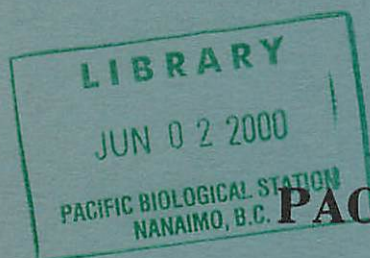


R. D. Humphreys
RESTRICTED

FISHERIES AND MARINE SERVICE



PACIFIC BIOLOGICAL STATION
NANAIMO, B.C.

ANNUAL REPORT and INVESTIGATORS' SUMMARIES

1975

C#1

Dr. W. E. Johnson, Director

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I N T R O D U C T I O N

INTRODUCTION

W. E. Johnson

A number of significant developments in 1975 reinforced the primary purpose of the Pacific Biological Station (P.B.S.) to provide improved information for culture, development and best use of Pacific coast living marine and anadromous resources.

Among these were the accelerated preparations for the 1975 Law of the Sea Conference with expected 200-mile economic zone legislation. This would inevitably sharpen attention on Canada's responsibilities for management of marine resources in an area of more than 260,000 sq. km. Marine fisheries biologists of this Station would be expected to improve current knowledge of the size, distribution and sustainable yield of major west coast stocks as a prelude to Extended Jurisdiction.

Similarly, planning for a major Salmon Enhancement Program gained momentum with the Minister's public announcement of the program in March. This program has vital implications for not only enhanced salmon and trout populations, but also for valuable natural salmon stocks and other fishes which will interact with them. The P.B.S. Salmon Enhancement Group accelerated its program to refine critical biological parameters essential for a successful Salmon Enhancement Program.

Concern has also grown for the sustained health of fishes as various production techniques concentrate populations, and movements of fish and eggs accelerate within Canada and between Canada and other countries. P.B.S. experts are heavily involved in the development of comprehensive safeguards against the proliferation of fish diseases.

Finally expanding cities with attendant industries and high energy demands continue to affect adversely the nation's waters and pose major threats for vital living aquatic resources. Amelioration is often extraordinarily complicated and can only be achieved after extensive knowledge is gained of the ecological requirements of the creatures which must be protected. Consequently there are at P.B.S. continuing biological studies related to such concerns as active coastal tanker routes, estuarine port developments, logging in precipitous watersheds and mining of heavy metals in lakes producing salmon.

The projects reported below reflect the continuing efforts of P.B.S. staff to anticipate such developments, to achieve a total program attuned to regional and national resource goals and to be responsive to the needs of their customers.

The following is an overview of accomplishments in 1975 of the three sections into which the work of P.B.S. was organized:

The Fish Populations Section continued to gather information which will allow more accurate description of the distribution, abundance and sustainable yield from stocks of major commercial and recreational importance. In addition staff members provided substantial input to international meetings concerned with stocks subject to exploitation by both Canadian and foreign fishermen. Major biological studies on Pacific cod and lingcod continued with high dependence upon the 52 m. research vessel G.B. REED. Field work on coastal rockfish resources terminated in 1974 but reporting on the population dynamics of this most valuable resource continued.

Salmon projects in this section related largely to international commitments, the assessment of west coast salmon hatchery methods and further development of spectroscopic techniques for differentiating stocks from different streams and lakes of origin. A new approach to forecasting herring abundance on the B.C. coast was introduced in 1975 and showed promise as a management aid. Meanwhile, methods of measuring herring spawning intensity and hatching success are being refined and should lead to further improvements in forecasting. Crustacea and Marine Invertebrates programs developed new information relating success of commercially important species to marine environmental conditions. Further estimates were made of shrimp stock abundance off the west coast of Vancouver Island, and new studies began on the ecology of abalone and echinoderms. Hydroacoustical surveys of herring and hake stocks were made under hitherto impossible sea conditions by use of a towed transducer.

The Salmon Enhancement, Aquaculture and Fish Health Section combines the three named programs into a single strongly collaborating unit. The Salmon Enhancement group made further advances in refining estimates of such parameters as optimum spawning densities and incubation requirements of sockeye salmon in spawning channels; best size composition for gravel spawning substrate; and optimum size and time of release to the sea of juvenile cohos. Of particular interest was the opening of a "designed stream" for coho which concentrates those features known to give high production in nature. Another field project on the northeast coast of Vancouver Island incorporates improved methods for freezing and storing pink salmon sperm and seeks to introduce a run of this species into a stream in barren years (in this case odd-numbered years).

Post treatment monitoring and analysis of data from the Great Central Lake fertilization experiment continued in 1975 as did the recovery of adult sockeye marked as fry in 1970 and 1971 for evaluating the Babine Lake enhancement facilities.

P.B.S. Aquaculture continued a successful blend of theory and practical application to elucidate problems which would be encountered in rearing salmon in floating net pens. Physiological factors governing adaptation to seawater, and conditions required for maximum food conversion and resistance to disease were assessed under laboratory conditions then put to further test in the experimental fish farm built in 1973. Several thousand fish were of marketable size this year.

Staff of the Fish Health program provided invaluable assistance in combatting disease encountered in the aquaculture and enhancement projects, and continued particularly active input to the development of standards for safeguarding fish health in government and private establishments. The diagnostic and consultative service was very active and improved histological techniques incorporated epoxy resin for imbedding specimens and examinations with the Station's scanning electron microscope. Long term parasitological studies continued to identify harmful parasites and determine specific effects on fish hosts.

The Fisheries Ecology Section continues to provide the vital ecological data required by managers when developing environmental safeguards. The protracted Carnation Creek study of the implications of modern logging methods on fish production in a coastal watershed is in its sixth year, -- the first during active logging. The Carnation Creek coordinating committee continues to advise on major aspects of the program. The interdisciplinary Babine Watershed Change Program also continues to benefit from an advisory committee drawn from federal, provincial and private organizations. This committee channels recommendations for studies and management action to the D.O.E. Regional Board.

The large, well-integrated Strait of Georgia Program benefits from the close collaboration of a wide range of specialists. Current emphasis is on understanding the ecological needs of juvenile salmon during their occupancy and dispersal from the Nanaimo River estuary. Considerable new information has been obtained on the size and migration route of juvenile chum salmon, their predators and competitors and of the food organisms which sustain them both on and off the tide flats. Staff members of this section were also heavily involved in responses to requests from Fisheries Operations and elsewhere for specific biological information for use in "impact studies"; in evaluations of several small water bodies in the Georgia Strait and west coast of Vancouver Island; and in estimating the potential commercial yield of zooplankton in Georgia Strait.

Considerable new information was gathered on the population dynamics of Georgia Strait hake, pollock and dogfish.

The following are detailed reports by the investigative teams:

I N V E S T I G A T O R S ' S U M M A R I E S

F I S H P O P U L A T I O N S S E C T I O N

Z. Kabata

This section conducts programs of study basic to management of a wide variety of marine and anadromous fishery resources, including exploratory fishing for new stocks and fishing grounds and assessment of long-term yield potentials to foster rational development of west coast fisheries. The section consists of seven programs. A separate report for each program is given below.

GROUNDFISH

S. J. Westrheim

In 1975 the activities of the Groundfish Program were: (1) monitoring the commercial fishery; (2) biological investigations; and (3) participation in domestic and international meetings dealing with research and management problems.

1. Monitoring the commercial fishery

Monitoring activities consisted of: (1) interviewing vessel captains for details on location of catch, and fishing effort expended; (2) sampling landings for species composition and biological data such as length, sex, and age of individual fish; and (3) sampling catches at sea to determine discard, qualitatively and quantitatively.

During 1975, reports were published in the Technical or Manuscript Report series dealing with: (1) catch statistics of the 1974 domestic trawl fishery; (2) an inventory of biological samples collected from the domestic fishery in 1974; and (3) Pacific cod catch statistics (Canada-USA, 1966-73) and length-frequency samples from Canadian trawl landings (1967-73).

2. Biological investigations

Biological investigations dealt with Pacific cod, lingcod, and rockfish.

(a) Pacific cod

Field studies involved collecting data on length-weight and length-girth relationships, maturity, and stomach contents, by area and season. G.B. REED cruises were completed to grounds off southwest Vancouver Island and in Hecate Strait during April, July and October. The last of this series is scheduled for February 1976. As of November 1975, a report on the April-July cruises has been approved for publication (Manuscript Report), and a report of the October cruise is ready for final typing.

Laboratory studies involved (1) compilation and analysis of biological data collected during the April, July, and October cruises; and (2) survey, compilation, and analysis of past file data. Two reports containing an inventory of all tagging experiments and an analysis of experiments undertaken to test various types of tags were published as Manuscript Reports. Analyses are under way which deal with : (1) migration and stock delineation; (2) growth; (3) species inter-relationships; and (4) validity of various sampling schemes currently in use.

(b) Lingcod

The lingcod age-determination study was conducted jointly with R. J. Beamish. Collection and processing of scales and fin rays was completed, and age readings are under way.

(c) Rockfish

No field studies on rockfish were undertaken during 1975. Reports were published on reproduction (JFRBC) and growth (FMS Technical Report) of these fish.

3. International commitments

Groundfish Investigation personnel attended and participated at the technical level in meetings of the International Groundfish Committee (Canada-USA), International North Pacific Fisheries Commission (Canada-Japan-USA), and the Canada-USSR Scientific Meetings on Fisheries. A total of 35 man-days was expended during 1975 in travel and attendance at these meetings. Considerable additional time was expended at other times of the year in preparing reports for these meetings and analyzing reports submitted to these meetings by other scientists.

SALMON POPULATIONS

J. McDonald

The purpose of this program is to provide the biological information and analysis required to improve production and management of our Pacific salmon resource.

In 1975 our effort was divided in three ways:

- (1) To meet regional and national requirements with respect to international commitments and negotiations involving salmon.
- (2) Participating in a large-scale cooperative U.S.-Canadian mark and recovery program designed to assess the effectiveness of current and new hatchery techniques for chinook and coho and to help determine the ocean distribution, areas of intermingling and extend of interceptions of each other's salmon stocks.
- (3) Developing X-ray spectroscopic techniques to provide a more effective way of identifying salmon caught in coastal waters or on the high seas as to their river of origin.

1. International salmonJ. McDonald, K. V. Aro
and P. Miller

Discussions with United States officials continued with the objective of reaching an agreement which would limit the interception of each other's salmon and which would allow each country to receive full benefits from her own enhancement programs. A round of meetings with advisors from industry and the British Columbia government was held in the spring to receive their views regarding Canadian requirements for an agreement. This was followed in August and again in September with discussions between United States and Canadian federal officials of the general terms of an agreement and methods of implementing it which could be a subject for formal negotiations early in 1976.

Throughout 1975 this Station continued with the responsibility of leading the scientific work required by our negotiators. Specific jobs were:

- (1) Arrange for, and carry out, exchange of scientific information with the United States.
- (2) Update information on the ocean distribution of Canadian and United States salmon stocks, areas of intermingling and estimates of interceptions.
- (3) Help develop for the next round of negotiations alternate Canadian strategies and possible agreements and to assess for each the advantages and disadvantages to Canada.

We continued to meet commitments of the International Convention for the High Seas Fisheries of the North Pacific through INPFC. Work by Canadian co-authors on comprehensive reports on the biology of salmon species in the North Pacific was essentially completed. The report on coho (senior author H. Godfrey, Canada) is in press. The reports on chum (senior author F. Neave, Canada) and sockeye salmon (co-author T. Bilton, Canada) are under editorial review. Reports on pink and chinook (Canadian co-authors Aro and Godfrey) are expected to be completed before the end of 1975. A Confidential Report entitled "Interceptions of Canadian salmon in offshore fisheries in the North Pacific Ocean and Bering Sea" was prepared for use of the Canadian Section, INPFC.

We continued to participate in the development and assessment, at the Regional level, of alternate management regimes required once a Canadian 200-mile fishing zone is in place. The effects on our salmon fisheries of alternate boundaries between Canadian and United States zones were examined.

2. Chinook and coho production evaluation

H. Godfrey

(a) Mark and recovery program

This is a cooperative Canada-United States program established to determine the production of chinook and coho by hatcheries, their contributions to fisheries of the two countries, the extent of interception of the stocks of one country by fisheries of the other, and the effects of a considerable variety of hatchery production treatments and procedures, including nutrition, disease and genetic studies. The principal activity of the project is the sampling of

catches and the recovery of marked fish. The program head continued as Director of the Canadian program until the end of the 1974-1975 fiscal year approximately, during which period the main effort was directed to the processing and preliminary analysis of the 1974 fishing season data, and the development and improvement of catch sampling and mark recovery field data reporting and processing, in order to achieve a high level of capability for in-season analysis and reporting of results.

Late in June of 1975, most aspects of this work were organized into a Regional Service reporting to the Director-General, Pacific Region, with two heads over field services and computer services. A Users' Committee was struck to advise the Service heads of their requirements.

(b) Informal Committee on Chinook and Coho

The Technical Working Group of this Committee (of which the program head is the Canadian Member) met in Seattle, Washington, on March 26-27, 1975. The principal matter dealt with was the cooperative chinook and coho catch sampling and mark recovery effort expended by the two countries during the 1974 salmon fishing season, and proposals for such work to be conducted during 1975. At this meeting, the Technical Working Group also supported a proposal to recommend to the Parent Committee that the Committee endorse and sponsor a Chinook and Coho Salmon Workshop.

3. Stock identification

T. Mulligan, L. Lapi
and S. Yamada

Development and testing of X-ray spectroscopic techniques to determine the river of origin of salmon continued in 1975 with the following general results:

- (1) A new X-ray fluorescence spectrometer was installed and calibrated. Readout was linked with the Nova and Xerox computers for data reduction and statistical analysis.
- (2) Testing of the techniques began using scales and other body parts from three sockeye stocks from Alberni Inlet. Elemental analysis of the freshwater growth region of their scales using the scanning electron microscope identified correctly about 65% of the sockeye as to specific stock. Results using the X-ray spectrometer are not yet available.
- (3) The feasibility of inducing "chemical tags" in juvenile salmon by introducing certain chemicals into their diets was examined. Results to date show that certain elements were absorbed in body tissues at levels readily distinguishable from those in control fish. Observations are continuing in order to demonstrate whether these levels remain constant or at least identifiable throughout the life cycle.

HERRING

A. S. Hourston

The scope and extent of activities in the Herring Program expanded considerably in 1975. Increased responsibilities arising from the formation of the Pacific Herring Committee and the resulting requests for more detailed and diverse biological information placed greater demands upon the staff. Allocation of funds from herring licence revenue and the participation of two highly competent German scientists (available through the Canada-West Germany cooperative scientific program) and a post-doctoral fellow, provided the means for temporary expansion. Most of the effort continued to be concentrated on improving the data base and analytical procedures for annual stock assessments and on providing this information in a form relevant to current management practice. Although the primary responsibilities of various staff members were to specific projects, most of the staff participated to some extent in most projects as part of a team approach.

1. Pacific Herring CommitteeA. S. Hourston, R. D. Humphreys,
and R. S. K. Isaacson

In 1975 the Pacific Herring Committee was formally established to develop proposals for approval by senior management on policy for utilization of the resource and strategy for management of the fishery. A. S. Hourston was appointed to the Committee to represent R & D line management and R. D. Humphreys was appointed executive secretary. Others appointed to the Committee were the managers of the Northern and Southern Operations Branch, Chief of the Economics Branch, Deputy Chief of Inspection Service and a program head from the Vancouver Laboratory.

Forecasts of runs were made for 26 individual fisheries (Management Units) for the first time in 1975. Subsequent stock assessments indicated that 17 of these forecasts were well within the target levels of accuracy. Data on two of the other runs were inadequate for meaningful stock assessments. The remaining 5 runs were underestimated, mainly as a result of lack of confidence in previous stock assessments. Forecasts were sufficiently in error to affect management strategy for only two of these runs.

Forecasts of 1976 runs indicate an overall abundance somewhat less than the near-record 1975 level but still well above average. Estimates of desired escapement will continue to be based on the rather crude procedures used in 1975 until a more realistic technique can be developed.

An ad hoc study of gillnet dropout carried out in 1975 showed that damage to fish not caught and to spawn depositions below the nets was negligible. As a result, the use of gillnets will continue to be encouraged by the Committee.

