate strait, natural mortality was found to be 38 per cent and fishing mortality 29 per cent.

The examination of otoliths or ear-stones removed from unselected samples of commercial landings has shown much about the rate of growth of the various species of groundfish and also about the succession of annual broods which build up the population. Rock soles, for example, were found to reach commercial size in their fourth or fifth years and to grow somewhat more rapidly and therefore enter the fishery younger in north Hecate strait than in either the gulf of Georgia or on the west coast of Vancouver island. For the rock soles, successful years for reproduction seem to have differed with different fishing grounds. Judging by the 1946 fishery, the big year-class in north and middle Hecate strait was that of 1942 whereas the Horseshoe ground further south showed the 1938 year-class as the strongest. The 1941 brood was best represented in Queen Charlotte sound and the broods of 1939 and 1940 in the strait of Georgia. The 1938 and 1939 year-classes were strongest in the west coast of Vancouver island samples.

Aside from being the focus of the economic interest the figures in commercial landings have an important part in the scientific studies. These have accordingly been collected through personal interviews by port contact men in Prince Rupert, Vancouver, and Victoria and tabulated for recent years according to species, and fishing area. They show an erratic condition in regard to the relative abundance of the various species landed. As an extreme example, in 1950, 4,233,000 pounds of lemon sole were recorded and 1,755,000 pounds of brill. In 1948 these amounts were, respectively, 1,794,000 pounds and 5,550,000 pounds. Records kept of the amount of fishing effort show corresponding irregular changes in the availability of fish to the fishermen. The number of pounds of lemon sole per hour's dragging in Hecate strait dropped from 1,152 in 1945 to about 545 in 1948 and 1949, and rose to 1,037 in 1950. Rock sole in Hecate strait yielded 1,022 pounds per hour in 1947, 810 in 1948, 1,214 in 1949 and 1,440 in 1950.

With international fisheries in extra territorial waters, there is little point in collecting the statistics or considering conservation for one country only. Through the courtesy of the Washington State Department of Fisheries, comparisons between Canadian and United States catches of groundfish in Hecate strait have been made possible. Percentages of total production constituted by Canadian landings indicate interesting trends and preferences in markets and fishing grounds. Lemon sole (1948) 73 per cent, (1949) 41 per cent; brill (1948) 66 per cent, (1949) 38 per cent; rock sole (1948) 88 per cent, (1949) 98 per cent; rockfish (1948) 1 per cent, (1949) 1 per cent; all species (1948) 45 per cent, (1949) 25 per cent.

The groundfish investigation is now being planned by Mr. K.S. Ketchen. It makes effective use of the small experimental trawler "Investigator No. 1" with a crew of four. This vessel is also used on occasion by other investigations. The three port contact men are also useful in many ways to other investigations. Four full-time assistants, four part-time assistants and one seasonal worker were attached to the investigation.

Albacore

The albacore investigation continues to study the recruitment of albacore to the general population by sampling the commercial landings. Four size-groups were found in the 1949 fishery and special techniques for examining the sectioned vertebrae are being used to establish the relation between the ages and the size-groups. Experiments to develop a suitable tag-hook are being carried on to attempt to tag these delicate fish without landing them. Observations are being continued on the relationship between fishing success and the water temperature. The work is being carried out by Mr. J.M. Partlo and a part-time assistant.

Pilchard

There was no pilchard fishery and the programme of investigation was restricted to an examination of records in an effort to determine the relation between the success of the Canadian fishery and oceanographic conditions in years when old pilchards were reasonably abundant.

Eulachon

The eulachon investigation was limited as in recent years to an analysis of catch information obtained from Fraser river fishermen by officers of the Fisheries Department. The tabulations showed for 1950 the poorest availability (catch per-unit-of-effort) in recent years. The poor run is probably associated with the floods of 1948 which reached their height during the incubation period in the cycle year.

Anchovy

The effort in the anchovy work is being directed toward finally reporting data already collected.

Whales

Under the International Whaling Conference agreements, Canada is obligated to collect statistical records on all whales landed and is requested to collect additional biological data. The 1950 catch included 105 humpbacks, 151 finbacks, 23 seis, 4 blues, 30 sperms, and 1 Baird's beaked whale. Studies on breeding, growth, age, and migration were carried out on these by collecting data on the reproductive organs, the proportionate measurements of various body parts, baleen plate thicknesses, stomach contents, and parasites. The work on whales is being done by Mr. G.C. Pike, with the help of a seasonal assistant.

Crabs

The crab programme has continued in northern British Columbia with special emphasis on the tagging work. The tagging has shown the change in the fishery on the east coast of the Queen Charlotte islands from one taking 10 per cent of the population annually to one taking 21.7 per cent in 1950. Estimates of total population also have been based on tagging results and show values for 1949 near three million individuals for each of the east and north coasts of the Queen Charlotte islands, and one hundred and sixty thousand for Naden harbour. The work on crabs is planned and carried out by Mr. T.H. Butler.

Polychaete worms

The work in this group has been continued excellently by Mr. and Mrs. Berkeley as volunteer workers to such effect that an account of the Polychaeta Sedentaria for the Pacific Fauna Series is expected shortly.

Experimental biology

A start on the physiological description of the five species of Pacific salmon has been made by studying the temperature tolerances of the fingerlings. Other studies have been made on the behaviour of chum, pink, and coho salmon in relation to their migratory habits and on the changes in reaction induced by hormones.

Oceanography

The programme of the Pacific Oceanographic Group includes many projects which have a vital application to biological problems. Most important are the programmes of basic research designed to establish general oceanographic conditions (like offshore or Georgia strait) or to follow seasonal changes and detect deviations from average and possible cyclic changes (daily sea-water observations, etc.). Detailed oceanographic studies where special biological problems are recognized as in Chatham sound, Barkley sound, or the Fraser estuary can be most effectively carried out at the present time by the oceanographic group. An ocean model laboratory equipped to carry out problems in prediction not amenable to theoretical approach or standard methods of observation at sea, has been set up. At the present time a model of Alberni harbour is being constructed under a fellowship from the University of British Columbia. This project will provide for the continued use of the Station the tide-generating and recording machinery, flow control, current metres, and sampling devices in return for the use of the laboratory. The Pacific Oceanographic Group is under the leadership of Dr. J.P. Tully. He has been assisted by two scientists and three technical or clerical assistants throughout the year, as well as by three scientists and seven others who had seasonal employment or who were appointed during the year.

ACKNOWLEDGEMENTS

The work of the Pacific Biological Station is such that it cannot be carried on effectively without the sympathetic co-operation of many people associated with the fishing industry. In very many cases the help has been evidenced in the return of tags, by supplying information, by accommodating personnel or equipment, or by giving constructive criticisms, all of which are invaluable. More tangible help has been given by some of the fishing companies which have, through arrangements made by Mr. R.E. Walker, chairman of the Pacific Sub-Executive, placed vessels at our disposal for use in the herring programme. The Anglo-British Columbia Packing Co., Ltd., British Columbia Packers Limited, The Canadian Fishing Co. Ltd., and Nelson Bros. Fisheries Ltd., have given much needed help by supplying seine boats and suggesting suitable crews.

Some individuals have given their time and thought to service on the Skeena River Advisory Committee. Grateful acknowledgement is made to the chairman, Mr. C.E. Salter, The Canadian Fishing Co. Ltd., for his services, and to the committee members, Messrs. K.F. Harding, Prince Rupert Fishermen's Co-operative Association; W. Johnson, Oslund, B.C.; B. Kristmanson, Oslund, B.C.; G.S. Reade, Fisheries Department; and T. Wallace, British Columbia Packers Limited.

PUBLIC RELATIONS AND RELATIONS WITH OTHER AGENCIES

A much publicized occasion on which the work of the Station was brought before the Canadian people was at the official opening of the new biological laboratory building. On that occasion the Minister, the Honourable Mr. Mayhew, outlined the policy of the Department in regard to research, and Dr. Reed, Professor Dymond, and Dr. Foerster described the aims and work of the Board and some of the difficulties attached to realizing the objectives.

Another important event in acquainting the people of Nanaimo and the surrounding area with the work of the Station was the demonstration, three months later, of the new building and the work being carried out at the Pacific Biological Station. Approximately five hundred visitors took advantage of an opportunity to see exhibits based on the work in salmon, herring, groundfish, oceanography, and marine invertebrates.

A museum to engender general public interest in the work of the Board, and by providing fixed self-explanatory displays to save staff members the obligation of entertaining casual visitors is a need which it is hoped will soon be fulfilled.

Relations with the Department of Fisheries have been very happy. Staff members have been repeatedly consulted on a variety of problems in conservation, enabling them to place their information and experience at the service of the Department and at the same time keep themselves and the Station posted concerning current happenings and thinking in practical fisheries problems. The efforts of the staff to be of assistance in setting up the multiple sales slip system of collecting fisheries statistics have been very well received and particularly rewarding for them in that the results obtained are directly useful in the Station's work and fill a long-felt want.

Understanding with the fishing industry is also satisfactory. Personal contacts and meetings at various levels of formality have shown industry representatives the extent to which their problems are those of the Fisheries Research Board. The help given to us by the industry and the critical interest shown are evidence of appreciation of the work underway.

Participation in the activities of scientific fisheries organizations is indication both of the extension of interest of the staff beyond the limits of isolated problems and of the regard in which staff members are generally held. Some of the activities may be briefly catalogued, as follows: Dr. D.J. Milne is president of the Pacific Fishery Biologists. Dr. J.L. Hart was president of the Western Division of the American Fisheries Society, and of the Western Division of the American Society of Ichthyologists and Herpetologists. At the annual conference of the British Columbia Academy of Sciences, Mr. Ferris Neave was invited to present a report on "Problems in Pacific Salmon Research". Dr. R.E. Foerster was programme chairman of the fisheries section of the Third British Columbia Resources Conference and presented the brief "Resource-use Problems in British Columbia Fisheries". Dr. J.P. Tully supplied special oceanographic data to the International Pacific Salmon Fisheries Commission staff, and Dr. Hart acted as biological consultant to the Canadian members of the International Fisheries Commission. Various staff members have been observers at meetings of the Pacific Marine Fisheries Commission.

BUILDINGS AND GROUNDS

The long awaited move into the new biological laboratory building was an important occasion during the year, as it relieved the over-crowded condition which had for several years been besetting the staff. The move took place early in January. Certain defects in the detail of arrangement or services in the building remain to be adjusted but in general the provisions for accommodating the biological staff are satisfactory.

The boat-house workshop has now been completed by the Department of Public Works and is occupied. This two-storey building is approximately 50 feet by 20 feet. It provides, on the lower floor, accommodation for general boat repairs, and on the upper floor for a wood-working shop, and an electric shop for constructing and repairing the electronic equipment used in the herring investigation.

Following its use for office accommodation, the residence building has been reconditioned. Plans are being developed for minor reconstruction of this building to convert it to multiple use. The plan calls for use of the two large ground-floor rooms as museum space, the main floor as temporary office accommodation for the Pacific Oceanographic Group, and the upper floor for two self-contained living apartments.

The present garages are temporary buildings and should be replaced as soon as feasible.

A new system for supplying fresh water was installed during the year. It so far has given very good service. A new salt-water fire-protection system is needed to replace the present worn out one. Provisional plans have been prepared and it is hoped that the work can be completed during the present fiscal year.

VESSELS

The "Investigator No. 1" remains the only larger vessel fully controlled by the Station. Since her refit, completed a year ago, she has given satisfactory service. Additional requirements in vessels have been met by borrowing for various periods throughout the year, six seine boats from the fishing companies, and by chartering, as needed, seven other smaller vessels. Plans and specifications have been completed for the 51-foot salmon service cruiser, and tenders for her construction are being called. The general requirements and lay-out for a Station seine boat have been assembled (to a large extent through the assistance of Mr. A.E. Drake of British Columbia Packers Limited). It is hoped that plans and specifications will soon be prepared.

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[x]Indicates papers carried over from the list of the previous year.

STAFF

With the official opening of the new biological building, Dr. Foerster returned to his scientific specialty as senior scientist in the salmon investigation. Dr. J.L. Hart took over the responsibilities of the directorship and his duties as head of the groundfish investigation were assumed by Mr. K.S. Ketchen. There were five additions to the scientific staff. In the groundfish investigation to assist Mr. Ketchen - D. MacKinnon, Assistant Biologist. To assist Dr. Foerster in the salmon programme - J.G. McDonald, Junior Biologist. In the Pacific Oceanographic Group - R.J. Waldie, Assistant Oceanographer, G.R. Harris and J.A. Shand, Junior Oceanographers.

Dr. W.E. Ricker, Editor of the Board's publications, is now established with his headquarters at the Pacific Biological Station. He has made himself freely available as a consultant and adviser.

Mr. Ferris Neave is carrying out his scientific work during the present academic year at the University of British Columbia. Six members of the staff are on educational leave - Messrs. W.E. Barraclough, J.R. Brett, and J.C. Stevenson on half pay, and Messrs. F.H.C. Taylor, J.G. Robertson, and T.H. Butler without pay.

During the current academic year the numerical deficiency in senior personnel on the staff of the Pacific Biological Station is acutely aggravated.

STAFF
(to December 1, 1950)

Scientific - Full-time

J.L. Hart, M.A., Ph.D., F.R.S.C.	Director
R.E. Foerster, M.A., Ph.D., F.R.S.C.	Principal Biologist
F. Neave, M.Sc.	Principal Biologist
J.P. Tully, M.B.E., D.Sc., A.I.C., F.C.I.C.	Senior Oceanographer
D.J. Milne, M.A., Ph.D.	Associate Biologist
J.C. Stevenson, M.A.	Associate Biologist (on educational leave)
A. Andrekson, M.A.	Assistant Biologist (to 16 Sep 50)
W.E. Barraclough, M.A.	Assistant Biologist (on educational leave)
J.R. Brett, M.A.	Assistant Biologist (on educational leave)
D.R. Foskett, B.A.	Assistant Biologist
A.S. Hourston, M.A.	Assistant Biologist
J.G. Hunter, M.A.	Assistant Biologist
K.S. Ketchen, M.A.	Assistant Biologist
J.I. Manzer, B.Sc., M.A.	Assistant Biologist
D. McKinnon, B.A.	Assistant Biologist (from 1 Sep 50
V.H. McMahon, B.A.	Assistant Biologist
W.P. Wickett, B.A.	Assistant Biologist
F.C. Withler, M.A.	Assistant Biologist
L.A. Doe, M.A.	Assistant Oceanographer
R.L. Fjarlie, B.A.Sc.	Assistant Oceanographer
R.J. Waldie, B.A.	Assistant Oceanographer (from 1 May 50)
K.V. Aro, B.A.	Junior Biologist
G.C. Broadhead, B.A.	Junior Biologist (to 14 Jun 50)
T.H. Butler, B.A.	Junior Biologist (on educational leave)
Dorothy Furk, B.A.	Junior Biologist (to 2 May 50)
K.J. Jackson, B.A.	Junior Biologist
J.A. Lanigan	Junior Biologist
Anne Lazareff, M.A.	Junior Biologist
J.G. McDonald, B.A.	Junior Biologist (from 1 Nov 50) (seasonal 15 May to 31 Oct 50)
R.G. McMynn, B.A.	Junior Biologist (to 30 Apr 50)
D.N. Outram, B.A.	Junior Biologist
J.M. Partlo, B.A.	Junior Biologist
G.C. Pike, B.A.	Junior Biologist
J.G. Robertson, B.A.	Junior Biologist (on educational leave)
F.H. Taylor, M.A.	Junior Biologist (on educational leave)
G.R. Harris, M.A.	Junior Oceanographer (from 8 May 50)
J.A. Shand, B.A.Sc.	Junior Oceanographer (from 1 May 50)

Technical and Administration - Full-time

G.F. Hart	Executive Assistant
E.K. Inch	Clerk Gr. 4
Ethel Robinson	Clerk Gr. 4
Irma Hilton	Clerk Gr. 3 (to 7 Jan 50)
G.T. Taylor	Clerk Gr. 3 (from 1 Apr 50)
Evelyn Keighley	Clerk Gr. 2B
Ruth Taylor	Clerk Gr. 2A
T.K. Anthony	Clerk Gr. 1 (from 24 Apr to 31 Jul 50)
Fay Collins	Clerk Gr. 1
Marjorie Elliott	Clerk Gr. 1
Enid Marsh	Clerk Gr. 1 (to 15 Apr 50)
Margaret Philp	Stenographer Gr. 2B
Hazel Cox	Stenographer Gr. 1 (to 31 May 50)
Alice Nyquist	Stenographer Gr. 1 (from 6 Jun 50)
Agnes MacLean	Typist Gr. 1 (from 1 Apr 50)
Laura Nicholson	Typist Gr. 1 (from 19 Jun 50)
J. Martell	Maintenance Supervisor Gr. 4
H.J. Hollister	Technician Gr. 2
A.G. Paul	Technician Gr. 2
R.H. Eaton	Technician Gr. 1
E.V. Epps	Technician Gr. 1
Esther Harper	Technician Gr. 1 (from 15 May 50)
Ruth Peterson	Technician Gr. 1 (from 16 Jan 50)
K.R. Sutherland	Technician Gr. 1
R.C. Wilson	Technician Gr. 1
A.N. Yates	Technician Gr. 1 (from 1 Nov 50) (seasonal 1 May to 31 Oct 50)
W.A. Boak	Assistant Technician Gr. 3 (part-time from 1 Jan to 4 May 50)
W. Caulfield	Assistant Technician Gr. 3
A.J. Dodimead	Assistant Technician Gr. 3 (to 7 Nov 50)
C.R. Forrester	Assistant Technician Gr. 3
R.H. Herlinveaux	Assistant Technician Gr. 3 (from 1 May to 30 Jun 50)
R.S. Isaacson	Assistant Technician Gr. 3
J.H. Larkman	Assistant Technician Gr. 3
H. Neate	Assistant Technician Gr. 3
W.G. St. Clair	Assistant Technician Gr. 3
R.M. Wilson	Assistant Technician Gr. 3
E.A. Ball	Assistant Technician Gr. 2 (from 1 Oct 50) (seasonal 1 May to 15 Sep 50)
K.A. Herlinveaux	Assistant Technician Gr. 2
G.V. Kidson	Assistant Technician Gr. 2 (from 23 Jan to 23 Sep 50)
D.H. McDermott	Assistant Technician Gr. 2 (from 1 Mar 50)

D.J. Odlum	Assistant Technician Gr. 2
J.A. Saker	Assistant Technician Gr. 2
W.C. Stephenson	Assistant Technician Gr. 2 (from 1 Apr 50)
W.L. Tait	Assistant Technician Gr. 2 (to 19 Oct 50)
B. Wildman	Assistant Technician Gr. 2
W.W. Morgan	Assistant Technician Gr. 1 (from 1 Jun 50)
C.J. Morley	Assistant Technician Gr. 1
N.J. Robson	Assistant Technician Gr. 1 (from 1 Aug 50
T. Russell	Caretaker Gr. 5
A. Rigby	Caretaker Gr. 3
J.C. Wallace	Caretaker Gr. 3 (from 1 Dec 50)
E. Baldwin	Watchman
O. Perrin	Watchman (from 30 Oct 50)
L.L. Beaton	Cleaner & Helper (to 28 Oct 50)
W.J. Hogan	Cleaner & Helper
G.T. Worden	Cleaner & Helper

Boat Crews

R.E. Hirst	Ship's Master
H.K. Pinchin	Ship's Master
W.R. Brandon	Marine Engineer
R.T. Hearns	Ship's Mate
D.H. Peerenboom	Cook-Deckhand

Term

R.R. Gardner	Junior Biologist (to 18 Sep 50)
T.H. Bilton	Technician Gr. 1
B.M. Chatwin	Technician Gr. 1 (from 1 Nov 50) (seasonal 1 May to 31 Oct 50)
E. Dombroski	Technician Gr. 1 (from 1 Nov 50) (seasonal 3 May to 31 Oct 50)
H.G. Irwin	Technician Gr. 1 (from 1 Nov 50) (seasonal 3 May to 31 Oct 50)
R.E. Lindsay	Technician Gr. 1 (to 30 Nov 50)

Part-time

N.R. Barwick	Observer - Babine
R.J. Karjala	Observer - Vancouver (from 1 Oct 50) (seasonal 1 May to 30 Sep 50)

Seasonal

W.S. Hoar, B.A., M.A., Ph.D.	Biologist (from 15 May to 31 Jul 50)
J. Adrian	Senior Research Assistant (from 8 May to 2 Sep 50)
W.J. Mitchell	Senior Research Assistant (from 22 May to 31 Aug 50)
J.V. Routley	Senior Research Assistant (from 8 May to 31 Aug 50)
H.W. Spencer, B.A.	Senior Research Assistant (from 1 Jun to 31 Aug 50)
G.G. Berry	Junior Research Assistant (from 5 May to 20 Sep 50)
W.G. Calderwood	Junior Research Assistant (from 1 May to 16 Sep 50)
M.H. Keenleyside	Junior Research Assistant (from 12 Jun to 1 Sep 50)
K.J. Ross	Junior Research Assistant (from 15 May to 30 Sep 50)
L.A. Wilson	Junior Research Assistant (from 14 May to 30 Sep 50)
E.B. Bennett	Assistant Technician Gr. 1 (from 17 Jun to 11 Aug 50)
J.R. Field	Assistant Technician Gr. 1 (from 30 Jun to 15 Sep 50)
C.E. Kules	Assistant Technician Gr. 1 (from 17 Jun to 31 Aug 50)
P.W. O'Shaughnessy	Assistant Technician Gr. 1 (from 26 Jun to 1 Sep 50)
R.F. O'Shaughnessy	Assistant Technician Gr. 1 (from 16 Jun to 31 Aug 50)
G.M. Saunders	Assistant Technician Gr. 1 (from 21 Jun to 11 Aug 50)
R.E. Wood	Assistant Technician Gr. 1 (from 19 Jun to 11 Aug 50)
F.G. Barber	Assistant Technician Gr. 3 (from 1 May to 30 Sep 50)

Volunteer Investigators

C. Berkeley, F.C.I.C.
E. Berkeley (Mrs.)

INDEX TO SUMMARY REPORTS FOR 1950

R.E. Foerster and F. Neave Appendix No. 1

THE SALMON INVESTIGATIONS

In order that the salmon resources of the Canadian Pacific coast may be most effectively utilized and in order that fishing operations may be conducted with greatest efficiency, it is desirable that information pertaining to the following broad questions be obtained:

(1) What is the present state of each fishery? Is it being fully exploited? Is it showing a decline?

(2) Where fluctuations occur, what are the responsible factors? Can they be predicted?

(3) What are the factors limiting the production of salmon? Can they be controlled or remedied and hence production increased?

All the evidence available indicates that it is during the early freshwater phase of the salmon's life cycle that greatest mortality occurs. From the time of spawning to the time of seaward migration of the young smolts the eggs, fry and fingerlings are very vulnerable to extremes of climate and stream conditions which can have extremely dire effect. Our research has been concentrated largely on this period of the salmon's life history; firstly, to elucidate those conditions which normally prevail in salmon streams and their effect on salmon production and, secondly, to ascertain whether those conditions are capable of control and improvement or whether by certain measures of artificial propagation effects of undesirable conditions can be avoided.

The study of the natural propagation of each of the five species of Pacific salmon and the environmental factors in stream or lake influencing survival of eggs and fry has thus been one of our main objectives. Without such fundamental knowledge as a background no safe, practical analysis of what may be wrong with any salmon fishery can be complete nor can the most effective remedies be determined and applied. When a fishery experiences a decline or suffers a serious set-back, overfishing is popularly considered the cause. Our researches indicate that this is not necessarily the case. Where stream conditions are very unfavourable - as they can be in certain years, for a variety of reasons - the salmon runs can be very materially reduced even were there no commercial fishing.

In addition to the freshwater work being done, some attention is also being devoted to the ocean phase of the salmon's life history. Of particular interest are the paths of migration taken by the fish on their way from ocean to spawning stream. With fishing activities moving further and further to sea and increasing in intensity, many runs may now be exploited far from the particular coastal area for which they are bound. Obviously, therefore, for regulatory purposes it is necessary to know these migration paths. Control of catch only in the area adjacent to the spawning stream is not enough. By the time the runs reach these areas they may already have been heavily reduced.

Another problem is that of the factors influencing the age at which salmon mature in the ocean and return to fresh water. In most species of Pacific salmon there are two or three age-classes of returning fish. Sockeye, for example, may return in the third, fourth, fifth or sixth year, with normally the IV- and V-year groups being the most prominent on the Skeena. Prediction and control of runs cannot be soundly based until it is known what factors are responsible. Length of ocean life may be determined during the early freshwater period; it may be related to rate of growth in

the sea or it may be chiefly racial. The relative uniformity of age so characteristic of the Fraser river sockeye runs is not exhibited in the sockeye populations of other British Columbia rivers.

A third problem is the extent of mortality occurring in the ocean. The only information available is that obtained for Cultus lake sockeye which indicated a 90 per cent mortality in the sea. It is desirable that we know what this ocean mortality is and to what extent it can vary from year to year as the result of oceanographic conditions. Then we may be able to establish a safe percentage production of seaward-migrating young which will be likely to assure a suitable return of adult salmon for the fishery and for perpetuation of the supply.

Another important phase of study involves the early life history of the salmon in salt water; i.e., the food required by the young fish and its availability, the reaction to prevailing marine conditions of temperature, salinity, etc., the degree of predation, especially after emergence from the nursery stream or river, and the normal habits in moving along inshore areas to the open ocean.

There follow brief outlines of work undertaken for each species under investigation:

Sockeye

Lack of regularity in the recurrence of large and small runs in the areas under investigation indicates that size of runs is controlled to an important degree by factors other than size of spawning escapement. The possibility of predicting or increasing the size of runs depends to a large extent on the recognition and evaluation of these factors. The chief aim of the investigation is therefore to assess the losses occurring at different stages of the life cycle and to relate these to the production of adult fish.

Quantitative estimates of the losses incurred on the spawning grounds (prior to the period of lake residence) are regarded as highly important, since this phase, if it can be shown to influence the resulting number of adults, offers the best hope for remedial action. Quantitative studies of fry production had not been undertaken anywhere until the season of 1948-49, when the output from a potential deposition of 300,000 eggs was measured at Port John. Facilities for measurement of fry production are now installed at Port John, Lakelse lake (Scully creek) and Babine lake (Six-Mile creek), - representing Coastal, Sub-coastal and Interior Plateau conditions respectively. Results already show an efficiency of reproduction varying from approximately 25 per cent to 1.8 per cent of available eggs, thus revealing a potentially important cause of fluctuations in the adult populations of such streams.

The conditions affecting the survival of young sockeyes in lakes are being studied at the present time principally at Lakelse and Port John. Limnological and meteorological data are being recorded and the effects of predators are under investigation. At Port John the total output of seagoing smolts is recorded, thus providing a measure of the success achieved under varying conditions. On the Lakelse river, construction of a counting weir for measurement of total smolt output from the watershed has been commenced. At Babine lake the trapping of the immense annual run of smolts is not deemed feasible at the present time but it is hoped to introduce a system of sampling sufficiently precise to show fluctuations in annual output.

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During the current season daily samples were taken during the main period of smolt migration. It is felt that the age and size composition of smolt runs should be carefully studied in relation to the resulting adult runs.

The operations indicated above have necessitated considerable expenditure of funds and time on the construction and improvement of counting weirs. While these may be deprecated on grounds of expense and the tying down of personnel, they are essential for obtaining the quantitative results which should form the basis for conservation measures.

The maintenance of the annual count of adults ascending the Babine river is considered to be highly important. It affords a measure of the potential egg deposition of the largest sockeye spawning area in the Skeena watershed and, through the recovery of marked fish, it gives an indication of the intensity of the fishery. Marked fish from the commercial catches have been recorded by observers stationed at each of the six canneries located near the mouth of the Skeena. These recoveries can be compared with the number recorded in the escapement at the Babine fence and provide information on catch to escapement ratios.

The commercial catches associated with the Nass, Skeena, Rivers inlet and Smith inlet have been sampled through the fishing season with respect to size, weight, age and sex ratio. Except in the case of Smith inlet such records have been maintained for many years by the Provincial Fisheries Department, at whose request the Pacific Biological Station has taken over. These records serve as a long-term guide to changes in the composition of the catch and provide basic information for future more intensive studies. While intensive investigations can only be made at present in certain areas, the aim is to keep in touch with important developments which may occur elsewhere.

Pink and chum salmon

The field work on these species has been mainly concentrated at Nile creek and Port John. The quantitative data obtained during the year have tended to support conclusions reached previously concerning certain points which are considered to be of basic importance in attempting large-scale conservation measures. Among these conclusions are the following:

1. Fluctuations in the adult stocks of pinks and chums originate to a very considerable extent in fresh water.
2. A very high proportion of the freshwater mortality occurs between the time when the adults enter the streams and the fry emerge from the gravel. Losses are often particularly heavy before the attainment of the "eyed" stage.
3. Pink and chum eggs deposited and incubated under generally similar conditions tend to produce similar percentage outputs of fry migrants.
4. Average output of fry migrants can be materially increased in some streams by suitable control of water levels.

At Nile creek, where certain essential laboratory facilities now exist, a study of the physical and chemical conditions to which the eggs are subjected at and after deposition is in progress. This is to elucidate the problem presented in (2) above. The re-establishment of pink salmon in this stream is also being attempted. In the initial experiment the production of sea-going migrants has compared favourably with natural production in good pink salmon streams.

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This field station has also been used with marked success for a "fundamental" study of the behaviour of young salmon. The need for basic scientific information on salmon becomes very apparent in many conservation problems and no apologies are offered for devoting a small proportion of available funds to such purposes.

At Port John, work has been mainly concerned with securing data on the reproductive efficiency of salmon under varying freshwater conditions. With four species of salmon available at this locality, it is hoped that sufficient facilities can be added to permit the supplementing of field observations with laboratory experiments.

At the request of the Department of Fisheries, an extensive operation involving the tagging of pink and chum salmon in the Johnstone strait area has been undertaken. The objects are to obtain information on the intensity of the fishery in this area and the extent to which fish migrating through Johnstone strait are also subjected to exploitation elsewhere. This work is now in progress. A comparison will be made between the results of this operation and those of a similar experiment carried out in 1945.

Outside of field work and the working up of resulting data, some progress has been made with the analysis of general statistical records. In particular, the accumulated reports of inspectors covering the spawning escapements for many years to the numerous streams of the Vancouver island district have been examined. These reports, while admittedly imperfect, when summed and applied to large areas appear to give useful indications of the ratio between catch and escapement and to support previous conclusions regarding the close relationship between salmon runs and meteorological conditions.

In the future development of the programme for pink and chum salmon the following points are considered to be especially important:

1. Present quantitative data are necessarily being obtained only from small streams. While the cumulative output of such watercourses (for these species) is very great and frequently influences the total adult population to a large extent, it is apparent that the output from larger rivers does not always vary in the same direction, - probably due in large measure to inherent differences in seasonal water flow. Both for purposes of prediction and conservation, the production of larger streams should be studied and compared with existing data. Since counting of fry is not practicable in such streams, a system of redd sampling, to show the relative survival from the deposited eggs, should be attempted. Such a procedure, if carried out in a desirably widespread way, would necessitate the co-operation of inspectors in the various administrative areas.

2. It is felt that methods for improving output of young fish, based mainly on small experiments at Nile creek, should be applied on a somewhat larger scale in the near future. This would entail the selection of one or more streams in which a definite attempt would be made to promote a large output by control of water flow, improvement of spawning beds and protection from predators. Such an operation should be carried out in co-operation with the Fish Culture Development Branch.

Spring and coho salmon

In recent years the effort devoted to catching spring and coho salmon in British Columbia waters has increased greatly without any marked increase in the number of fish caught. In fact little accurate information

is available regarding the condition of these populations. The industry has indicated general concern for the conservation of the spring and coho salmon. This was expressed in a brief submitted to the Board, January 4, 1950, by the Kyuquot Trollers Co-operative Association.

The Pacific Fisheries Marine Commission was formed in 1947 by the states of Washington, Oregon and California to co-ordinate the utilization and protection of the offshore fisheries. Canada and Alaska have been invited to attend all meetings and to participate in the joint programmes. In 1949 a coastwise tagging programme of adult fish was initiated and in 1950 the three States marked and released thousands of young spring and coho salmon. Starting in 1951 an extensive sampling of the catches along the entire coast is necessary to recover these marked fish. In 1949 the Commission approved a change in the fishing regulations allowing for the coho season to open on June 15 and for all spring salmon less than 26 inches (total length) to be released. The three States and Alaska have adopted these regulations with certain local adjustments. Whether Canada should adopt similar regulations is an urgent question.

To determine the present migration routes of the spring and coho salmon populations caught in British Columbia waters, a tagging experiment was conducted off the west coast of Vancouver island in 1949 and repeated on a reduced scale in 1950. This year a preliminary sampling of the commercial and sport catches was also carried out. An exploratory compilation of all past data available on catch, effort, fishing methods, tagging and marking experiments, growth and survival studies and spawning estimates has been undertaken. A complete summarization and appraisal of these data is at present in progress. Certain preliminary evaluations as to results, conclusions and recommended studies are reported. It is hoped that eventually a sound sustained yield management programme can be instituted for these two valuable species of salmon.

General

In view of increasing limitation imposed on the freshwater environment by deforestation, dams and the utilization of water for various purposes, the long-range problem of salmon conservation will become more and more a matter of increasing the output of young salmon per unit of available fresh water. Certain methods for increasing production are indicated above. Other possibilities lie in the field of selective breeding for such characters as high egg production, rapid growth, shortness of period spent in fresh water, etc. The homing tendencies of salmon lend themselves to such experiments and the successes of agriculture are an incentive to attempt them. The immediate necessity for fish ladders and other compromises should not divert attention from the long-range requirements for maintaining salmon stocks.

Co-operation with other agencies

Close relations have been maintained with the Chief Supervisor of Fisheries and the supervisors and inspectors of his staff. Matters of mutual interest have been frequently discussed with the biologists and engineers of the Fish Culture Development Branch and active assistance has also been forthcoming in both directions. Information has been exchanged with mutual

benefit by the salmon investigation and the International Pacific Salmon Fisheries Commission. The investigation has contributed to a pooling of information concerning problems of the offshore salmon troll fisheries of California, Oregon, Washington, British Columbia and Alaska, under the auspices of the Pacific Marine Fisheries Commission. The interest, advice and support of the Skeena River Salmon Advisory Committee must also be acknowledged. The members of the Committee, Messrs. Salter (Chairman), Wallace, Johnson, Kristmanson, representing the Industry, Supervisor Reade representing the Department and Mr. Harding, representing the Board, have taken a keen interest in the Skeena studies. Their opinions and suggestions from the practical and the administrative side, have been most valuable.

Organization

The rapid growth of the investigation has resulted in much time and energy being devoted to: (a) setting up and operating field stations, constructing counting weirs, etc.; (b) routine and administrative duties, which extend even to relatively junior personnel. In order to realize the main objects of the investigation it is very desirable that biologists should have more time in which to act as such. The transfer of a greater share of the indicated duties to non-biologists would made possible: (a) an improvement in the quantity and quality of biological research work in the future; (b) more prompt and thorough analysis of field data and improved dissemination of information in publications or other types of report; (c) fuller co-ordination between the work of different investigators.

The organization of staff, scientific, clerical and technical, for the year, and assignments, follows:

Overall direction and administration

R.E. Foerster, M.A., Ph.D.	Principal Biologist
F. Neave, M.Sc.	" "
W.L. Tait	Assistant Technician, Gr. 2
Miss M.K. Philp	Stenographer, Gr. 2B

Skeena river, coastal area

K.V. Aro, B.A.	Junior Biologist
R.F. O'Shaughnessy	Assistant Technician, Gr. 1 (Seasonal)
E.B. Bennett	" " " " "
G.M. Saunders	" " " " "
R.E. Wood	" " " " "
C.E. Kules	" " " " "

Skeena river, Lakelse lake field station

V.H. McMahon, B.A.	Assistant Biologist
J.G. McDonald, B.A.	Junior Biologist
T.H. Bilton, B.A.	Technician, Gr. 1
B.M. Chatwin, B.A.	" " "
J.V. Routley, B.A.	Senior Research Assistant (Seasonal)
R.E. Lindsay, B.A.	Technician, Gr. 1 (Term)
G.C. Broadhead, B.A.	Junior Biologist (to 14 Jun 50)

R.E. Foerster and F. Neave

Skeena river, Babine lake field station

F.C. Withler, M.A.	Assistant Biologist
E. Dombroski, B.A.	Technician, Gr. 1
H.G. Irwin, B.A.	" " "
R.H. Eaton	" " "
G.C. Berry	Junior Research Assistant (Seasonal)
M.H.A. Keenleyside	" " " "
L.A. Wilson	" " " "
N.R. Barwick	Observer (Part-time)

Port John field station

J.G. Hunter, M.A.	Assistant Biologist
A. Andrekson, M.A.	" " (Part-season)
J.G. Robertson, B.Sc.	Junior Biologist (Seasonal)
R.C. Wilson	Technician, Gr. 1
W.L. Stephenson	Assistant Technician, Gr. 2
J.K. Ross	Junior Research Assistant (Seasonal)
P.O. O'Shaughnessy	Assistant Technician, Gr. 1 "

Nile creek field station

W.P. Wickett, B.A.	Assistant Biologist
W. Caulfield	Assistant Technician, Gr. 3
H. Neate	" " " "
W.S. Hoar, M.A., Ph.D.	Biologist (Seasonal)
H.W. Spencer, B.A.	Senior Research Assistant (Seasonal)

Troll salmon investigation

D.J. Milne, M.A., Ph.D.	Associate Biologist
E.A.R. Ball	Junior Research Assistant (Seasonal)
W.G. Calderwood	" " " "

Scale reading; field surveys

D.R. Foskett, B.A.	Assistant Biologist
J.K. Ross	Junior Research Assistant (Part-time)

Johnstone Strait tagging experiment

B.M. Chatwin, B.A.	Technician, Gr. 1
J. Martell	Maintenance Supervisor, Gr. 4 (on loan)
R.E. Hirst	Ship's Captain (on loan)
N. Yates	Assistant Technician, Gr. 2

K.V. Aro

Appendix No. 2

COMMERCIAL FISHERY - SKEENA GILL-NET AREA - 1950 SEASON

In 1950 the sockeye season in the Skeena gill-net area opened on the second last Sunday in June - June 18.

Sockeye fishing started off relatively well in June with reported daily catches of 23 fish per boat. As these catches were larger than those for the corresponding period of the 1949 season, it appeared the season's

K.V. Aro

take would be good. The daily catches rose very slowly, reaching a peak of 31 fish per boat in the third week of July. Thereafter, they declined until only 20 fish per boat were reported daily during the first week of August. The total catch was 47,600 cases when the season ended on August 11. This is the lowest catch since 1947 when 32,000 cases were taken.

The number of boats fishing the Skeena in 1950 was lower than in the two preceding seasons. During the first week 550 boats were reported. They increased to 600 in the next two weeks after which they dropped to 250 for the last week of the season. This decrease was due to the movement of boats out of the Skeena area to other areas, such as the Nass river, Rivers inlet and Smith inlet, where the catches were exceptionally good. Adverse weather conditions prevalent in July and early August no doubt also contributed to decreased catches.

On the basis of the poor showing of 4_2 sockeye (16% instead of the average 47%) in the 1949 catch, it was thought the 1950 catch would have a low percentage of 5_2 fish. Such does not appear to have been the case for the fish were consistently large throughout the season. The average weight during June was six pounds increasing to 6.6 pounds in August. The large average weight of 6.34 pounds for the season would indicate the catch was comprised largely of 5_2 fish. It remains to be seen whether the age determinations will verify this supposition.

The pink salmon catch was low (24,500 cases) compared to the catch in 1948, the cycle year (50,000 cases). The chum salmon and steelhead catches were fair but both the coho and spring salmon catches were poor.

With the institution by the Department of Fisheries of the Sales Slip System of collecting fisheries catch statistics in the Skeena and Nass areas, an excellent opportunity presented itself to compare the Skeena catch figures with those collected by the Pacific Biological Station. It was found that in numbers of sockeye and pinks caught the figures obtained by the Pacific Biological Station were five and six per cent less than the figures obtained by means of the Sales Slip System. The Sales Slip System will be of great benefit in providing accurate statistics.

K.V. Aro

Appendix No. 3

WEIGHT CONVERSION SAMPLING

At the request of the Federal Department of Fisheries, sampling was undertaken at Inverness cannery on the Skeena river to obtain data for determining conversion factors from dressed to round weights for the five species of Pacific salmon and for steelhead. As some salmon are bought by dressed weight it is desirable in the preparation of statistics with the Sales Slip System to convert these dressed weights to round. Between June 27 and August 11 a total of 610 fish, 102 each of sockeye, pink, chum, coho and steelhead, and 100 spring, were sampled. The fish were weighed round, dressed by removal of the gills and viscera, and reweighed. In addition length measurements were recorded and scale samples were taken.

K.V. Aro

The conversion factors for the six species, as calculated from the data by Mr. D.B. Mundy of the Department of Fisheries, are shown in the following table:

Conversion Factors

	Jun 27-28	Jun 29 -Jul 7	Jul 11-15	Jul 18-22	Jul 25-29	Aug 1-5	Aug 8-11
Sockeye	88.93	89.09	88.95	89.36	88.79	88.90	88.34
Pinks	83.27	82.89	83.07	82.16	82.37	80.42	81.80
Chums	-	81.15	81.54	82.54	82.29	79.18	79.46
Springs	86.60	87.94	87.65	87.77	87.46	85.77	86.92
Coho	86.61	86.27	85.46	85.82	86.68	85.79	87.28
Steelhead	89.97	88.39	90.29	90.14	91.23	90.10	89.88

Each figure represents the average dressed weight as a percentage of the average round weight.

These figures show that the relationship of dressed to round weight, though exhibiting some fluctuation, is relatively constant within a species but differs significantly between species.

K.V. Aro Appendix No. 4

SOCKEYE SAMPLING - SKEENA AND NASS GILL-NET AREAS

The commercial catches of sockeye salmon taken in the Skeena and Nass gill-net areas were sampled randomly throughout the sockeye season to obtain scale samples, length and weight measurements, and sex data. To obtain sufficient samples four per cent of the Nass sockeye landed at North Pacific cannery and one per cent of the Skeena sockeye landed at Sunnyside cannery were sampled. Due to the low catches in the Skeena area it became necessary in mid-season to alter the sampling ratio of Skeena-caught sockeye to two per cent. A total of 2,340 and 1,430 samples was obtained of Nass and Skeena sockeye respectively.

As yet, time has not permitted analysis of the data. When analyzed the data will provide valuable information on the ages, sex ratios, average lengths and weights, and length-weight relationships of the sockeye taken in the commercial sockeye fisheries of the two areas. This sampling continues a series of studies started originally by the Provincial Fisheries Department in 1911 and conducted by Dr. C.H. Gilbert (1911-1924), Dr. W.A. Clemens (1925-1948) and since then by the Fisheries Research Board.

K.V. Aro Appendix No. 5

RETURN OF MARKED SOCKEYE SALMON IN 1950

The last large recoveries of marked sockeye salmon from the marking of yearlings by fin clipping at Babine and Lakelse lakes were expected

in 1950. Considerable numbers of V- and IV-year-old fish were anticipated from the 107,650 and 103,906 yearling salmon marked at Babine lake in 1947 and 1948 respectively and from the 100,019 and 4,709 marked at Lakelse lake in the same years. Some VI-year-old fish were also expected from the 1946 markings of 88,972 sockeye at Babine lake and 100,967 at Lakelse lake. The yearling sockeye had been marked each year at Babine lake by removing the adipose and both ventral fins and at Lakelse lake by removing the ventral fins only.

In 1950, as in 1948 and 1949, an observer was stationed at each of the six operating Skeena canneries to examine all of the sockeye caught in the Skeena gill-net area and as many sockeye from other areas as possible. Fish counted through the counting weirs on the Babine river at Babine lake and on Williams and Scully creeks at Lakelse lake were also examined for marked individuals.

Because of the great variation in the condition of the fins they were graded, as in previous years, into four groups depending on the size of the appendage. After the legitimate Babine and Lakelse marks had been segregated, many doubtful marks remained. These were from individuals on which only one of the ventrals was damaged. Some of these doubtful marks were very probably due to natural causes but it is felt some are Lakelse marks in which the fin was incompletely removed and which had undergone some degree of fin regeneration.

