

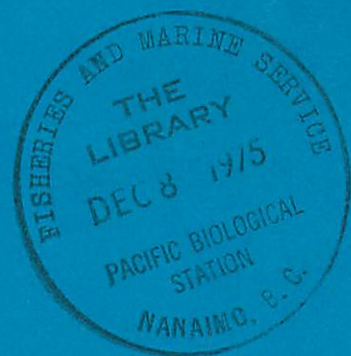
**FISHERIES AND MARINE SERVICE  
RESEARCH AND DEVELOPMENT DIRECTORATE**

**PACIFIC BIOLOGICAL STATION  
NANAIMO, B.C.**

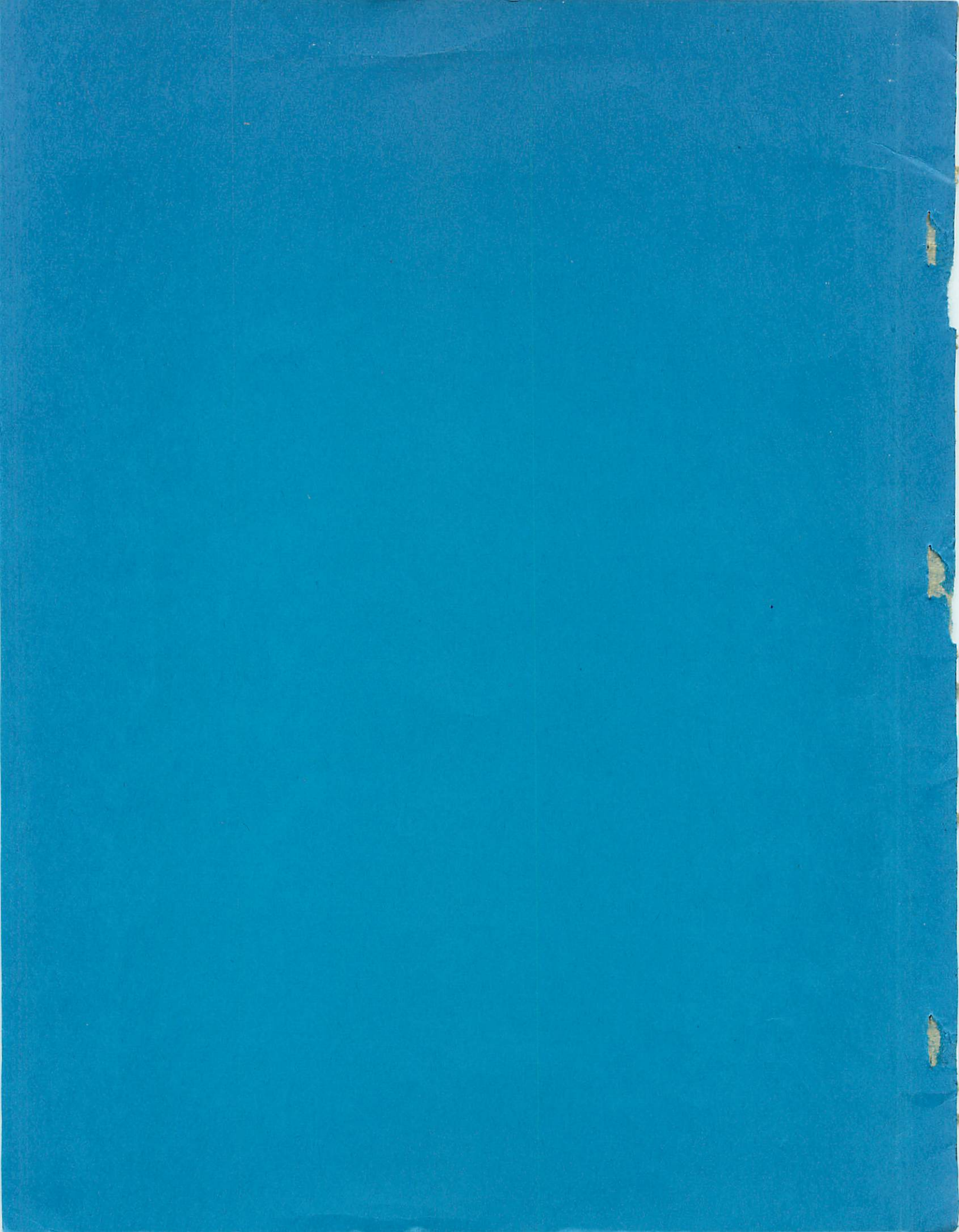
**ANNUAL REPORT  
and  
INVESTIGATORS' SUMMARIES**

**1973**

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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

This was a year of new leadership and some significant program changes at the Pacific Biological Station. Dr. W. E. Johnson, a staff member from 1955-65, and recent Director of the Freshwater Institute, Winnipeg, returned to become Director of the Pacific Biological Station.

In order to respond effectively to changing priorities for west coast fisheries, and ensure the continued relevance of research and development programs to the needs of fisheries' managers and the commercial and recreational fishing industries, both a strengthening and realignment of programs in the four current Pacific Biological Station research groups were begun. The process of change is expected to be continued in 1974.

In the Marine Fisheries Group strong thrusts were sustained in the major herring and groundfish programs. Herring program activities were consolidated, and a new scientist was recruited to assist with emerging complex management problems. These problems arose as the fishery, closed from 1967-72, filled a substantial catch quota and the stocks showed encouraging signs of recovering from their long slump. Several other projects provided information of considerable direct importance to the industry. These included a report on the potential of west coast groundfish stocks, discovery of new pink shrimp resources off the west coast of Vancouver Island, and advice to commercial oyster growers and to those growing spat for overseas and domestic markets.

The Salmon Management and Development Group continued to undertake programs in research in direct support of Pacific salmon management with emphasis on the major sockeye runs of the Skeena River, and on chinook and coho of the Strait of Georgia and other coastal waters. Considerable effort was again devoted to perfecting gravel-filled incubation boxes, particularly for pink and chum salmon eggs and alevins, and new evidence was uncovered of the likely importance to effective homing on pink salmon of using home-stream male gametes in fertilizing eggs from donor streams. Information emerging from these research projects have most important implications for efforts to increase Pacific salmon production. Staff members were also heavily involved in developing a statement of research requirements for a major west coast salmon enhancement program.

The Experimental Biology Group initiated new studies in salmon aquaculture in 1973 and a pilot model of an experimental floating fish farm was installed at Brandon Island adjacent to the Station. This project will help in assessing economic feasibility of such installations for private aquaculturists and provide much of the technical know-how they will require. Parasitologists and bacteriologists of the group continued to provide diagnostic and other expert services to government agencies and private groups. A major study of fish parasites of Aishihik Lake in the Yukon was undertaken in support of the regional Operations Directorate, and considerable time went to service on fish health committees including one charged with developing procedures for a national fish health inspection and certification program.

The Environmental Research Group shifted much of its effort in 1973 from Great Central Lake, where a major lake fertilization experiment was nearing completion, to the Strait of Georgia. Concern for the Strait as a major fish production area and nursery ground for young salmon, is now accentuated by proposals for major

new industrial development, increased population and consideration of major oil tanker routes. Staff members were called upon by service headquarters to serve on a number of task forces concerned with environmental impacts in and adjacent to the Strait and a draft cabinet submission was prepared for a greatly expanded Strait of Georgia program. This was the fourth year of pre-logging studies in a 15-year multi-agency study of effects of logging on salmon and trout in a west coast watershed.

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



## M A R I N E F I S H E R I E S G R O U P

S. J. Westrheim

During 1973, the composition of the Marine Fisheries Group was changed. The Lobster Transplant Investigation was terminated; Sablefish Culture was transferred to the Experimental Biology and Pathology Group; and Pelagic Fishes was subdivided into Herring and Hydroacoustics. By late 1973, the Group comprised the following Investigations: Crustacea (Shrimp and Crab in 1972); Groundfish; Herring; Hydroacoustics; and Marine Invertebrates.

All Investigations continue to be closely linked to utilized and latent marine resources, exclusive of salmonids.

## CRUSTACEA

T. H. Butler

The general objective of the Investigation is to provide biological foundation for rational utilization of shrimp and crab resources off British Columbia.

1. Assessment of shrimp stocks off Tofino and Nootka Sound

Late in 1972, the trawler PACIFIC TRIDENT, chartered by Industrial Development Branch (Fisheries Service), found concentrations of pink shrimp (Pandalus jordani) along the west coast of Vancouver Island, off Tofino and off Nootka Sound. The latter area was explored by this Station in 1955 and 1959 with promising results.

A commercial fishery began early in 1973 on the ground off Tofino. In order to determine, in the early stage of exploitation, boundaries of the two stocks, to estimate stock size, and to determine sex and age composition, a survey was conducted with G.B. REED from May 7 to 23. A total of 83 tows was completed.

On the basis of 57 tows, the ground off Tofino is 33 miles long and from 2 to 6 miles wide. Total area is 162 square miles, and the depth range is 59-83 fathoms. The best fishing depths were 60-76 fathoms. Biomass was calculated using a ratio estimate for expanding catch per sampled area (30 ft  $\times$  1 mi) to the entire ground, assuming a fishing coefficient of 1.0. The minimum estimate of stock size during May 1973 was 15.3 million pounds.

The ground off Nootka Sound, as determined by 26 tows, is 13 miles long, 1.75-3 miles wide, and has a total area of 26 square miles. The depth range is 69-81 fathoms. Shrimp were smaller than on the Tofino ground. The minimum estimate of the shrimp stock during the survey was 1.65 million lb. A total of 4,874 shrimp, from both grounds, was sexed and measured.

## 2. Crab study in Nanaimo River estuary

During 1973 a Department of the Environment cross-mission task force conducted an impact study of a proposed Nanaimo Harbour development. Because the Dungeness crab (Cancer magister) is an important commercial and recreational resource around Nanaimo, local stocks of the species were investigated from June to October. Traps, trawls, and tangle nets were used.

Dungeness crabs are relatively more abundant in the Nanaimo estuary than in other local areas such as Departure Bay. Legal males are more abundant off the present Assembly Dock, and females, breeding or not, evidently congregate more densely off Jack Point. More but smaller crabs of both sexes (1-3 years) inhabit the shallow ground off the Assembly Dock than other zones.

Beach surveys at low tide and some trawling demonstrated that the upper estuarine flats, particularly the east (Holden Creek) and west (Nanaimo River) channels are utilized by yearling crabs during June and early July as moulting sites. From July 24 to September 21, 486 legal males were tagged, most of them in the estuary but some around Newcastle Island and in Departure Bay. The question that prompted the tagging, the homogeneity of crab populations in the region, remains unanswered as recoveries to date have indicated only limited movements.

It is concluded that port development at either site would reduce the crab stock of the estuary substantially. Especially, off the Assembly Dock (No. 1 site), dredging would obliterate the juvenile crab habitat, and remove the main commercial fishing ground around the perimeter of these flats.

## 3. Mainland inlets prawn project

The main prawn trap fishery of the province is located in several large mainland inlets, adjacent to northeastern Vancouver Island. An investigation has been initiated because of an evident decline in production after 1970. The objective is to obtain data on prawn biology and population dynamics as required for a suitable management policy.

A preliminary survey was conducted in November 1973 with A.P. KNIGHT, and field studies will continue in 1974.

GROUND FISH

S. J. Westrheim

The Groundfish Program is concerned with the reaction of commercially important marine fish (except halibut) stocks to exploitation and environmental factors. We provide advice on status and management of stocks to industry and appropriate agencies. Principal species landed by Canadian vessels during 1962-71 were Pacific cod (40%), lingcod (19%), rock sole (13%), and Pacific ocean perch (7%). Approximately 17 additional species account for the remaining 21%.

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

#### 4. Monitoring the commercial fishery

Monitoring activities include: (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; and (3) sampling catches at sea to determine discard, qualitatively and quantitatively.

Reports were published in the Technical or Manuscript Report Series dealing with: (1) catch statistics of the domestic fishery in 1972; (2) inventory of biological samples from the domestic fishery in 1973; (3) species composition of rockfish landings; (4) length and age composition of English sole landings, 1953-71; (5) depth distribution of trawl catches, 1958-71; and three cruise reports for an IDB-supported trawler (with observer aboard).

#### 5. Biological investigations

Biological investigations dealt with: (1) identification and assessment of latent groundfish resources; (2) taxonomy, stock assessment, age determination, and reproduction of rockfishes; (3) factors affecting survival of eggs and larvae of halibut and flathead sole; (4) age determination of lingcod; and (5) tagged blackcod.

##### (a) Latent resources

In 1971, we began an echo-sounder and trawl survey with the G.B. REED of little-known grounds in Queen Charlotte Sound and Hecate Strait. During June-July 1973, approximately 1,600 sq mi of bottom were surveyed. A report of this cruise was published in the Technical Report Series. Approximately 5,500 sq mi of ocean bottom (>80 fm deep) have been surveyed, and the project is approximately 90% complete. Substantial stocks of fish were observed. Principal species were Pacific ocean perch (Sebastes alutus) over trawlable bottom, and redstripe rockfish (S. proriger) over untrawlable bottom. A report summarizing current results is in preparation.

##### (b) Rockfish biology

Rockfish taxonomic studies are nearly complete. We have added 10 species to the official fauna of British Columbia -- two of which are new to science. Dr. H. Tsuyuki of the Vancouver Laboratory collaborated in these studies. A report on taxonomy and distribution of the dusky rockfish (Sebastes ciliatus) was published in the Journal FRBC.

During September 1973, a G.B. REED groundfish cruise was completed in Queen Charlotte Sound to assess the status of two important stocks of Pacific ocean perch. A report of the cruise was published in the Technical

Report Series. Biomass estimates were lower than expected, and were due to lower catch rates which may have been caused by subnormal bottom temperatures.

Age determination and growth studies on Pacific ocean perch have provided evidence for identifying unit stocks separated bathymetrically, on the same bank, and latitudinally. These results were published in the Journal FRBC. Similar studies on about 12 other rockfish species are being summarized for publication in 1974.

Results of rockfish reproduction studies during 1963-73 have been summarized, and a report is in preparation which will deal with size at maturity, time of insemination and larval birth, and identification of post-birth larvae for some 30 species.

Laboratory studies (in cooperation with the Physiological Ecology Program) concerning the effect of environmental factors on survival of eggs and larvae of marine species have been conducted for a number of years. In 1972, Pacific halibut eggs were tested for the effects of temperature and salinity. A report was published by the International Pacific Halibut Commission. Another manuscript was completed dealing more comprehensively with flathead sole eggs and larvae.

(c) Lingcod

Development of an age-determination method for lingcod is proceeding slowly. A summary report containing available information on lingcod off British Columbia was published in the Manuscript Report Series.

(d) Blackcod

The control lots of tagged and untagged blackcod from the 1972 tagging experiment were released in December. A final report on the results is in preparation.

## 6. Meetings

At the request of the three major groundfish-processing organizations in British Columbia, we analyzed all available information to determine where the British Columbia groundfish industry could expand and by how much. In March, meetings were held in Nanaimo and Prince Rupert with fishermen and processors to present our results and discuss them with the interested parties.

An optimistic report was presented. At least four species of rockfish are substantially underfished, and possibly certain stocks of Pacific cod and lingcod as well. An expanded scientific program will be required to provide the necessary quantitative stock assessments.

Meetings of the International Groundfish Committee (Canada-USA), and International North Pacific Fisheries Commission (Canada-Japan-USA) were attended during 1973. A number of reports were prepared.