A management strategy for the 1975-76 season has been developed by the Committee which proposes to restrict catches from the roe fishery to levels that can be properly processed by the available plant facilities. A small "off season" food fishery has been initiated, supported by funds from other Government sources.

2. Improvement of monitoring techniques

R. D. Humphreys, C. W. Haegele
and D. C. Miller

The major weakness in the present approach to stock assessment appears to be major inconsistencies in the monitoring data on spawn depositions. A major effort was devoted to two aspects of this problem in 1975.

In order to examine the effectiveness of current procedures for estimating spawning intensity in distinguishing the relative abundance of eggs per unit area, Fishery Officers were asked to provide samples of spawn at the various levels of intensity encountered during this 1974 spawning season. Analyses of these samples was completed in 1975. The results indicate extreme variability in numbers of eggs per unit area at any given intensity, e.g. from 33,000/yd² to 1,188,000/yd² for Very Light Intensity and from 199,000 to 5,201,000/yd² for Medium Intensity.

In order to compare the intensity estimates by Fisheries Officers operating under normal field conditions with a more quantitative standard, an intensive underwater survey was undertaken during the 1975 spawning season on two spawning locations in Barkley Sound. These two locations were also surveyed in the traditional manner by a Fishery Officer. Divers found vegetation and spawn to a depth of -16 m covering an area of 242,000 m² at one site and 200,500 m² at the other. In contrast, the Fishery Officer, using traditional techniques, was unable to detect spawnings in deep water. His estimates of area covered by spawn were 56,000 m² and 54,000 m², respectively. Another major difference was discovered in the classification of spawnings by intensity category. For example, the Fishery Officer saw only 23% of the total deposition on one of the sites surveyed, but he classified 84% (46,000 m²) of what he saw as Heavy Deposition. On the other hand, PBS divers observed virtually all the spawn at the site, but classified as Heavy only 8% (18,400 m²) of what they saw. The net result of these discrepancies was that Fishery Officer estimates of total spawn deposition were 63% lower than the PBS estimate on one site, and 44% lower on the other.

The results of these two experiments suggest that current intensity classifications are either insufficiently precise or too poorly documented for successful use by Fisheries Officers in the field at the present level of monitoring effort.

In conjunction with the second experiment, experienced and inexperienced PBS personnel estimated spawning intensity in terms of layers of eggs as an alternative to the present intensity scale. Preliminary analysis suggests that this procedure results in less variability in the range of eggs per square yard within a category than does the present intensity scale. It was concluded that the introduction of this procedure, accompanied by the distribution of a well illustrated manual to all Fishery Officers would appreciably improve this aspect of the monitoring program.

Another weakness in the spawn monitoring data is the sparseness of information on the distribution and relative proportions of the various substrates involved and apparent inconsistencies in measurements of lengths and widths. In order to improve these aspects of the spawn monitoring data, procedures were developed in 1974 to prepare detailed topographic maps of major spawning grounds showing vegetation zones. These procedures involve low level aerial photography supplemented by diver surveys. Maps were prepared in 1975 for most of the Barkley Sound area, which was photographed in 1974 and surveyed by divers in 1975. Spawning grounds on the lower east coast of Vancouver Island were photographed in two flights during 1975. Ten more flights will be required to cover all major spawning grounds on the coast.

Analysis in 1975 of the results of tests conducted in 1974 to evaluate the effectiveness of current procedures for sampling the catch showed significant differences in the characteristics recorded for samples from loads taken from the same fishing area during the same fishing week. Tests also indicated that only one sample need be taken from anywhere within each load and that a sample size of 100 fish is minimal for an allowable error of 10% in the proportions of the major age groups.

A hastily devised procedure for equating the proportion of fish below a designated length defined for each management unit to the proportion of new recruits showed considerable promise as a quick means of estimating recruitment in the field in 1975.

3. Improvement and expansion of population analyses

A. S. Hourston and S. Kerr

Analytical procedures in the population analyses for annual stock assessments were modified further in 1975 to improve their precision and efficiency on the new Xerox computing system. A functional program package for the new system will not be available before 1976.

Preliminary analyses of egg counts from over 4000 pairs of herring ovaries collected in 1974 indicate appreciably higher fecundities at all lengths than those indicated by former studies. On this basis, the abundance of spawners in current stock assessments is overestimated.

4. Extension of knowledge of life history and ecology

(a) Egg survival and viability of hatch

H. Rosenthal, H. von Westernhagen
and A. S. Hourston

Preliminary results of laboratory experiments on spawnings of different intensities on a variety of substrates indicate better survival at higher egg densities on finer structured substrates such as eelgrass and red algae, than on flat surfaces such as kelp and rocks. This appears to result from a looser packing of eggs on the former. Some spawning intensities which were not quite heavy enough to result in egg mortality produced large proportions of deformed larvae and hence were probably too heavy for optimum production. Sperm densities required for effective fertilization were also investigated.

(b) Predation on herring larvaeH. Rosenthal, H. von Westernhagen
and S. Kerr

Field observations and laboratory experiments indicate heavy predation on newly hatched herring larvae by newly hatched Hyperoche (Gammaridae) and juvenile and adult herring when the larvae are encountered by the latter.

(c) Spawning behaviour

N. E. Stacey

In 1975, the first year of a study of herring spawning behaviour and its environmental regulation, mature herring from two stocks (local and migratory) were obtained prior to and during the spawning season and maintained in the laboratory. Observations of spawning behaviour of the captive fish indicate that two patterns of gamete release are employed by each sex and suggest that spawning behaviour of Pacific and Atlantic herring may be quite similar. Males were observed to release milt in midwater and also to attach to the substrate milt ribbons which could persist for two days. Females spawned on the substrate in a manner similar to males; patterns of egg deposition suggest they also release eggs in midwater.

When ovulated and spermiated herring were maintained in unisexual schools, spawning behaviour was inhibited and the papillae withdrawn. Addition of small quantities of herring sperm caused rapid and drastic changes in schooling behaviour, papilla extension, and, especially in males, both patterns of gamete release. The lesser response of females may be due to apparent sexually dimorphic schooling behaviour observed in schools of mixed sex.

Preliminary experiments are in progress to determine whether accelerated annual photoperiod is capable of advancing gonadal maturation and whether unisexual schools maintained under natural photoperiod will undergo gonadal maturation similar to wild fish.

(d) Maturation of ovaries

D. N. Outram

Ovaries from the Porlier Pass stock of herring were sampled periodically from July 1974 to June 1975, to examine changes in the external appearance, histology and gonosomatic index (ovary weight divided by the weight of the rest of the fish). Over 650 fish were examined in this way. From July to March, the gonosomatic index rose from less than 1 to over 21, the length of the ovaries increased from 58 mm to 129 mm and the colour changed from whitish to orange to translucent gold (at ovulation). The diameter of the eggs increased sharply at ovulation from about .8 mm to 1.2 mm at ovulation.

Ovary pairs examined were asymmetrical with the left ovary averaging 2.3% longer and 16% heavier than the right. Two fish were found to have 3 ovaries.

The ovaries of virgin fish maturing for the first time could only be distinguished from those of fish that had previously spawned by histological means.

CRUSTACEA

T. H. Butler

1. Mainland inlets prawn projectT. H. Butler, J. A. Boutillier
and A. N. Yates

Test fishing since November 1975 has revealed fairly constant catches over the whole region, but mean catches in Tribune Channel are somewhat lower. Accordingly, a recommendation was made to Fisheries Operations to establish an experimental closure in that area. There are no clear relationships between prawn abundance and seawater temperature and salinities. Determination of growth and age is in progress.

2. Hecate Strait crab survey

T. H. Butler

To assess the current situation in Hecate Strait, and to assess future prospects for the fishery, a trap and trawl survey was conducted in July, with the A.P. KNIGHT. Results are that, though fishing improved in 1975, legal male crabs remain at a low level of abundance. They are also considerably less widespread (within 50 square miles) than during the 1950s and 1960s (400 square miles). Because of a fair showing of yearlings and other sublegal age groups, compared with earlier years, future prospects appear good.

A report was submitted to the fishery industry and Fisheries Operations, with a recommendation for a closure in Hecate Strait, from July-September 15, to take effect in 1976. The proposed period was based on observations of soft-shelled crabs in 1975, and in earlier years (1947-1957).

3. Tofino shrimp fishery

T. H. Butler and A. N. Yates

A survey of the fishing ground to determine boundaries and to estimate biomass was conducted in May, using the G.B. REED. The total area was 193 square miles and stock size was 11.3 million lb. On the basis of a similar survey in 1973, the biomass was estimated at 15.3 million lb.

Landings from the commercial fishery in 1975 totalled 1.37 million lb, less than half the production in 1974. In 1975 there was a general fishing industry strike and market demand was low.

Sampling of the commercial catch has provided information on age and sex composition and total mortality rates.

4. Prawn explorationT. H. Butler, J. G. Lindsay
and C. B. Chic

This project was set up to assist the economic development of communities in the central coastal region. Financial support has been obtained from the Industrial Development Branch (75%) and the Department of Recreation and Conservation in Victoria (25%).

Two main grounds, Fish Egg Inlet and Kwatna Inlet, and others of minor importance, were found during the 1974-75 survey. Two additional productive areas,, Kitasu Bay and Gardner Canal were found during the second survey.

MARINE INVERTEBRATES

N. Bourne

Pendrell Sound oyster breeding projectN. Bourne, P. Breen
and G. D. Heritage

An estimated 65% of the oysters produced in British Columbia are cultured from seed, nearly all of which in recent years has been collected in Pendrell Sound. This project was begun in 1974 to determine whether the oyster industry can continue to rely on Pendrell Sound as a source of seed; how the collection of spat can be made more efficient; and how the annual spatfall prediction can be made more accurate at the least cost.

In 1975, the first plankton tows, taken on June 26, showed that some oyster spawning had already taken place. Large spawnings occurred between July 3 and July 8, followed by smaller spawnings nearly every day until August 4.

As a result of the large numbers of oyster larvae and good water conditions present in mid-July, the industry was advised to expose cultch. Approximately 46,000 strings of shell cultch, 1,500 bundles of cement-coated veneer, and 180 bundles of cement 'diamond chips' were exposed by three companies. The expected spatfall reached a peak on July 22, producing a commercially successful set. The count on experimental cultch exposed for one week during this period averaged 203 spat/shell, with a maximum of nearly 500/shell at one station.

A successful project was carried out in conjunction with the Provincial Government, the oyster industry, and the Industrial Development Branch to test the feasibility of commercial spat collection in deep water at one station.

Clam aquaculture

N. Bourne

An experiment in which manila clams were grown in Nestier trays was terminated in June. Preliminary analysis shows satisfactory growth but high mortality. Fouling of culture trays, predation within trays and decreases in ambient salinity may all have contributed to this mortality.

Experiments in which manila and butter clams were planted in Departure Bay, Ladysmith Harbour and Barkley Sound were also terminated. Data from these experiments are not yet analysed.

Mussel culture

D. B. Quayle

Studies involving culture of the bay mussel were carried out under contract by D. B. Quayle. Juvenile mussels were collected from the shore and placed on growing ropes, which were then suspended from rafts. After one year, yields of 15 kg whole weight per m of rope were obtained. Both biological and engineering aspects of culture are being studied, and a report is expected in 1976.

Sea urchin, abalone, and sea cucumber project

P. Breen

A project was initiated which will examine the fisheries ecology of abalone and echinoderms. In 1975 the project was limited to a thorough literature search because of demands made by the Pendrell Sound project in the absence of Neil Bourne.

Uptake and elimination of coliform bacteria by shellfish

F. Bernard

This project was completed in 1975, and results were presented at the Shellfish Workshop in Ottawa. A report on this project was written jointly with D. B. Quayle.

Standing Committee on Shellfish, Pacific RegionN. Bourne, P. Breen
and G. D. Heritage

Through the Committee, efforts were continued in 1975 to promote development of shellfish utilization. Guidelines for the construction and use of mechanical clam harvesters were drawn up. The program continued to be the agency responsible for examining samples of plankton blooms thought to be toxic.

HYDROACOUSTICS

F. H. C. Taylor
and L. W. Barner

In 1975 the Investigation was involved in the estimation of the distribution and abundance of hake and pollock stocks in the Strait of Georgia and of herring and hake stocks off the west coast of Vancouver Island.

In the Strait of Georgia, three cruises were carried out, in January, February and June, covering an area on each of about 1,200 square miles in two 4-day periods. Between one-third and one-half the time was devoted to midwater trawling to identify the species responsible for the sound scattering layers and the schools encountered.

Hake and dogfish were the dominant species. Pollock were present in some areas but in total were about one-fifth the hake stock. Brown catshark occurred in relatively small numbers on the first two cruises. In January and February, hake, dogfish and pollock were found in deep water, mainly over the five major basins forming the northern and central parts of the Strait. There was evidence of a southward movement of hake and pollock in February, leading to an increased concentration south of Texada Island. In June, hake and pollock were found in shallow water from 50-150 m in large concentrations along the Vancouver Island shore from Nanaimo to Comox. Dogfish were comparatively scarce. Visual observations suggested they may have been in the surface layer excluded from the integrator analyses because of surface reverberation. Relatively few fish of any kind were found on any of the three cruises in the southern part of the Strait subject to the influence of the Fraser River.

Estimates in absolute terms were made for hake and pollock, but not for dogfish because of the lack of any target strength information. In January there were 116,800 m tons of hake and 11,100 m tons of pollock, in February 88,000 m tons of hake and 17,800 m tons of pollock, and in June, 184,000 m tons of hake and 24,500 m tons of pollock. The foregoing amounts should be regarded only as rough indications of the size of the stocks. It is not possible at present to estimate the errors associated with the estimates of abundance. The major sources of error are most probably the assumptions of exclusive distribution of fish and plankton in relation to depth estimates of water volume associated with different levels of fish density, the species composition of the catches, and target strengths. The errors associated with fish density estimates and parameters of the electronic system would be relatively small.

Two surveys were made on the west coast of Vancouver Island, in September and November. The first covered the area from lat. 48°00'N to 49°20'N, and from the coast to the 100-fm contour; the second was limited to the area where fish concentrations had been found in other years between lat. 48°10'N and 48°50' N. Analyses of data from both cruises have been delayed because of the inevitable problems associated with the introduction of new equipment. This equipment will eventually result in faster data processing and more efficient use of time at sea. In November the use of towed transducers greatly reduced dependence on good weather. Surveying was carried on with winds as high as 40 knots. Previously, surveying was halted by 20-25 knot winds. However, both cable drag and signal attenuation were greater than had been anticipated. The former limited towing depth, the latter received signal strength.

First impressions suggest adult herring were less abundant in 1975 than in the previous year, and were of greater average size. Juvenile herring in November were unusually abundant and widely distributed. In September, the major concentration of herring was located on Swiftsure Bank, smaller concentrations occurred on the southwest and southeast corners of La Pérouse Bank, along the outer edge of the Prairies and on the Prairies below the Finger Bank. Scattered schools occurred off Sydney Inlet. In November, a large dense concentration was located below the Finger Bank and scattered schools occurred over the Prairies to the Juan de Fuca trench. Only scattered schools remained on Swiftsure Bank and on the southeast corner. No concentrations were found from the southwest corner north. The concentrations of hake found in September outside La Pérouse Bank between 50 and 100 fm, had disappeared in November and the concentration on the inner edge of the Prairies below the Finger Bank was much reduced.

FISHERIES OCEANOGRAPHY

W. P. Wickett

Reports were prepared on annual changes in crab, halibut, herring and rock sole stocks related to annual changes in the ocean. Salinity records at Station "P" and at coastal stations and mean sea level records were used as indices of factors affecting primary productivity and coastal water movements.

A report giving a method of predicting the percentage of Fraser River sockeye runs entering via Johnstone Straits, was sent to the International Pacific Salmon Commission. The method explains 71% of the variance for the years 1953 to 1973.

A short study on hours of bright sunlight in summer on the British Columbia coast shows that the sunlight and winter winds are still not independent variables in recent years. The interacting mechanism is unknown.

The cooperative work with the Oceanographic Branch, Ottawa, resulted in a second technical report on Atlantic Ocean transport.

