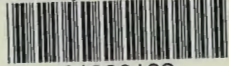


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FISH-POWER PROBLEM AND RELATED WORK

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FISHERIES AGENCIES IN BRITISH COLUMBIA

Prepared by

Research Sub-Committee

Fisheries Development Council

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orks by fisheries agencies in B
c1 ritish Columbia.

Department of Fisheries, Canada
Vancouver, B.C.

Revised December, 1961

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FISH-POWER PROBLEM AND RELATED WORK

BY

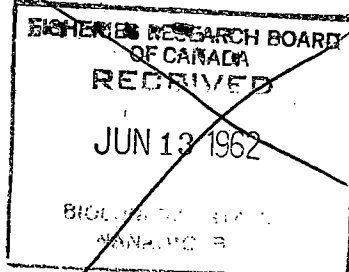
FISHERIES AGENCIES IN BRITISH COLUMBIA

Prepared by

Research Sub-Committee
Fisheries Development Council

Department of Fisheries, Canada
Vancouver, B.C.

Revised December, 1961



SUMMARY OF THE CURRENT STATUS OF RESEARCH PROJECTS
(Revised to December, 1961)

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PROJECTS COMPLETED OR DISCONTINUED SINCE LAST REPORT

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D 1, 3, 4, 5, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 31,
D 32, 33, 34, 37, 38.
E 7, 9, 10, 12.

SPECIAL NOTE.

Attention is drawn to the intention of the report as explained in the preface, which is to provide an up-to-date index of fisheries research on the fish-power problem in British Columbia for the convenience of those who may wish to use it. The following summaries have not been written with the intention that they should be quoted verbatim or otherwise used as direct scientific references. They are merely a summary and guide to the current status of research. Those interested in specific information are advised to consult the references listed or the responsible agency.

PREFACE

The Fisheries Development Council was formed in 1956 by the Minister of Fisheries for Canada with the objective of bringing all agencies, organizations and individuals affiliated with the fisheries resource together for a common understanding, study and discussion of the fisheries problems associated with industrial development in British Columbia.

The Terms of Reference of the Council as set out at the inaugural meeting on August 3, 1956 are as follows:

- (a) To study all aspects of problems of developing and conserving fisheries resources of the province and preventing of damage by industry and power development.
- (b) To hear, discuss, and consider reports by fisheries technical personnel on the various industrial and other projects under study or in prospect which would affect the fisheries resource.
- (c) To increase public interest in the conservation, management, and development of our fisheries resource.
- (d) To generally co-ordinate all available knowledge and also the activities of all interested parties associated with the fisheries resource in respect to the foregoing.
- (e) To make general or specific recommendations to the appropriate authorities for desirable action on the problems studied by the Council.

Organizations and individuals represented on the Fisheries Development Council are:

Department of Fisheries, Canada

Fisheries Association of B.C.

Department of Recreation and Conservation of the Province of
British Columbia

United Fishermen and Allied Workers' Union

International Pacific Salmon Fisheries Commission

Native Brotherhood of B.C.

Fisheries Research Board of Canada

Fishing Vessel Owners' Association of B.C.

Institute of Fisheries of the University of British Columbia

Mr. Roderick Haig-Brown, Campbell River, B.C.

Prince Rupert Fishermen's Co-op. Association

B.C. Federation of Fish and Game Clubs

The Research Sub-committee of the Fisheries Development Council was appointed in April 1957 as an ad hoc committee to study the problem of preparing an index of research to effectively summarize work being done on the fish-power problem. The purpose of such an index would be to provide a concise source of information in connection with research on the fish-power problem, so that Council members would be aware of the total effort being applied to various fisheries problems, the number of personnel involved, costs, and the degree of cooperation between various fisheries agencies.

The Research Sub-committee was made up of one member from each of the five British Columbia fisheries agencies and the Secretary of the Fisheries Development Council. The committee adopted a standard one-page format for research summaries and also agreed on the scope of research which was to be included. It was decided that while desirable to include work by fisheries agencies in Eastern Canada and the United States, this was considered too broad an undertaking for the present, and the summaries were limited to the work actually done by the five British Columbia fisheries agencies. Further, it was decided that research summaries on all multiple water use projects involving fish would prove too cumbersome for indexing purposes, therefore the scope of work covered was directed mainly to problems of fish and dams, or other physical obstructions such as intakes, channel excavations, diversions, etc. It was decided that pollution studies, in particular, were not to be included in the index.

Summaries of research were submitted by each of the five agencies during the latter half of 1957 and early 1958.

In May, 1958 the work of the committee was diverted to the preparation of a brief report concerning the present status of the fish-power problem. This report was to answer four questions asked by the Fisheries Development Council, viz:

1. What is the problem?
2. What is being done?
3. How much money is being spent?
4. How many people are working on it?

This statement was completed in December, 1958 and tabled at the 12th Council Meeting in January, 1959. In preparation of the definition of the fish-power problem and outlining research on it in general terms for the above report, the committee decided on a system which could also be used for indexing the research summaries. Hence, in the subject index of this report, the summaries have been grouped into 10 categories of fisheries problems and each category is subdivided into 3 types of research: basic biological, applied biological or applied engineering. The first nine categories are as outlined in the statement of the nature of the fish-power problem and the tenth category covers summaries which deal with the total effects of dams or other obstructions on fish, including possibly a combination of all of the first nine categories. The committee's Report to Fisheries Development Council Concerning Present Status of the Fish-Power Problem is included in this volume for reference purposes and immediately follows this preface.

The individual summaries are arranged chronologically, and by agency, so that they can be added to logically at such time as the Council considers it desirable to revise and update them. The numbering system is prefixed by letter, to denote the responsible agency, viz: "A" for the Fish Culture Development Branch of the Department of Fisheries of Canada; "B" for the Fish and Game Branch, Department of Recreation and Conservation; "C" for the Fisheries Research Board of Canada, Pacific Biological Station; "D" for the International Pacific Salmon Fisheries Commission; and "F" for the University of B.C. Within each agency, the summaries are numbered consecutively in Chronological order, such as D1, D2, D3 The Table of Contents lists

all the summaries in this volume in the order in which they are bound.

When this volume is revised from time to time, summary pages for new projects will be numbered for ready filing in the appropriate places, and revisions of certain existing summaries will replace the ones already filed in this volume. The date in the lower right-hand corner of each summary sheet would indicate if it is the latest issue. New Table of Contents, and Index by Main Subject Divisions sheets will be supplied whenever revisions are made to this volume. A mailing list of those in possession of these summaries of research will be kept by the Fisheries Development Council to facilitate circulation of revision sheets.

The committee hopes that the Fisheries Development Council will find this volume of interest and use to its members.

Sub-Committee Membership:

Chairman - K.C. Lucas, Engineer, Fish Culture Development Branch,
Department of Fisheries, Canada.

P.A. Larkin, Director, Institute of Fisheries,
University of B.C.

T.G. Northcote, Biologist, Fish and Game Branch,
Department of Recreation and Conservation.

D.F. Alderdice, Scientist, Fisheries Research Board of
Canada, Pacific Biological Station.

F.J. Andrew, Engineer, International Pacific Salmon
Fisheries Commission.

Secretary - B.A. Campbell, Department of Fisheries, Canada.

Research Sub-Committee
Fisheries Development Council
April, 1960.

REPORT TO FISHERIES DEVELOPMENT
COUNCIL CONCERNING PRESENT STATUS
OF THE FISH-POWER PROBLEM

1. THE NATURE OF THE FISH-POWER PROBLEM

To gain sufficient knowledge of the biology of salmon and trout and the principles of design of fish facilities to ensure adequate protection of such stocks affected by construction of dams.

Basically the major problems at present are:-

1. To ensure safe upstream passage of adult salmon and trout in river systems in which dams have created downstream changes in physical, chemical and biological factors.
2. To pass very large numbers of adult salmon and trout upstream over a dam or a series of dams without delay, injury or mortality.
3. To pass adult salmon and trout through reservoirs without delay, injury or mortality.
4. To ensure satisfactory spawning of adult salmon in headwaters affected by dams.
5. To ensure satisfactory incubation and rearing of pre-migratory fresh water stages in headwaters affected by dams.
6. To pass young migratory salmon and trout through reservoirs without delay, injury or mortality.
7. To pass very large numbers of young migratory salmon and trout downstream over a dam or a series of dams without delay, injury or mortality.
8. To ensure safe downstream passage of young salmon and trout in river systems in which dams have created downstream changes in physical, chemical or biological factors.
9. To obviate some of the above problems by employing alternatives to fish passage facilities (e.g. transplanting of runs, artificial culture of salmon, etc.).

Many types of effects of dams on fish have only recently been discovered. Further findings in these fields are to be expected and may multiply the diversity of the problems.

2. BIOLOGICAL AND ENGINEERING RESEARCH ON THE FISH-POWER PROBLEM

Research conducted on the nine sections defined under "Nature of the Fish-Power Problems" may be categorized into basic biological research,

applied biological research and applied engineering research.

A. Basic Biological Research

Nearly all agencies involved in the fish-power problem are contributing information, which directly or indirectly increases existing knowledge on the basic biology of salmon and trout affected by construction of dams. Basic biological research which is being conducted at present on the fish-power problem may be classified as follows:

1. Performance studies - to determine the ability of salmon and trout to swim, or perform other functions under given environmental conditions.
2. Tolerance studies - to determine the physical and chemical limits within which salmon and trout may successfully complete various stages in their life history.
3. Perception studies - to determine the array and sensitivity of salmon and trout sense organs to natural or artificial stimuli.
4. Behaviour studies - to delimit and define the types of behavior exhibited by salmon and trout and to determine the effects of various environmental stimuli upon this behavior.
5. Racial studies - to determine the types of racial characters present in salmon and trout stocks and to examine causes, environmental, genetic, or both for these differences.
6. Biochemical studies - to examine the biochemistry of salmon and trout locomotion, nutrition and other physiological processes.

B. Applied Biological Research

The majority of work of an applied biological nature being conducted on the fish-power problem may be divided into three categories:

1. Determination of effects on salmon and trout stocks of environmental alteration caused by construction of dams.
 - (a) Physical alteration, e.g. - increasing, lowering or fluctuating lake and stream levels - substituting reservoir environment for stream environment - imposition of delays, injury or mortality by presence of dams and/or associated structures.
 - (b) Chemical alteration, e.g. - introduction of various chemical materials which may act directly as fish toxicants, or may produce indirect effects on salmon and trout performance, tolerance, sensory perception or behavior.

- (c) Biological alteration, e.g. - introduction by damming or diverting watersheds of species of fish or other organisms which may compete with, prey upon, or parasitize indigenous salmon and trout stocks.
2. Assessment of effectiveness of fish passage and directing facilities.
 - (a) - Assessments of fish ladders, trapping and transporting devices and other methods of passing salmon and trout adults and young around barriers in route of migration.
 - (b) - Assessment of screens, light, bubbles, chains, electricity and other possible means of directing or guiding salmon and trout.
 3. Assessment and development of alternative methods of maintaining salmon and trout stocks.
 - (a) - Assessment of effectiveness of present methods of salmon and trout culture and stocking.
 - (b) - Development of new methods of increasing efficiency of salmon and trout culture and stocking.

C. Applied Engineering Research Being conducted on the Fish Power Problem is Concerned with:

1. Investigation of design and hydraulics of spillways, turbines and other structures in an attempt to eliminate or reduce features deleterious to salmon and trout migration or production.
2. Investigation of design and hydraulics of fish passes, guiding devices and other fish facilities which may be used to prevent delay, mortality or injury to passage of salmon and trout stocks.
3. Design of salmon and trout rearing facilities or other structures associated with alternatives to the passage of these fish.

3. WHAT IS BEING SPENT ON RESEARCH

Fisheries research related to the problems involved in conserving salmon and trout populations affected by proposed dams requires large expenditures by Federal, Provincial and State Governments and by private industry.

In British Columbia, the annual expenditures in fiscal year 1957-1958 directly or indirectly related to defining, investigating and attempting to solve these problems totalled about \$740,000. Contributions to this research effort are made by the Federal Department of Fisheries, Fisheries Research Board, International Pacific Salmon Fisheries Commission, B.C. Department of Recreation and Conservation, University of British Columbia and National Research Council.

In the United States, as in Canada, the principal research effort on the "fish-power" problem began in 1952. In the three-year period from 1952 to 1955, approximately \$3,350,000 was spent on investigations completed or being undertaken at that time. From 1955 to 1958, approximately \$4,260,000 has been spent. In the fiscal year 1957-58, the expenditure was approximately \$1,400,000 and it is expected that approximately \$2,000,000 will be spent in 1958-1959. This includes expenditures by the United States Fish and Wildlife Service, United States Army Corps of Engineers, and the States of Oregon and Washington, as well as by private industries building dams on salmon and trout streams in the Pacific Northwest.

Fisheries conservation agencies in the United States and in British Columbia have budgetted for a considerable increase in research effort in recent years. The Federal Department of Fisheries has estimated that its budget in fiscal year 1959-1960 for this purpose will be about double the 1958-1959 expenditure. The Fisheries Research Board has recently enlarged its laboratory facilities to enable a more extensive research effort on fisheries problems related to industrial development in British Columbia.

The total expenditure in the United States and in British Columbia exceeded \$2,000,000 in 1957-1958. Budget requests reveal that the total may reach \$3,000,000 in 1959-1960.

4. THE NUMBER OF PERSONNEL ENGAGED IN RESEARCH ON FISH-POWER PROBLEMS

The number of permanent and temporary personnel in British Columbia engaged in research on the fish power problem is estimated to be about 130 in 1958. This total has been compiled from information supplied by the International Pacific Salmon Fisheries Commission, the University of British Columbia, the B.C. Department of Recreation and Conservation, the Federal Department of Fisheries and the Fisheries Research Board of Canada. Various classifications of personnel included are listed approximately as follows:

	Personnel
1. Basic and applied biological research	- 54
2. Applied engineering research	- 20
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FISH CULTURE DEVELOPMENT BRANCH
DEPARTMENT OF FISHERIES, CANADA

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Columbia Cellulose Pulp Mill Water Supply.

Purpose : To study the maintenance of salmon runs in the Prudhomme Lake watershed, to determine the minimum flow requirements, and establish the required specifications for a fishway and screening devices required by the construction of a storage dam for the Columbia Cellulose Pulp Mill near Port Edward, B.C.

Duration : 1947-51. 1959 to date.

Location : Outlet of Prudhomme Lake, Kloiya River, near Port Edward, B.C.

In Charge : Formerly C. Bruce and H.A. Lynch: subsequently C.H. Clay: latterly R.N. Gordon.

Cooperating Agencies : U.S. Fish & Wildlife Service (Consultants on screen).

Personnel : Engineer, biologist.

Cost : \$3,700.

Results : A weir type fishway over the 16-foot Kloiya dam and a travelling Link-Belt screen for the water intake were completed in 1951. A second travelling screen was installed in 1961.

Assessment : The fishway and travelling screens were found satisfactory to protect the present fish populations.

Reports : Unpublished data on file.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Jones (Wahleach) Creek Hydro-Electric Power Development.
- Purpose : To determine the fisheries problems created by the Jones Creek hydro-electric power development and to recommend possible solutions.
- Duration : 1949-54. Assessment continuing.
- Location : Jones Creek near Laidlaw, B.C.
- In Charge : C.H. Clay, W.R. Hourston, L. Edgeworth.
- Cooperating Agencies : Fisheries Research Board of Canada, B.C. Electric Co. Ltd.
- Personnel : Engineer, biologist, up to four technicians.
- Cost : 1949 - 54: \$12,000.
- Results : It was concluded that the diversion of Jones Creek would seriously affect the salmon populations if consideration was not given to fisheries requirements. Three possible methods of preserving the runs were suggested.
1. Provision of a specified minimum flow.
 2. Construction of a controlled flow spawning channel for which flow requirements would be 40 percent of the flow requirements under the first alternative.
 3. Provision of a hatchery.
- Negotiations were carried out with the Company and the second proposal, the construction of an artificial channel, was implemented.
- Assessment : The operation of the channel over an eight year period from 1954 to 1961 has shown a history of relatively low cost, high fry survival and increasing adult returns. For these reasons it is considered that the channel is a satisfactory solution to the fisheries problem created by the Jones Creek hydro-electric development. If similar installations are considered in the future their efficiency might be increased by modifying some of the design features.
- Reports : 1. Jones Creek Report Part I, December 1949; Jones Creek Report Part II 1952, Department of Fisheries, Canada, (Mimeo).
2. Use of an artificial spawning channel by salmon, W.R. Hourston, D. MacKinnon, Volume 86 (1956), Transactions of the American Fisheries Society.
3. Man-made spawning channels for Pacific salmon, D. MacKinnon, Canadian Geographical Journal, July, 1961.
4. An assessment of the Jones Creek spawning channel 1954-61 D. MacKinnon, L. Edgeworth and R.E. McLaren (To be published in the Canadian Fish Culturist during 1962).

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : The Bridge River Hydro-Electric Power Development.

Purpose : To relocate a run of spring salmon which were prevented from reaching their natural spawning grounds by the diversion dam of the Bridge River power development.

Duration : 1949-1952.

Location : Bridge River near Lillooet, B.C.

In Charge : W.R. Hourston.

Cooperating Agencies :

Personnel : Biologists, engineers, student assistants and casual labour.

Cost : \$25,000.

Results : All migrating adult spring salmon were gillnetted below the diversion dam and held in retaining pens until mature. The salmon were then stripped and the fertilized eggs were planted "green" or held until "eyed" and then planted in other streams. Eggs were planted in Gates Creek, Yalakom River and Portage Creek. This procedure was followed for four years in order to relocate the entire spring salmon population.

Assessment : The Bridge River spring salmon relocation program was an emergency salvage measure only. Since no positive returns from the egg plantings were reported, the relocation program appeared to be unsuccessful.

Reports : Unpublished data on file.

June 1, 1958

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Effect of Flood Control Pumps on Juvenile Salmon.
- Purpose : To determine the mortality rates to young fish passing through flood control pumps in the Lower Fraser Valley.
- Duration : 1949.
- Location : Hatzic Pumping Station, 3 miles from Mission City, B.C.
- In Charge : W.R. Hourston.
- Cooperating Agencies : Fish and Game Branch.
- Personnel : Biologist, engineer, two casuals.
- Cost : \$1,000.
- Results : A sample of fish were introduced near the pump intake, allowed to pass through the pump and were retrieved below the pump outlet and examined for injuries and mortality. Three tests were made and the results were as follows:
- Test 1. In a sample of eight live fish ranging in length from 13.6 cms to 14.5 cms the pump mortality was 55.5%.
- Test 2. In a sample of 150 preserved fish ranging in length from 4 cm to 19.9 cm the number mutilated varied directly with the length.
- Test 3. In a sample of 89 live fish ranging in length from 4.5 cm to 7.4 cm the pump mortality was 40.5%. After 15 hours the total mortality was 48.3%.
- The mortality to fish in the tests varied directly with their length. The streams affected by the flood control program are utilized by coho, chum and pink salmon. Pink and chum fry migrate seaward after having attained a length of 3.8 to 4.5 cms. An insufficient number of fish in this size range were used in the tests to assess the mortality but it is suspected that it would be light. Coho yearlings migrate seaward when 8 to 11 cms long. Mortality to fish in this size range was about 50% and is considered critical.
- Assessment : More tests are recommended and more data on streams and pumping procedure is required before a solution to this problem can be reached.
- Reports : Typed report on file.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Harmac Pulp Mill Water Supply.
- Purpose : To provide adequate flows in the Nanaimo River for spawning, migration and rearing of salmon after diversion of flows to the pulp mill by pump and wells adjacent to the river, and to design a fixed screen to prevent entry of small fish to the mill water supply.
- Duration : 1949-1951.
- Location : Nanaimo River near Cedar, B.C.
- In Charge : C.H. Clay, E.W. Burridge, R.N. Gordon.
- Cooperating Agencies : Fish & Game Branch.
- Personnel : 2 engineers, 1 biologist, up to 6 technicians.
- Cost : \$15,000.
- Results : The survey of spawning grounds and a biological tagging program resulted in representations to MacMillan & Bloedel to provide additional flow in the Nanaimo River at low stages to provide for spawning, etc., after diversion of water for the pulp mill supply. As a result a storage dam was constructed at fourth Nanaimo Lake above the upstream limit of salmon migration to provide required flows. Fixed screens were designed for a pumphouse intake on the river to prevent entry of fish.
- Assessment : Flows are considered adequate for present, no assessment of screen efficiency to date. Recent reports indicate that the Company is now undertaking preliminary studies with a view to increasing the capacity of the diversion facilities. If, and when, construction is to be proceeded with, considerable modification of the existing pumphouse might be required in order to accommodate the additional screening which will be required. Preliminary assessments indicate that the increased diversion need not interfere with fisheries flows downstream.
- Reports : Manuscript report on tagging program, Department of Fisheries files.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Nanika River Hydro-Electric Power Diversion.
- Purpose : To determine the fisheries problems created by the proposed diversion of the Nanika River into Tahtsa Lake by the Aluminum Company of Canada, Ltd., and to recommend possible solutions to those problems.
- Duration : 1949, continuing.
- Location : Nanika and Morice Rivers, near Houston, B.C.
- Cooperating Agencies : International Pacific Salmon Fisheries Commission, Fish and Game Branch, Fisheries Research Board of Canada, Skeena River Management Committee.
- In Charge : C.H. Clay, R.E. McLaren, R.A. Crouter.
- Personnel : Engineers, biologists and up to eight technicians.
- Cost : 1949-1961 - \$35,000.
- Results : Biological surveys on the Nanika and Morice Rivers have located the main spawning areas, timing of the runs, etc. Engineering surveys have been carried out to map the spawning areas, cross-section and profile the streams, etc. During investigations it was found that the sockeye escapement to the Nanika River in the last seven years had declined from 70,000-100,000, to 1000-5000 fish. With the final obstruction in the Bulkley River now removed (Hagwilget Canyon, 1959) a 10-year rehabilitation program was put into effect in 1960. This rehabilitation program includes a \$150,000 hatchery constructed near the mouth of the Nanika River during 1960 and thorough biological study and management of the river system.
- Assessment : No decision to proceed with the Nanika River Diversion has been made by Alcan to date. Fisheries agencies have ascertained that the main sockeye spawning grounds of the Nanika River would be lost by the diversion unless suitable fisheries flow releases were provided. The major rehabilitation program now under way ensures that the value of the sockeye spawning grounds will be maintained in the future.
- Reports : Nanika River Report, Dept. of Fisheries, 1949 (Mimeo). Submission Presented by the Department of Fisheries of Canada to the Comptroller of Water Rights, B.C. Department of Lands at Victoria, B.C., October 31, 1949, Respecting the Application of the Aluminum Co. of Canada Ltd., for Water Licences on the Nechako and Nanika River Watersheds. The Utilization of Spawning Grounds on the Morice River System by Sockeye Salmon, E.H. Vernon, 1951, B.A. Thesis, University of B.C. Report on the Fisheries Problems Created by the Development of Power in the Nechako - Kemano - Nanika River Systems; Canada, Dept. of Fisheries, Fisheries Research Board of Canada and the I.P.S.F.C., 1951 (Mimeographed). Unpublished data on file.

June 1, 1958

Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Hydro-Electric Power Development on the Kemano River.
- Purpose : To assess the possible effects the diversion of water from the Nechako River system into the Kemano River would have on salmon populations in the Kemano River.
- Duration : 1950, continuing.
- Location : Kemano River, near Kitimat, B.C.
- In Charge : C.H. Clay, W.R. Hourston.
- Cooperating Agencies :
- Personnel : Engineers, biologists and technicians.
- Cost : \$20,000.
- Results : An engineering survey in 1950 established a traverse up the Kemano valley from which control for aerial photography enabled the supply of a detailed map of the river. A biological survey team located the major salmon spawning areas with the aid of these maps, and it was ascertained that a large portion of the spawning areas of several species of salmon occur between the Alcan powerhouse site near Horetzky Creek and the mouth of the Kemano River. When power diversions reach their ultimate stage of 9000 cfs., increases in river velocities, depths and scour could be severely adverse to the maintenance of spawning in this reach.
- Assessment : Discharges of the Kemano River near its mouth before Nechako River diversion varied from 80 cfs. to 28,000 cfs. The Kemano powerhouse presently has 7 turbines installed, however only 4-5 units are operating at one time, giving a total powerhouse discharge of up to 2750 cfs. Biological inspection has not detected any adverse effects on salmon to date, however studies will be continued as further power diversions occur.
- Reports : Report on the Fisheries Problems Created by the Development of Power in the Nechako-Kemano-Nanika River Systems; Department of Fisheries of Canada, The Fisheries Research Board of Canada, and the International Pacific Salmon Fisheries Commission, 1951 (Mimeo).
- Biological Survey reports and other unpublished data, Department of Fisheries.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Hydro-Electric Power Development on the Nechako River
- Purpose : To assess the effects of the diversion of the headwaters of the Nechako River by the Aluminum Company of Canada on the maintenance of spring salmon in the Nechako River, and to recommend protective measures.
- Duration : 1950, continuing.
- Location : Nechako River near Fort Fraser.
- In Charge : C.H. Clay, W.R. Hourston, R.E. McLaren, R.N. Gordon.
- Cooperating Agencies : International Pacific Salmon Fisheries Commission.
- Personnel : Engineers, biologist, technicians and casual labour.
- Cost : 1950 - 55 \$25,000.
1956 - 58 2,000.
1959 to date 950.
- Results : Investigations indicated that the Nechako River spring salmon spawning grounds above Fort Fraser could be seriously affected by the proposed diversion. It was concluded, however, that a stabilized flow during the spawning and incubation period could maintain a substantial portion of the run.
- Assessment : Construction of a temporary dam on the Cheslatta system created storage which was used for fisheries purposes during the period when the Nechako reservoir was filling. In 1955, when full storage level was reached, Nechako flows returned to near-normal levels. Since that time the spawning grounds have experienced heavy siltation as a result of erosion in the Cheslatta spillway route, and these effects have been reflected in an apparent decline of the run. Recent observations indicate, however, that the Cheslatta spillway channel is becoming more stable, and the resulting decreases in siltation on the Nechako spawning grounds gives cause for some optimism that the runs will return to near-normal.
- Reports : Report on the Fisheries Problems Created by the Development of Power in the Nechako-Kemano-Nanika River systems; Department of Fisheries of Canada, The Fisheries Research Board of Canada and the International Pacific Salmon Fisheries Commission, 1951, (Mimeographed).
Supplement Number 1 to above report. Temperature changes in the Nechako River and their effects on the salmon populations; Canada Department of Fisheries, I.P.S.F.C., 1952, (Mimeographed).
Annual Survey Reports and other unpublished data, Department of Fisheries, Canada.

June 1, 1958

Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Quesnel River Hydro-Electric Power Development
- Purpose : To ascertain the fisheries problems associated with the proposed power development on the South Fork of the Quesnel River.
- Duration : 1950.
- Location : Quesnel River system near Likely, B.C.
- In Charge : C.H. Clay, W.R. Hourston, R.E. McLaren.
- Cooperating Agencies : International Pacific Salmon Fisheries Commission.
- Personnel : Biologist, engineer, student assistants.
- Cost : \$3,500.
- Results : Results of the investigation showed that the major portion of the spring salmon population migrating to the system select the South Fork in preference to the North Fork. The analysis further showed that a power development in the North Fork would have no appreciable effect on the present spring salmon population. On the other hand, a development on the South Fork would pose several serious problems to the migration and spawning of spring salmon.
- Assessment : Because of the fisheries problems associated with a development on the South Fork, the B.C. Power Commission considered a possible development on the North Fork (Cariboo River) but have, for the present at least, abandoned plans for developing this stream. Further studies on the Quesnel System are being carried out by the Fraser River Board.
- Reports : 1. Quesnel River Report, Department of Fisheries, 1950 (Mimeographed).
2. Interim Investigation into measures for Flood Control in the Fraser River Basin, June, 1956, Fraser River Board.
3. Preliminary Report on Flood Control and Hydro-electric Power in the Fraser River Basin, June, 1958, Fraser River Board.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Hydraulic Model Studies of the Proposed Fishways for Moricetown Falls, near Smithers, B.C.

Purpose : (a) To study the single jet vertical slot fishway of six-foot width.
(b) A study of three model denil type fishways.

Duration : 1950.

Location : U.B.C. hydraulics laboratory, Vancouver, B.C.

In Charge : M.H. Campbell.

Cooperating Agencies :

Personnel : One engineer and one technician.

Cost : \$2,800.

Results : (a) From the single jet vertical slot fishway with a six-foot width, characteristics and limitations were developed for the following: pilasters; sills; pool lengths, head drop, and slope; length of nose of central column; width of slot; gate opening; and entrance channel considerations.
(b) From the three Denil models tested, each design had its limitations and disadvantages, it was felt that by modifications thereof, practical designs could be produced.

Assessment : Two single jet vertical slot fishways were designed and constructed at Moricetown Falls in 1951. These fishways have operated successfully since their installation.

Reports : Fishway Model Experiments, Canada, Dept. of Fisheries, 1950. (Mimeo).

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DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Westroad (Blackwater) River Hydro-Electric Power Development.

Purpose : To ascertain the fisheries problems associated with a proposed power development on the Westroad (Blackwater) River.

Duration : 1951.

Location : Westroad River near Nazko, B.C.

In Charge : R.E. McLaren.

Cooperating Agencies :

Personnel : Biologist, student assistant.

Cost : \$2,000.

Results : Preliminary data relating to the migration and spawning of spring salmon in the river system was collected. The lack of information concerning the proposed development prohibited a complete analysis of the fisheries problems.

Assessment : The B.C. Power Commission have not shown any further interest in this system as a source of hydro-electric power.

Reports : Blackwater River Report, Department of Fisheries, 1951. (Mimeographed).

June 1, 1958

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Nicola River Irrigation Diversions.

Purpose : To investigate juvenile salmon losses in irrigation diversions on the Nicola River and to design and test suitable screening devices.

Duration : 1951 - 1958.

Location : Nicola River, near Merritt, B.C.

In Charge : R.E. McLaren, L. Edgeworth.

Cooperating Agencies :

Personnel : Biologist, engineer, technicians.

Cost : 1951 - 58 \$12,000.

Results : The various irrigation diversions of the Nicola River were sampled and an index was developed to permit a quantitative comparison of the mortalities in the respective ditches.

Two types of self cleaning screens have been installed: a rotary type screen similar to those in general use in Washington State, and a flat perforated plate screen which was developed in California.

Results of tests conducted on these two types of screening devices revealed that with certain modifications to the bypass and to the approach velocity the screening efficiency could be greatly increased.

Assessment : Several operating and maintenance problems are apparent with each screen but each screen has served the purpose for which it was designed. Considering the advantages and disadvantages of each type of screen, the rotary screen was found to be superior for general use in irrigation ditches in the Nicola Valley.

Reports : Mimeographed reports of surveys on file.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Water Supply for Alcan Kitimat Smelter.

Purpose : To design a fixed screen for the cooling water supply to the Kitimat Smelter to prevent entry of downstream migrant fish.

Duration : 1951.

Location : Kitimat River.

In Charge : C.H. Clay.

Cooperating Agencies :

Personnel : One engineer, one biologist.

Cost : \$500.

Results : Design of a fixed plate screen to prevent entry of small fish to cooling water supply for smelter. Ensure low enough approach velocities to permit downstream migrant fish to continue migration downstream.

Assessment : No assessment of screen efficiency to date.

Reports :

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Fish Facilities for Tobique Narrows Dam, Tobique River, New Brunswick.
- Purpose : To advise and assist in developing fish facilities for an 80 ft. hydro-electric power dam on the Tobique River, tributary to the St. John River in New Brunswick.
- Duration : 1951-52. Turbine mortality assessment 1959-60.
- Location : Tobique River, New Brunswick.
- In Charge : C.H. Clay, W.R. Hourston, M.C. Bell (Consultant).
- Cooperating Agencies :
- Personnel : 2 engineers, one biologist.
- Cost : \$1,000. (not including turbine mortality studies).
- Results : A powerhouse collection system and weir-type fishway to pass Atlantic salmon and shad upstream over the dam was constructed and put into operation in the Spring of 1953.
- Assessment : Annual counts at the fishway indicate passage is successful for Atlantic salmon of all sizes. A total of 4600 salmon were counted in 1953. No tagging or other programs have been implemented to assess delay or mortality.
- An assessment of the mortality to downstream migrant salmon in their passage through the 13,500 hp Kaplan turbines at the site was conducted during 1959 and 1960 by biologists from the Maritimes Area Fish Culture Branch staff. Results of the 1960 tests on Atlantic salmon fingerlings at rated generator load indicate a mortality of 16.5% for 3½ to 5½ inch-long fish, and 23% for 5½ to 8½ inch-long fish.
- Reports :
1. Canada's Highest Fishway, Trade News Vol. 6, No. 7, Jan. 1954, Ottawa, Ontario.
 2. 1959 and 1960 Mortality Tests, Tobique Narrows Dam by Neil MacEachern. (Typed).

June 1, 1958

Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Kokish River Hydro-Electric Power Development
- Purpose : To study the salmon spawning grounds of the Kokish River and to recommend solutions to the fisheries problems posed by the power development.
- Duration : 1952 and 1957.
- Location : Kokish River near Beaver Cove, Vancouver Island.
- In Charge : C.H. Clay, W.R. Hourston, E.W. Burr ridge, D. MacKinnon.
- Cooperating Agencies : Fish & Game Branch.
- Personnel : Engineers, biologists and technicians.
- Cost : 1952 - \$ 500.
1957 - 2,500.
- Results : The salmon spawning grounds of the Kokish River System were found to be located below the proposed site of the B.C. Power Commission's powerhouse. Protection of the spawning grounds below the powerhouse would have to be considered in the event of plant shut-down.
- Assessment : Department of Fisheries withdrew their objection to the water license on the condition that a bypass valve be included at the powerhouse capable of discharging 170 cfs under minimum head conditions. While the Power Commission apparently is still interested in the eventual development of this site, no action has been taken as yet, nor have there been any announcements as to when construction might be initiated.
- Reports : Summary reports on files of the Department of Fisheries.