From approximately 480,000 sockeye examined from the Skeena gill-net area, 957 Babine, 253 Lakelse and 359 doubtful marks were recovered. The recoveries of marked fish in 1950 are compared with the 1948 and 1949 recoveries in the following table:

	1948	1949	1950
Number of sockeye examined	800,000	670,000	480,000
Babine marks	327	345	957
Lakelse marks	72	140	253
Doubtful marks	83	114	359

The return of Babine marks in general followed the trend of the commercial catch. The greatest concentration of recaptures occurred during the second and third weeks of July. The largest landings of the commercial fishery were also made during these weeks. The Lakelse marks were recorded in greatest concentration during the third week of June. Seventy per cent had been recovered by mid-July, similar to the 1948 season. Both these seasons are in contrast to 1949 when only 45 per cent of the Lakelse marks had been taken by mid-July.

From 180,000 sockeye examined from the Nass gill-net area, 57 Babine, 30 Lakelse and 64 doubtful marks were obtained. This shows a much greater concentration of marked Skeena sockeye in the Nass catches than in previous years. The following number of marked sockeye were obtained from areas other than the Skeena and Nass: Rivers inlet (148,000 fish), one Babine and two doubtful marks; Mink Trap bay (1,400 fish), one Babine and one Lakelse mark; Banks island (19,300 fish), two Lakelse and five doubtful marks; and in Wright sound (1,400 fish), no marks were found.

At the Babine fence 693 Babine, 25 Lakelse and 3 doubtful marks were obtained from 543,237 sockeye examined by October 7. As in 1947 and

K.V. Aro

1949 most of the marks were recovered at the Babine fence in the first half of the adult run. On August 23 when 50 per cent of the run had been counted, 94 per cent of the marks had been accounted for. When the yearlings were marked the marking tended to be heavier at the beginning of the migrant run. Thus it appears that the early-running migrants return early from the sea.

At Lakelse lake a total of 95 marked sockeye was recovered from a counted escapement of 2,083 sockeye to Williams and Scully creeks.

Though the number of marked sockeye recovered this season is greater than in previous years the per cent recoveries are still smaller than in similar experiments conducted elsewhere. The recoveries, however, have been valuable not only in demonstrating that the majority of the sockeye returned to their home-stream area but also in showing when the Babine and Lakelse fish were prominent in the commercial catch. As 60 per cent of the Babine marks were recovered from the commercial fishery, it would appear that the IV- and V-year-old runs to Babine lake underwent 60 per cent exploitation by the fishery. For the Lakelse lake run the catch to escapement ratio, based on marked sockeye secured, was roughly 70 to 30.

V.H. McMahon Appendix No. 6

LAKELSE LAKE STUDIES

In 1949, following a five-year study of the Skeena river salmon situation (sockeye salmon in particular) it was decided to establish Lakelse lake as a base for special fundamental studies of sockeye propagation. By means of special counting weirs in the outlet river the total "in-go" of adults and "out-go" of seaward-migrating smolts could be determined. Thus the efficiency of natural propagation up to the smolt stage could be revealed. With special studies made in the lake itself to determine the variations in lake conditions, the relationship of environmental factors to survival of young sockeye could be ascertained. With studies made of other fish populations in the lake, - predators and/or competitors - the relationship of these also to sockeye survival could be learned.

Furthermore, with an adult and fry counting fence in one of the tributary sockeye spawning streams - Scully creek - the production of fry could be determined and the relationships of climatic and stream conditions to successful hatch and downstream migration into the lake revealed.

The Williams creek adult counting fence which has been used to enumerate the sockeye proceeding to the major spawning grounds above Lakelse lake "went out" during the fall flood of 1949. It had to be replaced.

Therefore to prepare for the research work above outlined the 1950-51 season has been largely one of construction. Nevertheless certain lake work has been continued as reported in the summary reports that follow.

Fence repair and construction

Williams creek fence

Toward the latter part of June, the remains of the Williams creek fence were salvaged and during July a new fence was erected in its place.

V.H. McMahon

The new structure is approximately 76 feet long and 14 feet wide and has the upstream portions of the A-frames at an angle of 30 degrees with the bottom. This latter feature gives the pickets a more gradual slope than is the case in the Scully or old Williams creek fences, and thus provides the advantage of a greater screening area for the water.

The work was completed on August 3 and this fence along with those in the two adjacent mouths was immediately made ready to receive the adult salmon migrants.

Lakelse river fence

During the spring high water, in June, an engineer from the Fish Culture Branch of the Department of Fisheries visited the lake and surveyed a portion of the Lakelse river with a view to selecting a suitable location for the construction of a Wolf-type smolt-adult fence. No feasible position being found it was decided that a conventional trap type of fence be built instead. A suitable spot was located about three-quarters of a mile downstream from the lake where the river widens to about twice its normal width and the current and depth are greatly reduced.

The new fence is to be approximately 390 feet long, it will be 16 feet wide and the upstream portions of the A-frames will be set at a slope of 30 degrees. The screens to sit between the A-frames will be of galvanized iron, of a mesh size large enough to pass fry but small enough to hold the sockeye smolts.

A fence of such proportions requires a great deal of preparation. Immediately upon completion of the construction work at Williams creek, the work crew was transferred to the river. Banks were cleared and space was made available for the stacking of lumber, piles, pile-caps, bulkhead logs and pile-driver equipment. The lumber was ordered (approximately 43,000 B.F. in all) and work was started on the cutting of 150 piles, 40 bulkhead logs and 45 pile-caps. The pile-driver equipment was transported to the site and work on the cabin, adjacent to fence site, was commenced. The lumber was transported across the lake in a barge rented from a local resident. The loads were then split up, rafted down the river to the fence site, pulled up and piled on the banks.

Work on the fence itself has not as yet been commenced but it is hoped that favourable water levels will allow a start in the near future.

Meteorology and lake levels

Daily records of rainfall, minimum and maximum air temperatures, cloud coverage, wind velocity and direction, and lake-level changes were kept throughout the seasons from March 1. In addition, hours of sunshine were recorded this year as well as snowfall and ice conditions early in the season.

Plankton collections

Approximately bi-monthly collections of plankton were made at the deep-hole station throughout the year since the beginning of March. Whenever possible samples were gathered also from the five other stations established last year.

V.H. McMahon

Chemical analyses

Samples from the lower, central and surface waters of the northern deep-hole station and from the surface of the southern shallow station were analyzed approximately weekly, starting June 12, for total phosphate and nitrate content. Samples from Lakelse river and Williams creek, the main incoming water, were collected and analyzed every second week. The analyses were much simplified this year by the use of an Evelyn Photoelectric Colorimeter.

Bi-monthly analyses were done for the dissolved oxygen content of the lake waters using the Winkler method.

Netting

Nine net sets were made in March under the ice at two positions on the lake, each gang of nets being made up of 3 nets ($1\frac{1}{2}$", $2\frac{1}{2}$" and $3\frac{1}{2}$" meshes), 50 yards in length. The nets were pulled into the water by a rope which was first run out under the ice with the use of an "ice-jigger". A total of 22 fish was caught in these sets - 17 cutthroat trout, 4 Dolly Varden char and 1 squawfish. No whitefish, peamouths or sculpins were taken from the under-the-ice sets. A subsequent set at one of these positions on May 3, following ice break-up, yielded a total catch of 20 fish of which 6 were cutthroat trout, 3 Dolly Varden, 1 squawfish, 1 Rocky Mountain whitefish, 7 peamouth chubs and 2 sculpins.

There were three net sets made in May, seven in June and one in July. Netting was discontinued following July 7 because of pressure of work elsewhere. Also it was felt that ample netting had been carried out in previous years to provide sufficient data for the summer season.

T.H. Bilton

Appendix No. 7

CREEL CENSUS STUDIES AT LAKELSE LAKE

From May 1 to September 15 a creel census was in operation at Lakelse lake, as part of the predator fish study, one phase of the general Skeena river sockeye investigation. Fishermen were contacted while fishing on the lake or on Lakelse river.

The following data from each fisherman were recorded on a card: number of fish caught, species, number of hours fished, time of day fished, type of bait or lure used, area in which fish were caught, weather and remarks. When time permitted all the fish in a catch were sampled for length, weight, sex and scales. Stomach samples were taken from 10 per cent of the fish considered to be predacious on young sockeye salmon; e.g. cutthroat, Dolly Varden and squawfish. In order to obtain greater co-operation from the fishermen all the fish in each catch were cleaned for the information received.

T.H. Bilton

Total Number of Fish Caught and the Total Number of Hours Expended by the Anglers Contacted at Lakelse Lake and Lakelse River for the Months of May to September, 1950, together with the Average Catch per Fisherman Hour.

		Lake and River			Lake			River		
Month	Total No. of Fishermen Contacted	Total No. of Fish Caught	Total No. Hrs. of Fishing	Catch per Hour	Total No. of Fish Caught	Total No. Hrs. of Fishing	Catch per Hour	Total No. of Fish Caught	Total No. Hrs. of Fishing	Catch per Hour
May	47	287	152.0	1.888	85	47.0	1.808	202	105.0	1.921
Jun	126	483	392.0	1.232	326	278.5	1.159	157	113.5	1.383
Jul	198	535	400.0	1.337	336	277.0	1.212	199	123.0	1.617
Aug	56	147	112.0	1.312	61	43.5	1.402	86	68.5	1.255
Sep	1	2	1.0		2	1.0				
Totals	428	1,454	1,057.0		810	647.0		644	410.0	

The data for the past fishing season are summarized in the above table. Monthly catches by fishermen, and the yield per-unit-of-effort based on the number of fish caught over the number of hours expended were highest in both lake and river during the month of May. The greater availability of fish at this time may have been dependent upon the downstream migrations of the sockeye, coho and pink fry.

During June the yield per-unit-of-effort decreased in both lake and river. This decrease in availability may have been the result of the completion of the salmon migrations and thus a dispersion of the predacious fish from the creek mouths to other areas of the lake and Lakelse river.

In July the catch per-unit-of-effort increased again in both lake and river. It is felt that profuse hatching of mayflies in certain areas at this time probably accounted for this greater catch.

The catch per-unit-of-effort in August increased on the lake and decreased on the river. It is probable that the adult sockeye migrations into the streams were responsible for the increased catch of fish in the lake while the lower catch per-unit-of-effort in the river may have been due to a decrease in available food, and a resulting migration into the lake.

Throughout the first two weeks in September fishing had decreased to a minimum, only one contact being made during the whole period.

From May 1 to September 15 there were 428 fishermen contacted on the lake and in the Lakelse river. Their total catch throughout this period was 1,454 fish. Of these, 928 were sampled. Stomach content material has not yet been analyzed.

R.E. Lindsay — Appendix No. 8

WILLIAMS CREEK COUNTING FENCE - LAKELSE LAKE

The main adult counting fence at Williams creek was completely rebuilt this year, using salvagable materials available from the old fence, and a power pile driver assembled on the site. The main fence was constructed just upstream from the old fence and "A" frames were used instead of rock-filled pylons. The panels were placed at a 30 degree angle with the floor, with the upstream faces of the panels and the "A" frames flush. The reaction of the fence to drifting debris was much more satisfactory than in the past.

The west channel fence remained unchanged. The east channel fence of old Lakelse river panels of screening also remained unchanged except for minor modifications and repairs. Unfortunately the east fence was rendered inoperative during a freshet and could not be repaired adequately for several days.

Peaks of salmon runs were recorded at times when the creek levels were high due to heavier rains. Numerous "jacks" were noted on the spawning grounds but none was caught in the traps, and it is considered that they had no difficulty in passing through the pickets of the fence and traps.

Length samples were recorded and 12 representative redds were marked for later survival studies. The run was considerably lower than the 1949 run of 5,707 sockeye and, of the 1,471 sockeye counted through the traps, 1,003 were males and 468 females. It is estimated that approximately 36 salmon passed through the east channel while it was inoperative of which 24 would be male and 12 females. The grand total thus amounted to 1,507 sockeye composed of 1,026 males and 480 females. The sex ratio was approximately two males to one female.

	Males			"Jacks"		Females			
Year	No.	% of Total	Av. Length in Cm.	No.	% of Total	No.	% of Total	Av. Length in Cm.	Totals
1939	12,350	51.3	64.8	--	--	11,735	48.7	59.7	24,085
1949	2,685	47.0	65.5	22	0.4	3,000	52.6	58.8	5,707
1950	1,026	68.15	63.6	--	--	480	31.85	57.3	1,507

J.G. McDonald — Appendix No. 9

NATURAL PROPAGATION OF SOCKEYE SALMON AT SCULLY CREEK, LAKELSE LAKE

Fry Migration, 1950

Investigations into the natural propagation of sockeye salmon continued at Scully creek in the 1950 season. Spring work, under the direction of Mr. G.C. Broadhead, formerly of this Station, included a count of the fry migrants and studies of predation.

By June 3, 242,346 sockeye fry, 10,157 coho fry, and 1,445 coho yearlings had been counted and passed through the fence. At this date the fence was removed. The count of 242,346 sockeye fry resulting from the

deposition of 1,766,370 eggs from the adult run of 1949 established for the stream phase a survival of 13.7 per cent in the year under question.

Extensive studies of predation on the fry migrants by other fishes were also made. A large number of fry were marked by inserting a short length of coloured thread immediately beneath the dorsal fin. These fish were released at certain distances upstream and the majority recaptured at the fence the same night. Returns of the marked fry were as high as 29.5 per cent and as low as 3.0 per cent, depending upon the distance released above the point of recapture and the total number of migrants the night of the investigation. In relation to the above, stomach samples of cutthroat trout, coho yearlings, and sculpins were taken to indicate the number of fry eaten by each species. The rates at which the fry were digested were also found.

Adult run, 1950

The adult fence was put into operation on August 12; by October 2 a total of 462 sockeye had been passed through. Of this total, 195 or 42% were males, 121 or 26% were females, and 146 or 32% "jacks". As the counting fence is situated approximately 400 yards from the mouth of the creek, an estimate was made of the number of spawners below the fence. For 1950 a minimum of 150 was estimated, making a grand total of 612 sockeye in the creek. This is extremely low when compared with the count of 1,230 in 1949 and the stream estimates of previous years which averaged 1,700.

Every twenty-fifth female was taken for an egg sample and the average egg content was found to be 3,285. Thus the total possible egg deposition of the 121 females spawning above the fence is 374,532. For purposes of assessing the mortality at various stages of development of these eggs, 19 redds were marked for possible examination during the winter and early spring.

A tagging programme was carried out in order to investigate the distribution of spawners above the fence and the relationship between this distribution and the time of arrival at the fence. This programme was also utilized to indicate the preferred ratio of tagged to untagged fish for stream estimates made in this manner. Every tenth sockeye was tagged and baffles of yellow, cerise, red, cerise, and black cross were used in that order. As yet these data are to be evaluated.

Predation

Among the factors limiting survival from time of deposition to hatch, the one of predation was given fullest attention. Estimates of the number of adult trout in the stream at the time of salmon spawning range from 2-300. Stomach samples of 29 cutthroat trout were taken along with sex, scale samples and fork length. A preliminary analysis indicates an average of 20 sockeye eggs eaten per trout. From studies of digestion rates made, approximately 75 hours are required for complete digestion of the eggs at a temperature range of 9.5-11.0°C.

Predation by bear was found to be very heavy. Of the total number of sockeye observed in the creek, only a small percentage of dead recoveries was made. In one instance 41 carcasses were found along 500 feet of bank.

J.G. McDonald

Whether the fish taken by bear were in a spawned or partly spawned-out condition will require further investigation.

Fertilization: Sockeye eggs

The effect on egg fertilization of varying periods of exposure to water prior to addition of milt was also investigated. A female was stripped, using the expression and incision method. The eggs obtained were divided at random into eight nearly equal portions. These portions were kept in running water and fertilized by milt, all from one male, at intervals of 0, 5, 15, 25, 65, and 80 minutes. The eggs were then placed in hatchery trays for a period of 10 days. At the end of this time, 93.5 per cent of the eggs fertilized at 0 time were found to be fertilized and developing normally, while no fertilization was found to be apparent at all other time intervals. Because of the difficulty of obtaining a male and female in the required condition at the time required, along with a shortage of essential equipment, this experiment was of necessity limited. A more extensive study is hoped for in 1951.

F.C. Withler Appendix No. 10

SAMPLING OF SMOLT MIGRANTS FROM BABINE LAKE IN 1950

In order to obtain samples of migrant smolts for age and growth studies of sockeye during the lacustrine stage of their life history, a crude sampling technique was employed at the Babine fence. This consisted of an ordinary adult fish dip-net fitted with one-half-inch seine netting held in open sections of the fence. By this method it was possible to obtain samples of 100 smolts daily from May 26 until June 23. The samples will be examined during the winter at the Station.

The unexpected good results from a simple method suggest that modified but similar techniques might be employed to obtain indices of the sizes of the smolt runs in different years. The method, used in conjunction with a small marking programme, might allow calculations of the total smolt run using the same approach as in experiments involving estimates of total population through tagging. It is intended to expand the experiment in 1951 to determine the feasibility of such an operation.

F.C. Withler Appendix No. 11

ENUMERATION OF THE RUN AT THE BABINE FENCE

As in past years, the adult counting weir in the Babine river was operated in 1950 to enumerate the five species of Pacific salmon entering the Babine area of the Skeena. Because Babine lake is known to support 50 per cent or more of the Skeena sockeye escapement, the Babine fence affords an excellent opportunity to evaluate the number of fish reaching the major spawning ground of the Skeena.

F.C. Withler

The panels were installed by July 7. The first sockeye appeared in the traps on July 10. The fence will be operated this year until October 15, by which time the runs of all species, with the possible exception of cohos, will be over.

Enumeration

The following table compares the runs of the five species through the Babine fence in 1950 with those recorded in previous years. The figures for 1950 are those obtained by October 5, which is the approximate time of fence removal in other years.

	1946	1947	1948	1949	1950
Sockeye	475,705	522,561 (47.7% "jacks")	560,000[x]	509,132 (9.4% "jacks")	543,009 (Approx. 35% "jacks")
Spring	11,528	15,614		7,433	6,791
Pink	28,161	55,421		13,663	38,728
Coho	12,489	10,252		11,938	10,820
Chum	18	7		5	7
Total	526,901	603,855		542,171	599,355

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

The total sockeye run is the largest ever counted through the Babine fence. Due to the large percentage of "jacks", which will be approximately 35 per cent, the effective spawning population, however, will be close to 350,000 sockeye, an escapement midway between the escapements of larger fish in 1947 and 1949. The first sockeye passed through the fence on July 10; on August 27 the peak run of 21,238 passed; and by October 5 the run had declined to 122 sockeye per day. In conjunction with the "jack" sample of the sockeye run, records of the proportions of netted, gaffed and injured fish were kept.

Spring salmon counts are the lowest of four years of operation of the fence. Since 1947, the population of spring spawners passing the fence has declined yearly from approximately 16,000 to 7,000. Spring salmon spawn almost exclusively in the lower Babine river, above and below the counting fence, so that the fence figure is not an accurate measure of the absolute escapement in this area.

Pink salmon produced the second highest count since fence installation, the previous large run to the Babine occurring in 1947. Like the springs, pink salmon spawn above and below the Babine weir, so that the count given is not a final figure for the size of the run to the Babine, but merely an indication of the size.

Coho salmon have maintained a constant run for the four years of fence operation. Since the coho continue to pass upstream after fence removal, the counts given indicate only the magnitude of the first portion of the run.

F.C. Withler

A few chum salmon appear each year at the Babine fence.

Sampling of the run

A one per cent daily sample of the sockeye run through the Babine fence for length and sex was maintained in 1950. No figures are yet available but the general size of fish other than "jacks" indicates that the run will be composed largely of V-year-old fish. The overall sex ratio will tend to favour male fish because of the high "jack" count. The data on sex proportion in fish four years or older awaits computation.

Egg samples in the ratio of one to every 10,000 fish counted through the fence were taken. These will be enumerated this winter at the Station.

Scale samples have been taken every five days from the fish sampled for length and sex. Thus the scales from over 1,000 sockeye will be available for reading to determine the proportion of one- and two-year-in-the-lake types in the returning adults. These figures will be compared to those obtained from migrant smolts taken at the Babine fence in May and June.

Water levels and maximum-minimum water temperature readings were maintained at the Babine fence as in previous years. No tagging programme to test the speed of passage of sockeye through the fence in 1950 was carried out because a summary of previous tests shows that little delay in the passage of fish upstream is caused by the present fence.

F.C. Withler

Appendix No. 12

SIX-MILE CREEK FRY-ADULT FENCE

In order that information on the stream survival of sockeye from egg to fry be available for the spawning grounds of the great central plateau, where the vast majority of Skeena river sockeye spawn, a site was chosen in June of 1950 at Six-Mile (Gullwing) creek on Babine lake. Survival figures from Six-Mile, when compared with those from Port John and Scully creek, will complete the stream-survival picture for sockeye from extreme coastal to extreme interior conditions.

Construction

Clearing and excavation of the site commenced on July 1. Carpenters started construction of the fence on July 17 and finished the adult portion by August 3. Sockeye began to enter the creek on August 5. Construction of the fry portions of the fence was complete by September 16, and by September 23 a two-room cabin, suitable for winter use, was ready for occupancy.

The fence is 54 feet long, consisting of nine sections six feet wide. For adult operation there are conventional picket panels on a slope of 30 degrees. Upstream migrants are guided through a lead into a large trap from which they are dipped for measurement and sexing. The fry portion of the fence is of the "Wolf" type, in which water is passed through horizontal screens and the fry collected in troughs and pens.

F.C. Withler

Operation

A total of 1,237 adult sockeye passed through the fence from August 5 until September 11. Of these, 691 were males. On the basis of average egg counts of sockeye passing the Babine fence, the remaining 546 females carried approximately 1,800,000 eggs into the stream. The ovaries of every twenty-fifth female were taken for later enumeration to determine the potential deposition in the stream. All fish were measured and examined for marks. Because the spacing of the trap boards was too wide, a small but unknown number of kokanee entered the stream.

Surveys of the spawning fish were made every four days. The proportion of live to dead, the distribution of sexes on the stream, the apparent effect of water level on spawning and the number of predators were noted. Over 400 dead females were opened and examined to determine the number of eggs retained. Redds have been marked for later sampling of the developing eggs to discover the mortality at each stage.

In the spring of 1951 the resultant fry will be enumerated at the fry fence. It is hoped that it will be possible to check survival figures at Six-Mile with those on other streams of the lake. Attempts will be made to set up in different streams small enclosed sections where the progeny of a known number of adults may be counted. Experiments designed to elucidate the role of environmental conditions in the stream phase of the sockeye will also be carried out at Six-Mile creek, as in other areas.

W.P. Wickett

Appendix No. 13

OPERATION OF NILE CREEK FIELD STATION, 1950

A severe flood in November, 1949 washed out both the main fences. These were replaced this spring with a modified design in which all superstructure was eliminated and the horizontal pickets lengthened. The hope that large increases of flow 1000 c.f.s. could be handled was not realized as the fences were again destroyed on Thanksgiving Day, 1950. The lower fence is being replaced.

The water pipes and pumping engine have been repositioned with insulation and arrangements for drainage provided so as to avoid a repetition of the procedure required last winter to keep water flowing in the hatchery.

Six-inch logs had been set into the gravel, staked and buttressed with boulders to hold spawning gravel during floods but these have been swept out like match sticks. Much more rugged construction is required to improve spawning conditions in the lower portion of the stream.

Electric power has been a decided improvement, enabling experimental work to be carried on by summer workers from the University of British Columbia.

The competent work of the technical staff, Messrs. Eaton, Caulfield and Neate, is acknowledged.

W.P. Wickett

Appendix No. 14

NATURAL AND ARTIFICIAL PROPAGATION OF CHUM AND PINK SALMON AT NILE CREEK 1949-50

Evaluation of the natural percentage production of seaward migrants, and assessment of the influence of surface flow, and of stream predation on the freshwater survival was continued, using the methods of comparative propagation laid down by Mr. Neave.

The artificial methods are better producers of fry, both on a percentage and on an absolute basis. The methods used may be capable of enlargement to become practical ways of improving or restoring salmon populations. In the future it is hoped that a quantitative assessment of stream improvement practices will also be made.

						Fry				
CHUM	Section	Females	Egg Count	No. of Eggs	No. of Eggs Planted	Count, Live and Dead	Marked	% Survival from Predation	% to Emergence	% Production
1945 -46	1[X]	1564	2263	3,540,000		138,388	40,000 BV	62.00	6.20	3.9
1946 -47	1	827	2558	2,115,000		8,319	4,736 A.RV.	45.00	0.87	0.40
	2			761,000	254,000	20,275	13,956 A.LV.	13.89[V]	19.17[V]	2.66
1947 -48	1	473	2697	1,276,000		4,808		55.86	0.67	0.38
	2			491,000	275,000	52,109		61.00	17.40	10.6
	3			422,000		14,331		66.47	5.11	3.40
1948 -49	1	170	2263	385,000		23,188		34.75	17.40	6.03
	2			461,000	259,000	13,882		26.82	11.30	3.01
	3			402,000		47,635		46.12	25.70	11.8
1949 -50	1	485	2400	1,022,000		782		36.00	0.21	0.08
	2			504,000	48,500	3,939		36.67	2.13	0.78
	3			344,000		29,282		83.75	10.1	8.51
PINK										
1948 -49	1					53				
	2					1,505				
1949 -50	1	3				55				
	2	3				92				
	3			102,000		13,742		83.75	16.1	13.5

[X]Type of propagation -
Section 1, natural.
" 2, eyed egg planting.
" 3, green eggs, controlled water.

[V]From two tests near end of run.
BV - both ventral mark.
A.RV. - adipose, right ventral mark.
A.LV. - adipose, left ventral mark.

W.P. Wickett

Influence of surface flow

Unforeseen and adverse conditions were experienced during the year in all three methods of propagation under study.

Natural - 0.08 per cent - Excessive floods in November were sufficient to wash out No. 1 and No. 2 fences. (ca. 1500 c.f.s.). In the spring, bulldozers were at work changing the course of the stream above No. 1 fence and widening the channel below No. 2 fence.

Eyed eggs from hatchery - 0.78 per cent - Salt water was accidentally pumped into the storage tank, resulting in exosmosis of 70 per cent to 90 per cent of the eggs in the eyeing trays. Excessive cold may have been a contributing cause of death.

Controlled water section - 8.51 per cent chum; 13.5 per cent pink - Anchor ice and freezing of the inlet reduced the surface flow to a very low level for two weeks.

Protection from surface fluctuations appears to result in higher production. In 1947-48 the dam on the controlled section broke so that full protection was not given. In 1948-49 and 1949-50 salt was present in the eyeing station water supply, accounting for low survivals from eyed eggs.

Influence of predation

Some predation was eliminated this year in the controlled-water section (No. 3) by removal of coho and trout yearlings and screening of the intake.

Each year the results of weekly predation tests on all three sections show higher percentage survival when large numbers of fry are migrating than when few fry are migrating. For a given number of predators there is probably a critical fry population level below which the fry will be virtually exterminated. Three-day comparative predation tests with marked and unmarked fry showed a small (7%) but not statistically significant difference. The method of releasing marked fry in the stream to assess predation of migrating fry is therefore a valid one. Predators were observed to gulp fry indiscriminately from the school or mill of fish. A small difference in predation is apparently not the case in the ocean, judging by the return of fish marked in the spring of 1946. In that year 40,000 marked (BV) and 57,700 unmarked live fry were released. Six three-year-olds returned in 1948 and 22 four-year-olds in 1949 (about the normal age distribution). The ocean survival of the unmarked fry is 1.4 per cent if based on the return of 834 four-year-olds in 1949. This corresponds to an instantaneous mortality rate of 4.25. The marked fry ocean survival rate was 0.055 per cent or an instantaneous mortality rate of 6.31. The increase in the instantaneous mortality rate due to marking is 2.06 or 48 per cent.

If the fish lose their strong aggregating tendency after entering the sea, or it may be a question of size, the predators may single out individual fish rather than attack indiscriminately. The lack of full manouvering ability would then be a disadvantage and the increase in differential mortality explained.

W.P. Wickett Appendix No. 15

OXYGEN SUPPLY TO SALMON EGGS IN GRAVEL

Field determinations of the oxygen demand of chum salmon eggs were found to be:

Pre-eyed	.0004 mg./egg/hr.	at 8°C.
	.0002	0.1 - 0.7°C.
Faintly eyed	.0002	0.1 - 0.7°C.
Eyed	.0009	4°C.
Eyed - 10 days before hatching	.002	6°C.

Limiting values of dissolved oxygen and velocity of gravel-water flow may be calculated from the formula

$$B.O.D. = pV_e \frac{v}{d} (DO-C_o)10^{-6}$$

where	B.O.D.	= oxygen demand of eggs	mg./egg/hr.
	p	= porosity or voidage of gravel	
	V_e	= effective volume of water per egg	(approx. 0.6 vol. of egg)
	v	= velocity of water	mm./hr.
	d	= diameter of egg	mm.
	DO	= dissolved oxygen in gravel water	p.p.m.
	C_o	= critical saturation of DO at which consumption of eggs is reduced	p.p.m.

Values of velocity and dissolved oxygen less than the limiting values have been found in parts of the controlled-water section at Nile creek.

A modified well-point has been developed to sample water from twelve inches below the surface of the gravel. Further work will be carried out to evaluate its usefulness as a means of determining rate of flow using dyes. If successful, a simple method of surveying stream gravels for oxygen supply to salmonoid eggs should result.

H.W. Spencer Appendix No. 16

NUMERICAL ESTIMATES OF SALMON ESCAPEMENTS TO DISTRICT 3, 1934-49

Salmon-stream spawning reports were gone over and estimations of numbers of salmon ascending streams tabulated by species, by years and by inspectors' areas. These tables go back to 1934 except in the case of Alert Bay (only 1949 present), Nitinat (1940) and Alberni (1940) areas. Previous to these dates no estimations of the numbers of fish were available. Tables were also made for each statistical area as shown on Department of Fisheries Statistical Map, April, 1950, old areas appearing in brackets.

Records have been kept of the number of streams totalled per year. A list was made of these streams for each area and the years they were not recorded.

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For number of fish the letters on the Inspectors' reports were recorded as follows:

A	50	E	1,000	I-K	20,000	
B	100	F	2,000	L	50,000	
C	300	G	5,000	M-Z	100,000,	these being the maxima
D	500	H	10,000			of each grouping.

The figures available are not as accurate as could be desired owing to the extreme difficulty in surveying the streams because of high water or heavy underbrush near the stream beds. Estimations for the same stream also vary with the experience of the Inspector reporting.

The estimations for sockeye and steelhead are incomplete as in many cases the observer merely noted their presence in the stream but made no attempt to estimate numbers. Pink salmon figures are also lower than expected.

All streams reported are not equally accurate, as those near populated areas have more inspections and sometimes resident observers assigned to them while streams in isolated districts are not as frequently surveyed.

The classifying of individual stream escapements into heavy, light and medium gives little indication of the numerical size as it varies considerably with the person reporting and his knowledge of the stream. However, for the whole district, there is very close agreement between the subjective and numerical estimates of chum salmon.

I wish to extend my thanks to Mr. Tait, Supervisor of Fisheries, District 3, and his staff for their co-operation in making the records available; also to Mr. W.P. Wickett for his advice on the tables.

A. Andrekson — Appendix No. 17

ADULT SALMON MIGRATION INTO PORT JOHN LAKE CREEK, 1949

In order that no adults might migrate up this major lake tributary, on which the counting fence was located, until proper preparations to enumerate them had been made, the fry dam had been left in place. The dam was removed on August 27 and construction of new panels for the adult fence started. By September 8 these were completed and installed. No major rainfall occurred during the construction period. Consequently no freshets or fish migrations occurred.

The first sockeye appeared on September 17. In the following table are given the numbers of the three species of Oncorhynchus counted during the season:

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Week ending	Sockeye	Coho	Chums
Sep 9	0	0	0
16	0	0	0
23	147	1	0
30	465	1	0
Oct 7	293	0	0
14	703	19	6
21	4	0	0
28	0	12	0
Nov 4	0	4	0
11	0	12	0
18	0	24	0
25	0	7	0
Dec 1	0	4	0
8	0	4	0
15	0	1	0
22	0	7	0
Total	1,612	96	6

The sockeye (O. nerka) run coincided in time with that of 1948, but the peak was reached earlier. Sockeye that had passed into the lake early in July were found to intermingle with sockeyes that were coming from the sea in mid and late September. Therefore, the early run sockeye matured in the freshwater lake and there seemed to be no segregation of the two types on the spawning grounds. A portion of the late-run sockeye was tagged. Any separation or segregation was therefore quite simple to observe.

Each fiftieth female was taken and an egg count made. The average egg count from 16 females was 2,425.05 eggs. This gave a total egg deposition of 2,029,756.

Of the 2,245 sockeye passing through Hooknose creek fence, only 1,612 passed through the fence at the lake. Another 150 to 200 were accounted for in a stream directly across from the one that is fenced, thus leaving 450 unaccounted for. These may have spawned in the main stream or in the lake itself. No proof has yet been established of either of these possibilities, but during the spring (1950) fry migration, 153 sockeye fry were counted through the Hooknose fence, thus suggesting that at least some of the 450 may have spawned in Hooknose creek itself.

Of the 681 coho (O. kisutch) adults passing through the Hooknose fence, only 96 entered the lake stream with the fence. Of these, 62 were males, 34 females. Average egg count (1947) being 2,313 per fish, the approximate deposition in the fall of 1949 was 78,200 eggs. The balance of the coho must have spawned in Hooknose creek itself or in some of the smaller tributaries.

Of the six chums (O. keta) that passed through the upper fence, five were males and one was a female.

J.G. Hunter and A. Andrekson Appendix No. 18

PRODUCTION OF SEAWARD MIGRANTS AT PORT JOHN

The fry fence on Hooknose creek was installed and put in operation March 28. A few changes were introduced into the fence, in making experiments with different gauges of screen, varying slopes of the screens, and varying heights through which the water must drop before hitting the screens. The most successful innovation was the combination of the Holmes fence with the Wolf design. A flume to underpass water was tried but failed to meet with success.

After installation, pink and chum fry were observed and collected from March 29 onward, while the other species of Oncorhynchus followed at later dates.

The course of the run is indicated in the following table:

Table I. Dates and Numbers of the Different Species of Migrating Young Salmon

Week Ending	Pinks	Chums	Sockeye Fry	Sockeye Smolts	Coho Fry	Coho Smolts
Mar 31	49	100	0	0	0	1
Apr 7	246	199	0	0	0	1
14	1,777	123	0	0	0	3
21	10,025	623	0	0	0	16
28	15,368	1,460	28	6	0	18
May 5	14,428	2,770	89	448	134	46
12	9,936	14,605	28	6,948	2,630	727
19	2,015	12,733	3	3,867	2,896	1,074
26	206	9,652	8	2,369	5,253	654
Jun 2	11	1,541	1	1,399	3,629	328
9	0	627	0	247	3,385	85
14	0	30	0	19	2,585	29
Total	54,061	44,463	157	15,303	20,512	2,982

The general pattern of the run was similar to that of 1949. Peaks for the different species were at approximately the same times, but were of less magnitude. The ice cover left Port John lake about April 6. Hooknose creek was well frozen over above the zone of tidal influence.

Table II. Total Numbers Counted and the Percentage Survival of Migrants in Relation to the Potential Egg Deposition as Estimated in the Fall of 1948 and 1949

Species	Sex and No. of Adults		Average No. of Eggs	Potential Deposition	Downstream Migrants	Per Cent Survival
	Male	Female				
Pinks	650	523	1,650.46	863,190	54,061	6.239
Chums	362	343	2,082.76	714,386	44,463	6.223
Sockeye[x]	154	77	1,830.07		15,303	
Coho[x]	351	203	2,459.4		2,982	

[x]1948 parent year and count incomplete.

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From table II, it would appear that the coho migrants suffer a high mortality. This is not necessarily a valid conclusion since large numbers of coho fry (table I) are known to go to the brackish water of the sea soon after they emerge. Perhaps some of these remain at sea and do not move back into the freshwater lakes and streams during the winter. If this is true, the figure for percentage survival of the migrant coho salmon is of no value as a comparative figure.

The close correlation between percentage survivals of the pink and chum salmon (table III) is of interest.

Table III. Percentage Survival of Pink and Chum Salmon Counted at Port John from 1948 to 1950

Species	1948	1949	1950
Pink	0.866	8.020	6.239
Chum	0.990	7.346	6.223

Cold weather and frost caused high mortality in redds which had become exposed due to low water. As in previous years, redds located in the tidal zone of influence had a higher per cent survival than those above it, e.g., 81 per cent survival in the tidal area on January 11 as opposed to a very heavy mortality above the zone of tidal influence. It is generally believed that survival is much greater in the brackish areas of the stream but excessive mortality found above this zone is partly attributable to redd sampling technique.

Stream predation studies, using pink and chum salmon fry and the thread-marking technique, resulted in estimates of stream predation as being in the neighbourhood of 60-75 per cent.

No marking of migrants on a large scale was attempted this spring.

Detailed records of precipitation and stream levels have been maintained throughout the entire year.

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Appendix No. 19

COHO SMOLT MIGRANTS AT PORT JOHN, 1950

In order to add to the information being collected on the life history, habits, etc. of coho salmon in fresh water, the following observations were made. Samples, which were believed to be random, were taken each day during the seaward migration of the coho smolts. They were obtained mainly at the marine fence but a few were collected at the lake fence. The samples from the marine fence were anaesthetized, weighed, scale sampled, and then released. Some were retained each day as permanent samples and from these the sexes were determined. At the lake fence, only length measurements and scale samples were taken.

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Table I arranges the marine migrants into "time groups", showing actual number of migrants, number sampled, range of lengths and average lengths.

Table I. Average Lengths and Ranges of Lengths (in cm.), Numbers of Migrant Cohos, and Number Sampled at Port John Marine Fence, 1950

Time	No. of Migrants	No. Sampled	Range of Lengths (cm.)	Av. Length (cm.)
Apr 26-30	40	6	8.9 - 16.2	11.41
May 1- 7	118	48	6.8 - 19.7	11.49
8-14	1,130	66	7.7 - 15.9	11.28
15-22	904	71	7.8 - 14.6	11.37
23-29	494	63	8.3 - 13.3	10.88
30-Jun 4	218	74	8.2 - 14.2	10.68
Total	2,904	322	Average length	11.14

Approximately 11 per cent of the coho run was sampled. The larger fish appear to be the first to go seaward. This is a general trend, and the weights of the migrating groups (table II) are confirmatory.

Table II. Average Weight and Ranges of Weights (in gm.), of Coho Smolts Sampled at Marine Fence, Port John, 1950

Time	No. of Migrants	No. Sampled	Range of Weights (gm.)	Av. Weights (gm.)
Apr 26-30	40	6	--	--
May 1- 7	118	45	3.3 - 48.7	15.50
8-14	1,130	66	5.2 - 34.5	13.93
15-22	904	71	3.7 - 28.7	14.42
23-29	494	64	3.9 - 21.4	13.15
30-Jun 4	218	73	5.5 - 26.6	12.50
Total	2,904	325	Average weight	13.90

Table III. Average Length, Range of Lengths, and Number Sampled in the Given Time Interval. Samples taken at Port John Lake, 1950

Time	No. of Migrants	No. Sampled	Range of Lengths (cm.)	Av. Lengths (cm.)
May 1- 7	22	10	9.4 - 7.2	8.26
8-14	34	19	12.7 - 7.4	9.09
15-21	25	13	11.6 - 7.0	9.01
22-28	30	18	12.5 - 7.6	9.94
29-Jun 4	7	9	12.6 - 6.5	9.55
Jun 5-11	2	1	7.7	7.70
12-18	9	3	6.3 - 5.4	5.96
19-25	3	2	5.8	5.80
26-Jul 2	3			
Jul 3- 9	5			
10-16	5			
Total	145	75	Average length	8.16

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Here again it can be noted that, in general, the larger fish migrate first, with the exception of the first week. Approximately 52 per cent of the run was measured.

Age-Groups

The 330 scale samples from the marine fence were examined and these results are tabulated in table IV.

Table IV. Numbers of Smolts in Respective Age-groups

Age	1 year	1 year plus additional check	2 years	no annulus
No.	298	27	1	4
Percentage	90.3	8.2	.3	1.2

The group with the 1-year check and an additional check cannot be classed as two-year-olds because of nearness of second check to the first annulus. The reason for this second check is, as yet, undetermined.

Table V, which follows, groups the smolts sampled by J.R. Robertson from the lake at Port John into respective age brackets.

Table V. Age-groups of Port John Lake Coho Smolts

Age	1 year	1 year plus additional check	2 years	no annulus
No.	66	5	0	4
Percentage	88.0	6.7	0	5.3

Tables IV and V roughly coincide in percentage composition. The number of migrants without annulus in table V may be due to the lateness of sampling, as the majority came at the end of the sampling year.

J.G. Robertson

Appendix No. 20

SOCKEYE FRY PRODUCTION, PORT JOHN LAKE, 1950

The disposition of the 1949 sockeye escapement into streams tributary to Port John lake has already been reported in Appendix No. 17. The potential egg deposition from data obtained at the weir on Tally creek was 2,029,756. The fry return from this egg deposition was enumerated this

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spring. With associated meteorological data the results were as follows:

Week Ending	Sockeye Fry	Precipitation (in inches)	Average Temperature (Fahrenheit)
Apr 22	1		--
29	4		--
May 6	13		--
13	152		39.5
20	384		39.5
27	1,569	4.55	39.5
Jun 3	3,852	2.15	39.8
10	10,416	.00	40.9
17	16,105	.00	42.7
24	2,694	1.45	46.8
Jul 1	221	.55	48.5
8	22	.77	49.6
Total	35,433		

Under the conditions of natural incubation the per cent fry survival was 1.745 per cent (25.26% in 1949). This low return may be correlated with the severe winter. The resident investigator reported a complete freeze-up had occurred at one time of observation, and inspection of the redds showed extensive damage had been done. With this implication it may be added that other spring migrants (lampreys, trouts and cottids) were notably scarce as compared to the numbers counted in 1949.

The climatological data obtained over the period of migration showed less precipitation and colder stream temperatures than in 1949. The stream flow was maintained by the run-off provided by a heavy accumulation of snow.

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Appendix No. 21

LIMNOLOGICAL STUDIES, PORT JOHN LAKE, 1950

This programme was initiated in 1949 as a corollary to the sockeye investigation here. The bottom fauna studies were discontinued this year, but otherwise no changes were made in the methods of investigation.

The work was begun May 15, and to September 6 the maximum-minimum difference in the lake level was 2.32 feet. The temperature variation at the level gauge was 10.6°C. (maximum 19.7°C. June 16).

At Station I (72 feet of water) in the south end of the lake, 11 temperature series were taken using a reversing thermometer and shallow-type bathythermograph. Bottom temperatures varied from 5.2°C. (May 31) to 5.7°C. (Sept. 6). The surface fluctuation was between 9.8°C. (May 31) and 19.7°C. (Aug. 25). From Station II (145 feet of water) in the north end of the lake, 10 temperature series were taken. Corresponding data here were 4.8°C. to 5.2°C. (bottom) and 9.8°C. to 19.7°C. (surface). A short epilimnion and an extensive hypolimnion were peculiar to both stations. A thermocline lay approximately between the 5- and 30-foot levels throughout

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the season. The last recordings (Sept. 6) showed that while the surface layers were cooling off, the bottom water was still rising in temperature. This seemed to be associated with the extensive humus deposits in the lake.

Four series of oxygen determinations were made from each station commencing July 26. The minimum percentage saturation (63.2) occurred this date (Station II, in 49 feet) while the maximum recording (95.0) was taken August 25 (Station I, surface).

Transparency data were obtained at both stations with a Secchi disc and the somewhat brownish waters showed an average reading of 15 feet.

Plankton samples were collected in vertical series (12, 11) at the points of reference, and horizontal drags (12) were made over a fixed course in the limnetic region.

While no attempt has been made to analyse the data, general observations indicate the lake is temperate of the second order (bottom temperatures) and by reason of its thermal stratification and oxygen saturation it may be oligotrophic. However its colour, transparency, absence of water blooms, paucity of bottom fauna, and apparent absence of coregonine fishes, would indicate features of the eutrophic and dystrophic types. Its succession as evinced from adjacent terrain seems to be into a peat bog, characteristic of the latter type of lake.

Time and ice-cover permitting, helpful fall and winter data have been, and are being collected by Messrs. J.G. Hunter, A. Andrekson, R.C. Wilson and J.S.T. Gibson.