Papers were presented to the annual meeting of the Canadian Meteorological Society, A.S.L.O., the Hydrography Committee of I.C.E.S. and the Pacific Science Congress. Transport computations for the North Pacific Ocean for 1973 and 1974 were published as Technical Reports 522 and 540. This series is useful as an aid to analyzing anomalous fish catches and water movements.

A paper on mass transfer theory and its application to fish eggs was delivered to, and has been published by, the Electrochemical Society.

S A L M O N E N H A N C E M E N T , A Q U A C U L T U R E A N D
F I S H H E A L T H S E C T I O N

L. Margolis

This section conducts investigations to improve and develop methods for enhancing salmonid production, to establish the biological basis for saltwater salmonid aquaculture in floating netpens, and to identify the important diseases of fishes and develop methods for their prevention, control, and eradication. Disease diagnostic services and fish health certification of salmonid stocks are a responsibility of this Section.

SALMON ENHANCEMENT PROGRAM

This program is divided into three sub-programs dealing with (1) Incubation systems, (2) Juvenile production systems, and (3) Stock establishment and improvement.

I. SUB-PROGRAM: INCUBATION SYSTEMS

(a) Salmon behaviour studies

C. Groot, C. Turner,
and I. Miki

Sockeye salmon spawning density studies

A study of the effect of density of spawners on social interaction and egg deposition in sockeye salmon was repeated in 1975 in Fulton spawning channel No. 1. Nine pens, each measuring 8 × 8 yd were stocked with 40 to 200 spawners at increments of 20. The total number of 1,080 fish were loaded into the pens in 2 days.

Female-to-male and 4- to 5-year-old ratios in the pens were, respectively, 3 to 2 and 1 to 1, which are similar to ratios observed in the channel in 1972-1974. Instantaneous densities created this year ranged from 3.0-0.5 sq yd per female. Fulton channel No. 1 is usually loaded to densities of 1.1-1.2 sq yd per female.

The nine pens were arranged in random order and were separated by 8-ft sections to avoid interactions between pens. Three 20-ft high towers, located at strategic points, were used to make visual, film, and video observations of fish in the pens and in three 8 × 8-yd plots in the spawning channel. Actual spawning does not occur during daylight hours in sockeye salmon and therefore it must primarily happen at night. Low-light sensitive TV combined with red lights were used in 1975 to check on this assumption.

Observations were made on the sequence in which areas were occupied, on territory distribution, social interaction, longevity, time of dying, and gamete retention. Analysis of the data is still in progress. The kind of results that can be expected from this study are illustrated by the following observations and conclusions:

- (i) The table below indicates that the maximum number of territories for three initial density levels of 36, 72, and 108 females per pen occurred when 74 to 83% of the females were still in the pen. About one-half of the females (50-61%) were then spawning. The rate of die-off and the rate of spawning seem independent of loading density.

The maximum density to which sockeye salmon will pack themselves in the 8 × 9-yd spawning plots is 1.4 sq yd per female. Minimum territory sizes in control plots in the spawning channel were, respectively, 3.0, 2.6, and 1.8 sq yd per female. The channel is generally loaded to a level somewhat less than 72 females per 72 sq yd.

Female loading density	Ratio	No. females present	Ratio	No. females holding territory	Average min. territory size
36	0.77	28	0.61	17	3.4 sq yd/female
72	0.83	60	0.50	30	2.2 sq yd/female
36	0.74	80	0.58	46	1.4 sq yd/female

- (ii) Aggressive interactions per fish increase and number of diggings decrease with rising numbers of fish per unit area. Also, spawning success (percent of eggs deposited) shows a slight decrease with increased female density (total loading density of pens) to a density of approximately 0.8 sq yd per female and drops off sharply at higher densities. A similar effect occurs within a pen. As fish start to die off and total female density decreases, spawning success increases. These results suggest that with respect to egg retention a safe maximum loading density is around 1.0 sq yd per female. The packing level used for Fulton spawning channel No. 1 during the last few years is between 1.1 to 1.2 sq yd per female.

There is no relationship between male loading density and percent gonad depletion. On the average, males had about half of their testes in weight left upon dying.

- (iii) Time in days from entering the channel to 50% mortality was 12 1/2 days in the pens and in the channel. No significant difference occurred between males and females.

- (iv) One hundred sockeye (50 males and 50 females) were tagged with Petersen disc tags upon entering the channel. These fish travelled from 100-15,000 ft before spawning with a mean travelling distance of 4,100-5,000 ft for both males and females. The mean time to fish spawning in the pens and in the channel was 6 1/2 days after entrance for both sexes.

Reporting of sonic tracking studies

A manuscript on sonic tracking studies in Babine Lake has been accepted for publication. Results of sonic tracking studies with sockeye and chum salmon in Georgia Strait are presently being prepared for publication as a Technical Report.

(b) Salmon incubation requirements

R. A. Bams, and
D. G. Crabtree

1. During 1975 data analysis and reporting of a gene-transfer experiment on pink salmon, carried out from 1971-1973, was completed. The MS has been accepted for publication in the Board's Journal and should appear early in 1976.
2. A second publication was completed concerning method, equipment and techniques as developed and used at our Headquarters Creek hatchery facility over the years 1968-1974. This extensive report should appear shortly in the Fisheries and Marine Service Technical Report series.
3. A literature search was carried out in collaboration with Don Alderdice on published material relating to incubation of salmonids, covering primarily the years 1965-1975. Some 1,900 articles have been gathered into a collection location, indexing and subject coding has been completed, and we are in the process of computerizing this information for accessing and printout in a first report for distribution to other workers. This volume will allow ready access to the listed references by author and by a detailed subject index, which includes species and life stages. It is anticipated that the collection will be updated at intervals and thus comprise a current and complete source of readily available information of invaluable interest to all concerned with incubational aspects in, e.g., the impending salmon enhancement project.
4. Field work was restricted to hydraulic sampling of nine experimental spawning pens located in Fulton spawning channel No. 1. Purpose of this work was twofold: (1) to evaluate the technique in terms of accuracy of prediction of egg and alevin densities, and (2) to estimate density and survival of eggs and alevins in the experimental pens. In addition fry counts were attempted in three of the pens to obtain data on numbers, emergence patterns and fry runs, and stages of development at emergence. Preliminary analysis of the results has cast considerable suspicion on the suitability of the technique for density measurements, but various shortcomings in the first year's operations preclude firm conclusions. The 1975-1976 repeat operations are expected to allow adequate evaluation of the technique's possibilities. The fry-trapping operations in 1975 were equally fraught with operational difficulties and, again, a repeat operation in 1976 is hoped to give us more reliable results.

5. A limited effort was expended on preparing for measurement and recording of environmental conditions in gravel beds. Precious little appears available which is amenable to automation and mass-collection of data points from many sampling locations. Extensive equipment development and calibration will be necessary, presumably largely under contract with specialized engineering firms, if this approach is to be realized.

(c) Salmon development requirements

D. Alderdice and
F. Velsen

Factors affecting deposition, incubation and survival of salmonid eggs.
A bibliography of the literature, 1965-1975.

The search and documentation phase of this project was completed for the last 10-yr period. The volume of literature found and processed has necessitated a decision to report results in parts, the first being the period 1965-1975. Continuation of the project would involve two further periods: 1950-1964, and 1870-1949. A computer printout of the 1965-1975 results will be produced as a Technical Report, including numerical, author, species-developmental stage and subject indices for the 1,800 references involved.

Temperature and developmental staging in eggs of salmonids. Data compilation.

Available data on developmental staging and velocity in relation to temperature has been compiled as a basis for further work in Pacific salmon enhancement projects. These data will be presented as a Manuscript Report.

Design and flow tests of a new experimental salmon egg incubator complete.

Specifications have been drawn up for contracting to build 35 to 50 units. These will provide triplicate samples of about 200 each of salmon eggs for incubation under controlled conditions of temperature, dissolved oxygen, apparent velocity and ammonia.

Baseline data on gas transfer in salmon eggs.

Under contract (Dr. R. O'Brien, Univ. Victoria), preliminary studies were completed in 1975. Laser interferometry is being utilized as a technique for measuring gas transfer in salmon eggs. Results reported to date were from experiments conducted at 10 C and one atmosphere overpressure of oxygen (one atmosphere above ambient), with coho eggs just prior to hatching. Estimated oxygen utilization rates of 6 mg/egg/hr were obtained in 25-min runs. The estimated error ($\pm 10\%$) should be reduceable to $\pm 1\%$ in future runs, and utilization rates should be obtainable in approximately 12-min periods. Further, it was noted that when perfusion velocity drops to zero, a toroidal circulation develops around the egg -- providing it with a limited means of coping with transient oxygen deficits. This circulation is a function of density differences of oxygen solutions in water. Finally, preliminary results suggest -- taking into consideration apparent velocity, egg size and void space dimensions -- that 5/8-in crushed gravel should be near-optimal for incubation of Pacific salmon eggs.

Experiments on developmental staging in pink and sockeye salmon.

Literature reviews have pointed out major deficiencies in knowledge of developmental staging in Pacific salmon eggs in relation to temperature. Such data are basic to solution of problems related to egg development. Initial studies of staging are currently underway for pink and sockeye eggs (from Glendale River and Fulton River, respectively) at three temperatures, 5, 8, and 11 C. Results to date indicate that the incipient low lethal temperature for pink salmon egg development is near 5.5 C, applied as a constant temperature after fertilization. Egg samples from fertilization to hatching will be used to develop a chart of developmental stages in relation to accumulated temperature experience. Techniques for egg preservation and staining are complete, and all developmental stages will be photographed in colour.

II. SUB-PROGRAM: JUVENILE PRODUCTION SYSTEMS

(a) Hatchery juvenile productionH. T. Bilton and
D. W. JenkinsonTime of release

In April, May, and June, 1973, three groups of coho smolts totalling approximately 39,000 fish, were released into Rosewall Creek. In the fall of 1973, 333 jacks from these releases were recovered in Rosewall Creek. More than one-half of the jacks originated from the May smolt release with fish from the April release most poorly represented. Comparison of mean lengths and weights of fish from the three releases indicated those from the April release were the largest and those from the June release the smallest. During the summer and fall of 1974, 2,929 marked Rosewall coho were recovered in the commercial and sports fisheries, 714 of these originated from the April release, 1,108 from the May release, and 1,107 from the June release. Most (2,471) were recovered in the south, in Georgia Strait and outside off the west coast of Vancouver Island (384).

A total of 5,084 fish released from Rosewall Creek were estimated to have been caught in the fisheries. Analyses of the data indicated that the estimated proportions of fish from each release caught in Georgia Strait and caught off the west coast of Vancouver Island did not differ significantly. A higher proportion of fish from the April and June releases were caught in the northern British Columbia area than fish from the May release. In catches off the Washington coast, the highest proportion of Rosewall Creek fish originated from the June release. In the fall of 1974, a total of 1,797 adults were recovered in Rosewall Creek, of which 448 originated from the April release, 643 from the May release, and 706 from the June release. Comparison of mean lengths and weights of fish from each release indicated that fish from the June release were the smallest and those from the May release were the largest. The estimated total percent return (jacks and adults in the catch plus escapement) by release ranged from 15.77 for fish released in April to 22.26 and 23.23 for fish released in May and June, respectively. The ratio of pounds of adult fish that returned (catch plus escapement) to pounds of fish released indicated the fish released in May provided the greatest yield (56.6 lb returned to 1 lb of fish released) and

those released in June the lowest yield (41.1 lb to 1 lb). More detailed analyses of these results are given in a report that has been written to be submitted for publication as a Manuscript Report.

Time and size at release

Approximately 150,000 coho smolts, progeny of Big Qualicum coho of the 1973 brood-year, were released from the Rosewall Creek Hatchery in the spring of 1975. Fish of three different major size categories (20 fish/lb, 30 fish/lb, and 40 fish/lb) were marked, tagged, and released at three different times on April 14, May 12, and June 10, 1975. An additional 7,000 fish were tagged and released on July 8, 1975. The jack returns from these releases into Rosewall Creek are currently being monitored. Analyses of these data will be completed in the coming year. Recovery of adult coho from these groups will be made in the fisheries and at Rosewall Creek in 1976.

Accelerated growth studies at Rosewall Creek

(i) During the period February 7, 1974 to May 30, 1974, 14,202 coho fry of Robertson-Big Qualicum River origin of the 1973 brood-year were reared at a mean temperature of 15 C to a mean weight of approximately 10 g. Ten thousand six hundred and three were marked by removal of the adipose fin and nose-tagged using binary-coded magnetic wire tags, and were released into Rosewall Creek on June 10, 1974. At the same time, 12,665 normally reared (reared for 14 mo at ambient temperatures) coho of the same origin but from the 1972 brood-year were also marked, tagged and released into Rosewall Creek on the same date. Recovery of adult coho from these releases have been made in the fisheries and are currently being recovered at Rosewall Creek. Analyses of these data will be completed in the coming year.

(ii) An experiment was conducted to determine at what early life stage an advantage in growth might be achieved through acceleration by increased water temperatures, and if the advantage is maintained after the fish were returned to lower ambient water temperatures. Ten experimental populations of young coho salmon were held in separate tanks from fertilization for a period of 6 mo. These were reared at ambient and at higher water temperatures for various periods of time. Results indicated there was a strong positive correlation between final length and the accumulated degree days. There was little evidence to suggest that acceleration had an effect on the subsequent growth rates of fish after the water temperatures were lowered. There was a highly significant positive correlation between the number of degree days and the average condition factor, suggesting there was a greater tendency to store fats at higher temperatures. Repeated sampling did not have an adverse effect on growth, but there was some interaction between sex and treatment. Results of this experiment are given in a report to be submitted for publication as a Technical Report.

Accelerated growth studies at the Big Qualicum River

During 1975, the installation of a facility capable of rearing 45,000 juvenile coho at a temperature of 15 C was completed. A total of 50,000 Big Qualicum coho eggs from the 1975 brood are presently being incubated in the facility. It is anticipated the progeny from these eggs will be released in late May of 1976.

(b) Joint comprehensive report on high seas distribution of sockeye salmon

H. T. Bilton

A draft of the joint comprehensive report on the high seas distribution of sockeye salmon was completed in 1975 and has been submitted to the Secretariat of the International North Pacific Fisheries Commission for subsequent review by referees from each of the three countries.

(c) Average weight of pink salmon in catches from areas along the B.C. coast

H. T. Bilton

In recent years, pink salmon have been unusually small in size. Members of the fishing industry expressed concern with regard to the small size of pink salmon in 1972 and with an apparent trend towards smaller pinks in recent years. In 1973 a study made to determine if such a trend existed demonstrated this was the case with only a very low probability that it occurred by chance. In 1975, the question was re-examined incorporating both earlier data and additional recent data. The results indicated that from 1951-1974 there has been a significant trend towards smaller pink salmon in both the even- and odd-year catches. There was no evidence to suggest that the decrease in size of pinks was correlated with the numbers of fish in the catches. The most likely cause of the downward trend in the size of pinks may be due to selection of larger fish by the net fishery. A report has been written to be submitted for publication in our Journal.

(d) Stream juvenile productionJ. H. Mundie,
D. E. Mounce, and
D. D. Williams

To reduce the traditional hatchery costs of raising smolts, and to produce a natural product with high ocean survival, an attempt is being made to apply the principles of natural stream rearing to high density populations of coho in a semi-natural stream channel. The objective is to optimize conditions for juveniles by alternating high-velocity food-producing areas with low-velocity habitat for fish. A substantial output of smolts is necessary to justify costs; feeding must therefore be mainly on artificial foods, supplemented, however, by aquatic and terrestrial insects. These ensure a living component in the diet, and the acquisition of natural feeding behaviour by the fish.

Four sites alongside the Big Qualicum River, Vancouver Island, were surveyed by engineers of Fisheries Operations; one was selected in the vicinity of Hunt Creek. Design and construction of an adjustable inclined screen outlet, and excavation of the channel, were completed by Fisheries Operations in the winter months, with due protection of the main river. Channel banks were seeded in March. The inlet chosen was similar to the inlet of the Big Qualicum No. 2 spawning channel, with vertical screens and trash-rack parallel to the river, and a stepped river weir. It can pass up to 45 cfs. Its construction was done under contract during summer, along with digging of pools, and placing of riffle gravel and marginal rip-rap. The channel was opened in mid-September prior to the main returns of salmon to the river.