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Okanagan Flood Control Project.
- Purpose : To assess the effects of a proposed flood control project on the spawning grounds of Columbia River sockeye salmon and devise necessary fish facilities.
- Duration : 1952 - 1957. Assessment continuing.
- Location : Okanagan River between Vaseaux Lake and Osoyoos Lake.
- In Charge : W.R. Hourston, C.H. Clay, K.C. Lucas, E.W. Burrige.
- Cooperating Agencies : U.S. Fish and Wildlife Service, Washington State Dept. of Fisheries.
- Personnel : 2 biologists, 2 engineers and up to 6 field assistants.
- Cost : \$22,000. (not including hydraulic model studies reported in A23).
- Results : Section "B" of the flood control project was modified to permit retention of existing spawning grounds. In Section "C", design of 13 drop structures was modified to provide for passage of adults to spawning grounds. Water requirements during spawning, incubation and fry migration periods were outlined for consideration in connection with the operating schedule of project.
- Assessment : Project completed in 1957. Field studies indicated water conditions over spawning grounds satisfactory to date. However, a recent analysis of hydrometric records kept continuously since 1915 shows that despite improved storage potential, scheduled minimum river discharges for salmon propagation could not be maintained if 1928-32 drought conditions prevailed again in the future. Since project completion the drop structures in Section "C" have been subject to deliberate blocking by local farmers during the Summer season to raise water levels in the river channel in order to provide sub-irrigation of adjacent lands. This practice blocks salmon migration; however, schedules have been worked out with local authorities whereby the obstructions are removed prior to salmon migration in September.
- Reports : 1. The Salmon Problems Associated with the Proposed Flood Control Project on the Okanagan River in British Columbia, Canada: U.S. Fish and Wildlife Service, Washington State Department of Fisheries, Department of Fisheries, Canada, 1954 (mimeographed).
2. The Okanagan River Flood Control Project, C.H. Clay, 7th Tech. Mtg., Athens, Int. Un. Conserv. Nature, Brussels, Vol. IV, pp. 346-351, 1960.

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Spawning Ground Characteristics - Okanagan River.
- Purpose : To determine the physical characteristics of the spawning grounds utilized by sockeye salmon in the Okanagan River and to design and supervise the construction and testing of an experimental channel based on the criteria established. This project was related to the establishment of artificial spawning grounds in the Okanagan River in the event the existing grounds were destroyed by the proposed Flood Control Project.
- Duration : 1952-1954.
- Location : Okanagan River near Oliver, B.C.
- In Charge : K.C. Lucas and W.R. McKinley.
- Cooperating Agencies : U.S. Fish & Wildlife Service, Washington State Dept. of Fisheries.
- Personnel : 2 engineers, 1 biologist, 2 field assistants.
- Cost : \$1,000.
- Results : Data on the water depth, velocity and gravel size of spawning areas in the river were collected during the 1952 spawning period. An experimental channel was designed with a gradient varying from 2-6'/1,000, width 20 feet, depth 1-1½ feet, and velocity 1-3 f.p.s. The channel, 1,200 feet long, was constructed by the Department of Public Works in the summer of 1953. Special observations on the numbers of sockeye salmon entering the channel and the area selected for spawning were made in 1953 and subsequent years.
- Assessment : In 1953 only 248 salmon spawned in the channel. Assessment indicated that the channel was not constructed to specifications. The gradient averaged 6'/1,000 and the velocity averaged 4 f.p.s. It was also indicated that to function properly headworks to control discharge would be necessary. Since the fisheries problems related to this project were resolved no further investigations of this type of facility were carried out.
- Reports : Details reported in "The Salmon Problems Associated with the Proposed Flood Control Project on the Okanagan River in British Columbia, Canada". U.S. Fish & Wildlife Service, Washington State Dept. of Fisheries, Dept. of Fisheries, Canada, 1954. (Mimeographed).

June 1, 1958

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Duncan Bay Pulp Mill Water Supply.

Purpose : To design fixed screens and a bypass to prevent entry of downstream migrant salmon to the Duncan Bay pulp mill water supply intake, situated on the Campbell River.

Duration : 1952.

Location : Near Campbell River, B.C.

In Charge : C.H. Clay.

Cooperating Agencies :

Personnel : Engineer, biologist.

Cost : \$1,000.

Results : Design and installation of a fixed screen at the pumphouse some distance from the Campbell River to prevent entry of downstream migrant fish. Design of a bypass to carry fish back to the river from the face of the screen.

Assessment : Screen and bypass effective for intended purpose. Company is now undertaking feasibility studies in connection with a proposed mill expansion requiring additional diversion of 65 cfs. If this proposal is implemented, either a new intake or extensive modifications of the existing structure will be required.

Reports : None.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Fish facilities for Cleveland dam on the Capilano River.
- Purpose : To provide fish facilities for the upstream passage of coho salmon and steelhead trout over the Cleveland dam.
- Duration : Design 1952 - 53
Construction 1953 - 54
Operation 1954 - Continuing
- Location : Three miles above the mouth of the Capilano River and immediately below Cleveland dam.
- In Charge : C.H. Clay, W.R. Hourston, L. Edgeworth.
- Cooperating Agencies : B.C. Game Commission, Greater Vancouver Water Board.
- Personnel : One engineer, one biologist.
- Cost : 1952-54 \$15,000.
- Results : Trucking facilities were selected as being the most suitable method for passing adults upstream over the dam after consideration of the height of the dam, the size of the run and costs. Trucking facilities were also adaptable to a hatchery operation which might prove necessary in the future. The Water Board was provided with details of the functional design requirements and carried out the structural design. Construction of the fish facilities was completed in 1954 at a cost of \$290,000.
- Assessment : Observations of this operation between 1954 and 1957 indicate that the facilities are adequate to pass the upstream migrants over the dam. The numbers of adults which have been trucked around the dam are as follows:
- | | |
|-------------|-------------|
| 1954 - 3011 | 1958 - 3884 |
| 1955 - 5136 | 1959 - 2785 |
| 1956 - 1923 | 1960 - 3663 |
| 1957 - 5064 | 1961 - 2108 |
- Reports : Planning Anadromous Fish Protection for Proposed Dams, W.R. Hourston, C.H. Clay, L. Edgeworth, P.A. Larkin, E.H. Vernon, R.G. McMynn. Transactions of the Twentieth North American Wildlife Conference, 1955. Published by the Wildlife Management Institute, Wire Building, Washington, D.C.

June 1, 1958
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DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Puntledge River Hydro-Electric Power Development.
- Purpose : To investigate the fisheries problems associated with the development of the hydro-electric potential of the Puntledge River by the B.C. Power Commission and to recommend methods of overcoming these problems.
- Duration : 1952 to 1958 and continuing.
- Location : Puntledge River near Courtenay, B.C.
- In Charge : C.H. Clay, W.R. Hourston, K.C. Lucas, D. MacKinnon, R.N. Gordon.
- Cooperating Agencies : B.C. Power Commission, Fish and Game Branch.
- Personnel : 2 engineers, 2 biologists and up to 5 technicians.
- Cost :
- | | |
|------------------|----------------------------------|
| 1953 - \$ 9,800. | 1958 - \$61,500. |
| 1954 - 19,900. | 1959 - 42,100. |
| 1955 - 36,500. | 1960 - 12,600. |
| 1956 - 27,900. | 1961 - 4,500. |
| 1957 - 56,600. | 1953-61 incl. total = \$271,400. |
- Results : The fisheries problems posed by this power development can be grouped into four main categories: passage of downstream migrants into the power intake, passage of upstream migrants beyond the powerhouse, passage of upstream migrants over the diversion and storage dams, and maintenance of minimum flows for migration, spawning, incubation and rearing. The Department has made the following recommendations to the B.C. Power Commission to protect migratory fish: a louver screening system at the intake to prevent entry of downstream migrants; a barrier dam, fish collection and trucking system below the powerhouse to transport upstream migrants from the powerhouse to the upstream side of the diversion dam; a fishway over the new Comox Lake storage dam; and a schedule of minimum flows for each reach of the river.
- Assessment : The B.C. Power Commission completed construction of a \$100,000 pool and weir type fishway at their new Comox Lake impounding dam in 1958. No decision has been made to date to install the louver system or fish collection system which are estimated to cost \$720,000.
- Reports : The Fisheries Problems Associated with the Power Development of the Puntledge River, Vancouver Island, B.C. Department of Fisheries, Canada, 1958. Mimeo report 44 pp. 15 Appendices.

June 1, 1958
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DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Theodosia River Hydro-Electric Power Diversion.
- Purpose : To determine the minimum flow requirements in the Theodosia River below the proposed diversion dam of the Powell River Company Ltd.
- Duration : 1952 - 1954.
- Location : Theodosia River near Powell River, B.C.
- In Charge : C.H. Clay, R.N. Gordon.
- Cooperating Agencies : Water Resources Div., Dept. of Northern Affairs and National Resources; Fish and Game Branch.
- Personnel : Engineer, biologist, local Fishery Officer.
- Cost : \$2,500.
- Results : The dam with a sluice gate to spill the flows specified by the Department of Fisheries and the pertinent diversion canal to Olson Lake was completed in 1956.
- Assessment : Peak flows of the river are now diverted through the canal into Powell Lake thus reducing scouring of the main spawning grounds in the Theodosia River.
- The co-operation of the Powell River Co. in regulating the spill from the dam has been satisfactory to date and no losses to spawning fish have been noted.
- Reports : Preliminary Report on Effects on Sport Fisheries of a Proposed Diversion of Theodosia River by the Powell River Co. Ltd., B.C. Game Commission, 1952 (Mimeographed).
- Unpublished data on file.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Hydraulic Model Studies for Karmutsen Falls Fishway.

Purpose : To simulate various designs of roughened rock cuts, so designed as to act as baffles of a denil-type fishway.

Duration : 1952.

Location : University of British Columbia.

In Charge : M.H. Campbell.

Cooperating Agencies :

Personnel : Engineer, technician.

Cost : \$2,000.

Results : The model found most suitable was one with the paired projections with fishway runs 20 feet in length separated by rest pools 10 feet in length.

A further test was made with a topographic model of Karmutsen Falls with this type of fishway incorporated.

Assessment : A fishway of this type was constructed on the right bank around Karmutsen Falls, near Englewood, B.C., in 1952. Fish passage has been reported as satisfactory since the fishway was installed.

Reports : Unpublished data on file.

June 1, 1958

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Hydraulic model studies of proposed drop structures and fish passage facilities for the Okanagan Flood Control Project.
- Purpose : To determine the hydraulic characteristics of the 13 three-foot vertical drop structures planned for the Okanagan Flood Control Project and to design and test suitable upstream fish passage facilities over the structures for Columbia River blueback (sockeye) salmon.
- Duration : 1953. Assessment 1958 - 60.
- Location : University of British Columbia, Vancouver, B.C.
- In Charge : C.H. Clay, K.C. Lucas.
- Cooperating Agencies : B.C. Dept. of Public Works, Dept. of Public Works, Canada.
U.S. Fish and Wildlife Service, Washington State Dept. of Fisheries.
- Personnel : Two engineers, one technician.
- Cost : \$2,000.
- Results : A 1/10th-scale model of the free overfall type drop structure designed by the flood control authorities was tested and found to be unsatisfactory for safeguarding the proposed flood control channel from erosion at high discharges. A 1/25th-scale model was then built from which evolved a six-notched breastwall type of drop structure which corrected the faults of the first design. Two types of upstream fish passage facilities were tested in this model: one, a conventional vertical-slot fishway on each shore; and the other, two weirs in the stilling basin to break the water-surface drop into three parts, each of which would be passable to fish. The latter method was recommended as the most satisfactory method of providing for upstream fish passage as the whole drop structure constituted the "fishway".
- Assessment : A satisfactory design of drop structure for erosion control was evolved through hydraulic model testing, and the simple addition of two weirs in the stilling basin to ease the upstream passage of fish made the drop structure design quite acceptable to the fisheries agencies concerned. Field tests have shown the drop structures to be operating satisfactorily and conforming to model predictions.
- Reports : Model Studies of Proposed Drop Structures and Fish Passage Facilities for the Okanagan Flood Control Project. K.C. Lucas, Dept. of Fisheries, 1954. (Mimeo).

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Seton Creek Hydro-Electric Power Development.

Purpose : To investigate the fisheries problems which would be created by the B.C. Electric Company's Seton Creek hydro-electric power development, and to recommend remedial measures.

Duration : 1953-54.

Location : Seton Creek, near Lillooet, B.C.

In Charge : C.H. Clay, W.R. Hourston.

Cooperating Agencies : International Pacific Salmon Fisheries Commission.

Personnel : Engineer, biologist, technicians.

Cost : \$4,000.

Results : The B.C. Electric Company provided a fishway in the Seton Creek dam to provide for the upstream migration of runs of sockeye, pink, spring and coho salmon, and steelhead trout. The fishway design was based on hydraulic model studies carried out at the U.B.C. hydraulic laboratory by engineers of the I.P.S.F.C. in cooperation with engineers of the Department of Fisheries.

In order to protect pink salmon which spawn between Seton Dam and the mouth of Seton Creek, the B.C. Electric Company agreed to release a minimum flow of 400 cfs during the spawning period and 200 cfs during the incubation period.

The timing of the downstream fry and smolt migrations was determined by biological sampling programs so that the timing of construction in the stream bed could be arranged without causing harm to the fish.

Assessment : The fishway constructed in the Seton Dam by the B.C. Electric Company has operated satisfactorily since its completion. The Company has cooperated fully with the fisheries agencies in supplying the agreed minimum flows in Seton Creek.

The Company and its contractors arranged the construction schedule of the project so that a minimum of damage would occur to the fishery.

Reports : Report on Model Studies of Proposed Fish Protective Facilities for Seton Creek Dam, by A.C. Cooper and W.E. Boresky, I.P.S.F.C., 1953 (typed).

Unpublished data on file.

June 1, 1958

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Columbia-Fraser Hydro-Electric Power Development.
- Purpose : To study the fisheries problems that would arise as a result of the construction of 10 dams on the Fraser and Thompson Rivers to utilize the hydro-electric potential of water diverted from the Columbia River.
- Duration : 1953-1955.
- Location : Fraser and Thompson Rivers.
- In Charge : C.H. Clay, W.R. Hourston, R.E. McLaren, R.N. Gordon.
- Cooperating Agencies : International Pacific Salmon Fisheries Commission, B.C. Fisheries Department and Fish and Game Branch.
- Personnel : 3 biologists, 2 engineers, technician.
- Cost : \$10,000.
- Results : It was concluded that in spite of the provision of the best modern fish-protective facilities, the proposed scheme would destroy a valuable segment of the Skeena River Sockeye salmon fishery and would preclude the preservation and extension of all the salmon and steelhead runs originating in the Fraser and Thompson Rivers upstream from the proposed dams. The dams would delay the upstream migration of adults and kill a large proportion of the seaward migrants. Other problems would be created in relation to spawning grounds, stream and lake temperatures and ecology, and fry migration.
- Assessment : Further field studies have been carried out and are planned with reference to timing and distribution of species spawning upstream of Hope.
- Reports : A report on the Fish Facilities and Fisheries Problems Related to the Fraser and Thompson River Dam Site Investigations, Canada Department of Fisheries, I.P.S.F.C., 1955 (Mimeographed).

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Fish-passage Facilities for Beechwood Dam, Saint John River, New Brunswick.
- Purpose : To design suitable facilities for passage of upstream migrant salmon around the proposed 68-foot head hydroelectric dam at Beechwood.
- Duration : Design carried out at intervals throughout 1954.
- Location : On the Saint John River near Beechwood, New Brunswick, about 100 miles north-west of the City of Fredericton.
- In Charge : A.L. Pritchard, R.N. Gordon.
- Cooperating Agencies :
- Personnel : 1 engineer.
- Cost : \$5,000.
- Results : Fishways at the site were impractical on account of poor foundations and possibility of continuing settlement problems. The alternative facilities chosen consisted of a powerhouse collection system, holding pool, brail pool, brail, and an inclined trackway to convey the brail to the top of the dam.
- Assessment : Facilities came into operation in 1957 and since that time runs of over 2,000 Atlantic Salmon have been passed upstream each year. However, these counts are only about one-quarter to one-third of the estimated runs past this point prior to dam construction. Some success has also been experienced in passing gaspereau (alewives) and shad.
- Reports : 1. Beechwood Development, Trade News Vol. 10, No. 9, March 1958, and Vol. 14, No. 1, July 1961, P.11., Ottawa, Ont.
2. Beechwood Fish Hoist, by J.D. Denovan, Technical Session, E.I.C. Annual Mtg., June, 1961

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Cheakamus River Hydro-Electric Power Development.
- Purpose : To determine the fisheries problems created by the B.C. Electric hydro-electric power development on the Cheakamus River, and to recommend possible solutions to the problems.
- Duration : 1954 - continuing.
- Location : Cheakamus River near Squamish, B.C.
- Cooperating Agencies : B.C. Game Commission.
- In Charge : C.H. Clay, R.E. McLaren, L. Edgeworth, R.A. Crouter.
- Personnel : Engineers, biologists, up to five technicians.
- Cost :
- | | |
|-----------|-----------|
| 1954 - 57 | \$25,000. |
| 1958 | 19,000. |
| 1959 | 16,000. |
| 1960 | 10,000. |
| 1961 | 8,000. |
- Results : It was concluded that the diversion of the Cheakamus River would seriously affect the salmon and trout populations if fisheries requirements were not considered. Two alternate solutions were recommended to protect the fishery as follows:
1. Maintenance of flow over spawning grounds equal to the mean of the historic low mean monthly flows.
 2. Provision of artificial spawning and rearing facilities.
- The Cheakamus power plant commenced operation in 1957. The B.C. Electric chose to maintain a specified minimum flow over the spawning grounds rather than construct artificial spawning and rearing facilities.
- Assessment : Observations and studies of the runs to the Cheakamus River since 1957 indicate that the flows provided have been adequate to maintain the runs.
- Reports : A report on the Fisheries Problems Related to the Power Development of the Cheakamus River System, Department of Fisheries, Canada, 1957 (Mimeographed).

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Additional Water Storage for Columbia Cellulose Pulp Mill.
- Purpose : To determine the effect on the salmon runs of increased water storage on the Kloiyah River watershed for the expansion of the Columbia Cellulose Pulp Mill.
- Duration : 1954.
1959 - 61.
- Location : Kloiyah River Watershed, near Port Edward, B.C.
- In Charge : J.W. Stokes, R.N. Gordon.
- Cooperating Agencies :
- Personnel : Biologist, engineer, and fishery officer.
- Cost : \$1,700.
- Results : Production increases at the pulp mill in 1954 required that increased water storage be created on the Kloiyah River watershed. Three possible sources which were studied by the Company, were:
1. The diversion of part of the flow from Rainbow Lake, an adjacent system, into Diana Lake in the upper Kloiyah watershed.
 2. The construction of a storage dam at the outlet of Diana Lake.
 3. The expansion of the Prudhomme Lake reservoir by raising the previous maximum storage level four feet.
- The possible effect of each of these proposals on the fisheries was determined and when the Company decided to implement alternative #3 it was agreed that storage levels during salmon spawning periods (in order to maintain spawning on the lower section of tributary Diana Creek) should not exceed that which had occurred up to that time. In 1960 the Company implemented alternative #2. In order to maintain the coho populations during the rearing period, and the sockeye and coho stocks during spawning and incubation, the Company is required to maintain a minimum flow of 15 cfs at the mouth of Diana Creek.
- Assessment : Stipulation of permissible storage levels in Prudhomme Lake ensured that no spawning grounds would be lost through flooding. Provision of a specified minimum flow in Diana Creek ensured that adequate spawning, incubation, and rearing flows would be maintained in lower Diana Creek.
- Reports : Diana Creek Report, Dept. of Fisheries, 1954 (Mimeo).

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Crofton Pulp Mill Water Supply.
- Purpose : To ensure adequate flow for rearing of fish in the Cowichan River and to prevent entry of downstream migrants into the mill water intake.
- Duration : 1954 - continuing.
- Location : Cowichan River, near Lake Cowichan, B.C.
- In Charge : C.H. Clay, K.C. Lucas, L. Edgeworth.
- Cooperating Agencies : Fish and Game Branch.
- Personnel : 2 engineers.
- Cost : \$3,000.
- Results : Consultants for B.C. Forest Products developed the design of a low storage dam, submerged except at low flows, which would increase the low flow of the Cowichan River and improve conditions for rearing of salmon in addition to providing adequate water for operation of the pulp mill. A multiple fishway system spaced at intervals across the dam was designed to provide access over the 2 ft. head on the dam at low water stages. In 1960 one foot high flashboards were added to the dam to provide adequate storage for drought years. A fixed screen was included in the intake to prevent the entry of small fish into the mill water supply. As a result of heavy operating costs which were incurred in cleaning the fixed screens, they were replaced with travelling screens in 1960.
- Assessment : Until the Summer of 1958, water conditions have been too high since installation of the weir to assess its usefulness. However, with the drought conditions in 1958, storage in Lake Cowichan proved to be insufficient to maintain the agreed minimum flow at the weir of 250 cfs. Summer flows were reduced by mutual agreement between B.C. Forest Products and the Dept., however, conditions in the Cowichan River were probably much better than if natural conditions had existed. An assessment is being carried out to determine whether the addition of the flashboards will affect the migration of fish past the dam. Although no assessment of the efficiency of the travelling screens has been made to date, routine observations would indicate that they are an improvement over the fixed screens, particularly from a Company standpoint.
- Reports : Unpublished data on file.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Yukon River - Taku River Hydro-Electric Power Development.
- Purpose : To determine the fisheries problems created by the proposed diversion of the headwaters of the Yukon River to the Taku River watershed.
- Duration : 1954-1957.
- Location : Yukon River near Whitehorse and Marsh, Bennett and Tagish Lakes.
- In Charge : R.E. McLaren, R.N. Gordon.
- Cooperating Agencies : Alaska Department of Fisheries, Fish and Game Branch, R.C.M.P.
- Personnel : Biologists, engineers and technicians.
- Cost : 1954-1957 - \$7,500.
- Results : Limnological data has been collected on Marsh, Bennett and Tagish Lakes, and biological data has been collected on the tributary streams. This data is currently being analyzed with particular reference to the effect on the fisheries of the proposed power development. The Fish and Game Branch has completed a study on Atlin Lake and that part of Tagish Lake which is located in B.C. Considerable data has been collected on the salmon runs to the Yukon and Teslin River system. The U.S. Fish and Wildlife Service have also collected data on the salmon runs as a part of their Yukon River Basin studies. The Alaska Department of Fisheries have undertaken studies on the Taku River with particular reference to the possible effect on the salmon runs from the proposed diversion.
- Assessment : The power company have apparently shelved the Yukon diversion proposal and have directed their surveys to other areas further south. Insufficient data has been received from North West Power Industries Ltd. to assess the fishery problems posed by the proposed power development of the Yukon River.
- Reports : Unpublished data, Department of Fisheries. A limnological survey of Atlin and Southern Tagish Lakes with special reference to their proposed use as hydro-electric storage areas. I.L. Withler - Management publications No. 5 of the B.C. Game Commission 1956. Progress Report No. 111, 1956 field investigations fishery resources of the Upper Yukon River Basin between Eagle, Alaska and Carmacks, Yukon Territory. U.S. Fish & Wildlife Service, 1958 (For Administrative use only).

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Downstream Mortality Studies at Cleveland Dam on the Capilano River.
- Purpose : To determine the mortality to downstream migrant Coho and Steelhead passing over Cleveland Dam on the Capilano River.
- Duration : 1955-60.
- Location : Cleveland Dam, Capilano River in North Vancouver, B.C.
- In Charge : Formerly E.H. Vernon, now R.A. Crouter.
- Cooperating Agencies : Fish and Game Branch.
- Personnel : One biologist, five technicians.
- Cost : 1955 - \$6,000.
1956 - 4,000.
1957 - 4,000.
1958 - 4,000.
1959 - 3,500.
1960 - 3,500.
- Results : Tests were conducted through a range of discharges from 900 to 2,100 cubic feet per second. The spillway on the dam is of the drum gate type and two tests were made with the gate raised 2.8 feet. The percentage mortality was not significantly different in any of the tests conducted and the results from the test years 1955 and 1956 have been combined to calculate a mean mortality of 57 percent to coho migrants and 69 percent for steelhead migrants. Since 1956 the study has been restricted to one of long term assessment of adult return and smolt production.
- Assessment : The results indicate that seaward migrant coho and steelhead suffer a severe mortality in passage over Cleveland Dam. Smolt assessment studies indicate that a significant degree of coho residualism has been established in the reservoir.
- Reports : A report on the Effects of Cleveland Dam on Seaward Migrant Coho and Steelhead in Capilano River, 1953 - 1956. E.H. Vernon, and W.R. Hourston, 1957 (Mimeo).

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Mortalities to Downstream Migrant Salmon and Trout at the Puntledge Powerhouse.

Purpose : To determine the survival rate among the downstream migrants passing through the Puntledge River powerhouse turbine.

Duration : 1955.

Location : The B.C. Power Commission's Puntledge River Hydro Development near Courtenay, Vancouver Island.

In Charge : E.W. Burrige, L. Edgeworth.

Cooperating Agencies : Fish and Game Branch, B.C. Power Commission.

Personnel : One engineer, three biologists and three technicians.

Cost : \$6,900.

Results : Fry and smolts were introduced into the pipeline at the forebay and were recovered in a floating trap net in the tailrace. Ten tests, each consisting of 1,500 live and 500 dead fish, were run. The turbine tested was a vertical-shaft Francis reaction type operating at a net head of 354 feet. The runner setting is five feet above minimum tailwater.

Dead fish were released with each group of live fish in order that calculations could be made of the availability of the killed fish to the recovery gear. Of the fish killed during their passage through the turbine 75% to 86% had no visible injuries. The results of the tests are as follows:

<u>Size Group</u>	<u>Species</u>	<u>Live Recoveries</u>	<u>Dead Recoveries</u>	<u>Final Calculated Survival Rate</u>
4.9 inch	Steelhead	3.5%	3.9%	58.1%
2.7 inch	Kamloops	3.4%	3.4%	72.5%
1.8 inch	Kamloops	4.9%	4.2%	71.2%
1.4 inch	Salmon Fry	2.5%	3.2%	67.4%

Assessment : Mortalities through the turbine at the Puntledge powerhouse point up the need for an investigation into methods of screening the intake at the Puntledge diversion dam to prevent the entry of fry and smolts.

Reports : The Fisheries Problems Associated with the Power Development of the Puntledge River, Vancouver Island, B.C. Department of Fisheries, Canada, 1958. Mimeo Report 44 pp. 15 Appendices.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Attraction of Upstream Migrants to the Puntledge Powerhouse.
- Purpose : To study the effect of the powerhouse attraction on the movement of upstream migrants in the Puntledge River, and to recommend remedial measures.
- Duration : 1955-1956.
- Location : Puntledge River near Courtenay, B.C.
- In Charge : E.W. Burr ridge.
- Cooperating Agencies : B.C. Power Commission.
- Personnel : Biologist, two student assistants and casuals.
- Cost : 1955 \$14,200.
1956 8,700.
- Results : It became apparent in 1955 that upstream migrant spring salmon were attracted to and delayed at the new powerhouse on the Puntledge River. The existence of a counting fence and sampling station on the river upstream of the powerhouse enabled an appraisal of the problem. Periodic flow releases in the river combined with powerhouse shutdowns were shown to partially alleviate the delay. The installation of steel gratings in the tailrace over the draft tube exits in 1956 reduced head injuries to 30% from 56% head injured fish recorded in 1955.
- Assessment : The program was successful in supplying information on the existing Puntledge River power problems. The program also aided in developing a temporary technique used in attracting the salmon migrants away from the powerhouse and up the main river.
- Reports : The Fisheries Problems Associated with the Power Development of the Puntledge River, Vancouver Island, B.C. Department of Fisheries, Canada, 1958. Mimeo Report 44, pp. 15 Appendices.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Fraser River Board.
- Purpose : To study effects on fisheries of various schemes of hydro-electric development and flood control on the Fraser River.
- Duration : 1955 - 1958.
1959 - continuing - includes studies by Fraser River Board.
- Location : Fraser River Watershed.
- In Charge : G.H. Clay, L. Edgeworth, R.E. McLaren.
- Cooperating Agencies : International Pacific Salmon Fisheries Commission, Fraser River Board.
- Personnel : 3 engineers, 2 biologists.
- Cost : 1955-58 - \$ 20,000.
1958-61 - 130,000. (Fraser River Board).
- Results : Studies indicate that an integrated system of power development involving a series of high or low head dams on the main stem would eliminate the Fraser salmon runs under present conditions of knowledge of fish facilities. Flood control might be possible with limited hydro development and maintenance of the fishery. With respect to the latter, surveys were carried out from 1959 through 1961 and will be continued in 1962 to obtain basic biological data on salmon species which would be affected by a partial development of the Fraser River System. This partial system includes dams on the Clearwater and Quesnel Systems, Stuart Lake, and the Upper Fraser above Prince George.
- Assessment : A report covering these investigations will be submitted to the Federal and Provincial Governments in 1963. This report will include an assessment of the effects on the fisheries of the proposed dams as well as recommendations for the facilities necessary to maintain the runs should the developments proceed.
- Reports : 1. Interim Report on Flood Control, Fraser River Board, Victoria, B.C., 1956.
2. Preliminary Report on Flood Control and Hydro-electric Power in the Fraser River Basin, Fraser River Board, Victoria, 1958.
3. Progress summary of fisheries investigations Fraser River Board, 1961.
4. Progress summary of fisheries investigations, Fraser River Board, 1962 (Unpublished at time of writing).

June 1, 1958

Revised December, 1961.

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : The Effectiveness of the Jones Creek Artificial Spawning Channel.
- Purpose : To assess the value of the spawning channel for the spawning and incubation of salmon and the maintenance of the Jones Creek salmon stocks.
- Duration : 1955 - continuing.
- Location : Jones Creek near Laidlaw, B.C.
- In Charge : W.R. Hourston; now D. MacKinnon, L. Edgeworth.
- Cooperating Agencies : Fisheries Research Board of Canada.
- Cost : \$18,000. to 1961, and \$3,500. every alternate year in future.
- Personnel : Biologists, engineers, technicians and casual labour.
- Results : The first spawning of salmon recorded in an artificial stream occurred in 1955 when 400 pink and lesser numbers of chums spawned in the Jones Creek spawning channel. This was the remains of a run of 5,000 to 6,000 that spawned in Jones Creek immediately prior to the development. As a result of good conditions for incubation, survival to fry for this 1955 pink run and its succeeding generations in 1957 and 1959 were 38%, 37% and 63% respectively (4 to 6 times the average for natural streams). This good survival allowed the spawning run to build steadily from 400 in 1955 to 1,450 in 1957 to 2,600 in 1959 and finally to 5,000 in 1961.
- Assessment : It has been concluded that this type of installation has been successful in protecting the pink and chum salmon runs to Jones Creek.
- Reports : 1. Use of an artificial spawning channel by salmon, W.R. Hourston and D. MacKinnon. Transactions of the American Fisheries Society. Vol. 86, 1956.
2. An Assessment of the Jones Creek Spawning Channel 1954-61, D. MacKinnon, L. Edgeworth and R.E. McLaren. Canadian Fish Culturist (in press early 1962).

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Hydro-Electric Power Development at Moran Dam on the Fraser River.

Purpose : To study the fisheries problems that would arise as the result of the construction of a 700-foot dam on the Fraser River at Moran, 25 miles upstream from Lillooet.

Duration : 1955-1958.

Location : Fraser River near Lillooet, B.C.

In Charge : C.H. Clay, W.R. Hourston, R.E. McLaren, R.N. Gordon.

Cooperating Agencies : International Pacific Salmon Fisheries Commission, Fish and Game Branch.

Personnel : 2 biologists, 2 engineers.

Cost : \$5,000. direct expenses. Data also used from other investigations.

Results : It was concluded that due to the number of major fisheries problems associated with the proposed project for which there was no solution available on the basis of current knowledge, the runs of salmon and steelhead trout that would be affected could not be maintained at their existing levels of abundance.

Assessment : Studies continuing with reference to distribution and timing of species above dam site area.

Reports : Unpublished data on file.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Hydro-Electric Power Development of the Chilko-Homathko-Southgate Watersheds.
- Purpose : To determine the effects of hydro-electric development on the salmon populations of the Chilko-Homathko-Southgate River Systems.
- Duration : 1955, 1957-60.
- Location : Homathko and Southgate Rivers, Bute Inlet.
Chilko and Taseko Rivers, Chilcotin Region.
- In Charge : G.H. Clay, R.E. McLaren, R.N. Gordon, R.A. Crouter.
- Cooperating Agencies : I.P.S.F.C.
- Personnel : Biologists, engineers and technicians.
- Approximate Expenditure : 1955 \$500.
1957-60 \$18,500.
- Results : Reconnaissance surveys of the Homathko and Southgate Rivers were made in 1955 and 1957 and some spawning grounds located in these remote and glacial rivers. In the Chilko River watershed a reconnaissance survey made in 1958 was followed by more intensive surveys in 1959 and 1960 that determined the timing, magnitude and distribution of the adult Chinook salmon runs and also sampled the juvenile Chinook downstream migrations.
- Assessment : Observations indicate that determination of the spawning population on the Homathko and Southgate Rivers will be extremely difficult and will require a large scale survey. Surveys on the Chilko River have provided considerable basic data on the indigenous Chinook salmon population. More detailed studies will be necessary, however, if the proposed hydro-electric plans are developed further.
- Reports : Unpublished data on file.