## HERRING

A. S. Hourston

Reorganization of the Station's programs in 1973 involved moving the echo-sounder survey aspects of the Pelagic Fishes Investigation into the new Hydroacoustics Program and combining the remainder of the Pelagic Fishes Investigation with the Population Biology Investigation to form the new Herring Program. This was effected in July when the writer returned from Ottawa to head up the Herring Program. An additional research scientist (R. D. Humphreys) was recruited in December, raising the scientific staff to three and returning the total staff to its former level of seven.

7. Coordination of activities with Operations Division

Activities in 1973 were directed mainly towards establishing a closer liaison with Operations staff at all levels and cooperating more closely on the collection, analysis, and reporting of data from joint projects. Modifications were agreed upon on information collected by Operations personnel including catch records (new sales-slip form), in the number and size of samples taken and in the specimen data recorded (new sampling procedures), and in spawn surveys (additional data recorded and samples taken). Agreement was reached on standard areas and management units for data grouping (involving changes in statistical areas and in stock definition), on a standard fishing season, and on the type and form of results to be provided to resource managers (involving modifications in analytical procedures). These measures are to take effect in 1974.

8. Catch statistics

R. S. K. Isaacson

Between July 1, 1972 and June 30, 1973, the British Columbia herring fishery took 61,341 tons, the full quota for the season (50,000 tons plus 10,000 tons for the dogfish catch). This was the largest catch since severe restrictions were placed on the fishery to conserve the resource in 1967. A record 6,583 tons were taken by gillnet. The fishery for roe export to Japan accounted for over 90% of the catch, the remainder being used for food or bait. This fishery extended from February to June but took place mainly in March and April. Almost half the catch was taken from the west coast of Vancouver Island, while most of the remainder came from the Lower Central and Queen Charlotte Islands subdistricts. Only in the northern subdistrict was the catch appreciably lower than in the previous season (5,102 tons).

9. Sampling

R. S. K. Isaacson and J. S. Rees

A total of 185 samples (16,339 fish) was collected and processed by the Resource Development Branch in 1972-73. These fish were aged and the results analyzed at this Station. The newly recruited 1970 year-class (age III) predominated in the Northern and Lower East Coast of Vancouver Island, while the 1968 and 1969 year-classes were the major contributors elsewhere in the south. Contributions of the older year-classes were above average in all subdistricts but that of the incoming 1971 year-class was below average. Age V fish generally predominated in the gillnet samples, followed by age IV. The

proportion of age III fish in these samples was relatively small, even in areas where this year-class dominated in the seine samples.

#### 10. Spawning

A. S. Hourston and D. N. Outram

Herring spawn deposition is assessed from surveys conducted by Operations personnel. The numbers of eggs deposited in 1973 were estimated at 17,000 billion, up marginally from 1972 (16,300 billion). There was, however, a major shift in the distribution of spawning. Large egg depositions in the Northern, Upper Central, Lower Central, Upper East Coast and Lower East Coast subdistricts were between 40% and 400% higher than in 1972, while egg deposition in the Queen Charlotte Islands and on the Upper and Lower West Coast of Vancouver Island were down 45-80% from 1972.

#### 11. Status of the herring stocks

A. S. Hourston and S. Kerr

The abundance of herring in the catch and spawning escapement was estimated for those areas (management units) supporting an appreciable herring fishery and/or spawning in 1973. These assessments incorporated some (but not all) of the new procedures. The numbers of spawners were estimated from the numbers of eggs deposited and fecundity at age rather than from miles of spawn as in the past. The numbers of fish at age in the catch were estimated weekly and summed for the season to take into account changes with time in the composition of the runs sampled. Seasonal data back to 1950-51 were re-analyzed on the same basis to indicate trends. A preliminary reassessment was made of seeding needs.

In 1973, the population met or exceeded the seeding requirements in 30 of the 37 areas listed. In five of the remaining seven areas, seeding requirements were exceeded in 1972 and/or 1971. Only in Areas 052 (for which there are no data for 1972 or 1973) and 172 (which showed considerable improvement in 1973) have the stocks failed to recover to seeding levels. On the other hand, abundance approximated or exceeded that in the late 1950's and early 1960's in only 13 of these 37 areas. Northern and southern stocks appear to have stabilized for the past 4 years at about two-thirds of their former level of abundance and the central stocks achieved this level in 1973 (Fig. 1). Since recruitment in the last 2 years has been below average, further improvement may be expected in the future. However, because the fishery is now concentrating on older fish, the number of fish in a population of fishable stocks cannot be expected to regain its former level. Moreover, since natural mortality appears to exceed net growth before the fish mature, the biomass of the fishable stocks cannot be expected to attain former levels.

#### 12. Forecasts for 1974

A. S. Hourston and R. D. Humphreys

Forecasts of the 1974 run by management units were provided to the Operations Division as the biological basis for management of the 1974 fishery. Available information on the abundance of the incoming 1971 year-class (age composition in 1973 and in offshore samples in 1974 and environmental conditions in 1971) suggests below average recruitment, especially in the south. Contributions of the previously recruited year-classes should decline as the

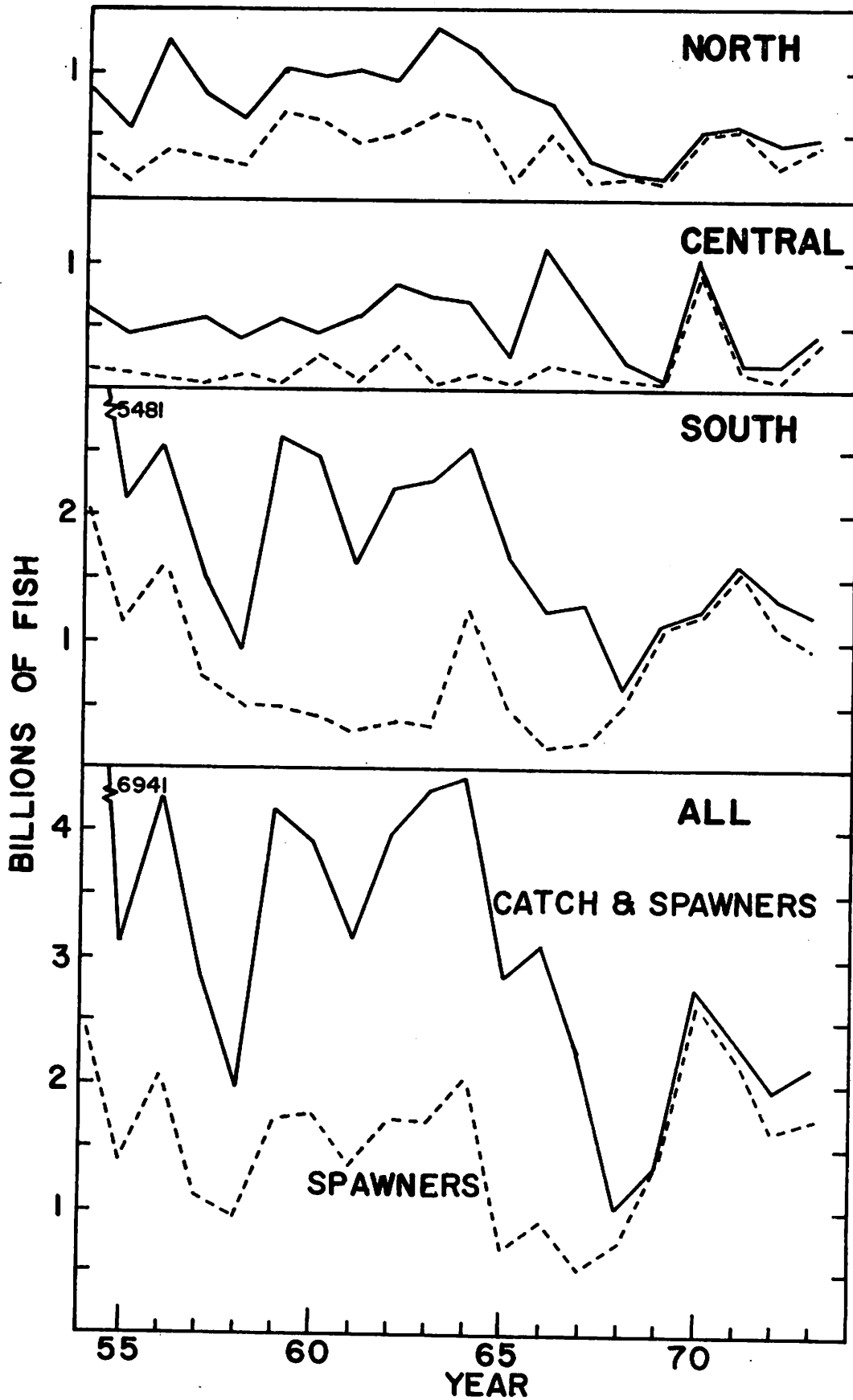


Fig. 1

relatively good 1967-69 year-classes are phased out. Consequently, overall abundance is expected to be lower in 1974 with surpluses over spawning requirements in individual subdistricts ranging between 7,000 and 32,000 tons. Over one-third of the anticipated surplus of 100,000-150,000 tons will be in stocks not usually considered suitable for a roe fishery.

13. Development of quantitative methods for estimating herring spawn deposition

D. N. Outram and  
C. W. Haegele

In 1973, a preliminary study was made of three major sources of variability in estimating the number of eggs deposited from spawn survey records. These were variations in the number of eggs per square yard with substrate, position (level above low tide), and time (egg loss after spawning). Observations were made on four spawnings of light intensity (25-100 eggs per linear inch of Zostera or Scytosiphon and 50-200 eggs per square inch of Fucus or Ulva) on the Lower East Coast of Vancouver Island. Considerable variation was found for all three factors. Consequently, modifications have been made in spawn survey procedures for 1974 including the taking of standardized samples from each spawning and the study will be expanded in 1974.

Other sources of error in estimating the number of eggs deposited include errors in measuring the dimensions of substrate beds, patchiness in substrate distribution and density, and the proportion of the various spawning substrates utilized in a single spawning. Since substrate beds are relatively stable from year to year, preparation of substrate maps from aerial photographs should appreciably reduce these sources of error. Four photographic missions were flown in 1973 to test the use of various types of film, photographic aids and flying altitudes to obtain photographs suitable for this purpose. A combination of false-colour infrared film (No. 2443) with a medium yellow filter for exposed vegetation and colour film (No. 2445) for submerged vegetation taken from an altitude of 3,000 feet over wide sloping beaches and from 1,500 ft over narrow steep beaches provided satisfactory delineation and identification of substrate beds. Most spawning grounds on the Lower and Middle East Coast of Vancouver Island were photographed in 1973.

14. Manipulation of maturity time

An initial attempt was made in 1973 to manipulate the time of maturity for herring in the laboratory by control of the daily photoperiod and gonadotrophic hormone injections. The objective was to provide mature herring for experimental purposes over a greater time period. Sexually mature herring captured in February 1973 did not complete the resorption of their gonads until September by which time the numbers of experimental fish were too depleted to warrant continuation of the project. Valuable experience was gained in the techniques of feeding and rearing herring over extended time periods which should permit a more successful experiment using spent herring.

15. Temperature and salinity levels associated with natural herring spawnings

Experiments conducted by Dr. D. F. Alderdice have shown that herring



egg development is most successful at relatively low levels of salinity (12-20‰). Beyond this range successful development is impaired for a sharply increasing proportion of the eggs. This and other related factors could have an important bearing on the selection of spawning sites (which varies from year to year) and on the survival of the eggs in natural conditions. Over 60 observations of temperature and salinity on spawning grounds on the east coast of Vancouver Island in 1973 showed temperatures and salinities of 6.5 to 8.5 C and 22.4 to 28.4‰, respectively, during spawning and 6.5 to 12.5 C and 17.9 to 28.7‰ during the incubation period. Observations from other areas are planned for 1974 as part of a continuing study of this relationship.

## HYDROACOUSTICS

F. H. C. Taylor

The Hydroacoustics Program was formed in June 1973. The objective is to provide more rapid and potentially more accurate estimates of abundance than traditional catch and sampling techniques. These estimates are required in inventorying fish stocks of either demonstrated or potential commercial value, in management of specific fisheries, and in the assessment of species interaction in particular regions. Digital echo integration, the method adopted, is more flexible than analog integration, and more accurate than echo counting for schooling fish.

In 1973 the basic equipment was assembled and two trial surveys were carried out. The first cruise involved the estimation of the abundance of herring stocks on La Perouse Bank in early fall; the second, the collection of information on the effect of shading, i.e., the loss of energy from multiple scattering and absorption by members of the school on the estimated average density of fish in the school.

The first cruise demonstrated clearly that the tape recorder recommended by the echo-sounder manufacturer was not satisfactory. There were two major problems: (1) variations in output between successive runs of the same tape, due to movement of the playback head, and (2) a "hump," equivalent in amplitude to that from a small fish school, immediately in front of the bottom echo. This was formed by energy from a strong bottom signal "splashing out" on either side of the aperture in the recording head. The effect of the hump can be removed by a more complicated, lengthier integration procedure.

The second cruise demonstrated that, while exceptionally thick schools (from top to bottom) will be required, the method shows promise. The responses from the external upwards-looking transducer are compared with those from the vessel-mounted downwards-looking transducer. The responses of the former can be reduced by as much as one-third by cavitation. This is produced by a screen of fine air bubbles on the face of the transducer as a result of the temperature difference between it and the water. The effect can persist for a long period, but can be prevented by keeping the transducer immersed and wiping the face of it thoroughly immediately before use.

16. Relationship of stock size, year-class strength, fish length, and maturity in herring

The hypothesis to be examined is that during the period of very low abundance the age of first maturity decreased and the size at age increased, and that during the ensuing recovery period when stock size increased, the reverse effects occurred.

Data are available from the early 1940's to the present, enabling the variations to be followed, not only during the late period of rapid change in stock size but also during earlier periods of exploitation during the growth of the fishery. Parallel estimates from computer-processed data using slightly different basic methods may be available for comparison from 1950-51 to the present.

Compilation should be completed by the end of the fiscal year. Analysis and reporting will be undertaken in 1974-75.

#### MARINE INVERTEBRATES

17. Pacific oyster breeding

N. Bourne and G. D. Heritage

Oyster spatfall forecasts were undertaken for the industry in three locations: Pendrell Sound, Hotham Sound and Ladysmith Harbour. Although physical conditions in Pendrell Sound were generally favourable during the summer of 1973 for Pacific oyster breeding, virtually no setting occurred. Surface water temperatures of 20 C or higher were recorded from July 16 to August 17, except for a 4 day period, July 24-27; surface water salinities remained above 15‰ throughout the breeding period. Extensive spawning was observed on July 20 and large numbers of larvae were found in the plankton on July 22 and 23 but they virtually disappeared soon after. Light spawnings were also observed on three later occasions during the first half of August but the resulting spatfall was minor. Light spatfall continued until the latter part of September. Maximum spat counts on experimental cultch at seven stations ranged from 4 to 17.

An exceptionally heavy commercial set of Pacific oysters was successfully predicted in Hotham Sound. Spat counts of over 2,000 per shell were recorded. Three companies exposed about 150,000 strings of shell there.

No Pacific oyster spatfall was recorded in Ladysmith Harbour.

Oyster larval development and setting has become atypical and erratic in Pendrell Sound in recent years. Because of this trend, a major project is planned to begin in 1974, partly in conjunction with the Marine Sciences Directorate. It is planned to study the detailed oceanography of the Sound along with biological parameters to determine if major changes have occurred in the Sound and whether the accuracy of spatfall predictions can be improved.