Channel dimensions are given below:

Length - 1,300 ft	Pool length - 30 ft
Surface width - 15 ft	Depth of riffles - 0.5 ft
Overall slope - 0.004	Depth of pools - 3 ft
Discharge - 0-15 cfs	Surface velocity in riffles - 2 ft/sec
No. of riffle/pool sequences - 25	Surface velocity in pools - 0.3 ft/sec
Riffle length - 20 ft	Gravel size - 0.75-1.5 in

At the fifth pool a concrete division has been provided to accept a permanent screen which will separate the fry of the year from the previous year's brood. A metering pad was also installed.

It is intended initially to operate the channel with 15 cfs of discharge and to raise two populations of fish in different sections, each of 10 riffles and pools. Research will centre on the role of the riffle invertebrates in recycling wastes, on maximizing aeration from the riffles to the pools, and on making insects available to the fish.

Several necessary features have yet to be installed, of which a chain-link fence to keep out predators, and a wooden footwalk are the major items.

Three field experiments related to the channel were carried out. In August, eight parallel troughs were set up in the Qualicum River, supplied with gravel and allowed to colonize with benthos. The troughs, apart from controls, received weekly additions of O.M.P. in geometrically increased amounts. After 6 wk the benthos was collected to determine its response to treatment. Analysis is not yet complete. Diversity of river benthos is found to decrease with increase in O.M.P. Chironomids respond most to enrichment; oligochaetes are uncommon.

A similar experiment was carried out in the rearing channel, but additions of fish faeces were used. This experiment is still in progress at the time of writing. The invertebrates of hatchery effluents are predominantly oligochaetes.

Finally, the rate at which benthos can be cropped for feeding fish is being measured by disturbing areas of channel gravel and recording the rate of recolonization from upstream.

III. SUB-PROGRAM: STOCK ESTABLISHMENT AND IMPROVEMENT

F. C. Withler and
R. B. Morley

New techniques are being applied to the question of introducing self-sustaining pink salmon runs into the barren cycle of streams having a pronounced "on-off" characteristic. Earlier attempts to establish such runs were based on the transfer of fertilized eggs from donor streams into receiving streams in their off-year. None of these transfers resulted in self-sustaining new runs of pinks.

Two techniques have been developed recently to transfer the male component of the on-year gene pool into donor eggs brought into the off-year cycle. One involves liquid nitrogen deep-freezing of on-year sperm so that they can be stored and applied to eggs in the off-year; the other involves injection of pituitary gonadotrophins into the juveniles of on-year runs, causing the males to mature at 1 yr of age and thus providing a source of on-year sperm with which to fertilize donor eggs.

A field trial to test the hypothesis that an infusion of the on-year gene pool into eggs brought from a donor stream will significantly increase the return of adults to the receiving stream, is underway on the Bear River. This stream is situated on the northeast coast of Vancouver Island, about 25 mi north of Campbell River. It has a large pink run in even-numbered years (estimated at about 150,000 in 1974) and none in odd-numbered years. In 1975, an access road was built to a site on the river where a hatchery capable of incubating 3 million eggs was built to facilitate the test. In preparation for the test, over 3,000 packets of milt from 1974 Bear River males had been taken and stored in liquid nitrogen until the fall of 1975. Further, eggs from the 1974 run had been incubated at elevated temperatures to accelerate development and the resulting juveniles injected with gonadotrophins by Dr. E. M. Donaldson of the West Vancouver Laboratory, so that approximately 300 precocious males were available in the fall of 1975.

To provide ova and "control" milt for the test, the Glendale River holding ponds were re-activated. (The Glendale River flows into Knight Inlet. It supports major pink runs in both odd- and even-numbered years. It lies approximately 25 mi due north of the Bear River mouth.) An estimated 2,722,560 ova were stripped between October 6-18 from 1,993 females captured and held in the holding ponds; some 571 males provided milt necessary for the tests. The eggs were treated as follows:

Fertilized by deep-frozen 1974 Bear River sperm	609,280
Fertilized by milt from precocious males	370,560
Fertilized by milt from 1975 Glendale males - "controls"	368,640
Fertilized by milt from 1975 Glendale males to provide "stock" eggs for incubation tests	1,374,080

The eggs have been held in Heath vertical stack incubators at the Bear River Hatchery. "Egg-picking" (removal of dead and fertilized eggs from the trays) was completed by the end of November. Fertilization rates for the four treatments outlined above were as follows:

Fertilized by frozen milt	45%
Fertilized by milt from precocious males	96%
Fertilized by milt from 1975 Glendale males (controls)	92%
Fertilized by milt from 1975 Glendale males (for incubation tests)	92%

The remaining live eggs are being placed in upwelling gravel boxes according to the methods developed by R. A. Bams at Headquarters Creek. Hatching is expected to begin around mid-December. It is expected that the fry will emerge in April and May, 1976. At that time the three test groups (frozen sperm, accelerated male, control) will be marked distinctively by fin-clipping and released into the Bear River.

IV. SUB-PROGRAM: LAKE FERTILIZATION

The assessment of post-fertilization conditions in Great Central Lake as seen in the nutrients, plankton, in-lake juvenile sockeye, and smolts and adults was continued through 1975. In addition, smolt samples were collected for parasite studies and some further sampling of stickleback was undertaken to complete earlier cestode studies.

As in previous years, the cooperation of the Salmon Populations Program and Fisheries Operations was of great assistance in sampling the adult sockeye and smolts.

A study of other lakes which might be amenable to fertilization was conducted through contractual arrangements. The results of the survey of 26 selected lakes is expected in the near future.

(a) Primary and secondary production

C. McAllister and K. Stephens

The biweekly sampling at two locations in Great Central Lake indicates a return to near prefertilization conditions. Again, with cessation of fertilization nitrate concentrations increased, confirming that phosphate is the limiting nutrient. Primary production remains much less than during fertilization. Statistical analyses performed during the year on past data confirm that production in fertilized areas of the lake exceeded that in control areas with a high degree of significance, in contrast to measures of plant standing stock. Calculations of nutrient budgets were continued and computation of grazing budgets initiated. The latter two efforts are viewed as important for design of future fertilization strategies, whether in Great Central Lake or elsewhere.

The zooplankton standing stock has declined to levels equal to or less than that found in 1969, the year prior to fertilization. However, the number of species of zooplankton in the samples is still higher than in 1969 and 1970. Thus, under pre- and early-fertilization conditions there were 12-14 species while in the last year of fertilization, 1973, there were 21 species. Currently 2 yr after the last fertilization, there are 18 zooplankton species present in the samples.

(b) Juvenile sockeye salmon

W. Barraclough and D. Robinson

Estimates of juvenile sockeye salmon in the lake were determined by a high frequency echo-sounder and midwater trawl. Efficiency of the trawl was inversely related to ambient light above 1.8×10^{-6} ft candles. These estimates had a low variance and good resolution was established between age groups of the juveniles. The results indicate a close correlation between numbers of spawners and progeny.

The in-lake survival of juveniles appeared to be at least doubled during the years of fertilization. In 1975, there was an estimated 2.7% survival from potential egg deposition to the November 1975 in-lake estimate of underyearling sockeye. This contrasts with 11.7% survival during years of fertilization and about 5% survival for the fish observed prior to fertilization.

The 1975 smolts were comprised of the smallest 1- and 2-yr-old seaward migrants observed to date. Unfortunately, construction in Robertson Creek channels prevented obtaining quantitative samples from the early part and peak of the smolt migration.

The data on age composition, circuli counts and measurements of juvenile sockeye salmon caught in Great Central Lake and the smolts emigrating from the lake from 1969-1974 have been completed and compiled in three data reports this past year. The data include all that were available from smolts emigrating from G.C.L. as well as the Somass River System in years prior to fertilization for comparative studies.

A computer program for the analysis of these data has been written and trial printouts completed. The results include the average number of circuli for the 1- and 2-yr-old smolts leaving the lake, the distances between each of the circuli during the years prior to, during, and after fertilization. These data provide a direct link with the freshwater growth shown on scales of the surviving adults that return to the lake.

(c) Effect of lake enrichment on production of adult sockeye

J. Manzer

Sockeye returning to Great Central Lake in 1975 experienced lake enrichment on young. The total run (catch plus escapement) was estimated to be 299,000 pieces, and was produced by the two smallest escapements since treatment was initiated (15,000 in 1970 and 39,000 in 1971). Total runs in 1973 and 1974 were estimated to be 400,000 and 181,000 respectively. The mean size of the run for the last 3 yr, which totally or partially included age-types which experienced treatment as young, is 5.6 times larger than the 14-yr mean (52,000) preceding lake fertilization.

The parent-progeny relationship for Great Central Lake runs prior to treatment was refined on the basis of acquired historical data on seasonal changes in age-composition of the commercial catch during 1969-1970. The new results confirm earlier analyses which showed that total adult sockeye production was inversely related to escapement size, and that the lake's natural replacement capacity is limited to escapements of approximately 50,000 adults.

The derived parent-progeny relationship for untreated years provides baseline information useful for measuring the effects of treatment on sockeye production. Production by treated runs continues to be inversely related to escapement size but on average reproductive efficiency has been increased by a factor of 4. Considering the return of individual major age-types (per spawner), production age of 1.2 sockeye is higher than that for older age-types (1.3 and 2.2). The rate of return of "jacks" (1-winter ocean sockeye) also appear to be increasing in importance in the escapement samples collected over the past 4 yr in relation to adults which have spent 2 or more winters at sea. However, this could reflect effects of the increased fishing rather than enrichment per se, or it might reflect changing oceanic conditions.

A comparison of production of sockeye by Great Central Lake with that by Sproat Lake, a closely neighboring untreated lake in the same drainage system, has provided additional information on the effects of fertilization on production. Preliminary indications are that the average return per spawner from three brood-

years (1966-1968) for the two lakes prior to treatment of Great Central Lake in 1970 was reasonably similar (2.1 and 2.7, respectively). Since enrichment, sockeye production by both lakes has increased, but reproductive efficiency has been greater for Great Central Lake (7.4 as compared with 4.3). The reason for increased sockeye productivity by Sproat Lake in the absence of experimental enrichment is not known, but at least two possible explanations exist:

- (1) Increased nutrient input into Sproat Lake as a result of increasing peripheral residential development.
- (2) Operation of a depensatory mechanism precipitated by the significant increase in smolt output from Great Central Lake concomitantly with enrichment, which could tend to reduce predatory pressure on smolts of all origins utilizing the Somass River and Alberni Inlet during seaward migration.

At this time, the latter explanation appears more reasonable and, if indeed operative, suggests the possibility that production of sockeye may be increased throughout a multi-lake drainage system by selection of particular lakes within the total system for treatment.

Processing of data obtained from scale samples of the commercial catch and escapements to different systems in the Alberni watershed for machine computations continued in 1975. Preliminary examination of scales has shown some differences in certain characteristics of the freshwater zone of the different stocks in different years. An attempt is being made to separate out the major stocks in the commercial fishery on the basis of these characteristics, and thus increase the precision of any measurement of the effects of fertilization on production of sockeye.

(d) Studies on threespine stickleback in Great Central Lake

J. Manzer

A manuscript reporting results of studies on distribution and feeding ecology of threespine stickleback in an experimentally fertilized sockeye lake, with comments on interspecific competition for food was completed in 1975 and submitted for primary publication.

A study on the relationship between infestation rates of threespine stickleback by the plerocercoid stage of the cestode Schistocephalus solidus and Cyclops abundance in Great Central Lake was initiated in 1975, using stickleback samples and plankton data collected since 1969. Cyclops and stickleback are first and second intermediate hosts for the parasite. Since Cyclops are important prey for stickleback, it can be hypothesized that increased production of Cyclops through lake fertilization will influence the incidence of infested stickleback. Preliminary results indicate that infestation rates for stickleback in 1970 and 1971 did not differ significantly. However, when infestation rates for stickleback of different sizes were compared, the incidence of Schistocephalus in stickleback less than 50 mm in length was higher in 1971 (0 age in 1970) than in 1970 (0 age in 1969). Plankton studies show that Cyclops biomass in 1970 was at least 3 times the 1969 (pre-fertilization) level.

V. SUB-PROGRAM: BABINE LAKE SOCKEYE DEVELOPMENT J. McDonald

In 1971, a mark-recovery program was begun to measure the lake's capacity to support the increased lake populations resulting from the enhancement program and to determine the contribution of sockeye produced in the artificial spawning channels to the Skeena River fishery.

Sockeye fry from the 1970 and 1971 brood-years, produced in Fulton River channel No. 2, were marked and released into the lake. Mark recoveries were made from the seaward migrations of 1972 and 1973. Beginning in 1973, annual spawning ground surveys have been conducted to recover returning adults with the following results:

<u>Year</u>	<u>Total examined</u>	<u>Marks recovered</u>
1973	7,594 (jacks only)	.16
1974	58,962 (all ages)	221
1975	35,589 (4's and 5's)	241

Scales and otoliths were taken to age the marked fish so that each fish could be assigned to its release group.

Recovery of marked adults in 1976 will be required to complete returns from the two brood-years marked and to allow estimates of channel adult production to be made.

AQUACULTURE PROGRAM

J. R. Brett

This program is divided into two sub-programs dealing with: (1) production of pan-size salmon in floating seapens and the development of recirculation systems (Experimental Fishfarm), and (2) research on accelerating salmon growth, early transfer of juveniles to sea water and nitrogenous excretion (Physiology), which provides the biological background for application in the fishfarm.

I. SUB-PROGRAM: EXPERIMENTAL FISHFARM

W. A. Kennedy, C. T. Shoop,
and W. Griffioen

Rearing of the 1974 salmon crop (i.e., the fish that were fry in 1974) continued through 1975. There were heavy losses among coho through failure to smoltify, among sockeye from disease, and among both from otter predation. The survivors of about 2,000 chum salmon, a second stock acquired in September 1974 as smolts after the main 1974 chum crop had all succumbed to the disease furunculosis, had to be destroyed early in 1975 because of heavy infection with piscine erythrocyte necrosis (PEN). These were the first group of salmon anywhere in the Pacific in which PEN was diagnosed. An additional group of about 6,000 sockeye that had been acquired as smolts late in 1974 were also reared. As of late 1975 there were about 3,000 sockeye and about 6,000 coho of the 1974 crop that were scheduled to be marketed in early

1976, a series of difficulties in obtaining bids having delayed marketing beyond the target date of late 1975.

The main 1975 salmon crop started as slightly more than 30,000 fry each of coho and pink salmon. Plans to also rear about 30,000 chinook salmon were upset when the disease IHN was diagnosed in the parent stock that had been selected at too late a date to arrange for an alternative source of eggs. Freshwater survival of coho and pinks was excellent. They were vaccinated against two kinds of vibriosis and against furunculosis; the coho by needle, the pinks by vaccine in the feed. None of the fish so vaccinated have developed any of the three diseases. However, shortly after transfer to seapens the pinks developed a heavy infection of PEN. Rather than destroy the pinks as had been advised, we isolated them and added liver to their diet to improve haemoglobin levels; several thousand recovered. Many coho did not become big enough for transfer to seapens (i.e., did not smoltify) and had to be kept in fresh water through 1975. There was heavy predation by otter on both coho and pinks in the seapens. As of late 1975 there were about 9,000 coho in fresh water, about 9,000 in seapens, and about 6,000 pinks in seapens, all in good health. Also in seapens were about 1,500 chinook salmon and approximately 2,000 steelhead trout, in both cases 1975-crop fish acquired as young fish from other sources. Two new, covered seapens (each 15 ft × 15 ft) were constructed and used for about 2,500 sockeye smolts in an experiment to assess various combinations of vaccines.

For the 1976 salmon crop, about 35,000 eggs of each of sockeye, chinook, and coho were taken in September, October, and November, respectively.