D.J. Milne

Appendix No. 22

COMMERCIAL FISHERY STUDIES ON SPRING AND COHO SALMON

The amount of salmon handled fresh and frozen has increased greatly in recent years. Because salmon catch figures are not published by species except where canned, it is difficult to determine the quantity and value of the commercial catch of spring and coho salmon in British Columbia. The annual catch is about 650,000 (10,000,000 lbs.) spring salmon and 2,500,000 (20,000,000 lbs.) coho salmon which may amount to one-third of the total salmon value. The general introduction of the Multiple Sales Slip in 1951 will provide the first reliable figures for these two species. Therefore from past data it has been impossible to determine with assurance the trends in the catches. The indication is that there has been a general decline in both species but it is difficult to show whether this is true or not. At present all that can be said is that over the last 50 years there has been a decline in the spring salmon to the Columbia river and in the coho salmon of the Fraser river area.

The majority of these two species are now taken by trolling (spring 70% and coho 60%) although in restricted areas many spring salmon are taken by gill nets and coho salmon by purse seines. During the last 10 years the number of trolling licenses has increased from 3,000 to 5,000. The modern trolling boat is large and well equipped with radiophones and other navigational instruments so that it can catch the fish anywhere on their long migration routes. A map of the present fishing areas in British Columbia is being compiled. It shows that most of the fishing is done on the continental

shelf within 25 miles of shore and at depths less than 50 fathoms. The season extends over a long period from April to October with July and August, the peak months. As all troll-caught fish are landed in a cleaned condition and are not counted, conversion factors are necessary to obtain round weights and numbers of fish. Much data, from both the Department of Fisheries and the industry, require summarization before the catch and effort picture is at all clear.

Commercial fishery off the west coast of Vancouver island

This year an attempt was made to arrive at reasonable estimates for the troll-caught fish off the west coast of Vancouver island in order to show the trend in the catches. Data were available from the Department of Fisheries from 1929 to the present. However on checking the accuracy of these data it was found that prior to 1945 the catches of each species had not been kept separate in the original tabulations and since then many gross errors occur. Therefore it has proved impossible to determine the catch of spring and coho salmon for each year or to evaluate the trend during this period. The annual catch of each species has evidently fluctuated between two and five million pounds.

Since 1947 Trip Reports have been filled out by our port observers for trollers landing fish in either Victoria or Vancouver. These fishermen have large boats and by carrying ice they can remain on the fishing grounds for five or six days before bringing in their catches. They are a select group in comparison to the larger number of smaller "day boats". The effort, catch and return per-unit-of-effort of these "ice boats" for the last two years are given below:

Year	No. of Boat-days	No. of Lbs. (dressed) Spring	Coho	Lbs. per Boat-day Spring	Coho
1949	2,149	321,204	537,863	150	250
1950	3,217	531,187	873,095	165	270

It appears that these fishermen had better fishing this season than in 1949. However the data available for the "day boats" indicates that the 1950 fishing was not as good as in 1949. Sales Slip returns from all boats next season will provide a much more accurate picture of the catch.

For example, the 1950 returns from the Sales Slip System operated in Areas 3 and 4 give the following data for troll-caught fish.

	No. of Boat-days	No. of Lbs. (round) Spring	Coho	Lbs. per Boat-day Spring	Coho
Area 3 (Nass R.)	5,626	35,664	570,724	6	103
Area 4 (Skeena R.)	5,438	381,864	621,194	70	114

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For certain sections of the catch there are valuable records available for the last ten years, such as daily catches at the Sooke traps on the southern coast of Vancouver island and the detailed records of the Fishermen's Co-operative trolling operations off the west coast of Vancouver island.

Sport fishery in the straits of Georgia

Sport fishing for spring and coho salmon is at present largely confined to the straits of Georgia with the exception of Alberni canal and Rivers inlet. As time goes on, these fisheries will expand greatly. This has already occurred off the western states. Therefore new records are being started and old ones are being maintained for the sport fishery.

The Fisheries Department estimated that in 1949 approximately 325 small power boats and 335 row boats from boat-rental houses caught 30,000 coho and 15,000 spring salmon in the straits of Georgia. In addition there is probably an equal number of privately-owned small boats.

At Cowichan bay on Vancouver island where records have been maintained for the past ten years (for a summary up to 1948 see Appendix 22, 1949) the 1949 season is summarized as follows:

	Boats	Line-hours	Springs		Cohos		Line-hours per	
			Large	"Jacks"	Large	Grilse	Spring	Coho (Large)
Entire season Aug 1-Nov 13	7,542	66,986	2,908	820	4,702	1,364	--	--
Spring sample period Aug 15-Sep 11	2,762	23,702	1,835	509	--	--	10.1	--
Coho sample period Sep 19-Oct 30	2,988	29,026	--	--	4,230	788	--	6.9

This represents the greatest effort and catch for both spring and coho salmon since the records were commenced. In the case of spring salmon the line-hours per fish are less than average and for coho salmon they are more than average. Similar records are being collected for the 1950 season.

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Appendix No. 23

A SUMMARY OF PAST BIOLOGICAL STUDIES ON SPRING AND COHO SALMON

Considerable data on the migration routes and ages at maturity of spring and coho salmon have been collected in the past but to define adequately the current stocks there is a great need for co-ordinating the results and rechecking them under present fishing intensities.

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Tagging experiments

From 1925 to 1930 a total of 6,456 spring salmon were tagged in 10 different areas of the coast. Of these 761 or 11.8 per cent were recovered. The majority travelled long distances in a south-easterly direction to the larger rivers, such as the Columbia river (50%), Fraser (25%), and Skeena river (10%). For spring salmon, international co-ordination is necessary since 65 per cent of the returns from the Queen Charlotte islands and 85 per cent from the west coast of Vancouver island were taken in American waters.

From tagging 817 spring salmon in 1949 off the west coast of Vancouver island, fewer returns (less than 20%) were made in American waters and less than 15 per cent were returned from the Columbia river. Whether this is due to the reduction in the Columbia river stocks or a change in the location of fishing is problematical. The fact that many returns were made off Barkley sound in the general area where they were tagged (13% in 1949 and 23% in 1950) strongly indicates that this is an important ocean feeding area.

From 1925 to 1930 a total of 7,126 coho salmon were tagged in 10 different areas of which 632 or 8.9 per cent were recovered. They migrated shorter distances than the spring salmon with a marked tendency to radiate in all directions from the point of tagging, especially in the case of the "bluebacks" in the straits of Georgia. Twenty-five per cent were returned from American waters. From tagging 512 coho salmon in 1949 off the west coast of Vancouver island, only 16 per cent of the returns were from American waters.

Hypothetical migration routes have been mapped for both species on the basis of the above tagging results but there remains a need for tagging experiments off the north-west tip of both Vancouver island (Scott islands) and Queen Charlotte islands (Langara island). Tagging experiments in these two areas are planned for 1951.

Age studies

Of 2,834 spring salmon scales collected from 1925 to 1930, 90 per cent were four and five years of age and 78 per cent went to sea as fry. The fish were older to the north-west of the spawning river; e.g., for Columbia river returns the average age is 3.4 at the Columbia river, 4.3 off the west coast of Vancouver island and 5.2 off the Queen Charlotte islands. By combining the age and tagging data the theory of a north-westward feeding migration of young fish with a south-eastward spawning migration of adults was formulated twenty years ago and still stands. Current studies in oceanography and in the fishing areas should throw more light on this theory.

The majority (83.6%) of the 737 spring salmon sampled off the west coast of Vancouver island in 1949 were three years of age in contrast to the condition in 1926 when 28.4 per cent were in their third year and 50 per cent were in their fourth year.

Of 6,312 coho salmon scales collected from 1925 to 1930, over 95 per cent were three years of age with less than one per cent going to sea as fry. The 1949 age data were similar yet the coho catches do not show three-year cycles. In coho salmon rapid growth occurs in the last summer when the fish usually double their weight from June to September.

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Further age- and growth-rate studies are in progress for possible regulatory changes and prediction purposes. In spring salmon does the number of small fish one year indicate that size of the run the following year?

Other studies

In coho salmon freshwater survival to the fry stage at Cowichan river averaged 22.8 per cent (11.8 to 40.0%) and to the yearling stage at Minter creek 1.6 per cent (.7% to 2.8%). Freshwater survival data are not available for spring salmon nor are ocean survival data available for either species. Fishing mortality rates are also lacking for both species. Certain food (salmon - herring relationship) and racial studies have been carried out on both species but more information is needed along these lines. The problem of the difference (heredity and/or food) between the red and white spring salmon has both theoretical and practical aspects. Much work still remains to be done before we will know what variations to expect in both the freshwater and ocean phases of these two species.

D.J. Milne Appendix No. 24

1950 BIOLOGICAL STUDIES ON SPRING AND COHO SALMON

Tagging experiments off the west coast of Vancouver island

The tagging experiments were repeated along lines similar to those conducted in 1949 except that for economic reasons only small fish (less than 8 lbs.) were purchased from the trollers.

From May 26 to September 5 at Ucluelet (south-west coast) Mr. W.G. Calderwood tagged 140 spring salmon (average total length 24.8 in.) and 262 coho salmon (average total length 25.4 in.).

From May 25 to August 21 at Kyuquot (north-west coast) Mr. E.A.R. Ball tagged 22 spring salmon (average total length 21.8 in.) and 110 coho salmon (average total length 25.9 in.). More small fish were available at Ucluelet (feeding area) than at Kyuquot (migrating area).

Up to October 20 only five spring salmon returns have been received but it is anticipated that the majority will be taken in 1951. For coho salmon 27 (10.3%) have been recovered from the tagging at Ucluelet but only two (1.8%) have been recovered from the tagging at Kyuquot. Since the distribution of the returns is similar to that in the 1949 experiments further tagging in this area is not planned for 1951.

Sampling of the troll catch

To determine the age and size sequence of the runs and to obtain conversion factors for dressed to round weights and total to fork lengths, the commercial catch was sampled regularly both during and between tagging trips.

At Ucluelet a total of 612 spring salmon and 482 coho salmon were sampled from May 17 to September 5. Eleven per cent of the spring salmon were white of which six (8.6%) were less than 26 inches total length. Of the red springs 79 (12.9%) were less than 26 inches total length. By June

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15, 28 per cent of the coho samples had been taken. The average dressed weight of the coho salmon increased from 3¾ pounds on June 1 to 8½ pounds on September 1.

At Kyuquot a total of 625 spring salmon and 725 coho salmon were sampled from May 17 to August 20. Six per cent of the spring salmon were white of which none was less than 26 inches total length. Of the red springs, 40 (6.8%) were less than 26 inches total length. By June 15 only eight per cent of the coho samples had been taken. The average dressed weight of the coho salmon increased from four pounds on June 1 to eight pounds on September 1.

As all fish are cleaned before they are landed, round weights and samples of gonad and stomach contents had to be obtained on tagging trips. During the season 120 stomach and gonad samples were taken at Ucluelet and 25 at Kyuquot. These have not yet been analysed. The average conversion factor from dressed to round weight for each species was determined to be 15 per cent added to the dressed weight.

At the southern tip of Vancouver island 109 spring salmon were sampled prior to July 17 from the Sooke traps. At the northern tip of the Island 86 coho and 15 spring salmon were sampled from August 22 to September 20. A few samples were also obtained from the Cowichan bay and Alberni sport fisheries.

Off the east coast of Vancouver island, 838 coho salmon (called "bluebacks" in Georgia strait) were sampled. The average dressed weight of 105 fish sampled at Nanaimo was 2.5 pounds on June 15, 3.0 pounds on July 15 and 4.0 pounds on August 15. During June, the first month of fishing, approximately 50 per cent were less than the legal size of 2½ pounds dressed. According to the fishermen these inside coho salmon were unusually small this year. On further analysis this may be related to the extremely low temperatures recorded last winter. Certainly the growth in 1950 is one-half pound less than comparable data collected at Nanaimo in 1928. It is also from two to four pounds less than the growth rate of the samples taken off the west coast of Vancouver island this season. Is this latter difference also related to temperature and food differences?

D.J. Milne Appendix No. 25

A DISCUSSION OF THE PROPOSED CHANGES IN THE TROLLING REGULATIONS

The three states, Washington, Oregon and California, and Alaska have recently adopted (with certain local adjustments) an opening date of June 15 for coho salmon fishing and a minimum size limit for spring salmon of 26 inches total length. The conservational aspect of these two regulations lies in the hope that by releasing small fish, which have a low market value, a higher production in weight will result from retaining only large fish. Should Canada adopt similar regulations?

In British Columbia the present commercial trolling regulations regarding size of fish and season are that fish less than 2½ pounds dressed are illegal and that the "blueback" fishing in the straits of Georgia opens on June 1. Any change in the regulations must be simple to assure satisfactory enforcement and must satisfy a sound biological and/or economic

need. The economic advantage of catching large fish is evident. The following discussion is confined to the general biological aspects of the proposed changes.

A minimum total length of 26 inches for spring salmon

Considering all areas this regulation would probably affect the present production by 10 per cent in number of fish and less than 10 per cent in weight. From sampling data, fish of this minimum length vary from 5 to 10 pounds so that it might be better to set a minimum weight as well as a minimum length.

Because these small fish would have to be released from the hooks they would suffer a mortality due to releasing (ca. 25% on the basis of experiments conducted in California) plus an unknown natural mortality over a period of up to a year. Tag returns indicate that less than 10 per cent of the small fish might be recaptured although most of them are only three years of age. Moreover, a portion of these small fish will mature and spawn as "jacks". For example the Columbia river escapement averages 20 per cent "jacks". These "jacks" or small precocious males are usually surplus on the spawning grounds and therefore should probably not be protected.

To compensate for these losses there is the gain in weight of up to a year's growth for the immature springs which survive. For those fish which are caught later in the same season this may amount to an increase in weight of 50 per cent and for those caught during the following season an increase of 100 per cent. Inasmuch as most fishermen avoid fishing for small fish, it is difficult to decide at present whether this regulation would be a sound conservational practice except in such feeding areas as off Barkley sound where small fish are more abundant.

An opening date of June 15 for coho salmon fishing

Considering the outside areas, this regulation probably affects less than 15 per cent by number and 10 per cent by weight of the present production. Because spring salmon fishing is in progress prior to this date any coho salmon caught would have to be released. The releasing mortality appears to be higher for coho salmon (ca. 40% on the basis of experiments conducted in California) and it should be particularly high on small coho caught on large spring hooks. There is also the unknown natural mortality during the summer months. Tag returns indicate that less than 10 per cent of these fish might be recaptured.

To compensate for these losses there is the rapid increase in weight of 100 per cent from June 1 to September 1 which would probably amount to a gain of 50 per cent for those which survive and are recaptured. Because spring salmon gear is not fished in such a manner as to attract small coho salmon, any overall gain in poundage derived from this regulation would be small except in a feeding area such as off Barkley sound.

In the straits of Georgia where "blueback" fishing starts on June 1 and where the coho salmon are small throughout June (many less than 2½ lbs. dressed) a later starting date might well be considered. With little or no spring salmon fishing to interfere there would be no releasing mortality and

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the increase in growth (½ to 1 lb. per month) might overbalance the natural mortality. However the problem of the sport fishery with a daily bag limit of 10 fish per person would also have to be considered in this area.

In conclusion it is evident that before the true conservational value of these two regulations can be decided more data is necessary, especially on the natural ocean mortality of these two species.

J.G. Robertson Appendix No. 26

THE PROBLEM OF THE SEX RATIO IN PACIFIC SALMON

"It appears probable that sex may be influenced sometimes by external factors as well as internal ones, and in this case the preponderance of one sex over the other..... need not be attributed alone to selective disorganization of germ cells, a selective fertilization, or a selective death rate, but might conceivably be controlled to a certain extent by environmental conditions, acting at some particular 'sensitive' period in the ontogeny of the organism in question" -- SHIELL, G.H.

At Port John, British Columbia, this hypothesis is being tested through the period of fry and yearling salmon migrations. It is hoped the study will lead to a clearer understanding of the sex relationship between commercially caught salmon and the escapement.

The following data were taken in the 1950 sex analyses. It is proportioned to the weekly migration at sampling levels of from 0.4 per cent (pinks) to 2.0 per cent (sockeye yearlings).

	Sockeye Yearlings	Coho Yearlings	Sockeye Fry	Coho Fry	Pink Fry	Chum Fry
Number	259	56	44	23	232	212
Per cent male	45.5	52.1	Undifferentiated		52.1	56.1
Per cent female	54.5	47.9	"		47.9	43.9

The difficulty in achieving a sound sex ratio of the incompletely differentiated chum, sockeye and coho fry lead to retention of samples in cages. The results are shown below.

	Port John Bay			Port John Lake		
	Sockeye	Coho	Chum	Sockeye Epilimnion	Sockeye Thermocline	Sockeye Hypolimnion
Number sampled	?	98	174	51	105	200
Per cent male	Lost to storms	55.1	47.7	Starved to death: Partial analysis shows that the gonads did not develop.		
Per cent female		44.9	52.3			

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The variation in age-groups of homing salmon, excepting the pinks, has made the latter worthy of particular attention in the fishery and on the spawning grounds. Samples taken from the commercial catch in 1950 showed the male sex to comprise 91.9 per cent of the gill-net catch and the seiners took 31.2 per cent males. The escapement into Hooknose creek was at the 50 per cent level by September 11.

By the method of chi-squares within the single samples (not shown) a marked fluctuation in the sex distribution of young salmon was noted. Due to the limited number of migrant salmon available for sex analysis and our disinclination to reduce substantially the natural runs of salmon and because of the relative constancy of the environment, the problem is being studied at the hatcheries of the University of British Columbia under the supervision of Dr. W.S. Hoar.

J.G. Hunter Appendix No. 27

TRANSFERENCE OF SOCKEYE FRY TO SALT WATER

A preliminary experiment conducted in the spring of 1949 showed that sockeye fry could readily adjust to salt water.

In the spring of 1950 an effort was made to release half the run of sockeye fry from Port John into the ocean. A total of 15,000 fry was finally released in this manner.

A few of these fry were held in circular screen pens which were located in Port John bay. It was intended that these fish provide some information on the growth made in salt water. Unfortunately rough weather prematurely terminated the experiment.

The following table shows the growth of the sockeye fry held in salt water.

Days in Salt Water	Size in Cm.
0	2.8
26	3.81
53	5.42
61	5.85

The food of these sockeye consisted entirely of those organisms which were carried by the water through the screen of the retaining pen. There is no reason to believe that the fry which were released into the sea did not fare as well, if not better, than those held captive.

A check on the scales of all returning sockeye three and four years hence will be required to ascertain the survival of those which have been liberated into the ocean as fry.

It is hoped that this experiment may be conducted on a larger scale from Lakelse lake in the spring of 1951.

D.R. Foskett — Appendix No. 28

SALMON AGE DETERMINATIONS

During the past year a paper has been prepared on the ages of the sockeye of the Skeena river and adjacent areas during the period 1944 to 1948. In conjunction with Mr. A. Andrekson, paper No. 35 in the series "Contributions to the Life History of the Sockeye Salmon" was prepared.

The advantages of the plastic impression method for scale reading was demonstrated with temporary apparatus in 1949. Consequently a desk with a constant temperature working surface and power-driven rollers was designed and is expected to be completed and in operation before the end of the year.

D.R. Foskett — Appendix No. 29

CHUM SALMON STREAM SURVEY; WEST COAST OF VANCOUVER ISLAND

A two-week survey of chum salmon streams in Barkley and Clayoquot sounds was made in 1949. In all 24 streams were examined, ranging in size from very small creeks to moderately large rivers. Of these, five were considered to be suitable for fencing as test streams though further observation is desirable. It is hoped that the field of observations may be extended this year so that the Station will have a more complete knowledge of conditions on the west coast of the island.

D.R. Foskett — Appendix No. 30

BEAR LAKE SALMON SPAWNING

A trip of one-week duration was made to Bear lake during the latter part of September. Examination of sockeye redds in the streams indicated that a moderately good run had taken place and though no counts could be made it was estimated that from three to four thousand sockeye had spawned. Sockeye redds along the lake shore were extremely well populated in the southern part of the lake but not in the northern part. Spawning in the deep water at that time did not appear to be as far advanced as in other years. However there were large numbers of fresh fish in the river thus indicating that the run was somewhat later than usual. In this connection it may or may not be significant that the lake temperatures were higher than is usual for this time of year.

Spring salmon spawning was considerably more advanced than when observed during the years 1945 to 1948. The actual number of spawners on the redds was estimated at about 7,500 but this did not include dead fish nor fish ripening in the pools and the total run would be much nearer 25,000 as estimated by Inspectors Elliot and Gelley. The former figure is, however, comparable to the estimates for 1945 to 1948 which were of spawning fish on the redds at the beginning of September.

There was no Indian fishery in this area this year.

During the past year analysis of data from work in this area has been proceeding, one paper having been prepared, and another is expected to be completed within the next few months.

A. Andrekson and D.R. Foskett — Appendix No. 31

OBSERVATIONS ON YOUNG SALMON FROM DEPARTURE BAY

During the summer of 1950, 30 small salmon caught in Departure bay by the herring investigation were received and examined in order to determine their species, age and food. The five pink salmon fry examined were caught on July 13 and had fed mostly on terrestrial insects though some crustacean larvae had been eaten by three of the specimens. The four coho which were captured on July 24 had fed wholly on terrestrial insects while the specimen caught on July 28 had eaten herring larvae and crustacean larvae. Six spring salmon had eaten chiefly herring larvae though insect remains were also present in one stomach and crustacean larvae in another. Two other spring salmon had empty stomachs. The larger chum salmon, i.e. between 100 and 200 mm. in length, had eaten herring fry and crustacean larvae while the smaller ones had fed on crustacean larvae and, predominantly, terrestrial insects. The large proportion of terrestrial insects in the stomachs of the pink, coho and chum salmon was unexpected. Identification of the specimens was difficult and could not be accomplished by means of external characteristics.

B.M. Chatwin — Appendix No. 32

PINK AND CHUM SALMON TAGGING IN JOHNSTONE STRAIT, 1950

In order to (1) determine the relative fishing drain on runs of pink and chum salmon migrating down Johnstone strait to the northern areas of the strait of Georgia, (2) ascertain the relative importance of the spawning areas producing the runs, and (3) obtain pertinent data on the seasonal changes, if any, in sizes, ages and sex ratios, a tagging programme was undertaken this autumn commencing approximately September 1.

Two tagging vessels are being used, one operating in the northern part of the Strait (Alert bay area) and the other in the south (Quathiaski area). Although only a relatively small pink salmon run was expected, the pinks showed up in goodly numbers and for the season 1,124 fish were tagged. To October 19, 320 recoveries have been made by fishermen.

The chum fishery is still in full swing (Oct. 19) and tagging will continue. To date, however, 3,071 chum salmon have been tagged and 476 returned.

When the fish move into the streams an effort will be made, in conjunction with the Departmental Inspectors' inspection of each stream, to recover tagged specimens either dead or alive on the spawning grounds.

J.C. Stevenson Appendix No. 33

HERRING INVESTIGATION: GENERAL INTRODUCTION

Herring research is motivated by the realization that the present system of managing the herring fishery is not based on scientifically-proven principles. It seeks to determine whether quota restrictions on catch, of the type which is presently imposed on most British Columbia herring populations, safeguard herring populations from excessive exploitation or whether they may result in wastage of the stocks. If the latter alternative applies, the aim of herring research will be to ascertain whether a modified quota system or a different method of herring management would ensure the maximum utilization of the resource without endangering its perpetuity.

The present long-term investigation is designed to permit the study of the changes occurring in two major British Columbia herring populations subject to contrasting methods of fisheries management. The population of the lower east coast of Vancouver island has an annual catch limit of 40,000 tons imposed upon it, whereas the west coast of Vancouver island population is subject to no major catch restrictions during the fishing season. The investigation also seeks to obtain information on the causes of natural fluctuation in abundance, the general relationship between size of spawning stock and resultant year-class strength, and methods by means of which changes in year-class strength and in population abundance can be detected and measured. As a better understanding of these problems is achieved it is expected that knowledge pertaining to prediction of recruitment and time of inshore migration might be gained which would have a valuable practical bearing on efficient utilization of the fishery.

Research methods used to carry out the investigation include collection of catch statistics, tagging and tag recovery, sampling of the catches and of the spawning runs, and estimations of the spawn depositions. In addition, research is being undertaken on the different stages in the early life history of the herring. These studies involve investigations on the mortality of spawn, and on the distribution, abundance, and survival of larval and juvenile herring.

Although most of the efforts of the herring investigation are devoted to studies of the west-coast and lower east-coast populations, certain studies are being carried on in the other major herring populations. Catch-statistics data are collected each season, and the sampling of the catches is continued. Surveys to determine the amount of spawn deposited are carried out each spring by fishery officers in the northern as well as the southern sub-districts of the province, and the data are submitted and analysed. In the spring of 1950 the tagging programme was extended to the central and northern areas of the British Columbia coast, and along with the tagging programme the spawning runs were sampled. These studies on herring populations not involved in the present major studies are of value in answering requests for information relative to quota extensions and to other similar matters. They also provide data which will be essential when the results of the present studies on the west coast and lower east coast can be applied to the other herring populations.

In 1949-50, the fourth season of the comparative study outlined above, the objects of herring research were actively pursued. The results of the studies are reported in the following Appendices, and summarized in the final Appendix on herring.

J.C. Stevenson

A year's activity for the herring investigation extends from September to August. In September final plans are laid for carrying out studies on the fishery. In late September or early October the fishery begins and continues usually until early March. During this period tag recovery and sampling of the fishery occupies most of the attention of staff members. Tagging begins in mid-February and is completed by early April. Spawn studies are carried on during the tagging period. In April and May larval studies are undertaken, and juvenile herring studies take place in the summer months. Some compilation and analysis of data take place all winter but it is not until early April when most of the staff has returned to the Station from field operations that any major effort can be directed to the detailed study of the data collected during the winter and spring. Most of the analysis of the data is completed by August, and the planning of the next season's investigation begins.

A total of 15 persons was employed in the herring investigation, as of September 1, 1950. The staff members are listed and their major responsibilities and duties are indicated, as follows:

Scientific staff		
A.S. Hourston	(Assistant Biologist)	Juvenile studies; larval studies.
K.J. Jackson	(Junior Biologist)	Studies on bird predation upon spawn.
J.A. Lanigan	(Junior Biologist)	Tag recovery; study of spawn extent on the west coast of Vancouver island.
Anne Lazareff	(Junior Biologist)	Age determinations; sampling.
D.N. Outram	(Junior Biologist)	Assisting in larval and juvenile studies; on leave of absence from September, 1949 to May, 1950.
J.C. Stevenson	(Associate Biologist)	In charge of herring studies.
Technician staff		
R.R. Gardner	(Technician Gr. 1)	Tag detector operator; larval studies.
K.A. Herlinveaux	(Assistant Technician Gr. 2)	Tagging operations; tag detector operator; equipment maintenance.
R.S. Isaacson	(Assistant Technician Gr. 3)	Catch statistics; sampling; age determinations.
J.H. Larkman	(Assistant Technician Gr. 3)	Maintenance of tag detectors; tagging operations.
D.H. MacDermott	(Assistant Technician Gr. 2)	Field and laboratory assistant (from March 1, 1950.)
A.G. Paul	(Technician Gr. 2)	Tagging operations; tag detector operator; maintenance of equipment.
J.A. Saker	(Assistant Technician Gr. 2)	Field and laboratory assistant.
B. Wildman	(Assistant Technician Gr. 2)	Field and laboratory assistant.

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Stenographic staff

Alice Nyquist	(Stenographer Gr. 1)	Stenographic and clerical duties (replaced Hazel Cox on June 6)

In addition, various part-time assistants were engaged in herring studies for periods extending from one to three months. They included J. Paul, O. Perrin, and K. Sutherland, who assisted in various phases of the field work during the spring months, N. Yates who aided in field and laboratory work connected with the larval studies, and Joan Ranger and Betty-Lou Geernaert who were employed in laboratory analysis of larval data.

R.S. Isaacson

Appendix No. 34

CATCH STATISTICS OF THE 1949-50 HERRING FISHERY

As in past seasons the data obtained from Pilot House Records and Daily Landing Forms form the basis of this report. Pilot House Records are completed by the captain of each herring seiner and provide information on the date, location, and tonnage of all his catches, as well as a record of the number of days his boat was fishing or scouting for fish. From these data "fishing effort" and "availability" are calculated. The Daily Landing Forms are completed by all plants processing herring and record accurate tonnages of each delivery, together with the date and locality of the catch, and method of processing.

A total of 183,200 tons of herring was taken from the coastal waters of British Columbia during the 1949-50 season. This is a decrease of only 6,000 tons from the record catch of the previous season, and the second largest in the history of the fishery. The distribution of the catch by sub-districts is given in the following tabulation:

Sub-district	Catch		Availability
	Tons	Per Cent	Tons/Seine/Day
Queen Charlotte islands	---	---	---
Northern	40,300	22.0	188.9
Central	41,500	22.7	93.0
Upper east coast of Vancouver island	9,000	4.9	42.4
Middle east coast of Vancouver island	14,800	8.1	159.0
Lower east coast of Vancouver island	40,300	22.0	98.4
West coast of Vancouver is.	37,300	20.4	47.2

Compared to the previous season the availability in the middle and lower east coast declined slightly, but a decrease to almost half that of the previous season occurred in the west-coast sub-district. In the latter instance a lack of any large-scale fishery in Esperanza inlet (good catch with a high availability in the previous season) could be considered

as a cause for this decrease. Increases in availability were shown in all the other sub-districts, particularly in the upper east coast.

Sub-district quotas were unchanged from those in force during the previous season--the west-coast sub-district continued to be free of quota restrictions for scientific study. The quotas were obtained in all but the upper east-coast sub-district, and the catch there was only a thousand tons short of the quota. Quota extensions of 5,000 tons to the middle east-coast sub-district, and 10,000 tons to the northern sub-district were easily attained.

No herring fishery took place in the Queen Charlotte islands sub-district again this season. One boat recorded spending a few days during July scouting for herring in Skidegate inlet (Area 2A) but no catches were obtained.

For the third season in succession the only fishery in the northern sub-district took place in the waters surrounding Porcher island (on the boundary between Areas 4 and 5). The boats entered the sub-district about the end of January following a period of cold weather which had kept them tied up for ten days. A large concentration of herring in Edye passage (Area 4) provided excellent fishing and by February 7 the 30,000-ton sub-district quota had been obtained. At the request of the industry a survey was made to determine whether a sufficient quantity of herring was still present on these grounds to permit the granting of an extension to the quota. This survey was conducted by Mr. J.C. Stevenson of the Pacific Biological Station using the Department of Fisheries patrol boat "Sooke Post". Large concentrations of herring were observed in Malacca passage and in Butler cove (both in Area 4). As a result of these findings it was recommended that a 10,000-ton extension to the quota be allowed. On February 15 this extension was granted and within two days 8,000 tons had been taken, all from Butler cove. However, the intense fishing appeared to scatter the fish and it required a week to catch the remaining 2,000 tons, 900 of which were taken from Ogden channel (Area 5). During the peak of the fishery in this sub-district the daily catch was limited to the capacity of the packing boats.

In the central sub-district, three boats were engaged in summer herring fishing during July at Klemtu passage (Area 6) and Bella Bella (Area 7). Only 26 tons of the catch were recorded in "Pilot House Records". However, records received from the Namu reduction plant which processed the fish, place the total catch at 829 tons. The pre-Christmas winter fishery in this sub-district totalled about 1,500 tons. Records indicate that this entire catch was obtained by one boat which fished throughout November and early December in Moses inlet (Area 9), taking approximately 1,000 tons, then moved to Kwakshua passage (Area 7) just previous to the Christmas closure. Immediately following the Christmas closure period a few excellent catches were obtained in Kwakshua passage, but within a few days the fish became very scarce and the boats moved to the more productive grounds at Surf, Racey and Helmcken inlets (Area 6). The fishing which developed in this area continued with a high level of abundance until the sub-district quota was obtained. Extremely cold weather during January together with a lack of packing boats served, to a large extent, to limit the catch.

The catch in the upper east-coast sub-district showed a marked improvement over the record low of the previous season, and was in fact the largest catch in this sub-district since the 1940-41 season. Following the completion of the quotas in the middle and lower east-coast sub-districts,

many of the boats entered the upper east-coast sub-district. Although no large concentrations of fish were found, good catches were obtained during the second and third weeks of November in the vicinity of Bones bay and Clio channel (Area 12). However, reports of excellent fishing in Barkley sound (Area 23) soon attracted most of the boats and thus virtually terminated the upper east-coast fishery. A few seine boats returned to Area 12 just previous to the Christmas closure but they were unable to locate any large body of herring. No fishing took place after Christmas in this sub-district.

The fishery in the middle east-coast sub-district was similar to that of the previous season--abundant and at times spectacular. The boats started fishing in Deepwater bay (Area 13) but after two weeks of mediocre catches, left the area and headed for Baynes sound (Area 14A). The fishery in Baynes sound lasted only two days by which time the sub-district quota had been taken. The catch during this short fishery was definitely limited to the capacity of the packers, and plants. Following the completion of a survey of the quantity of herring present on these fishing grounds it was decided to reopen this sub-district on November 27 with a quota extension of 4,000 tons (making the total quota for the sub-district 15,000 tons). Although by this time most of the fleet was operating in the west-coast sub-district, a few boats did return to fish for this extension and by the Christmas closure it had been fulfilled--almost entirely from Baynes sound (Area 14A).

The first herring catch of this season was obtained on October 20 at Nanoose bay (Area 14B) in the lower east-coast sub-district. After three weeks of intensive fishing, highlighted by excellent daily catches which were in many cases limited to the capacity of the packers and plants, the sub-district quota was completed. As in the previous season the Nanoose bay area produced about three-fifths of the total sub-district catch; the balance was taken from Trincomali channel (Area 17). For the second season in succession no large-scale fishing took place in the usually productive grounds at Swanson and Satellite channels (Area 18). As in the previous season this was probably due to the boats commencing fishing about two weeks later than usual, thus allowing the incoming fish to pass through these grounds into Areas 17 and 14B.

On November 14 seven seine boats entered Barkley sound (Area 23) in the west-coast sub-district and on that day caught 1,475 tons of herring off Swale rocks. This was the start of a period of excellent fishing in this area which lasted until the Christmas closure. During this period approximately 1,200 tons were caught in Sydney inlet (Area 24), but no catches were obtained from Areas 25, 26, or 27. When the boats resumed fishing after the Christmas closure they were unable to locate any worthwhile stock of herring in Barkley sound and moved to Esperanza inlet (Area 25) where moderately good fishing prevailed for a few days. On January 8, good fishing was reported in Ououkinsh and Nasparti inlets (Area 26). The boats headed for this area and excellent catches were obtained until January 13 when they were forced to tie up due to the extremely cold weather. When fishing was resumed on January 19 the body of fish appeared to have broken up into numerous small schools and the availability declined sharply, hence the boats left the sub-district and travelled to the northern and central sub-districts where good fishing was reported.

J.A. Lanigan Appendix No. 35

HERRING TAG RECOVERY FOR 1949-50

During the 1949-50 season a total of 1,133 herring tags was recovered by tag detectors and magnets. This number is considerably less than the 3,170 tag recoveries in 1948-49, and the 2,224 tag recoveries in 1947-48. The small number this year could have resulted from (a) the reduced catch on the west coast of Vancouver island and, (b) the reduction in the number of fish tagged on the west coast in 1949, (21,856 fish were tagged in 1949 as compared with 31,947 tagged in 1948).

Tag detector recovery

Four tag detectors were operated during most of the 1949-50 season. One of them, (old-type) was located at the Imperial plant and the other (new-type), operated at the Gulf of Georgia plant; each machine gave a better performance than in the previous year. The increased efficiency of the Gulf of Georgia detector appears to have resulted from various improvements made to the plant installation. On the other hand, the Imperial detector installation gave a better performance in spite of difficulties arising from changes made in the plant to accommodate a new weighing machine. In regard to the remaining two detectors, one was located at Nootka (new-type), and the other was installed at Kildonan (old-type). The Nootka set gave poor results for the fourth successive year. There was evidence that the detector itself performed more efficiently than in previous years, but various factors relating to the general installation continued to hamper operations. The exposed nature of the unloading system caused many of the workable parts of the detector to freeze in the cold weather, and the location of the marine-leg in relation to the chute prevented operation during certain stages of the tide. The Kildonan set was a reconditioned "old-type" detector and was operated for a short period to test its usability. Further improvements were added to the machine during the summer of 1950 and it is expected to give a good performance during the 1950-51 season. This year the detectors recovered 137 tags, as compared with 230 the previous year which represents a reduction of 40 per cent in recovery. The reasons for this low recovery are stated above. Of the 137 tags recovered, 66 were recovered by Imperial, 65 by Gulf of Georgia, 4 by Nootka and 2 by Kildonan installations. Of these recoveries, 88 were from catches made on the west coast, 48 from the lower and middle east coasts, and 1 from the upper east coast. When the percentage of the catch searched for tags by the detectors, and the efficiency of the tag detectors is known (discussed in a later Appendix), the probable number of tags in a catch may be calculated. The following tabulation gives the probable numbers of tags (computed from the actual numbers in parentheses) in the lower and middle east coasts and the west coast of Vancouver island.

	Area of Recovery.			
Area of Tagging	West Coast	Lower East Coast	Middle East Coast	Totals
West coast	747 (86)	92 (17)	7 (1)	846 (104)
Lower east coast	18 (2)	90 (18)	31 (6)	139 (26)
Middle east coast	---	15 (3)	25 (3)	40 (6)
Totals	765 (88)	197 (38)	63 (10)	1,025 (136)

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As in past years it was noted that most of the tags from the west-coast and lower east-coast taggings were recovered in the sub-districts in which they were originally used. This "homing tendency" was again found to be considerably more pronounced on the west coast where 88 per cent (747/846) of the tags were recovered in the general region of tagging, than on the lower east coast, where only 65 per cent (90/139) of the tags showed no movement outside the tagging areas.

The data suggest that movement of west-coast fish to the lower east coast was greater than in the two previous years. About 10.9 per cent (92/846) of the recoveries from west-coast taggings were taken in the lower east-coast catches, as compared with 3.3 per cent in 1948-49 and 5.8 per cent in 1947-48.

The immigration of lower east-coast fish into the west-coast sub-district was calculated at 12.9 per cent, (18/139). This was much greater than that estimated from 1947-48 data (2.9 per cent). In 1948-49 a tremendously large movement of lower east-coast fish to the west coast was calculated (30 per cent), but since the calculation was based on the recovery of only one tag it was not considered that the value was a good estimate of the extent of migration (Stevenson, 1950).

At the present time no explanation can be offered for the apparent large immigration and emigration of fish to and from the west coast during the past season.

In order to consider the mixture of fish between the different west-coast areas, the probable numbers of west-coast tags from the 1948 taggings (12-series) and from the 1949 taggings (13-series) are presented in the following table.

Area of Tagging	Area of Recovery--12 series					Area of Recovery--13 series				
	23	24	25	26	All Areas	23	24	25	26	All Areas
23	84	--	--	--	84	256	--	16	--	272
24	50	--	--	--	50	19	3	--	--	22
25	14	--	--	--	14	57	--	107	--	164
Totals	148	--	--	--	148	332	3	123	--	458

A considerably larger percentage of fish moved in a south-easterly direction along the west coast than in a north-westerly direction, according to the data pertaining to the 13-series. Area-23 tags were recovered in Area 25 to the extent of 5.9 per cent (16/272) whereas 34.8 per cent (57/164) of the Area 25 tags were returned from Area-23 catches. The relatively small north-easterly movement could be caused by a considerable proportion of the Area-25 herring not being subjected to a fishery. The only season in which the data have indicated a greater movement of fish in a north-westerly direction along the coast was 1948-49. It appears that this apparent reversal of the direction of the general movement might have been related to the extremely large catch in Area 25 in that season.

The large percentage of Area-24 tags taken in the Area-23 fishery is further evidence of the close relationship between the fish of Area 23 and 24. Data from previous years also indicated that more Area-24 fish moved to Area 23 than to Area 25.

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Magnet returns

This year 996 decipherable tags were recovered by plant crews from the magnets and machinery of the 13 reduction plants. The total represents a decrease of 66 per cent from that of the previous year. Reasons to account for this reduction in recovery from plants are similar to those given previously.

The following is a summarized table of the tags recovered during the 1949-50 season.

	Area of Recovery			
Area of Tagging	West-Coast Sub-district	Other Sub-districts	Indeterminate Sub-district	Totals
West-coast sub-districts	677 (2,116)	101 (94)	95 (500)	873 (2,710)
Other sub-districts	14 (15)	88 (153)	21 (62)	123 (230)
Totals	701 (2,131)	189 (247)	116 (562)	996 (2,940)

From the above table it can be shown that 13.0 per cent (101/778) west-coast fish moved to other sub-districts. Also that the migration to the lower and middle east coasts comprised most of this emigration from the west coast. On the basis of the 1949-50 data it appeared that about 12 per cent of the recoveries of fish tagged on the west coast were from lower east-coast or middle east-coast catches. Since tag-detector recovery has consistently suggested that there is very little or no movement of west-coast fish to the middle east coast the 12 per cent movement probably approximates the migration of west-coast fish to the lower east coast. The estimated movement of herring from the west coast to the lower east coast is considerably higher than those obtained in the previous year's data; similarily, the immigration of lower east-coast and middle east-coast tagged fish was also higher this year, 13.7 per cent as compared to 8.9 per cent in 1948-49. The origin of the 14 "outside" tags taken from west-coast catches shows that about 11 per cent of the fish tagged in "outside" areas were lower east-coast fish that were taken in west-coast catches, and about 3 per cent of the fish tagged in "outside" areas were middle east-coast fish from west-coast catches. It will also be noted from the table that 116 (12 per cent) tags were classed as indeterminate--tags with insufficient data to ascertain the general area of recovery.

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Appendix No 36

SOME POPULATION STATISTICS DERIVED FROM TAG RECOVERY

From tag-recovery data of the past three years (1947-48, 1948-49, and 1949-50), certain statistics relating to changes in exploitation and initial abundance have been calculated for the herring population of the west coast of Vancouver island, using formulae given in papers by Dr. W.E. Ricker. In these calculations it has been considered that the herring fishery conformed most closely to Ricker's type 1A fishery, where fishing mortality is

proportional to population present at any time during the fishing season and where recruitment and natural mortality are negligible. The applicability of all the various statistics which may be derived in this manner is restricted by limitations of the basic data and by known and possible deviations of the herring fishery from the theoretical type. However, in spite of these limitations certain population statistics pertaining to the west-coast fishery in recent years have shown general agreement with data obtained from age-composition and spawning-ground studies. It is considered that continuance of this phase of the research is valuable in enabling eventually a more complete assessment to be made of the significance of these statistics in herring studies.

Although actual rate of exploitation cannot be determined directly from herring tag recovery, it is possible to calculate the ratio of the exploitation rates in two successive seasons. Assuming that the tags are randomly distributed throughout the fishable population, the ratio of the probable percentage of first-year tags in the catches of two consecutive years should approximate the ratio of the exploitation rates in the same two seasons. Changes in the rate of exploitation and in fishing effort during the past two years are given in the following tabulation (for a discussion on the changes taking place from 1947-48 to 1948-49, refer to Appendix No. 78 of the 1949 Annual Report):

Period	Ratio of Exploitation Rates	Rates of Fishing Effort
1947-48 to 1948-49	0.85	0.72
1948-49 to 1949-50	0.33	1.15

The tremendous decrease in the rate of exploitation in 1949-50 is in contrast to the slight decrease noted from 1947-48 to 1948-49. Also it is noteworthy that whereas the decrease in rate of exploitation in the earlier period (0.85) was accompanied by a decrease in fishing effort (0.72), the greater decrease in rate of exploitation in 1949-50 (0.33) was associated with an increase in fishing effort. This presents an anomalous situation since Ricker's formula relating fishing effort to rate of exploitation implies that when fishing effort increases from one season to the next the rate of exploitation must also increase (although not necessarily proportionately), and that likewise when fishing effort decreases the exploitation rate will decrease.

There are various factors which may have caused the apparently aberrant statistics. The inadequacy of the basic data and the scope of the assumptions made in analysis may be partly responsible. However, it is suggested that abnormal conditions affecting a part of the population in 1949-50 might have constituted a more important factor. Evidence from age-composition and spawn studies indicated that only a small portion of the more northerly west-coast herring was fished in 1949-50. It was considered that certain unknown oceanographic factors might have prevented part of the population from coming inshore during the fishing season. If this were so, it would be expected that the catch would contain a relatively small number of tags, which in turn would result in a relatively small rate of exploitation in 1949-50. Since the conditions of the hypothetical fishery type require the whole adult population to be available to the fishery, any factors precluding this would be liable to influence the relationship existing between the various statistics.