18. Clam ecology studies

N. Bourne

Clam ecology studies are continuing and long term, and are designed to provide basic biological information for sound management practices. These studies continued in 1973 with a sea trip to the northern area to assess littleneck and butter clam resources and recruitment; continued examination of recruitment of razor clams on the Masset beaches; and the triennial clam survey on Seal Island in the Strait of Georgia. On beaches examined in the northern area, butter clam recruitment was about the same as observed in the previous year but littleneck recruitment was slightly higher. Extensive stocks of both littleneck and butter clams were found on most beaches; densities up to 47 butter clams (14.5 lb) and 89 (7 lb) of littlenecks per sq m were recorded. Extensive digging in the Spider Anchorage area produced 11 live and 3 dead Manila clams. All the Manila clams were large and apparently the same age, indicating a single year-class has settled here. No evidence of recent successful breeding was observed.

With increased interest in the razor clam fishery at Masset in 1973, landings were up. Beach screenings showed densities of the 1973 year-class were slightly lower than in 1972, although densities of 125 per sq m were recorded. Heaviest densities occurred on the western end of North Beach.

At Seal Island there was a 50% reduction in the number of legal size butter clams in a three-year-period from 8.98 per plot in 1970 to 4.4 per plot in 1973. However there was a threefold increase in the number of sub-legal size butter clams from 0.85 per plot in 1970 to 2.5 per plot in 1973, due mainly to large numbers of three-year-old clams, 30-40 mm shell length. The number of littleneck clams increased slightly from 1970 to 1973.

19. Clam aquaculture

Experimental work to determine the feasibility of culturing Manila clams in trays was continued in 1973, partly in Barkley Sound in conjunction with a shellfish producer there and partly in Departure Bay. Survival through the winter of 1972-73 was excellent with mortalities less than 5%; some growth was also recorded during the winter and early spring. However because of poorly designed trays and a heavy mussel set, water circulation in the trays during spring and summer was greatly reduced, resulting in increased mortalities and poor growth. Better designed trays are now being used and it is believed that good survival and growth will result in future. Another 50,000 seed Manila clams were purchased in 1973 and are being held in trays at four densities in Departure Bay. In 1974, it is hoped to obtain 300,000 to half a million seed clams to attempt a pilot plant commercial operation.

20. Clam predation

N. Bourne and J. C. Lee

In clam culture studies to date, heavy mortalities have resulted when clam seed under 5 mm was planted unprotected on clam beaches. These mortalities may be due to physical factors but may also be due to heavy predation. To determine whether shore crabs, Hemigrapsus oregonensis and H. nudus are serious predators on small clams, experiments were undertaken to study predation rates of these two crabs on juvenile sizes of three species of

bivalves, butter and Manila clams and mussels. Results showed that both species of crabs ate all three species of bivalves, H. oregonensis was a greater predator than H. nudus. Smaller clams were eaten more readily than larger ones, and Manila clams and mussels were eaten in greater numbers than butter clams. When clams were buried, more clams were eaten than when they were exposed in experimental dishes.

#### 21. Marine fauna survey

Under contract with Parks Canada, a study was undertaken to compile "A Marine Bibliographical and Review Study of Pacific Rim National Park." This study included a listing of current research projects underway in the Park, habitat types, and a list of marine species. The project was completed in 1974 and published in Manuscript Report No. 1276.

#### 22. Paralytic shellfish poisoning (P.S.P.)

N. Bourne

Levels of P.S.P. in shellfish generally declined in 1973 but remained high enough in many areas to require continued closures. Procedures were established in 1973 between the Inspection Branch of the Fisheries and Marine Service and the Pacific Biological Station to send all samples of water suspected of containing organisms causing red tide to the Biological Station for identification. If toxic-causing organisms are present, authorities will be notified and the suspected area quickly closed.

#### 23. Pendrell Sound

D. B. Quayle

Analysis of oceanographic and biological data collected in Pendrell Sound over the period 1948-1970 has been completed and submitted for publication in the Technical Report Series. Results of this research are being used for the basis of the proposed studies to determine recent causes of fluctuations in oyster larval development and settlement in Pendrell Sound.

#### 24. Oyster consultant service

At the request of the International Development Research Centre, D. B. Quayle spent 6 weeks in Gambia, Senegal and Sierre Leone, West Africa, as a consultant on oysters to the Fisheries Departments and to the oyster industries in these three countries. Continuation of the consulting service has been requested and it is expected that further visits will be undertaken.

#### 25. Mussel culture

A project begun in 1972 to investigate the economic feasibility of culturing mussels in British Columbia was continued in 1973. The project was greatly furthered by a visit to the mussel industry in Spain to observe methods of culture, processing and marketing. Culture of two species is being considered, Mytilus edulis and M. californianus, although major emphasis is on the former species. The principal aim of the project is to accumulate basic biological information on mussels and develop methods of culture suitable to conditions

in British Columbia. Initial stages of the project should be completed in 1974.

26. Effect of oil spills

A study to assess the effects of an oil spill on marine communities in Barkley Sound over a period of a year was completed in 1973. The oil, Bunker B, came from the M.V. VANLENE, which ran aground on Austin Island in Barkley Sound in 1972. Although the effects of this oil spill were not severe, dangers of future spills and methods of assessment are pointed out in the report which will be published as a Manuscript Report.

27. Wood borers

The project to study the attack pattern of the wood borers Bankia setacea and Limnorium lignorum was completed and prepared for publication. Results of the experiment to test protection by various chemical treatments applied to Douglas fir in a randomized block design, indicated the attack pattern was not uniform.

SALMON MANAGEMENT AND  
DEVELOPMENT GROUP

J. McDonald

BABINE SOCKEYE PRODUCTION AND WATERSHED CHANGE

H. D. Smith,  
F. P. Jordan,  
I. Miki and J. Martell

1. Sockeye production

Progress continued in (a) reporting on long-term studies of factors limiting natural production of sockeye salmon and (b) quality studies of Babine Lake sockeye smolts as needed for ongoing management of the stocks and for assessing production from enhancement projects.

A detailed report on historic levels of infection of juvenile sockeye by the intestinal parasite Eubothrium salvelini was published in the Journal FRBC and two FRB Technical, and one Manuscript reports were published on other aspects of the Babine studies.

The 1973 Babine smolt run totalled 89 million smolts (Fig. 2) as estimated by Fisheries Operations, utilizing techniques developed and employed by Pacific Biological Station personnel until 1972. (Responsibility for this assessment passed to the Operations Branch after the 1971 season.) The unprecedented numbers of late-run emigrants from the main basins of Babine Lake were larger than the average over the past 13 years suggesting that food production in the nursery area during the previous summer had not been limiting to their growth (Fig. 3).

2. Babine watershed change program

H. D. Smith

In this multi-disciplinary program, 1973 was the second year of studies. Basic water chemistry, lake circulation, primary production, zooplankton distribution and abundance, and juvenile sockeye studies by investigators from the Pacific Biological Station, Marine Sciences Directorate, Pacific Environment Institute and Fisheries Operations Branch were linked to gain understanding of the energy flow through the system. Atmospheric Environment Service and Water Management Service gave vital assistance to lake circulation studies and sedimentation and geochemical evolution were studied by the Pacific Detachment of the Canadian Centre for Inland Waters. Zooplankton studies initiated by the Pacific Biological Station were taken over by the University of British Columbia Institute of Animal Resource Ecology late in the summer.

A special study of likely effects of bubbler lines (used to maintain ice-free lanes across Babine Lake in winter) on primary production was undertaken by K. Stephens of this Station.

Analyses of 1973 data are complex and will continue for some time.

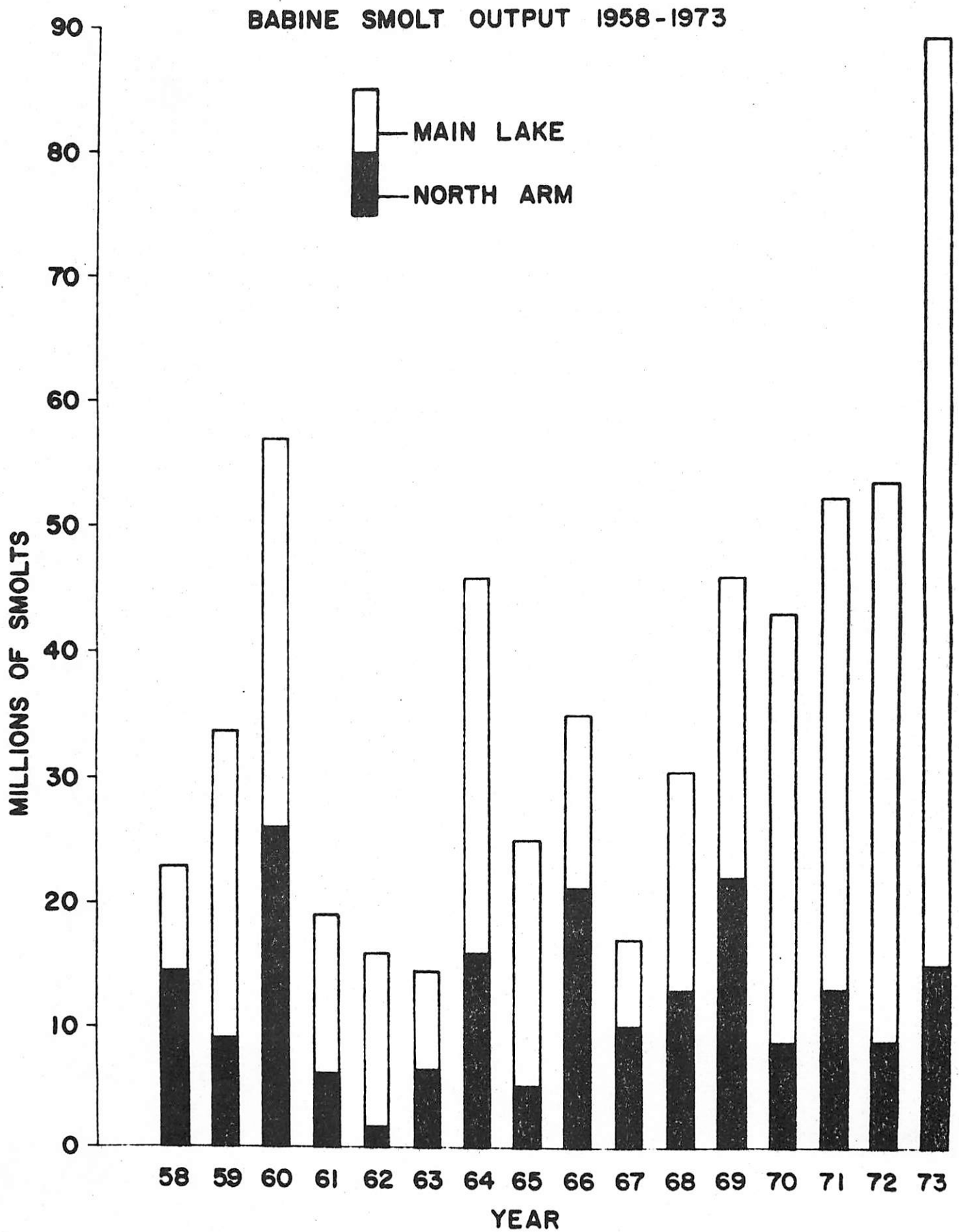


Fig. 2.

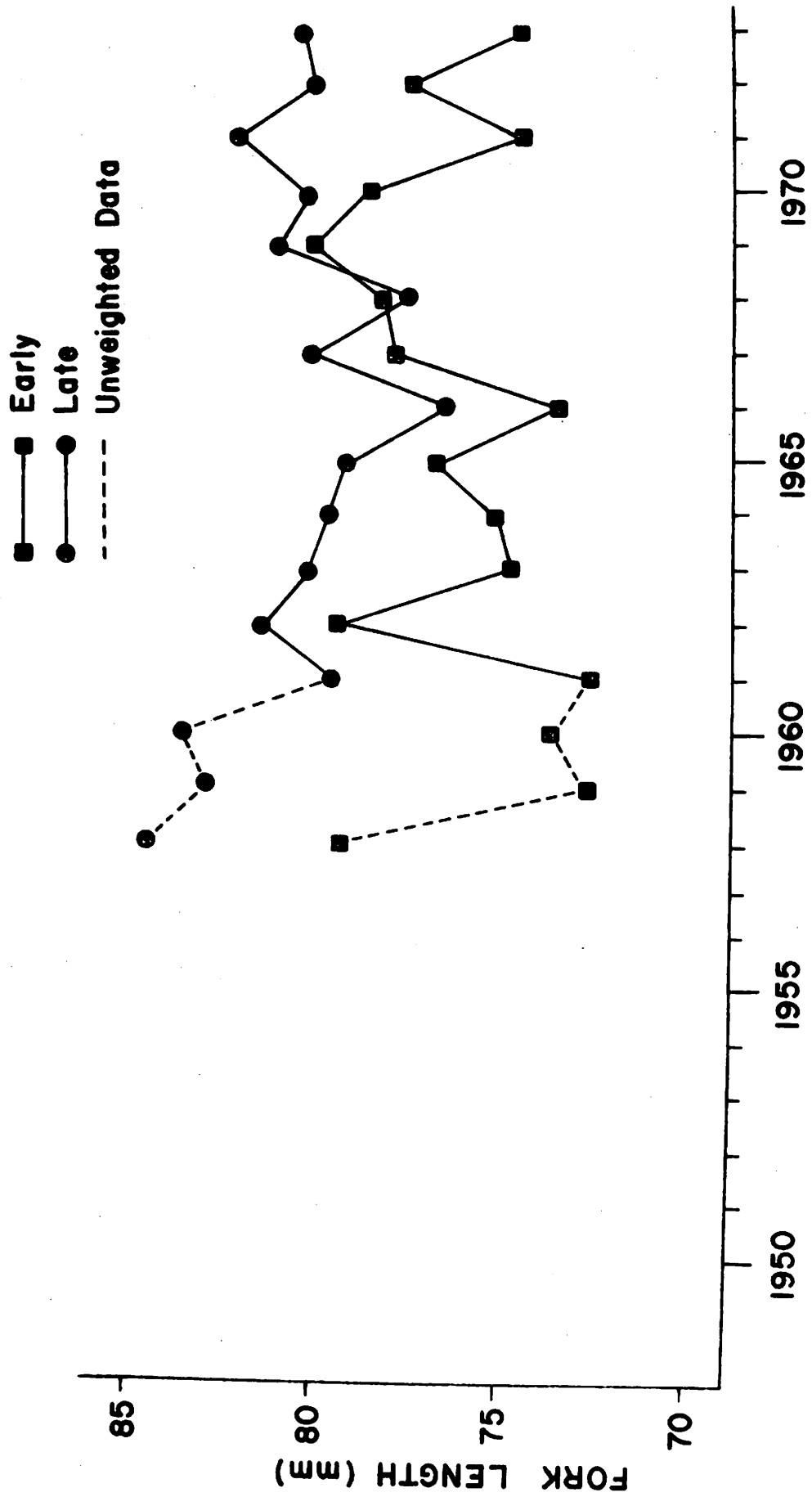


Fig. 3. Mean size of Babine smolts, 1958-73.



An annual report on the 1972 program was published in November 1973, and several manuscripts on specific phases of the work have been completed and will be published in 1974 by the Pacific Biological Station and other participating institutions.

## CHINOOK AND COHO INVESTIGATION

H. Godfrey and  
E. A. R. Ball3. Salmon ecology in Georgia Strait

Studies initiated late in 1972 on the ecology of Pacific salmon in these waters were continued through the winter into March 1973. Juvenile salmon were sought by seining in shallow water and further offshore, and in deeper water by a deeper seine and trolling gear. Stomach samples of salmon and other fishes were retained to provide additional information on interactions between species, particularly salmon, herring and dogfish, during the winter period. A total of approximately 1,400 salmon were caught, and varying numbers of other fish, including herring; 650 stomach samples have been analyzed; 711 salmon grilse were tagged and released (to provide information on subsequent movements and their origins). Of particular interest was the capture of marked Canadian hatchery fish: 11 seine sets in the Deep Bay area provided 68 marked Big Qualicum hatchery chinook salmon (grilse size) in a total catch of 172 chinook grilse.