A major objective in operating the experimental fishfarm has been to reveal problems that a commercial fishfarmer would encounter and to find practical solutions. Progress has been as follows:

1. Disease remains a major problem but there has been encouraging progress towards developing control methods. Vaccines seem to be completely effective in controlling both furunculosis and the two kinds of vibriosis. Experience in 1975 indicates that these diseases can also be controlled reasonably well in unvaccinated fish by antibiotics; the complete loss of chum salmon through furunculosis in 1974 is, in retrospect, regarded as a result of lack of experience. Finding PEN, first in chum then in pink salmon, was a setback. Although there is no recognized treatment for this new disease of salmon, there seems cause for optimism that it can be controlled by adequate diet.
2. Fatal gill damage from the plankter Chaetoceros convolutus remains a serious problem in sockeye rearing. Although steps were taken in 1975 that seemed to lessen mortality from Chaetoceros, they did not reduce it to an acceptable level. Since the problem pertains only to sockeye this species could be dropped; however, one more attempt will be made, applying as much acceleration as possible.
3. It became obvious in 1975 that predation by otters was much more serious than had been realized, and that heavy earlier losses to otters had been incorrectly attributed to other causes. Since mid-1975 we seem to have completely prevented otter predation by having a "lid" of netting laced to the top of each netpen. Use of a more aggressive guard dog than earlier is probably a factor.

4. Experience in 1975 confirms earlier conclusions that a better understanding of smoltification in coho is essential.
5. Limited experience with steelhead trout indicates strongly that they are less desirable for commercial seapen culture than any of the five local species of Pacific salmon because of poor saltwater adaptation and retarded growth.

In summary, (a) about 9,000 pan-size salmon (8%) from the 1974 crop have survived to the marketing stage, (b) about 25,000 salmon (36%) are alive (November 1975) from the 1975 crop of fry of which 6,000 pinks are already close to market size, and (c) the 1976 crop of 100,000 eggs has been collected and for the first time fertilized in our own hatchery (instead of supplied as eyed eggs).

II. SUB-PROGRAM: PHYSIOLOGY

This investigation is broadly based on studies of growth, nitrogen excretion, and salinity regulation in young salmon in relation to the effects of environmental temperature, photoperiod, and salinity. The major aim is to determine the physiological basis for rearing the fastest growing, healthiest fish for use in freshwater and marine aquaculture, and to respond to physiological problems as they develop in the operation of the Experimental Fishfarm.

(a) Multifactorial growth experiments

J. E. Shelbourn, W. C. Clarke,
J. Blackburn, and W. Damon

The 1975 objective was to study growth rate of juvenile salmon under the effect of dynamic changes in temperature and photoperiod, and over two size ranges. The size effect was achieved by starting at two different times in the year; each of the two runs lasted 8 wk, with the first two of these taken up by acclimation procedures. Dynamic changes in temperature and photoperiod were produced by linear increments within the assigned limits. Feeding was to excess.

First Run: This experiment was started in mid-March (equinox) with (a) sockeye fry at 0.8 g, (b) photoperiod regimes of 12-8 hr, 12 hr, 12-16 hr, 12-20 hr, and 20 hr, and (c) temperature regimes of 13-7 C, 10 C, and 7-13 C. In addition two other environmental combinations with coho fry were assigned to the remaining lab space.

Preliminary analysis of the data is based only on initial and final wet weight and length. The results were: (i) temperature had the most significant effect on growth rate, (ii) photoperiod effects are not apparent in the early phase, (iii) specific growth rates (G) for sockeye were in line with those of previous determinations. For the temperatures averaging 10 C (7-13, 10, and 13-7 C) G was 4.5%/day, at 13 C it was 5.5%/day, and for 17.5 C, 7.3%/day, (iv) coho growth rates were below those of sockeye for the same conditions (e.g., G = 3.3 and 4.3%/day, respectively, at 10 C).

Second Run: This was started in mid-June (solstice) with sockeye at 3.3 g and coho at 2 g; photoperiod regimes of 17-13 hr, 17 hr, and 17-21 hr; temperature regimes of 10 C and 17.5 C (both static). In addition, one photoperiod was replicated (17-13 hr) to assess room vs. photoperiod effects. The balance of tanks were allocated to larger (5 g) coho from the fishfarm to check on density effects (500 vs. 50 fry) for coho and sockeye, and also allocated to some of both spp. from selected stocks of the First Run. Briefly, the results were: (i) sockeye replications were significantly different at both 10 and 17.5 C, indicating a tank-to-tank variability that needs checking, (ii) despite this, the trend was for decreased growth with increasing photoperiod for both spp., (iii) significant response differences occurred in sockeye previously exposed to different photoperiods (continuously decreasing grew slower than increasing switched to decreasing), (iv) density increase depressed coho G; there was no effect on sockeye, (v) growth rates at two comparable temperatures (10 and 17.5 C) were 30% lower for the Second Run larger fish than the First Run fish.

(b) Environmental influences on salinity adaptation in juvenile salmon

W. C. Clarke,
J. M. Blackburn, and
W. Damon

Three experiments (in conjunction with the "multifactorial") were conducted to evaluate the combined effects of temperature and photoperiod on salinity adaptation of juvenile salmon at different sizes. Beginning in March, sockeye fry weighing about 0.5 g were reared in fresh water under a series of photoperiods at 10, 13 or 17.5 C. After 9 wk, salinity adaptation was assessed by measuring the rise in plasma sodium concentrations 24 hr after transfer to sea water. Decreasing daylength impaired salinity adaptation of sockeye at 13 and 17.5 C whereas at 10 C both increasing and decreasing daylengths improved salinity adaptation compared with fish on a static photoperiod. Coho fry showed no improvement in salinity adaptation when exposed to increasing or decreasing daylength at 10 C.

A second experiment was initiated in June with underyearling sockeye of 3.3 g and coho at 2 and 5 g in order to determine the effect of body size on smoltification. Fish were held under static, increasing, and decreasing daylengths at 10 and 17.5 C. After 9 wk the sockeye on all treatment combinations (weighing 8-16 g) appeared capable of adapting to sea water, although the declining daylength did cause a slight impairment. None of the coho groups (weighing 4-11 g) smoltified during the experiment. It is clear that the relation between size and salinity adaptation differs for sockeye and coho, the latter requiring a considerably greater weight to enter the sea in their first summer.

(c) Effect of premature transfer of cultured coho salmon to sea water

W. C. Clarke in collaboration
with Dr. Y. Nagahama, U.B.C.

Samples of stunted yearling coho culled from the netpens of the Pilot Fishfarm in May were transferred to tanks in the culture facility. These fish were only 10 g (in contrast to an average of 40 g for the remainder of the population) indicating that they had not grown in their 6 mo of seawater residence. They showed very prominent parr marks, a low condition factor (ca. 0.9) and poor appetite. Electron microscope examination of the pituitary gland revealed atrophic changes in certain cell types.

Within days of transfer to fresh water, the dwarfs showed improved appetite and growth resumed. After 80 days in fresh water the pituitary ultrastructure had returned to normal. However, these fish were not yet able to adapt to sea water as readily as coho from the same stock reared entirely in fresh water.

(d) Feeding metabolic rates of young sockeye salmon

J. R. Brett

From the studies on growth rate of sockeye salmon preliminary observations on the daily metabolic rates were assembled. These showed a direct relation between rate of oxygen consumption and size of ration, at any one of the temperatures studied (10, 15, and 20 C). Ration effect induced a maximum change at 20 C, from an average of 100 mg O_2 /kg/hr for starved fish (close to standard metabolic rate) to 415 mg O_2 /kg/hr at maximum daily food intake. The data were analyzed along with published records of standard metabolism to develop a predictive model in the form of isopleths of metabolic rate in relation to temperature and ration. The predicted rates compared favorably with published studies on hatchery-reared chinook salmon, and with other studies on fish where feeding metabolic rates have been recorded. In general these support the observations and concepts developed for sockeye salmon, and permit better estimates of likely energy expenditure in aquaculture systems and possibly in nature.

(e) Nitrogen excretion and metabolism of sockeye salmon

J. R. Brett

Water recirculating systems in hatcheries incorporate biological filter beds to convert toxic excreta (ammonia and urea) into non-toxic forms (nitrates). Success has been variable and limited. Little is known about the daily pattern of salmon excretion, resulting from the metabolism of proteins in the diet; less is known about the effects of changing environmental factors (temperature, oxygen, and acidity of the water).

Measurements of the rate of ammonia and urea excretion of fingerling sockeye salmon were made at 2- to 3-hourly intervals throughout the day (temp. = 15 C). One group of fish was fed a maintenance ration while another group was starved for 22 days. Ammonia excretion rose to a sharp peak of 35 mg N/kg/hr, 4-4 1/2 hr after the start of feeding (0830), and fell to a baseline level of 8.2 mg N/kg/hr after midnight. Urea excretion remained relatively steady at a mean rate of 2.2 mg N/kg/hr. Starved fish showed a nitrogen excretion rate close to that for both the steady state of urea excretion and the baseline rate of ammonia excretion of the fed fish.

Oxygen consumption rose to a peak of 370 mg O_2 /kg/hr just before and during a 1-hr feeding period, decreasing thereafter to a low of 170 mg O_2 /kg/hr at 0300 hr. This diurnal metabolic fluctuation continued in a variable and diminishing form during starvation; nitrogen excretion showed no such continued diurnal response. It was concluded that, for non-stressed salmon, ammonia is the chief excretory product of exogenous nitrogen metabolism.

These results help explain some of the major fluctuations occurring in hatcheries, and point to the necessity of testing the effects of varying diets, temperature, changing oxygen content, and of crowding the fish. Such information is of value in the development of salmon aquaculture.

FISH HEALTH PROGRAM

G. R. Bell

This Station is the responsibility center for fish health research and diagnostic services (including health certification) in the Pacific Region. The main goals of the program are the prevention, control, and when possible, the eradication of disease.

At present the program is mainly occupied with problems of infectious diseases, from viral to metazoan. The program and concerns relate not only to acute disease resulting in mass mortalities but also to diseases which manifest themselves in sublethal ways such as retardation of growth, reduced reproductive capacity, physiological disturbances, and altered behaviour, which may or may not be predisposers to other lethal effects. Parasitic organisms that produce no visible gross effects on their hosts but render them unfit for marketing also come under study. The program has been oriented towards aetiology, epizootiology, immunology, and chemotherapy, but it will depend increasingly upon the disciplines of pathology and ecology for its further development.

The Fish Health Program has three sub-programs: Microbiology (Research), Parasitology, and Diagnostic Services. Microbiology and Parasitology are largely research oriented in an effort to provide new information that will lead to improved fish health. However, personnel of all sub-programs work closely together to characterize and identify infectious diseases of commercially important fishes (mostly salmon), record the distribution of these diseases in the Pacific Region, and assess their actual or possible impact on fish and/or fish stocks. In addition, the program develops and tests means for the prevention, control, and eradication of important diseases in cultured and wild stocks. The Diagnostic Services Sub-program and to a lesser extent, the Parasitology Sub-program, are the principal direct means of providing information and advice on matters of fish health to Fisheries Operations and R&D personnel, to other government agencies (including the Fish and Wildlife Branch), and to the private sector. The Fish Health Program conducted an initial and apparently very successful Fish Disease Workshop attended by Federal and Provincial hatchery personnel and by private fish culturists.

Most of the work within the program is related to health problems of cultured salmonids in enhancement and aquaculture facilities because these highly valuable species appear to be more prone to disease than are wild stocks, and since cultured stocks are more readily open to preventive and remedial measures. Activities include routine monitoring of the health status of Fisheries Operations' hatcheries and the Station's pilot fishfarm. However, with the initiation of the Salmon Enhancement Program more work is being done on the disease status of certain stocks of wild salmonids.

There continues to be a major commitment of staff in the Parasitology Sub-program to the Strait of Georgia Program. Some Fish Health Program staff also continue to be involved in the development of national and international fish health protection programs.

In addition to the three sub-programs, the Station's Histology Service is included in the Fish Health Program for administrative purposes.

The work and accomplishments of each sub-program are reported separately on the following pages.

I. SUB-PROGRAM: MICROBIOLOGY (RESEARCH)

(a) Phagocytosis, a cellular defence mechanism G. R. Bell and G. S. Traxler

The ability of circulating leucocytes of non-immunized, cultured sockeye salmon to phagocytize bacteria in the blood stream was examined using two techniques: cannulation of the dorsal aorta (for the injection of bacteria and for blood sampling), and intracardiac injection. With the first technique no phagocytosis was observed in the peripheral blood but there was a rapid uptake of bacteria that was particularly impressive in the kidney. Some phagocytosis in the blood stream, mostly by polymorphonuclear leucocytes, was demonstrated using the second technique but there was the possibility that these phagocytes had actually drained from the renal portal system following caudal blood sampling. The results so far confirm the observations of others that phagocytosis in the peripheral blood of salmonids is insignificant or non-existent.

These results were reported in a MS entitled "Preliminary Observations on Phagocytosis in the Peripheral Blood of Sockeye Salmon (Oncorhynchus nerka)."
Fish Pathology. (In press.)

(b) Studies with vaccines T. P. T. Evelyn and J. E. Ketcheson

- (1) Three vaccines were produced in quantities sufficient to vaccinate all of Aquaculture's salmonid stocks (chiefly pink, coho and chinook salmon) introduced into sea water in 1975. The vaccines were administered to the salmon in the diet (pink salmon) or by intraperitoneal injection (coho and chinook salmon). The vaccines consisted of formalin-killed cells and were prepared against the three bacterial fish pathogens that had been shown to cause the greatest losses in salmonids held in sea water at this Station. The pathogens were: (1) Vibrio anguillarum, (2) a "new," unnamed Vibrio sp., and (3) Aeromonas salmonicida.
- (2) An experiment was initiated to evaluate the efficiency of the above-mentioned vaccines and vaccination methods under conditions of natural challenge (pen-rearing) in sea water.

Sockeye salmon fingerlings (average weight ca. 6.5 g) were vaccinated in June 1975, as outlined in Table 1 below. The sockeye, appropriately nose-tagged to denote the various treatments, were transferred in August 1975, to sea water where they were held in a single pen. All mortalities that occurred were examined to identify the treatment received and cause of death. Three months after transfer to sea water, some 450 of the approximately 2,824 fish in the experiment had died. Natural challenge apparently came chiefly from the two vibrios (mainly the unnamed Vibrio sp.); challenge by A. salmonicida was not detected. Short-term results (Table 1) clearly indicate the value of vaccinating fish; they also demonstrate the superiority of the parenteral over the oral method of vaccination and the value of using polyvalent vaccines where protection against more than one disease may be required.

Table 1. Mortalities of variously vaccinated sockeye salmon during their first 3 mo in sea water.

Vaccines and method of administration*	No. fish dead/ no. fish treated	% mortality	% mortality due to:				
			Va	Vx	As	Other	
Va	I.P. Injection	67/294	22.8	0	95.5	0	4.5
Vx	I.P. Injection	10/382	2.6	20.0	0	0	80
VaVx	I.P. Injection	8/395	2.0	0	12.5	0	87.5
VxAs	I.P. Injection	16/387	3.5	37.5	12.5	0	50
VaVxAs	I.P. Injection	10/451	2.6	10.0	20.0	0	70
VaVxAs	Oral	60/460	13.2	38.3	40.0	0	21.7
None	-	257/455	55.9	17.9	78.2	0	3.9
Unknown**	-	-	-	-	-	-	-

*Each killed pathogen (Va = V. anguillarum; Vx = Vibrio sp.; As = A. salmonicida) was given in a single dose at a rate of 3.0 mg wet packed cells/fish when injected and at a rate of 11.5 mg wet packed cells/fish (total weight fed over 15 days).

**Nose tags denoting the various vaccine treatments were missing from 22 fish.

(c) Studies with the Kidney Disease Bacterium

T. P. T. Evelyn and
J. E. Ketcheson

A recent report that the Mueller Hinton medium produced better growth of the kidney disease bacterium than did a medium developed for this purpose in this laboratory could not be confirmed. The report raised hopes that large-scale production of an anti-kidney disease vaccine might be possible. In fact, however, our tests indicated that the Mueller Hinton medium was inferior to the medium routinely used in this laboratory.

(d) Piscine Erythrocytic Necrosis (PEN)

T. P. T. Evelyn and G. S. Traxler

This condition was first observed at this Station in chum salmon in 1964. It was investigated this year when it reappeared in certain stocks of pink and chum salmon being held in sea water. Our studies (based on serial passage in fish of filtered [0.45 μ m pore size] diseased organ homogenates) indicate that the condition is infectious and probably due to a virus. If so, the virus is a "new" one for salmon and one that we have not been able to grow by any of several traditional in vitro methods. The infection may be acquired from marine fish; it was observed in cultured, captive herring, filtered organ homogenates of which reproduced the disease in chum salmon. To confirm further the viral aetiology, tissues from naturally and experimentally infected salmon have been prepared for electron microscopy.