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The initial population abundance in 1949-50 was estimated to be 2.08 times as great as that in 1948-49, according to Ricker's formula involving the relationship between rate of exploitation, catch, and initial population abundance. Although the numerical value of the estimate is questionable in view of the numerous assumptions involved in the calculations, it appears that the estimate is indicative of an increase in population size. Relatively great recruitment of the 1947 year-class appears to have caused the increased abundance.

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Appendix No. 37

EFFICIENCY TESTS ON MAGNETS IN REDUCTION PLANTS

The efficiency of magnet recovery of herring tags from the meal lines of the reduction plants varies from year to year. To maintain a close check on the efficiencies of these magnets, so-called "magnet efficiency tests" are conducted every season. These tests also give information on the time taken for tags to pass along the plant meal line (time-lag) which permits more accurate placing of the tags in their respective area of recovery. In determining the efficiency and time-lag certain human factors are involved: the diligence of the plant crew in keeping the magnets clear of scrap metal and the care taken by the crews in keeping the recoveries for each day separate from those of the preceding or following days.

During the 1949-50 season the four plants at Steveston, B.C., and four of the six plants on the west coast were visited at least once. The value of making at least two tests a year is recognized, but again, due to transportation difficulties, this year it was possible to visit some of the plants only once. In each test about 50 test tags were placed in fish and these tagged fish were scattered at random throughout the fish bins. The test tags were recovered from the magnets and plant machinery by the plant crews. A reward of 25 cents is paid for a test tag as compared with 50 cents for a bona fide tag.

As in the previous years it was again noted that there was a considerable variation both in the percentage of recovery and time-lag among the plants, although the average plant efficiency was found to be similar in the past two seasons. Two of the four west-coast plants showed an increase in efficiency over that of last year while the other two showed a slight decrease. Of the four plants at Steveston, two showed an increase in efficiency and one showed a decrease. The sharp decrease recorded for that plant was the result of only one magnet being used this year as compared with two in the previous season. The fourth plant, tested for the first time, failed to recover enough tags to give it an efficiency rating. This was due mainly to the plant crew's lack of interest in collecting the tags from the magnets and machinery and the failure to assign a date of recovery to the few tags that they did collect.

As before, most of the tags were recovered during the first five days after the tests were made. A few tags did not appear on the magnets or in the plant machinery until near the end of the season. At the beginning of the season, four tags were recovered from tests made during the previous year as compared with eight in 1948-49. This small number could be attributed to the careful attention of the plant crews not to miss any tags in the plant machinery

when the general overhaul takes place at the end of the season.

The same types of magnets were used again this year, viz; the electromagnet and Bepco permanent magnet, both types having proven efficient for tag recovery.

A summary of tests with a comparison of percentage plant efficiency in 1948-49, in parentheses, and 1949-50, are represented in the following table.

Plants	Numbers of Tests	Average Percentage Recovery
	West Coast Plants	
Kildonan	1 (2)	92.0 (84.0)
Ecoole	1 (1)	98.0 (90.0)
Port Albion	2 (1)	93.0 (98.0)
Nootka	2 (1)	68.0 (77.6)
	Average of west coast plants.	87.8 (87.4)
	Steveston Plants	
Imperial	2 (1)	79.6 (68.0)
Gulf of Georgia	2 (2)	58.2 (99.0)
Nelson Bros.	2 (1)	74.0 (68.0)
	Average of Steveston plants.	70.6 (78.3)
	Grand average	80.4 (83.5)

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HERRING TAGGING DURING THE SPRING OF 1950

In general the methods of obtaining and tagging herring were the same as those used in previous years with the exception of the additional use of a large commercial-type purse seine, 180 fathoms long and 12 fathoms deep. This may be compared to the smaller seines which were approximately 60 fathoms long and 6 fathoms deep and which were used exclusively for catching the fish in previous years. The experience gained this season with the larger seine suggests that the herring could be caught more readily and in better condition in deeper water than was possible with the smaller seines, but it will be necessary to test the net for another season before conclusions can be drawn on its efficiency. Three seine boats loaned by the fishing industry were used during the tagging programme and were as follows: the "Mina H.", which operated on the middle and lower east coasts between February 19 and March 28; the "Western Commander" which operated on the west

coast of Vancouver island from March 1 to March 24 and in the northern and central sub-districts for a period between March 24 and April 19; and the "Pacific Queen" which operated on the west coast of Vancouver island from March 2 to March 28 then in the northern and central sub-districts between March 27 and April 10.

In all a total of 56,435 herring was tagged in 1950. The number of tags is considerably greater than the previous year when 34,874 tags were used. This greater total is attributed to the fact that the tagging programme was expanded to include the northern and central sub-districts this year. There was an increased tagging in each of the other sub-districts.

The following is a list of the taggings made during the 1950 spawning season:

Sub-districts	Area	Place	No. Used
Northern sub-district of the coast of British Columbia.	5	Willis bay	2,548
North-central sub-district of the coast of British Columbia.	6	Parsons anchorage	3,061
	6	Thistle pass	2,512
	6	Wilby point	1,005
South-central sub-district of the coast of British Columbia.	7	Kilditdt sound	2,362
	7	Sabiston island	2,042
	10	Takush harbour	1,012
Middle east coast of Vancouver island.	14A	Lambert channel	2,019
	15	Ragged island	2,027
	15	Ragged island	2,019
Lower east coast of Vancouver island.	14B	Departure bay	2,030
	14B	Departure bay	2,018
	14B	Newcastle island	2,042
	17	Kulleet bay	1,064
	17	Dunsmuir islands	2,018
West coast of Vancouver island.	23	Toquart bay	1,994
	23	Snowden island	2,016
	23	St. Ines island	2,003
	23	St. Ines island	2,012
	24	Cypress bay	2,011
	25	Nootka plant	505
	25	Nootka plant	1,511
	25	Kendrick inlet	2,015
	25	Kendrick inlet	1,017
	25	Queen cove	2,543
	25	Port Eliza	2,490
	26	Rugged point	2,019
	26	Ououkinsh inlet	2,491
	27	Winter harbour	2,029
		Total----------	56,435

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A summary of the foregoing table is as follows, with comparative data for 1949:

1950		1949	
Area	No. Used	Area	No. Used
14A	2,019	14A	2,531
15	4,046	15	2,984
14B	6,090	14B	2,013
17	3,082	17	1,996
18	---	18	3,494
23	8,025	23	7,650
24	2,011	24	3,036
25	10,081	25	11,170
26	4,510	26	---
27	2,029	27	---

It is shown by the second table that more fish were tagged on the west coast in 1950 and that fish were tagged in all five west-coast areas as compared tc only three west-coast areas in 1949. Also the tagging on the lower east coast was increased this year due mainly to the large quantity of herring in Area 14B, Departure bay, during the spawning season.

The tags used during the 1950 spawning season along with those of previous years will be liable for recovery during the 1950-51 fishing season.

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Appendix No. 39

THE SAMPLING OF HERRING IN 1949-50

The herring sampling programme is designed primarily to investigate fluctuations in the abundance of successive year-classes and to study their influence on catch. In addition data are obtained on growth, sex ratio, and development.

A total of 310 samples consisting of 30,369 fish was taken in the 1949-50 season, as compared with 291 samples in the previous season. Samples from spawning runs, included in the above totals, comprised 26 and 20 samples, respectively, in the two years.

A comparison of the number of samples taken from each of the sub-districts in 1948-49 and 1949-50 is given below, along with the comparative intensity of the sampling of the catches (number of tons caught for each fishing sample taken):

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Sub-district	1948-49 No. of Samples Taken Fishing	Spawning	No. of Tons Caught Per Fishing Sample	1949-50 No. of Samples Taken Fishing	Spawning	No. of Tons Caught Per Fishing Sample
Queen Charlotte islands	--	--	--	--	2	--
Northern	34	--	524	41	1	983
Central	101	--	601	64	5	648
Upper east coast	13	--	115	12	--	750
Middle east coast	29	2	486	32	3	462
Lower east coast	31	3	1,294	52	5	775
West coast	63	15	873	81	12	460
	271	20	698	282	28	650

It will be noted that the average intensity of sampling was similar in the two years. In 1949-50 the sampling was more intensive in the west-coast and the lower east-coast fisheries than in the previous year. The relatively large catches in the upper east-coast and northern sub-districts caused a decline in sampling intensity in the past season. Large catches taken over a short period of time frequently tax the efforts of the available staff members. This was particularly the case in the lower east-coast fishery in 1948-49 and the northern fishery in 1949-50.

A more detailed distribution of the samples is given in the following tabulation (number of fish in brackets):

Herring Samples Taken During The 1949-50 Season

Sub-district and Areas		Fishing Samples		Spawning Samples	
Queen Charlotte islands sub-district		--	(--)	2	(89)
Area 2A	Skidegate inlet	--	(--)	2	(89)
Northern sub-district		41	(4,038)	1	(100)
Area 4	Edye pass	27	(2,661)	--	(--)
	Ogden channel	1	(100)	--	(--)
	Butlers cove	12	(1,197)	--	(--)
	White cliff	1	(80)	--	(--)
Area 5	Willis bay	1	(100)	1	(100)

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Herring Samples Taken During the 1949-50 Season (Cont'd)

Central sub-district		64	(6,281)	5	(500)
Area 6	Surf inlet	15	(1,458)	--	(--)
	Meyers pass	5	(476)	--	(--)
	Klemtu	1	(100)	--	(--)
	Gardner canal	2	(200)	--	(--)
	Helmcken inlet	3	(292)	--	(--)
	Racey inlet	2	(170)	--	(--)
	Thistle pass	3	(285)	1	(100)
	Laredo inlet	1	(100)	--	(--)
	Parsons anchorage	--	(--)	1	(100)
Area 7	Kwakshua pass	17	(1,700)	--	(--)
	Kilditd sound	7	(700)	--	(--)
	Boddy pass	1	(100)	--	(--)
	Cultus sound	2	(200)	--	(--)
	Bryden channel	--	(--)	1	(100)
	Troup pass	--	(--)	1	(100)
Area 9	Moses inlet	4	(400)	--	(--)
	Drainey inlet	1	(100)	--	(--)
Area 10	Fly basin	--	(--)	1	(100)
Upper east coast of V.I. sub-district		12	(1,160)	--	(--)
Area 12	Bones bay	12	(1,160)	--	(--)
Middle east coast of V.I. sub-district		32	(3,194)	3	(300)
Area 13	Deepwater bay	8	(800)	--	(--)
Area 14A	Hornby island	2	(200)	--	(--)
	Lambert channel	22	(2,194)	1	(100)
Area 15	Ragged islands	--	(--)	2	(200)
Lower east coast of V.I. sub-district		52	(5,120)	5	(500)
Area 14B	Nanoose bay	32	(3,121)	--	(--)
	Dodds narrows	4	(400)	--	(--)
	Northumberland channel	1	(100)	--	(--)
	Departure bay	--	(--)	3	(300)
Area 17	Trincomali channel	14	(1,399)	--	(--)
	Walker rock	1	(100)	--	(--)
	Kulleet bay	--	(--)	1	(100)
	Ladysmith harbour	--	(--)	1	(100)
West coast of V.I. sub-district		81	(7,887)	12	(1,200)
Area 23	Effingham inlet	19	(1,900)	--	(--)
	Barkley sound	32	(3,061)	--	(--)
	Peacock channel	1	(93)	--	(--)
	Middle channel	5	(491)	--	(--)
	Mayne bay	4	(393)	--	(--)
	Sechart channel	2	(200)	--	(--)
	David channel	1	(100)	--	(--)
	Uchucklesit inlet	1	(100)	--	(--)

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Herring Samples Taken During the 1949-50 Season (Cont'd)

Area 23	Toquart bay	--	(--)	2	(200)
(cont'd)	St. Ines island	--	(--)	2	(200)
Area 24	Sydney inlet	2	(150)	--	(--)
	Cypress bay	--	(--)	1	(100)
Area 25	Queen cove	2	(200)	1	(100)
	Espinosa inlet	2	(200)	--	(--)
	Kendrick inlet	--	(--)	1	(100)
	Nootka harbour	--	(--)	1	(100)
	Port Eliza	--	(--)	1	(100)
Area 26	Kyuquot sound	2	(200)	--	(--)
	Ououkinsh inlet	8	(799)	1	(100)
	Union island	--	(--)	1	(100)
Area 27	Winter harbour	--	(--)	1	(100)
		282	(27,680)	28	(2,689)

Tag-detector operators at Steveston, Kildonan, and Nootka were largely responsible for the collection of samples from the catches in the southern sub-districts. Arrangements were again made with plant personnel at Namu, Butedale, Prince Rupert, and Steveston to collect and freeze samples from catches made in the northern and central sub-districts. The contact man of the otter trawl investigation, W.G. St.Clair, aided in the sampling programme by freezing samples from the northern and central fisheries. One dollar per sample was paid to plant personnel who collected samples and arranged for their shipment, at a later date, to the Biological Station.

Miss Lazareff and Mr. Isaacson were responsible for making age determination on the scales and for supervising the compilation of the data. Several members of the herring investigation assisted in the compilation.

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Appendix No. 40

AGE AND GROWTH OF HERRING ON THE WEST COAST OF VANCOUVER ISLAND, 1949-50

In the 1949-50 season herring fishing took place in all west-coast areas except Area 27 (Quatsino sound). Although Area 23 (Barkley sound) produced the largest catch ever taken from the area, the total catch for the sub-district was less than in any year since quota restrictions were removed from the west-coast catch. The greatly reduced fishery in Area 25 (Nootka sound and Esperanza inlet) was the chief cause of the poorer total catch.

The average age composition of the west-coast fishery as a whole (weighted to numbers of fish caught in each individual area) is given for recent years in the following tabulation along with the average age composition of the area catches for the 1949-50 season:

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	I	II	III	IV	V	VI	VII	VIII	IX
1945-46	-	11.1	74.0	10.0	2.8	0.9	1.0	0.2	-
1946-47	-	5.0	53.0	32.1	6.0	2.5	0.9	0.5	0.1
1947-48	-	2.4	58.2	27.8	8.5	2.1	0.5	0.3	0.1
1948-49	-	7.4	45.2	32.9	9.6	3.4	1.0	0.3	0.1
1949-50	+	4.4	68.8	20.5	5.3	0.8	0.2	0.1	-
Area 23--1949-50	0.1	4.6	67.3	21.6	5.5	0.7	0.2	0.1	-
Area 24--1949-50	-	3.9	74.1	18.9	3.0	-	-	-	-
Area 25--1949-50	-	2.9	72.9	18.0	5.2	1.0	-	-	-
Area 26--1949-50	-	5.1	77.7	11.8	3.3	1.9	0.2	0.1	-

The 1947 year-class constituted over two-thirds of the west-coast catch in 1949-50 as III-year fish. This was the largest dominance of III-year fish in the west-coast fishery since the extremely large entry of the 1943 year-class in the 1945-46 season. Forewarning of the relative abundance of the 1947 year-class was given by its relatively high contribution as II-year fish in the 1948-49 fishery and in the 1949 spawning runs. In spite of the reduced west-coast catch in 1949-50 compared to that of the previous year, the 1947 year-class produced 233.7 million III-year fish in the 1949-50 fishery, as compared to 224.0 million III-year fish by the 1946 year-class in 1948-49.

Fish of Age IV and older were more poorly represented in the 1949-50 catch than in the catch of the previous year. This was largely a result of the strong recruitment of the 1947 year-class and the relative weakness of the 1946 year-class. The reduction in abundance of older fish might also be partly caused by four years of intensive fishing not subject to quota restriction.

The relatively large proportion of III-year fish in the 1949-50 west-coast fishery was reflected in each of the area catches, and in the samples from the spawning runs of all areas except Area 27. But whereas Area 23 yielded a record fishery a very poor catch was taken from Area 25, the other major west-coast fishing area. In view of the near average spawning which occurred in both areas in the spring of 1950, it appears that the lack of fish on the Area-25 fishing grounds was not caused by any drastic decrease in population abundance in the northern west-coast areas. This suggests that a considerable proportion of the adult stocks did not move inshore during the fishing season.

There is some evidence indicating that low water temperatures in January might be a factor in preventing herring schools from moving inshore. However, assuming that this accounts for the scarcity of fish in all west-coast areas in January, the lack of a fishery in Area 25 in the pre-Christmas period is not explained.

It is noteworthy that very similar conditions prevailed in the fishery during the 1945-46 season. As mentioned previously a strong year-class (that of 1943) entered the fishing runs as III-year fish. A large catch was taken from Area 23, Area 25 provided a small fishery, and the amount of fish left to spawn was not greatly different from that of 1950. The only obvious dissimilarity between the conditions of the two seasons was that in 1945-46, fishing was stopped on the completion of the quota, whereas quota regulations were not in force in 1949-50. However, the data indicated that fish were

not as abundant in Area 25 in 1945-46 as in the three subsequent years, and it is doubtful if removal of the quota limitations would have greatly increased the Area-25 catch.

In the season following 1945-46 the 1943 year-class (as IV-year fish) yielded a large Area-25 catch. Similarily, the present indications of a large residual population in the northern part of the west-coast sub-district suggest that good fishing will probably occur in the 1950-51 season in Area 25, providing the fish move inshore during the fishing season. From the analysis of data from the 1945-46 and 1949-50 seasons it appears possible that certain factors tend to prevent the fishing of an abundant year-class in Area 25 in its third year. Sampling data of previous years show that III-year fish dominate the catches and spawning runs in Area 25 less frequently than in Area 23. In some years fish of Age IV constitute the most abundant age-groups in the former area. This suggests either that the factors which prevent inshore migration have a greater effect on III-year fish in Area 25 than in Area 23, or that a larger proportion of the recruitment of new year-classes occurs at Age III in Area 23 than in Area 25. The possibility that there is a delay in the recruitment of fish in Area 25 poses the problem of what time of year recruitment occurs in the northern part of the sub-district.

On the evidence that most of the recruitment may not have taken place by the end of the fishing season and that in some years new recruits may join the adult population prior to spawning (in order to account for the sustained level of the spawning population), it would be presumed that recruitment would take place between the close of the fishery and the beginning of spawning. However, since previous information has generally indicated that almost all recruitment takes place after spawning and before the beginning of the fishery, acceptance of this theory presents considerable difficulty.

Although the abundance of fish in Area 25 in 1950-51 will probably depend largely on the 1947 year-class (as IV-year fish), the Area-23 fishery is expected to depend mostly on the strength of the 1948 year-class entering the fishery as III-year fish. Indications of relative year-class strength in the west-coast populations have been given with reasonable accuracy in recent years by an analysis of the representation of II-year fish in the fishery and in the spawning runs. In 1949-50, II-year fish (1948 year-class) comprised a smaller proportion of the catch than in the previous year, and in the spring of 1950 they were relatively much less abundant than in the preceding spring. Considering the data from the separate areas it was found that II-year fish were less abundant in Area-23 fishing samples in 1949-50 than in 1948-49 but that they were relatively more abundant in Area-25 fishing samples than in the previous season. Thus it appears that the 1948 year-class will supply fewer recruits to the fishing stock than the 1947 year-class and that the abundance of fish in Area 23 will be less in 1950-51 than in the 1949-50 season. A possible indication of poorer survival in the 1948 brood during its early stages was obtained from reports received in the summer of 1948 on the relative abundance of juvenile herring on the west coast in the summers of 1947 and 1948.

The dissimilarity between the age composition of the sample of spawning fish in Area 27 and that of spawning samples from other areas give support to indications of previous years that the herring of Area 27 tend to be more or less segregated from the rest of the west-coast population. The 1947 year-class was less strongly represented in the Area-27 sample than in the samples from other areas. This might account for the reduced spawning population in the area. The large contribution made by the 1945 year-class (as V-year fish) suggests that this year-class was relatively stronger in Area 27 than elsewhere on the west coast. This is confirmed by the sampling of the spawning runs in 1947-48 which showed that the 1945 year-class (as III-

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year fish) was relatively most productive in Area 27.

The average length of west-coast herring from the 1949-50 fishery was similar at each age to that obtained in the 1948-49 season. A difference in average weight was noted in the two seasons but the difference was small. It appears that generally similar food conditions existed in the summers of 1948 and 1949. A comparison of average length (in millimetres) and of average weight (in grams) in 1948-49 and 1949-50 is presented below (data are given only for the more abundant age groups):

	Year				
Average length	II	III	IV	V	VI
1948-49	159	188	201	213	222
1949-50	164	190	202	212	220
Average weight					
1948-49	50	87	111	138	158
1949-50	56	94	117	137	152

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Appendix No. 41

THE AGE AND GROWTH OF HERRING ON THE LOWER EAST COAST OF VANCOUVER ISLAND SUB-DISTRICT, 1949-50.

Along the lower east coast of Vancouver island once again the major fishery took place in Areas 14B and 17 with only a small catch of approximately 500 tons taken in Area 18. Fish of all ages ranging from I to VIII years were caught. The dominant year-class was that of 1947 which contributed two-thirds of the total catch as III-year fish. In the previous year recruitment of III-year fish from the 1946 year-class was also relatively great. Carry-over from this year-class in the 1949-50 fishery as IV-year fish was greater than usual. The presence of II-year fish in the commercial fishery was the lowest percentage (1.5%) in recent years. This suggests that the 1948 year-class might be below average. However, II's were considerably more abundant in the spawning runs--in Area 17 they formed about 13 per cent of the fish in the spawning samples but in Area 14l only about 5 per cent of the fish were II's.

Below is listed a table showing the percentage age composition of the lower east-coast sub-district for the years 1948-49 and 1949-50 and the age composition of the individual Areas 14B and 17 comprising this sub-district.

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	I	II	III	IV	V	VI	VII	VIII
1948-49	0.1	2.8	76.8	17.8	2.0	0.5	---	---
1949-50	+	1.5	66.7	26.9	4.1	0.6	0.1	+
Area 14B	---	1.6	69.9	25.2	2.8	0.3	+	+
Area 17	+	1.1	59.0	31.0	7.2	1.3	0.3	---

The percentage age compositions differed slightly in Areas 14B and 17. The percentage of III-year fish in Area 14B was higher than in Area 17 while the IV-year fish were more abundant in 17 than 14B.

A comparison of the average length (in millimetres) and of the average weight (in grams) of the lower east coast herring for the years 1947-48 to 1949-50 is given below.

	I	II	III	IV	V	VI	VII	VIII
Average length (mm.)								
1947-48	104	153	192	204	212	220	226	226
1948-49	92	162	187	199	212	233	---	---
1949-50	104	153	188	200	211	218	228	239
Average weight (gm.)								
1947-48	11	45	95	115	131	142	160	162
1948-49	8	54	85	104	131	154	---	---
1949-50	13	45	91	111	131	148	175	214

A general similarity in growth can be noted in the age-groups.

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THE AGE AND GROWTH OF HERRING IN THE MIDDLE EAST COAST OF VANCOUVER ISLAND SUB-DISTRICT, 1949-50

The age composition of the middle east-coast sub-district for 1948-49 and 1949-50 was as follows:

Year	I	II	III	IV	V	VI	VII	VIII
1948-49	+	2.0	68.7	23.4	4.3	1.4	0.2	---
1949-50	+	2.8	68.9	24.7	3.0	0.4	0.2	0.1

In the past two seasons a most striking similarity has occurred in all age-groups in the age compositions of the fish in the middle east-coast sub-district. The III-year fish again dominated the catch suggesting

that the 1947 year-class was of strength approximately equal to that of the 1946 year-class. The II-year olds were only slightly more abundant than in the past season. In general all age-groups were closely similar in the two years as well as similar to the percentage age compositions of the lower east coast.

Below are listed the age compositions for Areas 13 and 14A for the years 1948-49 and 1949-50.

	I	II	III	IV	V	VI	VII	VIII
Area 13								
1948-49	0.1	4.5	48.9	33.0	10.2	2.9	0.4	---
1949-50	0.1	5.7	79.2	12.7	1.7	0.3	---	0.3
Area 14								
1948-49	---	1.0	76.3	19.8	2.1	0.8	0.2	---
1949-50	---	1.8	65.4	28.6	3.4	0.5	0.3	---

As is past years a comparison of the constituent areas in the middle east-coast sub-district showed a variation in the age compositions. In Area 13 the 1947 year-class made up approximately 80 per cent of the entire catch while in Area 14A it was less. The IV-year fish (1946 year-class) were less abundant in Area 13 but in Area 14A they were relatively twice as numerous. The age compositions for Area 14A once again this year followed closely the age compositions of the lower east-coast sub-district.

A comparison of growth rates in length and weight for the middle east coast and the lower east coast for 1949-50 are given below:

Average Length (mm.)

	I	II	III	IV	V	VI	VII	VIII
1949-50 Lower east coast	104	153	188	200	211	218	228	239
1949-50 Middle east coast	115	155	185	201	214	224	238	227

Average Weight (gms.)

1949-50 Lower east coast	13	45	91	111	131	148	173	214
1949-50 Middle east coast	18	50	89	116	146	167	198	181

The growth rates in most cases were slightly higher for the middle east coast. However, the growth index (determined by taking the sum of the average lengths in millimetres of the III's and IV's) was lower for the middle east coast than the lower east coast, but this difference was not considered sufficiently large to be significant.

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THE AGE AND GROWTH OF HERRING IN THE UPPER EAST COAST OF VANCOUVER ISLAND SUB-DISTRICT, 1949-50

Although the fishing regions in this sub-district were reduced to just Sub-area 12E this season, the total catch has been the largest since 1941. This exceedingly large catch followed a most unproductive 1948-49 season in which the lowest catch on record had occurred. The individual samples from the Bones bay area showed great variations in the age compositions from day to day.

Below are listed the age compositions of herring in Sub-area 12E for the years 1946-47 to 1949-50.

Year	I	II	III	IV	V	VI	VII	VIII	IX
1946-47	0.2	17.8	33.4	16.0	18.0	10.2	2.2	1.0	1.0
1947-48	7.7	45.9	21.1	19.7	2.7	2.5	1.7	0.4	0.2
1948-49	0.8	34.4	38.1	16.6	6.6	3.4	---	---	---
1949-50	4.1	36.8	40.3	12.7	3.2	2.4	0.4	---	---

For the past two seasons III-year fish have dominated the catches with the II-year olds next in importance. Fish of all ages ranging from I to VII years were caught.

A comparison of the growth in length and weight for the 1948-49 and 1949-50 seasons for fish from Sub-area 12E is given below:

Average Length (mm.)

Year	I	II	III	IV	V	VI	VII
1948-49	113	137	171	193	195	213	---
1949-50	104	144	175	189	194	206	204

Average Weight (gms.)

1948-49	18	31	59	76	131	---	---
1949-50	18	38	78	103	115	136	128

Growth rates did not vary to any great degree in most cases while the growth indices for 1948-49 and 1949-50 were identical (364).

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THE AGE AND GROWTH OF HERRING IN THE CENTRAL SUB-DISTRICT, 1949-50

In the central sub-district herring catches were made in the following areas: Area 6 (Surf inlet, Helmecken inlet, Racey inlet, Thistle pass, Laredo sound, and Meyers pass in the main offshore fishery and Klemtu and Gardner canal in the local inshore runs), Area 7 (Kwakshua passage, Boddy passage, Cultus sound, Kildidt sound) and Area 9 (Moses inlet, and Drainey inlet).

Below are tabulated the average age compositions of the 1947-48 to 1949-50 fisheries in the central sub-district. Area 6 was once again divided into two groups; group 1 referring to the samples from the main offshore fishery and group 2 referring to the local inshore runs.

	I	II	III	IV	V	VI	VII	VIII	IX	X
Area 6										
1947-48 (2)	1.0	26.7	52.5	15.1	2.2	1.8	0.6	0.1	---	---
1948-49 (1)	---	8.8	7.0	24.3	51.2	5.8	2.0	0.7	0.1	---
1948-49 (2)	0.3	35.9	23.6	26.6	9.6	2.0	1.1	0.6	0.4	---
1949-50 (1)	---	4.9	52.6	8.8	14.5	17.2	1.4	0.4	0.2	---
1949-50 (2)	---	61.5	21.3	4.2	11.7	1.0	0.3	---	---	---
Area 7										
1947-48	---	0.1	12.5	70.1	11.2	3.4	0.8	0.9	0.9	0.2
1948-49	---	2.9	10.5	37.3	45.4	3.0	0.7	0.1	---	---
1949-50	†	7.9	54.0	10.7	13.1	13.3	0.8	0.2	†	---
Area 9										
1947-48	0.2	18.6	28.2	43.5	6.[illegible]	2.1	1.0	0.3	---	---
1948-49	2.9	38.0	28.8	20.8	8.1	1.3	---	---	---	---
1949-50	0.6	54.7	39.4	3.2	1.1	1.0	---	---	---	---

In Area 6 again both the main offshore and the local inshore populations were fished. In the main offshore run the 1947 year-class made up approximately one-half of the total catch as III-year fish in the 1949-50 fishery. The 1946 year-class was scarce, forming only 8.8 per cent IV-year fish. However, the 1944 year-class must have been exceedingly abundant to appear even in its sixth year in such force (17.2%). The year-class following the 1944 year-class was somewhat less prominent (14.5% V-year fish). In the local inshore runs II-year fish were by far the most abundant. The 1947 year-class contributed 21.3 per cent fish as III's while the 1946 year-class as in main offshore runs was very low. The V-year fish made up 11.7 per cent of the entire catch.

Fish of all ages from I to IX were present in the 1949-50 fishery in Area 7. The 1947 year-class contributed 54.0 per cent fish to the entire catch. As in Area 6, IV-year fish seemed to be particularly low. The V- and VI-year fish were of approximately equal abundance.

There was no fishery in Area 8 or in Area 10 although one spawning sample was taken from Area 10. Area 9 once again supported a fishery with the major samples coming from Moses inlet, and one sample from Drainey inlet. The dominant year-class for the 1949-50 catch was the 1948 year-class contributing approximately 55 per cent to the fishery. The percentage

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of III's entering the fishery was slightly higher than the percentage of II's in the preceding year, indicating that possibly the 1948 year-class was strong enough to overshadow the 1947 year-class. The IV's as in Area 6 and 7, made up a small percentage of the catch.

A comparison of the growth indices in Areas 6, 7, and 9 showed the local inshore populations in Area 6 to have the smallest growth index of (311). The offshore herring in Area 6 had an index very similar to that of Area 7 (378 for Area 6 and 371 for Area 7). Area 9 showed a small growth index (315) only a little higher than the index for the local populations of Area 6.

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THE AGE AND GROWTH OF HERRING IN THE NORTHERN SUB-DISTRICT 1949-50

In the northern sub-district a total catch of 39,400 tons was taken; easily doubling the catch in Area 4 in the 1948-49 season. This fishery has been the largest on record for the sub-district. The major part of the catch was taken from Area 4 with only a total of 900 tons coming from Area 5.

Below are tabulated the average age compositions of the 1948-49, 1949-50 fisheries in Area 4:

Area 4	I	II	III	IV	V	VI	VII	VIII	IX
1948-49	---	2.4	22.1	19.2	48.7	5.1	2.3	0.5	0.2
1949-50	---	5.3	61.3	12.3	9.6	9.2	1.6	0.6	0.1

When an area has not been fished for several years, older fish tend to dominate the population. In area 4 when the first fishery in several years developed in the 1948-49 season, fish of Ages III, IV, and V constituted the majority of the fishery with V-year fish the most abundant. In 1949-50 season, III's formed the dominant group. In both years a wide age spread was evident indicating a virtually unfished population.

A comparison of the growth index for Area 5 with the average growth index for the offshore population of Area 6 and Area 7 shows growth to be greater in the central sub-district than in the northern (growth index for Area 5 was 357 while the average for Areas 6 and 7 was 375).

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THE AGE AND GROWTH OF HERRING IN THE SPAWNING RUNS IN 1950

The expansion of the tagging programme into the northern part of the province in 1950 permitted the collection of spawning samples from the northern and central populations. As a result spawning samples were obtained from all sub-districts except the upper east-coast sub-district.

A total of 26 samples was taken from February 22 to April 16. In addition a sample from the Queen Charlotte islands (dated May 23) was received from fisheries officers. The localities, age compositions, and growth indices of the samples are as follows:

Area	Place	I	II	III	IV	V	VI	VII	VIII	IX	X	Growth Index
	Queen Charlotte islands											
2B	Skidegate inlet	-	5.6	16.8	30.3	7.9	16.8	12.4	3.4	3.4	3.4	372
	Northern											
5	Willis bay	-	-	69.2	8.5	10.6	10.6	1.1	-	-	-	360
	Central											
6	Thistle passage	-	-	76.0	8.3	7.3	8.3	-	-	-	-	372
	Parsons anchorage	-	-	46.3	12.6	23.2	16.8	1.0	-	-	-	374
7	Brydon channel	-	1.0	53.1	16.3	15.3	11.2	1.0	1.0	1.0	-	376
	Seaforth channel	-	-	48.9	16.3	17.4	15.2	2.2	-	-	-	381
10	Fly basin	-	3.3	28.6	19.8	36.3	11.0	1.1	-	-	-	360
	Middle east coast											
14A	Lambert channel	-	2.2	63.4	26.9	5.4	1.1	-	1.1	-	-	387
15	Ragged islands	-	-	70.0	20.0	7.0	-	1.0	2.0	-	-	386
	Ragged islands	-	1.0	51.7	24.7	9.3	7.2	1.0	-	-	-	395
	Lower east coast											
14B	Departure bay	-	2.2	60.9	29.4	6.5	1.1	-	-	-	-	396
	Departure bay	-	5.4	58.1	24.7	8.6	2.2	1.1	-	-	-	395
	Departure bay	-	7.2	60.8	26.8	4.1	1.0	-	-	-	-	388
17	Kulleet bay	-	15.2	68.7	12.1	2.0	2.0	-	-	-	-	385
	Ladysmith harbour	-	10.1	69.7	16.2	4.0	-	-	-	-	-	385
	West coast											
23	Toquart bay	-	3.2	84.0	9.6	2.1	-	1.1	-	-	-	388
	St. Ines island	-	13.7	63.2	17.9	4.2	1.0	-	-	-	-	383
	St. Ines island	-	4.2	71.6	22.1	2.1	-	-	-	-	-	385
	Toquart bay	-	2.1	75.0	18.8	4.2	-	-	-	-	-	386
24	Cypress bay	-	6.2	66.0	19.6	5.2	3.1	-	-	-	-	383
25	Kendrick inlet	-	9.4	75.0	13.5	-	2.1	-	-	-	-	385
	Nootka harbour	-	10.4	71.9	10.4	4.2	1.0	2.1	-	-	-	397
	Queen cove	-	9.2	71.4	11.2	4.1	4.1	-	-	-	-	393
	Port Eliza	-	42.9	51.0	5.1	1.0	-	-	-	-	-	386
26	Rugged point	-	7.3	74.0	14.6	4.2	-	-	-	-	-	388
	Ououkinsh inlet	-	5.3	66.3	16.8	7.4	2.1	1.0	1.0	-	-	388
27	Winter harbour	-	2.2	57.0	14.0	23.7	3.2	-	-	-	-	394

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For the first time in several years herring were obtained this year from the Queen Charlotte islands population. The age composition of these fish taken suggested that the 1946 year-class (IV's) was the most important contributor to the present stocks, and that the 1944 year-class (VI's) has probably been chiefly responsible for the high abundance apparently attained by the population in 1947 and 1948. The relatively large numbers of III-year fish in the samples probably indicated that the 1947 year-class is relatively strong and may increase the population in the 1950-51 season.

In the northern and central sub-districts the 1947 year-class (III's) constituted about the same proportion of fish in the spawning samples as in the fishing samples of the immediately preceding fishery. The unusually strong representation of VI-year fish (1944 year-class) noted in the fishing samples was also evident in the spawning samples but somewhat less pronounced. The single sample from Area 10 showed that the 1945 year-class (V's) was relatively strong in the small inshore population of that area.

The scarcity of II-year fish (1948 year-class) in spawning runs of the central and northern populations is noteworthy in view of the fact that II's formed about five per cent of the catch in Area 6 and about eight per cent of the catch in Area 7. In general, II-year fish tend to be relatively more abundant in the spawning samples from southern British Columbia than in the fishery. In 1945 when several spawning samples were taken from Area 5 and 6, it was also noted that II-year fish formed a very small proportion of the spawning runs along the northern coastline. It appears that whereas some of the southern British Columbia herring become mature at the end of the second year of age, virtually no herring from the major offshore northern runs mature until Age III.

In the southern British Columbia sub-districts the dominant 1947 year-class formed about the same proportion of both the fishing and spawning runs. On the middle east coast the proportion of II's (1948 year-class) in the spawning runs was similar to that found in the fishery samples, but II-year fish were considerably more numerous in the lower-east-coast and west-coast spawning runs than in the corresponding fisheries. In previous years it has been noted that II-year fish frequently occurred in considerable numbers in Area 13 spawning runs, but elsewhere in the middle east-coast sub-district II-year fish have been relatively scarce or entirely absent at time of spawning. An adequate explanation for these observations is at present lacking.

The influx of II-year fish in the west-coast spawning runs was much less pronounced than in 1949. This appears to indicate that the 1948 year-class will be less abundant than that of the preceding year-class.

Comparison of growth indices of fish from spawning and fishing samples derived from the same area indicated that the growth rate in spawning runs was similar to that in the catches. As in past years the greatest growth was found in the middle east-, lower east-, and west-coast sub-districts, smallest growth in the northern sub-district, and growth of intermediate character in the central sub-district. The spawning sample from the inshore population of Area 10 contained fish with growth rate similar to that of main offshore population of the northern sub-district. As mentioned in a previous Appendix very slow-growing fish were taken from Area 9 fishery in 1949-50, the growth index being only 317. The Queen Charlotte island herring showed a growth comparable to that found in samples from the central sub-district.

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HERRING SPAWN STUDIES, 1950

Studies on herring spawn in the spring of 1950 were chiefly directed to the assessment of the extent of spawning in each sub-district and the estimation of the amount of bird predation upon spawn. Fisheries officers again submitted reports on the spawning in each area, and members of the herring investigation staff supplemented this information with detailed surveys of most of the spawning grounds on the west coast of Vancouver island. Data obtained from these investigations are used in studying the relationship between the amount of spawn deposition and year-class strength, and in estimating the amount of fish which escaped the fishery. In addition, the spawn studies provide information of use in larval studies.

Studies relating to bird predation on spawn were carried out in the spring of 1949 at Queen cove and Port Eliza (Area 25). This spring these investigations were continued in Toquart bay (Area 23). Information was also collected on "natural" mortality on spawn as evidenced by dead eggs on the spawning grounds. The results of the 1950 studies along these lines are reported in the following Appendices.

Spawn deposition

The spawning data provided by fisheries officers permit the estimation of the amount of spawn deposited along the British Columbia coast. In the following tabulation the number of statutory miles of spawn are given for each area in 1949 and 1950 (miles of spawn weighted to estimated spawning intensities are indicated in brackets):

Sub-district and Area	1949		1950	
Queen Charlotte islands				
Area 2A-East	1.1	(2.5)	0.8	(1.5)
Area 2B-East	7.3	(25.0)	7.6	(24.5)
	8.4		8.4	
Northern				
Area 3 (Naas)	---	(---)	4.6	(9.6)
Area 4 (Skeena)	16.8	(54.4)	11.7	(38.2)
Area 5 (Grenville-Principe)	4.8	(17.0)	9.9	(31.4)
	21.6		26.2	
North Central				
Area 6 (Butedale)	10.9	(32.8)	14.4	(49.1)
South Central				
Area 7 (Bella Bella)	26.3	(86.2)	30.2	(105.6)
Area 8 (Bella Coola)	0.1	(0.2)	0.6	(1.7)
Area 9 (Rivers inlet)	1.6	(3.7)	---	(---)
Area 10 (Smith inlet)	2.8	(8.1)	1.8	(5.8)
	30.8		32.6	
Upper east coast of Vancouver island				
Area 12	17.7	(55.8)	23.0	(72.9)

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Middle east coast of Vancouver island				
Area 13 (Discovery passage)	1.2	(2.5)	11.2	(33.5)
Area 14A (Comox)	16.8	(78.0)	9.3	(35.6)
Area 15 and 16 (Pender harbour)	2.2	(7.1)	8.3	(26.6)
	20.2		28.8	
Lower east coast of Vancouver island				
Area 14B (Nanaimo)	3.6	(13.2)	6.6	(29.1)
Area 17 (Ladysmith)	10.8	(41.7)	7.0	(23.7)
Area 18 (Cowichan)	6.4	(19.0)	1.3	(2.2)
Area 19 (Victoria)	0.1	(0.1)	0.2	(0.2)
	20.9		15.1	
West coast of Vancouver island				
Area 23 (Barkley sound)	8.4	(27.6)	10.8	(27.3)
Area 24 (Clayoquot sound)	2.0	(4.2)	7.7	(22.4)
Area 25 (Nootka sound)	5.0	(19.2)	7.6	(25.7)
Area 26 (Kyuquot sound)	1.2	(4.2)	1.4	(5.4)
Area 27 (Quatsino sound)	5.1	(13.3)	3.2	(10.9)
	21.7		30.7	

In 1950 herring spawning showed an increase over that of the previous year in all but two sub-districts. On the lower east coast of Vancouver island there was an appreciable decrease in the amount of spawning recorded and in the Queen Charlotte islands spawning remained near the low level established in the previous year. A substantial increase in the extent of spawning occurred in the northern sub-district in spite of the record 1949-50 catch. A greater increase was found in the north central spawning than in south central spawning; the former sub-district also provided a much larger catch in the preceding fishing season.

The upper and middle east coasts of Vancouver island sub-districts have shown increases in amount of spawning for three successive years. The lower east coast of Vancouver island sub-district showed substantial increases from 1947 to 1949, but in 1950 the extent of spawn decreased. The decrease was attributed to a marked reduction in spawning in the Cowichan area. Whether or not the small spawning was a result of the greatly retarded growth of eel grass which was most noticeable in this area is not clear. The reduction in eel grass abundance in 1950 and its possible effect upon herring spawning is discussed in another Appendix.

Detailed west-coast survey

In 1950, for the fourth successive year, members of the herring investigation staff carried out a detailed survey of spawnings on the west coast of Vancouver island. These surveys were undertaken in order to obtain a more accurate estimate of the extent of spawning. The fisheries officers in the sub-district continued making their observations, thus providing two estimates of the amount of spawn deposited. For the most part each of the surveys was carried out independent of the other, although certain factors (chiefly the large amount of coastline and the limited time) at times required the two surveys to work together.

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The investigation survey has added several refinements to the conventional methods of conducting surveys of this type. Drag rakes of a standard design were devised in the first year to procure vegetation in water too deep for visual observation. In more recent years, large-scale maps were drawn from navigation charts, and aerial photographs of spawning localities were traced and mimeographed for the purpose of facilitating the estimation of the extent of spawnings, and drawings of eggs in various stages of incubation were made to allow determination of the age of spawn. These improvements were passed on to fisheries officers on the west coast, and some of them were given to officers in other sub-districts. In addition, efforts were made by the investigation's scientists to determine the most effective means of tackling spawning surveys. Attention was given to making accurate estimates of length, average, width, depth, and average intensity of spawnings. Annual lectures to fisheries officers have been given in recent years, providing an excellent opportunity in which to explain the improved methods and to attempt to ensure the greatest possible measure of uniformity among officers in collecting the data.

In 1950, as in previous years, the amount of spawn (in statutory miles) recorded by fisheries officers was considerably less that that estimated by herring investigators. A comparison of the two estimates is given in the following tabulation for each year:

Year	Fisheries Officers	Herring Investigation
1947	18.2	32.4
1948	23.0	43.8
1949	21.7	41.1
1950	30.7	43.5

It will be noted that the difference between the two estimates is less in 1950 than in any of the other years. This is possibly an indication that the officers are adopting the methods used by herring investigators in carrying out the surveys. However, another factor which helps to account for the smaller difference is that one officer's report recorded a considerably greater mileage of spawn than was obtained by the herring investigators.

While it is fairly well established that the fisheries officers tend to underestimate the extent of spawnings because of lack of time, the pressure of other duties, or lack of a suitable boat, there are other reasons for the difference which exists between the two estimates. The fisheries officers' estimates do not include spawnings found by fisheries officers and either missed or not observed by the investigators. Also, no corrections are made to the length of very wide spawnings in the officers' estimates, while in the investigators' estimates the lengths are altered on the basis of a standard width of spawning. The fact that the relative changes in spawning extent on the west coast of Vancouver island, as obtained from fisheries officers' estimates, are generally similar to those found in the herring investigators' estimates is considered to be of considerable importance.