An MS Report with some interpretation of results will be published shortly. Additional work on stomach contents, feeding behavior and competition among species will be completed and reported at a later date.

4. Survival of coho fry in the sea

It is generally held that out-migrating coho fry cannot survive in the saline medium of estuaries and nearshore waters and that the production of adult coho comes from the year-old (or older) smolts (since adult coho scales bear an apparent freshwater annulus). Yet there are anomalies in the situation; and in particular laboratory experiments have demonstrated that coho fry can tolerate an appreciable degree of salinity, and that the tolerance threshold can be raised by acclimatization procedures.

During 1973, laboratory and field observations initiated in the fall of 1972 were continued. Collections of fry were made near the mouths and in the tidal portions of several streams, at intervals until late March. Fry also were retained in fresh and salt water (various salinities) at the Station. One particular objective was to determine whether the scales of fry held in different salinities (from fresh water to approximately S 30%) would bear an apparent winter, freshwater annulus.

The scales of fry from the field collections have been examined, and measurements of widths of spaces and circuli were made at 154X magnification, using a potentiometer. The concern here was to obtain wholly objective data that would indicate a change in scale pattern of spaces and circuli, that would be

associated with what is subjectively recognized as an annulus. Three scales from each fish were used (and these have demonstrated the very great variability in size and pattern even among scales taken from the same fish at the same location). These data are presently being examined for appropriate statistical analysis by computer.

Scales from the fish that were held (and fed) in fresh water and normal sea water have been examined. All scales of both groups bore a check which, were it on the freshwater zone of an adult coho would, following customary procedure, be described as the freshwater annulus. A tentative conclusion at this time is not that natural coho fry that migrate to sea could be contributing significantly to the production of adult fish, but rather that the specifics of their early sea-life mortality need further investigation.

#### 5. International

As senior author, in 1973, H. Godfrey completed the INPFC Joint Comprehensive Report, "Coho Salmon in Offshore Waters." This was submitted to the Secretariat for publication in September 1973 (161 p.).

As member and technical adviser on sub-committees, H. Godfrey contributed to the Canada-United States Salmon Problems of Mutual Concern, and to the Canada-United States Reciprocal Fishing Privileges Agreement (by analysis of background information and preparation of technical reports).

#### 6. Georgia Strait development program

H. Godfrey served as Co-chairman with Dr. C. D. McAllister in developing this program, including a document for submission to Cabinet.

#### 7. EXPERIMENTAL HATCHERY EVALUATION R. A. Bams and D. G. Crabtree

The Experimental Hatchery program in 1973 pursued two main objectives and obtained results as follows:

Objective 1: To evaluate performance of a new hatchery method for Pacific salmon developed on the basis of earlier research.

This objective is studied in terms of individual and population characteristics of two comparable salmon populations, one of which is naturally propagated, the other artificially. Test populations are selectively marked by double fin clips, released into the hatchery stream, and recovered upon return from the ocean in the commercial fishery and in the river. The primary test criterion is relative survival to the adult stage. Other criteria are length, weight, fecundity, timing and variability of characters.

The program comprises three separate tests carried out on successive generations of a stock of pink salmon in the Tsolum River, Vancouver Island,

watershed. It was initiated in 1968 and third and final returns are due in 1974. Results to date have shown that yolk conversion efficiency in the new hatchery environment equals that in the stream, survival rates in the hatchery are manyfold those in the stream and are approaching a maximum at better than 90% of available eggs, and survival rates from fry to returning adult are virtually the same in fish from both incubational treatments.

Results of the 1970-72 test have been published in two technical reports (1973) and, also, will appear in the Journal FRBC in 1974 (submitted).

Objective 2: To evaluate the effectiveness of a cross-breeding technique on improving salmon-transplant methodology.

This objective tests the hypothesis that in transplants of salmon, significant advantage results from crossing the female element of a donor stock with the male element of a local stock established in the recipient river. The technique aims at capitalizing on the relatively much larger pool of reproductive cells (effectively perhaps 50 times) available in the males of a residual stock as compared to the females. If successful, far-reaching implications are evident, e.g., in restoration of greatly depressed runs, and in transference of (parts of) gene complements from one population to another.

Selectively marked test populations, consisting of homozygous Kakweiken River (KK) pinks and heterozygous Kakweiken and Tsolum river (TK) pinks, were released from the Tsolum hatchery in 1972 with a relative abundance of TK = .532 and KK = .468. In 1973, test fish were recovered as follows: from the fishery 452; TK = .546, KK = .454,  $\chi^2 = .435$ ,  $p = .51$ ; from the hatchery below the weir 147; TK = .769, KK = .231,  $\chi^2 = 33.5$ ,  $p = .000$ ; and from adjacent rivers 8, TK = 1.000. From these data it is concluded that crossbreeding with locally adapted males did not, in this case, influence survival and return from the ocean up to and including return to inshore waters, but significantly altered the rate of return to the recipient stream.

8.

## INTERNATIONAL SALMON STUDIES

K. V. Aro and  
J. McDonald

This investigation continued to provide the technical information and advice required as a basis for developing Canadian policy and strategy for negotiations with other countries. In 1973, emphasis was on negotiations with the United States regarding the interception of each other's Pacific salmon and the Reciprocal Fishing Privileges Agreement which provides for fishing various species within each other's coastal fishing zones. In addition we continued to meet Canada's commitments to the International North Pacific Fisheries Commission.

Negotiations with the United States are currently at an intensive level. Information was provided on migration routes, the extent of mixing of United States and Canadian stocks in various fisheries, and on the number and value of salmon intercepted by each country.

In regard to INPFC, work continued on the Commission's comprehensive

reports reviewing by species the biology of salmon in the North Pacific Ocean. The report on coho salmon (senior author H. Godfrey of Canada) was completed, as was the first draft of the report on chum salmon (senior author F. Neave of Canada).

## SALMON AND STEELHEAD CULTURE

F. C. Withler and  
R. B. Morley9. Accelerated maturation of pink salmon

Techniques for accelerating both the maturation and growth of juvenile pink salmon have been developed. With the aid of gonadotropins extracted from the pituitary glands of adult chinook salmon (developed by E. M. Donaldson, Pacific Environment Institute) it is now possible to bring juvenile males to maturity at one year of age, the progress of maturation being controllable by manipulating gonadotropin dosage. In addition, the males' growth rate has been increased markedly by manipulation of temperature during incubation and rearing, by special feeding regimes, and by controlling salinities. Eggs collected from Jones Creek (a tributary of the Fraser River) in October 1971, were incubated at about 11 C and the resulting fry and juveniles were reared in heated salt water until the following September 1972. Gonadotropin injections were begun in July 1972, and by the end of September the males were mature and had reached a much greater size than those developed in an earlier test under more normal temperature conditions. The average volume of milt produced was 7.1 ml per male, some 25 times that produced by males in the earlier test and about one-quarter that expected from a normal wild male. The average sperm density was slightly greater than that produced by the males of the earlier test, and represented about 10% of that of normal wild males. When this accelerated male milt was applied to lots of eggs equivalent in number to those of a single wild female (1,500), fertilization rates of 80% or better were achieved with volumes as small as 1.8 ml. With 3.5 ml or more the fertilization rate was consistently over 95%. The results of these tests show that, in an attempt to transplant pink salmon into a barren stream, it would be possible to fertilize several million donor ova with accelerated male milt from few enough males to bring the task of rearing them within reasonable limits (ca. 200 males per 1,000,000 fertilized eggs). Thus, in a stream having a distinct on-off year pink run, it is now feasible to transfer the male component of the on-year gene pool into the several million eggs which would be needed for a full-scale introduction attempt.

10. Cryogenic preservation of salmon sperm

Improved techniques for cryogenic preservation of salmon sperm have been developed. The milt of pink, sockeye and chum salmon has been subjected to freezing and short-term storage in liquid nitrogen. DMSO has been used as a protective agent throughout the tests, on the basis of encouraging results obtained elsewhere. The separate effects of different concentrations of protective agent, of different extending media, of different rates of thawing and freezing and of ways of applying the preserved sperm to the ova, have been analyzed. By combining the optimum methods, fertilization rates as great as 44% have been achieved for pink salmon sperm, 51% for chum sperm and 85% for sockeye

sperm. Preliminary conclusions are that the milt of each salmon species requires a different extending medium for optimum results, that fertility of the stored sperm is only slightly related to its apparent motility after thawing, and that fertility could be further improved by further refining the techniques which have been examined.

11. Compilation of literature on salmonid hybrids

A bibliography of 661 annotated references to material on hybridization between the species of the sub-family of Salmonidae and between salmonids and non-salmonids was completed and published in 1973. This work was done in cooperation with J. R. Dangel and P. T. Macy.

SALMON STOCK ASSESSMENT

H. T. Bilton and  
D. W. Jenkinson

12. Size trends in pink salmon

H. T. Bilton

The mean lengths and weights of pink salmon from the fishery from a number of statistical areas for the years 1955 to 1972 were compared. For the runs and the period examined the long-term trend indicated the unweighted mean rate of decrease in weight for odd-year runs was 0.044 lb per generation and for even-year runs it was 0.065 lb per generation. This gives an average of more than one-half pound in ten generations or one-quarter pound in ten years. Factors that account for this decrease are not known. Results of this study have been published in Technical Report No. 371.

13. Sampling of salmon catches

D. W. Jenkinson and  
H. T. Bilton

Sampling of the British Columbia commercial catches of sockeye, chum and pink salmon was discontinued in 1973. However, the results of the 1972 sampling program were published in 1973 in Manuscript Report No. 1253.

14. Juvenile coho salmon size and time of release experiments

H. T. Bilton  
and D. W. Jenkinson

In 1973 we initiated the first of several experiments to study the effects of size and time of release of young hatchery-reared coho upon their residency, growth, survival, age at maturity and homing.

This first experiment had two purposes: (a) to develop and perfect techniques in the rearing, marking, tagging and release of young coho, and (b) to provide preliminary information on the effects of time of release of young coho upon their residency, growth, etc.

In the spring of 1973 three groups of marked, nose-tagged coho smolts were released from Rosewall Creek. The first release of 11,073 coho

was made on April 16, the second of 12,673 coho on May 14 and the third of 11,396 on June 11. At the time of each release a sample of fish was retained to provide estimates of the mean length, weight and scale characters of smolts prior to going to sea.

In the fall of 1973 a number of the previously released coho returned to Rosewall Creek as maturing "jacks." A total of 321 jacks was recovered by electrofishing. Recovered jacks were measured for length, weight and scale characters, and the nose tag was removed from each fish and was examined. Results so far are shown in the following table:

	Release Date		
	April 16	May 14	June 11
Number of jacks recovered	51	135	71
$\bar{x}$ Length	35.5 cm	33.9 cm	30.7 cm
$\bar{x}$ Number F.W. circuli	18.1 (18.2)*	18.5 (20.0)*	18.6 (22.7)*
$\bar{x}$ Spacing ocean circuli	4.6	4.3	3.2

\* Mean number of circuli on scales of smolts at release.

Thus results indicate that most of the returning jacks originated from the second release on May 14, and the least number from the first release on April 16. However, jacks from the April 16 release had grown the most and those from the last release had grown the least. These size differences are what might be expected because of the differences in time each group had spent in the sea. However, the answer may be more complex. Examination of ocean growth on the jack scales indicates that the spacing of circuli on scales of jacks from the last release was the most compact, suggesting a slower rate of growth as well as having spent the shortest time at sea.

Comparison of the mean number of freshwater circuli on the jack scales with that for the group of smolts from which they originated indicates little difference between those from the first release, whereas jacks originating from the later releases had on the average fewer freshwater circuli than the average for the smolts from which they originated, suggesting the jacks originated from the smaller smolts of each group. Final assessment will be possible after the return of adults in 1974.

#### 15. Effects of environmental factors on circulus formation

A paper on the effects of starvation and feeding on circulus formation on scales of sockeye, kokanee, chinook and coho salmon was given at a Symposium on Ageing of Fish in Reading, England. This paper will be published under the proceedings of the Symposium.

## ENVIRONMENTAL RESEARCH GROUP

C. D. McAllister

1.

## ESTUARINE POLLUTION

R. R. Parker and  
B. Kask

This investigation was active in two distinct areas in 1973. In one area, studies of the primary processes operating in the food chain of Alberni Inlet, were continued. It was found that dissolved organic matter in the surface waters is very rapidly incorporated by heterotrophic bacteria with an efficiency of approximately 60%. It is hypothesized that these bacteria contribute significantly to the base of the food chain. Previous studies have shown that photosynthetic production is severely depressed and that phytoplankton from the nutrient-rich water from below the halocline is incapable of responding to light in a short-term experiment. In longer experiments, this phytoplankton was shown to be capable of rapid growth after a lag of about three days. This result agrees with predictions of the effects of removing the dark humic stain from the pulpmill effluent. Field studies of the time course of the spring phytoplankton bloom also confirm these findings. The bloom commenced at the seaward end of the inlet, where the stain is less concentrated, and spread towards the head of the inlet, where the stain concentration is greatest, as the season progressed.

In a second area of study the diets of estuarine fishes were investigated in cooperation with the Operations Branch. Approximately 10,000 stomachs from 50 species of fish collected in 10 estuaries were examined. Analysis of the data generated is only beginning. Preliminary results indicate that the diets vary between species and from season to season but that generally food organisms produced in the estuarine benthos are often dominant items in the diets of most fish.

2.

## FISHERIES OCEANOGRAPHY

W. P. Wickett

Several fisheries in addition to that of herring have declined in concert with salinities recorded at British Columbia shore stations. The mechanism was a decline in nutrients in the euphotic layer of the sub-arctic gyres. Nutrients and salt are upwelled in the Gulf of Alaska. Salinity at the outer shore stations follow in large measure the salinity at the ocean weather ship station. Salinity and nutrients were found to vary together latitudinally and vertically in the Gulf of Alaska. High accuracy shore station salinities are a continuing fisheries requirement for both hind- and forecasting.

Predicted and actual sea levels, barometric pressures, computed convergence and divergence of surface coastal water, surface and 175 m isotherm charts and shore station temperatures when used together constitute a system of real-time daily information for fishing strategy and of historical data for fisheries and marine research on historical events.

A start has been made on publication of research on the above studies. The investigation has received excellent cooperation from the Marine Sciences Directorate, Atmospheric Environment Service and the Department of National Defence.

## LAKE FERTILIZATION

W. E. Barraclough,  
R. J. LeBrasseur,  
C. D. McAllister and  
J. I. Manzer

The experiment was initiated in 1970 to determine the possibility of increasing production of sockeye salmon by controlled addition of inorganic fertilizer to a nursery lake. It was hypothesized that such additions would increase production of zooplankton and hence growth and survival of fry.

In 1973, the fourth and concluding year of controlled addition of dissolved nutrients was finished. The projected five-year period of enrichment was shortened to permit re-allocation of support for new priorities.

3. Size at emigration

W. E. Barraclough

The fry subject to enrichment in 1972 left the lake as smolts in 1973. Their average weight was about 5 g, more than twice the historical value and greater than smolts subject to the first two years of treatment.

4. Plankton production, 1973

R. J. LeBrasseur and C. D. McAllister

Primary production was again increased. However, under the lower flushing rates less zooplankton was lost from the lake, and the large buildup of phytoplankton which occurred in 1972 was not repeated. Some species of zooplankton again occurred in greater numbers than prior to enrichment. Of equal or possibly greater importance were changes in taxonomic composition, notably the decline of the sub-halocline species, Daphnia longerimes, and the increase in Daphnia pulex. The size of D. pulex and its vertical distribution are more advantageous to sockeye fry than those of D. longerimes.