(e) Fish health regulations and diagnostic procedures

T. P. T. Evelyn

In concert with Drs. R. M. MacKelvie and N. Medin (both of the Fisheries and Marine Service), the Fish. Res. Board Can. Misc. Spec. Publ. No. 23 on "Methods for the detection of certain pathogens of salmonid fishes"

was extensively revised and incorporated in the new (proposed) Canadian Fish Health Protection Regulations. In collaboration with the above experts, a "Manual of Compliance" was also produced in which guidelines for complying with the fish health regulations were outlined.

A manuscript, "Methods for the diagnosis of certain bacterial fish diseases," prepared with considerable advice and input from other fish disease specialists, was published as part of a larger work entitled "Suggested procedures for the detection and identification of certain infectious diseases of fishes." The work was sponsored by the Fish Health Section of the American Fisheries Society and was published by the U.S. Department of the Interior, Fish and Wildlife Service.

(f) Consultation

G. R. Bell

Discussion of a variety of problems with persons from various government agencies, universities, and from the private sector are considered to be a vital and noteworthy function of the sub-program. In addition to the Fish Disease Workshop, a short course on common diseases of salmon was given to members of the Cowichan Indian Band aquaculture group. Discussions were also held with two private salmonid culturists on aspects of disease control, and with the B.C. Fish and Wildlife Branch on the danger of disease transfer from hatchery to wild stocks. Problems of water quality at the Quinsam hatchery were discussed with certain Fisheries Operations' personnel. At the request of the Environmental Protection Service, investigations were conducted on some kills of marine fishes, and as a follow-up to our findings on the massive fish kill at the Capilano hatchery the effect of chlorine on the gills of coho parr was also investigated. The latter investigation showed that even 1 ppm of dissolved chlorine introduced as a gas, caused perceptible disintegration of gill epithelium within 20 min at 10 C. Death of the fish usually occurred within this time period.

II. SUB-PROGRAM: DIAGNOSTIC SERVICES

G. Hoskins and
L. Hulstein

This Service has seen a steadily increasing demand for its services; some 220 cases were processed this year compared to a total of 123 for 1974. An increasing proportion of the work has been to assist private aquaculturists with fish health problems.

Certifying the health of live salmonids for international and interprovincial shipments and spot checking already certified foreign imports has again become the responsibility of the Diagnostics Service. The importance of this task is illustrated by the recent discovery in British Columbia of enteric redmouth disease, a disease formerly recorded only in Saskatchewan and in a few American states. The outbreak in Saskatchewan occurred in imported stocks and there is strong evidence that the outbreak in British Columbia can also be attributed to importation.

Disease surveys have revealed that, as expected, the infectious haematopoietic necrosis (IHN) virus is enzootic in most sockeye populations in British Columbia and that the bacterial diseases, furunculosis and kidney disease, are much more widespread among wild salmon stocks than previously suspected.

A practical system for the isolation and identification of all known viral and microbial disease agents of cultured fish has been established. Antisera were prepared which have allowed much more rapid diagnosis of the bacterial diseases, however, additional sera of higher titre and greater specificity are needed.

Some routine haematological screening methods have been adapted for use with fish blood. To date, erythrocyte counts, haematocrit values, and the examination of stained blood smears have proven useful in judging fish health.

A program of regular monitoring and surveillance of the Federal salmon culture facilities has been initiated. Furunculosis, kidney disease, cold-water disease, and vibriosis are continually encountered as health problems in these facilities. It is noteworthy that "tuberculosis" has been found for the first time among stocks of salmon cultured at the Pacific Biological Station.

III. SUB-PROGRAM: HISTOLOGY SERVICES

During the past year this service has received 250 cases from 14 individual investigators for light microscopy involving some 2,500 tissue blocks. This resulted in the preparation of 4,800 stained microscope slides.

The service being offered has been expanded to include the processing of tissues for examination with both transmission and scanning electron microscopes. Some 150 tissue blocks have been embedded in epoxy resins for ultra-thin sectioning on a recently acquired ultra microtome.

Expansion of a reference library of microscope slides and photomicrographs of normal tissues from several marine and freshwater species continued.

IV. SUB-PROGRAM: PARASITOLOGY

- (a) Investigation of parasitic disease status of aquacultured salmon L. Margolis and T. E. McDonald

Monitoring of parasitic disease status of aquacultured salmon continued during the calendar year 1975, involving monthly sampling of fish from 1974 stock (coho, chum, and sockeye) and 1975 stock (coho, pink, and chinook). About 500 fish were examined. Parasitic infections discovered are tabulated below:

Sockeye from May 1974	Chum from May 1974	Coho from June 1974	Pink from Apr. 1975	Chinook from Sept. 1974
<u>Cryptobia</u> sp.	caligid larvae	<u>Scyphidium</u> sp.	<u>Scyphidium</u> sp.	<u>Scyphidium</u> sp.
<u>Contracaecum</u> sp.	<u>Lepeophtheirus</u> <u>salmonis</u>	caligid larvae	<u>Cryptobia</u> sp.	
caligid larvae	<u>Caligus</u> <u>clemensi</u>	<u>Caligus</u> <u>clemensi</u>	caligid larvae	

Sockeye from May 1974	Chum from May 1974	Coho from June 1974	Pink from Apr. 1975	Chinook from Sept. 1974
<u>Caligus</u> <u>clemensi</u>		<u>Lepeophtheirus</u> <u>salmonis</u>	<u>Lepeophtheirus</u> <u>salmonis</u>	
<u>Lepeophtheirus</u> <u>salmonis</u>				
<u>Bomolochus</u> <u>cuneatus</u>				

The parasites begin to appear on the fish in early spring and persist to late fall. The fish are free of parasites during the winter months. Peak intensities for Caligus clemensi occur in late spring and early fall. Sockeye appear to be most extensively infected. With one exception (Contracaecum sp.), all parasites belong to the ectoparasitic group, which suggests that little is eaten by the fish apart from the commercially prepared food provided. Copepods are most abundant and potentially, therefore, should be given most attention as possible harmful agents. Older fish tend to be less susceptible to infection with Protozoa, particularly with Scyphidium.

(b) The tapeworm Eubothrium salvelini and its effects on juvenile salmon production in Babine Lake and Great Central Lake N. Boyce

Examination continued of Great Central Lake and Babine Lake sockeye juveniles for Eubothrium salvelini.

Laboratory experiments on the effects of E. salvelini on juvenile sockeye were concluded. The results have not yet been fully analyzed, but they indicate that:

- (1) E. salvelini produces disease signs in juvenile sockeye (reduced growth and vitality, distended bellies);
- (2) infections averaging nine worms per fish produce a reduction in stamina that is detectable in activity-tunnel tests; infections with five worms or less produced no detectable lowering of stamina;
- (3) under the experimental conditions E. salvelini infection is capable of contributing directly to mortality.

As the result of earlier observations, experiments were conducted to determine relationship between the size of sockeye and its susceptibility to infection with E. salvelini. Fry more than 40 mm long were markedly less susceptible to infection. Whereas more than 50% of fry 26-35 mm long became infected, infection of 36-40 mm long fry was only 30%, and that of 41-45 mm long fry only 12%. These findings have significant practical implications. Fry protected from infection until they reach the critical size of 40 mm stand a much better chance of escaping it altogether. Since uninfected fry grow much better and since larger smolts have a better chance of surviving at sea, the end result might be reflected in increased numbers of returning adults.

(c) Salmincola californiensis a parasitic copepod
of cultured salmon

Z. Kabata and
D. Whitaker

Adult Salmincola californiensis, a harmful parasite of all Pacific salmon species in fresh water, proved refractory to treatment with chemical substances used in the water at concentrations tolerated by the fish, and environmentally acceptable. Treatment by oral route also proved unsuccessful, the fish being unable to tolerate sufficient quantities of chemotherapeutic food additives. Under the circumstances, the only way currently possible to control S. californiensis is to attack it at its free-swimming dispersal stages, during which they are susceptible to many chemical substances, including some that are biodegradable and not polluting. Further attempts to control adult parasites will be conducted as a low priority project.

F I S H E R I E S E C O L O G Y S E C T I O N

C. D. McAllister

This Section conducts programs primarily intended to aid management by providing information required for use in identification and protection of essential fish habitats, especially those under threat of modification due to human activities, and to provide fisheries information in the Strait of Georgia.

EFFECTS OF ENVIRONMENTAL CHANGE PROGRAMGENERAL

This Program is concerned with effect of environmental change on fisheries resources, and is comprised of three activities. The primary activity is a major study of impacts of logging on stream salmonid production. The project is a long-term one. Five years of prelogging control studies in an experimental watershed have been completed and 5 years of work during logging have commenced.

The Babine Environmental Change Sub-program (see below) continued activities at a lowered level, with emphasis on reporting.

The Impacts Sub-program is concerned with ad hoc demands regarding specific environmental problems, development of proposals for interagency task forces, and Departmental requests.

SUB-PROGRAM: LOGGING AND STREAMS

J. C. Scrivener

The Major activity under the effects of environmental change on aquatic resources program is the Carnation Creek Experimental Watershed Study. This is a long-term, interdisciplinary study in which seven federal and provincial agencies and MacMillan Bloedel Ltd. are participating. The Pacific Biological Station is responsible for conducting the research on the aquatic system as well as coordinating all aspects of the study. The broad objectives are:

1. To develop a better understanding of how undisturbed coastal rainforest-salmonid stream ecosystems work in order.
2. To explain and quantify the impacts of timber production on stream environments and their capacity to produce salmonid fishes in sufficient detail.
3. To provide continuous input to the further development of integrated resource management guidelines.

Prelogging baseline studies began in 1970 and are now essentially complete. Initial road building began in the spring of 1975 and the first logging commenced this winter. The recent labour dispute in the forest

industry forced a delay and minor revisions in the 5-year logging plan. A small 49 acre opening bordering the lowest 850 metres of Carnation Creek is being logged during the 1975-76 winter. The most intense harvesting treatment is planned for the autumn and winter of 1976/77. Road construction has been intensified this winter and most construction specified under the 5-year logging plan is being completed by April, 1976. These changes have permitted more prelogging baseline data to be obtained and a more detailed assessment of road construction impacts on the stream to be made for sub-watersheds and mainstream stations above the first opening. The new 5-year logging and forestry plan will not be complete until the spring of 1981. At that time more than 50% of the watershed and all openings adjacent to the mainstream anadromous fish area will have been logged.

All fish migrating in and out of Carnation Creek were counted and sampled at the trapping fence located at the head of tide. Compared with the mean outmigrations of the previous 4 years, 1975 counts were similar for coho smolts, lower for steelhead smolts, and greater for cutthroat. Chum fry counts were similar to those of 1973, when extremely low water during the previous autumn had caused most adults to spawn in the estuary below the fence. Chum fry counts were at least 10 times greater during 1971, 1972, and 1974. The adult return was 230 coho, 1,200 chums (80 above the fence), and about 8 steelhead. Coho and chum escapement was lower than those recorded in previous years.

Since 1972, fish movements in and out of tributary swamp areas have been monitored. These areas were dry during the summer, but coho moved into them in September-October and out again in May-June. Overwinter survival in these areas averaged 61% as compared to 30% for the whole watershed. Overwinter behavior, growth, and survival was reported in two FRB Journal Manuscripts published in 1975.

The summer resident fish populations were sampled 3 times from May to September at seven study sections in Carnation Creek for density, biomass, and growth. In addition, four control streams were sampled in early September. The late summer populations were similar to those reported in previous Annual Reports and in FRBC MS Report No. 1303 and 1351. Density, biomass, and growth data was also obtained from two tributaries and upper Carnation Creek.

A study of the relative roles of autochthonous and allochthonous production pathways leading to invertebrate fish food initiated in Carnation Creek in 1974 was continued in 1975. Sampling was done in relation to the boundaries of the proposed first logging under the old 5-year plan. It was found that autochthonous net production (mainly diatoms) was extremely low (average $3.9 \mu\text{g at. org. C cm}^{-2} \text{ day}^{-1}$) and limited by the available solar radiation, nutrients and by freshets > 70 cfs. Three periods of rapid growth and significant biomass accumulation were noted - April-May, July, and September. The latter two were related to clear, dry weather. During the period April to October diatoms are utilized by some species of immature insects. An adjacent watershed that was clearcut and burned 7 years ago had stream primary production higher than in Carnation Creek (average $5.9 \mu\text{g at. org. C cm}^{-2} \text{ day}^{-1}$). Primary production (epiphyton) in the estuary was much higher than in either stream ($24.1 \mu\text{g at. org. C cm}^{-2} \text{ day}^{-1}$). When dissolved phosphate and nitrate were experimentally doubled to $0.15 \mu\text{g at./l}$ and $9.7 \mu\text{g}$

at/l respectively at Carnation Creek, the average daily net production was double that of the controls. 1974 data was reported in Fisheries and Marine Service Tech. Report No. 558 and a manuscript of both 1974 and 1975 data is presently being submitted to the FRB Journal.

Insect food habitat studies in Carnation Creek confirmed that most production is based on the allochthonous pathway based on leaf litter from streamside deciduous species such as alder and salmonberry (Alnus and Rubus). Total fall from April 27 to November 25 confirmed 1974 estimates of 13.7 metric tons of deciduous leaves and 10.2 tons of coniferous needles.

Four of the five 24-hour coho and trout food monitoring studies which were carried out during the growing season (May-September) have now been analysed. The data indicated that coho food intake was greatest during evening twilight and that it consisted primarily of aquatic insects during the spring, and of terrestrial insects by August. Trout feed primarily on nymph and larval aquatic insects during evening twilight while sculpins forage in the riffles during the night.

Water chemistry studies continued. The previous prelogging conclusions were confirmed. July 1971 to May 1974 results are discussed in Fisheries and Marine Service Tech. Report No. 564.

The accumulation of hydro-meteorological and stream physical data from the 5 weirs, 11 hydro-meteorological stations, and 10 stream study sections in Carnation Creek watershed have necessitated the computer processing of data. During 1975, 16 programs were written to analyse and plot stream flow, precipitation, water and air temperatures, humidity, and chemistry data. Preliminary results indicated that hydrologically, these rain forest watersheds behave quite differently from other watersheds that have been studied in North America.

The Carnation Creek Coordinating Committee, charged with project surveillance and senior level coordinating among agencies, met on May 27, 1974. A major agenda item was a discussion of personnel changes. The committee stressed the need to refill the position of study coordinator as quickly as possible.

SUB-PROGRAM: BABINE ENVIRONMENTAL CHANGE

H. D. Smith

This program, aimed at understanding effects of environmental change on salmon and trout in the Babine Watershed was initiated in 1971 under the general aegis of the Regional Board, Pacific Region. A multi-agency steering committee was authorized by the Board in 1972.

Major field research projects to elucidate lake circulation and primary and secondary production and describe existing physical and biological features of the system were largely completed by 1974 and reporting is in progress. Several manuscripts and technical reports have been published and others are nearing completion.

The steering committee continues to meet annually or more often if needed and a small technical sub-group deals with any issues deemed

important for continuing surveillance or action by the steering committee. An analysis of aspects of the copper chelating properties of Babine Lake waters was prepared for the committee (Chau and Wong MS 1974) and circulated to interested members.

Results of 1973 and 1974 zooplankton studies were analysed in 1975 and UBC graduate student P. Rankin will report these in part in his M.Sc. thesis planned for completion in late 1975.

It is expected that a final report on this multi-agency program incorporating elements of the physical, primary, and secondary studies will be started in 1976.

SUB-PROGRAM: IMPACT ASSESSMENT

C. D. McAllister

Activities under this sub-program in 1975 were much fewer in number than in the previous year. The major effort concerned development of proposals for cooperative Canada-U.S. research in regard of threats imposed by tanker shipments of Alaska crude oil. Meetings of DOE, Provincial, NOAA and Washington State representative were held, and a Canadian "position" negotiated with OAS.

Commitments of time to the NWBC Task Force Steering Committee, Fraser Estuary Committees, the Federal-Provincial Committee on impacts of Algal Harvest, and to ad hoc matters continued but at a reduced level.