It suggests that estimates made by officers elsewhere also give indications of the relative amounts of spawn deposited in different years.

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Dates, places, and extent of individual spawnings followed the general spawning pattern of previous years. Among the exceptions to the usual pattern might be mentioned (1) the spawning in Ross passage (Area 24) which was recorded this year for the first time, (2) the unusually large spawning between Nootka cannery and Marvinas bay (Area 25), (3) the record spawning around Nuchatlitz village (Area 25), (4) the almost complete lack of spawn in the Port Eliza--Queen cove locality (Area 25), and (5) the new spawning at Rugged point (Area 26).

The spawning extent in the sub-district as a whole was slightly greater in 1950 than in the previous year. Areas 23, 25, and 26 showed increases, Area 27 showed a decrease, and the spawn deposition in Area 24 remained about the same in both years. The data on spawning extent (in statutory miles) are summarized according to area for 1949 and 1950, as follows:

Area	Extent in Miles	
	1949	1950
23	11.7	13.4
24	4.3	4.2
25	16.3	18.2
26	2.2	3.2
27	6.6	4.5
	41.1	43.5

The spawning on the west coast was slightly lighter in average intensity in 1950 than in 1949. On the basis of indicating intensity of deposition in individual spawnings as very light, light, medium, heavy and very heavy, and designating these intensities in the ratio of 1, 2, 3, 4, and 5, the following average intensities for each area in 1949 and 1950 were calculated (intensities weighted to extent of individual spawning):

Year	Area 23	Area 24	Area 25	Area 26	Area 27	All Areas
1949	3.1	3.1	3.5	3.4	2.6	3.2
1950	2.4	2.8	3.2	3.3	3.0	2.9

The small increase in extent of spawning in 1950 and the slight decrease in intensity appears to indicate that the amount of spawn deposited was similar in both years. Similar conclusions were drawn on comparing the relative amounts of spawn deposited in 1949 and 1948, and in 1948 and 1947. The spawning data indicate that during the period of non-quota fishing the spawning stock has been kept at a level of abundance well above the critical amount necessary to maintain the population.

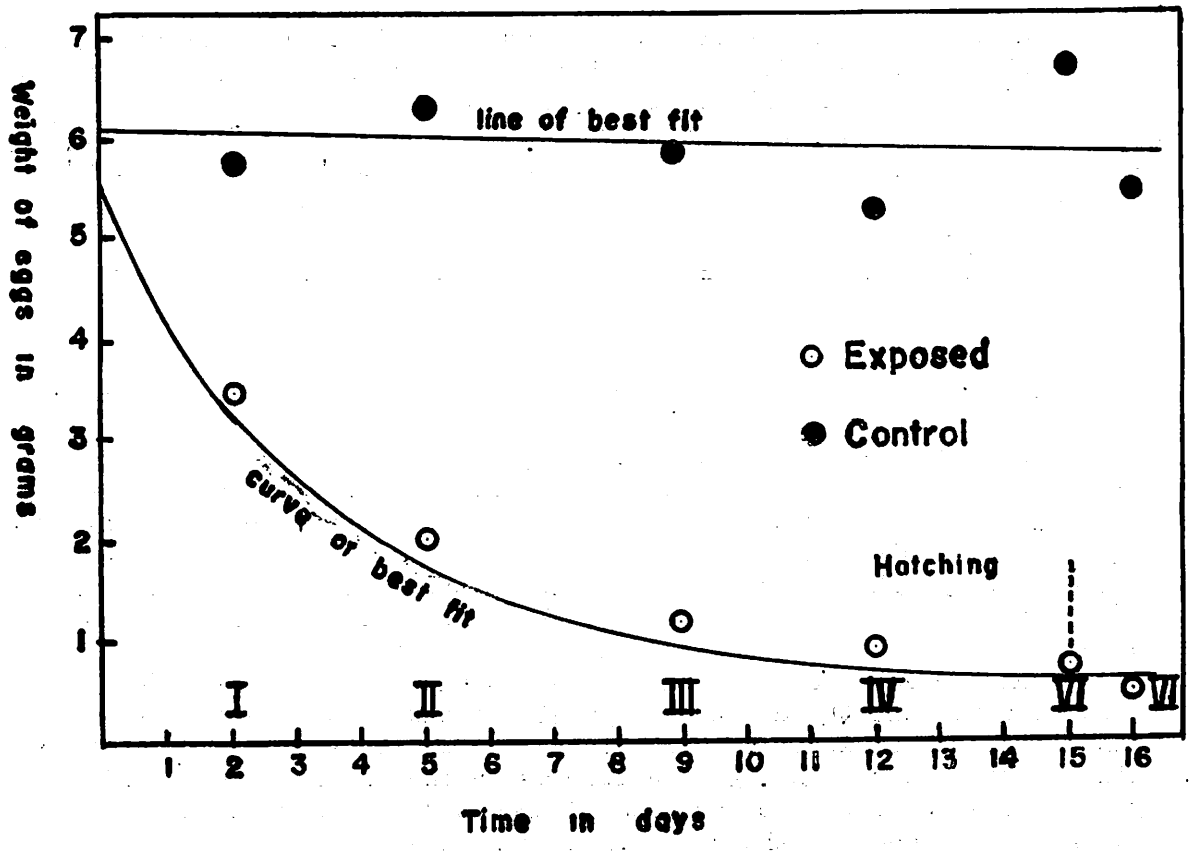
From the above data on extent and intensity of spawning depositions it appears that the amount of spawning (and hence the number of spawning fish) was at least as great in the major west-coast fishing and spawning areas (Areas 23 and 25) in 1950 as in the previous year, and probably greater. However, whereas Area 23 produced a record catch in the preceding fishing season, the catch in Area 25 was greatly reduced from that of the 1948-49 season. The apparently anomalous situation was discussed in the Appendix dealing with west-coast age studies.

K.J. Jackson Appendix No. 48

MORTALITY OF HERRING SPAWN BY BIRD PREDATION

The study of spawn mortality by birds was continued this year. This year the Toquart bay spawning grounds (Area 23), proved a suitable location for the experiment, which was carried out in a manner similar to that of last year at Queen cove (Area 25). Paired, adjacent plots were selected on the beach. One was covered by a net to exclude birds. The other was left uncovered so that birds might remove spawn (and substrate). Samples were taken from each plot with a view to comparing them to find the loss of spawn occasioned by bird predation. This year the sampling procedure was modified somewhat. Sampling visits were less frequent but more samples were taken at each visit to the plots, so that comprehensive data were obtained for particular periods, rather than scanty data over the whole predation period, from egg deposition to hatching. The total number of samples was greater than it was last year. In general the experiment was modified, on the basis of 1949 experience, to produce more accurate results.

The laboratory analysis of samples was unchanged in principle. Weights of spawn on substrate were determined for each sample. The use of a flotation apparatus designed to separate eggs from sand particles unavoidably collected while sampling saved much time, and made the analysis of the increased number of samples possible. From the data, the following graph (depicts the weight of eggs plotted against time) was drawn.



K.J. Jackson

Each Roman numeral on the graph represents a sampling visit. For instance II means that the second sampling visit occurred on day number 5. Day 0 is the day of spawn deposition. Since hatching was in progress on visit VI, it was decided to consider only the predation occurring between days 0 to 15, since egg weight, the unit of measure, could not be considered exact beyond the above limits. The percentage of eggs lost was calculated using the figure Q as the initial value. (Q was not an actual value.) It will be noticed that visit I occurred on the second day. The theoretical curve shown on Graph A was fitted to the data from exposed eggs, and Q was found by extrapolation to zero time. The percentages of eggs lost by visits II, III, and V were respectively 60.9%, 78.8%, and 92.8%. Two major conclusions may be drawn. Firstly, it seems that bird predation can cause very heavy damage to spawn. Secondly, the worst damage would appear to occur in the first third to half of the period between spawning and hatching.

It will be observed that control values do not vary excessively until hatching occurs. Their line of best fit (calculated by least squares method) has a very small negative slope ($m = -0.004$), indicating virtually no decrease. Thus it would seem that all loss of spawn from the exposed plots had definitely been caused by the depredations of the aquatic birds seen on the spawning grounds feeding on spawn. The principal offending species were herring gulls and glaucous-winged gulls. Some buffle-heads, golden-eyes, and scoters were seen feeding in the vicinity of the plots also.

K.J. Jackson and D.N. Outram Appendix No 49

NATURAL MORTALITY OF SPAWN, 1950

Several factors contribute to the loss of herring spawn. Among those known are bird predation, wave action and "natural" mortality. In the course of this year's survey dealing with extent of spawn on the west coast of Vancouver island, 41 samples of spawn were taken in connection with natural mortality studies. Last year only 13 were taken.

In 1947, 1948, and 1949 the west-coast average losses by "natural" mortality were respectively 2.9%, 5.6%, and 1.6%. This year a comparable, but relatively high average loss of 6.9% appeared for the entire west coast. Considered individually, by area, from north to south, Areas 26, 25, 24, and 23, yielded increasing average mortalities of 0.6%, 1.9%, and 12.6%. The reason for this north to south increase is obscure. It is interesting to note however, that the mortalities in Areas 24 and 23 were much higher than those in the two more northern regions, and this fact would seem to agree with the population picture. Populations in Areas 24 and 23 seem to mix with one another but not with populations in 25 and 26. The most important conclusion to be drawn from the above data, especially that which describes yearly losses, is that natural mortality causes only small losses. This conclusion is contradicted in some cases, however; for instance, a sample from Stopper islands in Barkley sound showed a 100 per cent mortality. However, such a condition is rare, the area is small, and it is not felt that incidences of high mortality greatly influence the estimate of natural mortality.

K.J. Jackson and D.N. Outram

There appears to be a differential mortality depending upon the type of substrate upon which the eggs are deposited. When average losses for each of the major substrates--kelp, eel grass, and fucus--were calculated, it was found that fucus samples exhibited a larger loss of 15.1%, while eeg grass and kelp showed a much smaller loss of 1.5%, and 0.5%.

Natural mortality may also be a function of intensity of deposition. Using the same standards for intensity as those employed in the extent of spawn analysis, it was found that high intensities of deposition were accompanied by low mortalities and vice versa. The average mortalities were as follows.

Light	8.1%
Medium	6.6%
Heavy	0.9%

To date salinity has been the only factor studied as a cause of "natural" mortality. Some of the general causes of mortality in organisms might be applicable to herring spawn losses. These may be separated into three major divisions:

1. Genetic mortality -- included here are such factors as non-fertilization, polyspermy and the action of lethal genes.
2. Environmental mortality -- the death of the organism in this case results from exposure to abnormal variations of such factors in the environment as dessication, wave action, temperature, substrate type and abundance, depth salinity, pH, currents and radiations.
3. Ecological mortality -- disease, predation, competition and overcrowding are characteristic of this type of mortality and will occur in populations of high density such as some herring egg communities.

Preliminary work has been done on the dessication factor. Past experiences in the field have indicated that heavy wave action and substrate type (each with their own differential dessication properties) also contribute to herring spawn losses. Further study of these three factors is contemplated this spring at the Toquart bay field station. The investigation of factors related to fertilization will also form a part of this study.

Anne Lazareff

Appendix No. 50

SOME OBSERVATIONS ON THE DEVELOPMENT OF THE HERRING EGG

During the spawning period of the herring, in Departure bay, several experiments were conducted to observe the developmental stages of the herring egg. At first, two samples of eggs were used; one group was placed in a container and suspended in the live tank while the second group was kept in the laboratory in running salt water. Ova, when removed from the female, were placed on glass slides and were artificially fertilized by suspending the slides in a solution of milt and salt water. Upon immersal into sea water the egg immediately began to absorb water

and to form about itself a thick gelatinous membrane which reached its maxi-thickness in the fertilized egg. Observation of an unfertilized ovum showed it to be a more or less opaque sphere. However, approximately one hour after fertilization one-half of the egg became clear and when disturbed tended to roll within the gelatinous membrane so that this region (the vegital pole) was always uppermost.

Three hours after fertilization the first signs of cleavage could be observed and by three hours and thirty-five minutes the first cleavage was nearly complete. At three hours and fifty minutes the second cleavage was already beginning and by four hours the second cleavage was complete. Further observations were not made for the next seventeen hours but division continued until at twenty-one hours the blastula stage could be seen. At twenty-five hours gastrulation was beginning and by the next day at forty-one hours the embryo stage was evident. Organ development and differentiation was beginning at this time and observation became more difficult because of the large size of the egg. However, twice daily until hatching specimens were preserved in Bouin's preservative and in B.C. Fixative. It is hoped in the near future to make some stained whole mounts and sections of the herring embryo for clearer and more accurate observation and comparisons with the living egg.

The first two groups of eggs were useful in observing the immediate changes in the egg but as they approached hatching they began to die off. In the first group (kept in the live tank) a coating of fine silt was deposited around the egg and gradually appeared to smother it. No eggs reached the hatching stage. In the seond groups (kept in the laboratory in running salt water) a similar situation occurred, only this time rather than silt coating the eggs it was rust. Of this groups only three larvae hatched and they did not live beyond the third day.

When normal spawning took place at Departure bay a third sample of eggs was collected. These were scraped from the sea weed and kept in the laboratory in sea water aireated by a slow current of air. The eggs remained very clean. Just as hatching was beginning the air current was removed from the aquarium for one day; approximately one hundred larvae hatched and about three-quarters of them remained alive for twelve days. On the thirteenth day fifty-seven died, leaving about twenty living larvae that died on the following day.

The differences in temperature at which these samples were kept may be significant. The temperature in the tank did not rise beyond 6.5° C. but generally stayed at 6.0° C. while in the laboratory the water temperature could not be lowered much below 10° C. The third sample was also kept at 10° C. although there were times when the temperature was higher, particularly on sunny days.

Many factors seem to influence the development of the ovum. First of all normal fertilization appears to be necessary for successful hatching. A wide range in temperature is possible although development is very poor, near 6.0° C. Whether or not the removal of the air current at the time of hatching had any effect still remains to be determined.

J.C. Stevenson

Appendix No. 51

DECREASE IN ABUNDANCE OF EEL GRASS IN THE SPRING OF 1950

A decrease in the abundance of eel grass was noted in certain areas of the British Columbia coast in the spring of 1950. Each fisheries officer in the southern section of the province submitted a report on the condition of eel grass growth in his area, and reports were also received from some of the fisheries officers in the north. In the south the greatest decrease was noted in the Cowichan and Nanaimo--Ladysmith areas (lower east coast of Vancouver island sub-district), and in the north a comparable decrease was reported in the Grenville--Principe area (northern sub-district). Other areas which suffered a smaller reduction in eel grass growth were Skeena area (northern sub-district), Alert bay area (upper east coast of Vancouver island sub-district), Victoria area (lower east coast of Vancouuver island sub-district), and the Clayoquot and Nootka areas (west coast of Vancouver island sub-district). No apparent decrease in eel grass abundance occurred elsewhere. It was estimated that the abundance was greater in the Quatsino area (west coast of Vancouver island sub-district) this spring than in the spring of 1949.

In most areas where the eel grass abundance was reduced it was considered that growth was merely retarded as a result of the cold winter and late spring. Some officers considered that the abnormally cold weather in the winter had frozen the upper portion of the plants during the exposure at low tides. This is substantiated by the fact that no report specifically mentioned diminution of eel grass growth below the intertidal zone. Apparently the green portion of the plants was frozen in some areas at low water but the roots were not damaged. Many officers stated that by May the growth appeared to be normal.

Although it seems evident that on the coast as a whole little permanent damage to the eel grass occurred, two reports indicated that some eel grass had been killed. Small dead patches were found in Chismore passage and Big bay in the Skeena area, and eel grass in several places in the Cowichan area was considered to be dead. There was no mention of diseased plants in any of the reports.

Since herring deposit most of their spawn on eel grass, changes in the abundance of eel grass are of some concern to herring investigators. It is of interest that in the Cowichan area where possibly the greatest reduction in eel grass was reported, a marked decrease occurred in spawn deposition this spring. There is not enough information available to state definitely whether or not the reduced spawning was related to the lack of eel grass cover. It is known that in the absence of eel grass or other vegetation, spawning will sometimes take place on bare rocks or even sand, and this spring it was found that more spawn than usual was deposited on bare rock in the area. It is also possible that some of the herring ready to spawn might have moved to another area in the sub-district after failing to locate suitable vegetation. However, the possibility that the spawning population was smaller than in the previous year must also be considered.

J.C. Stevenson Appendix No. 52

LARVAL HERRING STUDIES

Larval studies comprise one of the phases of the investigation into the early life history of the herring. These studies are designed to contribute knowledge on the distribution, growth, and survival of herring larvae in difficult years. The ultimate objective is to determine the effect of larval survival on recruitment to the fishable stocks.

Studies on larval herring were initiated on the west coast of Vancouver island in the spring of 1947 and continued in each subsequent year. Laboratory analysis of each year's data was carried out in the summer following each year's field operations. It is planned to analyse completely the data of the four seasons in the present winter.

The general method for collecting larvae has been to take quantitative, horizontal hauls by towing plankton nets behind an 18-foot scout boat. The hauls were carried out in close proximity to the major spawning beaches of the west coast of Vancouver island, and at various distances from the spawning localities. Sampling was undertaken at various depths (mostly from 0 to 6 fathoms), and at different times of day during the period of larval life extending from late March or early April to late May. In each succeeding year of the study a greater number of hauls was taken, ranging from 282 hauls in 1947 to over 1,600 hauls in 1950. In all, about 3,600 hauls were made.

In 1950 a series of cruises was conducted up and down the west coast of Vancouver island following a pattern similar to that of previous years. As in 1949 a field station was set up from which specific data were collected at one locality. In 1950 the field station was located in Area 23 (Toquart bay), whereas in 1949 its location was in Area 25 (Port Eliza).

In addition, a third phase of operation was carried out in 1950. This consisted of making a detailed study of the larval distribution in the western portion of Area 23. An oceanographic survey of the region was made by the Pacific Oceanographic Group in conjunction with the biological studies. The oceanographic investigation was conducted to determine the nature of the currents in that portion of Area 23 where most of the larval dispersal occurred. The joint biological-oceanographic survey was undertaken as a result of previous studies which had suggested that a relationship existed between total mileage of north-west winds in April and the eventual strength of the year-class (1949 Annual Report; Appendix No. 97). It was considered possible that the offshore currents resulting from unusually large amounts of north-west winds in April might cause relatively large numbers of young larvae to be taken out to sea where they might be unable to survive because of unfavorable environmental conditions.

A.S. Hourston and D.N. Outram Appendix No. 53

JUVENILE HERRING SURVEY ON THE WEST COAST OF VANCOUVER ISLAND

As in the past two seasons, efforts were made in 1950 to locate and capture juvenile herring on the west coast of Vancouver island. This study was carried out in conjunction with, and as a continuation of the larval herring studies. The survey was carried out from a seine boat operating on the whole west coast of the island and a field station at Toquart bay in Barkley sound. The methods employed are discussed separately as follows.

A.S. Hourston and D.N. Outram

Dusk and dawn observations for surface schools

Herring show a tendency to appear near the surface at dusk and dawn, where their flipping and flashing may be readily observed. Scouting for this purpose was mainly carried out from an 18-foot scout boat; observations were also made from the deck of the seiner and from shore at Toquart bay. Between May 17 and June 11, 22 sets of dawn and dusk observations were made from the seine boat and five from the field station. No schools of juveniles were sighted during this period, although several large schools of adults were found. However, it is not considered probable that the juveniles had schooled up before it became necessary to conclude the west coast operations.

Attraction of young herring to a light

Herring are known to be somewhat phototropic. Attempts were therefore made to attract the juveniles to lights set out over the water at night. For this pupose whenever the seine boat was anchored at night, a 200-watt light was hung over the side about one foot above the water surface. At the field station, two 200-watt lamps were placed on buoys at each end of 400 feet of waterproof electric cable. The power for these lights was provided by a motor generator mounted on the deck of an 18-foot scout boat. The mobility of this equipment made continuous night observations possible at any reasonably sheltered location near the field station. Good weather and a calm sea proved to be a necessary prerequisite for this work.

The first young herring were caught about 350 feet offshore from the field station (cabin point) on June 2, ten days before the west coast operations were concluded. All the herring captured during this survey were in the process of metamorphosis and were dipped out from around the light with a fine mesh dip net. The samples thus taken are tabulated below:

Date	Place	No. of Young Herring	Weather
June 2	Cabin point, Toquart bay	15	moonlight
June 3	Cabin point, Toquart bay	43	cloudy
June 6	Cabin point, Toquart bay	4	cloudy
June 7	Cabin point, Toquart bay	6	rain
June 8	Cabin point, Toquart bay	1	cloudy
June 8	Stopper islands	2	cloudy
June 9	Cabin point, Toquart bay	25	moonlight
June 10	Between Stopper islands and Cabin point.	1	clear, no moon
June 11	Cabin point, Toquart bay	4	fog, light rain
June 11	Between Stopper islands and Cabin point	2	fog, light rain
		103	

All of these metamorphosing herring were taken from the Toquart bay region of Barkley sound. The light attraction method was used 29 times from the seine boat and 10 times at the field station.

On several occasions, Coleman gasoline lamps were anchored out on buoys in an attempt to attract the herring, but without success. This was attempted six times from the seine boat and twice from the field station. The light from these lamps did not penetrate to the same extent as that from the

electric lights and could not be directed straight down into the water. This may account for their failure to attract the herring.

Most of the metamorphosing herring were captured between 2300 and 0230 hours on cloudy nights. The lamps were placed directly above eel grass beds, and within 200 yards of shore. Their light penetrated the water to a depth of two to three fathoms. When the herring appeared they seemed to be swimming against a moderate current. These tiny fish came singly into the light range at a depth of about one-half fathom and were quickly pursued up to the surface by a school of perch lurking beneath. Since they appeared singly and spasmodically, the herring could not have been schooled up at this stage.

All the young herring taken in this study were less than 30 mm. long and undergoing metamorphosis. They were still more or less transparent and had a slight reddish tint antero-ventrally. The body was just beginning to deepen and the pigmentation starting to take form.

A.S. Hourston

Appendix No. 54

THE LOCATION AND CAPTURE OF JUVENILE HERRING IN THE DEPARTURE BAY VICINITY

During the summer of 1950 a major investigation into various aspects of the juvenile stages of the life history of the Pacific herring was begun. The field work was still in progress at the time of writing (October, 1950). The purpose of this study was to follow the growth, distribution, movement and abundance of the herring from metamorphosis to maturity. An estimate of survival during this period should give a good indication of the probable recruitment of a year-class into the fishery at maturity.

The location and capture of the fish was the primary problem of the juvenile studies. Often the fish were located but the methods of capture then in use proved ineffective. In such eventualities new methods were tried out, and in this manner seven different methods or combinations of methods were employed, all with varying degrees of success. The methods used, the time interval over which they were effective, and their results (number of samples taken and number of fish involved) are tabulated below:

Method	Time Interval Effective	No. of Samples	No. of Fish
Plankton net towed behind a power boat	- Jun 6	--	--
Attraction to a light and capture with a dip net or lift net			
(a) metamorphosing	Jun 2 - Jun 11	10	131
(b) juveniles	Jun 20 - Jul 17	18	3,626
Beach seining	Jul 13 - Jul 28	4	469

A.S. Hourston

Drag seining at twilight	Jul 25 -	20	4,322
Herring rake	Sep 18 -	2	4
Attraction to light on a buoy and setting drag seine around the fish	Sep 21 -	2	25

Hauls with the plankton net were successful in obtaining larva up to about the beginning of June on the west coast. The last successful hauls were made on June 6. No metamorphosing herring were taken by this means in 1950, although some had been taken in previous years. Attraction to a 200-watt electric light and capture with a dip net was very effective for the early juvenile stages (to mid-July). It also yielded some results during the metamorphosing period although the "catch per-unit-effort" was quite low. Daylight beach seining at low tide provided two good samples but in most sets no juvenile herring were taken. It would seem that the period covered by this method would probably be more satisfactorily sampled by drag seining at twilight in deeper waters. The latter method proved very effective from mid-July to the beginning of September, after which time the juveniles became much more swift and active. Consequently their location and capture presented considerable difficulty. The successful use of the drag seine became largely dependent on the weather and the state of the tide at dusk, and when these conditions were adverse it was necessary to adopt other methods. A purse seine of one-inch mesh was used with some success but the fish escaped too easily through the mesh, and the tarred web used was very rough on those fish caught. Some small success has been achieved with a herring rake and by putting out a light at night and setting a drag seine around it, but the results have been far from ideal.

It would thus seem that the main need of this particular aspect of the investigation is to find an adequate method of locating and capturing herring during the period of metamorphosis and during the early fall.

One of the problems associated with the location and capture of the juveniles is that of devising some method of quantitative sampling comparable to the system of net hauls for the larva and the fishery for the adults. The juveniles are not planktonic like the larva and so cannot be quantitatively sampled by straining a certain volume of water with plankton nets. On the other hand, they are not extensively fished like the adults and so any method of quantitative estimation will depend entirely upon the efforts of our own staff. It is possible that some kind of trap or weir may be the answer to this problem but there is no guarantee that even this method would give a quantitative sample unless the whole region under study were more or less extensively fished.

A.S. Hourston — Appendix No. 55

THE SAMPLING OF JUVENILE HERRING IN THE DEPARTURE BAY VICINITY

A sampling programme was included in the juvenile investigations for the purpose of studying the growth of the young herring and the formation of their scale patterns. A size index could thus be established for the comparison of different sets of data. In addition, a comparison

of the growths of individuals, populations and year-classes could give valuable information on the factors involved in the growth of herring.

A sample of up to 200 juvenile herring was therefore taken from every catch made. These fish were preserved in 8 per cent formalin and are now in the process of laboratory analysis. In this analysis the standard length (as measured for the adults) is recorded to the nearest 0.5 mm. for 100 of the fish. The individual herring are then weighed to the nearest 0.05 gm., and, as a check on the weight, the sample as a whole is weighed and the average weights from both methods are compared. As a test of the validity of the sample measured, the remainder of the field sample is counted and weighed and the value for the average weight is compared with that for the sample measured. A few scales are mounted from each tenth fish measured for a study of the formation of scale patterns.

One of the anticipated problems involved in the juvenile studies is that of the randomness of sampling of the various methods of capture. If these methods are not random or nearly so, the sampling data from one method will not be comparable with those from another. Analysis of samples taken at approximately the same time but by different methods should give the answer to this problem.

A.S. Hourston Appendix No. 56

THE MARKING OF JUVENILE HERRING IN THE DEPARTURE BAY VICINITY

A marking programme was carried out on the juvenile herring in the Departure bay vicinity in order to determine a rough index of population abundance and to follow to some extent the dispersal and mixing of schools. In conjunction with this project, experiments were carried out to estimate the probable survival of the marked fish.

After a random sample had been preserved from each catch taken, the remainder of the fish were put into a "box-type" live-pen to be marked and released again. This live-pen consisted of four chambers about two feet cube with screening down either side, and was attached to the outside float at the biological station wharf. Fish taken at some distance from the float were transported there in a rowboat with a series of small slits, one-half inch by two inches, cut in the bottom. This "boat-type" live-pen proved to be a relatively efficient means of moving the fish and in all cases mortality was quite low. When it was tied up at the dock, the juveniles in the boat-type live-pen survived better than those in the box-type live-pen. Fish in both types of live-pens suffered a high mortality during rough weather and were subject to the attacks of birds. This latter difficulty was alleviated to some extent by attaching a door to the top of the box-type live-pen and covering the boat-type live-pen with a net; but even the net was not sufficient to provide complete protection from the attacks of gulls.

The herring were marked by removing both ventral fins with a pair of clippers. Thus, after the first lot of fish was released, every succeeding clipping was also an examination for previously marked fish. An estimate of the "marking" mortality was obtained for each set of fish by keeping one out of every ten marked juveniles overnight in the box-type live-pen.

For every marked fish kept, one unmarked control was put into the next chamber of the pen. The percentage marking mortality was taken to be the percentage mortality of the fish marked and kept overnight minus the percentage mortality of the controls kept overnight. In this manner, 11,914 juveniles were marked, of which it is estimated 9,209 survived the marking (approx. 75%). This estimate is for the operation only. Differential mortality from the action of predators may be quite large and it is planned to carry out experiments to give some indication of this effect. Another consideration in this estimate is whether the juvenile herring population of Departure bay is more or less static or is constantly changing by immigration and emigration.

Meanwhile, ignoring the above factors, some estimate of the size of a juvenile herring population may be obtained which could serve for comparison from year to year. Schnabel's formula for estimating a population from recoveries made while marking is in progress, seems to be best suited to the data. For these calculations the period involved must be long enough to include at least one recapture. In this study only four recoveries were made and two of these came in one sample. Thus although 16 different sets of fish were examined they must be grouped down to three for the purpose of calculation. The estimates for this study are:

B	A	C	AB	ΣAB	ΣC	$P = \frac{AB}{C}$
No. of Marked Fish at Large	No. of Fish in the Sample.	No. of Marked Fish in the Sample.				Population Estimate
2,203	117	1	389,931	389,931	1	389,931
5,272	1,130	2	5,957,360	6,347,291	3	2,115,764
7,894	159	1	1,255,146	7,602,437	4	1,900,609

Poisson Limits of 95 per cent confidence 1.0 - 10.2 ..... 7,602,436 - 745,337

Thus if these figures were truly representative, there would be between one-half million and eight million juvenile herring in Departure bay. However, this estimate is certainly quite low since the mortality of the marked fish was undoubtedly greater than that accounted for in these calculations. It is, however, of value as an index of the population size.

In future work, it is planned to increase the number of juveniles marked and to vary the type of mark in order to get some idea of local mixing and dispersal.

A.S. Hourston Appendix No. 57

THE TAGGING OF JUVENILE HERRING IN THE DEPARTURE BAY VICINITY

The main role of the tagging programme in the juvenile studies is to determine the extent of the homing tendency of the herring. The use of internal body-cavity tags appears to be the only method of ascertaining to what extent the populations of adult herring which tend to return more or less discreet spawning grounds are actually the fish which hatched in that particular locality. Data from this study would also supplement data from the marking programme in the determination of local mixing and population abundance.

It was planned to insert 5,000 small body-cavity tags (13 x 3 x $\frac{1}{2}$ mm.) this fall but at the time of writing (October, 1950) the herring in the samples taken had not attained a sufficient size to make this practicable. Nevertheless, five experimental taggings were attempted on herring averaging between 60 and 70 mm. in standard length. The tagging technique involved was similar to that used on the adults, and the live-pens constructed for the marking programme were also employed for the tagging experiments. The fish tagged in the first two experiments were all dead within 48 hours after tagging. One juvenile survived for 40 hours after the third tagging before it was killed by the attacks of gulls. Four fish from the fourth tagging lived four days before they were killed by the action of a storm on the live-pen. Two of the tagged fish from the fifth experiment survived over a week and were still alive at the time of writing. During that time the tagging wounds healed nicely. However, these fish were considerably larger (95 and 100 mm. in standard length) than other juveniles captured up to that time.

Notwithstanding the detrimental effect captivity must have had on these tagged fish, the mortality in these early experiments was too high to warrant an extensive tagging programme. On the other hand, the continued survival of the larger fish tagged would seem to indicate that if the juveniles are still available in quantity by the time they have reached a length of about 90 mm., a full-scale tagging programme would be in order.

J.C. Stevenson Appendix No. 58

SCOUTING FOR HERRING

During the 1949-50 fishing season scouting trips were made in almost all sub-districts to locate schools of herring and to assess abundance. For this purpose vessels, equipped with echo sounders, were placed at the disposal of the herring investigation by the industry and the Department of Fisheries. In addition, a considerable amount of information in the form of echo-sounder charts and scouting records were submitted by fishermen and patrol-boat captains during the season.

Scouting operations were carried out both while fishing was in progress and after the fishery was ended. Estimates of the herring abundance on or near the fishing grounds, made while fishing was going on, provided information on what total catch might be expected. Estimates made after the quota had been taken indicated the minimum quantity of fish which had escaped the fishery and hence proved useful in considering the advisability of recommending quota extensions.

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Three main scouting operations were conducted in 1949-50. One took place in November, another in January, and the third in early February. In November two vessels, loaned by the industry, were employed in surveying the middle and lower east coasts of Vancouver island after the quotas were taken. A moderate quantity of fish was found in one of the middle east-coast fishing areas (Area 13), but fish were scarce in the other area (Area 14A). It appeared that towards the end of the month the fish in the former area moved further south, permitting the quota extension of 4,000 tons to be readily taken in Area 14A. Some of the long inlets on the mainland shore (middle east coast of Vancouver island sub-district) were scouted on one of the trips. Interest was expressed by the industry in determining whether herring were present there during the fishing season. The trip gave no evidence of the presence of herring. Scouting on the lower east coast indicated that a small influx of fish occurred about two weeks after the quota was reached. Scouting which took place in early January and mid-February suggested that further movement of herring into the sub-district had occurred. During the November survey a considerable quantity of fish was found in the upper east-coast sub-district. On this information it was accurately predicted that the upper east-coast quota would be taken or approximated by the time of the Christmas closure.

During January Areas 23, 24, and 25 on the west coast of Vancouver island were scouted. It was found that fish were scarce in the major sounds from January 8 to 13, and that they were even less abundant in the period extending from January 14 to 19. The lack of concentrated bodies of herring accounted for the poor catch on the west coast during January.

The third major scouting trip was made in the northern sub-district when the industry made a request to the Department of Fisheries for a quota extension. The sub-district was thoroughly scouted with the aid of a patrol vessel of the Department of Fisheries and three vessels of the industry. The finding of large concentrations of fish in one locality resulted in recommending that an extension of 10,000 tons be granted.

J.C. Stevenson Appendix No. 59

FORECASTS OF THE HERRING FISHERY

Each year an attempt is made to predict the success of fishing in the major British Columbia herring populations. Such predictions aid the herring investigation in considering management policies, and they make available to the industry information which may be of value in the efficient utilization of the resource.

The present basis of prediction involves the analysis of data accumulated from various studies of the adult population. Information is provided by these studies on the relative abundance of different age-groups in fishing and spawning runs, the size of the catch and effort expended, and the relative size of the spawning population. These data are analysed to give an indication of the relative strength of the year-classes which will be the main contributors to the subsequent year's catch.

Several assumptions tend to limit the accuracy of prediction. It is assumed (1) that the herring are available to the fisherman in

proportion to their actual abundance, (2) that the age composition of the fishing and spawning samples is indicative of the age composition of population as a whole, (3) that the proportion of young fish in fishing and spawning runs gives a rough indication of the recruitment to be expected from new year-classes, (4) that the extent and intensity of spawn deposition is approximately proportional to the size of the spawning population, and (5) that the time of inshore migration is approximately the same each year.

The fifth annual forecast, giving the prospects for the 1949-50 fishery, was issued in September, 1949 (Circular No. 19). The predictions relating to abundance and probable catch proved to be fairly accurate. On the west coast of Vancouver island it was correctly forecast that the 1947 year-class would be more productive than the 1946 year-class. The reduced catch on the west coast was anticipated on the basis that the Area-25 catch would be smaller. However, the almost complete failure of the Area-25 fishery, caused apparently by the runs not coming inshore during the fishing season, was not foreseen. As predicted, the quotas were readily taken in the lower east-coast and middle east-coast sub-districts. The 1947 year-class entered the lower east-coast fishery in about the same relative strength as the 1946 year-class in the previous year. The relatively large catch from the upper east coast was predicted--the quota was nearly reached.

A larger fishery developed in the north central sub-district than predicted. Although the 1947 year-class (as II-year fish) was prominent in the 1948-49 catch, the apparently large reduction in the abundance of the spawning stock was considered to indicate that the population was at a relatively low level and that the population would not be increased sufficiently by the 1947 year-class to maintain a large fishery. However, it appears that the strength of the 1947 year-class in the north central area was considerably above average. On the other hand the forecast for the south central sub-districts was fairly accurate. The catch was less than the previous year but a moderately good catch supported by the 1947 year-class was taken. It was predicted that the 1949-50 fishery in the northern sub-districts would be at least as large as the 1948-49 fishery. Actually it was considerably better. Little advance information was given in the northern sub-district on the strong recruitment from the 1947 year-class.

The forecasts concerning the relative average size of fish expected in the 1949 fisheries were accurate for all sub-districts. On the middle east coast the predictions made regarding the size of fish in both major fishing localities proved correct.

It appears probable that the investigations on the early stages of the herring life history (reported in previous Appendices) might provide information which will eventually be useful in prediction.

The sixth circular (Circular No. 21) on the prospects of the herring fishery for 1950-51 was prepared in August, 1950.

J.C. Stevenson Appendix No. 60

HERRING INVESTIGATION: GENERAL SUMMARY

Herring research is directed towards the practical application of results. The studies on the adult populations of the west coast and lower east coast of Vancouver island have the practical objective of assessing the relative merits of two methods of management. In order to apply the results of this investigation eventually to the other populations of British Columbia, certain studies are being maintained on the adult stocks in the other sub-districts. In the meantime they serve as a guide to present management policy. The adult studies include tagging, age composition, and spawn assessment studies; collection of catch statistics; and estimating the amount of herring on fishing grounds by echo sounding. In addition to supplying data of value to the research, the last-named phase of the investigation provides for the use of the industry information on the presence or absence of fish in various localities. The results of the adult studies also serve as a basis for prediction of herring abundance and general size of herring in the major populations.

Studies on the early stages of the herring life history, carried out principally on the west coast of Vancouver island, are also related to the practical projects mentioned previously. They include studies on spawn survival, and on survival and distribution of larvae and juveniles. An ultimate object of these phases of the research is to study as intensively as possible successive year-classes from the time they are deposited as eggs on the spawning beaches until they enter the fishery as maturing fish. It seems probable that these studies will reveal the most vulnerable stage or stages in survival, thus permitting more accurate prediction than is now possible of recruitment and hence population abundance. By providing data on such "fundamental" studies as relationship between spawn deposition and recruitment, minimum amount of spawn for maintenance of the stocks, and factors affecting year-class survival these studies will have a direct bearing on the investigation designed to determine the most efficient system of herring management.

In this Appendix the results of the 1949-50 studies as outlined in foregoing Appendices are briefly summarized on the basis of principal lines of investigation. The Appendix will be concluded with a section on future plans of the herring investigation.

Adult studies on the west coast and lower east coast populations

The 1949-50 fisheries

The 1949-50 catch on the west coast (37,300 tons) was the smallest in the four-year period of the study, about 18,000 tons less than in 1948-49. Although one of the two major fishing areas (Area 23) produced a record catch the other (Area 25) had a very small fishery. Fishing effort was higher and availability was lower than in the previous year. The January catch was the smallest in recent years. Data over a six-year period indicated that in seasons when average January temperatures were low, post-Christmas catches were small, suggesting that low inshore temperature may be a factor preventing herring from migrating into the inlets and causing those that had migrated inshore to move offshore out of the range of the fishery.

The 40,000-ton quota on the lower east coast was taken without difficulty but more fishing effort was expended than in the previous year.

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Late commencement of the fishery for the second successive year apparently allowed incoming schools to move well into the sub-district, with the result that practically all of the catch was taken in Areas 14B and 17.

Tagging studies

The reduced catch on the west coast appeared to be primarily responsible for the smaller number of tags recovered by tag detectors (40 per cent less) and by plant crews (66 per cent less). Analysis of both detector tag returns and plant recoveries suggested that a much greater percentage of fish migrated into and out of the west-coast sub-district in 1949-50 than in the previous year. Reasons to account for the greater movement were lacking. As in past years the interchange of fish between the west-coast and the lower east-coast sub-districts was found to be greater than between the west coast and any of the other sub-districts.

Considerable mixture of fish again occurred between the different west-coast areas. Most of the movement along the coast took place in a south-easterly direction. The tendency for more fish to move south-easterly than north-westerly along the coast was found in three of the four years of the present study. Tags which had been out about two years showed greater dispersal than those which had been out less than a year.

Tag recovery data indicated that the rate of exploitation on the west coast was much less in 1949-50 than in the previous year. The initial population abundance was estimated to be considerably larger than in 1948-49. This corroborates results from age composition and spawning studies which suggested that part of the northern west coast stocks was not available to the fishery.

A total of 26,656 fish was tagged on the west coast, and 9,172 on the lower east coast in the spring of 1950. About 22 per cent more fish were tagged in each of these sub-districts than in the previous year. Tagging was better distributed between the various west coast areas in 1950 than in 1949.

Age composition studies

The 1947 year-class (III-year fish) constituted about two-thirds of the herring in the fishing and spawning samples of both populations. It was about equally dominant in the area catches and spawning runs of the two sub-districts. On the west coast it appeared that the 1947 year-class was considerably more productive than the 1946 year-class, and that its abundance was probably similar to that of the 1943 year-class. The fact that a very small fishery developed in Area 25 suggested that a portion of the northern west-coast runs had not come inshore during the fishing season.

The 1946 year-class was considered to have been more productive than the 1947 year-class on the lower east coast. The smaller recruitment of the 1947 year-class appeared to have resulted in increased fishing effort and lowered availability in 1949-50.

Extent and intensity of spawn depositions

Spawning-ground studies also indicated that the population in the northern part of the west coast was not as low as the small fishery in Area 25 might suggest. Extent of spawning in Area 25 was at least as great as it was in the preceding year. For the west coast as a whole it appeared that the general level of spawning established in the preceding three years

was maintained in 1950. Area 27 was the only area which showed a significant decrease in spawning. This was considered to indicate a decrease in the extent of the local runs, caused by a relatively poorer survival of the 1947 year-class in that area than in the areas to the south. Evidence from the age composition of a spawning sample from Area 27 supported this view.

On the lower east coast spawn deposition recorded in 1950 was 28 per cent less than that found in 1949. An even greater decrease in spawn extent was recorded recently in the Queen Charlotte islands population where fishing had not taken place for several years. The deposition of spawn in 1949 was only about 35 per cent of that recorded in 1948. In a paper published in 1947 Professor J.R. Dymond pointed out that marked decrease in population abundance is frequently encountered in many animal groups. He suggested that emigration or disease might be causative factors. With reference to the herring populations concerned, no evidence of disease has been apparent. It also appears improbable that emigration could explain the situation. Although movement of lower east-coast fish to the west coast appeared to be relatively high in 1949-50, migration of west-coast fish to the lower east coast was also higher than in previous years.

Implication of results on management studies

Relatively good year-class survival has resulted in high population abundance in both populations in the first four years of the present study. On the lower east coast a relatively large 40,000-ton quota has been readily taken in each year. In 1947, 1948, and 1949 the size of the lower east-coast spawning population appeared to increase, but in 1950 it suddenly decreased by an amount which cannot be readily accounted for by the fixed catch. Over the same period large catches were made on the west coast (ranging from 37,300 to 59,000 tons), and the size of the spawning population has remained relatively uniform. On the basis of past studies on spawning extent and resultant recruitment the level of west-coast spawning in recent years appears to be great enough (probably unnecessarily large) to ensure that the extent of spawn deposition will not be a limiting factor in year-class survival. Hence the results of the present investigation suggest that with large recruitment from a succession of good year-classes, fixed quotas may lead to abnormally high population abundance which can be vulnerable to diminution by "natural" factors, whereas lack of quota restrictions tends to allow the fishery to keep the size of the population in check.

It is emphasized that these indications are not conclusive and that they require further investigation. The extent of the present decline in the lower east-coast population is expected to be more apparent when the 1950-51 data become available. Among other organisms abrupt declines have been observed to follow peaks of abundance, and the lower east-coast herring may be presenting a similar picture. However, at least one more example of this sequence will be necessary to determine precisely the effect of over-population on future abundance of the stock.

This tentative conclusion has a direct bearing on the practical object of the investigation. If additional support to these present indications is given by results of future study, quota regulations on catch will appear unnecessarily restrictive in periods of high population abundance. This could possible mark a first stage in the progress of the

long-term investigation in which herring research is engaged.

Two further steps appear essential to the completion of the study. It will be necessary to determine the conditions obtaining in the two populations when population abundance is reduced by recruitment of a series of less productive year-classes. Also, the general applicability of the conclusions to the other herring populations of British Columbia will require careful consideration.

Adult studies on other herring populations of British Columbia

The 1949-50 fisheries

The total British Columbia herring catch in 1949-50 was 183,200 tons, about 6,000 tons less than the record catch taken in the previous season. All quotas were reached except that in the upper east-coast sub-district. It was about 1,000 tons short of fulfilment by the end of the fishing season. Quota extensions of 4,000 tons and 10,000 tons were taken in the middle east-coast and northern sub-districts, respectively.

Tagging studies

Tag-recovery data again indicated that considerable mixture of fish takes place between the middle and lower east-coast populations. Movement of west-coast fish to the northern and central sub-districts appears to be small. Fish of Area 27 accounts for most of the latter migration.