Observations in the Stamp River added support to the hypothesis that river coho fry benefited from increased zooplankton products in the lake. The incidence of diseased zooplankton decreased from the high levels of 1972 to the low values characteristic of 1969 and 1970, indicating that enrichment per se was not necessarily the cause of infection.

A considerable effort was expended in developing methods for computer analysis and display of the large volumes of complex data required in the project.

5. Growth of progeny of the 1972 spawning during 1973

W. E. Barraclough

Growth of fry in the lake in 1973 was higher and similar to that in 1972. This was associated with lower incidence of the parasite, Eubothrium. However, the high growth in 1972 occurred with a high incidence of the parasite.



6. Adult returns

J. I. Manzer

Fry spawned in 1968 and 1969 and subject to fertilization in 1970 returned as adults in 1973. An apparent increase in the proportion of 5<sub>2</sub>'s in the escapement suggests that smolts leaving the lake as "two year" fish in 1971 benefited more than those of the 1969 brood year. Reports based on cursory data now available suggest that returns of sockeye salmon subject to fertilization in Great Central Lake were proportionally greater than progeny of the same year from nearby lakes.

The data available to date have been reviewed with the Operations Directorate.

## LOGGING AND STREAM ECOLOGY

D. W. Narver,  
B. Andersen and  
J. C. Scrivener7. Carnation Creek experimental watershed

The Pacific Biological Station is responsible for conducting the research on the aquatic system as well as coordinating all aspects of the long-term, interdisciplinary, multi-agency Carnation Creek Experimental Watershed Study as described in previous Annual Reports. The 1973 studies were the fourth of a five-year prelogging calibration of the system.

All fish migrating in and out of Carnation Creek were counted and sampled. The 1973 outmigration was 19,200 coho fry, 1,750 coho smolts, 10,500 chum fry, 93 steelhead presmolts (100 mm), 113 steelhead smolts, 32 cutthroat trout, 320 Cottus aleuticus, and 850 C. asper. The adult migration was 43 jack coho, 85 large male coho, 71 female coho, 4,168 chums (553 above fence), and 10 steelhead.

The summer resident fish populations were sampled four times at seven study sections for density, biomass and growth. The late summer population density (fish/m<sup>2</sup>) in the 3,070 m inhabited by anadromous fish was .82 coho fry, .09 yearlings, .41 steelhead, .02 yearlings, .01 age II+, .36 C. aleuticus, and .01 C. asper. The biomass (g/m<sup>2</sup>) in this section of stream was coho fry 1.46, total salmonids 2.05, and total resident fish 3.49. Comparative (control) work on summer populations was again done in four adjacent streams and three Carnation Creek tributaries where salmonid density ranged from .33 to 1.32 per m<sup>2</sup> and salmonid biomass from 1.16 to 5.64 g per m<sup>2</sup>. Annual growth of fish in Carnation Creek is slow. October lengths of coho fry and yearlings were 50.6 mm and 75.7 mm compared to ranges of 50.6 mm to 66.2 mm for fry and 74.6 mm to 79.7 mm for yearlings in three adjacent streams. In four years of study the late summer fish populations have averaged 11,100 coho fry, 957 coho yearlings, 3,000 steelhead fry, 450 age I, and 170 age II steelhead.

A study of the winter ecology of juvenile coho and steelhead and the implications of possible habitat alteration by logging was completed. Snorkel observations revealed that with lowering water temperature from 9 to 2 C, coho and older steelhead tended to move into deeper water while most steelhead fry remained in shallow water. Coho and older steelhead most often were found within upturned roots and under logs. Results from upstream-downstream trapping at the mouth of two small tributaries indicated that many juvenile

salmonids moved out of the main stream in the late fall and remained in the tributaries during the winter. Overwinter survival of all coho in one tributary (dry in the summer) was 63% while overwinter coho survival for the entire system was 35%. A series of experiments comparing coho and cutthroat preference for alternative habitat types in side-pool areas as might occur before and after streamside logging were conducted. Both species demonstrated a strong preference for bay areas with overhanging bank cover as opposed to bays without cover and for bays with clean rubble (10-30 cm) substrate as opposed to silted rubble.

A study detailing the ecology of Cottus asper and C. aleuticus in Carnation Creek with emphasis on interactions with juvenile salmonids was completed. One result was that high densities of sculpins (bottom feeders) can severely limit the food supply of coho fry (drift feeders).

Monthly water sampling of Carnation Creek and three of its tributaries was continued in 1973. Again, the concentration of  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ,  $\text{Na}^+$ ,  $\text{HCO}_3^-$ ,  $\text{SO}_4^{--}$ , reactive  $\text{SiO}_2$ , and conductivity showed a strong inverse logarithmic relationship with flow. A similar but weaker correlation was obtained for  $\text{Cl}^-$  and T.D.S. No difference was apparent when data from 1971-72 and 1972-73 water years were compared. The results of intense freshet sampling during December 1972, and June, October and December 1973 indicated that these correlations could produce good predictive equations for most storms. However, the ion concentrations of summer and first fall freshets did not produce the same correlations. The concentrations of  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ,  $\text{Na}^+$ ,  $\text{HCO}_3^-$ ,  $\text{SiO}_2$ , and the conductivity still showed a strong inverse logarithmic correlation with flow, but the concentrations were greater during high flows. During the first fall freshet of 1973,  $\text{Cl}^-$  and T.D.S. showed a positive logarithmic correlation with flow. Simultaneous sampling of precipitation, throughfall precipitation (rain that has passed through the forest canopy) and bulk precipitation indicated that the  $\text{Cl}^-$  and T.D.S. that resulted in higher stream concentrations was being washed off the forest canopy. The concentration of  $\text{Cl}^-$  in throughfall precipitation was 100 times that of the precipitation (11.6 vs 0.1 ppm) and about three times that of the stream (11.6 vs 2.8 to 3.9 ppm). Concentrations in bulk precipitation indicated that the ions were probably accumulating in the canopy during the long dry summer.

Limited monitoring of invertebrate benthos, drift and emergence was continued in 1973. This data has been used to identify the species present; and to determine life histories, growth, changes in standing stock and seasonal changes in numbers leaving the stream system.

Work was initiated on measuring timing and volume of floral litter fall and on rates of leaf decomposition in stream water and on rates of transport out of the system.

Conceptual watershed models have been developed to assure the integration of terrestrial and aquatic field data. A watershed hydrology model was developed and tested as a beginning to the simulation of watershed processes. Programs were developed to automate processing of large amounts of digitized water chemistry, stream flow, precipitation, and temperature data, much of which is obtained by recording instruments.

STRAIT OF GEORGIA AND  
BIOLOGICAL OCEANOGRAPHYH. Godfrey,  
R. J. LeBrasseur,  
C. D. McAllister,  
R. R. Parker and J. Sibert8. Biological Oceanography

R. J. LeBrasseur

Research activities directly related to biological oceanography during 1973 were in four areas as follows:

a) Commercial harvesting of marine zooplankton

One vessel fishing out of Nanaimo harvested approximately 3,000 pints of euphausiids during the period from February through April when adult euphausiids occur in swarms near the surface. The catch was quick frozen and sold as a food supplement to aquariums and other persons handling live fish. The factor limiting production appears to be the vessel's freezer and storage capacity. Marketing of the product which wholesales for about 85 cents/pint, depending upon the size of the order, has not been a problem. Orders have exceeded the supply. The main licencing regulations limit fishing to areas where our past records indicate a scarcity of larval fish. In addition, fishermen are required to provide a written record of their operation. Two vessels have been licenced to fish plankton in Strait of Georgia during 1974 and we have had enquiries regarding fishing on the west coast. Should this type of fishing build up we can anticipate setting catch quotas for different areas and limiting the fishing to specific periods during the year. However, our present involvement involves very little work other than providing information to interested fishermen.

b) Ocean station P monitoring studies

R. J. LeBrasseur and J. Fulton

Nutrient, productivity and zooplankton samples continue to be routinely collected for us at the weathership station by Marine Sciences Directorate personnel. In addition, ships' personnel who enter the on-station fishing derby provide catch records, scales and stomach contents of their catch. Nutrient and productivity sample analyses are up to date; cursory examination of the data has not shown any unusual variation in the results over the recent years. Zooplankton analyses for 1970 and 1973 have not been completed due to the backlog of material returned to us from the Canadian Oceanographic Identification Centre. However, the data from all analyzed samples have been coded and are available for computer analysis. Interest in these data have been expressed by a number of outside agencies; most recently by the International Salmon Fisheries Commission and the Alaska Department of Fish and Game. In general, the zooplankton biomass currently appears to be at or slightly above the 17-year average. The samples from the live fishing have not been examined. However, whole specimens are brought in periodically for examination for heavy metals and chlorinated hydrocarbons. To date no evidence of contaminants have been found in these samples.

c) Microplankton in nearshore habitatsO. D. Kennedy and  
R. J. LeBrasseur

Samples for microplankton were collected daily at two locations at the Biological Station and at weekly intervals at nine locations about the Nanaimo area. The sampling at the Station was initiated to determine the suitability of the site for monitoring environmental changes and to provide estimates of the variance associated with our sampling techniques. Sampling at the other locations was initiated to determine if microplankton communities could be useful in characterizing different habitats and to provide an index of food availability for larval fish. Serious difficulties have been experienced in developing a satisfactory routine for analyzing the samples and processing the data. If microplankton collections are to be used as a survey tool sample analysis must be completed within an hour otherwise too few samples can be processed to provide useful coverage over a geographical area. On the other hand, a number of subsamples must be examined to provide reliable data. Statistical help is required to rationalize this problem and to advise on ways of treating the data as a community of organisms. Various methods suggest themselves and the whole study is currently being reviewed. In an earlier preview of the data for the Nanaimo Harbour Task Force it was noted that a greater number of species were present in the open waters of the Strait than in nearshore areas. Also, the more common species were found at all locations sampled, the main difference being in their numbers. For example, the area adjacent to Harmac had most the same species found in Departure Bay but they were present in fewer numbers at Harmac.

d) Nearshore fishingR. R. Parker, J. Sibert  
and R. J. LeBrasseur

Sampling on the sandy beach area of Departure Bay was initiated in October at the time of capelin spawning to explore problems associated with working in a nearshore area. Observations of fish, zooplankton, primary producers, nutrients and organic materials were made at bi-weekly intervals within 300 m of the shore. The opportunity was also taken to work with different sampling methods; for example, the fish were collected using a purse seine and an otter trawl, while for zooplankton a plankton seine is being tested along with the usual towed nets. The productivity observations on and near the beach do not suggest sources of food, either autotrophic or detrital, which might be exclusive to the beach area. The zooplankton abundance, however, was unexpectedly high and diverse in comparison to the open waters of the Strait where the catches during this same period would be declining and consist of a few copepods, coelenterates and, depending on the time of sampling, euphausiids. In Departure Bay in excess of 40 zooplankton species were present in the samples. A number of species of copepods, decapods, barnacles and clams have naupliar or larval stages present in the catches. Benthic organisms such as gammarid amphipods, cumaceans, mysids and isopods were also taken in the plankton tows. Forty-seven species of fish have been identified from the collections. The species occurring in greatest abundance include shiner perch, pile perch, chum and chinook salmon, herring, capelin, Pacific cod, flatfish (yellowfin sole, rock sole, lemon sole, and starry flounder), sculpins and stickleback. The catches have also included lingcod and dogfish. The larval fish have consisted mainly of capelin and greenling larvae. Stomach contents of the fish indicate that zooplankton are being eaten by all fish species while gammarids and

cumaceans were eaten largely by perch and flatfish species. Insects were also found in salmon and herring stomachs.

This survey and preliminary inspection of the data has revealed an unexpectedly high use of the nearshore area by a variety of fish species. It raises the question as to the applicability of these findings to other beach areas, to what extent the fish utilize the area off the beach and whether or not this is strictly a seasonal phenomenon.

#### 8. Strait of Georgia

C. D. McAllister, H. Godfrey,  
R. J. LeBrasseur, R. R. Parker  
and J. Sibert

Work in the Strait of Georgia was comprised of two major activities in 1973. The first was planning, through the Strait of Georgia Committee, and included development of a draft Cabinet Submission in collaboration with the Operations Division, Marine Sciences Division and to a lesser extent, the Environmental Protection Service, Canadian Wildlife Service and the Atmospheric Environment Service.

The second major activity devolved from memberships in Steering Committees of the Squamish, Roberts Bank and Nanaimo Estuary Task Forces, and contributions to other Ministerial committees concerned with impacts of development activities in the Strait of Georgia.

The latter activity interfered with the first, but aided in establishing priorities and patterns of liaison with other agencies and most of all in developing methodologies accepted by different agencies. Pacific Biological Station, through Drs. Parker and Sibert undertook to manage the analysis of fish samples, fish diets and zooplankton from material gathered by Operations, as well as P.B.S., from the Fraser Estuary, Nanaimo Estuary, and six other estuaries in Strait of Georgia. In addition, the task of rapidly handling the large volume of complex data and of developing machine programs for their analysis were undertaken.

The major effort expended in Ministerial impact studies in Strait of Georgia was largely at the expense of ongoing research, itself of demonstrated and immediate value to applied problems.

Other significant efforts in the **Strait of Georgia** in 1973 include:

- a) Support of study of production and ecology in a kelp bed typical of large areas of the Strait.
- b) A survey of the Strait to determine the extent of a sea urchin epidemic and its implications for stocks of seaweed.
- c) Experimental studies of the yeast infection associated with the decline of the dominant copepod of the Strait and determination of levels of infection in "healthy" zooplankton stocks.
- d) Field surveys on winter distribution and diets of chinook and coho.

- e) Preliminary work on diel variations of abundance, associations and diets of fish immediately adjacent to a typical sheltered beach in the Strait.

## STREAM ECOLOGY

J. H. Mundie and  
D. E. Mounce

(1) Studies continued on the analysis of aerial insects, utilizable by salmonids, from different types of vegetation in logged and unlogged stretches of the Chemainus River. Over 500 species were found, with greatest diversity occurring in a stretch bordered by willow. Abundance of insects was approximately the same in the different stretches. This is attributed to the similar microclimate, especially with respect to solar energy and wind, extending over the wide river. The conclusion is emerging that the planting of streamside willow, as a means of increasing terrestrial food items for salmonids, would not be justified.

(2) Observations were made on Campbell River on the effect of changes in discharge on the transport of fish food organisms. Proposed changes in operation, by the B.C. Hydro and Power Authority, of the John Hart powerhouse, for peaking purposes, would result in frequent and rapid changes in discharge. To obtain a measurement of the impact of these on invertebrates the composition and density of organic drift were determined during three consecutive discharges on August 19 at a site upstream of the confluence of the Quinsam River. Samples were taken with multiple marine plankton collectors 3-5 m from the bank under discharges of 1,100 cfs in late afternoon, 2,950 cfs in the evening and 1,100 cfs in darkness. The invertebrates in suspension consisted of three major components: (i) zooplankton originating from the Head Pond; this made up 70-90% of the drift over the periods sampled; (ii) insects (benthos) originating from the bed of the river; these consisted mainly of midge larvae and made up 10-30% of the drift; (iii) aerial insects which alighted on the water surface; these were partly aquatic and partly terrestrial in origin. They made up less than 1% of the drift.

The density of all invertebrates in suspension was  $93/m^3$  at 1,100 cfs during both daylight hours and darkness. A change in discharge from 1,100 cfs to 2,950 cfs resulted in, approximately, a six-fold increase in numbers of (i) a seven-fold increase in (ii) and a 20-fold increase in (iii). In addition a 30-fold increase in weight of transported leaves occurred.