STRAIT OF GEORGIA PROGRAM

M. C. Healey

Last year, the early sea life of young salmon was identified as a major area of research. Young salmon in the vicinity of Nanaimo, particularly outmigrants from the Nanaimo River were studied as components of an ecoplan. The study was collaborative, involving M. Healey on young salmon, E. Barraclough on competitors, R. LeBrasseur on pelagic food resources, and J. Sibert on epibenthic food resources. In addition R. Beamish was seconded to the program from groundfish to study the biology and fishery potential of hake and pollock in the Strait. F. Bernard, attached to the program, but on secondment in Ottawa, returned to Nanaimo in July and has submitted a proposal for next year. J. Mason was transferred to the program from stream ecology. His first responsibility was to write up and publish his previous research. Z. Kabata is involved in the program part-time, identifying the parasite fauna of commercially important fish species from samples provided by other members of the program.

Because of the collaborative nature of most of our program, individual sub-programs were not identified in last year's submission. Instead an area of responsibility was identified for each scientist and specific activities were identified under that responsibility. The same format is followed in this review of activities in 1975.

1975-76 GENERAL PROGRAM OBJECTIVE: Define and measure the parameters which control the distribution abundance and productivity of commercially important species in the Strait of Georgia

1. Dispersal of young salmon from freshwater nursery areas, their food habits and growth rates.

M. C. Healey

Downstream migrating salmon fry were trapped, tagged, and released in the Nanaimo River between March 8 and May 26. Simple Petersen estimates of daily downstream run gave a total run estimate of 51.6 million chum. The timing of migration of marked and unmarked fry suggested that simple Petersen estimates were probably biased, but that the direction of bias fluctuated. Whether there was any overall bias is not known. If the estimate of 51.6 million fry is correct, we marked about 0.75% of the run.

The run began slowly with a number of minor fluctuations leading up to two major peaks in trap catch on April 24-27, and May 9-10. Estimates of daily run also showed two peaks but at different times, on May 1 and 14.

We tagged the fish with six different colours. We had intended to mark about equal numbers of fish with each colour, but we misjudged the run and most of the fish were marked with the last colour in our series.

The Nanaimo River mud flat and 17 locations nearshore between Hammond Bay and Boat Harbour, and around the north east side of Gabriola were fished. All stations were sampled weekly from the second week of March until the second week of July. Chum fry were captured on the mud flat from the second week of March until the end of May and their pattern of abundance was similar to that of the downstream migrants. Small numbers of recent downstream migrants were also captured in other sampling areas in early April and fry were common in all locations by the end of April. Catches of young chum in areas other than the mud flat began to increase rapidly in the second week of May, peaked at the start of June, then declined rapidly until fishing stopped in July.

Marked fish were recaptured in all sampling locations and their pattern of abundance closely paralleled that of unmarked fish. No indication of strongly directed movement away from the Nanaimo River mouth occurred.

An estimated 0.75% of the run was marked. Average recapture from the mud flat was 1.02%. Recaptures off the mud flat averaged 1.23% until the end of May when it suddenly dropped to about 0.3%. The drop in percent recaptures was coincident with a rapid increase in total catch of both marked and unmarked fish off the mud flat. Although the increase in percentage recaptures as the fish moved away from the river mouth cannot be explained yet, the results suggest that we were dealing only with Nanaimo River fish until the end of May, but, thereafter the Nanaimo River fish were significantly diluted by foreign fish.

The timing and abundance of recaptures on the mud flat suggest that fish from the early part of the run spent an average of 18 days on the mud flat while fish from the latter part of the run spent only about 2.5 days

on the mud flat. Residence of all marked groups in the nearshore area sampled was similar, between 24 and 28 days.

Growth rate of marked fish averaged 5.5% per day in weight. No significant difference was found between growth on the mud flat and in the other nearshore areas. The earliest outmigrants had a poorer growth-rate than the other marked groups, but the comparison is based on only a very few returns from the first marking. We estimate that the population utilizing the mud flat took between 4,000 and 5,000 kg of food organisms, mostly small crustacea, from the mud flat area between the beginning of March and the end of May. When the data are analysed further we hope to make the same sort of estimate for the rest of the nearshore area sampled.

The young salmon fed on a wide variety of organisms. Harpacticoid copepods were a dominant food item of the young fish while on the mud flat and during the first weeks of their residence off the mud flat. In late May their diet shifted to other types of copepods, particularly C. plumchrus and Centropages, and to Oikopleura.

Full analysis of the samples collected this year will permit us to estimate rates of dispersal, distribution, abundance, biomass, production, food habits, and food requirements of young chum salmon in the Nanaimo area. Although the present estimates from this year's data are very preliminary they provide a comparative base on which we can build in subsequent years.

2. Determine abundance, population dynamics, and potential for exploitation of hake and pollock stocks in Georgia Strait.

R. Beamish

There appear to be about 120,000 tons of hake, 20,000 tons of pollock, and 60,000 tons of dogfish in the off-bottom waters of Georgia Strait. These concentrations would support a small spring or summer fishery for hake but no new fishery for pollock. Much information was collected and published in manuscript reports on the distribution and biology of hake, pollock and young dogfish, including a study of hake and pollock stocks south west of Vancouver Island.

In the winter hake and pollock schools concentrated in the Halibut Bank area. Pollock spawned in the Halibut Bank area in March. During spawning males and females were segregated. The spawning period was only about two weeks long. After spawning the pollock moved from the open Strait into the nearshore waters particularly in the Gulf Islands area. In spring, hake move from the Halibut Bank area over to the east shore of Vancouver Island where they formed tight schools and spawned from May to June. After spawning, hake moved into the northern area of the Strait where they remained until November. In December both hake and pollock began to congregate again at Halibut Bank. From June to December there were few hake or pollock in the open areas of the Strait.

Considerable information was collected on young dogfish under 60 cm (10-15 years old) in the Strait. Their biomass was estimated to be 10,000 to 20,000 tons in the Strait. In July to September they were well distributed

in the surface waters of the Strait and were as abundant as coho in purse-seine catches. In January and February they were concentrated in the Mitle Nach area. Young dogfish do not appear to compete with or feed upon young salmon or herring.

River lamprey were found to be as abundant as young coho in purse-seine catches throughout the Strait from July to September. In reality, they are probably more abundant because many of the smaller ones escape through the net. So far they have only been captured in the Strait in the summer months. Winter fishing has not been extensive, however. The lamprey are potentially important predators of young herring and salmon. Observations in aquaria suggest a single river lamprey can kill as many as 200 young fish in about 3 months. Few young fish survived a river lamprey attack. The river lamprey actually chews chunks out of its victim rather than simply sucking the juices.

With M. Healey a purse-seine survey of the whole Strait of Georgia was undertaken from late July to September during which 164 sets were made. Chum, coho, chinook, dogfish, and river lamprey were the most abundant species in catches from the surface waters at this time. Chum were about twice as abundant as coho, and coho about twice as abundant as chinook in the purse-seine samples. Dogfish and lamprey were as abundant as coho. Abundance of all species decreased from south to north in the Strait but this may have been due to the fact that the sampling progressed from south to north and the north part of the Strait was sampled later.

A total of 19 manuscripts were written this year; 12 concerning the biology of hake, pollock, dogfish, lamprey, salmon, and herring and their interactions in Georgia Strait, and 7 on work completed at Winnipeg before coming to PBS.

3. Standing stock and availability of nearshore and pelagic zooplankton as food for fish.

R. LeBrasseur

Near-surface zooplankton were sampled from April through June in the vicinity of Nanaimo Estuary in collaboration with fishing activities for young salmon. The purpose was to provide estimates of zooplankton stocks available as food for juvenile salmon and to examine horizontal aggregations of plankton. The sampling techniques included 5-minute surface Miller net tows, to estimate average abundance and a Longhurst-Hardy recorder, and an experimental plankton pump to examine aggregations. Each Miller net sample covered a distance of 450 m, the pumping, done while underway, covered 90 m and the Longhurst-Hardy sampler 45 m.

The samples have all been analysed but only preliminary examination of selected portions of the data have been made to date. In general the number of organisms increased rapidly (20-100/m³) in early April, reached maximum (500/m³) in mid-April to mid-May and thereafter declined rapidly. Within the sampling area, catches at outside stations were invariably larger than those at inshore stations. In the immediate vicinity of Nanaimo Estuary the mean catch was 60% lower than that for the total sampling area.

The between-station variance in numbers of organisms (an indicator of patchiness) appears to be related to the species composition of the catches. For example, the variance was lowest during the period of maximum catches and this was attributable to the predominance of C. plumchrus at all stations. As C. plumchrus declined in numbers and other species, particularly meroplankton, increased, the variance of catches increased. The appearance and disappearance of short-lived plankton forms from station to station creates severe sampling problems but their presence in dense aggregations may be of considerable importance to feeding fish. Aggregations of small plankton may be particularly important in situations like this year, when the entry of many juvenile salmon into the sea followed the maximum in zooplankton abundance.

Testing of both the Longhurst-Hardy and the pump is continuing. The Longhurst-Hardy sampler is self-contained and can be preprogrammed to sample at specific intervals. This permits relatively fine discrimination of zooplankton aggregations. Its major disadvantage lies in the time required to process samples. The pump on the other hand, permits almost instantaneous examination of catches but it samples over a greater distance.

The initial examination of the pump data demonstrates that we can demonstrate aggregations of organisms within a 450-m transect. During the period of maximum abundance of C. plumchrus and minimal variance between stations pump catches indicated for one transect that 88% of total catch occurred in one 90-m segment, and 180 m had no C. plumchrus at all. Conversely, meroplankton, suspected of contributing to the considerable variance later on, were found to be relatively evenly distributed in some transects. Subsequent analysis of the data is expected to yield information which will be useful in planning future surveys as well as suggesting causal mechanisms governing plankton distribution and success in fish feeding.

Ocean Station P

Routine monitoring of nutrients, productivity and zooplankton at Ocean Station P was continued. None of the analyses have been carried to the point where the data can be published. In view of the interest in this program outside our laboratory and the difficulty we have in maintaining up-to-date data reporting we propose to relinquish responsibility for this program to another interested agency. The past data will be analysed and published as opportunity permits.

Microzooplankton Studies

Three years of microplankton data collected from Departure Bay are being analysed. During this period there has been an order of magnitude increase in the number of phytoplankton cells. This increase is due mainly to an increase in the abundance of Chaetoceros sp. while Skeletonema sp. have declined. Chaetoceros sp. were particularly abundant during the last two summers. There is an indication that the size and duration of the bloom of Skeletonema costatum is an indicator of the bloom of Chaetoceros convoluta. The latter species, when in excess of 10,000 cells/l, has been a cause of fish mortality in the pilot aquaculture project. The timing of the spring phytoplankton bloom has also changed from mid-February in 1973 to end-March in 1974 and early May in 1975. Explanations for this change are being sought in the physical data.

Commercial Harvesting of Zooplankton

The harvest of zooplankton is still viewed as an off-season fishery by a number of commercial fishermen. There are 2-4 enquiries per month on gear, fishing, and licencing problems. Four licences have been issued allowing a catch of 200,000 pounds. Two of the licencees have counter lawsuits alleging theft of proprietary information. At the request of Fish. Ops. a report summarizing the state of knowledge of plankton resources in Georgia Strait was prepared. It is conservatively estimated that 500 metric tons of zooplankton may be harvested annually without endangering existing fish stocks in the Strait.

4. Abundance and productivity of benthic food resources of young salmon and other species in estuaries and factors influencing the production of fish food

J. Sibert

Considerable effort was expended in designing a sampling program for benthic copepods on the Nanaimo Estuary. Nets, cores, state of tide, core size, number of replicates, and separation methods were among the factors investigated. Stage of tide made no difference when sampling the top centimeter of mud. Certain species of meiofauna (importantly Harpacticus uniremis) were not sampled by cores. The size of the core is important. The number of replicates taken will depend on the level of accuracy desired but 3-5 is a minimum number.

In spite of sampling complications, three replicate cores were taken at seven stations on the Nanaimo flats at bi-weekly intervals from March and the sampling and analysis is continuing.

Salmon fry in the estuary seem to prefer harpacticoid copepods so emphasis was given to this component of the meiofauna. Over 20 species of harpacticoids have been identified from the mud flat. The fry eat many species but H. uniremis is by far the most important. Other species eaten are Tisbe furcata (epibenthic) and Huntemania jadenis (interstitial). A partial analysis of cores taken at one station from March to July shows a mean of 364 copepods per 10 cm². The average dry weight of these animals is 2.71 micro grams and, if the wet weight is 8.4 times the dry weight (Fulton), the biomass of harpacticoids is roughly 8.3 g/m². For 10 km² of mud flat the total biomass is about 8.3 x 10⁷ grams or about 15-20 times Healey's estimate of the chum salmon food requirements. Between March and May harpacticoid numbers dropped from 503 to 93 per 10 cm², the low count coinciding with the disappearance of young chum from the mud flat.

These calculations are refined guesses at the moment because of the large confidence limits of the counts (0.5 to 2 times the mean), the large spatial variability, the failure to sample H. uniremis adequately and, the unknown feeding range of the salmon on the mud flat.

Feeding rates of harpacticoids were measured in the laboratory

using radioisotopes. The rate of uptake of heterotrophically derived food (bacteria) is 8-10 times that of autotrophically produced food (microscopic algae). Feeding rates ranged from 3.3 micro gr C per hr for H. uniremis to 46 micro gr per hr for Dactilopodia crassipes. These rates are equivalent to 1 and 13.8% body carbon per hr respectively.

Some species of harpacticoids were reared through several generations in the lab as an indirect approach to production measurements. Mature adults were produced from eggs in approximately 19 days. An adult female can produce 3 broods of 9 to 90 eggs. In an experimental pond with a sand substrate, copepods increased from less than 1 to 249 per 10 cm² in 30 days. The interpretation of these changes in relation to changes in the natural population noted earlier are problematical. However, they indicate that we are capable of detecting changes in natural and artificial populations and ultimately we expect to be able to relate the two.

Production rates were measured for primary producers on the mud flat. Both macroalgal production and microalgal production were low, on the order on 1 and 80 mg C/m²/day respectively. Heterotrophic production was high, about 88% of total production per day, which was 1,021 mg C/m²/day. These figures are consistent with estimates of bacterial standing crop of 31.4 mg C/m² and 8.9 mg C/m² of microalgae.

These results coupled with the experiments on harpacticoid feeding suggest that the salmon-supporting food web on the mud flat is detritus based. Since the in situ benthic primary production is low, the source of detritus must be allochthonous. Possible sources are eel grass, sedge marsh and downstream transport of litter. Visual observation and preliminary attempts at measurement indicate that downstream transport is important.

Computer programs for the storage, retrieval, and tabulation of existing stomach contents data were virtually complete in May 1975. The computer programmer responsible for this work left in June and a replacement was not found until October. He is converting the programs to operate on the new computer. Some of the conversion problems are considerable and the task will not be complete until January 1976. Preliminary tabulation of the 1974 estuarine and nearshore stomach data should be complete by April 1976.

Cowichan Bay Study

At the request of the Habitat Protection Unit, Southern Operations Branch, a brief 2 1/2-day study of production in the Cowichan River estuary was undertaken. Participating were nine workers from PBS as well as others from Fish. Ops. Vancouver, PEI and Ron Foreman from UBC. Field activities expended 20 man days and 8 boat days of PBS resources, while laboratory analysis of samples involved at least another 80 man days. The results indicated that the Cowichan estuary has a higher primary productivity both in the water column and on the sediment surface than Nanaimo. The standing crop and composition of the meiofauna populations are similar.

Rupert Inlet Study

A brief field program was carried out in the Rupert-Holberg-Quatsino area jointly with the inshore oceanography group from Pat Bay. The purpose was to determine the magnitude of primary production in Rupert Inlet in relation to the high rate of vertical water movement in that system. The rate of growth in the phytoplankton populations was quite high, but large standing crops did not develop because of the lack of stable stratification due to intense mixing. These results should find important application when production in relation to tidal passes is studied in Georgia Strait. This collaborative project utilized approximately 60 man-days of Sibert and Stephens' time.