June 1, 1958
Revised December, 1961

- Subject : Somass River Hydro-Electric Power Development.
- Purpose : To determine the fisheries problems posed by the hydro-electric power development of the Somass River System and to develop possible solutions.
- Duration : 1956-1958. Considered as the Ash Power Development (A52) and Stamp Power Development (A53) after 1958.
- Location : Ash River, Stamp River, Sproat River, Sproat Lake and Great Central Lake, near Port Alberni, B.C.
- In Charge : C.H. Clay, W.R. Hourston, K.C. Lucas, R.E. McLaren.
- Cooperating Agencies : Fish and Game Branch, B.C. Power Commission.
- Personnel : Engineers, biologists, technicians and casual field assistants.
- Cost : 1956 - \$29,000. 1958 - \$76,000.
1957 - 86,000. See A52 & A53 for costs since 1958.
In addition, the B.C. Power Commission under-wrote fisheries engineering and biological costs of \$67,349. in 1956-57.
- Results : The main purposes of the fisheries surveys of 1956, 1957 and 1958 were to determine the numbers, timing and distribution of the various species of salmon frequenting the Somass River system and to define the fisheries problems created by the three phases of the proposed power development, viz. the Ash River, Stamp River and Sproat River power developments. At least 36 individual fisheries problems were defined, and although many of them could be overcome with techniques or facilities previously developed, several of the problems had no apparent immediate solutions. The fisheries problems associated with the Ash River power development were comparatively few in number and solutions were available. Hence it was agreed in late 1956 that the Ash River development could proceed providing that certain fisheries protective measures were taken. Further details of the Ash River project are reported in Summary No. A52. The Stamp and Sproat River developments were deferred by the B.C. Power Commission on account of the numerous difficult fisheries problems involved. While the latter project has virtually been abandoned, the intensive work continuing on the Stamp River development is reported in Summary No. A53.
- Assessment : The proposed three-phase development of the Somass River system has posed some of the most difficult fish conservation problems encountered to date in British Columbia. Available solutions to fisheries problems allowed the Power Commission to proceed with the first phase, the Ash River Development. Implementation of the second phase, the Stamp River Development must await the results of intensive applied research studies under way on downstream migrant guiding (A63), stream rearing requirements (A81), spawning requirements and artificial channels (A64) and beach spawning investigations (A54 and A70).
- Reports : A Preliminary Report on the Fisheries Problems Related to the Proposed Power Development of the Somass River System, Department of Fisheries, Canada, 1956 (Mimeographed). Salmon Spawning Ground Survey on the Somass River System, Department of Fisheries, Canada, 1957 (Mimeographed). Unpublished data.

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Nass River Hydro-Electric Power Development.
- Purpose : To determine the distribution, population and timing of salmon runs in the Nass River watershed, and to determine the effects of a hydro-electric development on the fisheries resource of this river system.
- Duration : 1956 - 1959.
- Location : Nass River, B.C.
- In Charge : J.W. Stokes, R.A. Crouter, R.N. Gordon.
- Cooperating Agencies :
- Personnel : 3 biologists, 3 technicians, 3 student assistants, 3 part-time casual labourers and 1 guide.
- Cost :
- | | | |
|------|---|-----------|
| 1956 | - | \$ 5,000. |
| 1957 | - | 22,000. |
| 1958 | - | 25,000. |
| 1959 | - | 27,000. |
- Results : In 1956 an aerial reconnaissance and limited spawning ground inspections were made. In 1957, 1958 and 1959 extensive studies were made of the Nass River salmon populations. These studies provided a measure of the annual salmon escapement and determined the timing and spawning grounds of the various salmon stocks. These studies also evaluated other factors pertinent to salmon production in the river and assessed the possible effects of the proposed hydro-electric development.
- Assessment : A hydro-electric development on this system would pose many serious problems to the salmon populations. Further study will be necessary if the plans to develop hydro-electric power on the Nass River are ever re-initiated.
- Reports :
1. Results of Nass River Biological Surveys for the Years 1956 and 1957 Including a Preliminary Assessment of the Possible Effects of the Proposed Hydro-Electric Project. Dept. of Fisheries, 1958 (Mimeographed).
 2. 1958 and 1959 data on file.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Puntledge River Downstream Migrant Salvage Program.
- Purpose : To salvage juvenile chinook salmon and trout downstream migrants at the B.C. Power Commission's Puntledge Plant power intake.
- Duration : 1956 - continuing.
- Location : Puntledge River power intake near Courtenay, B.C.
- In Charge : Formerly E.W. Burrige, J.W. Stokes; now D. MacKinnon.
- Cooperating Agencies : B.C. Power Commission.
- Personnel : 2 student assistants or technicians.
- Cost : 1956 - \$5,500.
1957-61 (approx. \$4,000. per year cost borne by B.C. Power Commission).
- Results : Two to five fyke nets are fished in the intake canal during the chinook fry and smolt migrations. Fish trapped are released in the river downstream at the intake. Chinook salmon fry make up the greater part of the catch with lesser numbers of chinook smolts and trout fry and smolts.
- Tests run during 1956 and 1957 showed that only 35% of the migrants entering the forebay were being picked up in the nets with the remainder passing by and eventually entering the pipeline intake. The percentage of the top four feet of the channel netted was approximately 36%.
- Assessment : This program was set up as a temporary measure to salvage downstream migrants in the Puntledge River forebay. The effort, expense and inefficiency of this project have proved that it could never be anything more than a temporary measure pending arrangement for permanent intake screens. Power Commission personnel now install and operate five nets every year and will continue operating until permanent facilities are provided. A permanent solution in the form of a louver deflector was recommended to the B.C. Power Commission in 1958, however, no action to install this facility has been taken to date.
- Reports : The Fisheries Problems Associated with the Power Development of the Puntledge River, Vancouver Island, B.C. Department of Fisheries, Canada, 1958. Mimeo Report 44 pp. 15 Appendices.

June 1, 1958

Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Alberni Pulp Mill Water Supply.
- Purpose : To provide adequate residual flows in the Sproat River for transportation and rearing of fish and to prevent entry of small fish into the mill water supply intake on Sproat Lake.
- Duration : 1956-1957, 1959-60.
- Location : Stirling Arm of Sproat Lake, near Alberni, B.C.
- In Charge : R.N. Gordon, K.C. Lucas.
- Cooperating Agencies :
- Personnel : Engineer.
- Cost : \$800.
- Results : A low weir, submerged at most river stages, was constructed at the outlet of Sproat Lake to store sufficient water at low flows to provide for adequate flow in the Sproat River for transportation and rearing of fish as well as storage for mill water supply from Sproat Lake.
- A new pumphouse intake, consisting of three rectangular openings, was constructed in the lake in 1960. The two openings through which water is now being drawn are provided with Link-Belt travelling screens. The third opening is stop-logged off but will be fitted with an additional screen if, and when, an increase in plant demand dictates that it be brought into service.
- Assessment : Satisfactory flows have been maintained in the Sproat River since construction of the weir. The screening installation meets all fisheries standards, and no evidence of mortality or injury have been observed.
- Reports : None.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Fishway for the Great Central Lake Storage Dam.
- Purpose : To design a suitable fishway to overcome an 18-foot hydraulic head created by a new storage dam constructed by MacMillan, Bloedel and Powell River Ltd., on the crest of a low falls at the outlet of Great Central Lake.
- Duration : 1956-1957, assessment continuing.
- Location : Outlet of Great Central Lake, near Port Alberni, Vancouver Island. Hydraulic model studies conducted at the University of B.C. hydraulics laboratory.
- In Charge : K.C. Lucas.
- Cooperating Agencies : H.A. Simons Ltd., MacMillan, Bloedel and Powell River Ltd.
- Personnel : One engineer, two technicians.
- Cost : Hydraulic Model Study - \$8,525.
Schematic Design and Assessment - 3,000.
- Results : Although the natural falls at the lake outlet was passable to fish, the new dam on the crest of the falls would create an impassable obstruction to salmon. A hydraulic model of the damsite and falls was constructed in order to determine the hydraulic conditions which would exist in the tailwater area of the falls. A suitable spillway and fishway entrance design was evolved through model testing. However, company engineers instead chose an alternative plan whereby the base of the falls was excavated to form a sheared barrier dam 10 feet high and 200 feet long, leading to a fishway on the right bank of the river. This fishway, a vertical-slot type, was actually two fishways in one; a low level fish exit was located upstream of baffle #13 and the high level fish exit upstream of baffle #18, making the first 13 baffles common to both. A telescopic gate up to 5 ft. high was provided at sill level at baffle #1 to allow maintenance of fish entrance velocities during backwater conditions caused by a combination of low forebay and high tailwater levels. Up to 75 cfs of auxiliary water is diffused into the fishway entrance baffle to create additional attraction to the fish entrance.
- Assessment : This dam and fishway, together with the Robertson Creek dam and fishway and the Sproat River weir, were constructed in 1957 by MacMillan, Bloedel and Powell River Ltd., at a cost of approximately \$800,000. for the purpose of maintaining adequate minimum flows in the Somass River to dilute effluent from the Port Alberni pulp and paper mill to safeguard fish. The Great Central Lake fishway has satisfactorily passed up to 100,000 adult sockeye, coho, and chinook salmon and steelhead trout per year since it went into operation in June, 1957.
- Reports : Data and laboratory observations on file.

June 1, 1958

Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Whitehorse Rapids Hydro-Electric Power Development on the Yukon River.
- Purpose : To assess the fisheries problems created by the construction of a power development on the Yukon River at Whitehorse Rapids and determine fish facilities required.
- Duration : 1956 - 1960.
- Location : Whitehorse Rapids on the Yukon River near Whitehorse, Y.T.
- In Charge : C.H. Clay, W.R. Hourston, R.N. Gordon, R.E. McLaren.
- Cooperating Agencies : R.C.M.P.
- Personnel : Engineers, biologists and technicians.
- Cost : 1956 - 60. \$35,000.
- Results : Construction of the Whitehorse Rapids dam would block the spawning migration of chinook (king) salmon, and the spawning and feeding migrations of several indigenous species of fish, unless adequate remedial measures were provided at the outlet. Studies showed that the dam did not provide favourable conditions for the location of a fishway entrance, or collection works, at the downstream face. It was recommended, therefore, that a barrier dam be constructed across the river some distance downstream from the dam and that a weir-type fishway be erected to pass fish from toe of the barrier dam to the forebay of the power dam. It was recommended also that bypass facilities be installed at the downstream face of the powerhouse to conduct fish back to the river. Construction of these facilities was initiated in August, 1958 and they were placed in service in June, 1959. Total cost of these facilities is reported to be \$820,000.
- Assessment : In 1958, when the power dam was only partially completed, a salvage program involving a temporary fishway, nets and a tank truck was employed to pass upstream migrants around the obstruction. In 1959 and 1960, detailed counts of fish passing through the fishway, and careful observations of the total numbers of fish migrating indicated that the facilities are successful for their intended purpose. There has been no evidence to date to indicate that losses are being sustained by the small percentage of fish passing through the turbines during downstream migrations.
- Reports : 1. The Fish Facilities at the Whitehorse Rapids Power Development, Yukon Territory by R.N. Gordon, R.A. Crouter and J.S. Nelson. The Canadian Fish Culturist No. 27, August, 1960.
2. Unpublished data, Department of Fisheries.

June 1, 1958

Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Puntledge River Louver Guiding Tests.
- Purpose : To test the effectiveness of louver screens for guiding downstream migrant salmon and trout from the Puntledge River power diversion intake.
- Duration : 1957 to 1959.
- Location : Test structure located on the Puntledge River six miles west of Courtenay, B.C.
- In Charge : K.C. Lucas; E.W. Burrige (1957), K.J. Jackson (1958) and W.J. Schouwenburg (1959).
- Cooperating Agencies :
- Personnel : 1957, one engineer, one biologist, 3 technicians, 2 field assistants. 1958-59, 2 engineers, one biologist, 2 technicians, 3 field assistants.
- Cost : 1957 - \$28,200.
1958 - 14,300.
1959 - 17,300.
- Results : Tests were carried out in a test flume 80 feet long, 10 feet wide and 6 feet deep through which the river was diverted by a dam 160' long and 6' high. Chinook salmon fry, which was the main species present, entered the flume during their natural migration downstream, as did small numbers of natural migrant steelhead smolts. In addition, numbers of sockeye smolts and hatchery steelhead smolts were introduced into the river upstream from the test site. The main variables selected for the tests were bar spacing and approach velocity. Test results showed a maximum successful guiding of 73% for chinook salmon fry with louver bars spaced two inches apart, face of bars perpendicular to the current, and an average approach velocity of 3.0 feet per second. Maximum successful guiding for other species were: sockeye smolts - 77%, native steelhead smolts - 81%, and hatchery steelhead smolts - 95%.
- Assessment : As a result of the louver tests a schematic layout and specifications for a louver deflection system were prepared by the Department and forwarded to the B.C. Power Commission as a suggested method of screening the 1,000 cfs Puntledge Power Development intake diversion. No decision to install the louver system has been made by the Commission to date.
- Reports : 1. The Fisheries Problems Associated with the Power Development of the Puntledge River, Vancouver Island, B.C. Department of Fisheries, Canada, 1958. Mimeo Report 44 pp. 15 Appendices.
2. Publication on louver studies in preparation.

June 1, 1958

Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Rainy River Water Supply Dam.

Purpose : To design a fishway for a diversion dam proposed by Canadian Forest Products in connection with the Port Mellon millwater supply.

Duration : 1957.

Location : One-half mile from the mouth of the Rainy River near Port Mellon, B.C.

In Charge : L. Edgeworth, J.P. Parkinson.

Cooperating Agencies :

Personnel : Engineer.

Cost : \$500.

Results : The dam was completed in 1960 and includes a Denil deep-channel fishway. The Denil type fishway was considered more suitable for this dam because of the limited space available, the low head (18'), and the size and species of the runs. The baffle design was modelled by the Washington State Dept. of Fisheries.

Assessment : No assessment has been made to date.

Reports : Hydraulic model Tests of a Denil Deep Channel Fishway by J.C. Clausen and E.R. Floodeen. A report to the Director of the Washington State Department of Fisheries, December, 1954.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Screens for Water Intakes, Prince George and Quesnel Thermal Generating Stations.

Purpose : To design screens for the cooling water intakes at the Prince George and Quesnel thermal generating stations of the B.C. Power Commission.

Duration : 1957.

Location : Quesnel and Prince George, B.C.

In Charge : C.H. Clay, A.C. Cooper.

Cooperating Agencies : International Pacific Salmon Fisheries Commission, B.C. Power Commission.

Personnel : 2 engineers.

Cost : \$900.

Results : A fixed screen to prevent entry of downstream migrant fish into the cooling water intakes of the thermal plants was developed. Both intakes were less than 100 c.f.s. One is located on the Fraser River at Prince George and the other on the Quesnel River at Quesnel.

Assessment : No assessment of efficiency has been made to date, but it is believed it will be close to 100%.

Reports :

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Georgia Generating Station Cooling Water Intake.

Purpose : To design screens for the cooling water intake of the B.C. Power Commission's Georgia thermal generating station.

Duration : 1957.

Location : Chemainus, B.C.

In Charge : R.N. Gordon.

Cooperating Agencies : Sandwell & Co.

Personnel : One engineer.

Cost : \$300.

Results : A travelling screen designed by the consulting engineer, Sandwell & Co., was examined and approved as satisfactory to prevent entry of fish from salt water to the cooling system of the 100,000 Kw. gas turbine thermal-electric power station.

Assessment : No assessment of efficiency of screen made to date.

Reports :

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Elaho River Hydro-Electric Power Development.

Purpose : To determine the fisheries problems posed by the diversion of the Elaho River to Princess Louise Inlet for hydro-electric power generation.

Duration : 1957.

Location : Headwaters of the Squamish River.

In Charge : L. Edgeworth, R.E. McLaren.

Cooperating Agencies :

Personnel : Engineers, biologists and technicians.

Cost : \$4,500.

Results : Data was obtained on the distribution and timing of the salmon runs in the Squamish River System. A preliminary analysis of the fisheries problems posed by the proposed power developments was completed.

Assessment : B.C. Electric Company have abandoned for the present their plans to proceed with a power development on the Elaho River.

Reports : Unpublished data.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Nimkish River Hydro-Electric Power Development.
- Purpose : To assess the fisheries problems that would be created by the hydro-electric development proposed by the B.C. Power Commission on the Nimkish River.
- Duration : 1957 - 1959.
- Location : Nimkish River near Englewood, B.C.
- In Charge : R.N. Gordon, D. MacKinnon.
- Cooperating Agencies :
- Personnel : Engineers, biologists, technicians and field and office assistants.
- Cost : 1957 - \$10,000.
1958 - 24,000.
1959 - 4,000.
- Results : Estimates of the numbers, timing and distribution of sockeye, coho, chinook, pink and chum salmon were made along with a description of their biotic, physical and chemical environment. The whole system was covered and commercially significant numbers of all five species were recorded in an environment that has potential enough to support increases in all species. Studies of fry and smolt production, downstream migrations, and the role of Nimkish Lake as a rearing area were conducted. These studies have provided considerable information on timing and numbers of downstream migrants of all species. In addition they have pointed out that Nimkish Lake is an exceptionally important rearing area for several million sockeye that have hatched in the upper system and migrated as fry to rear for a year in Nimkish Lake.
- Assessment : The Department is now in a position to outline the magnitude and complexities of the fisheries problems that would be created by the proposed hydro-electric development. The B. C. Power Commission have not indicated any firm plans for this project since the fisheries surveys have been completed.
- Reports : 1. Biological Survey, Nimkish River System, Department of Fisheries, Canada, 1958. Mimeo Report 38 pp.
2. Report on 1958-59 prepared to draft stage.

June 1, 1958

Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Campbell River Diversions Hydro-Electric Power Developments.
- Purpose : To determine water requirements for migration, spawning, incubation and rearing of salmon and trout in the Salmon, Quinsam and Heber Rivers, downstream from the diversion dams.
- Duration : 1957, continuing.
- Location : Salmon, Quinsam and Heber Rivers, near Campbell River, B.C.
- In Charge : D. MacKinnon, R.N. Gordon.
- Cooperating Agencies : Fish and Game Branch.
- Personnel : Engineer, Biologist, Technicians and Field and Office Assistants.
- Cost : 1957 - 58 \$12,000.
1958 - 59 3,500.
1959 to date 1,500.
- Results : Salmon and Quinsam: Numbers, distribution and timing of adult coho, pink, spring, chum and steelhead were assessed. Spawning and rearing potential of the river was described. It was found that the factor deciding water requirements was depth over the riffles and falls. In the case of the Salmon River reduction in discharge from the headwaters would have little or no effect on spawning, rearing, or incubation. In the case of the Quinsam these would be somewhat more affected by reduction in discharge. Gauging and metering has described the discharge pattern and the contribution of the headwaters and major tributaries to the river.
- Heber: Surveys show it to be chiefly a steelhead stream. Reduced water would have its most pronounced effect on one mile of river bed between a major tributary and an impassable falls. The value of this area will be determined and further studies will be made to determine the effect of reduced water on migration through the lower river.
- Assessment : An interim arrangement, which ensures that adequate residual flows will be maintained, has been in effect since 1958. In the meantime, the collection of flow data has been continued in order that a permanent agreement can be drawn up whenever sufficient data has been collected for this purpose. To date, it appears that the interim arrangement has been adequate to meet the fisheries needs and it is expected that no major revisions will be required.
- Reports : File reports on biological and engineering studies. Temperature and discharge records for Salmon and Quinsam Rivers on file.

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Clearwater River Hydro-Electric Power Development.
- Purpose : To ascertain the fisheries problems associated with proposed power developments on the Clearwater River system.
- Duration : 1957 - 58
1959 - continuing: included in Fraser River Board Studies.
- Location : Clearwater River near Clearwater Station, B.C.
- In Charge : D. MacKinnon, R.N. Gordon, L. Edgeworth.
- Cooperating Agencies : Fraser River Board.
- Personnel : Biologist, engineer and technicians.
- Cost : 1957 - \$1,000. 1959 - \$1,800. (Fraser River Board funds)
1958 - 2,500. 1960 - 5,500. " " " "
1961 - 5,000. " " " "
- Results : Preliminary surveys in 1957 and 1958 were directed to the studies of the timing, distribution, and populations of chinook salmon in the Clearwater River. More extensive surveys were undertaken commencing in 1959 by fisheries personnel of the Fraser River Board working under the direction of the Department of Fisheries.
- Assessment : The Fraser River Board is currently investigating a number of possible dam sites in the Fraser River System, including five dam sites on the Clearwater System. A report covering these investigations will be submitted to the Federal and Provincial Governments in 1963. This report will include an assessment of the effects on the fisheries of the proposed dams as well as recommendations for the facilities necessary to maintain the runs should the development proceed.
- Reports : 1. Unpublished data on file.
2. Progress summary of fisheries investigations, Fraser River Board, 1961.
3. Progress summary of fisheries investigations, Fraser River Board, 1962 (Unpublished at time of writing.)

June 1, 1958
Revised December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Ash River Hydro-Electric Power Development.
- Purpose : To develop solutions to the fisheries problems posed by the diversion of part of the flow of the Ash River from Elsie Lake to Great Central Lake for hydro-electric purposes.
- Duration : 1956-1958. Considered as a part of the Somass River Power Development - see A 38.
1958-1960, assessment continuing.
- Location : Ash River and Great Central Lake, near Port Alberni, B.C.
- In Charge : K.C. Lucas, D. MacKinnon, latterly R.N. Gordon.
- Cooperating Agencies : Fish and Game Branch, B.C. Dept. of Recreation & Conservation; and B.C. Power Commission.
- Personnel : Engineers, biologists, technicians and field assistants.
- Cost : 1956-1958 - costs included in Somass Power Development - see A 38.
1959-1961 - \$13,500. - Ash River only.
- Results : Investigations showed that the major fisheries problems posed by the proposed Ash River power development were flow reduction in the lower Ash River spawning and nursery areas, and attraction of adults to the powerhouse to be situated on the shore of Great Central Lake. To provide for the former, a minimum flow requirement of 125 cfs in the lower Ash River, has been specified, and is now in effect. In the event that Ash River spawning migrations might be attracted to the powerhouse outflow, the "shell" of a collection works was constructed integrally with the powerhouse. These works could be placed in service very quickly if they should prove to be needed.
- Assessment : The Ash River plant came on line in May 1959, and to date there has been no indication that Ash River fish are being attracted to the plant. While it is almost impossible to determine whether or not losses are occurring as a result of the diversion of part of the natural flow, evidence to date would indicate that the run is being fully maintained.
- Reports : A Preliminary Report on the Fisheries Problems Related to the Proposed Power Development of the Somass River System, Department of Fisheries, Canada, 1956 (Mimeographed).
Salmon Spawning Ground Survey on the Somass River System, Department of Fisheries, Canada, 1957 (Mimeographed).
Unpublished data.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject** : Stamp River Hydro-Electric Power Development.
- Purpose** : Through surveys, studies and research to develop possible solutions to the fisheries problems created by the proposed power development of the Stamp River.
- Duration** : 1956-1958. Considered as a part of the Somass River Power Development - see A38. 1959, continuing.
- Location** : Stamp River and Great Central Lake, near Port Alberni, B.C.
- In Charge** : R.N. Gordon, D. MacKinnon, F.C. Boyd.
- Cooperating Agencies** : B. C. Power Commission.
- Personnel** : Biologists, engineers, technicians and temporary field assistants.
- Cost** : 1959 - \$28,000.
1960 - 30,000.
1961 - 35,000.
- Results** : The hydro-electric development of the Stamp River has recently been rescheduled to commence in 1968. The most recent power proposal involves problems associated with effective screening of the power canal (see A63), maintenance of adequate flows to facilitate upstream and downstream migrations of adults and juveniles and provide suitable spawning and rearing conditions (see A64, A81) and maintenance of beach spawning sockeye populations in Great Central Lake (see A54, A70).
- Assessment** : To date, biological surveys have established the magnitude, timing and specific distribution of spawning, migrating and rearing populations. Information on the effect of extremes of discharge on the upstream passage of adults at fishways and natural obstructions, is accumulating. Engineering surveys, together with discharge and temperature records have documented the physical characteristics of the stream. Applied research studies at Robertson Creek and Forestry Camp Creek are aimed at developing solutions to the fisheries problems noted above.
- Reports** : A Preliminary Report on the Fisheries Problems Related to the Proposed Power Development at the Somass River System, Dept. of Fisheries, Canada, 1956 (Mimeographed).
Salmon Spawning Ground Survey on the Somass River System, Dept. of Fisheries, Canada, 1957 (Mimeographed).
Draft Reports:
Migration and Spawning of Salmon in the Somass River System 1958.
Downstream Migration of Juvenile Salmon in the Stamp River 1959.
Migration and Spawning of Salmon in the Somass River System 1959.
Migration and Spawning of Salmon in the Somass River System 1960.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Sockeye Beach Spawning Studies at Great Central Lake.
- Purpose : Through studies and research to record, in their natural state, the physical features of beaches utilized by spawning sockeye salmon and to determine the distribution, cyclic magnitude, density, timing and success of spawning in relation to the problems created by additional storage in the lake and seasonal drawdown.
- Duration : 1957 - continuing.
- Location : Great Central Lake headwaters of Stamp River near Port Alberni, B.C.
- In Charge : D. MacKinnon, F.C. Boyd, P. Ryan.
- Cooperating Agencies :
- Personnel : Engineers, biologists, technicians and casual field assistants.
- Cost : 1959 - \$11,400.
1960 - 7,200.
1961 - 12,000.
- Results : Biological studies have established the timing, distribution and magnitude of spawning populations. Observations and measurements have revealed that spawning occurs at a wide range of depths and water temperatures, and is exclusively associated with alluvial fans. Temperatures and water samples taken beneath gravel surface in spawning areas revealed dissolved oxygen and temperature differentials indicating subsurface percolation. A chronological sequence of behaviour activities has been observed and verified. Spawning gravel sieve analysis indicated a relatively high proportion of fines. Retrievable egg plants have indicated consistently high survival from egg to fry.
- Assessment : In Great Central Lake beach spawning sockeye enter the lake one to three months prior to spawning, move onto the beaches serviced by subsurface percolation two or three weeks before active spawning. There is no evidence of sustained attraction to surface flow entering the lake in the vicinity of the spawning areas. Rate of subgravel flow, dissolved oxygen content of percolating groundwater and gravel size compositions apparently assure a high survival of spawn. Eggs planted under controlled conditions eliminating groundwater percolation suffered complete mortality. It thus appears most probable that partial or complete cessation of groundwater flow resulting from increases in lake level occasioned by storage for hydro-electric purposes may, by eliminating the sensory attraction afforded thereby, render the beaches initially unacceptable to spawners seeking specific water sources and most assuredly profoundly decrease their productive potential.
- Reports : Unpublished data.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Cooling-water Supply for the B.C. Electric Company
Thermal-Electric Plant at Port Mann.

Purpose : To design an intake to prevent the entry of juvenile salmon
in the cooling water intake on the Fraser River.

Duration : 1957-59.

Location : Near Port Mann.

In Charge : C.H. Clay.

Cooperating
Agencies : International Pacific Salmon Fisheries Commission.

Personnel : One engineer.

Cost : \$200.

Results : Flat plate screens were designed by the consulting engineers,
B.C. Engineering Co. Ltd. The design was examined and
approved as satisfactory for a diversion of up to 36,000,000
gpd.

Assessment :

Reports :

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Beechwood Dam Fishway Entrance Experiments.

Purpose : To find the best entrance shape and flows to attract Atlantic salmon, shad, and gaspereau into the powerhouse collection gallery.

Duration : 1957 - 1960.

Location : Beechwood Dam, Saint John River, New Brunswick.

In Charge : R.R. Logie, K.E.H. Smith.

Cooperating Agencies : Fisheries Research Board of Canada, Atlantic Biological Station.

Personnel : Two biologists part time.

Cost : \$1,000.

Results : It appeared that shad entered the fishway in greatest numbers when a deep, slow velocity weir orifice is used at a location remote from a turbine boil. Other species entered both these and standard entrances readily.

Assessment :

Reports : Notes on Shad Movements at Beechwood Fishway, Saint John River, N.B. by K.E.H. Smith, Manuscript Report, 10 pps., Dept. of Fisheries, Ottawa, Canada.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Hydraulic Model Study of Puntledge Louver Installation.
- Purpose : To determine the flow conditions in the region between the future intake gates and the proposed louver installation and to design a suitable energy dissipation zone to achieve the required smooth flow conditions approaching the louver system.
- Duration : February-March, 1958.
- Location : Hydraulics Laboratory, Department of Civil Engineering, University of British Columbia.
- In Charge : M.J. Holden.
- Cooperating Agencies :
- Personnel : Engineer, technician.
- Cost : \$4,600.
- Results : A 1/10th-scale model of the present intake structure, an experimental stilling basin area and the proposed open channel containing the louver structure was built in one of the laboratory flumes. Through trial and error methods a satisfactory stilling basin design evolved. The addition of flow straighteners downstream of the improved stilling basin, gave satisfactory approach flow conditions to the louver installation.
- Assessment : This model study constituted a part of the overall louver investigation program. These hydraulic studies demonstrated that satisfactory louver approach flow conditions can be achieved by proper design. No decision to install the louver system has been made by the B.C. Power Commission to date.
- Reports : The Fisheries Problems Associated with the Power Development of the Puntledge River, Vancouver Island, B.C. Department of Fisheries, Canada, 1958. Mimeo Report 44 pp. 15 Appendices.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Hydraulic Model Study of the Puntledge Louver Bypass.
- Purpose : To test the hydraulics of the fish bypass structure designed to meet the requirements of the proposed louver installation for the Puntledge River power intake.
- Duration : April-May, 1958.
- Location : Hydraulics Laboratory, Department of Civil Engineering, University of British Columbia.
- In Charge : M.J. Holden.
- Cooperating Agencies :
- Personnel : Engineer, technician.
- Cost : \$4,100.
- Results : The bypass design was based on the type developed by the U.S. Bureau of Reclamation for the Delta-Mendota pumping station near Tracy, California, but differs considerably in detail. A $\frac{1}{4}$ -scale hydraulic model of the proposed bypass was constructed in a glass-sided laboratory flume so that flow patterns within the bypass could be observed using dyes and neutrally buoyant particles. Provision was made to measure water velocity at eleven points within the bypass model. The main purpose of the tests was to ensure that fairly uniform approach velocities would be obtained throughout the full depth of the bypass at all operating depths, and that flow conditions inside the bypass were non-turbulent and velocities uniformly accelerated. A satisfactory bypass design was quickly evolved after some modification of the original guide vane design inside the bypass. Optimum bypass flows were also established by observing the model behaviour.
- Assessment : No decision to install the louver system has been made by the B.C. Power Commission to date. These bypass model studies were very useful, however, during the design of the floor-type louver bypass for the Robertson Creek Experimental Test Flume in 1959.
- Reports : The Fisheries Problems Associated with the Power Development of the Puntledge River, Vancouver Island, B.C. Department of Fisheries, Canada, 1958. Mimeo Report 44 pp. 15 Appendices.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Cowichan Lake Committee.
- Purpose : To study Cowichan Lake and Cowichan River with regard to flooding and erosion, and to consider such remedial work as deemed necessary to relieve these problems. The Committee was formed as a result of a recommendation by the Comptroller of Water Rights to the Deputy Minister of Lands and Forests, that a committee be established to study Cowichan River and Cowichan Lake.
- Duration : 1958-1960.
- Location : Cowichan River System.
- In Charge : L. Edgeworth (fisheries aspects).
- Cooperating Agencies : Water Rights Branch, Department of Agriculture, Village of Lake Cowichan, B.C. Forest Products.
- Personnel : One engineer.
- Cost : \$600.
- Results : From a thorough examination of both the Cowichan River and Lake, it appears that neither flooding or erosion are creating critical conditions in the area, with the possible exception of the lower reaches between the City of Duncan and the sea. The report of the Committee made recommendations to the Provincial Minister of Lands and Forests regarding the removal of slash and debris from the Cowichan River; the operation of the weir at the outlet of Cowichan Lake by B.C. Forest Products; suitability of river structures for providing adequate waterways; and the need for continuation of hydrometric and meteorological programs by the Federal and Provincial Governments.
- Assessment : The recommendations of the Committee if carried out, would prove beneficial to the fisheries as well as other interests concerned with flooding and erosion in the Cowichan System. The work of the Committee was useful also in providing a better understanding of the problems and interests of the various agencies connected with the investigation.
- Reports : Preliminary Report Respecting Flooding and Erosion on the Cowichan River, Cowichan Lake Committee, December, 1959.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Cooling-water Supply for the B.C. Electric Burrard Thermal Plant.

Purpose : To design travelling screens to prevent the entry of juvenile salmon into the cooling water intake in Burrard Inlet.

Duration : 1958-59.

Location : Near Ioco.

In Charge : C.H. Clay.

Cooperating Agencies : International Pacific Salmon Fisheries Commission.

Personnel : Two engineers, one biologist.

Cost : \$300.