Chinook fry may benefit, therefore, from greater availability of food organisms associated with rising discharge, provided their feeding territories are not diminished by the change, and provided they are not, themselves, displaced by the high velocities.

The long-term effects of frequent surges are uncertain. The cumulative losses of benthos from the river may amount to a significant depletion not compensated for by increases in drift of zooplankton. The high discharges of invertebrates to the estuary, however, may benefit chinook smolts during their stay there. Similarly the constant loss of leaves from the river will diminish production based on organic decomposition, although some benefit may accrue in the estuary where the input of organic material contributes to estuary food chains. Of the two effects, the first would seem to have the greater influence on chinook production.

## E X P E R I M E N T A L   B I O L O G Y   A N D   P A T H O L O G Y

L. Margolis

## ETHOLOGY

C. Groot, C. E. Turner  
and K. Simpson1. Sockeye smolt migration

Studies of smolt migration out of Babine Lake in 1973 had two objectives:

- (a) to determine the depths at which smolts migrate through the Main Lake en route to the outlet and to what extent these depths change over the diel period.
- (b) to ascertain if Main Lake smolts "wander" into Morrison Arm (marking of Fulton River and Pinkut Creek fry by F.R.B. in 1972 made recognition of these stocks possible).
  - (i) Echo sounder observations in the Main Lake area showed dense targets in two distinct layers, at 25 to 40 and 50 to 65 m. Midwater trawl catches, although low in numbers of fish, confirmed that these targets were sockeye smolts. After dusk the two layers merged and rose to depths of 15 to 45 m, descending and separating again as dawn approached.

These findings strongly suggest that the direction finding mechanisms of smolts in the deeper parts of Babine Lake are of a non-visual nature.

- (ii) Five smolts, previously marked at the Fulton River, were recovered in Morrison Arm. This indicates that some smolts migrating northward through the Main Lake miss the North Arm entrance and get diverted into Morrison Arm. However, they must be able to get out again since no smolts are recovered in Morrison Arm in October.

2. Movements of Babine Lake underyearling sockeye

Movements of underyearlings in Babine Lake were monitored by regular sounder with a high-frequency echo sounder from May to January. Horizontal movements observed were largely those previously found by McDonald (i.e., a very marked migration towards the south end of the lake, reversing in July to a slow northward movement). This results in concentrations in the northern areas by winter but soundings immediately after breakup suggest that some southward movement occurs in late winter.

Juveniles stayed in two layers during the day after June, depths varying between 16 and 60 m. Diurnal vertical migrations were observed throughout the year but they only rose to about 10 m as young fry and as pre-smolts

in January when ice covered the lake.

### 3. Ultrasonic tracking

#### (a) Skeena River estuary

Ultrasonic tracking trials performed by Fisheries Operations staff in the Skeena Estuary were analyzed. These studies revealed that sockeye salmon move passively up and down the estuary with ebb and flood flows before continuing their migration upstream. Slowing down of migration upon reaching the "home" coast area followed by a short holding period in or near the estuary is a general phenomenon of Pacific salmon migration in many areas.

#### (b) Georgia Strait

Ultrasonic tracking of sockeye and chum salmon in Georgia Strait revealed differences in migrating patterns between the two species. Sockeye salmon primarily swim during daylight hours, while chum salmon are more active at night. Chum generally swam faster (2.5 km/hr) than sockeye (1.8 km/hr). However, when swimming speeds are calculated at mean lengths per second, both species moved at about the same speed (sockeye 0.9 L/sec, chum 1.0 L/sec).

### 4. Sockeye smolt orientation studies

Kent Simpson finished his thesis on orientation differences between populations of juvenile sockeye salmon in Babine Lake. This was for a M.Sc. degree at the University of Victoria, British Columbia.

## MICROBIOLOGY

G. R. Bell

### 5. Diagnostic service

G. R. Bell, T. P. T. Evelyn,  
G. E. Hoskins and J. E. Ketcheson

Most of the year was taken up with providing information, advice and diagnostic service, all relating to matters of fish health, to Fisheries and Marine Service and Fisheries Operations Directorate personnel, to outside agencies and to private fish culturists. A list of diagnostic cases is attached.

Besides aiding fisheries enhancement and aquaculture programs, diagnostic investigations are giving a picture of disease distribution in British Columbia. Notable is the finding of an infectious haematopoietic necrosis (IHN)-like virus in the Cowichan and Nimpkish systems because this could affect decisions on the siting, design and operation -- ultimately, the success -- of fish culture facilities on these systems. The location of certain diseases will also affect the choice of wild stocks serving as sources of eggs for aquacultural operations.



## LIST OF CASES, 1973

DR	Date	Species	Source	Reason for examination	Diagnosis or findings	Comments
170	Jan. 17/73	Rainbow trout	Manitoba Whiteshell Hatchery	Health inspection service: rapidly increasing losses	Cause of mortalities unknown. No virus or bacteria detected.	These fish were originally from Steelhead Co. Mission City, B.C. Certified by this laboratory in May 72.
171	Jan. 23/73	Coho	Big Qualicum River Project	Health inspection service: a few mortalities	Cause unknown. No <u>Myxobolus</u> found	Because of physical deformities these fish were examined for <u>Myxobolus</u>
172	Feb. 2/73	Rainbow trout	Mrs. Broz Richmond, B. C.	High mortalities	No bacterial pathogen found: cause unknown	4 fish examined
173	Feb. 6/73	Goldfish	Mrs. Moriez	High losses	Citrobacter species	Infection caused by poor water quality
174	Feb. 12/73	Coho fry Chinook fry	Moccasin Valley Trout Co.	From a batch showing fin rot	Fin rot	No infectious bacteria appear to be present
175	Mar. 2/73	Blackcod	W. Kennedy Nanaimo	Died	Furunculosis	Experimental stock collected at Hardy Bay
176	Mar. 6/73	Rainbow trout	John Alexander Steelhead Creek Trout Co. Mission, B. C.	High losses	Hexamita infected. No evidence of bacterial or viral infection.	Fingerling sized fish. Some in this lot imported from Idaho.
177	Mar. 6/73	Rainbow trout	R. S. Boyd Surrey, B. C.	Increasing mortality rate	No indication of infectious disease	This may have been a temperature/oxygen problem
178	Mar. 8/73	Blackcod	W. Kennedy Nanaimo culturing facilities	Died	Furunculosis	Experimental stock collected in July from Hardy Bay.
179	Mar. 18/73	Rainbow trout	Redfish Creek (H. Andrusak)	Lesion of left side	No indication of a bacterial infection	Single fish; captured alive in a sample net

DR	Date	Species	Source	Reason for examination	Diagnosis or findings	Comments
180	Mar. 19/73	Pink	Nanaimo Station	Died	Furunculosis plus a vibriod contaminant	Single fish; from Microbiology's experimental stock
181	Mar. 26/73	Sockeye	West Vancouver Laboratory	Low but chronic mortalities	No indication of an infectious agent	Three fish examined
182	Mar. 27/73	Blackcod	Dr. W. Kennedy Nanaimo facilities	Large bleeding lesion	Furunculosis	Single fish
183	Mar. 28/73	Rainbow trout	Steelhead Creek Trout Co. Ltd. Mission, B. C.	Health inspection	No evidence of viral infection	Pooled ovarian fluid samples
184	Mar. 29/73	Pink	Nanaimo Station	Increasing losses	No evidence of bacterial or viral infection	These fish have been on a special feed; this may be a diet problem
185	Mar. 30/73	Chinook	Moccasin Valley Trout Co.	Health check	Healthy fish	3 fish examined
186	Apr. 3/73	Coho	Rosewall Creek Facility	Eroded, saddle-shaped area around the adipose fin	Myxobacteriosis	Fish tagged with an adipose fin clip
187	Apr. 3/73	Herring	Nanaimo Station Fish Culture facilities	Increasing mortality rate	<u>Pseudomonas</u>	Wild fish
188	Apr. 16/73	Blackcod	Dr. W. Kennedy Nanaimo facilities	Died	Furunculosis	cf. DR 175, DR 178, DR 182
189	Apr. 27/73	Coho	Rosewall Creek Facility	Health check cf. DR 186	Healthy; no indication of myxobacteriosis	Previously these fish were infected with myxobacteria
190	Apr. 18/73	Rainbow trout	Steelhead Creek Trout Co. Ltd. Mission, B. C.	Appear to have "strawberry disease"	No virus found. Infected with <u>Salmincola</u>	"Strawberry condition" may be caused by the copepods

DR	Date	Species	Source	Reason for examination	Diagnosis or findings	Comments
191	May 3/73	Chinook	Big Qualicum River Hatchery	Increasing losses	Gill disease involving both fungus and myxobacters	
192	May 7/73	Chinook	Robertson Creek	High mortality rate	Inconclusive	A few fish found with myxobacterial infection
193	May 8/73	Kokanee	Cowichan Lake	"Die off"	Viral infection: possibly IHN	First virus isolation on Vancouver Island
194	May 9/73	Sockeye	Rosewall Creek (Babine stock)	Health certification	Healthy	Shipment of experimental stock to U. S. A.
195	May 23/73	Coho	Robertson Creek	Increasing losses	Unknown	Virus assay inconclusive because of spontaneous CPE
196	May 23/73	Sockeye	Rosewall Creek (Babine stock)	Sudden increase in losses	Bacterial gill disease	Gills loaded with bacterial cells with fusiform morphology
197	May 29/73	Catfish	Deer Lake Burnaby, B. C.	"Die off"	Unknown	
198	June 19/73	Pink	Brett	Increasing losses after handling	<u>Vibrio anguillarum</u>	Experimental stock
199	June 25/73	Cutthroat trout	Great Central Lake	Dead	Unknown	Single fish
200	July 4/73	Chum	Vanstone	Fish obviously sick	Vibrosis - not <u>anguillarum</u>	Causative organism is much slower growing than <u>V. anguillarum</u>
201	July 6/73	Coho	Stock D 71-2 Nanaimo	Dead fish	Vibrosis	

DR	Date	Species	Source	Reason for examination	Diagnosis or findings	Comments
202	July 10/73	Coho	Culture Room Nanaimo Station	Dead - a few fish with black tails	Mechanical injury due to grading operation	
203	July 23/73	Chum	Jim Walker's experimental stock	Massive losses	<u>Vibrio anguillarum</u>	Returning fish to fresh water stopped mortalities
204	July 23/73	Chinook	Troll caught	Large internal lesion in muscle on left side	Sterile abscess	Haemorrhaging caused by heavy blow to side?
205	July 26/73	Chinook	Moccasin Valley Trout Farm	A few dead fish each day	<u>Vibrio anguillarum</u>	Preserved samples examined microscopically
206	July 27/73	Goby	U. British Columbia	High mortalities at experimental fish	No indication of infec- tious disease (virus not tested)	Possibly a virus infection but suitable tissue cultures not available
		Rockfish	" "	" "	Gill infection with trematode <u>Microcotyle</u> <u>sebastis</u>	Load of trematodes possibly enough to cause severe stress
207	July 27/73	Sockeye	Pacific Biol. Stn.	Unusually high mor- talities	No indication of infec- tion by microscopic agents	
208	July 30/73	Kokanee 1 Whitefish	Canim Lake, B.C.	"Die-off" in lake	No bacterial or viral pathogens. Gills moder- ately infected with <u>Ergasilus nerkae</u> and gut with larval tapeworm	Immediate cause of death not infectious disease. See DR 153 and 154 (1972)
209	July 31/73	Clownfish ( <u>Amphiprion</u> )	Vancouver Public Aquarium	Unusually high mor- talities	Gross and microscopic observations along with bacterial cultures indi- cate probably absence of infectious disease	Suspect deterioration of water quality in recirculating system.
210	Aug. 1/73	Sockeye Coho	Otter Point area in St. Juan de Fuca	Dead and "gasping" fish found at surface	No bacterial, fungal or protozoan disease	Heavy plankton bloom and reports of "gasping" fish, along with microbial findings, suggest O <sub>2</sub> depletion as cause of death

DR	Date	Species	Source	Reason for examination	Diagnosis or findings	Comments
211	Sept. 21/73	Sablefish	Vancouver Public Aquarium	Lesions on body	(Fixed specimen) columnar epithelium missing or necrotic	Suspect dermatotropic virus
212	Sept. 21/73	Rainbow trout	Vancouver Public Aquarium	Death of a venerable display fish	Protozoan infection of the gills: degeneration of nephrons moderately severe (fixed specimen)	Multiple causes of death possibly aggravated by pre-spawning stress
213	Sept. 21/73	Rainbow	Vancouver Public Aquarium	Death	Abnormalities of skin and gill	Death possibly from excess mucus on gills
214	Aug. 29/73	Chum	Pacific Biol. Stn.	Increasing mortalities in experimental mariculture pens	Vibriosis	Terramycin therapy of benefit
215	Sept. 5/73	Sockeye	Pacific Biol. Stn.	" "	Vibriosis	" " "
216	Sept. 4/73	Sockeye	" " "	" "	No consistent evidence of bacterial disease	
217	Sept. 6/73	Rainbow (fingerlings)	Summerland Provincial Hatchery	Numbers of dead and moribund fish alarming to culturist but possibly relatively small	No virus detected: low numbers of myxobacteria on gills insufficient to cause a problem	Possible diminishing myxobacterial gill disease, Nyamine 3500 treatment begun
218	Sept. 18/73	Sockeye	Pacific Biol. Stn.	Low but steady mortalities in experimental mariculture pens	No evidence of bacterial, fungal or protozoan pathogens	Cause of mortalities and illness might have been due to irritation of gills by spined algae
219	Sept. 19/73	Chum	Pacific Biol. Stn.	Mortalities	Some histopathologic evidence of a virus infection	Tissue cultures not immediately available for virology
220	Sept. 24/73	Coho	Pacific Environment Inst.	Gross physical abnormalities	Some gill tissue protruding from anterior portion of body wall. No evidence of microbial disease	Probably a genetic or teratogenic abnormality, not due to infectious disease

DR	Date	Species	Source	Reason for examination	Diagnosis or findings	Comments
221	Oct. 9/73	Coho	Cowichan Bay	Sports caught fish with extensive capillary haemorrhage on the viscera	Bacterial kidney disease	A severe and rare type of infection for a fish caught in the wild
222	Oct. 9/73	Sockeye	Nimpkish River and Woss Lake, B.C.	Massive pre-spawning mortalities and many fish observed gasping at surface (est. 20,000 dead out of 100,000 fish)	Heavy <u>Dermocystidium</u> infection of gills. One of 5 fish carried IHN-like virus: 2/5 carried <u>A. salmonicida</u>	Probable immediate cause of mortalities invasion of gills by <u>Dermocystidium</u> . Presence of virus of considerable epidemiological importance.
223	Oct. 15/73	Chum	Pacific Biol. Stn.	Death and/or deterioration of fish in experimental mariculture pens	Possible vibriosis	
224	Oct. 23/73	Chinook	Big Qualicum River	Routine test of ovarian fluids of spawning fish (53 fish)	No virus and no overt signs of infection	No IHN or IPN yet detected after two seasonal examinations
225	Nov. 5/73	Chinook	Pacific Biol. Stn.	Excessive mortalities of fish in experimental mariculture pens	Vibriosis	
226	Nov. 6/73	Sockeye	Pacific Biol. Stn	" "	Vibriosis	Again confirming that this is one of the most important disease of salmonids cultured in the sea
228	Nov. 27/73	Coho	Robertson Creek (Port Alberni)	Moderately severe pre-spawning mortalities	Most obvious and immediate cause of death, mycosis. One of 3 fish had trypanosome-like cells in kidney and 2/3 fish infected with <u>A. salmonicida</u> (agent of furunculosis)	The 2 fish appeared to be only carriers of <u>A. salmonicida</u>

DR	Date	Species	Source	Reason for examination	Diagnosis or findings	Comments
227	Nov. 16/73	Coho	Robertson Creek (Cowichan Lake)	Monitoring of pre-spawners for viral carriers such as in kokanee population; cf. DR 193	Viscera from 13 fish and ovarian fluids from 8 of these fish all negative for virus	Important to continue surveillance of this water system for viruses because of possible hatchery development
229	Dec. 4/73	Chum	Pacific Biol. Stn.	A few fish in experimental mariculture pens looking emaciated	Kidney and spleen of two fish negative for bacteria. Kidney cyst in one fish possibly a tumour	No indication of vibriosis
230	Dec. 10/73	Rocky Mtn. whitefish	Vancouver Public Aquarium	Mortalities	Primarily bacterial kidney disease. No virus detected using fathead minnow and rainbow trout gonad cell lines	Immediate removal of diseased fish from tanks, the best initial approach
231	Dec. 11/73	Carp	Vancouver Public Aquarium	Dead and moribund fish	One of two specimens suffering from piscine tuberculosis in viscera	The first case diagnosed by the Nanaimo group
232	Dec. 12/73	Pink	Pacific Biol. Stn.	Deaths and overt signs of disease	Bacterial aetiology unlikely; possibly a virus but results of tissue culture equivocal	Surface disinfected eggs for this stock came from the Adams River and incubated at Rosewall Creek

## 6. Yukon disease survey

An extensive summer program was carried out collecting fish samples from two watersheds in the Yukon to assess the danger of introducing possibly devastating microbial fish diseases from one system to the other by linking of the systems for hydroelectric development. This program, undertaken in cooperation with the Parasitology group and with Fisheries Operations (Northern Branch), resulted in the collection of five species of fish totalling 319 specimens. Analysis of the samples is now in progress and the only potential pathogen encountered at this early stage appears to be a protozoan detected in the blood of humpback whitefish from both systems.