The study of herring emigration from the northern and central sub-districts was initiated in 1950 with the expansion of the tagging programme into northern waters. A total of 14,542 fish was tagged in Areas 5, 6,7, and 10.

Age composition studies

The 1947 year-class (III-year fish) dominated not only the fishing and spawning runs on the west- and lower east-coasts of Vancouver island, but also those of all other major populations in 1949-50. On the middle east coast it constituted about the same proportion of the population as on the west coast and the lower east coast. In the northern sub-district and the main offshore runs of the central sub-district, the year-class was generally less abundant than in the south but in these areas it formed at least half of the fishing stocks. The 1944 and 1945 year-classes made above-average contributions to most of the northern and central runs, and the 1946 year-class was poorly represented in the north. The local inshore runs of the central sub-district and an appreciable proportion of the upper east-coast runs were dominated by II-year fish of the 1948 year-class. The age composition of two herring samples from the Queen Charlotte islands showed a large age-spread, presumably resulting from the lack of fishing in the area. The 1946 year-class was dominant, forming about 30 per cent of the fish. The 1944 year-class was still well represented, but the 1945 year-class was apparently of below-average strength.

The exceptionally strong representation of the 1947 year-class in practically all major populations is noteworthy. Possibly the factors affecting survival in the early life history were unusally favorable in 1947 along the entire coast of British Columbia.

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Extent and intensity of spawn depositions

In the spring of 1950 more spawn was deposited in all sub-districts than the previous year, except in the lower east coast of Vancouver island and the Queen Charlotte islands. In the former sub-district the decrease in spawning was discussed previously. About the same amount of spawn was deposited along the Queen Charlotte islands in 1950 as in 1949.

Early life-history studies

Spawn studies

Studies on the survival of spawn are being pursued along two main lines. One phase attempts to determine the amount of spawn eaten by birds. At the present time predation by gulls is being investigated. In 1950 two experiments were carried out. One experiment (data from the other are not yet analyzed), conducted under exceptionally favorable conditions of study, showed a progressive reduction of spawn in the plot exposed to birds, but indicated that practically no diminution occurred in the protected plot. The data suggested that the particular spawning deposition investigated suffered about 90 per cent mortality above the zero tide level. Some of the difficulties in technique experienced in previous year's studies were overcome in 1950.

Another phase of the spawn studies is directed to assessing the amount of dead eggs on the spawning grounds. The average percentage of this "natural" mortality was again found to be small.

Larval studies

Studies on the distribution and abundance of larvae were continued in 1950 for the fourth successive year. Studies were conducted in most of the major west-coast broods from hatching to metamorphosis. Special studies on vertical distribution and on abundance at different times of the day and night were carried out at a field station in Area 23. In addition, the distribution of larvae in the western section of Area 23 was intensively studied in connection with an oceanographic survey of the area. The purpose was to determine the effect of currents on larval dispersal. It is planned to analyse the larval data during the winter of 1950-51.

Juvenile studies

A major study of the juvenile stage of herring was begun in the summer of 1950. At the time of writing (August, 1950) the field work is still in progress. The immediate objective of this phase of the work is to study the abundance, distribution, movements, and growth of juvenile herring. It seems possible that knowledge of the survival of herring during the first summer might be indicative of year-class strength at the time of recruitment to adult stocks.

Plans for research in 1950-51

It is considered that the general aim of herring research in 1950-51 should be the continuation of the present lines of study with strict adherence to the present major objectives. Continued emphasis will be placed on the improvement of techniques for collecting data, so that (1) in some cases more data can be collected, (2) more accurate data may be obtained, and (3) that data may be collected more efficiently. To this end efforts will be made to improve further (1) the accuracy and completeness of pilot house records on catch, (2) the efficiency of tag detectors and

magnets, (3) the quality of records on tag returns from reduction plants, (4) the efficiency of tagging methods, (5) the distribution of tagging, (6) the adequacy of the sampling programme, and (7) the accuracy of the assessment of spawn depositions.

It is planned to continue the spawn studies on bird predation and on "natual" mortality for another year on the same basis as in 1949-50. It is considered that by 1951-52 it should be possible through methods learned by experience to expand the bird predation studies to obtain data more representative of the west coast as a whole. Plans are also being developed to carry out experimental work on the factors which cause "natural" mortality on the spawning grounds. A beginning may be made in the spring of 1951 on this study. Another new line of study in spawn research is contemplated for the spring of 1951. It is planned to make a preliminary study on factors affecting the movement of herring towards the spawning beaches. Information on this problem might explain why herring sometimes forsake customary spawning grounds for new localities, why typically early and typically late spawnings are generally limited to certain well-defined localities, and what the "trigger action" is involved in causing spawning to take place. What bearing have temperature, salinity, presence of suitable substrate, light, etc., on time and place of spawning? Information on this problem might explain why herring are sometimes found in late spring and summer unspent.

Plans for future larval research in the spring of 1951 will largely depend on the complete analysis of the four years of data now on hand. The immediate task is to determine what conclusions on larval survival may be drawn from the data. This will suggest in what direction the study should be continued.

Likewise, future plans for the juvenile studies must await the completion of the first year's work and the analysis of the data.

The need of a suitable vessel devoted exclusively to herring research is again emphasized.

K.S. Ketchen Appendix No. 61

THE GROUNDFISH INVESTIGATION

The groundfish investigation has as its ultimate objective the definition of the principles governing the abundance of those species which contribute to the otter-trawl and line fisheries. Obviously, such principles cannot be defined until the abundances themselves have been accurately defined. It is towards this more immediate objective that the main attention of the investigation is now being directed.

At its incipience the investigation was severely hampered by an almost total lack of previously conducted research either on the biology of the species involved or on their fisheries. The problems have been vastly complicated not only by the intricate actions (and interactions) of the many species and populations but by the highly selective and versatile action of the gear used to fish for them. Because market demand has had such a pronounced effect upon the quantities and types of fish taken, the prediction of the course of the fishery during the relatively unstable war and post-war period was rendered very difficult. Launching the investigation from a very broad base was the only logical course.

Through this general survey substantial advances have been made in the standardization of common names of species caught, the location of the important areas for each species, the tabulation of catch and effort, and in the study of movement and distribution of population. As information continues to accumulate it is becoming more and more clear which areas and species are proving to be of most consistent importance. Judicious narrowing of the investigation to these species and areas now appears necessary and such specialization in certain subjects is taking on increasing importance.

The major trawl fishery occurs in the open waters of the coast, in Hecate strait and off the west coast of Vancouver island. Accurate description and understanding of the dynamics of populations in these areas requires repeated and thorough survey. However, because of the vastness of these areas and the severe weather conditions which prevail throughout the greater part of the year, satisfaction of this requirement is rendered almost impossible. Although much information has been accumulated, large gaps in the life histories of the more important species still exist. For example, the major spawning grounds of almost all species on the open coast are still to be located. Without this information, the logical basis for correlation of oceanographic conditions with the fluctuations in the strengths of year-classes, is lacking.

While the investigation of open waters continues on a very broad basis, considerably more time is being devoted to the population problems in the strait of Georgia. If the annual catch in this area is compared with that in outside waters such attention would appear unjustified. However, there are two reasons for this part of the programme: (1) The restricted area of the strait and its more favourable weather conditions permit of much more thorough and frequent sampling. Thus the problems surrounding the factors involved in migration and fluctuations in availability and abundance can be given far more detailed study, the results of which may contribute much to the understanding of the conditions in the more inaccessible areas. (2) Through the recommendations made in 1946 many of the trawling areas in the strait were closed to trawl fishing in order to eliminate or greatly reduce competition with other types of gear.

K.S. Ketchen

Many of the recommendations were, of necessity, without sound biological basis and consequently the resulting regulations have been considered open to modification. Some of the more important of these areas are being made the subject of investigation to show whether the regulations are in keeping with the greatest production.

The various phases of the investigation are outlined under the following headings:

The collection of catch records

Continued improvement has been made in the coverage of landings at the important ports (Appendices 62 and 63). During the year ending October 1, over 1,500 trip reports from trawlers, 500 from trollers, and 100 from longliners were made out by the contact men. Certain minor ports in the middle coast region are at present being missed, but this gap will be closed as soon as the Department's recently introduced sales slip system is extended to cover the whole province. The accumulation of information on trends in catch per-unit-of-effort (Appendix 64) is continuing and critical analysis in an attempt to refine these data is about to begin. Through the co-operation of the Washington State Fisheries Department great strides have been made in obtaining data on how much fish and what kinds of fish are being caught by American vessels operating off the British Columbia coast (Appendix 65).

Tagging

Tagging operations on all fishing grounds have been in progress for the past six years and have been directed towards the establishment of population identity and the description of migration routes and mortality rates due to fishing and natural causes. In 1950 about 8,780 flatfish were tagged and 9,400 were marked (Appendices 66, 67, 75, and 77). On a smaller scale tagging of certain roundfish species has been continued (Appendix 81). With the development of more suitable tagging methods for roundfish this phase of the programme will be increased considerably.

Studies based on the recovery of tags are given in Appendices 67 to 70 inclusive. The close agreement of natural mortality rates calculated from tagging (Appendix 69) with those calculated from age distributions (Annual Report 1947, Appendix 62) strengthens the conclusion on minimum size limits for optimum catch as proposed in the 1948 report (Appendix 34).

Sampling of catches

During the year ending October 1, over 66,000 otolith samples were collected by the port observers and by the personnel attached to the "Investigator No. I". In addition, 29,500 measurements and 1,200 stomach samples were collected. Age and length studies to determine growth rates and the extent and effects of fluctuations in the strengths of year-classes are under way in connection with three or four of the more important species of flatfish (Appendices 72, 73, 74, 76, 78, 79, and 80) and with the more important roundfish (Appendices 82, 85, 86, and 87). There is evidence of great fluctuation in the year-class strength of Hecate strait flatfish and there appears to be an agreement between species with respect to the dominant year-classes.

K.S. Ketchen

Gear experiments

The study of the selective action of nets of various mesh size, has long been regarded as an important phase of the investigation, but until this year lack of sufficient funds has prevented its development. To supply an answer to the increasing problem of the destruction of small flatfish in Hecate strait, nets with cod-ends of different material and mesh size have now been constructed. Experiments will begin early in November.

Along different lines the gear experiment phase of the investigation has extended into the study of gear efficiency (Appendix 89) and in deep water exploration (Appendix 90).

Personnel

Fourteen persons in addition to the four crew members of the "Investigator No. I" have been associated with the groundfish investigation. Their names and main responsibilities within the investigation are listed as follows:

W.E. Barraclough: On educational leave since February, 1949. Determination of the age and growth of the brill.

W.A. Boak: To May 1. Part-time sampler in Vancouver.

Fay V. Collins: Typing and secretarial duties for groundfish investigation (also tuna and whale).

C.R. Forrester: Field technician. Tabulation of catch records, lemon sole otolith reading.

J.L. Hart: To April 1, in charge of groundfish investigation.

R. Karjala: From May 1, sampler in Vancouver, part-time from October 1. Age and growth determination of blackcod.

K.S. Ketchen: From April 1, in charge of groundfish investigation. Otolith, tagging, and general life-history studies of lemon sole.

J.I. Manzer: Tagging techniques, general tagging programme, lingcod life-history studies.

J. Mitchell: From May 1 to September 1 - senior research assistant aboard "Investigator No. I". Tabulation of tag recoveries.

D.G. Odlum: Contact of fishing vessels landing at Victoria. Sampling of catches (groundfish and tuna).

Ruth I. Peterson: From January 16. Age and growth studies on rock sole and gray cod. Special research assignments for the Director.

W.G. St. Clair: Contact of fishing vessels landing at Prince Rupert. Sampling of groundfish and tuna catches.

K.S. Ketchen

R.M. Wilson: Contact of fishing vessels landing at Vancouver. General liaison with industry at production level.

N. Yates: During May. Assistance in tabulation of catch records and tag recoveries.

Activities of the research trawler "Investigator No. I"

The trawl investigation was without the services of the "Investigator No. I" from June 1949 until February 1950 because of a lay-up for major repairs. To minimize this loss and its effect upon important population studies, the commercial trawler "Phyllis Carlyle" was chartered during November 1949 for sampling and tagging work in the Baynes sound-cape Lazo area.

Following the return of the "Investigator" late in February she was engaged in the following field operations which, between February and October, involved over 1,000 running hours and over 200 effective drags:

Period	Project
Feb 24 - Mar 4	- Tagging and sampling in the Baynes sound-cape Lazo area.
Mar 10 - Mar 24	- Continued sampling at cape Lazo. - Deep water dragging experiments. - Construction of new nets.
Mar 27 - May 2	- Tagging and sampling in Hecate strait.
May 9 - May 14	- Dogfish studies at Fraser river.
May 16 - May 19	- Lingcod sampling in Baynes sound.
May 26 - Jun 10	- Summer painting and gear repair.
Jun 14 - Jul 3	- Tagging and sampling off west coast.
Jul 4 - Jul 26	- Annual vacation of crew and gear repair.
Aug 1 - Aug 17	- Sampling and tagging in Baynes sound area. - Deep water dragging experiments.
Aug 24 - Sep 2	- Blackcod sampling off west coast.
Sep 5 - Oct 4	- Vessel on loan to Hecate strait crab investigation (trawl records collected incidentally).
Oct 5 - Oct 30	- Repairs and overhaul.

C.R. Forrester — Appendix No. 62

TABULATION OF TRAWL LANDINGS RECORDED ON TRIP REPORT FORMS

Trawl landings as recorded by the contact men in Vancouver, Victoria, and Prince Rupert, have until this year been summarized in two tables. One of these gave the total landing figures, while the other gave only those landings for which the amount of effort expended was known. In order to distinguish and compare more readily the major fisheries and areas, it has been considered advisable to dispense with this method of presentation in

favour of three tables for the areas Queen Charlotte sound and Hecate strait, west coast of Vancouver island, and strait of Georgia. (These figures are probably not complete.)

The statements of monthly fishing effort which have appeared in previous years have been excluded from these tabulations because they lack sufficient refinement to be of much value. A more detailed consideration of the subject of catch and effort appears in Appendix 64.

Trawl Landings from Queen Charlotte Sound and Hecate Strait*

	Lemon Sole	Rock Sole	Brill	Rex Sole	Dover Sole	Flounder	Gray Cod	Ling Cod	Rock Fish	Dog Liver
1949										
Nov	24	7	115	3	13	-	70	26	26	17
Dec	34	-	79	1	1	9	61	15	10	4
1950										
Jan	-	-	-	-	-	3	5	-	-	-
Feb	115	2	7	6	-	5	120	5	13	1
Mar	356	25	8	12	2	-	235	16	6	-
Apr	772	57	29	15	2	-	120	11	3	-
May	1,348	69	83	6	4	9	91	26	12	-
Jun	581	416	57	24	17	-	112	30	5	1
Jul	409	721	71	28	80	-	15	32	2	-
Aug	141	153	51	41	121	-	10	30	1	-
Sep	104	87	60	30	33	-	65	21	5	-
Total	3,884	1,537	560	166	273	26	904	212	85	23

*All weights given are in thousands of pounds.

West Coast of Vancouver Island*

	Lemon Sole	Rock Sole	Brill	Dover Sole	Flounder	Gray Cod	Ling Cod	Rock Fish	Skate	Dog Liver
1949										
Nov	1	1	7	2	1	11	3	2	1	2
Dec	2	1	-	-	1	8	-	1	-	-
1950										
Jan	-	-	-	-	-	-	-	-	-	-
Feb	3	4	-	-	11	30	-	-	-	-
Mar	2	2	3	-	16	4	1	-	-	-
Apr	12	13	13	-	2	109	9	2	4	3
May	8	20	241	11	8	140	134	4	8	10
Jun	10	50	314	2	11	57	283	15	4	7
Jul	3	18	329	3	1	60	365	3	4	7
Aug	2	15	214	2	-	43	206	-	1	10
Sep	3	6	73	62	-	25	72	16	3	9
Total	46	130	1,194	82	51	487	1,073	43	25	48

*All weights given are in thousands of pounds.

C.R. Forrester

Georgia Strait area - inside Vancouver Island*

	Lemon Sole	Rock Sole	Brill	Flounder	Gray Cod	Ling Cod	Rock Fish	Skate	Dog Liver
1949									
Nov	19	5	-	1	83	2	4	2	4
Dec	34	11	-	13	71	1	7	3	12
1950									
Jan	77	7	-	19	89	-	3	3	13
Feb	20	12	-	90	170	-	8	4	4
Mar	44	8	-	49	210	6	9	5	1
Apr	19	6	-	17	64	4	5	3	1
May	18	8	-	8	18	2	2	2	5
Jun	19	1	-	7	9	4	5	4	3
Jul	15	2	-	4	9	7	1	5	1
Aug	21	1	-	4	10	5	1	2	2
Sep	17	1	1	3	66	7	1	2	5
Total	303	62	1	215	799	38	46	35	51

*All weights given are in thousands of pounds.

C.R. Forrester

Appendix No. 63

A COMPARISON OF THE IMPORTANT TRAWL-CAUGHT SPECIES IN BRITISH COLUMBIA

	Catch in Thousands of Pounds									
Year	Lemon Sole	Rock Sole	Brill	Rex Sole	Dover Sole	Flounder	Gray Cod	Ling Cod	Rock Fish	Dog Liver
	786	2200	1174	30	501	194				
46 1947	637	1,783	952	24	406	157	751	298	81	304
47 1948	1,794	1,617	5,550	112	110	149	859	1,011	64	667
48 1949	1,337	1,337	2,763	127	122	183	1,447	1,891	103	587
49 1950	4,233	1,729	1,755	166	355	292	2,190	1,323	174	122

The brill in 1948 constituted 51 per cent of the British Columbia flatfish landings. Almost 50 per cent of that species was captured on the Oval hill bank in Hecate strait. The failure of the Oval hill fishery in the following year was responsible for the marked decline in the total brill landing for 1949.

The usually large lemon sole landings from the northern Hecate strait area early in 1950 are reflected in the total landing figure for that species which this year comprised 51 per cent of all flatfish landings.

The landings of rock sole, unlike those of brill and lemon sole, have undergone no major fluctuation over the past four years. Production of rex sole, rockfish, gray cod, and lingcod appears to be increasing. The sudden drop in dogfish liver landings in 1950 was mainly the result of a collapse in liver prices.

C.R. Forrester Appendix No. 64

AVAILABILITY OF THE IMPORTANT FLATFISH

The catch per-unit-of-effort tables for lemon sole, rock sole, and brill presented in the report for 1949 are again tabulated with the calculated figures for the 1950 fishery. For lack of a complete understanding of the many complex factors operating in the fishery, the figures must for the present be regarded as only provisional. Attempts are under way to determine the effects of such factors as price changes, shift in effort to other grounds, modifications in gear, etc., to learn the true relationship of this apparent availability to the actual availability.

Lemon Sole Availability (Pounds per Hour)

	1945	1946	1947	1948	1949	1950	
Hecate strait	1,152	821	708	549	542	1,037	797
Strait of Georgia	154	86	101	96	80	137	129

Both the Hecate strait and strait of Georgia fisheries show a higher return than in any year since 1945. The Two Peaks-Butterworth rocks fishery appears to be responsible for the jump in the Hecate strait figures.

The changes in the availability in the strait of Georgia are more difficult to explain because of the complications arising from the control of fishing by closed areas and season regulations introduced in 1947.

Rock Sole Availability (Pounds per Hour)

	1945	1946	1947	1948	1949	1950	1951	1952
~~Hecate strait~~ lbs per hour	728	812	1,022	810	1,214	1,440	1594	1537

The apparently high and increasing availability of rock sole in Hecate strait in relation to the other species of flatfish may be attributed partially to two factors:

(1) The rock sole is not exploited by Canadian boats to the same extent as the lemon sole, principally because the season for that species coincides with the salmon season which draws a certain number of boats away from trawling.

(2) As indicated in another summary report comparing the catches of Canadian and American trawlers, the Americans appear to have little demand for the rock sole.

Brill Availability (Pounds per Hour)

	1945	1946	1947	1948	1949	1950	1951
Northern Hecate strait	797	712	672	770	1,005	963	974
Southern Hecate strait	-	390	1,222	1,002	1,074	683	1143
Queen Charlotte sound	777	557	550	393	395	401	891
West coast of Vancouver island	194	290	364	391	399	408	305

Except in the southern Hecate strait fishery there does not appear to have been any major change in availability between 1949 and 1950. The slow rise in availability on the west coast of Vancouver island appears to be continuing. Overall trends in other areas are not as evident because of the greater fluctuations from year to year.

K.S. Ketchen Appendix No. 65

COMPETITION BETWEEN AMERICAN AND CANADIAN TRAWLERS OFF THE BRITISH COLUMBIA COAST

Through the co-operation of the state of Washington Department of Fisheries all of the available catch records of American trawlers operating off the British Columbia coast in 1948 and 1949 have been made accessible to this investigation. Without this information the knowledge of the trends, extent and potentialities of the groundfish resource, would be quite incomplete.

American trawlers have been fishing off the lower British Columbia coast since early in the second world war. By the end of the war they had extended their sphere of operation to the Queen Charlotte sound and Hecate strait area which is today the scene of the major trawl fishery. A comparison of the available figures for American and Canadian boats landing from the 300-mile stretch of coast between cape Scott on the northern end of Vancouver island and Dixon entrance at the northern end of Hecate strait is given in the following table. The weights given are in thousands of pounds.

Species	1948 Catch			1949 Catch		
	American	Canadian	Per Cent Canadian	American	Canadian	Per Cent Canadian
Lemon sole	602	1,640	73	1,421	974	41
Brill	2,329	4,514	66	2,442	1,476	38
Rock sole	170	1,207	88	30	1,229	98
Flounder	317	35	10	205	43	17
Rex sole	-	108	100	7	129	95
Lingcod	693	379	35	1,415	645	46
Blackcod	246	-	0	327	-	0
Gray cod	1,922	287	13	2,453	544	18
Rockfish	3,566	20	1	6,854	80	1
Total	9,845	8,190	45	15,154	5,120	25

The total catch of food fish was over 18,000,000 pounds in 1948 and over 20,000,000 pounds in 1949. In 1948 approximately 45% was taken by Canadian vessels as compared with 25% in 1949. About 68% of the flatfish landings were made by Canadian boats in 1948 while in 1949 they were about 49%.

Differences in the market demands of the two countries are very apparent. American fishermen have little interest in the rock sole and rex sole, but on the other hand have a far greater interest than Canadian fishermen in rockfish, gray cod, and flounder. The blackcod catches cannot be compared since American vessels are permitted to land small blackcod (generally the larger blackcod are not available to trawlers) while there are regulations in Canada preventing such landings.

Providing the stocks have suffered no major decline, it would appear that a very substantial rockfish (Sebastodes sp.) fishery could be developed by the Canadian fleet. However, the main rockfish grounds appear to be in the southern part of Hecate strait and Queen Charlotte

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sound, an area not at present frequented to any great extent by Canadian trawlers. About 34% of the landings of rockfish in the state of Washington came from the lower Hecate strait area in 1948 and 1949.

Figures on dogfish (liver) catches have not as yet been tabulated, nor have the catches from the fishing grounds off the west coast of Vancouver island.

K.S. Ketchen Appendix No. 66

THE LEMON SOLE TAGGING PROGRAMME IN HECATE STRAIT

With the view to obtaining a greater understanding of the movements and rate of exploitation of lemon soles in Hecate strait, a major tagging operation was carried out during April, 1950. Of a total of 3,960 fish tagged, 3,003 were released in the open waters of the strait on the main trawling grounds near the Butterworth and Warrior rocks. The remaining 957 were released in the inshore waters of Chatham sound and Tuck inlet near Prince Rupert.

Between April and the end of September 1,224 tagged fish or 41.4 per cent of the original number tagged on the outside grounds were recovered on the outside grounds. This is 29 per cent higher than the recovery from the 1945 tagging and may be attributed partially to the fact that the lemon sole remained available for a much longer period in 1950, but mainly to a very great increase in fishing effort.

With respect to the Canadian fishery, 746 tags were recovered from the catch of 1,300,000 pounds in May, 203 tags from 650,000 pounds in June, 88 tags from 290,000 pounds in July, and 14 tags from 150,000 pounds in August. The ratios of tags recovered to pounds of fish captured in those months declined from .006 to .0001, indicating either a more complete dispersal of the tags on the grounds, or recruitment, or both.

Of the 1,244 tags recovered from the tagging off the Butterworths and Warriors, 278 or 23 per cent were recovered on the Two Peaks grounds some 20 to 30 miles from the area of tagging. This extensive north-westerly movement in the spring months confirms the findings of J.I. Manzer, reported in previous Summary Reports.

American vessels contributed 40 tags or 3.2 per cent of the total recovery in the months under consideration. Their fishing operations were confined almost entirely to the Two Peaks area, which probably accounts for the much lower recovery. Less than a week after the commencement of tagging off the Warrior rocks, American vessels reported by radio their first recoveries on the Two Peaks grounds. It would appear then that the rate of migration of some individuals or schools may be as much as four or five miles per day.

In view of the possibility that some 1950 recoveries are still to be reported, particularly from American vessels, a more detailed study at this time is considered inadvisable.

The supplementary tagging of lemon sole in the inshore waters had as its purpose to determine whether or not those fish contributed to the main spring run in the open strait. To the end of September none of those

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tags had been recovered by the commercial fleet. However, the returns from another year will be required before any conclusions can be drawn. In a test drag by the "Investigator" in August in one of the inshore tagging areas two tags were recovered.

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Appendix No. 67

THE LEMON SOLE TAGGING AND MARKING PROGRAMME IN THE STRAIT OF GEORGIA

Since November of last year 3,680 tags and 9,400 marks have been released in the Baynes sound - cape Lazo area along the east coast of Vancouver island. The majority of these were liberated from the chartered vessel "Phyllis Carlyle" during the month preceding the opening of the cape Lazo area for winter fishing. The purpose of this experiment was to make estimates of population sizes and rates of exploitation and to gain some understanding of the relationship of the Baynes sound population (in a closed area) to that off cape Lazo (in an open area).

Population estimates

By the time the cape Lazo fishery had opened, 840 tagged fish and 2,400 fish marked by the removal of one of the pectoral fins had been released on the grounds. The fishermen were depended upon to report the recovery of tags but the recovery of marks was carried out by shore observers and samplers. A total of 170 tags was recovered during the eight-week open period and of 12,070 fish examined from the catches landed at Vancouver, 125 were marked. From these recoveries estimates were made of the population of commercial-sized fish which was present on the grounds during three periods of the fishery. In the following table estimates made from both tags and marks are compared with availability as determined from catch records.

	Period I	Period II	Period III
Availability (lbs. per hour)	65	270	190
Population estimated from: 1. Marks	148,000	392,000	320,000
2. Tags	177,000	300,000	380,000

The population trend over the three periods as shown by mark returns agrees very closely with the availability trend, whereas that from tag returns does not. This difference has been attributed to the marked difference in sex ratio in the two groups of fish used for tagging and marking. Sampling studies have in the past indicated that male fish arrive on the grounds before females and that they do not leave as quickly. Since 95 per cent of the marked fish were males, as compared with 71 per cent in tagged fish, it might then be expected that the estimates from marks would show closer agreement with the availability trend.

A rough estimate of the rate of exploitation as determined from marks was 23.6 per cent as compared with 20.7 per cent from tags. If only tagged male fish are considered, the latter figure is increased to 22.8 per cent. If the female lemon soles move off the grounds more quickly than the males the estimated rate of exploitation will be greater when the females are excluded from the calculations.

Migration

The trawl operators are of the opinion that the lemon sole population in Baynes sound is resident, and therefore, because of the complete closure of that area, it is being allowed to go to waste. In order to determine the truth in this contention tagging and marking were carried out in Baynes sound at the same time as the tagging operation in the adjacent cape Lazo area.

Of the 194 tags recovered on the cape Lazo grounds during the winter fishery of 1949-50, 19 had been released in the same region during the 1948-49 season, and 170 had been released during the two-week period just prior to the 1949-50 season. The remaining five tags had been released in the adjacent waters of Baynes sound. One month after the close of the cape Lazo fishery two out of five tags picked up by the "Investigator" in the course of a day's dragging were from Baynes sound.

Since only five of the 1,500 tags released within Baynes sound were recovered during the course of the fishery, it would certainly appear that the contribution, during the December-January period, is very slight. However, there are suggestions that the same may not be true after that period. The fact that four of the five tags recovered by the fleet were picked up in the last week of January and the reporting of several Baynes sound tags from above cape Lazo in March and April, suggests that a more substantial exodus of fish from Baynes sound occurs after the fishing season closes.

The amount of movement in the other direction from the cape Lazo grounds into Baynes sound is more difficult to assess because of the differences in likelihood of capture (fishing effort) in the two areas. A total of 440 hours fishing in the cape Lazo area by the commercial fleet may be compared with 9 hours fishing by the "Investigator" in Baynes sound. In February, 4,500 lemon soles were captured by the "Investigator" at various stations in Baynes sound. Twelve tags and 26 marks were recovered, of which two tags and one mark were from the cape Lazo ground. The other tags and marks showed a very pronounced southerly movement in the sound, that is, away from the cape Lazo ground. In contrast with the condition in November, no significant numbers of fish were encountered in the vicinity of the Comox bar (which lies between Baynes sound and cape Lazo) during February. However, by April that area was once again occupied. It would appear that if any sizeable outward movement takes place it is in the late winter or early spring, and if any inward movement occurs it is in the late fall.

K.S. Ketchen Appendix No. 68

STUDIES OF THE FACTORS INVOLVED IN LEMON SOLE MIGRATION AND DISTRIBUTION

Although the description of the movements and distribution of the lemon sole on the various fishing grounds of the coast is still incomplete, attempts are underway to determine the factors which direct and limit these activities. Such information can be of very considerable value in the interpretation of the often times violent fluctuations in availability of the important species.

For the present year the study has been confined mainly to the cape Lazo area because more is known about the fish movements in that area than in other areas and because it is possible to keep the area under fairly frequent observation. The commercial fishery in the winter of 1949-50 unlike that of 1948-49 which met with moderate success throughout its duration, failed to materialize until late in January. That water temperatures were higher at the time the 1949-50 fishery began may be significant, for if the rate of maturation of the lemon sole is dependent on the rate of decline in water temperature in the fall, then it is possible that the higher water temperatures in 1949 may have delayed the arrival of the fish on the grounds.

Sharp increases in availability were noticed to occur after two strong gales in mid-December and mid-January. These gales could have affected the fish either by direct mechanical disturbance or by their effect upon the temperature structure in the water. Mature female fish, which until January had not appeared on the regularly trawled grounds (40-45 fathoms) were located early in December around the periphery of the ground in shallower water (20 fathoms). The mixing of the cold surface layers with the deep layers as a result of the storm may have provided the stimulus which directed the females down into the deeper water where they became available to the fishery.

Within Baynes sound the female fish moved into the deeper waters of the channel from the shallow Comox bar flats as the spawning season approached. In February and March only spent fish inhabited the shallower waters. With increase in depth more and more spawning or ripening fish were encountered.

During February and again in April a large number of bathythermograph records was taken over a wide area of Baynes sound, cape Lazo and their approaches in an attempt to discover the reason why the lemon soles were concentrating in the upper end of the cape Lazo bight and in the deeper regions of Baynes sound. Under first analysis of the bathythermograph slides there were strong indications that the lemon soles were congregating in regions of warmer temperature. However, when the slide temperatures were recorded without the use of a surface temperature, the relationship was more or less destroyed. It was then believed that the surface temperatures were being distorted by strongly stratified layers of fresh water. In view of these deficiencies the bathythermograph is now being replaced by the reversing thermometer for obtaining bottom temperatures.

During the winter of 1950-51 assistance is to be obtained from the Pacific Oceanographic Group in the collection of data on currents and salinity and further data on temperature structure.

J.I. Manzer Appendix No. 69

MORTALITY RATES IN LEMON SOLE AS DETERMINED FROM TAG RETURNS

Knowledge of rates of growth and mortality is essential for the determination of optimum yield. One of the methods by which these rates can be assessed is by tagging. Application of this method has already provided data on growth rates (Annual Report 1948, Appendix No. 40) but it has not been until this year that data have become adequate for estimating mortality rates. The estimates are for northern Hecate strait lemon sole.

Tagged fish, released in 1945 and recovered in subsequent years, have been used in this study. The calculations have been based on the numbers of tags which would have been recovered had fishing and natural mortalities remained constant from year to year, and on the assumption that untagged and tagged individuals die at the same rate, once the latter have recovered from the shock of tagging. With the exception of 1947, when a serious reduction in fishing effort resulted in only a few tags being recovered, the conditions are believed to have been approximated. The departure in 1947 is minimized, however, by weighting-up the recoveries on the basis of data for normal years.

Logarithms of the number of tags recovered have been plotted against the year of recovery. The logarithms were found to lie along a straight line which by the principle of least squares was found to have a slope of -0.359 log-units per year. This slope converted to a natural logarithmic value represents the total instantaneous mortality rate (.826), and which has fishing and natural mortality as its components. Since the instantaneous fishing mortality rate is the ratio of the expected number of recovered tags before natural mortality is operative to the number of tags put out (1,305), the expected number of tags was calculated to be 447 (antilog 2.65), a value of .342 was computed. The instantaneous natural mortality rate then is .484. Using formula derived by Ricker (1944), the instantaneous rates were converted to seasonal mortalities and these were found to be as follows: Total mortality = 56.2%, natural mortality = 38.3%, fishing mortality = 29%. The seasonal natural mortality rate is in close agreement (38% as compared with 35%) with that determined from age-group analysis. This is the only mortality for which rates are available for comparison.

J.I. Manzer Appendix No. 70

SURVIVAL OF TAGGED FLATFISH

Tagging experiments and observations carried out in 1947 along with subsequent recoveries have provided data on the survival of tagged fish which when released exhibited varying degrees of discomfort and distress. Information of this type is essential if accuracy of estimates based on tag returns (mortalities and fishing intensity) is to be increased. At the time of tagging the apparent condition of each tagged fish was recorded either as "certain" or "doubtful", depending upon its ability to descend. Data have been obtained for lemon sole, rock sole, and brill, each of which was tagged under favourable field tagging conditions.

J.I. Manzer

Certain assumptions have been made regarding the use of the data for this purpose, and the validity of the results is dependent upon their accuracy. Once the factor of condition ceases to operate, which is assumed to be after readjustment of the fish has been accomplished and which should occur in a relatively short time, natural and tagging mortality in both categories is the same for fish of corresponding size. Also, the differential total mortality rate which might exist between fish of different size-groups need not then be considered as it will be the same for both categories. The difference, therefore, between the number of "certain" and "doubtful" recoveries would be a measure of the influence of condition upon subsequent recovery, and is in reality a measure of a type of mortality.

Chi-square values, corrected for continuity, have been determined for each species and with the exception of brill the difference in the mortality between fish of different condition does not exceed that which would be expected by chance alone. For brill, the mortality of "doubtfuls" was found to exceed the expected rate by 75 per cent.

K.S. Ketchen

Appendix 71

THE CAPE LAZO AND NANOOSE BAY FISHERIES OF 1949-50

In 1947 most of the trawling areas in the strait of Georgia were closed to trawlers in order to eliminate or greatly reduce their competition with hand-liners in the fishery for lingcod. Because of severe fresh fish shortages in Vancouver in the following winter it was recommended that some of the areas be reopened on an experimental basis. The main purpose of the experiments was to determine whether or not the trawlers could utilize available stocks of sole, gray cod, and dogfish without undue destruction of lingcod. The cape Lazo and Nanoose bay grounds have been opened for three successive winters on this restricted basis and it is now fairly obvious that not only the capture of commercial-sized lingcod but the destruction of undersized lingcod is of little significance. There is considerable agitation afoot for an extension of present boundaries and periods, but sufficient evidence to qualify such modifications is not as yet available.

In addition to the obsevations on lingcod, studies are being made of the kinds, quantities, and condition of the other species which go to make up the main fishery. Special log record forms have been issued to the fishermen during the past two season in order to obtain data on catch per-unit-of-effort. The catch of lemon sole in the 1949-50 season was 54,000 pounds as compared with 48,000 in 1948-49. However, 70 per cent of this poundage was obtained during a ten-day extension of the fishery. The average availability for the open period was 140 pounds per hour as compared with 160 pounds in the previous year.

The December-January fishery at Nanoose bay in 1948-49 was an almost total failure. In an effort to remedy this situation the dates for the fishery in 1949-50 were advanced to February and March. During that period 145,000 pounds were landed. The average hourly catch was 285 pounds as compared with 190 pounds in the same period two years previously.

K.S. Ketchen

In the first year of restricted fishing the cape Lazo area was opened quite late in the spawning season with the result that the fish were thin and therefore undesirable for filleting. It was reported that only 28 per cent of the weight of fish landed was recovered as fillets; that is 21,400 pounds. During the 1949-50 season which was open before the main spawning had got underway, the recovery from the 54,000 pounds was 36 per cent or 19,500 pounds, or only 2,000 pounds less than that recovered from the much larger catch of 1948. This may serve to illustrate the undesirable effect of delaying the opening of a fishery which depends upon a run of fish which are about to spawn. If the fishery is opened at a later date there may be more fish captured, but, as a result of deterioration from spawning, there is not a proportionate increase in usable fish flesh.

K.S. Ketchen Appendix No. 72

THE RESULTS OF THE CAPE LAZO AGE SAMPLING PROGRAMME

The results of age determinations reported in the 1949 summary report (Appendix 35) showed that the lemon sole taken in the winter of 1948-49, although larger than those taken in the previous winter, were actually of younger age. Such irregularities may arise in two ways: (1) since the fish segregate on the grounds according to size and depth, any major shift in fishing effort to different depths would have a substantial effect on the size distribution of the fish; (2) the schools of fish which arrive on the spawning ground may be distinctly different from other schools with respect to age and size for reasons of differences in growth conditions on their summer feeding grounds. Singly or together these two factors create a serious problem of obtaining samples which will give a general picture of the changes which occur in the population from year to year.

During the winter of 1949-50 a more intensive study was made of this sampling problem. Just prior to the opening of the fishery, samples were collected from three depths, 36 fathoms, 39 fathoms, and 42 fathoms, which cover the main trawling area. The age distributions found in each sample is given in the following table. The female fish were very poorly represented in all samples and therefore have been excluded.

	Age Frequency (%)								
	III	IV	V	VI	VII	VIII	IX	X	Total
36 f.	1.1	18.0	25.1	23.7	16.8	6.6	6.9	1.4	421
39 f.	1.0	9.6	18.5	30.1	27.4	8.6	3.9	0.5	404
42 f.	2.3	16.1	12.7	21.3	24.1	16.5	5.2	0.9	211

With increase in depth the modes have shifted (with some overlapping) from V through VI to VII years. The average lengths of these samples were 308 mm., 320 mm., and 317 mm., respectively with modes moving from 305 mm. to 315 mm. to 330 mm. The movement of the length modes agrees more closely with the movement of age modes than with the changes in average size. Nevertheless, the discovery of such a high degree of heterogeneity

makes the interpretation of the samples collected from the commercial fishery which occurred in the same area shortly thereafter, very difficult.

The commercial fishery which lasted for eight weeks has been divided into three periods. Several samples were collected from the landings during each of these periods. The results of the readings are tabulated below.

	Age Frequency (%)									
	III	IV	V	VI	VII	VIII	IX	X	XI	Total
Period I										
Male	2.6	14.0	22.8	34.4	15.5	8.1	1.7	0.9	-	663
Female	3.4	17.2	27.6	25.9	10.9	9.8	4.6	0.6	-	174
Period II										
Male	0.3	20.2	28.3	19.6	18.9	7.5	5.3	-	-	322
Female	1.9	27.8	23.6	19.3	14.6	7.5	3.3	1.4	0.6	212
Period III										
Male	2.6	21.1	26.8	25.8	15.0	6.6	1.9	0.3	-	1,292
Female	1.9	16.7	26.4	22.0	14.6	10.8	6.1	1.2	0.3	576

From Period I to Period II the mode in male fish shifted from VI-year-olds to V-year-olds while in female fish the mode shifted from between V and VI to IV. Yet this decrease in modal age directly contradicts the sharp increase in size which occurred at that time. The average size of males increased from 319 mm. to 328 mm. while in females the increase was from 374 mm. to 390 mm.

In Period III the average size of male fish returned to 318 mm. while that of females remained about the same. Yet the modal age-group, particularly in female fish, shifted to older age-groups somewhat similar to the condition in Period I.

It is conceivable that these seemingly contradictory observations could have been entirely the result of a shifting fishing effort or a shift in the position of the fish at the various depths. However, the phenomenon was undoubtedly more complex. Coincidental with the abrupt displacement of the mode in the age distribution to a younger year-class in Period II was the sudden increase in availability from 65 pounds to 225 pounds per hour. It has been more or less confirmed from other studies that this was the result of an influx of a new school of fish from some region outside the area of study.

The enormous difficulty of assessing the average condition with respect to age and size has been very forcibly expressed in these sampling experiments in the cape Lazo area. Under the present fishing regulations, the likelihood of obtaining random samples from fisheries of short-lived duration like that of cape Lazo is not very great. Consequently an accurate picture of the trend over a period of years is going to be very difficult to obtain.

K.S. Ketchen Appendix No. 73

CHANGES IN THE BAYNES SOUND STOCK OF LEMON SOLE

Since its closure to trawling in 1947 the Baynes sound area has been under observation to determine the effect upon the stock of a cessation of fishing, and to determine whether or not existing regulations should be modified to enable at least a partial exploitation of that stock.

As pointed out in the Appendix on tagging in the strait of Georgia and in the 1949 Summary Report (Appendix 41), the stock in Baynes sound, although receiving some recruits from and contributing some to the cape Lazo grounds, seems to remain much as a unit throughout the year.

Before the closure the average catch per hour by commercial boats was about 150 pounds. Since 1947 the catches have been very heavy, ranging from 600 to 2,000 pounds per hour, depending upon the area. This sharp increase appears to be more the result of a reconcentration of the fish or recruitment from outside areas than an increase in weight of the original inhabitants.

Differences in the average size of lemon soles caught in the three regions within Baynes sound (Deep bay, Fanny bay, and Union bay) have remained fairly consistent over the past three years. As may be seen in the following table the Deep bay fish (females) are smaller than those at Union bay. Within each area, however, there has been a substantial increase in average size from that which existed shortly after closure. The increase has been more rapid in Deep bay and Fanny bay than in Union bay because the fish are of younger age and consequently growing more rapidly.

Average Size of Female Lemon Soles (mm.)

Year	Deep bay	Fanny bay	Union bay
1948	283	343	376
1949	315	356	383
1950	338	367	393

Sampling at intervals more frequent than once a year has created some difficulty in the interpretation of the size changes. An example is drawn from the study at Union bay. In June of 1949 the average size of females in that areas was 383 mm. In November, presumably at the end of the growing season the average was still 383 mm. In February of 1950 the average had changed significantly to 384 mm., and in August the size had increased abruptly to 393 mm.

The cause of these irregularities has been revealed in the age-determination studies. The age-frequency distributions for females taken during the period in question are given in the following table.

Year-class Frequency (%)

	1947	1946	1945	1944	1943	1942	1941	1940	1939	Total
Jun	-	2.5	25.3	38.6	14.7	11.0	5.4	2.5	-	438
Nov	0.2	10.0	41.2	29.6	8.4	5.1	3.8	1.3	0.4	452
Feb	-	4.5	38.6	31.2	15.8	5.2	4.2	0.2	0.2	422
1950 Aug	1.4	12.4	20.5	29.9	16.9	11.1	5.1	1.5	0.7	280

K.S. Ketchen

During the late fall and winter of 1949-50 the 1944 year-class, which has formed the mode in June, 1949, was relegated to a secondary position by the 1945 year-class. Apparently by August the 1945 year-class or more exactly the group of fish in which the 1945 year-class dominated had retired from the area. The influx of the younger fish during the winter seemed to mask the increase in size of the more resident fish.

Although mark and tag returns in the sound are indicative of a strong southerly movement between November and February, it is not as yet certain from what direction the younger fish entered Union bay. There is a possibility that these fish may be the early inward migrants from cape Lazo. That such a movement may occur has been suggested in the summary report on tagging and marking.

C.R. Forrester

Appendix No. 74

THE AGE COMPOSITION OF BOAT HARBOUR LEMON SOLES, 1947-50

The Boat harbour fishery, like that at cape Lazo, depends to a large extent on a winter spawning run of lemon soles. In the winter of 1947-48 the grounds were closed to trawlers as a conservation measure, but in the following year the regulations were altered to permit fishing from the middle of May until the middle of January.