Results : Travelling band screens were designed by the consulting engineers, Balfour Beatty & Co. Ltd. The design was examined and approved as satisfactory.

Assessment :

Reports :

December, 1961.

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Irrigation Diversions by B. C. Fruitlands.

Purpose : To design an intake to prevent the entry of juvenile salmon into the irrigation intakes on the Thompson and North Thompson Rivers.

Duration : 1958-60.

Location : Near Kamloops.

In Charge : L. Edgeworth.

Cooperating Agencies : International Pacific Salmon Fisheries Commission.

Personnel : One engineer.

Cost : \$400.

Results : A low level screened intake and a high level rock filter intake were designed by B.C. Fruitlands for both the Thompson and the North Thompson diversions. The Thompson River intakes were approved as satisfactory for the diversion of 20 cfs and the North Thompson intakes for 10 cfs.

Assessment :

Reports :

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Design of Fishways and Other Fish Passage Facilities.

Purpose : To describe presently used methods for designing fish passage facilities at dams, and for designing fish screens, fences, barrier dams, artificial spawning channels, etc.

Duration : 1958 to 1961.

Location : Vancouver, B.C.

In Charge : C.H. Clay.

Cooperating Agencies : Fisheries Institute, University of B.C., F.A.O., and Fisheries Agencies in various countries.

Personnel : One engineer, several engineers and draughtsmen part time.

Cost : \$10,000.

Results : Described in text.

Assessment :

Reports : Text entitled "Design of Fishways and Other Fish Facilities", by C.H. Clay. Available from Queen's Printer, Ottawa. Cat. No. Fs 31-1961/1.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Louver Guiding Tests at the Robertson Creek Experimental Test Flume.
- Purpose : To test the effectiveness of louvers for guiding downstream migrant sockeye and coho smolts from the intake of the proposed Stamp River Power Development.
- Duration : Construction - 1959.
Testing - 1960, 1961, continuing.
- Location : Test Flume located on Robertson Creek, 12 miles N.W. of Alberni, B.C.
- In Charge : K.C. Lucas.
- Cooperating Agencies :-
- Personnel : Biologist, engineer, 3 technicians, and 3 casuals.
- Cost : Capital cost of basic test flume-\$72,000. (Fish Culture Br. \$48,500.)
(Fisheries Res.Bd. 23,500.)
Capital cost of louver test appurtenances - \$12,200.
Operating costs, 1960 tests - 20,000.
Operating costs, 1961 tests - 20,500.
- Results : 1960 tests were conducted in a 10-foot flume width with the louver bypass width fixed at six inches. Variables tested were approach velocity, bar spacing and colour of louvers. Two louver lines in tandem were also tested. Results from 1960 tests were inconclusive in assessing the efficiency of louvers for this location, but served as valuable preliminary background for a comprehensive test program in 1961. The bypass width was made a variable in the 1961 tests and the flume width of 20 feet was used. Other variables tested in 1961 were illumination, approach velocity, bypass acceleration and bar spacing. Results showed that the louver principle works with up to 96% efficiency for sockeye smolts and 95% for coho smolts, providing the bypass is adequate. The data clearly points up the importance of providing optimum bypass conditions in order to realize the full guiding potential of louvers.
- Assessment : On the basis of the Robertson Creek tests, a louver deflector would be acceptable for screening the proposed Stamp River intake if it incorporated the following features: convergence of the louver line at an angle of up to 15° towards a wall bypass location, approach velocity no greater than 4 feet per second, bypass acceleration in the order of 140% of approach velocity, bypass width of 18 inches, 2-inch louver bar spacing and no artificial illumination or cover. Further tests to improve a louver bypass are contemplated in 1962 and 1963.
- Reports : Publication being prepared.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Artificial Spawning Channel at Robertson Creek.
- Purpose : To provide facilities for applied research on the solutions for fisheries problems associated with the Somass River system hydro-electric power development, and at the same time to institute a fisheries development project for pink, coho and chinook salmon in the Upper Somass River system.
- Duration : Project in partial operation by October, 1959.
All major facilities operational since October, 1960. Continuing.
- Location : Robertson Creek is eleven miles N.W. of Alberni, B.C.
- In Charge : K.C. Lucas, D. MacKinnon.
- Cooperating Agencies : MacMillan, Bloedel & Powell River Ltd.
- Personnel : 2 biologists, engineer, 2 technicians, casuals.
- Cost : Capital cost of project including camp (1959-61) - \$303,100.
Estimated operating cost per year (incl. salaries) - 60,000.
- Results : The spawning channel occupies the total 4200-foot length of Robertson Creek, which flows as a secondary outlet of Great Central Lake into the Stamp River. A spawning area of 8,000 square yards has been provided in three sections of the creek divided by drop structures which allow some variation in the hydraulics of each section. The channel cross section is trapezoidal with a bottom width of 35 feet. Flows in the channel are regulated by valves at the Robertson Creek control dam, with normal flows of 100-150 cfs provided for spawning and a maximum flow of 250 cfs possible. Spawning gravel sizes range uniformly from a minimum of $\frac{3}{4}$ inch to a maximum of 4 inches. Special facilities at the mouth of the channel allow for trapping and transporting migrants to any desired section of the channel. A large fishway observation room is also provided for experimental work.
- Assessment : This project provides a natural fish cultural laboratory where both research and development projects can be implemented with great advantage. Biological programs to date include three pink salmon eyed-egg transplants: 1.6 million in 1959, 0.7 million in 1960, and 5.0 million in 1961. Adult pink salmon returns from the 1959 plant (which had 95% egg-to-fry survival) were 119 to Robertson Creek and 33 to the parent Stamp River. In 1961, 222 chinook and 653 coho spawners were transplanted to sections of the channel and their distribution, spawning site characteristics, etc. were studied.
- Reports : 1. The Robertson Creek Spawning Channel, K.C. Lucas. The Canadian Fish Culturist, No. 27, August, 1960.
2. A Successful Transplant of Salmon Eggs in the Robertson Creek Spawning Channel, D. MacKinnon. The Canadian Fish Culturist, No. 27, August, 1960.

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Seymour River Water Supply for Greater Vancouver Water District.
- Purpose : To study the fisheries problems posed by the reconstruction of the Seymour Falls dam, and an accompanying expansion of the water diversion facilities; and to advance recommendations for fisheries protection.
- Duration : 1959-60.
- Location : Seymour River below Seymour Falls, North Vancouver, B.C.
- In Charge : R.N. Gordon.
- Cooperating Agencies : Fish and Game Branch, B.C. Department of Recreation and Conservation.
- Personnel : One engineer, one technician.
- Cost : \$1,500.
- Results : Reconstruction of the dam situated on the crest of Seymour Falls does not in itself constitute a fisheries problem, because Seymour Falls is the upstream limit of migration. However, impoundment of water behind the dam and diversion of water from the reservoir could reduce residual flows downstream from the dam to a critical level insofar as the fisheries interest is concerned. For this reason, flow records obtained since 1927 were subjected to a detailed study, and as a result a schedule of flow requirements for fisheries purposes was drawn up. It has since been accepted by all parties and is now in effect.
- Assessment : Prior to reconstruction of the dam, there was no agreement regarding minimum flow requirements below the dam, and the discharge records show that flows of a far lesser magnitude than those contemplated by the current agreement have occurred in the past. For this reason, it is believed that the schedule of flows now in effect will adequately safeguard the fisheries. Observations to date have indicated that adequate flows are being maintained.
- Reports : Unpublished data, Department of Fisheries.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Facilities for Anadromous Fish Passage, Passamaquoddy Project.

Purpose : To investigate the problem of providing for passage of anadromous fish, chiefly Atlantic salmon, through the dams forming part of the proposed Passamaquoddy Tidal Power Project, and to suggest facilities required.

Duration : 1959-60.

Location : Vancouver, B.C., Seattle, Washington, and St. Andrews, N.B.

In Charge : Milo C. Bell and C.H. Clay.

Cooperating Agencies : U.S. Fish and Wildlife Service and Fisheries Research Board of Canada, Atlantic Biological Station.

Personnel : 2 engineers part time.

Cost : \$1,000.

Results : Facilities were suggested for passage of Atlantic salmon at the proposed project.

Assessment : No decision to proceed with the Passamaquoddy Project has been made to date.

Reports : Milo C. Bell and C.H. Clay, 1960. Facilities for Anadromous Fish Passage, Passamaquoddy Project. Journal Fisheries Research Board, Canada, 17 (4).

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : City of Alberni Water Supply.

Purpose : To design screens to prevent entry of juvenile salmon into the City of Alberni water supply intake on the Somass River.

Duration : 1959.

Location : Near Alberni.

In Charge : L. Edgeworth.

Cooperating Agencies :

Personnel : Engineer.

Cost : \$200.

Results : Removable flat plate type screens were designed by the consulting engineers, Associated Engineering Services Ltd. The design was examined and approved as satisfactory for a diversion of up to 2,000 gpm.

Assessment : No formal assessment, but routine inspections by Fishery Officer indicate screens operating satisfactorily.

Reports :

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Water Supply to Paper Plant of MacMillan, Bloedel and Powell River Ltd., on Annacis Island.

Purpose : To design screens to prevent the entry of juvenile salmon into the water supply intake on the Fraser River.

Duration : 1959-60.

Location : Near New Westminster.

In Charge : C.H. Clay.

Cooperating Agencies : International Pacific Salmon Fisheries Commission.

Personnel : One engineer.

Cost : \$100.

Results : Removable flat plate screens on a floating barge were designed by the consulting engineers, Sandwell and Company Ltd. The design was examined and approved as satisfactory.

Assessment :

Reports :

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Experimental Downstream Migrant Deflector for Forebays.
- Purpose : To investigate the feasibility and cost of a large-scale experimental moving-element apparatus for guiding downstream migrant salmonids in relatively deep bodies of water with low velocities.
- Duration : 1958-59.
- Location : Great Central Lake and Nimpkish Lake, B.C.
- In Charge : K. C. Lucas.
- Cooperating Agencies : Pacific Biological Station of the Fisheries Research Board.
- Personnel : One engineer and two students.
- Cost : \$4,800.
- Results : The objective of the investigation was to examine the feasibility of testing a deflector in the order of ten times the size of the hanging-cable deflector successfully tested at Lakelse River (1955) and Port John (1956) by the Fisheries Research Board of Canada for guiding sockeye and coho smolts.
- Surveys for possible test sites were carried out in 1958 and the outlets of Great Central Lake and Nimpkish Lake were found to be suitable locations from the point of view of availability of fish and the physical properties of the site.
- In 1959, Swanson, Wright and Co. Engineers Ltd. were retained as consultants to conduct preliminary design studies to a point where general feasibility of the preliminary design from structural, mechanical and electrical standpoints were assured and reasonably accurate estimates of detailed engineering and construction costs could be prepared. An experimental deflector that was 600 feet long and 40 feet deep using extruded aluminum shapes for deflector elements was designed. The design was otherwise generally similar to the small-scale unit tested at Hooknose Creek. Estimated cost of the large-scale experimental deflector was \$188,000.
- Assessment : Tests conducted by the Fisheries Research Board of Canada at Lakelse River and Hooknose Creek have demonstrated that a small-scale deflector of this type is quite effective in guiding sockeye and coho smolts. However, these results cannot necessarily be extrapolated directly to large-scale applications. The large-scale experimental deflector was designed to a preliminary stage to ensure the engineering feasibility of such a design. Biological testing will be undertaken when a possible application for this type of deflector is apparent.
- Reports : Research on Guiding Young Salmon at Two British Columbia Field Stations, J.R. Brett and D.F. Alderdice. Bull. Fish Res. Bd. Canada, No. 117, 1958.
- Report on Preliminary Design and Cost Estimates of Experimental Migrant Salmonid Deflector, Swanson, Wright & Co. Engineers Ltd. for the Department of Fisheries of Canada. September, 1959 (Mimeo).

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Study of Delta Hydraulics Associated with Sockeye Beach Spawning.
- Purpose : To determine the hydraulic and geologic factors associated with the selection of spawning sites by beach spawning sockeye salmon, to predict the probable effect on the beach spawning population of the proposed power development on Great Central Lake, and to assess the feasibility of artificial spawning beaches as a possible solution to the problem.
- Duration : 1959 continuing.
- Location : Great Central Lake, Vancouver Island, B.C.
- In Charge : K.C. Lucas, P. Ryan, F.C. Boyd.
- Cooperating Agencies :
- Personnel : One engineer, one biologist, one technician.
- Cost : Capital costs - (1959-61) - \$170,100.
Operation costs during 1961 - 7,000.
- Results : In 1959 an artificial spawning beach measuring 50 ft. by 100 ft. and extending from 10 to 60 feet below water surface was successfully constructed on a section of Forestry Camp Creek alluvial fan only sporadically utilized by spawning salmon. During sockeye spawning in 1960, a percolation rate of 1/100 gpm per sq. ft. (50 gpm total) was applied to the artificial beach through the underlying network of perforated plastic pipes. Despite the fact that between 2300 and 4500 gpm of flow was percolating from other parts of the delta, principally 1200 ft. east of the artificial beach, several dozen sockeye spawners were observed holding over the deep portion of the artificial area, and several redds were later located. Average survival of basket plants of eyed sockeye eggs in the artificial beach was 98%.
- In 1961, control of the stream source of percolation for the delta was effected by the construction of a 48-foot high concrete arch dam on bedrock at the upstream end of the alluvial fan. All stream flows up to 165 cfs are intercepted at the dam and diverted to the lake via a 42" diameter pipeline 1800 feet long. These works eliminated the major source of ground water percolation in the fan except from heavy rains. Five deep holes drilled into the delta and provided with perforated casings allow the measurement of water table fluctuations, subsurface temperatures and ground water conductivity. A ground water piezometer was modified to detect and measure subaqueous percolation on the delta front.
- After closure of the diversion dam in August of 1961, water table levels in the delta lowered considerably and percolation rates in natural spawning areas fell to a very low level. Considerable numbers of sockeye congregated at the artificial beach during October and November and 50 to 100 fish spawned there. The majority of sockeye moved to the natural spawning areas after heavy rains in late November increased natural percolation to pre-diversion levels.
- Assessment : With further studies it is hoped to predict the effect on Great Central Lake sockeye beach spawning of a change in lake levels by the proposed Stamp River power development. A possible solution to problems which may occur would be artificial spawning beaches such as the one presently under study.
- Reports : To be prepared.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Chase Waterworks District Water Supply Intake.

Purpose : To design an intake to prevent the entry of juvenile salmon into the water supply intake on the South Thompson River.

Duration : 1960-61.

Location : Near Chase.

In Charge : L. Edgeworth.

Cooperating Agencies : International Pacific Salmon Fisheries Commission.

Personnel : One engineer.

Cost : \$300.

Results : A flat plate type screen was designed by the consulting engineer, M.L. Wade. The design was examined and approved as satisfactory for a diversion of up to 1,000 gpm.

Assessment :

Reports :

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : City of Prince Rupert Water Supply.

Purpose : To design screens to prevent the entry of juvenile salmon into the City of Prince Rupert water supply intake on Shawatlan Lake.

Duration : 1960-61.

Location : Near Prince Rupert.

In Charge : L. Edgeworth.

Cooperating Agencies :

Personnel : Engineer.

Cost : \$100.

Results : Removable flat plate type screens were designed by the consulting engineers, Associated Engineering Services Ltd. The design was examined and approved as satisfactory for a diversion of up to 4,000 gpm.

Assessment :

Reports :

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Water Supply to Dow Chemical Plant on Tilbury Island.

Purpose : To design screens to prevent the entry of juvenile salmon into the water supply intake on the Fraser River.

Duration : 1960-61.

Location : Near Ladner.

In Charge : C.H. Clay.

Cooperating Agencies : International Pacific Salmon Fisheries Commission.

Personnel : One engineer.

Cost : \$100.

Results : Removable flat plate type screens were designed by the consulting engineers, Phillips, Barratt and Partners. The design was examined and approved as satisfactory for a diversion of up to 7,800 U.S.gpm.

Assessment :

Reports :

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Water Supply for a Proposed Pulp Mill at Gold River.
- Purpose : To determine the fisheries problems associated with a proposal to divert water from the lower Gold River to a pulp mill to be situated at the mouth of the river on Muchalat Arm; and to recommend fisheries protective measures.
- Duration : 1960. Continuing.
- Location : Gold River, discharging into Muchalat Arm, Vancouver Island, B.C.
- In Charge : C.H. Clay, R.E. McLaren.
- Cooperating Agencies : Fish and Game Branch, B.C. Dept. of Recreation and Conservation.
- Personnel : Engineer, biologist, technicians.
- Cost : \$1,500.
- Results : The Tahsis Company proposes to construct a pulp mill on the shores of Muchalat Arm, which would draw water from the Gold River via an intake located just upstream from tidal waters. Spawning ground surveys have indicated that the diversion would not have a detrimental effect on spawning below the intake if certain minor precautions are observed. Studies of available discharge records have supported this conclusion and it is believed that if the intake is adequately screened, no fisheries problems will result.
- Assessment : There has, as yet, been no announcement as to whether or not this proposal will be implemented. However, the Company's engineers have already designed a plant intake which complies in all respects with the standards laid down for fisheries protection, and no problems are anticipated if the development should be initiated.
- Reports : Unpublished data.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Water Supply for a Proposed Pulp Mill at Union Bay.
- Purpose : To determine the fisheries problems associated with a proposal to store and divert water from the Tsable River to a proposed pulp mill at Union Bay; and to recommend fisheries protective measures.
- Duration : 1960-61. Continuing.
- Location : Tsable River, near Fanny Bay, B.C.
- In Charge : R.E. McLaren, R.N. Gordon.
- Cooperating Agencies : Fish and Game Branch, B.C. Dept. of Recreation and Conservation.
- Personnel : Engineer, biologist.
- Cost : 1961 - \$200.
- Results : Canadian Collieries Resources Ltd. propose to construct and operate a pulp mill at Union Bay. Application has been made for water licenses which would permit storage of water in Poum Lake in the headwaters of the Tsable River, and diversion of water from the Tsable at a point approximately three miles from the mouth. Since coho, chum, and pink salmon, and steelhead trout utilize the lower six miles of the river, preliminary assessments show that the proposal, if and when it is implemented, could pose several fisheries problems. Specifically, these are; ensuring that adequate flows are maintained in the river, screening of the intake, and provision for fish passage at the point of diversion. Studies of these problems will be continued as basic data regarding both the fisheries resource and the proposed development become available.
- Assessment : The Company apparently has not yet reached a decision as to whether or not the proposed development will be undertaken. However, in the event that an affirmative decision should be made, collection of basic data concerning the fisheries of the system is continuing.
- Reports : Unpublished data.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Forebay - cleaning operation, Shuswap Falls Power Development.
- Purpose : To analyze a B.C. Power Commission proposal to sluice silt deposits from the forebay of the Shuswap Falls power development; and to recommend procedures and precautions which would safeguard the fisheries interests.
- Duration : 1960-61. Continuing.
- Location : Shuswap River, between Mabel Lake and Shuswap Falls, near Lumby, B.C.
- In Charge : R.N. Gordon, D. MacKinnon.
- Cooperating Agencies :
- Personnel : One engineer, one biologist, one technician.
- Cost : \$1,200.
- Results : By the fall of 1960, silt and debris accumulating over the years in the forebay of this plant, had reached a level where it reportedly constituted a threat to the plant machinery. The Power Commission proposed to remove this material in the spring of 1961, by emptying the forebay of all water, and, by means of alternating "cutting" and "flushing" flows, controlled by an upstream storage dam, silt and debris could be removed hydraulically through two low-level sluiceways in the dam. This proposal posed two possible threats to the fisheries resource. Siltation of coho and spring spawning beds downstream from the dam was a very real possibility, as was the reduction in flow. For this reason, efforts were made to have the operation scheduled for a period after emergence from the gravel, but flow conditions expected at that time of year were not compatible with the proposed operation. In view of the urgency with which the Power Commission viewed the situation, the operation was allowed to proceed on schedule with fisheries observers at the site.
- Assessment : While heavy siltation was noted in the slow-moving reaches of the river, the main spawning areas did not appear to be seriously affected. Test samples of coho and spring redds indicated normal survival.
- Reports :

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

Subject : Mill Water Supply for Noranda Mines Ltd.

Purpose : To design screens to prevent the entry of juvenile salmon into the mill water supply on the Toquart River.

Duration : 1961.

Location : Barkley Sound.

In Charge : L. Edgeworth.

Cooperating Agencies :

Personnel : One engineer, one biologist.

Cost : \$100.

Results : Removable flat plate type screens were designed by the consulting engineers, Wright Engineers Ltd. The design was examined and approved as satisfactory for a diversion of up to 2,500 gpm.

Assessment :

Reports :

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Moricetown Falls Hydro-Electric Power Development.
- Purpose : To assess the fisheries problems associated with a proposal to develop hydro-electric power at Moricetown Falls on the Bulkley River; and to determine what fisheries protective devices will be required.
- Duration : 1961, continuing.
- Location : Moricetown Falls on the Bulkley River, near Smithers, B.C.
- In Charge : R.E. McLaren, R.N. Gordon.
- Cooperating Agencies : Fisheries Research Board of Canada.
Fish and Game Branch, B.C. Dept. of Recreation and Conservation.
- Personnel : Engineers, biologists, technicians, and casual field assistants.
- Cost : 1961 - \$17,000.
- Results : When the B.C. Power Commission served notice of this proposed development in January, 1961, the fisheries agencies expressed grave concern with respect to the important runs of sockeye, coho, spring and pink salmon and steelhead trout which could be seriously affected by the development. The Power Commission was advised that several years of study and data collection would be required before the fisheries problems inherent in the power proposal could be evaluated. The Power Commission then suggested that power developments on the Fulton and Pinkut systems (q.v.-pp.A 79 and A 80) tributary to Babine Lake, would constitute suitable stop-gap developments pending completion of the fisheries studies. In view of the importance of all of these systems to the fishery, a comprehensive study of the fisheries problems associated with all three proposals was initiated in the spring of 1961 and is still continuing. Data concerning the magnitude, timing, distribution, etc. of the spawning migrations was collected this year, as was similar data relating to downstream migrations. Other related factors such as temperature and discharge were carefully recorded, and preliminary engineering studies were initiated. It is contemplated that all of these studies will be continued in 1962.
- Assessment : When sufficient data has been collected and details of the power development are made known, recommendations for fisheries protection will be developed.
- Reports : Unpublished data.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Fulton River Hydro-electric Power Development.
- Purpose : To assess the possible fisheries problems posed by a proposal to develop hydro-electric power on the Fulton River; and to recommend fisheries protective measures.
- Duration : 1961, continuing.
- Location : Fulton River, tributary to Babine Lake, near Smithers, B.C.
- In Charge : R.E. McLaren, R.N. Gordon.
- Cooperating Agencies : Fisheries Research Board of Canada.
Fish and Game Branch, B.C. Dept. of Recreation and Conservation.
- Personnel : Engineers, biologists, technicians, and casual field assistants.
- Cost : 1961 - \$7,000.
- Results : The B.C. Power Commission proposes to develop the hydro potential of this system by damming the outlet of Fulton Lake to create a storage reservoir, and divert flows from the Lake to a powerhouse to be located at the base of the falls, which is impassable to migrating fish. Superficial assessment of the proposal reveals no direct threat to the fisheries of this stream inasmuch as the power development would be located upstream from the spawning grounds. However, in view of the importance of the Fulton to the fishery (20% of the Skeena sockeye run) it has been deemed necessary to study all aspects of the proposal to ensure that the fisheries will be maintained. In 1961, therefore, a comprehensive program was initiated to collect data regarding water quality; temperature; discharge patterns; timing, distribution, and magnitude of the spawning migration, etc. These studies will be continued in 1962 as all of these factors will be of importance whenever it becomes necessary to decide whether or not the proposal can be implemented, and if so, what protective measures will be required on behalf of the fisheries interests.
- Assessment : When sufficient data has been collected and the details of the power proposal are revealed, recommendations for fisheries protection can be advanced.
- Reports : Unpublished data.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Pinkut (15 - Mile) Creek Hydro-Electric Power Development.
- Purpose : To assess the fisheries problems associated with a proposal to develop hydro-electric power on Pinkut (15 - Mile) Creek, tributary to Babine Lake; and to recommend protective measures.
- Duration : 1961, continuing.
- Location : Pinkut Creek, tributary to Babine Lake, near Burns Lake, B.C.
- In Charge : R.E. McLaren, R.N. Gordon.
- Cooperating Agencies : Fisheries Research Board of Canada.
Fish and Game Branch, B.C. Dept. of Recreation and Conservation.
- Personnel : Engineers, biologists, technicians, and casual field assistants.
- Cost : 1961 - \$5,000.
- Results : The B.C. Power Commission hydro proposal envisages the construction of a low dam at the outlet of Taltapin Lake to create a storage reservoir, and the diversion of water from the lake to a powerhouse to be situated at the base of a falls, which is impassable to salmon. This proposal and its related fisheries problems are not unlike those associated with the Fulton River proposal (q.v.-pp.A 79), and since the latter is given higher priority by the power agency, fisheries studies in 1961 were concentrated accordingly. Nevertheless, certain basic data regarding escapement and distribution of spawners was obtained at the Pinkut in 1961, and thermographs were installed to record water temperatures. A water level recorder was installed for measuring river discharges. These studies will be continued in 1962.
- Assessment : If either the Moricetown Falls or Fulton River power development is undertaken, development of the Pinkut site would not be required before 1970. For this reason, present studies are being concentrated on the former sites, although certain basic data collection has already been initiated at the latter. These studies will be intensified if the power agency should place new emphasis on the Pinkut as a power site.
- Reports : Unpublished data.

December, 1961

DEPARTMENT OF FISHERIES, CANADA
Fish Culture Development Branch

- Subject : Coho Salmon Underyearling Rearing Studies.
- Purpose : To assess the environmental requirements of rearing underyearling coho salmon with specific reference to the effect of reduced flows from hydro-electric development on the rearing capacity of streams.
- Duration : 1961, continuing.
- Location : Experimental Rearing Facilities are adjacent to a portion of the Robertson Creek spawning channel, near Alberni, B.C.
- In Charge : D. MacKinnon, C.P. Ruggles, K.H. Kupka.
- Cooperating Agencies :
- Personnel : Biologists, engineer, technicians and temporary field assistants.
- Cost : Capital cost of facilities (constructed 1959-61) - \$50,500.
Design and construction overhead (1959-61) - 6,000.
Operating cost, 1961 - 15,700.
- Results : A unique experimental facility has been provided to study the environmental requirements for rearing underyearling coho salmon. The facility has been designed so that a variety of natural stream conditions can be simulated simultaneously in a system of parallel channels for comparative-type experiments. Most of the major stream environmental variables can be controlled and measured in the experimental area. Experiments were initiated in 1961 to assess the approximate natural holding capacity of the channels. It was found that a four-foot deep channel had about the same fish capacity as a one-foot deep channel, viz. two to three fry per square yard of bottom. The coho fry reared in the deep channel showed more growth than those in the shallow channel.
- Assessment : The establishment of suitable flows for rearing of underyearling stream resident salmon and trout has been a major uncertainty in diversion-type hydro-electric and water supply developments. This is the first major program designed to provide answers to these problems which are so prevalent in British Columbia water-use projects.
- Reports : The Robertson Creek Spawning Channel by K.C. Lucas. The Canadian Fish Culturist, No. 27, pp 1-25, August, 1960.

December, 1961

FISH AND GAME BRANCH
DEPARTMENT OF RECREATION AND CONSERVATION

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Effectiveness of Hatcheries in Maintaining Trout Populations in Lakes.

Purpose : To estimate the contribution of hatchery-reared trout to existing natural populations in lakes.

Duration : Continuing.

Location : Paul Lake, near Kamloops, British Columbia.

In Charge : R.G. McMynn and P.A. Larkin.

Cooperating Agencies : Institute of Fisheries, University of B.C.

Personnel : Creel census crews intermittent.

Cost : \$2000 annually.

Results : Creel census records show that up to 50% of trout stocked in one year may be taken by anglers in the year following. Trout must be reared for one year before they can contribute a high percentage of the catch following release. Planted fry do not contribute greatly to the sport fishery in lakes where any species of competitive and/or predator species cohabit with trout.

Assessment : The purpose of the study is to assess the economic and biological factors involved in maintaining or supplementing trout stocks with hatchery reared trout.

Reports : Interval reports, Game Commission, typed.

July 1, 1957

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Trout Lake Study.

Purpose : To assess the effects on fisheries of proposed West Kootenay water storage project at Trout Lake.

Duration : 1949-1950.

Location : Trout Lake and associated system.

In Charge : P.A. Larkin.

Cooperating Agencies :

Personnel : One biologist, several summer assistants part time.

Cost : \$10,000.

Results : Surveys indicated that neither productivity nor spawning facilities of Trout Lake should be seriously affected by lowering of lake level. Compensation for loss of spawning grounds in upper Lardeau River is suggested. A minimum flow on Lardeau is recommended.

Assessment : Maintenance of adequate flow in Lardeau River is most important factor to be considered. Further study when water-storage and regulation are implemented, is suggested.

Reports : P.A. Larkin, 1951. The effects on fisheries proposed West Kootenay water-storage project at Trout Lake. Manag. Publ. B.C. Game Commission 1.

July 1, 1958

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Nechako Lakes Study

Purpose : To assess effects on sport fish populations of the Kenny dam project.

Duration : 1950 to present.

Location : Nechako system.

In Charge : P.A. Larkin, R.G. McMynn, J.C. Lyons.

Cooperating Agencies : Aluminum Company of Canada.

Personnel : Two biologists, part time.

Cost : \$5,000.

Results : A preliminary survey established the nature of the lakes before flooding. To date no after-effects survey has been conducted. A barrier was constructed on Eastern lakes system to prevent upstream migration of undesirable species.

Assessment : In need of further study.

Reports : Manuscript on file Fish and Game Branch.

July 1, 1958

FISH AND GAME BRANCH
Department of Recreation and Conservation

- Subject : Campbell River Drainage Area Study.
- Purpose : To assess the effects on fisheries of present and future water utilization in the Campbell River drainage area.
- Duration : 1951-1953.
- Location : Campbell River drainage area.
- In Charge : P.A. Larkin, D.R. Hurn.
- Cooperating Agencies :
- Personnel : Three biologists part time.
- Cost : \$2,000.
- Results : Present and probable effects on lake productivity resulting from morphometric changes and fluctuation of water level, on spawning facilities and on fishability of waters are postulated from data of short term field surveys.
- Data obtained on growth rate of present trout stocks and fishing success from creel census.
- Assessment : The necessity of more extensive investigations to reveal in greater detail the complexity of environmental changes resulting from water utilization as well as follow-up surveys is stressed.
- Reports : The Effects on Fisheries of Present and Future Water Utilization in the Campbell River Drainage Area, R.G. McMynn and P.A. Larkin. Manag. Publ. B.C. Game Comm. No. 2, 1953.

July 1, 1958
Revised December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Whatshan Lake Study.

Purpose : To assess effects on sport fish populations of reservoir clearing.

Duration : 1951 to present.

Location : Whatshan dam (near Needles)

In Charge : P.A. Larkin (formerly). R.G. McMynn.

Cooperating Agencies :

Personnel : One biologist part time.

Cost : \$1,000.

Results : An experimental area on standing timber was left in order to assess effects of flooding on bottom organisms in uncleared reservoirs.

Assessment : Recheck of experimental area required.

Reports : Internal reports, Fish and Game Branch files.

July 1, 1958.

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Production of Trout in Hydro-Electric Reservoirs

Purpose : To assess the effects on native trout populations of storage on lakes for power development.

Duration : 1951 - indefinite.

Location : Various recently developed storage reservoirs.

In Charge : R.G. McMynn, E.H. Vernon.

Cooperating Agencies :

Personnel : Two biologists.

Cost : \$1,000 to \$8,000 annually.

Results : Complete limnological and spawning area surveys have been made on several lakes previous to installation of storage dams. No results will be available until the reservoirs are filled and follow-up surveys completed.

Assessment : Effects of changed and fluctuating lake levels on trout production may be profound and quantitative information is required before compensatory measures can be initiated.

Reports : Larkin, P.A. 1951. The effects on fisheries of proposed West Kootenay water storage project at Trout Lake. Management Publ. B.C. Game Commission No. 1.

McMynn, R.G. & P.A. Larkin. 1953. The effects of present and future water utilization of the Campbell River drainage area. Management Pub. B.C. Game Commission No. 2.

Withler, I.L. 1956. A limnological survey of Atlin and Togish Lakes. Management Pub. B.C. Game Commission No. 5.

Various internal reports.

July 1, 1957.

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Stream Flow and Production of Trout

Purpose : To study the relation of low summer stream flows to the production of resident and migratory trout. To maintain and augment minimum flows.

Duration : 1952 - indefinite.

Location : Salmon River, Langley; Big Qualicum River; various other coastal streams.

In Charge : E.H. Vernon.

Cooperating Agencies :

Personnel : One biologist, part time.

Cost : To date \$2,000; projected 1958 - 59 - \$10,000.

Results : From a two-year study of Salmon River, Langley; it was concluded that further diversion of water for irrigation would seriously reduce numbers of trout and salmon. As a result of recommendations no further diversions have been permitted. An industrial water storage project on Cowichan River was modified to include additional storage for augmenting summer low flows. Engineering plans have been completed for storage of water in Horne Lake to augment summer flows in Big Qualicum River. The biological effects of this project are to be assessed.

Assessment : Many hydro projects include diversion of water from streams to the detriment of fish. Generally reduction of flow will reduce production of fish in streams but more precise information on optimum flows is required.