## 7. Pathogenic myxobacteria

G. R. Bell and G. E. Hoskins

Myxobacteria isolated from severe necrotic areas and around adipose fin clips on coho fry were injected subcutaneously into healthy fish. After three to eight days, the fish showed extensive and characteristic necrosis of the muscle around the injection site. The histopathology of the disease was documented and attempts were made, unsuccessfully, to detect exo- and endotoxins from three, typical isolates. The organisms grew sparsely on a standard medium used to culture myxobacters but the growth could not be appreciably increased by culturing on a variety of medium formulations mostly using Krebs Cycle intermediates, alone or in combination with extracts of fish muscle, or with fish blood plasma. Dextrose, sucrose and lactose did not affect growth but mannitol was inhibitory, as was an acid medium (pH 6.5 or less).

## 8. Vascular anatomy of salmon

G. R. Bell

Techniques for preparing plastic casts of the salmonid vascular system have been improved and photographs of these casts will be used as part of a manuscript on practical aspects of the gross anatomy of salmon.

## 9. Bacterial kidney disease

a) T. P. T. Evelyn, G. E. Hoskins, and G. R. Bell

A manuscript has been published describing the isolation, identification and characterization of a strain of kidney disease bacterium that has been found for the first time in a wild fish in British Columbia.

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

Work is continuing on improved methods for the culture of various isolates of the slow-growing kidney disease bacterium.

## 10. Committees on fish disease control

a) National (T. P. T. Evelyn)

Much time was spent serving on a five-member national committee



established by the Program Planning and Coordination Branch of the Fisheries and Marine Service to produce a manual (now essentially completed) of nationally approved procedures for the detection of certain pathogens of salmonid fishes (to be used in a fish health inspection and certification program designed to prevent the spread of salmonid diseases into and within Canada).

b) Provincial (G. R. Bell)

Problems of epizootiology were discussed as a member of the recently formed "Inter-agency Committee on Fish Transplants and Introductions" that is concerned, among other things, with the possible spread of fish diseases via contaminated stocks.

PARASITOLOGY

Z. Kabata

The work of this sub-program included several projects associated with parasitic diseases in fishes and parasites in marketable fish products. In addition to their research projects, staff were involved in service work concerned with diagnosis and consultation on parasites and parasitic diseases of aquatic animals.

Reports on progress with individual research activities are as follows:

11. Yukon freshwater fish parasite survey

R. Arthur and L. Margolis

During the summer of 1973 we participated in an environmental impact study being conducted by the Operations Branch of the Fisheries and Marine Service in the Yukon Territory. As part of a hydroelectric development project, it has been proposed that water from Stevens Lake be diverted into nearby Aishihik Lake. Since these two lakes belong to different watersheds, possibility had to be considered of transfaunation of fish parasites and its economic consequences. (Aishihik Lake is at the headwaters of the Alsek River system, emptying into the Pacific, whereas Stevens Lake drains into the Yukon and Bering Sea.)

More than 400 fish of seven species were examined between early June and late September. All seven species were present in Aishihik Lake, but only three were caught in Stevens Lake. Necropsis included examination of all tissues for protozoan as well as metazoan parasites. Over 30 species of the latter were recovered. Parasite counts often numbered in the hundreds, occasionally reaching several thousand per fish.

Many of the metazoan parasites have been identified and preliminary examination of results indicates that several species might be significant. Comparison of the parasite fauna of the three species of fish common to both lakes shows that some of the parasites are present in only one of the lakes studied. The large monogenetic fluke Discocotyle sagittata was found in Aishihik Lake on humpback whitefish but was absent from Stevens Lake. On the other hand, the tapeworm Trienophorus nodulosus occurred in Stevens Lake but not

in Aishihik. The ciliated protozoan Trichodina sp. occurred on slimy sculpins in Aishihik but not in Stevens Lake.

Due to the vast amount of material collected, a large quantity of parasites remains to be sorted and some species are still to be identified through detailed microscopic study, particularly larval helminths. Samples of kidney, brain, and gall bladder remain to be examined for protozoan parasites.

12. Parasites in pollock flesh

L. Margolis and T. E. MacDonald

A study of the occurrence of parasites in the flesh of Pacific pollock (Theragra chalcogramma), as part of a general investigation of the quality and potential for marketing of British Columbia stocks of this fish, revealed comparatively light parasitization (not likely to affect marketing) when compared with published accounts of parasitism in western Pacific and Bering Sea stocks. Three parasite species were found in the flesh: larval nematodes of the genera Anisakis and Terranova, and a larval pseudophyllidean tapeworm. The larval trypanorhynch cestode Nybelinia sp., the parasite causing greatest concern in utilization of western Pacific and Bering Sea stocks because of its unsightly appearance in the flesh, was not present in the British Columbia samples examined.

Final analysis of the data concerning the relationship of parasite abundance and age or size of the fish, and extent of parasitism of the flesh in relation to conditions of handling and storage following capture remain to be done.

13. The tapeworm Eubothrium salvelini and its effects on juvenile sockeye salmon production in Babine Lake and Great Central Lake

N. P. Boyce and  
H. D. Smith

Work was completed on elucidation of the life cycle and related aspects of biology of E. salvelini. Cyclops scutifer and C. bicuspidatus of prosome length more than 500 $\mu$  have proved to be the most effective intermediate hosts. Temperature of 15 C has been determined as optimal for development of larval tapeworms in these hosts. Fry of fork length less than 40 mm have proved to be more susceptible to infection than are larger fish. A study of the effect of various fish diets on E. salvelini infection is in progress, as well as on efficacy of various anthelmintic drugs on the worm and study of nutrient-absorbing surface of the worm. Incidence and intensity of infection was determined for Babine smolts and Great Central Lake fry and smolts captured in 1973.

14. Parasitic copepods of fishes, with emphasis on Salmincola californiensis, a parasite of the Pacific salmon

Z. Kabata and  
B. Cousens

It has been found that this copepod, when adult, has few exchanges with external environment, so that it is difficult to attack it from outside. Two lines of approach were identified: one persisting in attempts to kill the

parasite by substances added to water and acting on the parasite directly, with the aid of mildly polluting or non-polluting substances not specifically produced for antiparasite action (disinfectants, detergents); the other employing a less direct route, aiming at the parasite through the fish by the use of feed additives. Only the first approach was tested experimentally. Salt water proved totally ineffective against Salmincola, in all its stages, eggs included. One brand of disinfectant killed 50% of free-swimming larvae, about 4% of attached larvae, but did not harm adult parasites. A household detergent was almost 100% lethal to the pre-adults, but had little effect on adults. Sub-lethal effects were studied experimentally on isolated parasites, with the aid of previously determined and standardized vital signs (peristalsis, maxillary contractions). Detergent proved to have measurable effect on adults, though below lethal limits. Further experiments are required.

Experimental study of the newly discovered sense organ of Caligus clemensi (a copepod parasitic on herring and salmon) was initiated. Preliminary results indicate that this organ plays some part in host recognition and causes the parasite to reject unsuitable hosts with which the copepod comes in contact. Similar sense organs, presumably chemoreceptors, were located in other caligid copepods.

#### PHYSIOLOGICAL ECOLOGY

##### 12. Development of Pacific herring eggs

D. F. Alderdice, T. R. Rao  
and F. P. J. Velsen

A study has been completed of the efficiency of embryonic development of Pacific herring eggs. Yolk utilization and tissue production, relative to salinities and temperatures of incubation, have been followed from egg fertilization up to yolk exhaustion in hatched larvae. Dry weights and caloric equivalents were measured for embryonic components (chorion, embryo or larva, and yolk) at five developmental stages. The study was conducted to quantify the relationship, identified earlier, that larval biomass is maximized at specific incubation salinity-temperature levels. It appears that conditions which maximize larval biomass are consistent with those optimizing egg development and early larval survival. Analysis of the data is continuing.

##### 13. Efficiency of experimental designs

D. F. Alderdice and  
J. A. C. Thomson

Standard factorial designs used in biological investigations often present tactical problems when the number of factors simultaneously investigated is three or greater. Confounding of first- or second-order terms to reduce the number of experimental trials generally is inefficient when the relations investigated require second-order models for their effective description. In addition, changes in the nature or function of biological material with time often make the use of sequentially conducted fractional factorial designs of questionable value.

Orthogonal composite factorial designs, and variants of them, have

been documented as a means of overcoming some of these difficulties. Seventeen of these  $n(2^k) + 2(k) + n$  designs ( $k = 2, \dots, 5$  factors) have been examined with respect to (1) precision with which quadratic effects are determined, and (2) the extent by which third-order aliases may inflate estimates of the main effects. In these designs a major reduction of experimental trials can be achieved with little or no loss of precision or increase in bias relative to  $3^k$  designs. For example, a  $2^5 + 2(5) + 3$  design estimates quadratic effects with somewhat greater relative precision, and main effects with a slight increase in potential bias from non-negligible cubic effects, relative to a  $3^5$  design. The replicated centre point of such designs also provides an estimate of experimental error. However, in terms of relative precision, the orthogonal composite design indicated provides information in about 19% of the trials associated with a full  $3^5$  factorial design. Characteristics of the designs examined are being documented to assist others in their general use.

## PHYSIOLOGY AND AQUACULTURE

J. R. Brett

This program is divided into (A) relevant bioenergetic research (Physiology), and (B) fish production (Pilot Fish Farm).

A. Physiology

This study of the bioenergetics of salmon in relation to environmental factors has changed major emphasis from pollution-oriented research to aquaculture-oriented research. The change focuses increased importance on understanding the extent to which growth can be manipulated by control of environmental factors acting in concert. Considerable time has been spent on reviewing Station proposals (West Coast Committee) and examining world literature on aquaculture -- for the most promising lines for Canadian development (Government-Industry Seminar).

14. Growth acceleration of salmon

J. R. Brett and J. A. C. Thomson

Laboratory research has shown that use of increased temperature at egg and fry stages can greatly accelerate growth, advancing time to sea-entry by one year (for sockeye and coho). Because of the high cost of heating water, it is important to determine the most strategic combination of elevated freshwater temperatures in early life, coupled with transfer to naturally warming sea water at smolt size.

Using data developed over the past six years on the instantaneous growth rate of sockeye salmon in relation to temperature, ration and size, a mathematical model was developed for predicting expected weights for any temperature regime (program ACCEL). Applying the constraint that young salmon must enter the sea (Departure Bay) on both a rising temperature and increasing photoperiod, the model has been used to prescribe the critical temperature path for raising sockeye to pan size, within one year (1974). Temperatures of 10 C (egg to hatch -- early January), 12 C (alevin to feeding fry) and 14 C (fry to fingerling) project a size of 24 g on June 10th when the 30-yr mean temperature of Departure Bay is 14.3 C. Transfer to sea water at this size and time should provide an 8-oz fish by mid-December.

15. Metabolic energy equivalents

J. R. Brett

The final analysis of a set of experiments conducted over a number of years to determine the correct equivalent for converting metabolic rates of sockeye into energy units (calories) was completed. A direct comparison was made between the loss in body substance (protein and lipid) and the total oxygen consumed by four groups of salmon forced to swim for 330 to 350 miles.

Energy loss from depleted body substance exceeded that estimated from total oxygen uptake by an average of 19.8%. The difference is thought to be from excretion of partially metabolized fuels (anaerobic metabolism) and loss from sloughed body tissues. There was insufficient reason to conclude that the standard equivalent for mammals (4.8 Kcal/l O<sub>2</sub>) was substantially different for fish. This is the first time such evidence has been available.

16. Exploratory tests on diet change

J. R. Brett and M. Bell

Past experience of introducing wild salmon to an artificial diet, or the necessity to switch feeds during culture, has resulted in severe reduction in consumption and loss of weight. Basically the fish are faced with a change in both taste and texture, and have to adapt to the new situation.

To determine the "power" of these components, exploratory tests were conducted on fingerling sockeye and chum salmon accustomed to feeding on a soft, moist pellet (30% water). When presented with a hard, dry pellet (10% water) of two different feeds, a drop of about 75% of the average daily intake occurred, requiring at least ten days to return to normal consumption. Tests involving texture change only (freezing, drying) caused about a 15% decrease followed by four to five days for recovery. Taste changes (same texture) resulted in almost the same depressed intake as a complete diet switch, and was obviously the most disturbing component.

Adaptation to a new dry diet was abetted considerably by mixing the new diet with the old at the rate of 10%/day for chum salmon, but not so markedly with sockeye. The addition of an appetizer (zooplankton body fluid) did not improve the rate of adaptation. The presence of a high proportion of previously adapted fish (50% teachers) induced rapid feeding amongst the balance. In the absence of such "teachers," the 10%/day approach is recommended when changing diets.

17. Multifactorial experiments on sockeye growthJ. E. Shelbourn, M. Bell  
and T. Mayes

In May-June and November-December 1973 an assessment was made of the combined effects of temperature, ration, salinity and photoperiod on the growth rate of young sockeye. Two size groups were studied: fry (spring time) weighed 1.5 g, and fingerlings (fall) weighed 15 g. The treatment levels used were the same for each run:

Temperature - C	8	13	18
Ration - %/day	3	4.5	6
Salinity - ‰	4	10	16
Photoperiod - hr	6	12	18

The experimental design chosen was a composite factorial, estimating a full factorial with approximately the same precision, but with only 26 combinations instead of 81. Unfortunately in the application of the design some biologically inappropriate combinations occurred. For example, 3% ration at 18 C resulted in a negative growth rate for fry, and 6% at 8 C turned out to be an excessive ration for fingerlings.

Full analysis of the data has yet to be completed. However, visual inspection of sample mean weights, plotted every two weeks indicates that temperature and ration obviously affect growth rate, but that salinity and photoperiod effects are either insignificant or masked. Statistical analysis has been performed on the fry data, but provides no significance of interactions, due largely to the high variability of the two replicate tanks (specific growth rates of  $0.38 \pm .08$  and  $0.50 \pm .11$ ). Growth rates between sizes are obviously different, being higher for the smaller fry.