The age distributions which appear in the following table, with the exception of those for the winter of 1947-48, were taken from the commercial catch. The 1947-48 samples were collected from the "Investigator No. I" during the closed period.

	Age Frequency (%)										
	II	III	IV	V	VI	VII	VIII	IX	X	XI	Number
1946-47											
Male	-	8.8	20.8	30.3	29.4	11.6	4.0	1.4	0.7	-	500
Female	-	2.1	30.6	32.3	22.6	6.8	3.0	1.5	0.9	0.2	924
1947-48											
Male	0.3	2.5	25.5	39.3	18.1	10.9	2.1	1.0	0.3	-	394
Female	-	1.6	22.3	39.1	20.6	10.6	3.7	1.3	0.8	-	385
1948-49											
Male	-	1.4	13.7	33.1	35.1	13.3	2.4	1.0	-	-	145
Female	-	5.8	12.2	25.6	35.3	11.5	5.1	3.8	0.6	-	156
1949-50											
Male	0.1	7.7	32.7	13.1	23.2	15.6	7.0	0.6	-	-	661
Female	-	2.5	42.0	17.1	13.3	16.4	5.3	2.3	0.6	0.3	683

In 1947, V-year-olds (1942 year-class) dominated in the samples of female fish and were followed closely by IV-year-olds (1943 year-class). The 1943 year-class appeared in the following year as the strongest year-class and again in the winter of 1948-49. This dominance appears to have been accentuated by the closure of the fishery in the winter of 1947-48.

C.R. Forrester

The 1949-50 samples were marked by the insurgence of a very strong 1946 year-class (IV-year-olds). However, no significant change in the average size accompanied this change in age distribution. This phenomenon has been reported in the age study of cape Lazo samples. The distribution in male fish with a few exceptions followed the same general trend as that in females.

J.I. Manzer

Appendix No. 75

A CONTINUATION OF THE STUDY OF WEST COAST BRILL

The brill fishery off the west coast of Vancouver island forms an important part of the otter-trawl fishery in southern British Columbia. Becasue of its importance, therefore, the species has been the subject of considerable investigation. One of the studies which is being undertaken is to determine the normal range and the independence of the schools of brill found on various grounds at different times of the year. The most direct method by which such information can be obtained is by tagging, and as in previous years, a tagging trip was made (June 14-July 6) to the west coast. In conjunction with the tagging work, sampling of brill for age, sex, and size was also carried out. Opportunity was also taken to carry out studies in other species of interest to the groundfish investigation. These included age and growth of the west coast butter sole and tagging of lingcod. Reports on these are to be found elsewhere (Appendices No. 80 and 81, respectively).

Several areas which are known to be brill grounds were explored. These included Esperanza inlet, Sydney inlet, Lennard island, Firing Range off Florencia island, and the Big bank. Brill were most abundant on the Firing Range. While present in small quantity on the Big bank and off Lennard island they were entirely absent in the other two areas. Examination of stomach contents suggested that the occurrence of brill on the Firing Range may have been brought about by a feeding migration, with euphausiids constituting the main diet. Hydrographic conditions, however, are not to be discounted. There is also some evidence that the males preceded the females onto the grounds. This differential appearance of the sexes was also found in Hecate strait (Annual Report, 1949, Appendix No. 46).

In all, 1,030 brill were tagged. Nine hundred and fifty-one were released on the Firing Range, 54 off Lennard island, and 25 on the Big bank. To date (October 1) 234 recovered tags have been reported. Except for 11 tags which were recovered by the American trawl fleet all recoveries were the result of Canadian effort. Assuming random distribution of tagged fish throughout the general population and distrubion of fishing effort according to availability, a minimum exploitation rate of 24.6 per cent is calculated. The recoveries indicated little movement of fish off the tagging ground.

Otoliths were also obtained for age analysis of the stock on the Firing Range, and are awaiting laboratory examination.

W.E. Barraclough — Appendix No. 76

THE AGE DETERMINATION OF THE BRILL

The examination of all brill otoliths collected from the commercial catch of 1945, has now been completed. The age distributions are given in the following table according to three general areas.

Year-class	Year-class Frequency (%)					
	Lower west coast (San Juan)		Middle west coast (Lennard island)		Queen Charlotte sound	
	Male	Female	Male	Female	Male	Female
1941	7.4	5.2	2.7	-	7.4	1.8
1940	11.1	14.1	14.6	8.4	7.1	4.6
1939	19.8	11.9	12.0	12.0	-	2.8
1938	7.4	9.6	20.0	16.9	7.1	9.2
1937	12.3	15.6	18.7	25.3	-	17.4
1936	7.4	5.9	13.3	9.6	28.7	8.3
1935	8.7	11.1	4.0	2.5	14.3	12.9
1934	12.3	7.4	6.7	6.0	14.3	10.0
1933	4.9	5.9	4.0	6.0	14.3	11.0
1932	4.9	8.1	2.7	3.6	7.1	12.8
1931	2.5	3.0	1.3	7.2	-	3.7
1930	1.3	1.5	-	-	-	5.5
1929	-	0.7	-	2.5	-	-

In all three areas, the 1937 year-class predominated in samples of female fish. No such agreement can be found in male fish. Greater representation of more recent year-classes is evident in the west-coast samples than in those from Queen Charlotte sound. This may be a reflection of the history of the fishery, the Queen Charlotte area being of more recent development.

Preliminary studies of the age composition in 1946, 1947, and 1948 have been made. In none of the samples so far examined is there evidence of continued dominance of the 1937 year-class in female fish. In the west coast areas there has been a substantial reduction in the number of older age-groups and the predominating year-class in 1946 appeared to be that of 1940.

J.I. Manzer — Appendix No. 77

MOVEMENT OF CAPE SCOTT BRILL

Recoveries from tagging experiments carried out off cape Scott during 1949 (Appendix No. 44, 1949) have provided additional information on the movements and inter-relationship of brill on the west coast. A total of 68 fish have been recovered, 88.2 per cent of which were recaptured in the tagging area. Three per cent of the recoveries indicate movement towards Queen Charlotte sound and Hecate strait while 8.8 per cent

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were recovered to the south of the tagging area. Of this number two-thirds were recovered in the Swiftsure-cape Flattery area. These data essentially confirm what has been found from other tagging experiments, that is, there is a small amount of disperison, but the majority of recoveries usually occur in the area of tagging.

R.I. Peterson Appendix No. 78

AGE ESTIMATIONS OF ROCK SOLE

During 1947 age estimation work on rock sole, Lepidopsetta bilineata, was initiated by K.S. Ketchen. Since January of this year a more concentrated effort has been put forth to learn more of the age composition of this economically important species.

To date over 16,000 otoliths have been examined representing samples taken for the years 1944 to 1947 from north Hecate strait, middle Hecate strait, the Horseshoe grounds, Queen Charlotte sound, the gulf of Georgia, the west coast of Vancouver island, Dixon entrance, and a few samples from Hecate strait for which no definite position was given.

Only those samples for which exact positions are known and whose numbers exceed 100 are used as a basis for this report. As the 1944 samples comprise less than 200 fish for three areas, the results of the age estimations are considered insignificant for comparison with the other years.

The following is a compilation of the results of the age estimations by years and for each area represented to show the general distribution of year-classes. The frequencies are expressed in per cent and the total number of fish representing each area is included.

1. Northern Hecate strait

	Year-class Frequency (%)					
	1945		1946		1947	
Year-class	Male	Female	Male	Female	Male	Female
1944			0.5	0.6	3.5	0.5
1943			16.5	7.6	62.9	45.6
1942	3.3	0.8	61.8	38.6	28.6	34.3
1941	25.5	6.9	11.9	13.9	2.2	6.1
1940	24.2	10.7	5.4	8.1	1.1	3.7
1939	20.3	12.6	2.0	10.7	1.3	4.9
1938	13.1	20.2	1.4	9.0	0.3	1.9
1937	8.5	25.5	0.4	6.1	0.1	1.6
1936	2.6	12.5		3.2		0.8
1935	1.3	6.6		1.2		0.3
1934	1.3	3.1		0.6		0.1
1933		1.0		0.3		0.1
1932		0.2				
Total no. fish	153	609	1,242	2,362	1,338	2,217

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The dominance of the 1937 year-class in the 1945 samples and its subsequent disappearance from the catches of the following years was also observed in the lemon soles caught in this area. The success of the 1942 and 1939 year-classes in 1946 and 1947 also parallels the results of the lemon sole age analysis for north Hecate strait, and these observations, on the rock sole, independently made, confirm the results of a preliminary study as reported by K.S. Ketchen in the 1947 Annual Report, Appendix No. 67.

A strong recruitment of a 1943 year-class is evident for the 1947 catch.

2. Middle Hecate strait

	Year-class Frequency (%)			
	1946		1947	
Year-class	Male	Female	Male	Female
1944	2.5	0.1	1.9	0.6
1943	15.8	3.4	40.5	11.5
1942	27.5	13.5	26.6	16.3
1941	12.7	12.4	8.9	10.7
1940	19.3	16.5	10.7	13.0
1939	14.1	19.7	8.9	18.6
1938	6.0	16.5	1.3	10.5
1937	1.4	10.7	1.3	9.1
1936	0.7	4.5		4.3
1935		1.2		2.3
1934		0.7		1.9
1933		0.7		0.8
1932				0.4
Total no. fish	284	684	158	515

The successful 1942 and 1939 year-classes are evident with a greater representation of the 1939 year-class than was found in the north Hecate regions. A dominance of 1943 year-class fish appeared in 1947, the males contributing the higher percentage of recruits.

3. Horseshoe and Queen Charlotte sound grounds

Though the Horseshoe ground are in Hecate strait the picture presented by the table below is remarkably different from that of the other areas dealt with in Hecate strait, there being no fish under five years old represented. The 1937 year-class dominating the 1945 Hecate strait samples is also evident here for the same year. In 1946 the 1938 year-class was dominant and though not appearing in any other Hecate strait area, appears as the dominant year-class in the west-coast samples.

The 1940 and 1941 year-classes seem to have been appreciably stronger in Queen Charlotte sound than in the Hecate strait regions. The predominant 1939 year-class found in most of the Hecate strait region is also evident among the females taken in this area in 1946.

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Year-class	Year-class Frequency (%) Horseshoe grounds 1945 Female	Horseshoe grounds 1946 Female	Queen Charlotte sound 1946 Male	Queen Charlotte sound 1946 Female
1943			2.6	0.7
1942			26.7	10.1
1941		2.5	35.9	23.2
1940	0.9	10.8	21.0	18.7
1939	9.5	17.0	12.3	21.8
1938	21.6	26.5	0.5	16.8
1937	33.6	19.1	1.0	6.9
1936	18.2	15.4		1.4
1935	9.2	5.9		0.7
1934	5.9	2.2		
1933	0.9	0.6		
1932	0.2			
Total no. fish	357	324	195	583

4. Strait of Georgia and west coast of Vancouver island

Year-class	Year-class Frequency (%) Strait of Georgia 1946 Male	1946 Female	1947 Male	1947 Female	West coast 1946 Male	1946 Female	1947 Male	1947 Female
1944			0.2				0.6	0.5
1943			7.8	3.9			15.8	3.2
1942	5.4	2.8	28.2	15.9	1.8	1.1	21.8	5.4
1941	20.4	12.9	27.8	24.0	11.2	6.4	20.1	12.9
1940	35.4	14.3	22.9	24.9	15.4	10.4	21.8	23.3
1939	25.2	27.2	10.1	18.2	33.1	21.7	11.7	19.0
1938	10.9	23.9	2.3	9.5	29.6	30.2	5.6	24.6
1937	2.0	14.3	0.6	2.3	8.3	18.2	1.7	7.3
1936	0.7	3.2		0.5	0.6	9.1	1.1	2.8
1935		0.5		0.4		2.4		0.5
1934		0.9		0.4		0.5		0.4
1933								0.1
Total no. fish	147	217	485	559	169	374	179	847

It would appear that the fishery in the strait is in a comparatively stable condition, no one year-class predominating. It is also of interest that the 1947 samples show a strong representation of the 1940 year-class as do the west-coast samples. The 1947 samples show a dominant 1942 year-class in the male portion of the population and that year-class with that of 1939 appeared relatively successful in the females.

Most of the fish caught off the west coast are females with a dominant 1938 year-class. Of those males appearing in the fishery the VIII-year-olds make the major contribution to the catches of both 1946 and 1947, being supported by a successful 1942 year-class in 1947.

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In surveying the general picture presented by the age analysis of rock soles from 1945 to 1947 the following observations are noteworthy:

(1) Each year the fishery claims more than twice as many females as males.

(2) The female population exhibits more constancy in year-class dominance from area to area, the males being more greatly affected by selection factors.

(3) In 1945 the 1937 year-class (females) was predominant in all areas sampled but was not evident in 1946 or 1947.

(4) The 1939 year-class, though relatively successful in the 1945 catches in the Queen Charlotte sound and Hecate strait areas, assumed a major role in the 1946 and 1947 fishery.

(5) The 1941 and 1940 year-classes comprise the greater part of the catch along the southern coast whereas in the northern regions their contribution is negligible.

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Appendix No. 79

GROWTH RATES OF ROCK SOLE

Using the age-length data, the rates of growth of the rock soles from the various fishing areas for the years 1946 and 1947 have been determined. The following is a table summarizing these data in which the fish from the gulf of Georgia, northern Hecate strait, and the west coast of Vancouver island are compared. The average lengths are in centimetres and the number of fish involved is designated in parentheses. If the number involved was less than five, that average length was omitted.

Year-class	1946 Females			1946 Males		
	Gulf of Georgia	Northern Hecate strait	West coast	Gulf of Georgia	Northern Hecate strait	West coast
1945	-	-	-	-	-	-
1944	-	30.0 (15)	-	-	28.7 (6)	-
1943	-	30.8 (181)	-	-	30.5 (205)	-
1942	31.2 (6)	33.9 (912)	-	29.4 (8)	32.7 (768)	-
1941	30.9 (28)	35.0 (330)	36.3 (24)	30.7 (30)	33.8 (148)	32.8 (19)
1940	33.4 (31)	37.9 (191)	38.3 (39)	32.1 (52)	36.0 (67)	33.2 (26)
1939	35.2 (59)	40.3 (253)	41.7 (81)	32.1 (37)	37.0 (25)	34.5 (56)
1938	36.4 (52)	41.8 (213)	43.7 (113)	32.7 (16)	36.6 (18)	36.6 (50)
1937	37.5 (31)	43.2 (145)	44.8 (68)	-	36.6 (5)	39.2 (14)
1936	37.7 (7)	43.6 (75)	46.4 (34)	-	-	-
1935	-	43.8 (28)	48.2 (9)	-	-	-
1934	-	46.3 (13)	-	-	-	-
1933	-	48.7 (6)	-	-	-	-

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Year-class	1947 Females			1947 Males		
	Gulf of Georgia	Northern Hecate strait	West coast	Gulf of Georgia	Northern Hecate strait	West coast
1945	-	-	-	-	-	-
1944	-	33.6 (12)	-	-	32.3 (47)	-
1943	30.9 (22)	33.5 (1012)	30.2 (27)	29.8 (38)	32.5 (841)	30.3 (28)
1942	34.6 (89)	35.7 (760)	33.8 (46)	31.4 (137)	33.9 (383)	31.7 (39)
1941	36.1 (134)	37.2 (135)	36.9 (110)	32.0 (135)	34.8 (30)	32.5 (36)
1940	37.9 (139)	38.8 (81)	38.9 (197)	33.0 (111)	35.4 (14)	34.1 (39)
1939	37.9 (102)	40.9 (109)	40.9 (161)	33.3 (49)	37.5 (17)	35.0 (21)
1938	39.2 (53)	42.7 (43)	42.9 (208)	34.4 (11)	-	34.8 (10)
1937	38.9 (13)	43.4 (36)	45.2 (62)	-	-	-
1936	-	43.9 (18)	47.5 (24)	-	-	-
1935	-	44.9 (7)	-	-	-	-

It is at once apparent that there is a marked difference in the rates of growth of the female and the male fish of the same given area, the females having a much faster growth rate. Equally apparent is the difference in growth rates of the fish from any one area compared with either of the other two. The rock soles of the gulf of Georgia have a slower rate of growth than those of northern Hecate strait while the west-coast rock soles are faster growing than those of northern Hecate. The results for the male fish are not in complete agreement with those for the females. This may be attributed to the fact that the males have a slower rate of growth, consequently a smaller size, and hence are more greatly affected by net selection and culling.

It has been observed that the rates of growth of the rock soles from Queen Charlotte sound, middle Hecate strait, and the Horseshoe grounds are similar to the growth rate of the northern Hecate strait fish.

Though only a very small number (96) of rock sole otoliths from Dixon entrance have been examined, the indications are that the fish from this area have a growth rate comparable with, if not exceeding, that of the west coast of Vancouver island.

J.I. Manzer Appendix No. 80

AGE AND GROWTH OF WEST COAST BUTTER SOLE

A sample of 489 otoliths was obtained of the butter sole population found off the west coast, and the data on growth have been compared with those for the Hecate strait population. A comparison of the average lengths in millimetres for males and females of each age and area is given below. The values have been determined from unculled catches and are influenced only by selectivity of not too dissimilar fishing gear. The bracketed figures indicate the relative strengths of the various age-groups for the west-coast fish. The data for Hecate strait are those presented in Appendix No. 40 of the 1948 Annual Report.

Age	Male		Female	
	West coast	Hecate strait	West coast	Hecate strait
II	250 (0.7)	143	216 (2.3)	190
III	235 (8.8)	210	250 (11.7)	237
IV	249 (55.4)	261	266 (42.8)	284
V	263 (22.9)	294	288 (24.9)	334
VI	268 (8.1)	318	299 (10.6)	355
VII	277 (2.0)	335	302 (5.6)	366
VIII	265 (1.4)	343	300 (1.5)	376
IX	270 (0.7)	346	305 (0.6)	385
X		352		394

The females in both areas grow more rapidly than do the males. Also, Hecate strait fish grow faster than the west coast fish, once having attained their third year. The difference in growth may be due to different environmental conditions in the respective areas, but the affect which differential fishing can have upon growth is not to be disregarded, the west-coast fish never having been exploited commercially. The lack of evidence of continuous growth of west coast VIII- and IX-year-old males is believed to be the result of poorly represented age groups.

Percentage age frequency data for the west coast population show the strongest age-group to be the group IV fish. More than 55 per cent of the males and 40 per cent of females are IV's. That the males appear to have a higher mortality rate than do females is indicated by a more rapid reduction in the relative strengths of successive age-groups. This higher mortality rate for males was also found in Hecate strait butter sole.

J.I. Manzer Appendix No. 81

LINGCOD TAGGING AND RECOVERY, 1949-50

Lingcod tagging was continued during 1949-50 whenever occasion permitted, and in conjunction with other bottom fish studies. Tagging operations have been limited, however, in size and purpose by a nearly exhausted supply of suitable tags (celluloid ring lip). A total of 76 tags was released. Taggings were carried out in the following areas.

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East Coast of Vancouver Island

Fanny bay	5
Deep bay	4

West Coast of Vancouver Island

Sydney inlet	5
Lennard island	2
Firing Range	42
Big bank	18

Seventeen tags have been received, six of which were put out six or more years ago in connection with the line fishery. The remainder are from west-coast taggings carried out since 1947. Sedentariness of lingcod continues to be shown by these latest recoveries.

J.I. Manzer Appendix No. 82

INVESTIGATION OF METHODS FOR AGE DETERMINATION IN LINGCOD

Since knowledge of the age composition of the stocks of lingcod is lacking, and since such information can be used to provide information on growth, mortality, and fluctuations in recruitment, some time was spent investigating methods by which the age in lingcod can be determined. Because the major portion of the commercial catch of lingcod is landed dressed with heads off, only the use of body parts were considered practical. Accordingly, otoliths and flat head-bones were disregarded. Scales were considered but not in the manner which already has been found by other investigators to be unsuitable. Instead of examining these directly an impression of the pattern was made on a cellulose acetate slide but unlike the results for other species no improvement was noted in the readibility of the scales. Dorsal, pectoral, and pelvic fin-rays were also considered. These were dried and sectioned transversely. The surfaces were than polished and examined with reflected and transmitted light. Although rings which might be annual were indicated, the method was rejected because of the indistinctness of these. Promising results have been obtained from abdominal vertebrae. Selection of these was decided upon because of their size and accessibility in dressed fish. Upon cooking, cleaning, and drying, concentric rings which may be interpreted as annual growth have been observed. To test the consistency of this interpretation, a check of vertebral readings against otolith readings is contemplated.

J.I. Manzer Appendix No. 83

OBSERVATIONS ON JUVENILE LINGCOD

The life history of the lingcod, a species which is of considerable commercial importance, is not completely determined. In an attempt to

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eliminate some of the gaps, as much data as was possible were collected on these whenever the opportunity arose. As a result of this effort the distribution and food of juvenile fish are better known.

Distribution

Average total length measurements indicated that the size of lingcod increased with depth. Weighted figures also showed that young lingcod (I's, II's, and some III's) were most abundant on or near kelp beds. While found in lesser abundance in gravel areas with some kelp they were almost entirely absent on muddy grounds. The greater inhabitation of kelp patches may have been the result of increased protection which such areas afford against predators. Temperature appeared to have little influence upon distribution.

Food

That the lingcod even in the juvenile stages are a piscivorous eater is shown by the examination of the stomach contents of 65 fish. Of the fish found to have food, 85 per cent indicated a strict fish diet, with herring being the main item. Euphausiids, shrimps, amphipods, squid, and worms were also noted in some cases.

J.I. Manzer Appendix No. 84

CONVERSION FACTOR FOR LINGCOD

Because lingcod are marketed dressed with heads off some means of determining total lengths from commercial catches is necessary if data on growth and size composition of the stocks are to be obtained. One of the methods by which length data can be calculated is the use of a conversion factor, the validity of which is dependent upon the degree of constancy between the body proportions of fish of different size, sex, and area. Accordingly, an investigation of the use of a conversion factor was begun. The one selected for consideration was determined from the ratio of the total length (T) to the distance from the insertion of the pectoral fin to the tip of the caudal fin-rays (P).

Preliminary data collected from 68 fish from four areas indicate that the average values for the ratio T/P remains acceptably constant for the above prescribed condition. The average value of the factor for all fish was calculated to be 1.37. The study is to be continued.

R.I. Peterson Appendix No. 85

AGE ESTIMATIONS OF GRAY COD

Since 1945 infrequent sampling of gray cod, Gadus macrocephalus, has made available for otolith examination about 1,500 specimens. Their readings are now completed and represent the gulf of Georgia, the west coast of Vancouver island, Queen Charlotte sound, and northern Hecate strait.

R.I. Peterson

The following table summarizes the per cent frequencies of the age-groups for males and females taken from the various fishing areas for 1950.

Area	No.	Age-group II	III	IV	V	VI	VII	VIII
				Males				
Gulf	197	8.1	40.1	31.0	20.3	0.5	-	-
West coast	74	1.4	29.7	55.4	9.5	2.7	1.4	-
Q. Char. snd.	76	9.2	55.3	31.6	3.9	-	-	-
North Hecate	182	2.7	70.9	13.2	8.8	3.8	0.5	-
				Females				
Gulf	194	16.0	36.6	30.9	14.9	1.5	-	-
West coast	78	11.5	48.7	26.9	9.0	3.8	-	-
Q. Char. snd.	78	6.4	61.5	23.1	3.5	3.5	-	-
North Hecate	182	4.4	72.0	12.6	3.8	2.2	4.4	0.5

This tabulation shows that males and females are of equal numerical strength in the fishery.

With the exception of the west-coast males, all the samples from all the areas show a marked predominance of the III age-group. Because in the previous years' sampling the sexes were combined they are excluded from the summary table but in those years, as well, the II, III, and IV age-groups were the major contributors to the catches.

In comparing the gray cod with its relative on the Atlantic coast, Gadus callarias, it is of interest to note that the gray cod fishery of the Pacific resembles the inshore cod fishery of south western Nova Scotia where the contributing age-groups are III and V as opposed to the VII to XII age-groups which play the major roles in the offshore Atlantic banks fishery.

R.I. Peterson — Appendix No. 86

GROWTH RATES OF GRAY COD

Because the growth rate of gray cod is so rapid it is necessary in making comparisons between areas to use samples taken at approximately the same time of year. The data available are insufficient to enable such comparisons. However, the following figures serve to show the difference in growth rates between females and males. The average lengths are expressed in centimetres and the number of fish in each age-group is in paretheses. Only age-groups with over five individuals are included.

It is evident that the females are faster growing than the males. Generally speaking the average lengths of these age-groups correspond to those of similar age-groups of the cod (Gadus callarias) taken in the inshore fishery of south-western Nova Scotia.

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Area	Males II	Males III	Males IV	Males V	Females II	Females III	Females IV	Females V
Gulf	32.9 (16)	53.5 (79)	63.1 (61)	70.2 (40)	34.6 (31)	53.9 (71)	64.2 (60)	72.2 (29)
West coast	-	58.9 (13)	61.3 (26)	71.2 (6)	47.1 (9)	57.2 (28)	65.0 (14)	-
Q. Char. snd.	41.7 (7)	51.9 (42)	58.4 (24)	-	51.4 (5)	60.1 (49)	63.4 (18)	-

K.S. Ketchen Appendix No. 87

INVESTIGATION OF THE BRITISH COLUMBIA BLACKCOD FISHERY

In response to a request from the Pacific Marine Fisheries Commission a more detailed consideration is being given to the blackcod fishery in waters adjacent to the British Columbia coast. Although not evident in the accompanying table of total landings in Washington, British Columbia, and Alaska, there has been over the past decade a rapid decline in catch per-unit-of-effort on some of the more important grounds.

Year	Catch in Thousands of Pounds Washington	British Columbia	Alaska	
1942	2,141	1,228	8,123	11,400
1943	2,024	2,096	6,628	10,600
1944	3,090	2,232	7,385	12,500
1945	1,819	2,099	8,351	12,100
1946	3,334	2,379	9,019	14,600
1947	2,098	1,309	-	

Particular concern has arisen over the decline in the fishery off the lower end of Vancouver island on the Swiftsure bank. Contribution to understanding of the decline can be made through the solution of a number of problems: (1) Is the decline occurring in other areas besides the Swiftsure bank? (2) Is the Swiftsure blackcod population separate from others on the coast? (3) In what manner and to what extent do the otter-trawlers compete with the long-liners? (4) Are there any marked changes occurring in the size and age composition of the stock of blackcod?

The trip report system used by the groundfish investigation covers landings of long-liners as well as trawlers and should prove of valuable assistance in defining the blackcod grounds and in answering questions pertaining to competition and catch per-unit-of-effort. However, as this system of collection has reached reasonable completeness only since 1948, data for a few more years will be required before trends in the fishery can be accurately described.

The study of the interdependence of the various blackcod grounds will necessitate extensive tagging. Before this can be initiated, however, the development of a more suitable type of tag than the conventional Peterson disc tag, seems highly desirable. The investigation of various types of jaw tags is proceeding.

K.S. Ketchen

The main contribution to the blackcod study in 1950 has been the investigation of ways and means of sampling the commercial catches for age and length. Although the otoliths appear to be suitable for assessing the age of blackcod, they are not available for collection since the catches are landed with heads off. It has been necessary therefore to seek out other means of age determination. Mr. R.J. Karjala, an under-graduate student at the University of British Columbia, who has been employed as summer sampler in Vancouver, has taken as his problem the determination of whether or not any correlation exists between the rings on the otoliths and the rings on the scales of the blackcod. This study has necessitated the issuing of permits to certain trawlers to land small samples of under-sized blackcod and has also necessitated the persuasion of some trawl and long-line operators to land some of their legal-sized fish with heads on. Mr. Karjala has collected 366 sets of otoliths and scales of which 206 were from the west coast of Vancouver island and Queen Charlotte sound. An additional 180 samples were collected by the "Investigator No. I" during her trip to the Swiftsure bank region during the month of August.

The practice of landing blackcod with their heads off has created another sampling problem, that of determining the total length of the fish from a body measurement. At present, workers in California, Washington, and British Columbia are using different body length measurements for determining the total length. It is desirable that some measurement be standardized for the whole coast. Accordingly, studies of the suitability of four measurements, two of which have been proposed by this Station, are now under way, not only with respect to blackcod, but to other species which are also headed before landing, such as the lingcod (see Appendix 84). Five measurements of about 150 blackcod and 135 lingcod were made from the "Investigator No. I" during the summer, and are to be compared with respect to the facility of measurement and the degree of variability.

C.R. Forrester Appendix No. 88

PREDATION STUDIES OF DOGFISH AT THE MOUTH OF THE FRASER RIVER

It is generally recognized that in the spring months each year the dogfish congregate off the mouth of the Fraser river. The question has arisen as to whether the accumulation is associated with the seaward migration of young salmon or the return to the sea of the spring eulachon run. Accordingly, the "Investigator No. I" was engaged for a short period during May of 1950 in the study of dogfish predation at the mouth of the river.

Examination of 70 dogfish stomachs showed the following: empty - 26; invertebrates - 26; fish remains - 18. The fish remains consisted of: eulachon - 2; hake - 4; flatfish - 1; herring - 1; sand lance - 1; and 8 fish remains, probably eulachon. No definite specimens of young salmon were encountered.

Supplementary examinations were made of long-jaw flounder. It was noted that this species preyed more extensively on eulachon than did the dogfish. Nearly all of the stomachs of feeding fish examined contained eulachon. Here again there were no indications of young salmon.

C.R. Forrester

Considering the short period covered, and the fact that the trawl net samples only the fish which are near the bottom, little conclusion can be drawn from these observations. If the problem warrants greater attention, some other sampling device (possibly gill-nets) should be incorporated with bottom sampling, and the operation extended over several tidal cylces during the period of downstream migration.

K.S. Ketchen Appendix No. 89

THE DEVELOPMENT OF METHODS OF DETERMINING THE WORKING GAPE OF TRAWL NETS

A knowledge of the spread of otter-boards and the working gape of trawl nets is of considerable value in the study of population density and in making comparisons of the efficiency of various types of gear. Preliminary attempts have been made to determine the effective sweep of two types of trawling gear: (1) the double-gear or American style as employed by the "Investigator", (2) the single gear or Canadian type as employed by the "Phyllis Carlyle".

Large steel floats were attached to the otter-boards by means of sufficient lengths of cod-line to permit them to come to the surface while the boards were on the bottom and while the boat was towing. A line bearing another float was allowed to trail off the stern of the vessel from which the distance to the other floats was measured. The angle between the stern of the vessel and the two floats attached to the boards was then determined by sighting and the approximate distance between the floats was determined by means of the method of similar triangles.

The distance between the otter-boards of the "Investigator", towing at normal speed, was found to be about 110 feet. Knowing the length of the bridles and ground-line and with the aid of a scale drawing, the working gape of the net was found to be about 46 feet. Actually this could be measured more directly by attaching floats to the ends of the wings, but because of a lack of suitable floats the two measurements could not be made simultaneously.

The gear of the "Phyllis Carlyle" was tested in a similar manner on the same ground and at the same depth. The spread between the boards was found to average about 75 feet, while the working gape was estimated to be about 40 feet. The differences between the effectiveness of the two types of gear lay much more in the distance between the boards than between the working gapes of the nets. The difference in suspension and length of bridles probably accounts for the wider spread of the American type gear.

Evidence of an optimum towing speed for maximum spread of the otter-boards was observed in the experiment from the "Investigator". The figures for various engine speeds as compared with the resultant spread of the otter-boards are given in the following table:

Engine Speed (r.p.m.)	Distance between Otter-boards (ft.)
1,050	105
1,100	110
1,150	105
1,200	90

K.S. Ketchen

The difficulty of maintaining constancy in the effectiveness of sampling is all apparent. Boat skippers may maintain constant engine speeds in dragging, but tidal speeds are never constant. Thus it may be expected that while towing into a tide or with a tide at normal engine speed the spread of the boards may be less than that at slack water.

K.S. Ketchen Appendix No. 90

DEEP WATER DRAGGING EXPERIMENTS

In the past year first attempts have been made to extend the trawling operations of the "Investigator No. I" to depths beyond which the Canadian commercial fleet normally operates. This exploratory work has a twofold purpose: (1) to locate and make known populations of fish which are not now being exploited, and (2) to assist in the completion of the ecological studies on the various demersal fish species.

Dragging to depths of 190 fathoms in the strait of Georgia during the spring months met with fair success. The regular balloon-type trawling gear was used and appeared to have been functioning satisfactorily. Catches averaged 300 pounds of fish per 30-minute drag, most of which were composed of dogfish and ratfish. Other species encountered were: long-jaw flounder, dover sole, brown shark, blue skate, blackcod, Sebastodes diploproa, Sebastolobus, and a rare specimen of Sebastodes introniger. None of these species was of sufficient size or abundance to support a commercial fishery. Among the invertebrates were large anemones, spider crabs, shrimps (food of fish species) and considerable number of the red squid Gonatus fabricii.

It is of interest to record that some dogfish, as well as long-jaw flounders taken at a depth of 190 fathoms, had been feeding on herring shortly before they were captured.

Summer dragging in deep water covered a wider area of the strait but proved much less successful. Catches seldom exceeded 50 pounds per 30-minute drag. It may have been that the net was not operating efficiently or that it was not on the bottom during the entire dragging period. At such great depths this possibility is very difficult to investigate. On the other hand there may have been an actual absence of fish from the grounds as the result of an inshore movement during the summer months, similar to that which occurs among fish in the shoaler waters.

Several stations have now been set up for periodic sampling throughout the year.

J.M. Partlo Appendix No. 91

THE ALBACORE INVESTIGATION

The albacore investigation is planned to obtain an understanding of the basic biological principles controlling the supply of albacore to the British Columbia fishery. The factors of immediate concern appear to be the recruitment to the fishery of successive year-broods, growth, migrations, feeding, and the factors of the environment which control the "catchability" by the fishermen. During the course of the year worthwhile advances have been made toward an understanding of all these factors. To study the succession of year-broods in the fishery very extensive length sampling of commercial catches was carried out during 1949 and 1950. A preliminary analysis of the data collected in 1949 has been completed but the tabulation of the 1950 measurements has not yet been undertaken. Length records give relative indications of the age composition of catches, but other methods of study are required to indicate actual ages. A method of age determination by counting concentric rings on the vertebral centra was investigated and gave promising results. Experiments with tagging methods on a substantial scale have been attempted. Observations on food have been made but the results are not ready for reporting. Observations made on the environment during 1950 are not yet ready for reporting. These have been made by commercial fishermen, and recorded in special log books in which water temperatures and number of fish caught can be entered, as well as personal observations made aboard a fishing vessel. These later observations are less systematic than in the previous year when regular patterns of observations were made, but they are more intimately connected with the fishery. It is hoped to tie them in with systematic oceancgraphic observations made by the Pacific Oceanographic Group.

J.M. Partlo Appendix No. 92

ALBACORE SAMPLING

The intensified programme of albacore sampling was continued during 1950 in the ports of Prince Rupert, Vancouver, and Victoria by Messrs. W.G. St. Clair, R.M. Wilson and R.J. Karjala, and D.G. Odlum, respectively. The results have not yet been tabulated.

A superficial analysis of the data collected in 1949 has now been completed. Four dominating length-groups are indicated with centres of abundance around lengths 53 cm., 63 cm., 67 cm., and 71 cm. The two groups of smaller fish characterized southern fishing grounds south of Destruction island. Northern areas showed a predominence of larger fish with the two groups represented overlapping in size in such variable proportions that they cannot be specified or separated with certainty on the basis of the work done so far.

J.M. Partlo Appendix No. 93

AGE STUDIES ON ALBACORE

The scales and otoliths of albacore have been found to be unsuitable for age studies due to the absence of discernible concentric ring formations. Attention was accordingly directed to the vertebrae whose centra were found to bear concentric rings and therefore became the object of further investigation.

Samples of vertebrae were taken from 207 measured albacore after they were pre-cooked in the first stage of canning. The vertebrae were then prepared by soaking in caustic soda for several days, washing in water, "fixing" in 95 per cent alcohol, and sectioning in two equal parts sagitally. Concentric rings on the end faces of the centra could then be discerned and counted with excellent consistency. However, proof that the marks are annual remains to be established. Attempts to establish proof by comparing lengths and ages were not convincing. This failure may be associated with the selection of fish for vertebral sampling to cover the widest possible range of sizes rather than taking them randomly.

Five-ring-classes, from three to seven, were present in the material. The three-ring-class was poorly represented by only four fish, which were the shortest fish sampled. Five-ring-class fish were best represented, and were closely followed in number by fish possessing six rings.

A few vertebrae from large imported Japanese albacore were examined. It was found that the imported fish were considerably larger than local fish with a corresponding number of rings. This observation, if supported by larger samples, would indicate some segregation of the population although not necessarily genetic distinction.

J.M. Partlo Appendix No. 94

ALBACORE TAGGING

The hook-tag method described in the 1949 Annual Report under Appendix No. 66 was continued during 1950 with one modification. The bulky plastic tag originally used was discarded because it was believed to be a source of discomfort and unnecessary worry to the fish. As a replacement, thin Z-nickel sheeting, embossed with the original legend and numbered, was wrapped to the shank of the hook and secured with Z-nickel wire.

During the summer 1950, 325 tags were released between 35 miles south-west of Esteban point and 20 miles west by south of Langara island. It was originally planned to release 1,000 tags during 1950, but after tagging 325 fish it was decided that a modification of the hook was desirable and tagging was discontinued as an economic measure. It is planned to modify the hook for further use by decreasing the spring tension of the locking device to allow the hook to set more readily in the fish's mouth.

J.M. Partlo Appendix No. 95

PREPARATION OF CIRCULAR NO. 20

As a means of keeping those actively engaged in the albacore fishing industry advised of the progress of the albacore investigation, a circular series was started in 1948. Circular No. 20 was prepared and published in June, 1950 as a continuation of this series. Miss Winona Bethune assisted in preparing the circular by analysing log-book data and writing the section entitled "Report on Albacore Log-book Records for 1949". The circular included the following reports:

A General Description of the 1949 Albacore Fishery of British Columbia
The Length of Albacore in the Commercial Catch
Determination of Age in Albacore
Report on Albacore Log-book Records for 1949
Albacore Catches in Relation to Water Temperatures
Albacore Tagging
Observations on Albacore Fishing Gear
Food of Albacore
Changes in Rectal Temperatures of Albacore
Plankton Sampling

J.L. Hart

Appendix No. 96

PILCHARD INVESTIGATION

The pilchard fishery remains dormant and in consequence the investigation has been restricted to examinations of a few incidentally-caught specimens and studies of the records aimed at discovering factors in the environment (i.e., aside from the abundance of the population) related to the appearance of pilchards on our coast.

A few pilchards taken with herring catches in Barkley sound were taken by D. Outram and Anne Lazareff but the report on the aging is not available. The report on a sample taken in a similar way in January, 1949, is now on hand and shows the distribution of the forty fish by brood years to be as follows:

1939 - 6	1942 - 4	1945 - 2
1940 - 10	1943 - 6	1946 - 4
1941 - 4	1944 - 2	1947 - 2

The sample is not only very small but is suspected of being unconsciously biased. It can, however, support the negative statement that there is no evidence of a strong, young brood of fish coming in to augment the fishery.

Dorothy Furk Manzer, prior to her separation from the staff, continued her studies of possible relationships between the catch per-unit-of-effort by the Canadian pilchard fleet and various meteorological and oceanographic occurrences for which records are available. Several negative results were mentioned in last year's Summary Report No. 59. New work shows seawater temperatures in March and April at cape Mendocino to be positively correlated ($r = +0.73$) with the "fishing index" for the period 1932 to 1941, suggesting that high water temperatures in spring off northern California may encourage earlier or more complete northward migration. The relationships are much complicated and correlation does not extend into the earlier years of the fishery.

A further attempt to establish relationships between local weather and ocean current conditions was undertaken by Isabel Gould, working under the supervision of Dr. J.P. Tully, along lines which have proved effective in other investigations. The approach was to use wind as deduced from differences between barometric pressures at selected stations as an indicator of the strength of the wind-driven currents. Miss Gould's examination of the available records showed that no usable relationship could be found between the barometric pressure gradient and either wind force or wind velocity. The approach was accordingly abandoned.

At a meeting of the representatives of agencies investigating pilchards held at the Scripps Institution of Oceanography, I represented the Pacific Biological Station. Many of the technical discussions centred around the work in biological oceanography associated with the fundamental studies and suggested many stimulating lines of thought. Of more immediate importance to the Candadian pilchard fishery were the estimates of the strengths of the various year-broods in California waters. The 1946 and 1947 year-classes have been good enough to supply improving fishing in California but are not at all outstanding. Later year-broods are very weak or indifferent. There can be, accordingly, no prospect for a restoration of a prosperous Canadian fishery for the next two years.

Dorothy M. Manzer Appendix No. 97

EULACHON CATCH STATISTICS

The Biological Station again had the co-operation of the Department of Fisheries in the compilation of eulachon statistics for the 1950 run on the Fraser river. The officers of the Department were responsible for the actual collection of the statistics and the Biological Station for the analysis of the records. The unit of fishing effort was the same as that of previous years, i.e., the catch in pounds of eulachon per 100 square fathoms of gill net per one hour's fishing. The following tabulation presents the results for this season as compared to previous years, as well as the average catch by week calculated over the eight-year period from 1942-1949 inclusive.

Week No.	1946	1947	1948	1949	1950	Eight-year Average
00	-	-	-	-	-	0.2
0	-	-	-	-	-	1.8
I	1	7	6	-	-	4.6
II	7	18	6	13	3	20.8
III	6	129	24	19	8	47.8
IV	22	281	100	51	25	123.8
V	100	318	158	194	44	173.5
VI	193	146	127	144	40	107.8
VII	510	-	10	-	33	94.4

The 1950 figures indicate a very poor fishery--in fact so poor as to indicate a near failure. These figures are well below those of 1949 (a relatively light fishery) and also below those of the eight-year average. The unit of effort did not rise above 50 pounds, whereas the eight-year average catch for weeks IV, V, and VI (covering the peak of the runs) was 123.8, 173.5, and 107.8 pounds, respectively.

The drastic decline of the 1950 run over that of previous years may be attributed, in part, to the Fraser river flood of 1948. It has been indicated that the eulachon reach maturity in two years, when they return to the river to spawn and die. As the 1948 flood reached its height toward the end of May and the early part of June, it is quite possible that the extremely high, debris-filled waters damaged the eggs and young of the eulachon to such an extent that the recruitment to the population was severely reduced, resulting in a very small spawning population in 1950.

G.C. Pike Appendix No. 98

AGE, GROWTH, AND MATURITY STUDIES IN ANCHOVY

The fishing of anchovy on the British Columbia coast during 1949 and 1950 was limited to but one catch in each of these years. Consequently anchovy studies based on sampled catches have been greatly retarded. Methods and procedures used in the study were outlined in Appendices 111, 112, 113, 114, and 115 of the 1947 Annual Report. Tentative conclusions expressed in these appendices have been but slightly changed or supplemented by the 10 samples from the 1948 catch and one sample from the 1949 catch.

The Pacific anchovy occurs rather irregularly in most of the inlets of the British Columbia coast as far north as Ogden channel. Large schools are frequently observed in coastal waters of southern British Columbia but their occurrence is sporadic and subject to marked yearly flunctuations. Populations supplying the commercial catch are composed mainly of second-, third-, and fourth-year fish. Fifth and the occasional sixth-year fish occur in the main schools, but those in their first year appear to remain apart from the adults. Indirect evidence derived from examination of the gonads indicates that maturity is reached in the second year and that spawning occurs in June, July, and August. Individual females were found to carry approximately 600,000 maturing eggs, and these are spawned out in two or more batches each spawning season.

Growth rates and age-groups have been determined, using smoothed length frequency curves and checked by otolith and scale readings. Females are slightly larger than males and the sex ratio in summer catches shows a slight predominance of females. Following an initial fast growing period during the first year, growth is fairly constant. The following tabulation gives the average lengths of anchovy in July as derived from the smoothed length frequency curves.

Year		First	Second	Third	Fourth	Fifth	Sixth
Av. length in mm.	Male	108.0	126.0	138.0	147.6	155.0	
	Female	109.5	128.0	141.0	151.0	159.0	166.5

The occurrence in the catches of fish with ripening gonads and the occasional occurrence of young first-year fish indicate that this population of anchovy is to some extent self-perpetuating. An offshore population is indicated by the occurrence of postlarval anchovy in the stomachs of tuna fish caught up to 120 miles offshore. There is a strong possibility that this offshore population may supply a part of the catch in the inshore waters.