Reports : McMynn, R.G. & E.H. Vernon. 1954. Physical and biological observations on the Salmon River, Fort Langley. (typed only)

July 1, 1957.

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Libby Dam Study.

Purpose : To assess the effects on fisheries of a proposed dam on the Kootenay River at Libby, Montana.

Duration : 1952 and 1961.

Location : Kootenay River from U.S. Border to Wardner, B.C.

In Charge : F.P. Maher.

Cooperating Agencies : U.S. Fish and Wildlife Service.

Personnel : One biologist, one assistant.

Cost : \$500.

Results : Dam will flood 42 miles of excellent Kootenay River fishery and replace it with a reservoir of doubtful value for fishery or other recreational purposes. Reservoir draw-down will cause unsightliness and reduce productivity.

Assessment : Compensation should be by provision of access and development of fishing areas nearby.

Reports : Effects on Fisheries of Columbia River Development, F.P. Maher, 1961.

July 1, 1958
Revised December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

- Subject : Factors in Migration of Young Rainbow Trout in Outlet and Inlet Streams of a Lake.
- Purpose : To determine factors involved in movement of young rainbow trout from outlet and inlet spawning streams to lake.
- Duration : 1953-1957.
- Location : Loon Lake, near Clinton, B.C., Institute of Fisheries Laboratory, University of British Columbia.
- In Charge : T.G. Northcote.
- Cooperating Agencies : Department of Zoology, University of British Columbia.
- Personnel : Two biologists part time, two assistants summer.
- Cost : \$10,000.
- Results : Rainbow fry in the outlet stream maintain their position for the first few weeks after emergence, while similar fry in the inlet stream lose position in the dark and are carried downstream towards the lake. After the outlet fry reach a length of 40 m.m. or larger and corresponding to higher water temperatures in July, many begin an active upstream movement towards the lake during the day. A similar upstream migration of fingerlings was also noted. Both of these migrations were affected by water temperature. Downstream movement of fry in the inlet stream could be halted by the use of artificial light, and similarly, the presence of moonlight inhibited such movement. Conversely, the occurrence of heavy cloud cover promoted downstream fry movement. The few fingerlings inhabiting the inlet stream show no distinct trend of movement.
- Assessment : This study will determine effects of water temperature (both the effects of different temperature levels as well as temperature changes) and of illumination on the behaviour of young rainbow trout. This information may be of considerable value in predicting effects on trout populations of dams and diversions which usually alter temperature and other characteristics of the trout's environment.
- Reports : Movement of Young Rainbow Trout in the Inlet Spawning Stream of Loon Lake (Typed), T.G. Northcote, 1957.
Effect of Photoperiodism on Response of Juvenile Trout to Water Currents, T.G. Northcote. Nature, 181: 1283-1284, 1958.
Migratory Behaviour of Juvenile Rainbow Trout, Salmo gairdneri, in Outlet and Inlet Streams of Loon Lake, British Columbia, T.G. Northcote. J. Fish. Res. Bd. Canada (in press), 1962.

July 1, 1957
Revised December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Mica Creek Dam Study.

Purpose : To assess the effects on fisheries of a proposed dam on the Columbia River at Mica Creek.

Duration : 1954 and 1961.

Location : Columbia River from Mica Creek to Donald, B.C.

In Charge : F.P. Maher.

Cooperating Agencies : U.S. Fish and Wildlife Service.

Personnel : One biologist, one assistant.

Cost : \$1,300.

Results :

Assessment : At the present time no sport fishery is present in the area to be flooded. Establishment of a reservoir should provide a limited fishery. Reservoir should be cleared of standing timber.

Reports : Effects on Fisheries of Columbia River Development, F.P. Maher, 1960.

July 1, 1958
Revised December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Experimental Planting of Steelhead in Streams.

Purpose : To develop economical methods of maintaining steelhead populations with hatcheries.

Duration : 1954, continuing.

Location : Lower Mainland and Vancouver Island.

In Charge : R.G. McMynn.

Cooperating Agencies :

Personnel : Two biologists, hatchery staff.

Cost : \$15,000. annually.

Results : Returns of different sized and aged steelhead smolts raised in hatcheries have been compared. Smolts released in excess of 11.5 per pound yielded considerably greater adult returns than did smolts released smaller than 11.5 per pound. Smolts released prior to June 10 yielded considerably greater adult returns than did smolts released after June 10. Highest survival was realized from smolts of 10 per pound released in mid-April in the Vedder River.

Assessment : Steelhead plantings, for maximum benefit, should be undertaken at optimum size and time.

Reports : Steelhead Propagation in British Columbia, J.W. Cartwright, 1954-1959.

July 1, 1957
Revised December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Atlin and Southern Tagish Lakes Study

Purpose : To assess possible effects of proposed hydro-electric storage reservoirs in Yukon River - Atlin Lake - Taku River power project.

Duration : 1955

Location : Atlin, Southern Tagish Lakes.

In Charge : R.G. McMynn.

Cooperating Agencies :

Personnel : Two biologists, part time assistants.

Cost : \$22,000.

Results : Limnological surveys indicate that Atlin Lake is relatively unproductive and would not be seriously affected by raise in lake level although some lake spawning grounds may be temporarily damaged. Tagish Lake shares similar unproductive features with Atlin, but may be more seriously affected by raising of lake level.

Assessment : Slight proposed increase in lake level on Atlin lake may not have serious affect on productivity, however an increase in lake level of some 60 feet on Tagish lake may be deleterious.

Reports : I. L. Withler, 1956. A limnological survey of Atlin and Southern Tagish lakes. Manag. Publ. 5. B.C. Game Comm.

July 1, 1958.

FISH AND GAME BRANCH
Department of Recreation and Conservation

- Subject : Effects of Water Diversion on Fish Distribution
- Purpose : To assess possible effects of several proposed water diversions on fish distribution in British Columbia.
- Duration : 1956.
- Location : Northern British Columbia.
- In Charge : C.C. Lindsey.
- Cooperating Agencies :
- Personnel : Two biologists, part time.
- Cost : \$600.
- Results : The continental divide forms a break in fish distribution; 35 of the 57 species on the Pacific slope in B.C. do not occur in the Mackenzie or Yukon River drainages of the province, and 11 of the 33 species in the latter area occur nowhere on the Pacific slope. Some proposed water diversions for hydroelectric development would cross the continental divide, and are likely to produce striking changes in fish distribution. A proposed Liard-Stikine diversion would probably introduce several species, including trout, into the upper Liard River, and several other species, including northern pike (*Esox lucius*) into the Stikine River. A proposed Peace-Fraser diversion would introduce into the Fraser River arctic grayling, and possibly several other species including northern pike. Other proposed diversions are discussed, and their probable affects on fish distribution are listed. Any diversion introducing pike into waters supporting Pacific salmon (*Oncorhynchus*) is liable to be economically harmful, as pike are voracious fish-eaters. Pike are also vectors of *Triacnophorus* tape-worm, which has been found in Alaska to encyst in the flesh of Pacific salmon in a watershed inhabited by pike.
- Assessment : See results.
- Reports : C.C. Lindsey, 1957. Possible effects of water diversions on fish distribution in British Columbia. J. Fish. Res. Bd. Canada 14 (4) : 651-668.

July 1, 1958.

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Residualism in Coho Salmon.

Purpose : To study the effects of a small recently created reservoir on the migratory behaviour of coho.

Duration : 1956-1959.

Location : Cleveland Dam, Capilano River, Vancouver, B.C.

In Charge : I.L. Withler.

Cooperating Agencies : Fish Culture and Development Branch, Dept. of Fisheries.

Personnel : One biologist, one technician.

Cost : \$6,000.

Results : From preliminary observations during study of spillway mortalities at the dam, it appears that if the seaward migration of coho is delayed to the summer, many migrants remain in fresh water until the normal migration period the following spring. It also appeared that at least some of these delayed migrants tended to mature after a few months of marine life and return as mature fish of approximately one pound. The program for 1957 is restricted to sampling with gill nets in the reservoir and taking scale samples and measurements of the adult run.

Scale-reading and length measurements indicate that growth within the reservoir is more rapid than for fish within the river.

Assessment : Information on the effects of reservoirs on the migration of salmon and trout is required in predicting the effects of future impoundments.

Reports : Data on file.

July 1, 1957
Revised December, 1961.

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Investigation of Genetic Characteristics of "Summer" and "Winter" Runs of Anadromous Steelhead Trout.

Purpose : To assess the characteristics of runs of steelhead trout with respect to timing of entrance to fresh water from the sea. To investigate physiological and morphological differences in steelhead trout with reference to their state of sexual maturity on entrance to fresh water from the sea. To apply this knowledge to artificial propagation of juvenile migrant steelhead trout.

Duration : 1956, continuing.

Location : Capilano River, Vancouver; Smith's Falls Hatchery, Cultus Lake, Chilliwack.

In Charge : S.R. Smith.

Cooperating Agencies : Institute of Fisheries, Department of Zoology, University of B.C.

Personnel : One biologist, hatchery personnel part time.

Cost : \$5,000. annually.

Results : Progeny of "winter" steelheads, which enter fresh water from the sea in an advanced state of sexual maturity and of "summer" steelheads, which enter fresh water from the sea in a sexually immature state return during the same season of the year as did their parents. Summer steelhead have bifurcate gill rakers, winter steelhead do not.

Assessment :

Reports : A Note on Two Stocks of Steelhead Trout (Salmo gairdneri) in Capilano River, British Columbia, S.R. Smith, 1960.
Variations among Life-history Characteristics of Steelhead Populations along the Pacific Coast of North America, I.L. Withler, 1960.

July 1, 1957
Revised December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Rainbow Trout of Kootenay Lake.

Purpose : To obtain detailed information on the life history of Kootenay Lake rainbow trout with special reference to the Lardeau River spawning run.

Duration : 1956, continuing.

Location : Kootenay Lake area.

In Charge : R.G. McMynn, J.W. Cartwright.

Cooperating Agencies :

Personnel : Biologist, part time assistants.

Cost :

Results : Detailed life history data obtained between 1958-1960; adult spawner counts continuing.

Assessment :

Reports : Investigation of the Rainbow Trout of Kootenay Lake, British Columbia, with Special Reference to the Lardeau River, J.W. Cartwright. British Columbia Fish and Game Branch Manag. Publ. 7, 46 p. 1961.

December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Peace River Survey.

Purpose : To assess possible effects of hydro-electric development on the Upper Peace River and its tributaries.

Duration : 1959.

Location : Peace, Parsnip, and Finlay Rivers.

In Charge : I.L. Withler.

Cooperating Agencies :

Personnel : Two biologists.

Cost : \$500.

Results :

Assessment : A net gain to the sport fishery within the reservoir area will probably be realized if water is stored in the upper Peace River. A commercial fishery for whitefish might become established following establishment of a reservoir. The reservoir should be cleared of standing and free-floating timber. Measures should be taken to prevent the transfer of Northern pike and *Triaenophorus crassus* (a tapeworm) from the Peace to Fraser River system.

Reports : Fisheries Problems Associated with Development of the Peace River and its Upper Tributaries for Hydro-electric Purpose, I.L. Withler, 1959.

December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Chilko, Taseko Lake Survey.

Purpose : To assess possible effects of proposed hydro-electric development on the Taseko and Chilko Lake system.

Duration : 1959, continuing.

Location : Chilko, Taseko Lakes and Rivers.

In Charge : I.L. Withler.

Cooperating Agencies : Department of Fisheries of Canada and International Pacific Salmon Fisheries Commission.

Personnel : Two biologists.

Cost : \$200.

Results : Storage of water for hydro-electric purposes will have no effect on sport fish of Taseko and Chilko Lakes. Chilko Lake reservoir should be cleared of standing timber. Minimum flows should be maintained in Taseko and Chilko Rivers downstream of diversion points for preservation of steelhead runs.

Assessment : Assessment of steelhead runs in rivers continuing.

Reports : None to date.

December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Competitive Relations Between Juvenile Salmo and Oncorhynchus in Coastal Streams.

Purpose : To determine environmental requirements for juvenile trout and salmon in streams and to examine some factors which may limit their production in streams.

Duration : 1959, continuing.

Location : Several coastal streams including the Salmon, North and South Alouette, Little Campbell and Chilliwack rivers.

In Charge : G.F. Hartman.

Cooperating Agencies :

Personnel : Biologist and assistants part time.

Cost : \$7,000. annually.

Results : Collections of fish and environmental data have been obtained from all study streams for at least one complete year; laboratory experiments now being set up.

Assessment :

Reports :

December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Evaluation of Hatchery Stocking Program.

Purpose : To evaluate (a) comparative survival of wild and domestic stocks, (b) survival of equivalent numbers of hatchery fish at four sizes, (c) effect of heavy egg planting, (d) graded hatchery plants.

Duration : 1959, continuing.

Location : Several lakes.

In Charge : S.B. Smith.

Cooperating Agencies :

Personnel : Several biologists and assistants part time.

Cost :

Results : Netting data still incomplete.

Assessment :

Reports :

December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

- Subject : Fulton River Survey.
- Purpose : To assess possible effects of hydro-electric development on the Fulton River, tributary to Babine Lake.
- Duration : 1960.
- Location : Fulton Lake and River.
- In Charge : I.L. Withler.
- Cooperating Agencies : Department of Fisheries of Canada and Fisheries Research Board of Canada.
- Personnel : Two biologists.
- Cost : \$200.
- Results :
- Assessment : This hydro-electric development will have little effect on the present sport fishery of Fulton Lake as sport fish are few and the proposed reservoir is isolated. The reservoir should be cleared of standing and free-floating timber. The Fulton River is site of famous "Millionaires Pool", this sport fishing area will be unharmed if a minimum flow is established to protect runs of salmon.
- Reports : Some Effects of Development of Hydro-electric Power on the Fulton River System, and Some Recommendations for the Protection of Fish and Game Species and General Recreation, I.L. Withler, 1960.

December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : High Arrow Dam Study.

Purpose : To assess the effects on fisheries of a proposed dam on the Arrow Lakes.

Duration : 1961.

Location : Arrow Lakes.

In Charge : F.P. Maher.

Cooperating Agencies :

Personnel : One biologist, one assistant.

Cost : \$800.

Results : Losses to sport fisheries due to dam construction will be substantial because of flooding of spawning streams. Losses may be minimized by reservoir clearing, construction of artificial spawning grounds, stocking and stream improvement work.

Assessment :

Reports : Effects on Fisheries of Columbia River Development, F.P. Maher, 1961.

December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Duncan Lake Dam Study.

Purpose : To assess the effects on fisheries of a proposed dam at Duncan Lake.

Duration : 1961.

Location : Duncan Lake.

In Charge : F.P. Maher.

Cooperating Agencies :

Personnel : One biologist, one assistant.

Cost :

Results : Sport fishing within lake presently of little value. Spawning area for trout downstream of the dam must be protected as it provides fry for Kootenay Lake fishery. Further survey required. Reservoir should be cleared.

Assessment :

Reports : Effect on Fisheries of Columbia River Development, F.P. Maher, 1961.

December, 1961

FISH AND GAME BRANCH
Department of Recreation and Conservation

Subject : Sport Fish Survey of Morice Lake and River.

Purpose : To assess possible effects of proposed hydro-electric development on Morice Lake and Morice and Bulkley Rivers.

Duration : 1961, continuing.

Location : Morice Lake and River, Bulkley River.

In Charge : I.L. Withler.

Cooperating Agencies : Department of Fisheries of Canada and Fisheries Research Board of Canada.

Personnel : Two biologists.

Cost : \$200.

Results : None to date. A survey will be undertaken to determine the effects to steelhead trout and resident sport fish of water storage on Morice Lake and power development on the Bulkley River.

Assessment :

Reports :

December, 1961

PACIFIC BIOLOGICAL STATION
FISHERIES RESEARCH BOARD OF CANADA

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : The Relation Between Number of Spawners and the Number of Fry Produced for Pink and Chum Salmon at Port John, B.C.
- Purpose : To determine the density of spawning pink and chum salmon which provides the optimum yield of migrant fry at Port John.
- Duration : Continuing since 1947.
- Location : Port John, B.C.
- In Charge : Dr. F. Neave.
- Cooperating Agencies :
- Personnel : One scientist, two technicians, three seasonal employees.
- Cost : 1955-56 - \$20,000. 1957-58 - \$20,400. 1960-61 - \$16,400.
1956-57 - 18,900. 1959-60 - 15,500.
- Results : Information has been obtained on variation in success of natural reproduction for pink, chum, sockeye and coho salmon, desirable density of spawners, relation between number of fry and returning adults, and effects of predators on migrating fry.
- Fresh water survival of the two species has varied between 0.9 to 37 per cent over 14 years, in which period a range of 0.6 to 5.2 of migrant pink fry returned as adults. At Port John an optimum fry output (pinks, chums combined) of about 1 1/2 million results from the spawning of 10,000-12,000 adults, a density of the order of one female to 1 1/2 square yards of suitable spawning gravel.
- Assessment : This program has initiated studies leading to estimates of optimum spawning density which could lead to more efficient use of available spawning area should the latter be restricted through multiple water use (e.g., damming and reduction in spawning ground or improvement of spawning areas to maintain stocks).
- Reports : Principles affecting the size of Pink and Chum Salmon Populations in British Columbia, Dr. F. Neave. Journal Fisheries Research Board, Canada, 9(9): 450-491, 1953.
- Survival and Production of Pink and Chum Salmon in a Coastal Stream, J.G. Hunter. Journal Fisheries Research Board, Canada, 16(6): 835-886, 1959.

June 20, 1957
Revised December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : To Determine the Physical and Chemical Requirements of Developing Salmon Eggs.
- Purpose : To acquire a better understanding of the factors influencing survival of incubating eggs.
- Duration : Started 1949: laboratory study completed 1954.
- Location : Biological Station.
- In Charge : W.P. Wickett.
- Cooperating Agencies :
- Personnel : One scientist, one technician.
- Cost : 1955-56 - \$ 900.
1956-57 - 1,200.
- Results : Survival of salmon eggs largely dependent on adequate flow of well-aerated water. Sufficient water provides necessary oxygen to and removal of waste products from the developing eggs. Such gas transport by water is dependent on velocity of water flow through the gravel. The velocity being dependent on permeability of the gravel and the hydraulic gradient. Temperature influences rate of potential oxygen utilization and formation of waste products by the egg. Laboratory studies show that oxygen levels below saturation result in delayed development and hatching, production of deformed alevins or death. Oxygen requirements increase as hatching approaches. Carbon dioxide levels up to about 125 ppm do not interfere with oxygen consumption but survival of eggs is related to carbon dioxide concentration at all levels. Volume discharge/unit area (apparent velocity) should be above 10 cm/hr for high survival.
- Assessment : Knowledge of the factors which influence survival of eggs should provide means for assessment of production as well as an indication of what constitutes good spawning gravel and remedial measures which might improve natural production. Information on all species and an increased understanding of temperature relationships is required.
- Reports : The Oxygen Supply to Salmon Eggs in Spawning Beds, W.P. Wickett. Journal Fisheries Research Board, Canada, 11(6): 933-953, 1954. Some Effects of Temporary Exposure to Low Dissolved Oxygen Levels on Pacific Salmon Eggs, D.F. Alderdice, W.P. Wickett, and J.R. Brett. Journal Fisheries Research Board, Canada, 15(2): 229-249, 1958. Environmental Variability and Reproduction Potentials of Pink Salmon Populations in British Columbia, W.P. Wickett. H.R. MacMillan Lecture Series, 1960 (in press).

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : Study of Behaviour Patterns in Young Pacific Salmon.
- Purpose : To improve understanding and knowledge of factors influencing migration and survival of young salmon.
- Duration : Continuing from 1949. Discontinued 1958.
- Location : Port John, B.C.
- In Charge : Dr. W.S. Hoar.
- Cooperating Agencies :
- Personnel : One seasonal scientist.
- Cost : (Included with Summary C 1).
- Results : Migrating, unschooled pink fry quickly take cover under stones. Schooling experience greatly reduces cover-taking response for pink, but not for sockeye or chum fry. Small schools of the three species when startled: pink fry do not take cover, chum and sockeye do; chum fry re-emerge after several minutes, sockeye fry not until evening fall in light intensity. The three species form a series in suppression of cover response after schooling experience.
- Schools of pink, chum, sockeye fry quickly establish stable direction of swimming in circular channel. This reaction persists in chums when removed from channel for 48 hours, about 24 hours for sockeye and less than 12 hours for pinks.
- Assessment : A knowledge of behaviour and mechanics of migration are essential if migratory runs are to be manipulated in the course of multiple water use.
- Reports : The Behaviour of Chum, Pink and Coho Salmon in Relation to their Seaward Migration, Dr. W.S. Hoar. J. Fish. Res. Bd., Canada, 8(4): 241-263, 1951.
The Behaviour of Juvenile Pacific Salmon, with Particular Reference to the Sockeye (Oncorhynchus nerka), Dr. W.S. Hoar. J. Fish Res. Bd. Canada, 11(1): 69-97, 1954.
Control and Timing of Fish Migration, Dr. W.S. Hoar. Biol. Rev. 28(4): 437-452, 1953.
The Evolution of Migratory Behaviour among Juvenile Salmon of the genus Oncorhynchus, Dr. W.S. Hoar. J. Fish. Res. Bd. Canada, 15(3): 391-428, 1958.

June 20, 1957
Revised December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : Salmon Repellent.
- Purpose : To guide upstream migrating salmon by preventing their approach to obstacles or polluted area.
- Duration : 1951-59. Discontinued.
- Location : Tests conducted on various southern British Columbia streams.
- In Charge : D.F. Alderdice, Dr. D.R. Idler.
- Cooperating Agencies : Technological Station, Vancouver, B.C.
- Personnel : One scientist, one technician.
- Cost : 1955-56 - \$2,500.
1956-57 - 2,000.
- Results : Chemical odour deterrent to all species of adult salmon discovered in skin of man and predatory animals. The detection threshold is about one part odour material in 80,000,000,000 parts water. Isolation of the active repellent fraction is in progress. One of the molecules associated with the odour reaction is an amino acid, L-serine.
- Assessment : Multiple water uses pose obstacles in the path of upstream migrants. It is possible that the introduction of repellent odours might deter the attempt of salmon to force their way past such obstacles (e.g., turbine tailrace where an alternative channel is available for migration).
- Reports : Some Observations on Olfactory Perception in Migrating Adult Coho and Spring Salmon, J.R. Brett, and D. MacKinnon. Prog. Repts. Pac. Coast Stns., No. 90, pp. 21-23, 1952.
Further Observations on Olfactory Perception in Migrating Adult Coho and Spring Salmon - Properties of the Repellent in Mammalian Skin, D.F. Alderdice, J.R. Brett, D.R. Idler, and V. Fagerlund. Prog. Repts. Pac. Coast Stns., No. 98, pp. 10-12, 1954.
Olfactory Perception in Migrating Salmon. I. L-Serine, a Salmon Repellent in Mammalian Skin, D.R. Idler, V.H.H. Fagerlund, and H. Mayoh, with collaboration of J.R. Brett, and D.F. Alderdice. J. Gen. Physiol., 29(6): 889-892, 1956 (FRB No. 444).

June 20, 1957
Revised December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : Swimming Speeds of Young Salmon.
- Purpose : To determine the maximum water velocities which can be stemmed by young salmon for a period of two or more hours.
- Duration : 1953-57. Discontinued.
- Location : Biological Station.
- In Charge : Dr. J.R. Brett.
- Cooperating Agencies :
- Personnel : One scientist.
- Cost : 1955-56 - \$2,200.
1956-57 - 1,700.
- Results : Maximum swimming speeds for salmon underyearlings are less than 1 ft/sec. (0.68 mph) in almost all instances. At temperatures of 5°C or less these cruising speeds average about 0.5 ft/sec. Coho show an optimum performance at about 20°C and maintain a high level of performance even when approaching lethal temperature levels. Young sockeye display an optimum at about 15-16°C and have a greater ability to perform at low temperatures than do the coho.
- Assessment : Such information has a direct bearing on approach water velocities to irrigation screening, turbine intakes, by-pass mechanisms and guiding or deflecting gear.
- Reports : The Effect of Temperature on the Cruising Speed of Young Sockeye and Coho Salmon, J.R. Brett, M. Hollands, and D.F. Alderdice. Ms. Biol. Stn. 1958.

June 20, 1957
Revised December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : Guiding of Salmon Fry or Smolts by the Use of a Moving Curtain of Cables.
- Purpose : To develop means of guiding downstream migrant salmon smolts and fry, using their visual reactions.
- Duration : 1953-1957.
- Location : Puntledge and Lakelse Rivers and Port John, B.C.
- In Charge : Dr. J.R. Brett.
- Cooperating Agencies : Fish Culture Development Branch.
- Personnel : two scientists, one technician.
- Cost : 1955-56 - \$9,000.
1956-57 - \$5,500.
- Results : In experiments at Lakelse River (1955), Port John (1956), sockeye and coho yearlings successfully guided (over 90%) by charged moving curtain of 1/4-inch cables spaced up to 8 inches in water velocities of 1-2 ft/sec. Although tests have been restricted to shallow water, no limitation in length of curtain is suggested for operating under these conditions. Fry have not been guided by any of the methods tried.
- Assessment : Under small-scale experimental conditions, the method is quite effective for sockeye and coho smolts, but it is not a general solution to the whole problem. The next logical step is to perform a large-scale test of the method. Large-scale tests of several other methods have not yet yielded positive results. Further work must be done to evaluate the possibility of deflecting fry.
- Reports : Experiments using Light and Bubbles to Deflect Migrating Young Spring Salmon, J.R. Brett, and D. MacKinnon. Prog. Repts., Pac. Coast Stns., No. 92: 14-15, 1953.
Research in Salmon Migration over High Dams. The Nature of the Biological Problem, J.R. Brett. Trans. Sixth B.C. Resources Conf., 96-102, 1953.
Preliminary Experiments using Lights and Bubbles to Deflect Migrating Young Spring Salmon, J.R. Brett, and D. MacKinnon. J. Fish. Res. Bd. Canada, 10(8): 548-559, 1953.
Research on Guiding Young Salmon at Two British Columbia Field Stations, J.R. Brett, and D.F. Alderdice. Bull. Fish. Res. Bd. Canada, No. 117, 1958.
Trough Experiments on Guiding Sockeye Salmon Fingerlings, J.R. Brett, D. MacKinnon, and D.F. Alderdice. Prog. Repts. Pac. Coast Stns., No. 99: 24-27, 1954.
Lakelse River Experiments on Guiding Sockeye and Coho Salmon Fingerlings, J.R. Brett, and D. F. Alderdice. Prog. Repts., Pac. Coast Stns., No. 106: 14-20, 1956.

June 20, 1957

Revised December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : Study of Sight in Salmon.
- Purpose : To improve understanding of movements and habits of salmon, and to learn how to influence them.
- Duration : 1954-57.
- Location : Biological Station.
- In Charge : Dr. J.R. Brett.
- Cooperating Agencies : Part of the program to date has been carried out by a U.B.C. student as a research problem.
- Personnel : Two scientists, one seasonal employee.
- Cost : 1955-56 - \$2,700.
1956-57 - 3,500.
- Results : Studies of structure of Pacific salmon retina continued, along with changes in retina occurring in fish adapted to light and dark conditions. Times for adaptation of coho retina to light and dark investigated.

Minimum light intensity at which young coho may detect and feed on plankton approximately 0.00001 foot-candles (bright moonlight about 0.002 foot-candles).

Sockeye and coho smolts sampled from Lakelse River dark-adapted by 9:30 p.m. when incident light intensity - 0.3 ft-c. Port John pink and chum fry commenced migrating 15-30 minutes after aquarium controls started to dark-adapt. Such retinal changes may cue fish to start evening migration.
- Assessment : The habits and movements of salmon appear to be influenced to a large extent by vision. A knowledge of the visual ability should provide insight into how habits and movements may be subject to manipulation. Such information has already proven to be of value in the interpretation of methods for deflecting or guiding smolts.
- Reports : The Structure and Photomethenical Responses of the Pacific Salmon Retina, M.A. Ali, and J.R. Brett. Ms. Biol. Stn. 1957.

June 20, 1957
Revised December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : Off-Year Pink Salmon Transplant into the Fraser River System at Jones Creek Spawning Channel.
- Purpose : To assess the feasibility of establishing a run of pink salmon in Jones Creek during an "off-year" in the Fraser River.
- Duration : 1954-1958.
- Location : Jones (Wahleach) Creek, near Laidlaw, B.C.
- In Charge : W.P. Wickett, D. MacKinnon.
- Cooperating Agencies : Fish Culture Development Branch, B. C. Electric Co. Ltd.
- Personnel : Three scientists, five technicians.
- Cost : 1954-58 - \$18,000.
- Results : Three million pink salmon eggs taken from fish in the Lakelse River were planted in the eyed stage in the spawning channel at Jones Creek in 1954. From this plant 1.1 million fry were produced, a survival of 37 per cent compared to an average of 10 per cent for natural streams. Approximately 2,700 adults returned to the channel in 1956, with about a further 300 taken by Indian fishery and about 1,500 in Fraser River gill-net fishery. Of the 4,500 total adult return, as many more may have been taken in a more distant fishery. This run was eliminated in the ensuing years as a result of poor fry survival caused by ice scouring and de-watering of sections of the channel, along with an intensive gill-net fishery for Adams river sockeye which moved through the fishing area simultaneous to the returning adults of 1958.
- Assessment : Results were sufficient to encourage further attempts to establish new runs by this method.
- Reports : Transplantation of Pink Salmon into the Fraser Valley in a Barren Year, F. Neave and W.P. Wickett. Prog. Repts., Pac. Coast Stns., No. 103: 14-15, 1955.
An Artificial Spawning Channel, W.R. Hourston and D. MacKinnon. Ms., Trans. Amer. Fish. Soc., 1956.

June 20, 1957
Revised December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : Development of Techniques for Measuring Incubation Conditions in Spawning Gravels.
- Purpose : To evaluate or improve natural or artificial spawning facilities by determining the range of physical conditions present in gravels and correlating these with egg survival.
- Duration : 1954, continuing.
- Location : Biological Station and local streams.
- In Charge : W.P. Wickett, in cooperation with Pacific Oceanographic Group.
- Cooperating Agencies :
- Personnel : One scientist, three technicians.
- Cost : 1955-56 - \$3,000. 1957-58 - \$1,400. 1960-61 - \$5,000.
1956-57 - 4,800. 1959-60 - 5,000. 1961-62 - 100.
- Results : Measurement of permeability of and pressure gradients through gravels and the collection of water samples from gravel beds for determination of oxygen content now possible with "Mark 6" standpipe sampler. The new standpipe sampler will allow measurement of permeability from 20 cm/hr to approximately 100,000 cm/hr with a probable error of 1.3 per cent. At a representative permeability of 6,300 cm/hr, the apparent velocity of water flowing through gravel may be obtained within a range from approximately 1,000 cm/hr down to 1 cm/hr with a probable error of about 10 per cent. 1958 - instrument now completed and calibrated.
- 1960 - "Mark 7" instrument for use in lakes completed and calibrated. Water movement into and out of gravel normal to gravel surface measured to depths of 70 feet.
- Assessment : Ability to measure apparent water velocity and oxygen content of water flowing through spawning beds with necessary accuracy is now assured in streams or on lake shores.
- Reports : Measuring the Oxygen Supply to Salmon Redds, W.P. Wickett, and R.A. Pollard. Prog. Repts. Pac. Coast Stns., No. 99, pp. 20-21, 1954. The Oxygen Supply to Salmon Eggs in Spawning Beds, W.P. Wickett. J. Fish. Res. Bd. Canada, 11(6): 933-953, 1954. Measuring Seepage through Salmon Spawning Gravel, R.A. Pollard. J. Fish. Res. Bd. Canada, 12(5): 706-741, 1955. Groundwater Standpipe Mark VI, L.D.B. Terhune. Ms. Biol. Stn., 1956.

June 20, 1957
Revised December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : Survey of Spawning Escapements of Spring Salmon to the Fraser River System.
- Purpose : To observe the present spawning escapements to determine how practical it is to separate red and white stocks by the colour of the flesh in spawned-out fish.
- Duration : 1956, continuing.
- Location : Harrison and South Thompson tributaries of Fraser River.
- In Charge : Dr. D.J. Milne.
- Cooperating Agencies : Department of Fisheries, Pacific Area.
- Personnel : One scientist, one technician.
- Cost : 1956-57 - \$3,000.
1957-58 - 1,000.
- Results : About one-quarter (150,000 fish) of total B.C. spring salmon escapement spawns in the Fraser system. About three-quarters spawn above Hope, of which half spawn in the Thompson system. A large part of these escapements would be influenced by proposed dam construction on the Thompson and Fraser Rivers. Based on the operations of the commercial gill-net fishery there are two distinct runs. Earlier, smaller, red-fleshed fish migrate May to August; later, larger, white-fleshed fish migrate with peak in latter part of September. All spawned-out fish examined were white-fleshed so the two stocks will have to be distinguished from live fish captured during the spawning migration or in the early stages of spawning.
- Assessment : Judging from size of fish, scale characteristics and time of spawning, the fish spawning in the lower Harrison River are white-fleshed while those spawning in most of the tributaries of the Thompson River are red-fleshed. Further studies by tagging and estimating the spawning escapements of both stocks of spring salmon are necessary to provide a basis for management and to evaluate the effect of future changed conditions on these important stocks.
- Reports : Data and summary report on 1956 operations are on file.