A similar series of experiments has been drawn up for 1974, with additional species, and with a new design based on appropriate temperature and ration combinations to ensure positive growth in every tank.

#### B. Pilot fish farm

W. A. Kennedy

In early 1973 a pilot fish farm, an important part of the Station's Aquaculture program, was authorized and commenced. The main activity in 1973 was construction of (a) the marine component of the fish farm, namely a flotation system for supporting box-shaped pens of netting for holding fish in the sea; and (b) the freshwater component of the fish farm, namely a small fish hatchery in which fry growth can be accelerated by heated water.

By year end major construction on the marine component had been completed and it was attached by a special anchoring system to Brandon Island near the Pacific Biological Station. Work on the hatchery was well advanced with completion expected in early 1974.

To gain experience in rearing salmonids in seawater, fry of sockeye, coho, chinook, pink and chum salmon were acquired from a variety of sources -- a few hundred to a few thousand of each species. By August, one or more lots of each of the five species were being held in cages in the sea, which continued beyond the end of the year. Growth has been good although the coho more or less stopped growing after October. Disease has been a problem but not insurmountable. Holding these salmon has been an enlightening experience in many ways and by revealing problems it has been a very useful aid to planning for the rearing of salmonids on a larger scale in 1974.

In preparation for full scale operation in 1974 we have procured fertilized eggs of sockeye, coho, and chum salmon, roughly 40,000 of each species. By the end of the year most of the sockeye eggs had hatched.

#### 18. Sablefish culture

The study was terminated on December 11, 1973.

Since its inception in December 1966, the objective of the sablefish

culture study has been to assess, from a biological viewpoint the feasibility of a commercial operation based on capturing juvenile sablefish and rearing them to commercial size for slaughter. The assessment has now been carried as far as seems useful for the present.

It has been demonstrated that, over the size range 500 g to 4 kg, sablefish are easy to rear and comparatively free of disease. Given favourable conditions they gain about 150 g per fish per month, have a mortality of slightly less than 1% per month and use about 5 kg of scrap fish for every kilogram of gain in weight. They thrive on all of the nine species of fish tried as feed and probably would thrive on almost any mixture of marine fish, whole or offal, provided that it were fresh and varied. Water temperatures above 12 C are unfavourable to smaller sablefish, and temperatures above 10 C are unfavourable to sablefish of more than 2 kg.

While the biological factors seem favourable for a commercial operation, economic and other non-biological factors have not been assessed by qualified experts. To assess them properly would seem to require a sizeable pilot plant operation at a location remote from Nanaimo. I do not recommend it at this time.

On the basis of my own assessment of economic and other non-biological factors (for which I claim no special competence) it would seem that if scrap fish were available at about two to three cents per pound, then a commercial operation to rear sablefish for market might be profitable. Probably the best procedure would be to use box-shaped fish pens made of nylon netting (2-in mesh, stretched measure, for juveniles, up to 5-in mesh for larger fish) the top edges of the boxes being supported by a suitable flotation system (maybe salvaged logs). Pens roughly 30' x 30' x 20' deep should be used; at least 10,000 pounds of sablefish could be held in each pen of that size if tidal currents were enough to give at least one water change every hour. A sheltered, tide-flushed location should be chosen where sea surface temperatures seldom exceed 10 C and where salinity is never less than 2‰. Serious consideration should be given to combining conventional commercial fishing with sablefish culture, using scrap fish and offal from the commercial operation for sablefish feed. Only good quality offal should be fed. A fish farmer would need to develop an economical way of capturing juvenile sablefish.

#### 19. Tag loss and tag mortality

In August 1972, as a supplement to a tagging program using FD-68D anchor tags, I set up an experiment to assess tag losses and tagging mortalities. During routine tagging of juvenile sablefish for release and possible recovery, every twentieth fish was set aside for the study, 50 tagged fish in all. A control lot of 50 untagged juvenile sablefish of comparable size captured at the same time and place was also taken. Extreme care was used during transportation to avoid loosening the tags. The two lots of fish were held in Nanaimo under identical conditions in neighboring 8' diameter tanks until November 28, 1973.

None of the fish lost their tags during the 15 1/2 months that they were held and all tags were firmly anchored at the end of the time. The tags caused infection in some cases and 10% of the tagged fish died from tag-related infection. However 10% of the untagged fish also died -- of undiagnosed causes. There was no significant difference in growth between tagged and untagged fish.

20. Stock Identification

T. J. Mulligan

The objective of this investigation is to develop a means to identify stocks of anadromous and marine fishes by the use of X-ray spectroscopy to reveal qualitative and quantitative differences in elemental chemical body constituents.

In September the writer assumed responsibility for this investigation from Dr. John Calaprice who left to assume new responsibilities at the Huntsman Marine Laboratory, St. Andrews, New Brunswick. Priority was given to an examination of the status of the X-ray detection equipment as compared to the present state of the art. The detection system employing the scanning electron microscope to create the X-radiation was much closer to present standards than was the X-ray fluorescence equipment. Consequently effort was concentrated on optimization of the microscope system. This optimization is essentially complete and the equipment is ready for use in investigating the chemical elements present in the freshwater growth region of sockeye salmon scales.

A significant proportion of time has been spent on the development of computer programs to handle the X-ray data and to extract the meaningful physical information, namely the concentrations of elements in the sample being analyzed. These programs are now working but are still undergoing tests and further development.



S T A F F   L I S T

## S T A F F   L I S T

All employees are listed who were on strength as at December 31, 1973. The arrangement of investigations and services applies to the major portion of the year.

Director	W. E. Johnson, Ph.D.
Assistant Director	K. S. Ketchen, Ph.D.
Executive Assistant	W. E. Reynolds
Chief Scientist (H.Q. Staff)	W. E. Ricker, Ph.D., F.R.S.C.
ST-SEC-3 (Director's Secretary)	Ruth Gale
<u>Office of the Director</u>	
SE-REM-3 (Director)	W. E. Johnson, Ph.D.
SE-REM-2 (Assistant Director)	K. S. Ketchen, Ph.D.
AS-5 (Executive Assistant)	W. E. Reynolds
<u>Personnel</u>	
PE-2	J. F. Griffin
CR-4	Laura Rasmussen
<u>Fisheries Biology Group</u>	
ST-SEC-2	S. J. Westrheim, M.Sc. (Group Head)
	E. Eleanor Kehler (Group Secretary)
<u>Groundish</u>	
SE-RES-3 in charge	S. J. Westrheim, M.Sc.
SE-RES-3	W. A. Kennedy, Ph.D.
EG-ESS-9	C. R. Forrester
EG-ESS-7	W. R. Harling
EG-ESS-5	D. Davenport
EG-ESS-5	M. S. Smith
EG-ESS-6	R. M. Wowchuk
EG-ESS-3	Doris E. Chilton
CR-5	Janice E. Smith

Pelagic Fishes

SE-RES-2 in charge  
BI-3  
EG-ESS-7  
EG-ESS-5  
EG-ESS-5  
EG-ESS-4  
EG-ESS-4

F. H. C. Taylor, Ph.D.  
D. N. Outram, B.A.  
L. W. Barner  
C. W. Haegele, B.Sc.  
J. S. Rees  
R. S. K. Isaacson  
E. Stolzenberg

Marine Invertebrates

SE-RES-3  
SE-RES-2  
BI-2

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N. F. Bourne, Ph.D.  
F. R. Bernard, Ph.D.

Shrimp and Crab

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EG-ESS-7

T. H. Butler, M.A.  
A. N. Yates

Lobsters

SE-RES-2 in charge  
EG-ESS-7

R. J. Ghelardi  
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Populations Biology

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A. S. Hourston, Ph.D.

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R. Ann Thompson

**Salmon Hybridization and Culture**

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EG-ESS-4

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**Chinook and Coho**

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**Salmon Stock Assessment**

SE-RES-2 in charge  
EG-ESS-5

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D. W. Jenkinson

**Babine Sockeye Ecology**

SE-RES-2 in charge  
GT-4  
EG-ESS-5

J. McDonald, M.A.  
A. S. Coburn  
J. R. Scarsbrook

**Babine Sockeye Assessment**

SE-RES-2 in charge  
EG-ESS-7  
SE-RES-2  
EG-ESS-4

H. W. D. Smith, M.Sc.  
F. P. Jordan  
J. Martell  
I. Miki, B.A.

**Babine Environmental Quality**

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H. W. D. Smith, M.Sc.

**Experimental Hatcheries**

SE-RES-2 in charge  
GT-3

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

**International Salmon Studies**

BI-3

K. V. Aro, B.A.

Experimental Biology & Pathology Group

ST-5

Parasitology

SE-RES-4 in charge

SE-RES-3

BI-2

BI-1

Physiology

SE-RES-4 in charge

BI-2

EG-ESS-7

BI-1

Mariculture

SE-RES-4 in charge

Microbiology-Disease

SE-RES-2 in charge

SE-RES-2

BI-2

Physiological Ecology

SE-RES-2 in charge

EG-ESS-6

Ethology

SE-RES-2 in charge

EG-ESS-7

Ecological Genetics

SE-RES-2 in charge

EG-ESS-5

L. Margolis, Ph.D. (Group Head)

L. Mavis Colclough (Group Secretary)

L. Margolis, Ph.D.

Z. Kabata, D.Sc.

N. P. Boyce, M.Sc.

T. E. McDonald, B.Sc.

J. R. Brett, Ph.D., F.R.S.C.

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G. R. Bell, Ph.D.

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J. R. Calaprice, Ph.D.

R. M. Hungar

EG-ESS-4

A. J. Solmie

Chemical Tags  
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Environmental Research Group

ST-5

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Beulah Smith (Group Secretary)

Lake Fertilization  
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BI-1  
EG-ESS-6  
BI-2

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O. D. Kennedy, B.Sc.

K. V. C. Stephens

D. G. Robinson

Biological Oceanography  
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SE-RES-2  
BI-2

R. J. LeBrasseur, Ph.D.

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J. D. Fulton, B.Sc.

Marine Impoundments  
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EG-ESS-6

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Fisheries Oceanography  
SE-RES-2 in charge  
BI-3

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J. I. Manzer, M.A.

Stream Ecology  
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BI-1

J. H. Mundie, Ph.D.

D. E. Mounce, B.Sc.

Ecology & Production of Freshwater Fish  
SE-RES-2 in charge

J. C. Mason, Ph.D.

Crayfish Culture  
SE-RES-2

J. C. Mason, Ph.D.

Estuarine Pollution  
SE-RES-3 in charge  
EG-ESS-4  
BI-1

R. R. Parker, Ph.D.  
Beverley A. Kask, B.Sc.  
T. J. Brown, Ph.D.

Logging and Stream Ecology  
SE-RES-2 in charge  
BI-1  
EG-ESS-6

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

Administration & Program Support Services

ST-5

W. E. Reynolds

S. L. Marcus

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LS 2  
CR-2

Emily A. Young, B.A., B.L.Sc.  
S. Dixon

Fish Culture  
GT-4

R. M. Humphreys

Fish Culture - Nanaimo  
GL-MAN-7  
GL-MAN-6

W. Griffioen  
D. Pozar

Fish Culture - Rosewall Creek  
 GL-MAN-7  
 GL-MAN-7

G. E. Johnston  
 E. W. H. Moore

Histology  
 EG-ESS-6

J. W. Bagshaw

Publications and Information

CR-5  
 CR-3  
 DD-5 (Drafting)  
 PY-6 (Photography)  
 ST-5 (Secretary to Dr. Ricker)  
 ST-4  
 ST-4  
 OE-2

Ethel E. Robinson  
 Beverly Rumsby  
 A. A. Denbigh  
 C. Morley  
 Barbara Morsvoll  
 Terezia Beg  
 P. Childs  
 Gloria D. Melliush

Computations

CS-3 in charge  
 CS-2  
 CS-1  
 DA-CON-2

J. A. C. Thomson, M.Sc.  
 F. W. Nash, B.Sc.  
 Arlene Sandnes  
 Kathleen R. Mitchell

Equipment Research & Development

EN-ENG-4 in charge  
 EL-4  
 EL-4  
 GL-MST-10  
 DD-4

J. S. Ford, B.A.Sc., P. Eng.  
 M. C. Armstrong  
 R. A. Cooke  
 G. T. Atkinson  
 D. J. Redman

Office & Material Services

PG-3  
 PG-1

O. O. Morgan  
 J. R. Hancock



## Financial Management

FI-1 (Finance)  
 CR-4  
 CR-4  
 CR-4  
 CR-2  
 GL-MDO-4 (Driver and Stores)  
 CR-2

L. Noon  
 S. C. Grando  
 Margaret K. Philp  
 Mary Arbanas  
 D. White  
 J. G. Naysmith  
 I. Linda Riddell

## Buildings, Grounds &amp; Services

GL-MAN-11  
 HP-6  
 HP-2  
 HP-2  
 HP-2  
 HP-2  
 HP-2  
 GL-MAN-6  
 GL-ELE-4

H. G. Reinstein  
 F. E. Drader  
 H. W. Gulich  
 M. H. Shillington  
 M. B. Waddell  
 A. Brown  
 T. Gillies  
 J. M. McArthur

## Shops &amp; Services

GT-5  
 GL-WOW-9

J. H. Brennan  
 M. Ilich

## Vessels

"G. B. Reed"

SO-MAO-8  
 SO-MAO-7  
 SO-MAO-4  
 SO-MAO-3  
 SO-MAO-2  
 SO-MAO-3  
 SO-MAO-2  
 SC-DED-3  
 SC-DED-2  
 SC-DED-2  
 SO-MAO-2  
 SC-DED-3  
 SC-ERD-2  
 SC-DED-6  
 SC-DED-3  
 SC-DED-3  
 SC-DED-3

J. Liston  
 R. May  
 J. Swindell  
 W. H. Colp  
 W. H. Craigie  
 W. S. Sutherland  
 A. J. Fletcher  
 D. Housego  
 A. J. Ranger  
 J. R. Selsby  
 R. H. McLaughlin  
 R. P. Marshall  
 H. J. Rothwell  
 E. C. Ryan  
 G. A. Wiseman  
 W. E. Wolden  
 W. P. Rowbottom

SC-STD-5  
 SC-STD-4  
 SC-STD-4  
 SC-STD-1  
 SC-ERD-2  
 SC-ERD-2  
 SC-ERD-2

J. J. Backmann  
 J. W. Young  
 M. A. MacLean  
 K. J. Goodman  
  
 F. Kreger  
 L. E. McLeod

"A. P. KNIGHT"

SO-MAO-4 (Captain)  
 SO-MAO-3  
 SO-MAO-2  
 SC-STD-4  
 SC-DED-4

E. R. Pollard  
 W. P. Winstanley  
 R. H. McLaughlin  
 J. W. Young  
 A. Gow

"Caligus"

SO-MAO-3

R. C. Page

"Investigator No. 1"

SO-MAO-4

J. T. Ferguson

Marine Support Services

SO-MAO-4  
 SO-MAO-3  
 SO-MAO-3  
 SO-MAO-2

C. Stewart  
 W. D. Nichol  
 L. V. M. Soper  
 R. B. Coomber

Personnel from the Arctic Unit

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

NON-STAFF RESEARCH WORKERS

Honorary Research Associate  
Honorary Research Associate

R. E. Foerster, Ph.D.  
F. Neave, Ph.D.

P U B L I C A T I O N S



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- Allen, K. R. 1973. Analysis of the stock-recruitment relation in Antarctic fin whales (Balaenoptera physalus). Rapp. P-V Reun. Cons. Perm. Int. Explor. Mer 164: 132-137.
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