A publication to make available the information and conclusions drawn from these anchovy studies will be forthcoming in 1951.

G.C. Pike

Appendix No. 99

WHALE INVESTIGATION - GENERAL INTRODUCTION

In keeping with Canada's obligation as a party to the International Whaling Agreements, the whale investigation is being continued in the collection and analysis of biological data from whales landed at the Coal Harbour whaling station on Vancouver island. It is becoming increasingly apparent that sound basic biological knowledge is necessary for the effective conservation of the world's whale resources. Facilities provided by the comparatively small whaling operations on this coast permit contributions to be made to the present fund of biological knowledge, but more important than this they allow the study of the particular stock of whales inhabiting the north-eastern Pacific ocean, a stock about which very little is known.

Methods and procedures for a systematic collection of data from each whale landed has been organized. These data have as yet no great significance, but over a period of years will provide an authoritative picture of the stock by permitting sound averages and trends to be drawn. General observations from each whale include length, sex, species, general condition, blubber thickness, occurrence and extent of parasites or diatoms, type and quantity of food in the stomach, and length and sex of foetus when present. For each male the weight and size of testes is recorded and occasional histological samples taken to show the state of maturity and the degree of sexual activity. From each female the weight and size of ovaries, number and size of corpora lutea, diameter of largest maturing follicle, thickness and state of uterine cornu and of mammary glands are recorded. Such a collection of data provides information on breeding, growth, age, and to some extent on distribution.

Incidental to, but integrally a part of the above programme, is the measurement of proportional parts from these whales and the determination of age from the baleen plates. These two projects are dealt with in separate appendices. Marking of whales at sea will provide direct evidence of their migrations and distribution, as well as furnishing a check on estimates of growth rate and age.

G.C. Pike

Appendix No. 100

THE 1950 CATCH OF WHALES

Increased efficiency in capturing and processing is evidenced in the steady increase in the catch of whales during the three years' operations of the whaling station at Coal Harbour, B. C. The species composition of the 1950 catch shows no great change from the previous year's catch except for a slight decrease in the number of sperm whales taken. It is notable that the large percentage of humpbacks taken the first year has been replaced by the larger and more remunerative finbacks.

G.C. Pike

Comparison on Whale Catches of 1948, 1949, and 1950 Seasons by Species

Species	Total catch			Per cent of catch		
	1948	1949	1950	1948	1949	1950
Humpback	113	78	105	61.6	30.2	33.4
Finback	39	105	151	21.5	41.2	48.1
Sei	2	2	23	1.2	0.8	7.3
Blue	-	2	4	-	0.8	1.3
Sperm	28	68	30	15.6	27.5	9.6
Bottlenose	-	-	1	-	-	0.3
Total	182	255	314			

An important consideration in considering the effect of whaling on the stock is the number of immature individuals taken in the catch. It is a relatively simple matter to decide if a female is mature by examination of the ovaries. With males it is more difficult. By reference to the ovaries it was found in 1949 that 34.6% of the female humpbacks and 27.1% of the female finbacks were immature. In the 1950 catch 42.4% of the humpbacks and 46.3% of the finbacks were immature. Sei whales were all mature and all but one of the six blue whales captured during these two years were mature. The catch of sperm whales during the 1950 season consisted mostly of young mature bulls. In 1949 the catch of sperm whales showed many old mature bulls, which were only infrequently encountered in 1950.

G.C. Pike

Appendix No. 101

BODY PROPORTIONS OF FINBACK AND HUMPBACK WHALES

An essential part of the biological study of whales is the establishment of external characters and the limits to which individual variations in these characters may occur. As a basis for the comparison of whales from different localities the British Discovery Committee has instituted a series of measurements of body parts. This series, averaging about 18 measurements for each individual, has been followed in this study of finback and humpback whales. The 60 sets of measurements taken during the 1949 whaling season have been supplemented by an additional 223 sets taken during the 1950 season.

Tentative conclusions as to the average condition with respect to body proportions of whales from this coast have been drawn from the 1949 data. For purposes of comparison individual measurements are expressed as percentages of the total length. In accordance with the findings from measurements of whales caught in the Antarctic it is found that males and females are essentially similar except for a difference in the position of the genitalia. The average size of individual measurements are found to be greater for head parts and less for tail parts than in the Antartic individuals.

G.C. Pike

The variation of body proportions with size is marked and reflects a faster growth rate in the head regions than in the tail regions. Mean values of each percentage measurement expresses in metre-length groups shows that with increasing lengths the head becomes proportionately longer and the tail parts proportionately shorter. Width of the head, flippers, and tail become increasingly less. These changes with length reflect changes with age. By comparison with Antarctic measurements it is found that growth rates of head parts are greater and those of tail parts less in whales of corresponding size from this coast. The conclusion is that the growth rate for whales from this locality is less than for their southern counterparts. In support of this conclusion is the shorter average lengths of these whales in statistics of northern catches and the shorter average length at which sexual maturity is reached as found in this investigation.

Although conditions are favourable to the development of subspecific differences between whales from the two hemispheres, existing knowledge gives no evidence of such differences. Results of this study do not suggest subspecific distinction between humpback and finback whales from the two hemispheres, but they do evidence a marked difference in growth rate.

G.C. Pike Appendix No. 102

AGE STUDIES FROM BALEEN PLATES

Age and growth has been a subject of much concern in the study of whales. Length bears little relation to age and no direct method has yet been found for judging the age of any individual whale. A recently developed method for age determination makes use of a periodicity in the growth of the baleen and promises to be an outstanding contribution in providing a means for determining age in young whales. Using this method a recording apparatus was constructed for the determination of age from 114 baleen plates of humpback and finback whales caught during the 1949 season. The thickness of each plate is recorded from base to tip on a revolving drum. A series of levels or steps appear, and these are taken to represent the age of the individual. The method provides age with reasonable assurance to three or four years, and when used together with a method involving the number of corpora lutea in the ovaries, gives results probably valid up to an age of six or seven years.

Grouping of the individual recordings of plates from 66 finback whales by interpretation of the number of thickness levels, shows a range of ages from one to six years. About 50 per cent of the individuals are three and four years of age. By reference to the baleen recordings and assuming the interpretations to represent ages correctly, we may tentatively conclude that female finbacks reach sexual maturity usually at three years but also at two or four years, and at an average approximate length of 59.5 feet. This is contrary to the general accepted view that finbacks all become sexually mature at two years. About 88 per cent of the 48 humpbacks whose plates were recorded were found to be less than five years of age. In keeping with the generally accepted view, all female humpbacks older than two years were found to be sexually mature.

An additional 276 baleen plates for age determinations were collected during the 1950 season's field work.

G.C. Pike

Appendix No. 103

WHALE MARKING PROGRAMME

Preparations are under way for the initiation of a whale marking programme during the coming year. It is desirable that whale marking be done on as large a scale as possible in the interest of sound conservation policy. In addition to providing information on distribution and migration, whale marking will provide data on growth and age, and on the proportions in which different species are removed from the stock by hunting. As yet no positive proof has been evinced of the mixing of stocks of whales from the southern and northern hemispheres of the Pacific, nor has it been proven whether or not stocks of whales from the eastern and western parts of the Pacific are discreet.

The programme will be fashioned after that conducted by the British Discovery Investigations. Marking is done by firing a dart from a 12-bore single-barrelled shotgun. The mark itself is a stainless steel tube 9 1/4 x 1/2 inches with a 2 3/4 ounce lead head at one end and a cartridge crimped onto the other end. Each mark will bear the name of the Fisheries Research Board and a serial number. The position of the ship, number of the mark, and species of whale is recorded when the mark is fired. Recovery data will include the number of the mark, the vessels position at the time of capture, length and sex of whale, and condition of the whale and the wound.

It is planned to use two marking guns for the initial trials. One will be placed aboard a whale-killer boat and a second aboard some ship such as the H.M.C.S. "Cedarwood" which undertakes extensive sea voyages off this coast. It would be particularly desirable to have whales from the Bering sea or gulf of Alaska marked, as this region is the extreme of the whale's northern feeding migration. One of the killer boats operating from Coal Harbour, the "Speedmac", a fast 65-foot craft, would be ideal for marking in permitting whales to be run down quickly and marked at close range. In addition to marking small "undersize" whales it could also mark larger whales such as finbacks and blues which cannot be harpooned by so small a boat.

T.H. Butler

Appendix No. 104

SUMMARY OF MARINE CRUSTACEA STUDIES

Crab

Field studies of the Queen Charlotte island fishery were continued during the past summer. An increased tagging programme was carried out on the east- and north-coast fishing areas. More tags were recovered from tagging carried out in May and June than from the latter series in August. This points to the value of tagging early in the season. The high tag recoveries from the east coast are due directly to increased fishing of both Canadian and American vessels. The American fishermen co-operated in the forwarding of recovered tags.

It is recommended that tagging should be continued in the future, and that the main part of the work be completed early in the season. Recoveries then will provide a more accurate picture of fishing intensity and magnitude of crab populations.

As recovery data and catch figures are not complete at this time, population estimates are not presented for 1950. However, the populations for 1947-49 are given in a later Appendix. The lower tag recoveries in these former years gave estimates with quite broad fiducial ranges. These estimates are nevertheless an important part of the study in demonstrating fluctuations in the population.

The more detailed report of larval studies (Appendix No. 107) demonstrates the need for further study in this important phase of the crab investigation. A clearer understanding of the early life-history stages should prove of value in correlating the abundance and distribution of adult crabs.

Through the co-operation of the trawl investigation the M/V "Investigator No. 1" was made available in September for tagging and prospecting work. Experimental tows were made in localities not fished at the present time, and 51 crabs were tagged in these places. Of special interest were the deeper water tows on the north coast area, but dragging to a depth of 30 fathoms showed no large concentration of crabs. If the vessel could be obtained for a longer period and at a more suitable time of the year, valuable studies could be conducted. In Hecate strait, especially, information regarding distribution and life history is needed.

Other phases of the crab investigation, such as width frequency, distribution, growth and reproductive habits were continued during 1950. For the life-history and reproductive studies, about 50 crabs of both sexes were preserved for later study.

Some field work was conducted on crabs in the Fraser mouth area. In December, 1949, two trips were made on the trawler "Norma N" to observe whether trawling causes damage to crabs. No damage of trawl-caught crabs was observed on these trips. However, at that time the net loads were light and soft crabs were absent. Samples of catch totalling about 200 crabs were measured and sexed. A small programme in this heavily-fished area might prove interesting as a comparison with the Queen Charlotte island crab fishery.

Shrimp

Mr. R.M. Wilson, port observer in Vancouver, has distributed about 20 shrimp log-books to fishermen working out of Vancouver. The shrimp

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fishermen have shown great interest in keeping these log-books. Data from them are under consideration.

Observations of the operation of the shrimp-sorting machine are presented separately. As is pointed out, more observations are needed to determine the extent of injury by the machine to undersized shrimps.

T.H. Butler Appendix No. 105

THE 1950 CRAB TAGGING EXPERIMENT

Crabs were tagged on the east-coast area during the period May 5 to August 28. Recoveries to September 30 totalled 211 tags. Of the total number tagged, only 970 tags have been considered; the minimum fishing intensity, then, is 21.7 per cent. This latter value is considerably higher than previous years when the percentage recovery was well below 10 per cent. The increased fishing intensity in 1950 is due directly to the increase in fishing gear, mainly belonging to American crab boats.

An interesting feature this year was a movement of tagged crabs, directly related to an increase in catches in the area into which movement occurred. Crabs were tagged in an area about six miles off shore during May and June; in July the fishing in this area dropped off, and good fishing was then found in a location about one mile off shore. Crabs tagged off shore then appeared in the inshore area, thus indicating a movement of the population inshore about five miles within a short period.

During the period from August 4 to September 7, 620 crabs were tagged on the north coast. A total of 48 tags had been recovered by September 15. Of the total number tagged, only 325 tags have been considered; the minimum fishing intensity, then, is 14.7 per cent.

A total of 191 crabs was tagged in Naden harbour. As the fall fishing did not commence until October 1, recovered tags have not reached the writer.

T.H. Butler Appendix No. 106

CRAB POPULATION ESTIMATES FROM TAGGING EXPERIMENTS

Using tag-recovery data and catch statistics, population estimates have been calculated for the seasons of 1947, 1948 and 1949. The paper by Chapman (Bulletin International Pacific Salmon Fisheries Commission, 2:67-85, 1948) was consulted for the method of calculation of fiducial limits (95% confidence level).

The recovery data have been modified slightly to include only series from which tags have been recovered. Series which have not produced recoveries are generally those which were tagged late in the season.

The population estimates with fiducial limits, catches and recovery data for the three fishing areas are presented in the following tables:

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East Coast

Year	Effective Tagging	Recoveries	Catch	Population Estimates	Upper Limit	Lower Limit
1947	464	30	44,569	689,350	982,300	459,300
1948	478	23	141,681	2,952,000	4,432,100	1,843,500
1949	404	37	249,605	2,731,625	3,751,000	1,898,800

North Coast

Year	Effective Tagging	Recoveries	Catch	Population Estimates	Upper Limit	Lower Limit
1947	406	31	51,132	669,690	948,750	451,530
1948	694	26	86,694	2,314,100	3,387,000	1,490,990
1949	409	10	73,083	3,026,700	3,571,200	1,416,500

Naden Harbour

Year	Effective Tagging	Recoveries	Catch	Population Estimates	Upper Limit	Lower Limit
1947	358	121	96,737	277,770	339,400	237,800
1948	508	176	87,374	252,100	292,400	217,500
1949	252	85	54,411	161,300	199,600	130,200

It will be noted the ranges between the fiducial limits for the above population estimates are broad. However, the estimates give an indication of the magnitude of the crab populations present on the fishing grounds.

As yet, no index of population density has been devised. It is hoped that an index using number of traps and fishing area may prove suitable in future calculations.

Following is a table comparing the population estimates and the annual average catch per trap. This latter index has been calculated from log-books.

Year	East Coast Population Estimates	East Coast Crabs/Trap	North Coast Population Estimates	North Coast Crabs/Trap
1947	689,350	7.5	669,690	5.1
1948	2,952,000	10.0	2,314,100	7.6
1949	2,731,625	9.8	3,026,700	6.8

There is a degree of correlation between the population estimates and the availability. With the use of a proper index of population density, this relation should become more apparent.

T.H. Butler Appendix No. 107

CRAB LARVAL STUDIES

During the summer of 1949 a limited number of surface plankton tows was taken on the three crab fishing grounds. Later this material was examined to determine the occurrence of larvae of the commercial crab. Zoeal larvae were quite numerous in the samples, but due to the lack of keys and descriptions, complete identification was not possible.

In March and April, 1950, a rearing experiment was carried out to obtain larval specimens which could be used for identification purposes. Nineteen ovigerous females were obtained in two lots from the trawler "Norma N". The female crabs were retained in wooden boxes previously used in the lobster larvae rearing experiments. A good hatching of pre-zoeal larvae resulted, and at the termination of the experiment on April 23, two larvae in the first stage had been collected.

The first zoeal stage thus forms a starting point for identification of the series from the plankton. That is, if first-stage zoeal larvae are identified in plankton tows, it should be possible to rear them to the second stage. During the recent summer, plankton tows were taken during July and a few first-stage larvae were identified. These larvae were kept in glass jars and fed on a diet of brine shrimps. In a set of four trials, all larvae were dead before moulting into the second stage had occurred.

The writer considers the larval studies to be an important phase of the crab investigation. Undoubtedly a correlation can be shown in distribution and abundance between larval and adult crabs. However, without exact identification of the larval stages, plankton collections are of little value.

In the field both ovigerous females and larvae are obtainable at appropriate times during the fishing season. The installation of a suitable saltwater circulating system in Massett would greatly facilitate future rearing experiments.

T.H. Butler Appendix No. 108

TESTS OF MORTALITY CAUSED BY SHRIMP-SORTING MACHINE

The shrimp-sorting machine constructed by Mr. A.W. Lantz of the Pacific Fisheries Experimental Station was given its second trial on a shrimp-fishing vessel on March 13 and 14, 1950. Mr. Lantz invited the writer to accompany him on the shrimper "Yuri M" to carry out observations on the survival of undersized shrimps which pass through the machine and return to the sea.

The method of observing survival was to collect two samples, one of shrimps passing through the machine, and a sample taken directly from the shrimp net as a control. These two samples were then placed in hatchery-type wire baskets and lowered to a depth of 15 fathoms for a period of half an hour. Only one trial was carried out due to adverse weather and tidal conditions.

Upon return to the surface, the samples were examined and in the

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machine-sorted sample of 136 shrimps, 15 were dead. In the control of 156 shrimps, 12 dead were found. This single observation is not sufficient for statistical consideration. Further data are required to determine whether undue injuries result from passage through the sorting machine.

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Appendix No. 109

A PROPOSED RELATIONSHIP BETWEEN THE EXPLOITATION OF A CRAB POPULATION AND THE LIFE HISTORY OF THE CRABS.

Observations made on the crab population in Hecate strait along the east coast of Graham island lead to conclusions concerning the modification of the life history of the crabs by the fishery which may, if substantiated, have a bearing on the development and management of the fishery.

Early observations were that in 1946, when the fishery began, a large proportion of the legal-sized males were small and they were so heavily fouled with barnacles and hydroids that it appears they had not moulted for some time. During the early years the incidence of soft-shelled crabs in the fishery was very low. These observations indicated that considerable proportions of crabs were not moulting and this view was supported by the tagging work begun in 1947. Although a crab must lose its tag in moulting, numbers of crabs carrying tags put on 12 to 14 months previously have been recovered as well as a few on which the tag had been out for 25 or 26 months.

These conclusions are at variance with those obtained for other parts of British Columbia (Spencer, MacKay), or Washington (Cleaver), or Oregon (in progress) where all the evidence seems to indicate regular annual moulting of the males.

Later observations in North Hecate strait indicate that conditions have been changing there recently. The proportion of small heavily-fouled males has decreased, suggesting, except for the size, that an accumulation of old individuals has been caught off. There has also been a substantial increase in the proportion of soft-shelled (unsalable) crabs in the area. This increase has been so great as to threaten the successful pursuit of the fishery.

Consideration of three points in the life history of the crab suggests an explanation of these observed changes in the fishery: (1) the sex ratio of crabs in North Hecate strait (and presumably in other virgin stocks) strongly favours the male; (2) the males are polygamous (Cleaver); (3) in breeding, a hard-shelled male embraces a soft-shelled newly-moulted female and moults following mating. If moulting depends upon success in breeding the presence in the early fishery of small old crabs can be explained, since, like other crustacea, a crab must moult to grow and many males must remain unmated. The reduction by the fishery (which takes out males) of the disproportion of non-breeding males leads to the disappearance of the small fouled crabs and the increasing proportion of the soft-shelled males.

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The appearance on the fishing grounds of high proportions of soft-shelled crabs in an active fishery presents problems in administration. In some fisheries these have been met by having summer closed seasons. This type of control should be invoked in Hecate strait only following particularly careful consideration as weather conditions there are so different that the summer months are the only time in which a trap fishery is feasible.

E. and C. Berkeley Appendix No. 110

POLYCHAETE STUDIES

Our paper on the Polychaeta Sedentaria of western Canada appeared in the "Annals and Magazine of Natural History" early in the year, enabling us to complete the account of that section of the Family in our contribution to the Canadian Pacific Fauna series. The illustrations for the latter are not yet quite complete, but they should be finished and the whole ready for publication within a few months.

Quite a number of enquiries bearing on polychaete taxonomy have been submitted to us during the year, chiefly from workers in the U.S.A., and several small collections, made by workers both at the Station and elsewhere, have been examined.

The rearrangement and cataloguing of our own collection incident on moving into the new building also occupied a considerable share of our time.

J.R. Brett

Appendix No. 111

TEMPERATURE EXPERIMENTS WITH PACIFIC SALMON

A start on the "physiological description" of one group of Pacific coast fishes has been made by investigating the temperature tolerances of salmon fingerlings. Each of the five species (spring, coho, sockeye, pink, chum) has been maintained at different levels of temperature acclimation including 5° C., 10° C., 15° C., 20° C. and 23° C., and the limits of heat tolerance (upper lethal temperature) and cold tolerance (lower lethal temperature) determined. Experiments using temperature gradients have provided records of the preferred or selected temperatures for these levels of acclimation. In addition, experiments on low oxygen tolerance have been conducted, but the principal aim has been to establish a basic knowledge of the temperature relation for the five species.

At levels of acclimation of 10° C. and above, the spring and coho salmon have a significantly higher temperature tolerance which may be used to distinguish them physiologically from the remaining three species. If long-term (one week or more) upper lethal temperature experiments are conducted, the sockeye show a significant increase in their temperature resistance-time over that for the pink and chum salmon. In this manner three levels of heat tolerance may be demonstrated among the five species.

At low temperatures the problem of determining when a fish is living or dead has usually prevented the recording of actual times to death since vital activities (respiration, muscular contraction, etc.) are usually so depressed that no visual criterion of death can be applied. In such a case samples of the fish must be returned to warmer water and records of recovery made. Among the Pacific salmon, however, it was discovered that with the approach of death from a low temperature the immobile and closely compressed opercula commence to fan out perceptibly. This criterion can be shown to be significant when compared with data from recovery at warmer temperatures.

The relation between resistance-time to low temperature and the level of that temperature has not been resolved into a simple equation, as has been the case for heat-tolerance relations. It is apparent that two reasons for death complicate the cold-tolerance relation. The first of these is a rapid lethal factor possibly acting directly on the nervous system, while the second is much slower in effect and is partly or wholly related to osmotic balance.

Ideally, the lethal temperature has been defined as that temperature at which 50 per cent of the population can live indefinitely. The following table lists the upper lethal temperatures derived for a sample of 100 fish exposed for a period of one week.

Acclimation	Spring	Coho	Sockeye	Pink	Chum
23°C.	24.9°C.	24.9°C.	24.3°C.	23.8°C.	23.8°C.
20°C.	24.9°C.	24.7°C.	24.3°C.	23.8°C.	23.6°C.
15°C.	24.5°C.	24.3°C.	24.0°C.	23.1°C.	23.5°C.
10°C.	24.2°C.	23.9°C.	23.4°C.	22.5°C.	23.0°C.
5°C.	22.0°C.	22.7°C.	22.3°C.	21.3°C.	21.6°C.

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These experiments have been conducted at the Southern Research Station of the Department of Lands and Forests, Ontario, under the direction of Dr. F.E.J. Fry. The excellent facilities of the laboratory and co-operation of Dr. Fry and his staff have been greatly appreciated.

W.S. Hoar

Appendix No. 112

THE BEHAVIOUR OF CHUM, PINK AND COHO SALMON IN RELATION TO THEIR SEAWARD MIGRATION

The downstream movement of chum, pink and coho salmon was studied at Nile creek during May and June. An attempt was made to define the prominent behaviour patterns of these fish, to measure quantitatively, under different conditions, the intensity of these activities, and to describe the downstream movement in terms of these findings. Fish were observed in the stream and in laboratory aquaria. Reactions to current were studied in circular tubs and in troughs. The following behaviour patterns were described: schooling, milling, aggregating tendencies, rheotaxis, "nipping", defence of specific territory, cover reactions, feeding and photosensitivity at night. Pertinent findings were:

(a) Chum and pink salmon fry in fresh water show characteristic milling and schooling behaviour during the day and are positively rheotactic and on the move both night and day. At night schooling ceases and the fish rise toward the surface. Rheotaxis is less marked with the loss of visual and contact stimuli, and the fish are displaced downstream.

(b) Coho fry are related to particular objects in the streams. By nipping they frequently defend specific territories and become widely distributed in the stream. At night they are in less rapid waters and maintain their positions.

(c) Coho migrants show a pronounced tendency to aggregate, a lessening of nipping, chasing and territory behaviour, and a lowered threshold for photic stimulation both day and night. At night they rise to the surface, become very active and are displaced downstream when they reach swift water.

(d) Increased temperature modifies behaviour so as to promote downstream movement. In chums a marked negative rheotaxis may develop while coho migrants show a lessening of their mild territory activity. Sudden elevation in water level will increase the rate of downstream displacement.

W.S. Hoar

Appendix No. 113

SOME BEHAVIOUR PATTERNS OF MIXED GROUPS OF COHO SALMON AND STEELHEAD TROUT FRY

Nipping, chasing and territory defence were studied with equal numbers of salmon and trout in a group. The three patterns of behaviour are similar in both species of fish. In mixed groups, the coho were found to hold

W.S. Hoar

more than 90 per cent of the territories defended. Nipping and chasing were observed between trout and trout, trout and coho, coho and coho. The relative numbers of "nippings" recorded were: trout to trout 25%; trout to coho 8%; coho to trout 40%; coho to coho 27%. Because of adverse water conditions, the experiments were not completed, but it was quite evident that, under the conditions of observation, the coho dominated and displaced the trout.

D. MacKinnon Appendix No. 114

HORMONE AND BEHAVIOUR STUDIES ON THE YOUNG CHUM AND COHO SALMON

Experiments on chum migrants, coho fry and coho migrants at Nile creek from May 15 to August 31 were designed to show:

1. The responses of chum migrants and coho fry to differences in flow.
2. The effects of hormones on schooling of chum migrants and aggregating of coho fry.
3. The effect of male sex hormone injections on early maturity of coho migrants.
4. Light reactions of chum migrants and coho fry and the effects of hormone treatment on these reactions.

(1) Responses to flow differences

Fish were observed in a long rectangular bisected trough. Each arm of the trough presented a different flow situation. It was found that:

1. The chums perceived and moved into the area of greater flow. This was the case when the temperature was the same in the two flows, when the temperature was lower in the increased flow and when the temperature was higher in the increased flow.
2. The cohos reacted similarily, but after two or three hours in the trough, the initial response lessened and the cohos became indifferent to the faster flows and in some cases chose the lesser flow. It is probable that there is no actual change in response and the results are explainable by the active territorial behaviour of the coho (described by W.S. Hoar in another report in this issue).

(2) Effects of hormones on schooling and aggregating

Chum migrants and coho fry were immersed in thyroxine, thiourea, stream water and testosterone solutions and observed in circular tubs which had been divided into four equal sections by painted lines. It was found that:

1. Chum migrants treated with thyroxine or testosterone show a less intense schooling reaction than the control or thiourea-treated fish.
2. Although the cohos don't school, their aggregating tendencies are increased by thiourea treatment.
3. Disturbance increases the schooling tendency of chums and the aggregating tendency of coho.

D. MacKinnon

(3) Sex hormone injections

One-tenth of a milligramme of testosterone (aqueous suspension) was injected three times weekly into the dorsal musculature of one group of coho migrants while isotonic saline was injected into another group. This procedure was carried out for periods up to four weeks. High mortality from handling, fungus infection, and injection injury discouraged completion of this experiment.

Observations of the injected fish showed no evidence of secondary sex characteristics, and microscopic observations of the gonads showed no increase in gonad development. Samples were preserved for histological study.

(4) Light reactions

Preliminary light-reaction experiments were carried out on chum migrants and coho fry which had been treated by immersion in thyroxine solutions, thiourea solutions and stream water.

The observations indicate that the chums generally respond by moving into the areas of greater illumination while the cohos seem to prefer the areas of less illumination.

In the chum series the thiourea-treated fish show the reverse of the thyroxine-treated and control fish by "choosing" the areas of least illumination.

This work was done under Dr. W.S. Hoar on a National Research Council scholarship (University of British Columbia). The full facilities of the Fisheries Research Board Nile creek field station were used.

D. MacKinnon Appendix No. 115

BIOLOGICAL SAMPLING ON OFFSHORE CRUISE II

An offshore trip on H.M.C.S. "Cedarwood" was made to determine the possibility of fitting a biological programme into the offshore operations of the Pacific Oceanographic Group.

It was decided that an attempt be made to take vertical sectional plankton hauls at a series of stations where chemical and physical data were to be obtained and to attempt to tow a hoop net (6' diameter, $\frac{1}{8}$" mesh) at chosen offshore locations.

The object of the plankton hauls was to determine the time necessary for the operation, the limitations of the gear, and the general compatability of the operation.

It was found that the time taken varied only with the depth of the haul. By using the "messenger" system designed by E.G. Hart, 1935,[X] equal sections above, below, and through the thermocline could be fished in one haul requiring about 30 minutes of the operation's time. The sections fished do not have to be of equal length, but each section must be equal or less in length than the section or sections below it to sample a column in one haul.

The operation was greatly hindered by gales and heavy seas. These adverse conditions served to bring out the limitations of the gear and to indicate modifications necessary for a successful programme. The modifications are mainly in the strengthening of the parts where the nets are fastened to the rod.

Weather conditions did not permit towing the hoop net for juvenile fish. It is thought that this net should not be towed at a speed in excess of 2 knots. The engines on the "Cedarwood" will permit a minimum cruising speed of 3.5 knots. The captain of the ship is quite sure that the net can be towed at a speed ranging from 2 knots to 1.5 knots by "kicking it ahead" and shutting off the engines periodically. The "Cedarwood" engines are well fitted for this type of operation owing to previous work requiring low cruising speeds.

Both these operations require two men exclusive of the crewman who handles the winch. Consequently the biologist should be fully prepared to co-operate with the oceanographers. By mutual co-operation an efficient routine can be worked out that will benefit both the oceanographer and the biologist, and provide some important information at a relatively low cost.

[X] E.G. Hart. Some devices for the manipulation of marine plankton collections on board ship. Journ. du Conseil, Vol. 10, No. 2, 1935.

J.P. Tully

Appendix No. 116

TEMPERATURE AND SALINITY CYCLES

Daily seawater observations and some oceanographic data were examined to evaluate the cyclic nature of the variations in temperature and salinity. Cycles correlated with the semi-diurnal tidal period, were daily in regions where the water could enter the region by one route and leave by another, and semi-daily in regions having only one opening such as inlets, etc.

Aside from this the annual cycles were the most apparent. The temperature appears to follow the seasonal trend with a maximum in late summer and minimum in late winter, with secondary fluctuations evidently due to wind. The salinity is a minimum during early summer, associated with the greatest runoff from the big rivers, a maximum in the autumn when land drainage is least. Intermediate levels of salinity in winter and spring are associated with considerable coast drainage while the higher reaches of the big rivers are ice-bound.

The long-term trend indicates that the annual average seawater temperature increased from 1917 to a maximum in 1945, in an oscillating series whose minima occurred at intervals of 5, 6, 8 and 13 years, and the minimum (since 1917) occurred in 1948.

W.M. Cameron

Appendix No. 117

OCEANOGRAPHY OF CHATHAM SOUND

The investigation of the data collected in Chatham sound during the summer of 1948 is nearing completion. More detailed review has confirmed the essential features outlined in Progress Report No. 76, published in 1948.

The dynamics of the circulation have been examined critically. It has been demonstrated that the mass distribution is in approximate balance with the deflecting force of the earth's rotation. Calculation of relative currents under this assumption agree in magnitude and direction with the currents measured during the survey. Deduced fresh water transports through restricted portions compare favourably with the river discharges.

The confirmation of the applicability of the equation of Sandstrom and Helland-Hansen to the restricted waters of a sound is encouraging. It suggests that lateral friction in coastal waters of this type is of secondary importance and that synoptic surveys may be interpreted in terms of the stationary circulation theory.

H.J. Hollister

Appendix No. 118

DAILY SEAWATER OBSERVATIONS

The programme of daily observation of surface seawater temperatures

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and the collection of water samples for salinity determinations is continuing at eleven lightstations and at the Pacific Biological Station. In addition temperatures are observed at the Department of Fisheries' wharf, on the Fraser river.

These data, provide a back-log of information that can be used in studies to determine the duration, and frequency of repetition of the coastal oceanographic conditions which are being investigated in the survey projects, and their relation to meteorological conditions.

It is the purpose of this investigation to accumulate these records as reference data for all other investigations in the Canadian coastal seas, to determine their significance as submarine climatological indices, to determine their relation (if any) with success of the coastal fisheries, and to evaluate annual cycles and trends, and geographic differences. Studies based on these data may be anticipated.

R.J. Waldie

Appendix No. 119

GEORGIA STRAIT PROJECT

Oceanographic investigations are being conducted to provide a clear description of the structure, mechanics, and dynamics of the waters of Georgia strait, and their relations to the seasonal cycles of weather and land drainage.

Seven synoptic surveys of the area have been made since December 1949, and two more will be made this winter. Each survey was completed in 8 to 12 days and provides data for the description of the oceanographic state at one time, and the series includes the whole cycle of seasonal changes.

A survey consists of seventy or more "serial stations" strategically distributed in the area, at each of which salinity, and dissolved oxygen were observed at 10 or more depths between the surface and the bottom, and continuous temperature measurements made by bathythermograph. More than 500 stations, which have provided more than 5,000 seawater samples have been observed this year.

The salinity analysis shows that the fresh water from the Fraser river enters the strait, flows out over sea water and mixes with it to form a stable, readily distinguishable brackish zone which is considerably less saline than the sea water zone below it. It is evident that this upper brackish zone varies with the locality and the seasons of the year. It is freshest and very muddy near the river mouth and as it progresses away from the river it becomes deeper and more saline. Practically all the variation of temperature, salinity and density occur in this upper brackish zone, while the properties of the lower zone remain nearly constant throughout the year.

It is proposed to analyse the series of synoptic surveys obtained this year and define the relation of structure and mechanism to the discharge of the Fraser river, and provide a series of charts, showing type situations, with a key to show the conditions of their occurrence, that can

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be interpreted for military and fisheries uses.

It is probable that an occasional survey will be desirable hereafter to fill the gaps in the existing data, and to confirm the correlations.

L.A.E. Doe — Appendix No. 120

THE OFFSHORE PROJECT

Two oceanographic surveys, comprising three cruises, were made in the Pacific ocean adjacent to the British Columbia coast. Each survey was scheduled to occupy about one hundred stations, from ten to fifty miles apart, on lines across the area. On each station temperature, salinity, and dissolved oxygen content were observed from the surface to 3,600 feet (1,100 meters) depth.

The first survey, in H.M.C.S. Cedarwood, covered the whole area from the latitude of cape Flattery to Dixon entrance and westward to 141°W (680 miles offshore). The second survey was made in two cruises. Both started under favourable conditions but were interrupted and finally curtailed by a series of gales. The first, in Cedarwood during late September, covered the northern half of the area. The second, in C.G.S. Wm. J. Stewart, attempted and partially completed the southern portion to about 137°W (450 miles offshore).

Temperature and dissolved oxygen concentrations were determined at sea. Determination of salinity was attempted in Cedarwood, but was found impractical and all the samples were titrated ashore, by the Knudsen procedure. The data are being analysed to show the distribution of temperature, salinity, density, dissolved oxygen, and the gradient currents in the area, at the peak of summer, and during early autumn.

On conclusion of the first survey it became apparent that the supposed mid-ocean expanse of warm water off the British Columbia coast was only a limited band parallel to the coast containing three huge "clouds" of warm water. This band was narrow (20 miles) and near shore at the northern end of the survey, and wide (120 miles) and further offshore at the southern end. Cold water lay between the coast and the warm belt and also beyond it in mid-ocean.

Evidently the West Wind Current lost its heat in the long traverse across the ocean from Japan, but joined with "locally warmed" water of the British Columbia coast. Whether this is a normal season or not, the assumptions regarding warm water in mid-ocean in these latitudes must be modified.

R.L.I. Fjarlie — Appendix No. 121

THE FRASER RIVER ESTUARY PROJECT

A detailed oceanographic investigation of the approaches to the Fraser is being conducted to determine the nature of river discharge into

R.L.I. Fjarlie

the sea, and to locate suitable areas for sewage discharge in the vicinity of Vancouver that would avoid pollution of the beaches near the estuary.

Since May 1st, eight surveys of the area have been completed, from the time of minimum too maximum river flow. On each cruise salinity stations were occupied as many times as possible in order to observe the oceanographic situation at periods of low and high water for both spring and neap tides. Observations of free floats were carried out at the same time in an attempt to correlate existing current patterns with the synoptic picture. Fourteen photographic surveys of the surface water movement of the whole estuary for the period from high tide to high tide of a spring and neap cycle were completed. The relative dispersion of the water from the various river mouths was measured by using a gang float technique, with floats released simultaneously from each outlet, at intervals over a complete tide cycle.

While the tide is rising, the fresh water discharge from the river accumulates in the estuary, and is released as a cloud as soon as the ebb commences. The clouds are carried a short distance by the momentum of their discharge from the river, and then join the tidal system, gradually losing their identity as they merge with clouds discharged on previous tide cycles.

In general the river water moves persistently northward along the mainland shore. All the discharge from the North Arm of the river moves into English bay during the flood tide, and a small part intrudes Vancouver harbour. The northward moving discharge from the Middle Arm lies to seaward of the North Arm water, a part enters English bay, but none intrudes as far as Vancouver harbour. Discharge from the South Arm of the river moves northward without entering English bay.

The future programme calls for completion of the analyses of the data according to standard oceanographic practice, and investigation of other means of analysis to utilize the simultaneous observations of salinity and current structure which have been obtained.

J.B. Nuttall

Appendix No. 122

A MODEL STUDY OF STRATIFIED FLOW IN ALBERNI HARBOUR

A hydraulic model of Alberni harbour is being constructed to study the mixing of fresh and salt water, sewage disposal, and to determine the effects of proposed dredging operations.

The prototype area includes Alberni harbour from Polly point in the inlet to the first bridge crossing the Somass river, on a horizontal scale of 1:1000, and vertical scale of 1:84. The model is 23 feet long by 8 feet wide including approach channel. The time scale is 1:109 by which one year in the prototype can be reproduced in 80 1/3 hours.

The model bed is moulded in cement, and provision has been made to place sand in the errodible areas so that scour and silting can be studied.

Fresh water is supplied to the river through a calibrated weir. Tidal effect is closely approximated by integrating the four major tidal components in a tide machine, connected to operate valves which admit and

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discharge salt and mixed water. A correcting servo-mechanism has been included in the control gear to ensure accurate reproduction of the tidal height under all conditions of river flow.

Work was begun on the model bed in July, 1950 and this was substantially completed in September. The control gear is being constructed at the University of British Columbia and it is hoped this will be installed in December.

Verification tests are to be completed by May, 1951 when the model will be ready for research.

This work is being conducted partly under a research grant from Bloedel, Stewart and Welch Limited, through the Institute of Oceanography, and partly with the facilities of the Ocean Model Laboratory. The physical assets from the research will remain in the laboratory.

L.A.E. Doe — Appendix No. 123

OCEANOGRAPHY IN BARKLEY SOUND

An intensive oceanographic investigation of the Loudoun channel region of Barkley sound was carried out in April to determine conditions while the herring were in the larval stage. The thesis had been advanced by J.C. Stevenson that retention in the sound until they had reached the free-swimming stage was a necessary condition for the survival of the larvae. The purpose of the investigation was to study the currents and circulation and to discover, if possible, what conditions might cause the larvae to be dispersed prematurely in years whose class-strengths are subsequently found to be below normal.

Direct measurements of current with captive floats were made every two hours throughout a day, in a number of selected positions, at depths of 2, 3, 5, and 10 fathoms. Salinity and temperature observations were made every three hours. Some supplementary observations on surface currents were also made with free floats.

The water from the Maggie river was found to follow the northwest shore of Loudoun channel to the ocean. Some of the fresh water from Alberni inlet finds its way through Sechart channel into Loudoun channel where it joins with that from the Toquart river to form an upper zone of relatively low salinity over the whole area. The net flow of this upper zone water appears to be biased slightly to the westward, indicating a gradual discharge out through Loudoun channel to the ocean.

In general the currents are weak and variable - of the order of a small fraction of a knot in most cases. This is undoubtedly a necessary condition for the retention of the herring larvae in the sound. Two conditions are suggested which might disrupt this, producing a stronger outwards or offshore set which would carry the larvae out to sea. One, as advanced by Stevenson, is an abnormal prevalence of westerly or northwesterly winds. The second would be an unusually heavy fresh water discharge into the sound from its various sources. To establish either of these hypotheses observationally would require repeated investigation in the future.

L.A.E. Doe

One interesting incidental discovery was that while the tide rises and falls twice daily, as is normal on the coast, the current changes direction through only one cycle per day. This had previously been observed in Nootka sound, but had been considered a purely local anomally. It now appears that the phenomenon may be of more general occurrence.

G.R. Harris

Appendix No. 124

LOST LAGOON SURVEY

A survey of the salinity, temperature, and dissolved oxygen content of Lost lagoon in Vancouver's Stanley park was undertaken to determine if these waters were suitable for certain biological forms reported there. The service was requested by Mr. C. Berkley at the Pacific Biological Station in connection with his studies of polycheate worms.

The water was brackish (salinity 5.6 to 6.2 $^{o}/_{oo}$), warm, and the dissolved oxygen content varied widely, presumably a result of cut grasses which have not been removed. Connection with the sea is controlled by a tidegate connected to Coal Harbour and circulation appears to be small.

J.P. Tully

Appendix No. 125

OIL IN BUTE INLET

A wax has been reported floating in Bute inlet during the cold weather in late January and early February. We have not seen the wax and have had to rely on reports and samples collected by local residents. According to these, the substance has appeared more or less regularly during the coldest part of the winter for the past twenty years.

Dr. Lyle A. Swain of the Fisheries Experimental Station, Vancouver reports 56% to 57% unsaponifiable matter and up to 46% free fatty acids, with no cholesterol or glycerols. He suggests it is esters of fatty acids and alcohols. Evidently it is a marine rather that a petroleum oil.

Because of the character, quantity, and evident recurrence of the oil it is possible that it may have commercial value. It is supposed that plankton, either indigenous to the region, or carried in from Georgia strait is killed in great numbers by contact with the fresh water in the freshet season (April through July). It sinks to the bottom, decomposes anaerobically, and releases oil which is prevented from rising to the surface by the silt in the water. In the winter when the silt content of the water is small the oil reaches the surface, freezes to wax, and is detected. This is compatable with the theory of origin of some petroleum oils.

The region was examined oceanographically on August 2, and again on September 10, when it was observed that the salinity structure was normal to a depth of 600 feet, but there was a temperature minimum between 150 and

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200 feet, and the deep layers appear to be stagnant since the dissolved oxygen concentration decreases markedly below the temperature minimum. The sounding gear in Ehkoli was not adequate to reach the bottom which is at 2,000 to 2,400 feet. No oil was observed in the inlet, in the water or in the bottom muds at 600 feet or less.

It is planned to continue the investigation with the medium duty winch in Cedarwood, and an attempt will be made to observe the floating wax in January and February.

I. Gould Appendix No. 126

ATTEMPTED CORRELATION OF BAROMETRIC PRESSURE DIFFERENCE AND WIND VECTORS

It has been proposed that the occurrence of pilchard is affected by the amount of wind blowing North or South parallel to the coast. Theoretically these vectors should be proportional to the pressure gradient normal to the coast.

The difference in barometric pressure between Burrows island and Umatilla lightstation were determined from data compiled by the U.S. Coast Guard from 1925 to 1950, corrected for constant errors and compared to the observed winds at Umatilla, and to weather maps.

No correlations were found.

This does not vitiate the method which has been used elsewhere, but it does indicate that these data were not suitable for the purpose, possibly because of unreliable observations.

If such analysesare attempted again, only data from the network of first calss observing stations should be used.

J.P. Tully Appendix No. 127

OCEAN MODEL LABORATORY

A new laboratory has been built, in which hydraulic models of coastal seaways and oceanographic principles can be constructed. This is a shanty roofed building 20' x 40' with 10' at one end taken for a draughting room, and washroom. The laboratory is 20' x 30' with 10' clear to the rafters with gravel floor, provided with cement piers on 8' centers. Water is laid in a wooden ditch, which also serves as overflow drain, along one side of the laboratory. The fresh water supplies 0.04 to 0.06 c.f.s from the Stations water supply, and a booster pump, whose use is optional, raises this to 0.10 c.f.s. The salt water supply is 0.11 c.f.s. by gravity feed from the fire protection tank. A sewer from the wooden ditch in the laboratory is provided through a 6" tile drain to the sea.

At the present time a model of Alberni harbour is being built by J.B. Nuttall under a fellowship from the University of British Columbia. This project will provide the tide generating and recording machinery, flow control, a permanent model base and precise level, current meters, and sampling devices, in return for the use of the laboratory.

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As soon as possible, it is planned to set up a flow channel to investigate the mathematical theory of mixing and oceanographic structure discussed by Mr. Cameron in the Chatham project and observed in all coastal data. Also a rotating model to study the nature of fresh water flow from a simple channel into a simple basin is planned in support of the current investigations. Both of these models are needed to solve oceanographical principles which have not been described as yet.