June 20, 1957
Revised December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : To Determine the Limits of Tolerance to and Metabolic Demands Imposed by Environmental Stress in Salmon.
- Purpose : To provide an improved understanding of the effects of changes in the environment on viability and normal function of salmon.
- Duration : Indefinite, beginning 1958.
- Location : Biological Station, Nanaimo, B.C.
- In Charge : Dr. G.R. Bell.
- Cooperating Agencies :
- Personnel : One scientist
- Cost : 1957-58 - \$7,000.
1959-60 - 2,000.
1960-61 - 2,000.
- Results : Studies to date have considered the establishment of measurable criteria of the normal fish, including radiographic definition of structure and position of major blood vessels, nerve centers and excretory organs. Work has begun on the cellular haematology of salmon.
- Assessment : Preliminary results indicate that the levels of serum transaminases may be an aid in the diagnosis of tissue injury.
- Reports : Some Radiographic Observations on the Gastrointestinal and Urinary Systems of Anaesthetized Pacific Salmon (*Oncorhynchus*), G.R. Bell, and J.E. Bateman. Can. J. Zool. 38, 199, 1960.

July 10, 1958
Revised December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

Subject : General Description of Behaviour (Ethology) in Pacific Salmon.

Purpose : To define the totality of behaviour from fry to adult on a comparative basis.

Duration : Indefinite, beginning 1958.

Location : Biological Station.

In Charge : C. Groot.

Cooperating Agencies :

Personnel : One scientist, one technician.

Cost : 1959-61 - approximately \$8,000. per year.

Results : A detailed comparative study on the aggressive behaviour of fry and on the spawning behaviour of adults is almost completed and ready for publication.

Assessment : This is one of the several programs instituted to provide fundamental information on salmon biology.

Reports :

July 10, 1958
Revised December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : Ecological Relationships Between Salmon and Their Surroundings.
- Purpose : To provide descriptions of salmon migrations in natural and man-made environments, and to reveal the environmental cues to which salmon respond and orientate.
- Duration : Indefinite - start 1958.
- Location : Initial projects, 1958-62 on Somass River system and east coast creeks, Vancouver Island.
- In Charge : Dr. D.V. Ellis.
- Cooperating Agencies : Department of Fisheries, Pacific Area.
- Personnel : One scientist, one technician, one seasonal.
- Cost : \$12,000. to date.
- Results : New observations and recording techniques have been devised, relying principally on a system of categorizing salmon movements, regularly operating observation posts both above-surface and underwater, and using photographic recording methods.
- A great number of biological phenomena common to animal migration in general have been found operating within salmon migrations. They vary from innate species differences and internal rhythms to instinctive and learned responses to environmental stimuli.
- Assessment : Migration descriptions and analysis of common factors in different migrations provide a factual basis of information which can be drawn upon by biologists and engineers, concerned with predicting and anticipating the effects of industrial water-use developments on salmon migrations.
- Orientation and response studies provide basic information necessary for effective human control of migrations.
- Reports : Diving and Photographic Techniques for Observing and Recording Salmon Activities (In preparation), D.V. Ellis.
Movements of Migrating Adult Salmon over Short Distances (In preparation), D.V. Ellis.
An underwater movie demonstrating salmon activities during migration, has been prepared.

July 10, 1958
Revised December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : Biochemical Changes in Salmon Occurring with Migration and Maturation.
- Purpose : To investigate normal changes, to evaluate the effects of environmental modification on these changes, and to investigate their environmental and hormonal induction.
- Duration : Indefinite, beginning 1958.
- Location : Biological Station, streams of Vancouver Island area.
- In Charge : Dr. W.E. Vanstone.
- Cooperating Agencies : Technological Station, Vancouver; Department of Fisheries, Pacific Area.
- Personnel : Two scientists.
- Cost : 1958-59 - \$2,500.
1959-60 - 2,500.
1960-61 - 2,500.
- Results : Coho plasma proteins, separated by zone electrophoresis, have been investigated from the fingerling to the spawned-out adult. One protein fraction (related to gamma globulin?) increases throughout the period studied; smolt transformation is associated with the temporary disappearance of another protein fraction. A lipoprotein fraction (serum vitellin?) is associated with egg formation. Geographic differences in plasma protein pattern are evident.
- Estradiol monobenzoate injection produces in the maturing male blood changes normally associated with egg formation, while enhancing the normal changes in the maturing female.
- Changes in plasma volume are also associated with migration.
- Assessment : Blood chemistry studies have indicated a potential method of measuring extent of maturation in migrating salmon.
- Reports : Plasma Proteins of Coho Salmon (Oncorhynchus kisutch) as Separated by Zone Electrophoresis, W.E. Vanstone, and F. Ho. J. Fish Res. Bd. Canada, 18(3): 393-399, 1961.
Effects of Estradiol Monobenzoate on Some Serum Constituents in Migrating Sockeye Salmon (Oncorhynchus nerka). J. Fish. Res. Bd. Canada, 18(5): 859-864, 1961. F. Ho, and W.E. Vanstone.

July 10, 1958

Revised December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : To Determine the Natural Conditions that Produce the Maximum Fry Output of Pink and Chum Salmon.
- Purpose : To assess conditions influencing present stocks and to provide data for increasing stocks.
- Duration : Started 1949, continuing.
- Location : Biological Station, Nanaimo, B.C.
- In Charge : W.P. Wickett.
- Cooperating Agencies : Fish Culture Development Branch, Department of Fisheries.
- Personnel : One scientist, two technicians.
- Cost : Approximately \$5,000. per year.
- Results : The maximum fry output is largely set by the permeability of stream gravels. Other environmental factors induce random stresses and fluctuations which normally prevent the maximum being reached. Control of the environment can bring about an increase in the output of a stock as well as increasing the chances of the maximum being reached. Graph of optimum spawning density of pink and chum salmon against mean permeability provided. Drought and flood bring about major reductions in stocks. Temperature restricts the range of the pink stocks. Attention has more recently been directed from pink and chum toward coho salmon.
- Assessment : Data useful in assessing the influence of both deleterious and useful alterations of streams have been gathered.
- Reports : File Reports on Puntledge, Salmon and Wilfred Creeks, W.P. Wickett. Biological Potential of the Qualicum River. Ms. Rept. Series No. 676, 78 pp., 1959.
Damage to the Qualicum River Stream Bed by a Flood. Prog. Rept. No. 113: 16-17, 1959.
Review of Certain Environmental Factors Affecting the Production of Pink and Chum Salmon. J. Fish. Res. Bd. 15(5): 1103-1126, 1958.
Environmental Variability and Reproductive Potentials of Pink Salmon Population in British Columbia. H.R. MacMillan Lecture Series, 1960 (in press).

December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

Subject : Measurement of Water Movement in Lake Spawning Gravel.

Purpose : 1. To locate and measure outflowing water in lake spawning areas.
2. Describe other sources of water movement in lake gravel.

Duration : Started in 1960; now handled by Fish Culture Development Branch, Department of Fisheries.

Location : Great Central Lake, B.C.

In Charge : W.P. Wickett; (see "Duration").

Cooperating Agencies : Fish Culture Development Branch.

Personnel : One scientist, three technicians.

Cost : \$4,000. to date.

Results : Water movement through the gravel of lake spawning sites has been found to be related not only to underwater seepage but also to variations in hydraulic gradient produced by oscillations in lake level (seiches). Water may, therefore, move into as well as out of the gravel in locations examined. Work is at a preliminary stage.

Assessment : It seems possible for eggs to be able to survive anywhere along a permeable lake shore, although the adults may use very restricted areas of the submerged shoreline.

Reports : File Reports 3-4-3-3, No. L1 and L2, 1961, Biological Station, Nanaimo, B.C.

December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : Swimming Studies on Adult Salmon.
- Purpose : To determine the energy demand of swimming at various speeds, and the maximum sustained levels.
- Duration : Started 1960 - continuing.
- Location : Robertson Creek, Alberni, B.C.
- In Charge : J. R. Brett.
- Cooperating Agencies : Technological Station, Vancouver, B.C.
- Personnel : One to two scientists plus two technicians, 3 months/year.
- Cost : \$35,000. to date.
- Results : Maximum sustained swimming speeds for adult sockeye at 65-68°F ranged from 2.7 to 2.9 ft/sec. according to size. Continuous swimming without any form of rest can be maintained at these levels for at least 100 hours. Observation indicates that a speed of 1.5 ft/sec. can be maintained almost indefinitely. High temperatures and fungus infection (Saprolegnia) have hampered progress, but point out that the development of this infection at points of injury can be rapidly lethal in fresh water.
- Assessment : The facilities for these studies are still under development. It will take two to three years to obtain direct energy measures of a conclusive nature.
- Reports : Performance of Adult Sockeye in Robertson Creek Flume in 1960, J.R. Brett. Ms. Rept., Biol. Stn.
Report for 1961 in preparation, J.R. Brett.

December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

Subject : Respiratory Metabolism of Young Salmon.

Purpose : To determine the effects of environmental stress on the metabolic rates of salmon.

Duration : Started 1960 - continuing.

Location : Biological Station, Nanaimo, B.C.

In Charge : J.R. Brett.

Cooperating Agencies : Design assistance: Pacific Naval Laboratory, Esquimalt, B.C.

Personnel : One scientist and one technician.

Cost : \$10,000. to date.

Results : Apparatus has been designed to impose controlled swimming speeds and temperature on young salmon. Preliminary tests indicate that the design is satisfactory. Experimental work has just commenced. 1961 - resting and active rates of respiratory metabolism in young sockeye salmon have been determined for swimming rates up to fatigue levels. Maximum differences are of the order of ten times at 15° and 20°C.

Assessment : This experimental "tool" should provide a great deal of useful basic information on salmon capacities.

Reports : A Proposed Tunnel Design for a Fish Respirometer, John Mar. Tech. Memo. 59-3, P.N.L., Esquimalt, 1959.

December, 1961

FISHERIES RESEARCH BOARD OF CANADA
Pacific Biological Station

- Subject : Orientation and Navigation During Long Distance Migrations in the Pacific Salmon.
- Purpose : To obtain information on general migratory behaviour during long distance migrations, and in particular to ascertain the directing stimuli governing these migrations.
- Duration : Indefinite, beginning 1959.
- Location : Biological Station, Great Central Lake, and Babine Lake.
- In Charge : C. Groot.
- Cooperating Agencies : Part of the program is a joint effort with Dr. W.E. Johnson of this Station.
- Personnel : One scientist, one technician, and one seasonal.
- Cost : 1959-61 - \$2,000. per year.
- Results : Sockeye salmon smolts during their seaward migration show the capacity to orient to celestial phenomena under experimental conditions, thus indicating the presence of a time-compensated orientation mechanism. One of the celestial phenomena used in celestial orientation appears to be the sun; however, significant directional tendencies are maintained during overcast and twilight periods. In general, the directional tendencies shown under experimental conditions show a correlation with the compass direction in which the fish would have to swim to get out of the lake.
- Assessment : Knowledge of the cues or sensory abilities which allow salmon to make directed long-distance migrations should assist in understanding the extent to which environmental alteration might affect migration ability.
- Reports :

December, 1961

**INTERNATIONAL PACIFIC
SALMON FISHERIES COMMISSION**

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Obstruction at Hell's Gate.
- Purpose : To determine the adequacy of sockeye passage at Hell's Gate.
- Duration : 1938 to 1945.
- Location : Fraser River watershed.
- In Charge : Director.
- Cooperating Agencies :
- Personnel : Staff biologists and various field and office assistants.
- Cost : Estimated, \$200,000.
- Results : Tagging of upstream-migrant adult sockeye showed the necessity of correcting the conditions of very difficult fish passage at Hell's Gate. Analysis of historical data indicated that the depletion of the Fraser River sockeye runs was caused largely by the dumping of rock into the Fraser Canyon during railroad construction, started in 1911. Rock dumping at Hell's Gate in 1913 caused a severe block of migrating salmon. It was shown that a delay of 12 days or more at an obstruction is sufficient to prevent sockeye from reaching their spawning grounds and that lesser delays can greatly lower the salmon's reproductive ability.
- Assessment : The investigations provided the basis for construction of the fishways at Hell's Gate and also a great deal of additional information, including information concerning the adverse effect of delay during the upstream migration. The severe depletion of sockeye stocks, as a result of the obstruction at Hell's Gate, caused an estimated loss of revenue to the fishing industry of more than a billion dollars.
- Reports : Effect of the Obstruction at Hell's Gate on the Sockeye Salmon of the Fraser River, by W.F. Thompson, I.P.S.F.C., Bulletin 1, 1945.

July 22, 1958

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Enumeration and Identification of Adult Sockeye and Pink Salmon Populations During Migration in the Fraser River.
- Purpose : To determine the daily numbers and racial identity of the adult sockeye and pink salmon populations migrating upstream in the Fraser River.
- Duration : Started 1939, continuing.
- Location : Fraser River watershed and commercial fishing areas adjacent.
- In Charge : Director.
- Cooperating Agencies : Canada, Dept. of Fisheries, Fisheries Research Board of Canada, Washington State Dept. of Fisheries.
- Personnel : Various numbers of biologists and field and office assistants.
- Cost : Estimated, \$345,000. for enumeration; \$176,000. for identification.
- Results : Methods have been developed for differentiating most of the races of Fraser River sockeye in the commercial fishery. Daily samples of fish are obtained from different sections of the commercial fishery and analyses made of scale ring counts, lengths, and other characteristics. It has been shown that adult sockeye migrate at a fairly uniform rate and that in general the original order is retained during migration over distances as great as 600 miles. The order of spawning is closely related to the order of arrival on the spawning grounds. Spawning ground arrival curves are obtained each year and the spawning populations are enumerated on all of the spawning grounds. Statistical examination of the commercial catch immediately before and after each fishing closure is one means of measuring the periodic amount of the escapement. Test fishing during the closures is a means of verifying the amount of escapement.
- Assessment : Enumeration of the spawning populations and calculation of the daily numbers of sockeye or pinks escaping the commercial fishery are essential for proper management of the Fraser River sockeye and pink salmon fishery. In addition, this information is essential for protecting the resource against the hazards of industrial developments. For instance, if sufficient research had not been conducted, it would not have been possible to justify the specification that dams constructed on the Fraser River would have to provide passage for 750,000 sockeye in one day.
- Reports : See list on reverse side of this page.

July 22, 1958
Revised December, 1961

- Reports** : Effect of the Obstruction at Hell's Gate on the Sockeye Salmon of the Fraser River, by W.F. Thompson, I.P.S.F.C., Bulletin 1, 1945.
- Problems in Enumeration of Populations of Spawning Sockeye Salmon, Part 1, A Study of the Tagging Method in the Enumeration of Sockeye Salmon Populations, by G.F. Howard, and Part 2, A Mathematical Study of Confidence Limits of Salmon Populations Calculated from Sample Tag Ratios, by D.G. Chapman, I.P.S.F.C., Bulletin 11, 1948.
- A Study of the Spawning Populations of Sockeye Salmon in the Harrison River System, with Special Reference to the Problem of Enumeration by Means of Marked Members, by M.B. Schaefer, I.P.S.F.C., Bulletin IV, 1951.
- The Chronological Order of Fraser River Sockeye Salmon During Migration, Spawning and Death, by S.R. Killick, I.P.S.F.C., Bulletin VII, 1955.
- Collection and Interpretation of Sockeye Salmon Scales, by R.I. Clutter and L.E. Whitesel, I.P.S.F.C., Bulletin IX, 1956.
- The Effects of Regulatory Selectivity on the Productivity of Fraser River Sockeye, by Loyd A. Royal, The Canadian Fish Culturist, No. 14, October, 1953.
- Annual Reports, I.P.S.F.C.
- An Examination of Factors Affecting the Abundance of Pink Salmon in the Fraser River, by E.H. Vernon, I.P.S.F.C., Progress Report, 1958.
- Character of the Migration of Pink Salmon to Fraser River Spawning Grounds in 1957, by F.J. Ward, I.P.S.F.C., Bulletin X, 1959.
- A Preliminary Review of Pertinent Past Tagging Investigations on Pink Salmon and Proposal for a Coordinated Research Program for 1959, by Pink Salmon Coordinating Committee, Report No. 1, 1958.
- Second Progress Report on the Coordinated Research Program for 1959, by Pink Salmon Coordinating Committee, 1960.
- Third Progress Report on the Coordinated Research Program in 1959, by Pink Salmon Coordinating Committee, 1960.
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INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

Subject : Fishladder Hydraulic Design

Purpose : To develop adequate hydraulic designs for fishladders.

Duration : 1943 to 1953

Location : University of British Columbia and University of Washington.

In Charge : Milo C. Bell.

Cooperating Agencies : University of British Columbia and University of Washington

Personnel : Various numbers of engineers, consultants and assistants.

Cost : \$100,000, including experimental work on models of Hell's Gate.

Results : Hydraulic model studies were made to study the effects of variables in the hydraulic design of fishways (weir and vertical slot) and diffusion chambers for fishways. The relationships between head, discharge, pool size, crest differential, flow pattern, energy dissipation, etc. were studied.

Assessment : Early investigations of the hydraulic design of fishladders were conducted with specific reference to natural obstructions to the passage of Fraser River sockeye, such as Hell's Gate, Bridge River Rapids, and Farwell Canyon. In later years, the work was extended to include a study of small vertical-slot and weir fishladders for possible use at small dams.

Reports : Unpublished data.

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Effectiveness of Hell's Gate Fishways
- Purpose : To measure the adequacy of the Hell's Gate fishways.
- Duration : 1945 to 1950.
- Location : Fraser River watershed.
- In Charge : Director.
- Cooperating Agencies : None.
- Personnel : Biologist and various numbers of field assistants.
- Cost : Estimated, \$40,000.
- Results : It was shown by means of tagging analyses, that the fishways enabled sockeye salmon to negotiate the Hell's Gate reach as easily as at non-block levels.
- Assessment : Through its activities in removing the Hell's Gate obstruction and other minor obstructions, the Commission has made the Fraser River system as accessible to sockeye salmon as at any time in its history. The sockeye runs have increased tremendously in recent years and it is expected that these runs will reach historical levels of abundance in a very few cycles. The wholesale value of the increase in the sockeye pack in the cycle 1952 to 1955 over the parent cycle years 1948 to 1951, was \$31,633,362. The significant increases in the commercial catch in recent years and the realization that the historical levels of abundance can be reached in the not-too-distant future are important deterrents to damming of the Fraser River.
- Reports : A biological Study of the Effectiveness of the Hell's Gate Fishways, by G.B. Talbot, I.P.S.F.C., Bulletin III, Part I, 1950.

July 22, 1958.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Flow Pattern at Hell's Gate
- Purpose : To study variations in flow pattern at Hell's Gate in relation to the migrations of sockeye salmon.
- Duration : 1945 to 1950.
- Location : Hell's Gate and office analysis of data.
- In Charge : R.I. Jackson.
- Cooperating Agencies : None.
- Personnel : Engineer and various numbers of field assistants.
- Cost : \$20,000.
- Results : Studies showed that the water slopes through the Hell's Gate reach were much greater during water levels at which sockeye were blocked than during passable stages. At all river stages that were found by tagging analysis to block the passage of adult sockeye, the average of the maximum water slopes was about 0.37. The average of all maximum slopes at stages designated by tagging analysis as passable was less than 0.04. The relationship between passability and slope corroborated without exception the conclusions reached by the biological studies of the passage of sockeye at Hell's Gate.
- Assessment : Apart from the information given concerning water slopes and sockeye passage, the report on this study is valuable in that it presents the complete history of the blockade of Hell's Gate.
- Reports : Variations in Flow Pattern at Hell's Gate and Their Relationships to the Migration of Sockeye Salmon, by R.I. Jackson, I.P.S.F.C., Bulletin III, Part 2, 1950.

July 22, 1958.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Effect of Water Temperatures on Survival of Sockeye Salmon During Adult Migration, Spawning, Incubation of Eggs and Emergence of Fry.
- Purpose : To determine environmental limitations with respect to water temperature and the effect of variations in that environment on survival.
- Duration : 1945, continuing.
- Location : Fraser River watershed.
- In Charge : Formerly, J.A.R. Hamilton - now P. Gilhousen.
- Cooperating Agencies : None.
- Personnel : Biologist and various numbers of field, office and laboratory assistants.
- Cost : \$75,000.
- Results : Temperatures in excess of 68°F during the adult migration appear to have an adverse effect on survival and temperatures in excess of 60°F during spawning seriously interfere with normal egg deposition. A temperature of 50°F is considered optimum for spawning, with 48° and 55° being the preferred temperature limits. The upper temperature limit for newly-spawned eggs is about 60°F. Tests indicate that in order to survive, the eggs must reach a certain, but as yet undefined, stage of development before the onset of the winter cold water period.
- Assessment : In order to safeguard the Fraser River sockeye salmon against artificial changes in the environment through industrial development, it is essential that a great deal of research be conducted to determine the effect of water temperature on fresh-water survival since temperature is one physical factor recognized to be of great importance to reproduction, development, and physiological activity.
- Reports : Brief Review of Temperature Study, by J.A.R. Hamilton, I.P.S.F.C., unpublished manuscript, 1956.
- Also other unpublished data.

July 22, 1958.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Temperatures During Migration, Spawning, and Incubation
- Purpose : To obtain a continuing record of existing water temperatures on the migration routes and spawning grounds of Fraser River sockeye.
- Duration : 1945, continuing.
- Location : Fraser River watershed.
- In Charge : Formerly J.A.R. Hamilton, now P. Gilhousen.
- Cooperating Agencies : None.
- Personnel : One biologist, office assistant and various field assistants.
- Cost : Estimated, \$80,000.
- Results : During the spawning period, daily temperatures are measured by means of recording thermometers on nearly all of the sockeye spawning grounds. Daily temperatures are also measured on the major migration routes, particularly those that have been or may be affected by water use projects. An attempt is also being made to utilize existing records of air temperature and also tree ring counts for estimating past water temperatures in order to determine possible long term changes in environment and provide insight into historical variations in production. A study conducted in 1956 showed that in any cross-section of a spawning stream, the average daily temperature at the depth sockeye eggs are deposited is the same as the average daily temperature of the flowing stream.
- Assessment : A precise knowledge of water temperatures is essential for measuring the tolerance limits in spawning and egg incubation for obtaining the maximum production, and for determining the possible adverse effects of hydroelectric and other multiple water use projects.
- Reports : Report on the Fisheries Problems Created by The Development of Power in the Nechako-Kemano-Manika River System; Canada Department of Fisheries, Fisheries Research Board of Canada and I.P.S.F.C., 1951, (Mimeographed)
- Supplement Number 1 to above Report, Temperature Changes in the Nechako River and their Effects on the Salmon Populations; Canada Department of Fisheries, I.P.S.F.C., 1952, (Mimeographed)
- Also unpublished data.

July 22, 1958.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Irrigation Diversions
- Purpose : To determine the effect of irrigation diversions on sockeye salmon production and to recommend remedial measures.
- Duration : Started 1946, continuing.
- Location : Fraser River watershed.
- In Charge : Formerly, Milo C. Bell and R.I. Jackson; now, A.C. Cooper.
- Cooperating Agencies : Canada, Department of Fisheries.
- Personnel : Engineer, biologist and field and office assistants, part-time.
- Cost : \$10,000, estimated.
- Results : Some diversions surveyed have been found to have no adverse effect on sockeye production but a serious problem exists in the Salmon River near Salmon Arm, where the residual flow at the lower end of the river is hardly sufficient for salmon migration and spawning, and there is no provision for a certain minimum residual flow.
- Assessment : A serious problem exists in British Columbia with respect to multiple water use in that the present policy of the Water Rights Branch is not to stipulate maximum diversion rates for irrigation users but only the total quantity of diversion allowable annually under each licence. Thus, the needs for fisheries are not given adequate consideration. In the case of the Salmon River, a partial solution has been obtained in that the Comptroller has agreed to appoint a Bailiff to restrict irrigation use whenever it can be shown that the residual flow in the Salmon River is not sufficient for maintaining the fisheries resource.
- Reports : The Problem of Restoration of Salmon in the Salmon River, Canada Department of Fisheries, I.P.S.F.C. unpublished manuscript, 1954, (Mimeographed).

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Spawning Ground Criteria
- Purpose : To measure the physical conditions of natural streams used by sockeye salmon for spawning and the relationship of these conditions to survival of sockeye eggs and alevins.
- Duration : 1946 to 1956, and continuing.
- Location : Chilko River, Adams River, Stellako River, Horsefly River, Weaver Creek, New Westminster and U.B.C. Laboratories.
- In Charge : Formerly R.I. Jackson - now, J. Pyper.
- Cooperating Agencies : None.
- Personnel : Engineer and field and laboratory assistants.
- Cost : \$ 25,000.
- Results : Data on depths, stream velocities, gravel velocities, gravel composition, discharges, slopes, cross-sections, and areas of the major stream spawning grounds of the Fraser system are being collected and analyzed. An instrument has been developed for measurement of water flow through spawning beds and the concentration of dissolved oxygen in the water. The mechanics of flow of water through gravel beds have been studied qualitatively. Since sockeye tend to select the most favorable spawning areas, studies of density and distribution of spawners in different areas form an important part of this work.
- Assessment : Surveys of the physical conditions on the spawning grounds are nearing completion, but further work is planned in measuring the rate of water flow through spawning beds and in studying the construction of redds. This information is useful in assessing the effects of proposed water use projects on spawning ground conditions and in designing artificial spawning channels.
- Reports : Unpublished data.

July 22, 1958.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

Subject : Flood Control Potentialities in the Fraser River Watershed

Purpose : To study the feasibility of various flood control developments on salmon and non-salmon producing streams of the Fraser River watershed.

Duration : Started 1948, continuing.

Location : Office analysis of data.

In Charge : A.C. Cooper, M.C. Bell.

Cooperating Agencies : None.

Personnel : One engineer and various office assistants, part-time.

Cost : \$4,000.

Results : Studies of the engineering and economic feasibility of various proposals for controlling floods in the Fraser Valley and localized areas upstream are made in order to determine, investigate and provide alternates for those that would have a major adverse effect on sockeye and pink salmon production. Flood control proposals for Harrison, Shuswap, Quesnel and Stuart Lakes were considered unacceptable from the fisheries standpoint, whereas proposals for the Clearwater and the North Fork of the Quesnel Rivers would have less adverse effect. Flood control proposals in the upper Fraser above Prince George are also being considered.

Assessment : Most, if not all, of the flood control proposals on the Fraser watershed would have an adverse effect on salmon production but some proposals would have a much more serious effect than others. Studying the various proposals and possible alternates is essential for maximum protection of the fishery.

Reports : Unpublished data.

July 22, 1958.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

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- Subject : Hydroelectric Development in the Chilko River Watershed
- Purpose : To study the feasibility of maintaining production of sockeye salmon in the Chilko River watershed relative to proposed hydroelectric development.
- Duration : 1948 to 1950, and continuing.
- Location : Field observations at Chilko and office analysis of data.
- In Charge : Formerly, Milo C. Bell and R.I. Jackson - now, A.C. Cooper.
- Cooperating Agencies : Canada, Department of Fisheries.
- Personnel : Engineer, biologist, consulting engineer and office assistants.
- Cost : \$10,000, estimated direct expense. Supplementary data obtained from other investigations.
- Results : In two consecutive years out of each four, the Chilko River now originates about three-quarters of the catch of sockeye salmon from the entire Fraser River system. All of the various plans for using Chilko Lake for the development of hydroelectric power would have a very serious effect on sockeye production. It has been concluded that the continuance of the existing Chilko sockeye fishery requires that there be no interruption, addition, diversion, or obstruction to either the natural inflow or the natural outflow of Chilko Lake or Chilko River. The following problems are involved: fry migration up Chilko River and over the proposed dam at the outlet of Chilko Lake, migration of adults in the reduced flow in the Chilcotin and Chilko Rivers, migration of adults over the proposed dam into Chilko Lake for maturation and their return downstream over the dam for spawning in Chilko River; environmental conditions for spawning and incubation of eggs in the reduced flow on the spawning grounds, withdrawal of migrants from the lake through the power diversion or false attraction of migrants to a submerged power outlet at the upstream end of the lake, and diversion of non-productive silt-laden water from Taseko Lake into Chilko Lake.
- Assessment : The B.C. Power Commission is now reconsidering its proposal for using Chilko Lake for power development in view of a recent submission of biological and engineering data by the Department of Fisheries and the Salmon Commission. A large amount of power can be produced without interfering with the valuable fishery resource in Chilko Lake and River. Recent studies have indicated the feasibility of diverting water from Taseko Lake to the coast by means of a submerged pipeline across Chilko Lake, thus allowing half the hydro development while preserving Chilko in its natural state for sockeye production. This would allow development of the power potential of the Homathko River in stages. Another alternate consists of diverting the Taseko to the Southgate, by-passing Chilko Lake by means of a tunnel around the south end of the lake.
- Reports : Interim Report on the Chilko River Watershed, 1949, (published). Also unpublished memorandum reports and other data.

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

Subject : Hydroelectric Potentialities in the Fraser River Watershed

Purpose : To study the feasibility of various proposed power developments on salmon and non-salmon producing streams of the Fraser River watershed.

Duration : Started 1948, continuing.

Location : Office analysis of data.

In Charge : A.C. Cooper.

Cooperating Agencies : None.

Personnel : One engineer and various office assistants, part-time.

Cost : \$10,000. exclusive of Chilko and Nechako studies, reported elsewhere.

Results : In order to better understand the relative value of proposed hydroelectric developments on major rivers of the Fraser River watershed, independent studies are made of the engineering and economic feasibility of possible developments on salmon and non-salmon producing streams. Major sites have been studied that include various sites on the main stem of the Fraser River, and Quesnel, Adams, Stuart, Shuswap, Chilliwack, Chehalis and Lillooet Rivers. Many possible alternate developments on non-salmon streams, including the Cariboo and Clearwater Rivers, have also been studied.

Assessment : A continuing study of proposed power developments on salmon streams and alternate developments on non-salmon streams is essential in order to provide maximum protection and extension of the salmon stocks.

Reports : Unpublished data.

July 22, 1958.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Sockeye Salmon Productivity.
- Purpose : To measure the various survival rates under natural conditions during the different phases of the life history of Fraser River sockeye salmon.
- Duration : Started 1948, continuing.
- Location : Chilko Lake, Cultus Lake.
- In Charge : J. Weir.
- Cooperating Agencies :
- Personnel : Varies from year to year.
- Cost : Estimated, \$120,000.
- Results : Continuing data are being accumulated to show the natural survival rates of the species. At Chilko Lake, there is a variability in the survival from eggs to fry from 5 to 13 per cent, but a consistent survival rate from fry to yearling migrants of about 50 per cent. Survival from eggs deposited to returning adults is about 0.3 per cent. At Cultus Lake, the survival from eggs to yearlings varies from 1 to 5 per cent.
- Assessment : Continuing data are being accumulated to determine variations in the natural rates of survival during the different phases of the life cycle of the sockeye salmon. The results are valuable, not only in maintenance and rehabilitation, but also in assessing the possible adverse effects of industrial development.
- Reports : Unpublished data.

July 22, 1958

Revised December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Transplantation of Sockeye Salmon Populations.
- Purpose : To rehabilitate sockeye salmon to barren or near-barren areas.
- Duration : Started 1948, continuing.
- Location : Upper Adams River, Salmon River, Barrier River, Portage Creek, Creek X (Nadina River), Middle Shuswap River.
- In Charge : Formerly J. D. Remington, now R. Stewart.
- Cooperating Agencies :
- Personnel : Biologist and about three field assistants.
- Cost : Cost was very high during the early stages when a hatchery was built and operated in the Quesnel area but in recent years the cost has been about \$10,000. annually. Estimated total expenditure, \$165,000.
- Results : Releases of hatchery-reared fingerlings have failed to provide any adult returns except that Horsefly River stock reared and released in the Horsefly drainage did return to the hatchery. Any attempt to advance the growth of hatchery-reared kokanee to stimulate their seaward migration also failed to provide adult returns. The only method that has been found satisfactory consists of transplanting fertilized eggs to an area having a temperature cycle and migration distance compatible with that of the donor stream.
- Assessment : Every effort is being made to rehabilitate sockeye runs in barren or near-barren areas. In view of the stringent requirements for successful transplantation there seems no possibility that major runs affected by industrial development could be compensated for by transplantation to other areas.
- Reports : Annual Reports, I.P.S.F.C.

July 22, 1958
Revised December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Lake Productivity.
- Purpose : To assess the productivity of lakes in the Fraser River watershed for rearing sockeye salmon and to determine the limnological factors limiting or controlling productivity.
- Duration : Started 1949, continuing.
- Location : Fraser River watershed.
- In Charge : J. Goodman.
- Cooperating Agencies :
- Personnel : Various numbers of biologists, engineers, and field and office assistants.
- Cost : \$30,000.
- Results : The bottom contours of all of the known and potential sockeye producing lakes of the Fraser system have been surveyed. Studies of plankton production, distribution of fry and fingerlings and studies of kokanee and trout populations have been underway for several years. A knowledge of the freshwater growth of sockeye can be obtained from measurements of the nuclear area of the scale. A relationship between numbers of fish and available food supply is established and in addition a measure of the spatial distributions of feeding fish in the large lake-rearing areas is made possible. Annual predator abundance, possible cyclical occurrence of parasites or competitors, and effect of each annual population of sockeye on the freshwater food supply are being continuously studied in an effort to find the cause or causes of the quadrennial cycle in productivity.
- Assessment : This study must necessarily be conducted over a period of many years. The information is very valuable in studying the feasibility of increasing the productivity of sockeye salmon and of bringing additional lakes, such as Horsefly Lake, into production. In addition, it is essential in studies of the possible adverse effects of industrial developments and water diversions, such as the proposal to divert part of the Columbia River into Shuswap Lake. Available information indicates that this diversion would have a serious adverse effect on the productivity of Shuswap Lake.
- Reports : Seasonal and Annual Changes in Availability of the Adult Crustacean Plankters of Shuswap Lake, by F.J. Ward, I.P.S.F.C., Progress Report, 1957.