Productivity Intercalibration

A study of the variability in the ^{14}C uptake technique for measuring primary production was conducted jointly with J. Stockner of PEI. Differences in results and techniques were resolved. It is hoped that a manual for a standard method will be produced.

Diurnal Variation in Productivity Variables

Several biological, chemical and physical variables were measured over 24 hr at three dates during the year. The coefficient of variation over a single day were compared with the variation shown in 26 bi-weekly samples. The results cast doubt on the validity of single samples as representative of conditions in the water column for the day of sampling. This study was performed by R. Naiman and has been written up for publication.

5. Abundance, distribution, and food habits of potential competitors or predators of young salmon in the Nanaimo area

E. Barraclough

It was recognized that E. Barraclough's prime responsibility was to publish his backlog of data on Georgia Strait and other fishes. His involvement was therefore, indirect and advisory. However, A. Phillips joined our group and was given the task of examining non-salmonid fishes collected during regular sampling for young salmon in the Nanaimo area, and together with D. Robinson will play a more direct role in 1976-77 studies at Qualicum.

Manuscripts on existing data that are in preparation include the following:

1. Distribution and abundance of juvenile fish in the surface waters of the southern Strait of Georgia during spring and summer of 1966-69.
 - a. Salmonids to be completed February 1976.
 - b. Larval and juvenile pelagic and demersal fish to be completed February 1976.
 - c. Commercially and non-commercially important fish to be completed as time permits.

2. Food of larval and juvenile fish in the surface water of the southern Strait.
3. A paper has been completed on estimates of abundance of sockeye in Great Central Lake and submitted to the Journal.
4. Seasonal distribution of hake and pollock in the pelagic waters Georgia Strait. Most of the original data collected with a midwater trawl from about 20 different stations at 4 depths and over 4 seasons have been tabulated and graphed.
5. Occurrence of lamprey attacks on: a. young salmon, b. hake, pollock, and other pelagic fish in Georgia Strait. Two species of lamprey are involved, Lampetra ayresi attacks on juvenile salmon, and Lampetra tridentatus on pelagic fishes. A report on these observations to be completed before summer 1976.
6. Fishes associated with the echo-scattering layers in Georgia Strait. Report to be completed before summer 1976.
7. Occurrence of Lampetra ayresi (Lampetra japonica?) in Great Central Lake. Attacks by lamprey on juvenile sockeye in the Lake. Report to be completed by summer 1976.
8. The larval stages and distribution of Cottus asper in Great Central Lake. These data relate to an undescribed aspect of the life of Cottus asper. Completion winter 1976.
9. Contributions to the knowledge of little known fish in the waters of B.C., new records, new species.

Since joining the program A. Phillips analysed samples collected during the spring and summer sampling in the Nanaimo area. Non-salmonid species have been identified and their relative abundances assessed. Stomach analyses performed to date on most common non-salmonid species suggest that there are significant numbers of potential competitors, identified by size and abundance, eating the same items as the salmon. The data also indicate possible onshore/offshore movements of fish with associated feeding patterns. In view of the extensive program planned for next year, efforts have been undertaken to develop streamlined food analysis techniques while maintaining compatibility with other phases of the fish investigations.

6. Identification of parasitic fauna and parasite load in commercially important fishes in Georgia Strait

Z. Kabata

In the course of the calendar year 1975, samples of chum (and some

chinook) fry were collected in the Nanaimo River and its estuary. Marine commercial fish species (hake, pollock and hake) were collected in several localities in Georgia Strait.

At the time of sampling, salmon fry were on their way out of the river or newly arrived in the estuary. Their length was in the order of 50-60 mm. Although it is not unusual to find parasites on fish only 3 days old, the fry sampled were almost completely free of infections. One chum taken in the estuary was infected with an adult tapeworm obviously acquired in the river. Several carried nematode larvae. A single chinook harboured an intestinal fluke. The examination of the salmon fry samples has not yet been completed, but it appears that their parasitic infections are encouragingly low.

The hake population sampled (Stuart Channel) harboured 15 species of parasites. Ectoparasites were represented by 4 species (3 copepods and 1 gill fluke). Seven species of adult endoparasites were present (4 flukes, 1 tapeworm, and 2 nematodes). There were also 4 species of larval parasites, all intestinal (2 flukes and 2 nematodes). With one exception, all species showed increase in prevalence and intensity of infection with the age of the fish. The blood fluke Aporocotyle margolisi, however, showed the opposite infection pattern, being much more common in the smaller and younger fish. This is a possible indication of severe harm inflicted by this parasite on the host. A. margolisi lives in the heart and large blood vessels of hake. The pattern of its distribution might be due to the early elimination of the infected fish from the population. It should be flagged as a parasite with possible impact on its host population.

The herring samples examined so far harbour nine species of parasites. Only two of them are ectoparasites (copepods). The endoparasites are represented by 3 species of intestinal flukes, 2 of larval nematodes, 1 larval tapeworm and 1 gall-bladder protozoan (Ceratomyxa orientalia). No significant impact of these parasites on the host population is evident so far.

The samples of pollock are yet to be examined.

7. Description and analysis of benthic invertebrate communities

F. Bernard

Jan. 1/75-Aug. 1/75. Seconded to Ottawa as Coordinator, Marine Programs, Water Pollution Control Directorate, EPS.

Since returning in August a write-up of shellfish-bacteria experiments has been completed. A start has been made to sort and catalogue benthic samples from the Strait of Georgia taken in the past. These samples will provide a general community map, an inventory of community types and aid in identifying important producers and exploitable resources.

J. C. Mason activities 1975-76

J. Mason has only recently joined the Georgia Strait Program and most of his time last year was spent in writing up his accumulated data. The following is a list of manuscripts either in press or ready for presentation.

1. Populations of sympatric sculpins (Cottus aleoticus and C. asper) in four adjacent salmon-producing streams on Vancouver Island. Fish Bull. (In press)
2. Some features of coho salmon fry (Oncorhynchus kisutch) emerging from simulated redds and concurrent changes in photobehavior. Fish Bull. (In press)
3. Some aspects of the downstream movement of juvenile coho salmon (Oncorhynchus kisutch) including lunar periodicity in the fry stage. J. Fish. Res. Board Can. (In press)
4. Crayfish production in a small woodland stream. Second Internat. Symp. Crayfish. Baton Rouge, La. (In press)
5. Supplemental feeding of underyearling coho (O. kisutch) in an experimental stream. J. Wildl. Manage. (Submitted)
6. Evaluating a substrate tray for sampling the invertebrate fauna of small streams with comment on general sampling problems. Archiv. Hydrobiol. (Submitted)
7. Research problems in stream ecology in British Columbia (with D. Narver). Fish. Mar. Ser. Res. Dev. Tech. Rep. No. 562.

The remainder of J. Mason's time has been spent in supervising G. Glova's Ph. D. studies in reviewing papers internally and externally, and in participating in planning for future work.

S T A F F L I S T

Staff List

All employees are listed who were on strength as at December 31, 1975. The arrangement of investigations and services applies to the major portion of the year.

Director	W. E. Johnson, Ph.D.
Executive Assistant	W. E. Reynolds
Chief Scientist	K. S. Ketchen, Ph.D.
Scientific Assistant to the Director	H. W. D. Smith, M.Sc.
Director's Secretary	S. Young

Office of the Director

Director	W. E. Johnson, Ph.D.
Executive Assistant	W. E. Reynolds
Scientific Assistant to the Director	H. W. D. Smith, M.Sc.

Personnel

Tom Moffatt
Joan Sutherland

Administration and Program
Support Services

Financial Management

W. E. Reynolds
P. Childs

S. Grando
M. Arbanas

Buildings, Grounds and Shops

P. Vogt
F. E. Drader
M. Hill
H. W. Gulich
T. Gillies
M. H. Shillington (Term)
J. M. McArthur
G. J. Richard
S. A. Vivian
M. Ilich

Office Services

O. Morgan
R. Hancock
M. K. Philip
J. G. Naysmith
G. Wilson (Term)

Library Services

E. A. Young

Publications and Information

T. Beg
A. A. Denbigh
G. D. Melluish
D. J. Redman
L. G. Murray

Computations

J. A. C. Thomson, M.Sc.
M. Marshall
K. R. Mitchell
F. W. Nash, B.Sc.

Equipment Research and Development

M. C. Armstrong
G. T. Atkinson

Fish Culture - Nanaimo

R. M. Humphreys
D. Pozar

Fish Culture - Rosewall

G. E. Johnston
E. W. H. Moore
R. Traber (Term)

"G. B. REED"

J. Liston
W. E. Wolden
J. R. Selsby
R. D. Clowes
J. W. Young
B. A. J. Petreman
J. J. Backmann
F. Kreger
M. A. Maclean
J. Swindell
E. C. Ryan
D. N. Housego
W. P. Rowbottom
L. E. McLeod
W. H. Colp
W. S. Sutherland
R. May
R. P. Marshall
E. R. Cuming
A. O. Jorgenson

"A. P. KNIGHT"

E. R. Pollard
W. P. Winstanley
R. H. McLaughlin
S. F. Head
F. T. Shiels

"CALIGUS"

R. C. Page

Marine Support

J. H. Brennan
G. A. Wiseman
W. D. Nichol
L. V. M. Soper
H. Rumming
J. T. Ferguson
A. J. Fletcher

Fisheries Population

Management

K. S. Ketchen, Ph.D.
J. M. U. Nott

Groundfish

S. J. Westrheim, M.Sc.
D. E. Chilton
D. Davenport
W. R. Harling
J. E. Smith
N. L. Venables
R. M. Wowchuk

Crustacea

T. H. Butler, M.A.
A. N. Yates
J. A. Boutillier, B.Sc.

Invertebrates

P. Breen, Ph.D.
G. D. Heritage, B.Sc.
B. Adkins, B.Sc.

Herring

A. S. Hourston, Ph.D.
C. W. Haegele, B.Sc.
R. D. Humphreys, M.Sc.
R. S. Isaacson
S. L. Kerr
D. N. Outram, B.A.
J. S. Rees

Stock Identification

T. J. Mulligan (Term), Ph.D.
S. Yamada (Term), Ph.D.
L. Lapi (Term), B.Sc.

Salmon Population

J. McDonald, M.A.
K. V. Aro, B.A.

Hydroacoustics

F. H. C. Taylor, Ph.D.
L. W. Barner

Fisheries Oceanography

W. P. Wickett, M.A.

Crayfish

J. C. Mason, Ph.D.
R. A. Ptolemy (Term)

Salmon Mark and Tag Recovery Program

H. Godfrey, M.A.
E. A. R. Ball

Salmon Enhancement, Aquaculture
and Fish Health

Management

L. Margolis, Ph.D.
P. Cowie
A. Thompson

Salmon Development Requirements

D. F. Alderdice, Ph.D.
F. Velsen

Salmon Incubation Requirements

R. A. Bams, Nat, Phil, Drs.
D. G. Crabtree

Salmon Behaviour

C. Groot, Ph.D.
I. Miki, B.A.
C. E. Turner

Hatchery Juvenile Production

H. T. Bilton, B.A.
J. W. Jenkinson

Stream Juvenile Production

J. H. Mundie, Ph.D.
D. E. Mounce, B.Sc.

Stock Establishment and Improvement

F. C. Withler, M.A.
A. S. Coburn
J. Martell
R. B. Morley, B.Sc.

Microbiology

G. R. Bell, Ph.D.
T. P. T. Evelyn, Ph.D.
J. E. Ketcheson, B.Sc.
G. S. Traxler, B.Sc.

Diagnostic Services

G. E. Hoskins, B.Sc.
L. P. Hulstein

Histology

J. W. Bagshaw

Parasitology

Z. Kabata, D.Sc.
N. P. Boyce, M.Sc.
T. E. McDonald, B.Sc.
D. J. Whitaker, B.Sc.

Pilot Fish Farm

W. A. Kennedy, Ph.D.
W. Griffioen
E. W. Stolzenberg
C. T. Shoop
A. J. Solmie

Physiology

J. R. Brett, Ph.D., F.R.S.C.
W. C. Clarke, Ph.D.
W. Damon
J. E. Shelbourn, M.Sc.
J. M. Blackburn, B.A.

Fisheries Ecology

Management

C. D. McAllister, Ph.D.
J. Free

Chemistry Lab

Lake Fertilization

W. E. Barraclough, Ph.D.
J. I. Manzer, M.A.
D. G. Robinson

Effects of Environmental Change
on Aquatic Resource

J. C. Scrivener, B.Sc.
B. C. Andersen, B.Sc.

Babine Environmental Change

Nearshore Resource Ecology

R. J. LeBrasseur, Ph.D.
J. D. Fulton, B.Sc.
O. D. Kennedy, B.Sc.
D. B. Sutherland
F. Bernard, B.Sc.

Pelagic Resource Ecology

R. J. Beamish, Ph.D.
R. J. Scarsbrook
M. S. Smith

Estuarine Resource Ecology

J. R. Sibert, B.A., Ph.D.
T. J. Brown, M.Sc.
B. A. Kask, B.Sc.
K. V. C. Stephens

Population Ecology

M. C. Healey, Ph.D.
R. Hungar
F. P. Jordan
R. Schmidt, B.A., M.A.
A. C. Phillips (Term), B.Sc.

Personnel from the Arctic Unit

M. A. Biggs, Ph.D.
I. B. MacAskie

NON-STAFF RESEARCH WORKERS

Honorary Research Associates

R. E. Foerster, Ph.D.
F. Neave, Ph.D.
W. E. Ricker, Ph.D., F.R.S.C.

Postdoctorate Fellows

P. A. Breen, Ph.D.
R. Kieser, Ph.D.
R. J. Naiman, Ph.D.
C. Sankurathri, Ph.D.
N. E. Stacey, Ph.D.
D. D. Williams, Ph.D.

PUBLICATIONS

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- Humphreys, R. D. 1975. An evaluation of the extent of gillnet dropout in a roe herring fishery in British Columbia. Fish. Mar. Serv. Pac. Biol. Sta. Circ. 102: 2 p.
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- Withler, F. C. 1975. Book Review of: A. Netboy, 1974. The Salmon: their fight for survival. Houghton Mifflin Co., Boston, 613 p. J. Fish. Res. Board Can. 32(12): 2582 p.

3. Sub-publications

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1975. British Columbia Pacific oyster breeding. Fish. Mar. Serv. Res. Dev. Pac. Biol. Sta. Newsletter 4: 4 p.
1975. British Columbia Pacific oyster breeding. Fish. Mar. Serv. Res. Dev. Pac. Biol. Sta. Newsletter 5: 2 p.
1975. British Columbia Pacific oyster breeding. Fish. Mar. Serv. Res. Dev. Pac. Biol. Sta. Newsletter 6: 3 p.
1975. British Columbia Pacific oyster breeding. Fish. Mar. Serv. Res. Dev. Pac. Biol. Sta. Newsletter 7: 3 p.

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1975. British Columbia Pacific oyster breeding. Fish. Mar. Serv. Res. Dev. Pac. Biol. Sta. Newsletter 9: 3 p.
1975. British Columbia Pacific oyster breeding. Fish. Mar. Serv. Res. Dev. Pac. Biol. Sta. Newsletter 10: 4 p.
1975. British Columbia Pacific oyster breeding. Fish. Mar. Serv. Res. Dev. Pac. Biol. Sta. Newsletter 11: 3 p.
1975. British Columbia Pacific oyster breeding. Fish. Mar. Serv. Res. Dev. Pac. Biol. Sta. Newsletter 12: 4 p.
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- Kennedy, W. A. 1975. An experimental fishfarm for salmon at the Pacific Biological Station. Fish. Mar. Serv. Res. Dev. Tech. Rep. 543: 33 p.
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- Scrivener, J. C. 1975. Water, water chemistry and hydrochemical balance of dissolved ions in Carnation Creek watershed, Vancouver Island, July 1971-May 1974. Fish. Mar. Serv. Res. Dev. Tech. Rep. 564: 141 p.
- Sibert, J. 1975. Residence of juvenile salmonids in the Nanaimo River estuary. Fish. Mar. Serv. Res. Dev. Tech. Rep. 537: 23 p.
- Smith, J. E. 1975. Catch and effort statistics of the Canadian groundfish fishery on the Pacific coast in 1974 (Data record). Fish. Mar. Serv. Res. Dev. Tech. Rep. 542: 74 p.
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