July 22, 1958

Revised December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Hydroelectric Development on the Nechako River
- Purpose : To assess sockeye conservation problems relative to the Alcan hydro development in the Nechako River System and to recommend remedial measures.
- Duration : 1949, continuing.
- Location : Field studies in Nechako River and tributaries, plus analysis of data in office.
- In Charge : Formerly Milo C. Bell and R.I. Jackson, now A.C. Cooper.
- Cooperating Agencies : Canada Department of Fisheries and Fisheries Research Board of Canada.
- Personnel : Engineers, biologists, and various numbers of field and office assistants.
- Cost : \$30,000, estimated direct expense.
- Results : Calculations indicated that protection of the salmon resource would require consideration of discharge, depth, and velocities in the residual river below Kenney Dam and that in order to maintain a water temperature of less than 68°F during the migration period, cold water should be released into the Nechako River from the reservoir at a depth of 200 feet or more.
- Assessment : No agreement could be reached with the Company for the release of water for temperature control and a serious problem therefore exists in the Nechako River which requires continuing study.
- Reports : Report on the Fisheries Problems Created by the Development of Power in the Nechako-Kemano-Nanika River Systems; Canada Department of Fisheries, Fisheries Research Board of Canada, and I.P.S.F.C., 1951, (Mimeographed).
- Supplement Number 1 to above report, Temperature Changes in the Nechako River and Their Effects on the Salmon Populations; Canada Department of Fisheries, I.P.S.F.C., 1952, (Mimeographed).
- A Review of the Sockeye Salmon Problems Created by the Alcan Project in the Nechako River Watershed, I.P.S.F.C., 1953, (published).
- Also unpublished temperature data.

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Hydraulic Studies of Flat and Cylindrical Wire Screens
- Purpose : To determine the hydraulic characteristics of wire screens for application in screening migrant salmon from water diversions.
- Duration : 1949 - 1950.
- Location : Hydraulics Laboratory, University of British Columbia.
- In Charge : F.J. Andrew, with Professor E.S. Pretious as consultant.
- Cooperating Agencies : University of British Columbia.
- Personnel : Engineer and one technician.
- Cost : \$5,000, estimated.
- Results : Head-discharge relationships for eight different mesh sizes of screen were obtained at a number of angles of inclination to flow for flat plate screens and for drum screens.
- Assessment : This study formed the first phase of an investigation of mechanical fish screens.
- Reports : Head-Discharge Relationships for Wire Screens in Plane and Cylindrical Forms, by F.J. Andrew. Unpublished manuscript, 1951 (typed).

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Mortalities to Downstream-Migrant Salmon at Baker Dam
- Purpose : To measure the mortality rates of downstream-migrant sockeye and coho passing over the spillway and through the turbines at Baker Dam.
- Duration : 1950 - 1954.
- Location : Baker Dam, on Baker River, tributary to the Skagit River, near Concrete, Washington.
- In Charge : J.A.R. Hamilton and F.J. Andrew.
- Cooperating Agencies : Washington State Department of Fisheries.
Canada Department of Fisheries.
- Personnel : Biologist, engineer, and up to 12 field assistants.
- Cost : \$40,000, estimated.
- Results : Over 95 per cent of the migrants leaving Baker Dam reservoir used the spillway and less than 5 per cent used the turbine outlet, which was submerged 85 feet at full reservoir. Sixty-four per cent of native sockeye and 54 per cent of native coho were killed in passing over the 250-foot high spillway with one gate open, and 34 per cent of sockeye and 29 per cent of coho were killed in passing through the turbines at full-load conditions. These data obtained by sampling the migrating populations with fyke nets, were supported by data showing that sockeye, marked as downstream migrants and released over the spillway and through the turbines, upon return as adults had experienced a spillway mortality of 63 per cent and a turbine mortality of 37 per cent. Much of the injury and mortality to the yearling salmon was caused by abrasion on the spillway and pressure changes and cavitation in the spillway and turbines.
- Assessment : This was the first study that conclusively showed that downstream migrants suffer a very high mortality rate in passage over high dams.
- Reports : An Investigation of the Effect of Baker Dam on Downstream Migrant Salmon by J.A.R. Hamilton and F.J. Andrew, Bulletin VI, I.P.S.F.C., 1954 (published).

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

Subject : Preliminary Study of Methods of Guiding Sockeye Smolts

Purpose : To make a preliminary study of methods that might be effective for guiding sockeye smolts away from hazardous areas at dams.

Duration : Spring, 1952.

Location : Cultus Lake.

In Charge : A.C. Cooper.

Cooperating Agencies : None.

Personnel : Two men.

Cost : \$2,000, estimated.

Results : No completely successful method of leading fish to an opening was found. Lights provided a definite attraction to migrants at night but not all of the migrants used the lighted path. Low-frequency metallic noises, rapidly moving objects in the water, and white flash boards repelled the fish. Low amplitude, high frequency sound waves had no noticeable effect on the migrants.

Assessment : Results from this study provided the basis for more comprehensive studies at Cultus Lake in 1953.

Reports : Downstream Migrant Study - Cultus Lake, 1952. Unpublished manuscript, (typed).

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject** : Relative Efficiencies of Various Stimuli for Guiding Downstream-Migrant Sockeye.
- Purpose** : To make a comparative study of the effectiveness of various stimuli that might be useful for guiding or deflecting sockeye smolts away from hazardous areas at dams.
- Duration** : Spring, 1953.
- Location** : Cultus Lake.
- In Charge** : F.J. Andrew.
- Cooperating Agencies** : None.
- Personnel** : Biologist, engineer and three assistants.
- Cost** : \$10,000, estimated.
- Results** : Comparative tests showed that a veil of rising air bubbles attracted fish during daylight but repelled them during darkness. Illumination of the bubble wall during darkness increased the efficiency of repulsion. The variable results obtained indicated that a veil of rising air bubbles would probably not be very effective for guiding downstream-migrant sockeye at a large dam. Lights located above the water surface also gave variable results in guiding the fish but a significant attraction of the fish was obtained when subsurface spotlights were used. A shaded or protective passageway was partially effective in attracting fish during daylight. High-frequency sound waves were again found to be completely ineffective. An electric fish screen was developed that gave much more effective guiding than any of the other stimuli tested.
- Assessment** : Since the electric screen developed in this study was much more effective than any of the other stimuli tested, a more comprehensive investigation of this electric screen was conducted at Cultus Lake in 1954.
- Reports** : An Investigation of the Problem of Guiding Downstream-Migrant Salmon at Dams, by F.J. Andrew, L.R. Kersey, and P.C. Johnson. I.P.S.F.C. Bulletin VIII, (published).

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Mortalities to Downstream-Migrant Sockeye at Ruskin Dam
- Purpose : To measure the mortality rate suffered by downstream-migrant sockeye passing through a turbine at Ruskin Dam.
- Duration : 1953.
- Location : Ruskin Dam, on the Stave River, near Mission.
- In Charge : R.I. Jackson.
- Cooperating Agencies : Canada, Department of Fisheries.
Washington State Department of Fisheries.
- Personnel : Three engineers, biologist, and four field assistants.
- Cost : \$10,000, estimated.
- Results : Mortalities to hatchery-reared sockeye passing through this Francis turbine under a head of 130 feet were estimated to be 10 per cent at full load.
- Assessment : This test was conducted in order to obtain an estimate of the mortality rate to be expected in the turbine that was to be installed in the hydro electric installation at Seton Creek, near Lillooet. The turbine proposed for installation at Seton was almost identical to that tested at Ruskin. Since the measured mortality rate was very low, methods of preventing fish from entering the proposed Seton turbine were considered unnecessary. However, an agreement was made with the B.C. Electric to the effect that the actual mortality rate would be measured at Seton after the plant was in operation and the need for protective facilities at the dam would be reconsidered at that time.
- Reports : A Study of Mortality Rates in a Turbine at Ruskin Dam by J.A.R. Hamilton and F.J. Andrew, 1954. Unpublished manuscript (typed).

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Design of Fish Facilities for Seton Dam
- Purpose : To devise facilities for the passage of adult salmon over the proposed Seton Creek Dam and for the transportation of salmon up to the dam, and to develop means of providing suitable hydraulic conditions in the tailwater pool of the dam.
- Duration : 1953.
- Location : Hydraulic Laboratory, University of British Columbia.
- In Charge : R.I. Jackson.
- Cooperating Agencies : Canada, Department of Fisheries and B.C. Electric Company.
- Personnel : Two engineers, Professor E.S. Pretious as liaison with the University of British Columbia where the work was done, and carpenters and other skilled workers from the University.
- Cost : \$3,000, estimated.
- Results : Determined the layout of fish facilities and auxiliary water supply at the Seton Creek Dam.
- Assessment : Observations of fish passage in 1956 (see summary) indicated that the fish facilities, as designed by means of these hydraulic model studies, were adequate for the safe upstream passage of adult sockeye salmon.
- Reports : Report on Model Studies of Proposed Fish Protective Facilities for Seton Creek Dam, by A.C. Cooper and W.E. Borecky, 1953. Unpublished manuscript (typed).

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Artificial Spawning Area at Horsefly.
- Purpose : To determine the feasibility of producing sockeye salmon in Horsefly Lake, by the use of an artificial spawning area for incubating the eggs and to further investigate the effects of gravel type and rate of flow on fry production.
- Duration : Started 1953, concluded 1959.
- Location : Quesnel Field Station, Horsefly Lake.
- In Charge : Formerly J.A.R. Hamilton and J. Pyper; now J. Remington and J. Pyper.
- Cooperating Agencies :
- Personnel : Biologist, engineer and two assistants, and construction and maintenance forces.
- Cost : \$60,000. estimated.
- Results : Since Horsefly Lake does not have a natural spawning area adjacent to it, an artificial spawning area is required before this lake can be utilized as a sockeye producer. Experiments indicated that high egg survival could be obtained by pumping water from the lake and introducing it into an improved gravel bed by means of perforated plastic pipes so that the water would disperse and percolate up through the gravel. The survival rate from eggs to fry has been about 60 per cent, as compared to about 10 per cent in natural streams but for reasons that are not understood at the present time, the production of smolts from the lake has been unsatisfactory.
- Assessment : Although no success has been obtained in producing a seaward migration of yearling sockeyes from Horsefly Lake, valuable information has been gained concerning artificial spawning areas. Physical factors of Horsefly Lake itself and the effect of prevailing uplake winds on surface currents are believed to be the causes of the failure of the smolts to migrate rather than biological conditions in the lake.
- Reports : Unpublished data.

July 1, 1957

Revised December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Transplantation of Adult Sockeye Salmon
- Purpose : To determine the feasibility of establishing sockeye runs in barren areas by transplanting adult spawners.
- Duration : 1953 to 1957.
- Location : Horsefly Lake artificial spawning area and Upper Horsefly River.
- In Charge : J.D. Remington.
- Cooperating Agencies : None.
- Personnel : Biologist and up to four assistants, exclusive of experiments at Horsefly artificial spawning area, reported separately.
- Cost : \$ 1,000 in 1957, exclusive of experiments at Horsefly artificial spawning area.
- Results : Attempts to establish a sockeye run in the Horsefly River above the normal spawning area by introduction of adult spawners failed completely. All or nearly all of the 1002 live fish transported from below Horsefly Falls to the Upper Horsefly River migrated downstream over the falls to return to their normal spawning area despite the existence of the same temperature cycle and apparently excellent spawning gravel in the upper river. The same stock of fish, when transported to Horsefly Lake, spawned successfully in an artificial spawning area but in this case they were held in an enclosure surrounding the spawning area; they were not required to migrate upstream from their point of release. Even in this case, however, egg retention after spawning was higher than under natural conditions.
- Assessment : These experiments have suggested some of the apparently insurmountable problems that would be involved in attempting to transplant a major sockeye population from their natural spawning area to another area if the former was destroyed by a hydroelectric or other water-use development.
- Reports : Unpublished Reports.

July 22, 1958.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Electric Screens for Adult Salmon
- Purpose : To investigate the feasibility of electric screens for keeping adult salmon away from hazardous areas such as at dams and for guiding them to by-passes.
- Duration : Fall, 1953.
- Location : Sweltzer Creek, Cultus Lake.
- In Charge : F.J. Andrew.
- Cooperating Agencies : None.
- Personnel : Engineer, biologist, and four men.
- Cost : \$6,000, estimated.
- Results : The electric screens tested consisted of two parallel rows of 1-inch diameter vertical electrodes energized with direct, interrupted direct, 60-cycle alternating and half- and full-wave rectified alternating current. These electric screens were effective in stopping the fish provided the electrical stimuli caused a sufficient impairment of the fishes' swimming ability and the water velocity exceeded 2.0 feet per second. In lower water velocities, some fish were killed when they became immobilized and settled to the bottom in the electrified area. A distinct disadvantage of the electric screens tested was that fish made repeated efforts to penetrate the electrified zone rather than lead along it to a by-pass. The fish also seemed to become fatigued after repeated electrical exposures.
- Assessment : The results did not indicate that electric screens would be effective in guiding adult salmon at dams, but that they might be effective in certain applications where it was required only to stop the upstream migration. Before electric screens can be considered satisfactory for practical use, the biological effects of electrical stimulation must be thoroughly examined.
- Reports : Electric Screens for Adult Salmon, by F.J. Andrew, P.C. Johnson and L.R. Kersey. I.P.S.F.C. Progress Report, 1956, (mimeo.).

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Effect of Electrical Exposure of Adult Sockeye on Survival of Eggs.
- Purpose : To determine if the electrical exposure suffered by adult sockeye salmon in the experimental electric screens used at Cultus Lake would have an adverse effect on the survival of the eggs and sperm.
- Duration : 1953 - 1954.
- Location : Sweltzer Creek, Cultus Lake.
- In Charge : P.C. Johnson.
- Cooperating Agencies : B.C. Game Commission.
- Personnel : Biologist, engineer, and three assistants.
- Cost : \$5,000, estimated.
- Results : The intensity of electrical stimulation used in these tests did not appear to have an adverse effect on egg survival nor was the proportion of abnormal fry increased. It was noted, however, that adult salmon appeared to become fatigued after electrical exposure and this might have an adverse effect on their ability to reach the spawning grounds and to spawn successfully.
- Assessment : Before electric screens can be considered satisfactory for practical use with adult salmon, the biological effects of electrical exposure must be examined more thoroughly than was possible in this experiment.
- Reports : To be prepared.

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Factors Influencing Efficiency of Electric Fish Screens for Downstream-Migrant Sockeye Salmon.
- Purpose : To make further improvements in the guiding efficiency of the type of electric screen developed in 1953 and to investigate the effect of various electrical stimuli and electrode arrangements.
- Duration : Spring, 1954.
- Location : Sweltzer Creek, Cultus Lake.
- In Charge : F. J. Andrew.
- Cooperating Agencies : None.
- Personnel : Biologist, engineer and three assistants.
- Cost : \$10,000, estimated.
- Results : The stimuli tested included direct current, interrupted direct current, rectified 60-cycle alternating current, rectified 400-cycle alternating current, interrupted rectified alternating current, and condenser discharge impulses and it was found that direct current and interrupted direct current gave the highest guiding efficiencies. One of the most effective electrode arrangements consisted of using two parallel rows of vertical rod electrodes, one inch or smaller in diameter, with a 24-inch space between rows and a 12-inch space between electrodes in each of the two rows. In the relatively small-scale tests that could be conducted in Sweltzer Creek, the type of electric screen developed in these experiments was over 90 per cent effective in guiding sockeye smolts.
- Assessment : In view of the success obtained with electric screens in these small-scale experiments, a test was conducted under prototype conditions at Baker Dam and it was found that the type of electric screen used was almost completely ineffective.
- Reports : An Investigation of the Problem of Guiding Downstream-Migrant Salmon at Dams, by F.J. Andrew, L.R. Kersey, P.C. Johnson. I.P.S.F.C., Bulletin VIII, 1955, (published).

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Survival of Yearling Sockeye Salmon After Electrical Exposure
- Purpose : To investigate the immediate and latent effects of electrical exposure on yearling sockeye salmon.
- Duration : 1954 to 1957.
- Location : Sweltzer Creek, Cultus Lake.
- In Charge : P.C. Johnson.
- Cooperating Agencies : B.C. Game Commission.
- Personnel : Biologist, engineer, and five assistants.
- Cost : \$10,000, estimated.
- Results : Exposure to the intensity of electrical stimuli used in the electric screens at Cultus Lake and Baker Dam can result in immediate mortality to some fish but under proper conditions this immediate mortality can be reduced to a negligible proportion. Fish held for 30 days after exposure did not show any adverse effects. Yearlings marked and released after exposure showed the same survival rate to the adult stage as fish that had not been exposed to electrical stimuli. There appeared to be no significant difference in the growth rate of the two groups. Some of the adults that had been exposed and marked as yearlings were artificially spawned to determine whether the reproductive ability of exposed fish was affected. This latter phase of the experiment has not been completed but preliminary results do not indicate any adverse effect of exposure.
- Assessment : All available information indicates that the growth and survival of yearling sockeye are not adversely affected by the intensity of electrical stimulation used in electric screens provided the electric screens are properly designed.
- Reports : To be prepared.

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

Subject : Laboratory Study of Survival of Sockeye Eggs and Alevins in Spawning Gravel.

Purpose : To determine the factors affecting survival of eggs and alevins in gravel.

Duration : 1954, concluded 1957.

Location : Laboratory, New Westminster and University of British Columbia.

In Charge : J. Pyper.

Cooperating Agencies : University of British Columbia.

Personnel : Engineer and one assistant part time.

Cost : \$10,000:

Results : In connection with the problems of obtaining maximum fry production from natural spawning areas and of developing artificial spawning areas, the survival rate of eggs and alevins was measured in natural and "improved" gravels under various flow conditions. Survival was shown to be directly related to the rate of percolation of water through the gravel which, in turn, was related to the head or slope and the composition or permeability of the gravel. Survivals were also measured for various gradations of gravel and depth of cover over the eggs and for various placements and concentrations of eggs within the redd.

Assessment : The physical factors affecting survival of eggs and alevins under controlled conditions are now fairly well defined but the reasons for the much higher survival in artificial hatching conditions than in natural streams are not completely understood.

Reports : Unpublished data.

July 22, 1958
Revised December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Silt Deposition on Spawning Grounds.
- Purpose : To investigate the effect on egg survival of depositions of silt such as from placer mining operations.
- Duration : 1954, concluded 1959.
- Location : Horsefly River and laboratory in New Westminster.
- In Charge : A. C. Cooper.
- Cooperating Agencies :
- Personnel : Two engineers and one assistant.
- Cost : \$5,000. estimated.
- Results : Depositions of sediments on sockeye spawning grounds can reduce the survival rate of eggs and alevins being reared in the gravel. The reduction in survival is in proportion to the reduction of flow through the gravel, which in turn varies with the concentration of sediment and the sediment particle sizes. Placer mining operations could be injurious to salmon productivity by physical destruction of spawning grounds in the process of washing gravel for gold, by increasing the turbidity of the river, and by adding to the stream abnormal quantities of sediment which would later be deposited or carried along as bed load and which would affect the survival of eggs and alevins in the gravel, and of fry in the stream.
- Assessment : A report prepared on this work, resulted in the Chief Gold Commissioner of British Columbia ruling that no further placer mining leases would be granted on the Horsefly River or its tributaries.
- Reports : A Study of the Horsefly River and the Effect of Placer Mining Operations on Sockeye Spawning Grounds, by A. C. Cooper, 1956, unpublished manuscript, (typed).
Also unpublished data.

July 1, 1957
Revised December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Electric Fish Screen for Downstream-Migrant Salmon at Baker Dam (1955)
- Purpose : To measure the practical guiding effectiveness of a large-scale electric fish screen at Baker Dam.
- Duration : Spring, 1955.
- Location : Baker Dam, Concrete, Washington.
- In Charge : F. J. Andrew.
- Cooperating Agencies : Washington State Department of Fisheries; Canada, Department of Fisheries; and Puget Sound Power and Light Company.
- Personnel : Engineer, biologist and seven men.
- Cost : \$40,000, estimated.
- Results : An electric screen, 250 feet long by 50 feet deep placed across the forebay of Baker Dam was not effective in leading fish to a by-pass provided at the crest of the dam. Sockeye and coho smolts continued to migrate over the spillway irrespective of whether the electric screen was operating or turned off. This electric screen was energized with direct current and was similar to the type of electric screen that had been found very effective in previous small-scale experiments. One of the serious problems encountered in the large-scale experiments was that the electric screen interfered with the normal migration in that it caused some of the fish to sound to below their normal swimming depth. Another serious problem was that the fish were reluctant to enter the artificial by-pass channel.
- Assessment : This project was the first study on a prototype scale of an electric screen for guiding downstream-migrant sockeye and coho salmon. It provides a good illustration of the inadequacy of small-scale experiments for predicting the practical effectiveness of fish-protective facilities for large-scale use at dams.
- Reports : An Investigation of the Problem of Guiding Downstream-Migrant Salmon at Dams, by F.J. Andrew, L.R. Kersey and P.C. Johnson, I.P.S.F.C. Bulletin VIII, 1955, (published).

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Effect of Horsefly River Falls on Survival of Sockeye Fry
- Purpose : To measure the mortality rate suffered by newly-emerged sockeye fry passing over Horsefly Falls.
- Duration : 1955.
- Location : Horsefly River.
- In Charge : J.A.R. Hamilton.
- Cooperating Agencies : None.
- Personnel : Biologist and two assistants.
- Cost : \$5,000.
- Results : The total drop in about 2,000 feet of falls and rapids is about 100 feet, the largest single drop being about 28 feet. There was no indication that these falls would have a serious adverse effect on the survival of newly-emerged fry. Four tests indicated no mortality and one test indicated a mortality of 5.6 per cent.
- Assessment : This experiment was conducted as part of an investigation of the feasibility of developing the river above Horsefly Falls as a sockeye spawning ground. Since the fry mortality will probably be negligible in the falls, the next stage of the investigation can proceed. Adult sockeye will be transported by truck and released above the falls in order to permit a thorough study of the suitability of this environment for sockeye spawning. The mortality rate in this natural falls is much lower than would be expected in the efficient, man-made energy dissipators of spillways at dams.
- Reports : Effect of Horsefly River Falls on Downstream-Migrant Sockeye Fry, by J.A.R. Hamilton and Roger Goodland, I.P.S.F.C. Unpublished manuscript, 1955.

July 22, 1958.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Fisheries Problems Related to the Proposed Diversion of the Columbia River Into the Fraser River System
- Purpose : To study the fisheries problems that would arise as a result of the construction of 10 dams on the Fraser and Thompson Rivers to utilize the hydroelectric potential of water diverted from the Columbia River.
- Duration : 1955.
- Location : Office analysis of data from various investigations.
- In Charge : Cooperative effort.
- Cooperating Agencies : Canada, Department of Fisheries; B.C. Fisheries Department and B.C. Game Commission.
- Personnel : Engineer, biologist, consultants, and office assistants.
- Cost : \$10,000, estimated direct expense. Supporting evidence obtained from prior knowledge from other investigations.
- Results : It was concluded, in spite of the provision of the best modern fish-protective facilities, that the proposed scheme would destroy a valuable segment of the Skeena River sockeye salmon fishery and would preclude the preservation and extension of all the salmon and steelhead runs originating in the Fraser and Thompson Rivers upstream from the proposed dams. The dams would delay the upstream migration of adults and kill a large proportion of the seaward migrants. Other problems would be created in relation to spawning grounds, stream and lake temperatures and ecology, and fry migration.
- Assessment : Experimental programs have been started to obtain further information concerning the many problems involved in protection of the fishery resource.
- Reports : A Report on the Fish Facilities and Fisheries Problems Related to the Fraser and Thompson River Dam Site Investigations, Canada Department of Fisheries, I.P.S.F.C., 1955, (mimeographed).

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Electric Fish Screen for Downstream-Migrant Salmon at Baker Dam (1956).
- Purpose : To make further tests of a prototype electric screen and to study by-pass design.
- Duration : Spring, 1956.
- Location : Baker Dam, Concrete, Washington.
- In Charge : F. J. Andrew.
- Cooperating Agencies : Canada, Department of Fisheries; Washington State Department of Fisheries; Puget Sound Power and Light Company.
- Personnel : Biologist, engineer, and seven men.
- Cost : \$27,000, estimated.
- Results : An electric screen 200 feet long and 50 feet deep energized with direct current was placed across the forebay of the dam and a by-pass trap, much larger than the one used in 1955, was provided at the crest of the dam. The type of electric screen used in these experiments was again found to be ineffective. A webbing barrier, only 15 feet deep placed across the forebay in the same location as the electric screen was much more effective. The by-pass used in these experiments was quite effective in collecting fish during darkness but was ineffective during daylight.
- Assessment : The results of this investigation confirmed the results of the previous work at Baker Dam with respect to the ineffectiveness of prototype electric screens for keeping smolts away from hazardous areas at dams. Electric fish screens being developed by other fisheries agencies using other electrode arrangements and electrical conditions should be thoroughly investigated at the prototype level but further large-scale tests with the type of electric screen used in these studies at Baker Dam seem unwarranted.
- Reports : Further Experiments with an Electric Screen for Downstream-Migrant Salmon at Baker Dam, by F.J. Andrew, P.C. Johnson, and L.R. Kersey, I.P.S.F.C. Progress Report, 1956, (Mimeo.).

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Energy Studies of Migrating Adult Sockeye.
- Purpose : To measure the utilization of body oils of sockeye salmon in their ascent of the Fraser River and to investigate the tolerance of various races to migrational delays.
- Duration : Started 1956, continuing.
- Location : Fraser River watershed, from the ocean to the spawning grounds.
- In Charge : Dr. W.A. Clemens and S.R. Killick.
- Cooperating Agencies : Fisheries Technological Station, Vancouver, B.C.
- Personnel : Two biologists and two biochemists.
- Cost : \$60,000. estimated.
- Results : The passage of Stuart Lake and Chilko Lake sockeye was studied in 1956. The analyses are still incomplete but preliminary examination of the results from Stuart Lake sockeye indicate a steady decrease in muscle-oil from Lummi Island to death in Forfar Creek. On the average, a Stuart Lake sockeye in 1956 started its migration with 13 ounces of muscle-oil. After spawning it had about one ounce remaining. A tentative conclusion is that a Stuart Lake sockeye in 1956 could not have withstood a delay at a dam or other obstruction of more than three or four days. However, a more complete analysis of the data must be made before final conclusions can be drawn.
- Assessment : The results from this study are so important in determining the tolerance limits of adult sockeye to migrational delay at dams and obstructions that the field and laboratory work will be expanded. It is planned to study the variations among races and from year to year and cycle to cycle. The data will be analyzed and a report prepared as soon as possible.
- Reports : The Energy Expenditures of Fraser River Sockeye Salmon During the Spawning Migration to Chilko and Stuart Lakes, by D.R. Idler and W.A. Clemens, Progress Report, I.P.S.F.C., 1959.

July 1, 1957

Revised December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Passage of Adult Sockeye at Seton Dam.
- Purpose : To study the passage of adult sockeye salmon in Seton Creek, as affected by the Seton Creek hydro-electric development.
- Duration : Started 1956, continuing.
- Location : Seton Creek, near Lillooet.
- In Charge : F.J. Andrew.
- Cooperating Agencies : Canada, Department of Fisheries.
- Personnel : Engineer, biologist and two field assistants part time.
- Cost : \$4,000. estimated in 1956.
- Results : In order to reach their spawning grounds in the Seton-Anderson watershed, sockeye salmon must migrate past the Seton powerhouse, located on the Fraser River, 4,500 feet downstream from the old Seton Creek channel, and they must ascend a 26-foot dam in Seton Creek. In 1956, no major problems were encountered because the powerhouse did not start operating until after the runs had passed. Approximately 9,000 sockeye were counted through the fishway, which is the highest head vertical-slot (Hell's Gate type) fishway in existence. Some fish that had passed through the 350-foot long fishway appeared to be excessively fatigued, and it was indicated that the 26-foot total head might be the allowable maximum for this type of fishway. One fish is known to have passed through the fishway in 11 minutes but the average time of passage was 20 or 30 minutes. When the spillway gate was operating, fish accumulated in eddies immediately downstream from this gate rather than move to the other side of the dam to enter the fishway, where the velocities were very much lower.
- Assessment : If the Seton-Anderson salmon runs could be built up to their historical levels of abundance, it has been estimated that the average annual wholesale value of all of the species combined would be about \$1,700,000. It is essential, therefore, that all of the fish passage and spawning problems be thoroughly studied in order to protect the runs as much as possible. More extensive studies are planned for this year.
- Reports : Sockeye and Pink Salmon Investigations at the Seton Creek Hydro-electric Installation, by F.J. Andrew and G.H. Geen, I.P.S.F.C., Progress Report, No. 4, 1958.

July 1, 1957

Revised December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Deflection of Downstream-Migrant Salmon at Baker Dam (1957).
- Purpose : To investigate the feasibility of using a 450-foot long by 30-foot deep webbing barrier for deflecting fish to a by-pass in the fore-bay of Baker Dam and to study possible improvements in the by-pass used in previous experiments.
- Duration : Spring, 1957.
- Location : Baker Dam, Concrete, Washington.
- In Charge : P.C. Johnson and F.J. Andrew.
- Cooperating Agencies : Canada, Department of Fisheries; Washington State Department of Fisheries; and Puget Sound Power and Light Company.
- Personnel : Biologist, engineer, and eight assistants.
- Cost : \$15,000, estimated.
- Results : The experiment is still in progress, but preliminary results indicate a significantly improved deflection of coho smolts but unsatisfactory deflection of sockeye. A new by-pass design using lights, mirrors, velocity and electricity to attract fish appears to be an improvement over previous designs.
- Assessment : It is indicated that downstream-migrant salmon cannot be diverted to a small by-pass by means of a shallow surface barrier in spite of the fact that the fish may be predominantly on the surface. It would appear that sockeye, at least, sound under the barrier rather than enter the by-pass. A continued investigation of by-pass design is indicated.
- Reports : To be prepared.

July 1, 1957.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Mortalities Suffered by Downstream - Migrant Sockeye at Seton Dam.
- Purpose : To measure the mortality rates suffered by downstream-migrant sockeye at Seton Dam.
- Duration : 1957 and 1958.
- Location : Seton Dam, near Lillooet.
- In Charge : F. J. Andrew.
- Cooperating Agencies : Canada, Department of Fisheries.
- Personnel : Engineer, biologist and three assistants.
- Cost : Estimated, \$ 6000.
- Results : The 58,500-horsepower vertical-shaft Francis turbine operating at full load, under a head of 136 feet, was found to cause a mortality rate of nine per cent. The mortality rates in passage through the fish-water sluice and the siphons were seven and one per cent respectively. Many fish were killed in the turbine even though it was submerged 16 feet below tailwater. Higher mortalities may be expected when the turbine is operated at part load and when the tailrace is at a lower elevation.
- The fish-water sluice was tested under the most adverse discharge conditions. An alternate gate arrangement presently being used probably results in significantly less mortality.
- Assessment : The Seton Creek hydroelectric plant is typical of many proposed installations in that it causes a significant mortality among downstream-migrant salmon and there is no known method for effectively and economically preventing these fish from entering the hazardous water passages.
- Reports : Sockeye and pink salmon investigations at the Seton Creek hydroelectric installation, by F.J. Andrew and G.H. Green, International Pacific Salmon Fisheries Commission Progress Report, 1958.

July 22, 1958.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Rate of Travel of Seaward-Migrant Sockeye.
- Purpose : To determine the rate of travel of seaward-migrant sockeye in different water velocities in order to study the possible adverse effects of large, low-velocity reservoirs on the migration route.
- Duration : Started 1957, continued 1960.
- Location : Chilko River, Shuswap Lake, South Thompson River, Kamloops Lake, Little River, Seton Lake, Cultus Lake, Sweltzer Creek.
- In Charge : S.R. Killick, F.J. Andrew.
- Cooperating Agencies :
- Personnel : Two biologists, one engineer and a various number of field assistants.
- Cost : Estimated \$9,000.
- Results : The data are not completely analyzed but preliminary calculations for Kamloops Lake, South Thompson River, Shuswap Lake, Chilko River, Seton and Cultus Lakes indicate fish moved downstream at a speed of about one-half the average water velocity in rivers and 3 miles per day in lakes. In Little River, in water velocities of 0.9 fps and higher the fish travelled at virtually the same speed as the water; in lower velocities they actively swam downstream at speeds slightly higher than that of the water.
- Assessment : Indications are that downstream-migrant sockeye would suffer considerable delay if they had to travel through long low-velocity reservoirs. Studies will be undertaken to determine the effect of migrational delay.
- Reports : To be prepared.

July 1, 1957
Revised December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Velocities in Forebays of High Dams.
- Purpose : To investigate the patterns of flow to surface and subsurface outlets at dams in order to provide a better understanding of the behavior of downstream-migrant salmon in forebays of high dams.
- Duration : Started 1957, continuing.
- Location : Baker, Mud Mountain and Merwin Dams in Washington State, and laboratory in New Westminster.
- In Charge : A.C. Cooper.
- Cooperating Agencies : U.S. Fish and Wildlife Service, Scripps Institute of Oceanography.
- Personnel : Two engineers and part-time assistants.
- Cost : Estimated, \$ 6,500.
- Results : Prototype velocity measurements, using a modified Roberts Meter, have revealed a rapid acceleration of flow immediately upstream from subsurface outlets. The shape of the forebay is an important factor in controlling the distance to which subsurface currents persist upstream in the reservoir. The lack of a surface spill appeared to be the primary cause of fish sounding to subsurface exits but the velocities from the surface, where most of the fish are found, to the subsurface outlets were so low that they could not be detected with this meter. An electrical analog technique is being used in the laboratory to study the flow patterns to outlets at various depths and of various sizes and shapes.
- Assessment : Since downstream-migrant salmon travel mainly in the surface layers of reservoirs, it may be possible to prevent these fish from entering turbines by submerging the outlets to sufficient depth, provided other problems do not develop such as an adverse temperature environment below the dam. However, relatively little is known concerning the factors that cause fish to sound in reservoirs. Fish are known to sound to a depth of 140 feet at Mud Mountain Dam.
- Reports : None to date.

July 22, 1958.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Migration of Adult Sockeye and Pink Salmon Past the Seton Creek Powerhouse.
- Purpose : To determine whether sockeye and pinks are delayed or otherwise adversely affected in the tailrace of the Seton Creek hydroelectric project.
- Duration : 1957 and 1958, continuing.
- Location : Seton Creek, near Lillooet.
- In Charge : F. J. Andrew.
- Cooperating Agencies : Canada, Department of Fisheries.
- Personnel : Engineer, biologist, and two assistants, part-time.
- Cost : \$ 6,000. per year.
- Results : The Seton powerhouse is located on one bank of the Fraser River 4500 feet downstream from the mouth of Seton Creek. The flow from the powerhouse is about 4000 cfs whereas the flow from Seton Creek is only 400 cfs. Adult salmon must migrate past the powerhouse in order to reach their spawning grounds in the Seton-Anderson watershed. Gates Creek sockeye, which migrate upstream in July and August, seemed to pass the powerhouse without adverse effect. Adult pink salmon suffered an average delay of one day in the tailrace but some individual pink salmon and late-running sockeye salmon were delayed for considerably longer periods. This delay occurred in spite of periodic powerhouse shutdowns and appeared to be related to the level of the Fraser River, the delay being greatest during low water. Some of the pink salmon and Portage Creek sockeye salmon appeared to be seriously affected. Further study is required.
- Assessment : The Seton Creek hydroelectric installation is typical of diversion projects. Getting the adults out of the tailrace and into their normal migration route, from which most of the water has been diverted, is just one of the many problems that require continuing study.
- Reports : Sockeye and Pink Salmon Investigations at the Seton Creek Hydroelectric Installation, by F.J. Andrew and G.H. Green, I.P.S.F.C., Progress Report, 1958.

July 22, 1958.

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Adult Sockeye Migration in Relation to River Discharge.
- Purpose : To determine the effect of river discharge on the upstream migration of adult sockeye.
- Duration : 1957, continuing.
- Location : Office analysis of data.
- In Charge : P. Gilhousen.
- Cooperating Agencies :
- Personnel : Biologist and office assistants.
- Cost : \$4,000.
- Results : A relationship has been established between the volume of spring and summer discharge and the time of entry of Adams River sockeye into the Fraser River, the fish being delayed in years of low discharge.
- Assessment : Delay of sockeye in arrival on their spawning grounds usually results in reduced productivity because the fish arrive when the flow conditions and temperature are not optimum for spawning. Since it has been established that low spring and summer discharges delay the fish, reduced productivity may be expected to result from power and flood control schemes, all of which reduce the spring and summer discharges and increase the winter discharge.
- Reports : The Behaviour of the Dominant Late Adams Sockeye Run during a Portion of the Spawning Migration, by P. Gilhousen, I.P.S.F.C., Progress Report, 1958, (Manuscript).

July 22, 1958
Revised December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Passage of Sockeye Through Turbines and Pressure Locks.
- Purpose : To study the effects of pressure and pressure release on yearling and adult sockeye salmon.
- Duration : Started 1958. Continued as D 46 and D 47, 1959-1961.
- Location : New Westminster Laboratory and Cultus Lake.
- In Charge : A.C. Cooper.
- Cooperating Agencies :
- Personnel : Two engineers, physiologist, and two assistants part time.
- Cost : Estimated for 1958, \$8,000.
- Results : An apparatus, consisting of a tank, high-pressure pump, vacuum pump, and control devices, has been constructed and successfully tested. This apparatus was designed primarily for investigating the effects of high pressure on adult sockeye in order to study the feasibility of passing adults upstream over dams 700 feet high by means of pressure fish locks. The apparatus can also be used for stimulating the pressure and vacuum conditions that juvenile salmon are subjected to in passage through turbines operating at heads of up to 700 feet and draft tube vacuums of up to 28 inches of mercury. Preliminary tests with yearling sockeye are in progress.
- Assessment : Tests with this equipment will provide basic information concerning the feasibility of passing adult sockeye over high-head dams by means of pressure fish locks. Even if the fish are found to be capable of withstanding high pressures, however, years of experiments will be required for investigating the problems involved in attracting large numbers of fish into and out of pressure locks, the capacity of this system of handling fish, behaviour of fish in locks, fatigue due to excitability, etc. The present experiments are therefore considered as the first step in a major experimental program.
- Reports :

July 22, 1958
Revised December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Introduction of a Foreign Discharge into a Sockeye Rearing Lake.
- Purpose : To investigate the effect of the flow of Bridge River hydro-electric plant on sockeye production in Seton Lake.
- Duration : 1958-1961.
- Location : Seton and Anderson Lakes.
- In Charge : G.H. Geen.
- Cooperating Agencies :
- Personnel : Biologist and one assistant part time.
- Cost : Estimated, \$4,500.
- Results : Monthly limnological surveys on Seton and Anderson Lakes have revealed that the introduction of a foreign discharge from Bridge River into Seton Lake has caused this sockeye rearing lake to become very turbid and has lowered the average temperature during the summer growth period. In Anderson Lake, which has not been affected by the Bridge River hydro-electric development, plankton production extends three or four times as deep as in the turbid water in Seton Lake. Even in the top 20 feet, the plankton are much more abundant in Anderson Lake than in Seton. Samples of fish have been obtained from these two lakes for age-growth analyses.
- Assessment : The Bridge River diversion into Seton Lake provides an opportunity for assessing the adverse effects of foreign discharges on sockeye productivity. The proposed diversions, for hydro-electric purposes, of Columbia River water into Shuswap Lake and Taseko Lake water into Chilko Lake would probably have the same adverse effects as observed in Seton Lake.
- Reports : Limnological Changes in Seton Lake Resulting from Hydro-electric Diversions, by G.H. Geen and F.J. Andrew, Progress Report No. 8, I.P.S.F.C., 1961.

July 22, 1958
Revised December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

Subject : Experimental Sockeye Hatchery on Upper Pitt River.

Purpose : To increase fry production from an unstable spawning area and to improve the quality of artificially propagated fry.

Duration : 1960, continuing.

Location : Seven Mile Creek, tributary of Upper Pitt River.

In Charge : R. Stewart.

Cooperating Agencies :

Personnel : Biologist, field technician and various numbers of field assistants.

Cost : Estimated \$6,000. yearly, plus \$20,000. capital cost.

Results : Fertilized eggs are incubated in hatchery troughs in total darkness. When they approach the fry stages they are adjusted gradually to light. The upper half of each release trough is covered so that the young fish can seek either a light or dark area, and they may leave the hatchery at their own selected time.

Assessment :

Reports :

December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Pressure Studies on Adult Sockeye.
- Purpose : To explore some of the possible effects of pressure locks on upstream migrating adult sockeye.
- Duration : Started 1958, continued 1959.
- Location : Temporary Field Station, Cultus Lake, B.C.
- In Charge : J. Pyper, H.H. Harvey.
- Cooperating Agencies :
- Personnel : Engineer, physiologist, one assistant - all part time.
- Cost : Estimated \$6,000. yearly.
- Results : In 1958, 40 adult sockeye were studied in early October and 66 in late November and December. Pressure tested and control fish were marked and held in a pen in Sweltzer Creek. In the early studies 50 per cent of the pressure treated females died during the first three weeks of holding. During this same time there were no losses among control females or among test and control male sockeye. The pressure treated females appeared to dig excessively within the holding pen and those fish which died evidenced severe wear about the caudal peduncle. In the late series of tests, these results were not duplicated. Mortalities among test and control fish were not appreciably different. Over the range of test conditions, there was no evidence that the sockeye were affected by the rate of pressure increase or decrease, magnitude of pressure or duration of exposure to pressure.
- In 1959, 60 adult sockeye were exposed to pressure or control conditions then held in a large pen on the spawning grounds. The pen was lost in a severe storm after the fish had been held approximately 5 weeks. During this time pressure-treated fish showed a mortality of 10 per cent compared to 0 per cent among controls. A second series of pressure-treated and control fish were held in a pen in Sweltzer Creek. Four fish from each of the two test and control groups were sampled at weekly intervals to maturity. Clinical studies indicated somewhat more variation in plasma and muscle sodium and potassium, blood hematocrit and muscle dry weight among test than control fish. Examination of gonadal, adrenal cortical and pituitary tissues is yet incomplete.
- Assessment : The conditions of fish pressure locks, release of fish at depths behind a dam could not be duplicated with the present apparatus. Within the test chamber the fish were relatively quiet, possibly more so under pressure, and showed little propensity to swim upward. This suggests that they may be reluctant to leave a pressure lock designed to transport them through the base of a dam. The extent of injuries or mortalities such locks may inflict on fish is still uncertain. It is clear from the studies above that a very extensive experiment will be necessary to provide a statistically sound answer.
- Reports : Internal preliminary reports 1958 and 1959.

December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Pressure Studies on Sockeye Smolts.
- Purpose : To understand some of the effects of pressure and pressure change on downstream migrant sockeye.
- Duration : Started 1959, completed 1961.
- Location : Temporary Field Station, Cultus Lake, B.C.
- In Charge : H.H. Harvey, J. Pyper.
- Cooperating Agencies :
- Personnel : Physiologist, engineer, two assistants - all part time.
- Cost : Estimated \$10,000. yearly.
- Results : Description of apparatus and methods may be found under D 43. Pressure per se altered the behaviour of sockeye smolts. This effect was quantified by measurement of pectoral fin movements. Pressure change produced a variety of effects depending on rate and magnitude of change, exposure to vacuum conditions, the immediate history of the fish, etc. Sockeye smolts exposed to rapid pressure reduction commonly failed to lose expanding swimbladder gas via the pneumatic duct. Under high vacuum test conditions this was sometimes accompanied by ruptured swimbladders. This unphysostome-like behaviour led to an examination of both the bladder and the duct. Histologically the pneumatic duct proved to be a rather convoluted tubule and ill-adapted to rapid release of gas. The use of the swimbladder and pneumatic duct by sockeye was also studied with special attention to autonomic control. A number of other pressure-related causes of injury or mortality were studied. Dissolved nitrogen within sockeye smolts was found to equilibrate slowly with the nitrogen of the fishes' aquatic environment. As a consequence of this slow process of equilibration, fish may become temporarily supersaturated internally. This may result from fish moving from one water mass to another of lower gas content or from cold to warmer water. Such fish subsequently exposed to vacuum conditions succumbed to emboli as gas left solution within the fish. Blood studies showed rapid equilibration of blood and water nitrogen. Subtration leaves tissue fluid nitrogen as the slowly equilibrating fraction of dissolved nitrogen and the source of gas involved in formation of embolisms.
- Assessment : Pressure changes within turbines may result in a variety of injuries. These may be immediately fatal, fatal at a later date or non-fatal. Of particular importance is the level of dissolved nitrogen within the fish passing through the turbines. Also of importance is the extent of inflation of the swimbladder. In all of the studies the adverse effects increased with increasing vacuum conditions.
- Reports : Several Internal. H.H. Harvey and W.S. Hoar. The Sounding Response of Sockeye Salmon. Manuscript. H.H. Harvey. Analysis of Dissolved Nitrogen in Fish Blood. Can. J. Zool. 39(6) 1961. H.H. Harvey. Dissolved Nitrogen as a Tracer of Fish Movement. Manuscript.

December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Supersaturation of Hatchery Water Supplies.
- Purpose : Examination of potential hatchery water supplies with special reference to dissolved gases.
- Duration : Started 1961, continuing 1962.
- Location : New I.P.S.F.C. Hatchery on Seven Mile Creek, Upper Pitt River.
- In Charge : H. H. Harvey.
- Cooperating Agencies :
- Personnel : Physiologist, biologist, technician - all part time.
- Cost : Estimated \$2,000.
- Results : Oxygen saturation in Seven Mile Creek varies over the range of 98 to 122 per cent. Saturation in the creek is related directly to discharge. The cause of this phenomenon was found to be the nature of stream itself. Seven Mile Creek falls precipitously within a deep gorge cut in the Coast Range granodiorite. The stream is in effect a series of falls and plunge basins. Water tends to air-equilibrate during free fall. Water passing into the plunge basins at the bases of the falls contains considerable entrained air. A portion of this air enters solution at depth under the increased hydrostatic head. At higher levels of discharge the depth of the plunge basins increases and the mass of falling water is greater resulting in more gas being forced into solution. In the portion of stream studied, small air-equilibrating falls were flooded out during higher discharges thus enhancing gas retention in solution.
- Assessment : Treatment of supersaturated water came under study following an understanding of the cause. Supersaturated water was found to be surprisingly stable over the range of 100-120 per cent saturation. Simple aeration by jetting did not lower saturation below 106 per cent. Even this low level of supersaturation resulted in injuries and mortalities among alevins. A 20 foot tall splash tower has proved more satisfactory, reducing water saturation to very close to 100 per cent.
- Reports : Several Internal. Analytical Methods are Reported in H.H. Harvey, Can. J. Zool. 39(6), 1961, and H.H. Harvey and S.B. Smith, Can. Fish. Cult. in press.

December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Artificial Spawning Channel at Seton Creek.
- Purpose : The replacement of natural spawning areas for pink salmon, lost due to flooding above the power-canal intake dam on Seton Creek.
- Duration : Built during 1960-1961. First spawning in 1961. Will be in use every second year on the odd year when Fraser River pink salmon normally return to spawn.
- Location : On Seton Creek, near Lillooet, B.C.
- In Charge : Construction - A.C. Cooper. Operation - R. Stewart.
- Cooperating Agencies : B.C. Electric Company Limited.
- Personnel : Biologist and technician.
- Cost : To build - \$40,000. To operate - \$2,000. per year.
- Results : The artificial channel is 3,000 feet long. It has a trapezoidal cross section with a bottom width of 20 feet at the surface of the gravel. Depth of spawning gravel is 16 inches, which is a specially-prepared fines-free material varying in size from $\frac{1}{2}$ " plus to 4" minus. Maximum flow in the channel is 40 cfs obtained through 2-20 inch diameter steel siphon pipes from the adjoining power canal. Rock drop structures provide spawning sections 100 feet in length (one section is 900 feet long). Depth of water is 1.5 feet and mean velocity is 1.2 feet per second. At the confluence of the channel with Seton Creek, a fence, gate and trap are incorporated for limiting the ingress and egress of spawners. Counting traps may also be installed here to enumerate the production of fry. Approximately 6,700 adult pink salmon voluntarily entered the artificial channel and spawned successfully in 1961.
- Assessment : As well as replacing natural spawning ground, the channel will serve to assess the survival of eggs in improved-flow gravel under controlled-flow conditions. Silting of the spawning gravel is not anticipated since the water for the project issues from the outlet end of Seton Lake and is relatively clean at all times.
- Reports :

December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

Subject : Early Life History of Fraser River Sockeye.

Purpose : To assess the influence of environmental factors on emergence and migratory behaviour of fry.

Duration : In progress.

Location : International Pacific Salmon Fisheries Commission.

In Charge : J. Roos.

Cooperating Agencies :

Personnel : Biologist.

Cost : Estimated \$5,000.

Results : A report is being prepared bringing together as much as possible of the available information on the early fresh water phase of the life cycle of the various races of Fraser River sockeye.

Assessment :

Reports : In progress.

December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

- Subject : Sockeye and Pink Salmon Production in Relation to Proposed Dams in the Fraser River System.
- Purpose : An overall assessment of the fish-power problem which would be created by a series of proposed dams on the Fraser River.
- Duration : 1959-1960.
- Location : International Pacific Salmon Fisheries Commission.
- In Charge : F.J. Andrew and G.H. Geen.
- Cooperating Agencies :
- Personnel : An engineer and a biologist.
- Cost : Estimated \$15,000.
- Results : A comprehensive review is presented of available information concerning methods of passing adult and juvenile salmon over dams, the possible effects of environmental changes on production of sockeye and pink salmon and methods of artificially propagating these species.
- Assessment : The report shows that serious depletion of salmon stocks would result from dam construction on the Fraser River, due to inadequacy of both upstream and downstream fish passage facilities at dams, detrimental environmental changes and migration delays and impracticality of artificial propagation as a substitute.
- Reports : Sockeye and Pink Salmon Production in Relation to Proposed Dams in the Fraser River System by F.J. Andrew and G.H. Geen, I.P.S.F.C., Bulletin XI, 1960.

December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

Subject : Migratory Behaviour of Adult Fraser River Sockeye.

Purpose : To analyze variability of migratory behaviour of Fraser River sockeye races for purposes of fishery regulations.

Duration : 1960.

Location : International Pacific Salmon Fisheries Commission.

In Charge : P. Gilhousen.

Cooperating Agencies :

Personnel : Biologist.

Cost : Estimated \$4,000.

Results : Possible relationship of migratory variability of Adams River and other sockeye races to moon phase and summer discharge in Fraser River is shown.

Assessment :

Reports : Migratory Behaviour of Adult Fraser River Sockeye, by Philip Gilhousen. Progress Report, I.P.S.F.C., 1960.

December, 1961

INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

Subject : Fraser River Board.

Purpose : To study the effects of various schemes of hydro-electric development and flood control on the Fraser River.

Duration : 1960, continuing.

Location : Victoria, B.C.

In Charge : A.C. Cooper.

Cooperating Agencies : Department of Fisheries, Canada.

Personnel : One biologist, one engineer, various numbers of field assistants.

Cost :

Results : Collection of bathythermographs and turbidities during summer months on Clearwater, Hobson, Cariboo and Quesnel Lakes. Also continuous stream temperatures from summer, 1960 to fall, 1961, on Fraser River above Prince George, Quesnel River at Quesnel, North and South Forks of the Quesnel River and North Thompson River at Kamloops. The period of migration of sockeye smolts out of Bowron Lake was also determined.

Assessment :

Reports :

December, 1961

UNIVERSITY OF BRITISH COLUMBIA

UNIVERSITY OF BRITISH COLUMBIA

- Subject : Temperature Resistance of Fish.
- Purpose : To understand factors responsible for variable resistance to extreme temperature. Currently the effects of seasonal variations in light are being studied.
- Duration : Continuing project since 1946.
- Location : Department of Zoology.
- In Charge : Dr. W.S. Hoar.
- Cooperating Agencies : National Research Council and Fishing Companies in Vancouver.
- Personnel : G. Beth Robertson.
- Cost : About \$1,500 per annum since 1950, and lesser amounts prior to that time.
- Results : Demonstration of effects of certain dietary factors, sex, size and seasonal light changes on temperature resistance.
- Assessment :
- Reports : Hoar, W.S. Seasonal variations in the resistance of goldfish to temperature. Trans. Royal Society of Canada, 49 pp. 25-34, 1955.
Hoar, W.S. Photoperiodism and thermal resistance of goldfish. Nature. August, 1956.

July, 1957.

UNIVERSITY OF BRITISH COLUMBIA

- Subject : Behaviour of Migrating Juvenile Pacific Salmon
- Purpose : The analysis of the behaviour.
- Duration : Since 1949 and continuing.
- Location : U.B.C. and Port John Field Station of Fisheries Research Board of Canada.
- In Charge : Dr. W.S. Hoar.
- Cooperating Agencies : Fishing Companies in Vancouver and Fisheries Research Board of Canada.
- Personnel : Dr. W.S. Hoar and various graduate students.
- Cost : Approximately \$1,000 per annum.
- Results : Detailed descriptions of behaviour of juvenile salmon in fresh water and demonstrations of effects of various factors which modify these patterns.
- Assessment :
- Reports : Series of publications since 1950 in Journal of Fisheries Research Board of Canada and the Canadian Journal of Zoology.

July, 1957.

UNIVERSITY OF BRITISH COLUMBIA

- Subject : Distribution of Fishes in British Columbia
- Purpose : To collect, preserve, identify and catalogue the fishes of British Columbia as a basis for predicting possible effects of water use developments.
- Duration : 1954, continuing.
- Location : Institute of Fisheries, U.B.C.
- In Charge : Dr. C.C. Lindsey.
- Cooperating Agencies : Fish and Game Branch, National Research Council, Dr. H.R. MacMillan grant.
- Personnel : Dr. C.C. Lindsey and associates.
- Cost : \$5000 per annum.
- Results : Revision of Carl and Clemens "Freshwater Fishes of British Columbia; many indications of dangers of water diversions to Salmonoid stocks.
- Assessment : An important field of investigation, particularly in British Columbia where fish distribution is irregular.
- Reports : Lindsey, C.C. Possible effects of water diversions on fish distribution in British Columbia. J. Fish. Res. Bd. Canada, 14(2): 651-668, 1957.

January, 1959.

UNIVERSITY OF BRITISH COLUMBIA

- Subject : Behaviour and Physiology of Juvenile Salmon Entering Salt Water.
- Purpose : To understand the effects of changing environmental salinity on the behaviour of salmon.
- Duration : 1955, continuing.
- Location : Zoology Department and Institute of Fisheries.
- In Charge : Dr. W.S. Hoar.
- Cooperating Agencies : National Research Council and Fishing Companies of British Columbia.
- Personnel : Graduate students.
- Cost : \$2,500. per annum.
- Results : Marked changes in locomotor activity occur for a brief period (4-10 hours) after salmon enter sea water. These are being related to chemical changes in blood and tissues.
- Assessment :
- Reports : Responses of Juvenile Chum, Pink and Coho Salmon to Sharp, Sea-water Gradients, A.H. Houston. Can. J. Zool., 35: 371-383, 1957.
- Locomotor Performance of Chum Salmon Fry (Oncorhynchus keta) during Osmoregulatory Adaption to Sea Water, A.H. Houston. Can. J. Zool., 37: 591-605, 1959.
- Osmoregulatory Adaption of Steelhead Trout (Salmo gairdneri Richardson) to Sea Water, A.H. Houston. Can. J. Zool., 37: 729-748, 1959.
- Influence of Size upon the Adaption of Steelhead Trout (Salmo gairdneri) and Chum Salmon (Oncorhynchus keta) to Sea Water, A.H. Houston. J. Fish. Res. Bd. Can., 18, 3, pp.401-415, 1961.

July, 1957

Revised December, 1961

UNIVERSITY OF BRITISH COLUMBIA

- Subject : The Role of the Thyroid Gland in Osmotic Regulation of Fishes.
- Purpose : To understand mechanisms which permit some fish to survive in wide range of salinity while others are restricted to fresh or salt water.
- Duration : 1955 - 1958.
- Location : Vancouver Aquarium.
- In Charge : Dr. W.S. Hoar.
- Cooperating Agencies : National Research Council.
- Personnel : Graduate students.
- Cost : \$2,000. per annum.
- Results : Demonstration that variable thyroid activity seems to be correlated to variable salinity resistance in flatfish and that the thyroid acts on some phase of metabolism related to excretion and absorption of chlorides.
- Assessment :
- Reports : The Osmoregulatory Role of the Thyroid Gland in the Starry Flounder (Platichthys stellatus), C.P. Hickman. Can. J. Zool., 37: 997-1060, 1959.
- The Minimum Dosage of Thiourea Effectively Inhibiting Thyroxine Synthesis in the Flounder (Platichthys stellatus), J. Kinnear. Can. J. Zool., 38: 917-922, 1960.
- A Comparative Study of Iodine Metabolism in Juvenile Oncorhynchus, J.G. Eales. M. Sc. Thesis, Dept. Zool., Univ. Brit. Col., 58 p., 1961.

July, 1957
Revised December, 1961

UNIVERSITY OF BRITISH COLUMBIA

Subject : The Eye of Young Pacific Salmon.

Purpose : The physiology of the eye in relation to emergence from the gravel and downstream migration of Pacific salmon.

Duration : 1956-58.

Location : Department of Zoology.

In Charge : Dr. W.S. Hoar.

Cooperating Agencies : B.C. Power Corporation Grant.

Personnel : M.A. Ali.

Cost : \$2,500.

Results : Comparison of rates of adaptation of eye to light and darkness at different stages in development is being correlated with migratory behaviour.

Assessment :

Reports : Some Observations on the Structure and Photomechanical Responses of the Pacific Salmon Retina, J.R. Brett, and M.A. Ali. J. Fish Res. Bd. Canada, 15: 815-829, 1958.

Retinal Responses of Pink Salmon associated with its Downstream Migration, M.A. Ali, and W.S. Hoar. Nature 184: 106-107, 1959.

The Ocular Structure, Retinomotor and Photobehavioral Responses of Juvenile Pacific Salmon, M.A. Ali. Can. J. Zool., 37: 965-996, 1959.

The Effect of Temperature on the Juvenile Sockeye Salmon Retina, M.A. Ali. Can. J. Zool., 38: 169-171, 1960.

July, 1957

Revised December, 1961

UNIVERSITY OF BRITISH COLUMBIA

Subject : Recent Progress in Fish-Power Research.

Purpose : To provide a review of recent developments for the benefit of interested agencies.

Duration : 1956.

Location : University of British Columbia.

In Charge : E.S. Pretious.

Cooperating Agencies :

Personnel : E.S. Pretious, G. Contractor, L. Kersey.

Cost : \$1,500.

Results :

Assessment :

Reports : Fish Production and Power Development on the Fraser River, E.S. Pretious, L. Kersey, and G. Contractor, 1957.

July 1, 1957
Revised December, 1961

UNIVERSITY OF BRITISH COLUMBIA

- Subject : Metabolism of Fish Following Muscular Exercise.
- Purpose : To determine the effects of muscular exercise on blood levels of lactic acid, hydrogen ion, carbonate and haemoglobin and on reserves of carbohydrate (glycogen) in muscle and liver.
- Duration : 1956, continuing.
- Location : The Department of Physiology, U.B.C., and the Summerland Trout Hatchery operated by the Fish and Game Branch at Summerland, B.C.
- In Charge : Dr. Edgar C. Black, Associate Professor, Physiology Department, U.B.C.
- Cooperating Agencies : The project is made possible by the support of National Research Council of Canada, the Fish and Game Branch, Department of Physiology of the U.B.C., and a B.C. Power Corporation Grant. The physiological work was carried out in 1956 at the Institute of Fisheries, U.B.C.
- Personnel : Dr. Edgar C. Black, and Arthur Hanslip and Wing-Gay Chiu, medical students from U.B.C.
- Cost : \$3,000. (summer, 1957).
- Results : Work on the carbonate, lactic acid and hydrogen ion in blood of Kamloops trout will be completed in 1957. A beginning has been made on alterations in glycogen in muscle and liver following vigorous exercise in spawning and immature Kamloops trout. As might be predicted from the work of Secondat (1950) in France, on correlated changes in blood levels of lactic acid, carbonate and pH in the carp following severe muscular exercise, even greater changes occur in the Kamloops trout which is a more active fish. Our results show a positive correlation for pH, lactic acid, and carbonate changes in the blood, changes which persist for 6 hours for lactic acid, and up to 24 hours for carbonate.
- Assessment : The results indicate that the consequences of severe muscular exercise in salmonoid fish are not only of long duration (4-8 hours) but also that the acid buffering capacity of the fish is markedly reduced. These findings may be of use in interpreting fatigue and endurance to swimming against swift currents of water.
- Reports : Hyperactivity as a Lethal Factor in Fish, E.C. Black. J. Fish. Res. Bd. Canada, 15: 573-586, 1958.
Muscular Fatigue and Mortality in Troll-caught Chinook Salmon (*Oncorhynchus tshawytscha*), R.R. Parker, and E.C. Black. J. Fish. Res. Bd. Canada, 16: 95-106, 1959.
Changes in pH, Carbonate and Lactate of the Blood of Yearling Kamloops Trout (*Salmo gairdneri*) During and Following Severe Muscular Activity, E.C. Black, Wing-Gay Chiu, Francis D. Forbes, and Arthur Hanslip. J. Fish. Res. Bd. Canada, 16: 391-402, 1959.
Fatigue and Mortality in Troll-caught Pacific Salmon (*Oncorhynchus*), R.R. Parker, E.C. Black, and P.A. Larkin. J. Fish. Res. Bd. Canada, 16: 429-448, 1959.
Alterations in Glycogen, Glucose and Lactate in Rainbow and Kamloops Trout (*Salmo gairdneri*), following Muscular Activity, E.C. Black, A.C. Robertson, A.R. Hanslip, and Wing-Gay Chiu. J. Fish. Res. Bd. Canada, 17: 487-500, 1960.

June 25, 1957

Revised December, 1961

UNIVERSITY OF BRITISH COLUMBIA

Subject : Recent Progress in Fish-Power Research.

Purpose : To provide a review of recent developments for the benefit of interested agencies.

Duration : 1957.

Location : University of British Columbia.

In Charge : Dr. P.A. Larkin.

Cooperating Agencies :

Personnel : Dr. P.A. Larkin.

Cost : \$300.

Results :

Assessment :

Reports : Power Development and Fish Conservation on the Fraser River, P.A. Larkin. University of B.C. Institute of Fisheries, 40 pp. 1951.

The Effects on Fresh Water Fisheries of Man-made Activities in British Columbia, P.A. Larkin, and Graduate Students. Canadian Fish Culturist 25: 27-59, 1959.

July 1, 1957
Revised December, 1961

UNIVERSITY OF BRITISH COLUMBIA

Subject : The Investigation of Fish-Power Problems.

Purpose : To review the nature of fish-power problems at a symposium.

Duration : April, 1957.

Location : University of British Columbia.

In Charge : Edited by Dr. P.A. Larkin.

Cooperating Agencies : Dr. H.R. MacMillan grant.

Personnel :

Cost : \$3,000.

Results :

Assessment :

Reports : "The Investigation of Fish-Power Problems". H.R. MacMillan Lectures in Fisheries, U.B.C. includes papers by Clemens, Vernon, Hourston, Rawson, Neave, Black, Brett, Collins, Fry and Hoar.

January, 1959
Revised December, 1961

UNIVERSITY OF BRITISH COLUMBIA

- Subject : The Salinity Preferences of Young Salmon.
- Purpose : Understanding of the physiology of migration from fresh to salt water and vice versa.
- Duration : January 1957 - June, 1958.
- Location : Department of Zoology, U.B.C.
- In Charge : Dr. W.S. Hoar.
- Cooperating Agencies : National Research Council.
- Personnel : Dr. Berta Baggerman.
- Cost : \$11,000.
- Results : Experimentally produced changes in the level of thyroid hormone will alter preferences of salmon for sea water. It is possible to induce, in this way, preference for sea water or fresh water.
- Assessment : Basic information on role of hormones in migration.
- Reports : Salinity Preference, Thyroid Activity and the Seaward Migration of Four Species of Pacific Salmon (Oncorhynchus), B. Baggerman. J. Fish. Res. Bd. Canada, 17: 295-322, 1960.
- An Experimental Study of Salinity Preference and Related Migratory Behaviour of Juvenile Pacific Salmon. J.E. McInerney. M.Sc. Thesis, Dept. Zoology, Univ. Brit. Col., 73 p., 1961.

July, 1957
Revised December, 1961

UNIVERSITY OF BRITISH COLUMBIA

Subject : Passage of Young Fish Through Turbines.

Purpose : To assess the effects of pressures above and below atmospheric on young salmonoids relative to the problem of fish mortality in turbines.

Duration : 1957-1958.

Location : Hydraulics laboratory, University of B.C.

In Charge : Prof. J.F. Muir.

Cooperating Agencies : B.C. Power Corporation grant.

Personnel : One engineer, one technician.

Cost : \$1,500.

Results : Preliminary tests show some effects of pressure on migrants.

Assessment : Possibility of new designs for turbines being considered.

Reports : Passage of Fish Through Turbines, J.F. Muir. Proc. Amer. Soc. Civil Eng. Vol. 85, No. P01 (1947): 23-46, February, 1959.

March, 1959
Revised December, 1961

UNIVERSITY OF BRITISH COLUMBIA

Subject : Nature of Odour Perception Mechanisms in Salmon.

Purpose : To assess the types of substances to which salmon odour receptors will respond as a potential method for attracting or guiding salmon.

Duration : 1957, continuing.

Location : Department of Zoology, U.B.C.

In Charge : Dr. Wolfgang Pfeiffer.

Cooperating Agencies : B.C. Power Corporation grant.

Personnel : One scientist, one technician.

Cost : \$5,000. estimated.

Results : Experiments in progress. Some success in isolation of olfactory pigments.

Assessment :

Reports :

January, 1959
Revised December, 1961

UNIVERSITY OF BRITISH COLUMBIA

Subject : Acquisition of Odour Imprinting Mechanisms in Young Salmon.

Purpose : To assess the possibilities of training young salmon to respond to odours.

Duration : 18 months, 1958-1959.

Location : University of B.C.

In Charge : Dr. W.B. Malcolm.

Cooperating Agencies : B.C. Power Corporation grant.

Personnel : One scientist.

Cost : \$5,000. estimated.

Results : Experiments in early stages.

Assessment :

Reports :

March, 1959
Revised December, 1961