Annual Report

SALMONID ENHANCEMENT PROGRAM 1977

Environment Canada | Environnement Canada
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July 28, 1978

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Our file Notre référence

In 1977, after several years of preparation, the Federal/ Provincial Salmonid Enhancement Program was finally launched in its official form. This report describes the first year of the five-year Phase I program and represents a successfully coordinated effort between several agencies and interest groups. Bearing in mind that it is always easier to subdivide than amalgamate, the program can be seen as a real accomplishment for everyone involved.

Now is the time to start thinking about next year's annual report so that we can all keep abreast of the new projects and developments. Thanks, everyone, for your continued cooperation.

Judy

Judy McDonald

JMcD/cb

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SALMONID ENHANCEMENT PROGRAM

ANNUAL REPORT 1977

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Cover: Stripping salmon to collect eggs at the Dominion Fish Hatchery built 1884 at Bon Accord Creek Port Mann townsite on the Fraser River, B.C.
(Drawn by P. Drukker Brammall 1974, reconstructed from material courtesy Special Collections, U.B.C. Vancouver City Archives. Photographic Section, Vancouver Public Library).

I. INTRODUCTION

In March, 1978, government representatives from all over the province attended the SEP annual meeting in Parksville.

Development of Salmonid Enhancement

Pacific salmon and trout have secured a special place in the social, cultural and economic environment of coastal people. For several thousands of years pre-dating man, salmon and trout inhabited the ocean and fresh water streams, and the abundance of these fish became an indicator of the life force of the coastal surroundings. Because of the interaction between people, fish and environment, a culture evolved. Eventually, coastal man became aware of communities around him, and salmonids were major trade items between and within societies. As communities grew, the cultural and economic aspects of life increased in complexity, and the demand for salmon and trout intensified. Ensuring *that this r*esource remains abundant is a primary concern of past, present and future societies.

Although historic levels of the salmonid species are difficult to document, it is now evident that declines in basic stock levels have occurred over at least the last half century. In the early years of the fishery, the industry concentrated heavily on the most valuable species in the most accessible areas, often over-harvesting some stocks and under-harvesting others. Characteristically, when one species or one area declined in productivity, the intensity of fishing would shift to another species or another area. It was not until the 1930's that the industry had seriously fished on all species in all areas, and most stocks were well below previous levels and still declining. After World War II, a marked increase in industrial development and urban growth provided an increased threat to the already depressed stocks. By this time, overfishing, illegal fishing and lack of management knowledge were also recognized as causes of the decline of these stocks. A species-by-species, area-by-area investigation of past performance and future capacity concluded that the five species of Pacific salmon have a combined productive capacity of between 300 and 360 million pounds per year — twice as great as that of the present day.

The importance of preserving salmon was stressed for the first time in the 1880's, and by the turn of the century major efforts had been directed into hatchery programs. Millions of fry and fingerlings were incubated, raised and transplanted. Obstruction removal, fry salvage and predator control were also practised. By the late 1920's, a growing knowledge of the complex biological processes involved in fish production prompted a critical look at hatcheries and through a certain amount of misinterpretation and economic maladies the hatchery programs were discontinued. In the 1950's, salmon management efforts were directed toward fishing restrictions, international aspects, and protection of salmon from the effects of competing resource uses such as logging, dams and irrigation projects. Salmonid enhancement has continued through the years, with ever-increasing knowledge of fish culture techniques as well as of the importance of environmental preservation and proper harvesting methods. In 1977 the time was right and the Salmonid Enhancement Program (SEP) was initiated to return Canada's Pacific salmonid resource back to its historic levels on the basis of a profitable government venture.

The necessity for an immediate start stemmed primarily from the fact that British Columbia's streams cannot continue to be protected for the production of salmonids on the argument of their potential value for fish production if the government is not willing to make a commitment to actually develop the resource. SEP is proceeding on a large, comprehensive scale so that clear increases in the benefit flow can promote diversity of the resource bases as well as recovery of investment costs. The geographical breadth of the program involves all the major watersheds of Canada's Pacific coast, coastal and inland communities and eventually questions of ocean pasturage and international fishing management. In summary, the ultimate target of this program is no less than to use

the resource base as fully and effectively as possible, only constrained by physical limitation and economic justification.

Enhancement Technology

The salmonids are those species of salmon, trout and char belonging to the family Salmonidae. The Salmonid Enhancement Program is concerned with enhancing the five species of Pacific salmon and searun rainbow and cutthroat trout (Table 1).

Table 1:

Species of salmon, trout and char found in Canadian waters.

Salmon	Trout	Char
*Sockeye	*Rainbow (steelhead when searun)	Dolly Varden
*Coho	*Cutthroat	Lake trout
*Chinook	Atlantic salmon	Arctic char
*Chum	Brown trout	Brook trout
*Pink		

*SEP target species.

Anadromous salmonids spend only a small portion of their life cycle in fresh water; however, during this time, very high natural mortalities occur in nature. Once habitat protection and proper harvesting methods are assured, enhancement technologies can be used to improve survival at one or more stages of the life cycle. Enhancement is a fishery resource management tool for controlling or improving conditions to improve survival in fresh water and increase the overall abundance of salmonids.

Spawning channels, hatcheries and fishways are the principal facilities applied to achieve increased fresh-water production of young salmon. Other methods such as incubation units, rearing ponds, stream improvements and flow control are portions or outgrowths of these techniques.

a) Spawning Channels:

Spawning channels are simply man-made streams designed to provide the best conditions for spawning and incubation. By providing controlled water flow (quality and quantity), graded spawning gravel and spawner density control, spawning channels are capable of providing egg-to-fry survivals four to eight times as great as those in natural streams. Channels are used to produce pink and chum salmon which do not rear in fresh water, and are also useful for sockeye salmon if underutilized lake rearing capacity is available in the system.

b) Hatcheries:

Hatcheries are fish culture operations that incorporate both egg incubation and juvenile rearing and feeding activities. They are used primarily to produce chinook, coho and steelhead smolts. Although hatcheries have been used in North America for nearly a century, successful fish culture has only been achieved within the last 15 years, largely through intensified research on nutrition, disease control, feeding technologies, water quality and timing of fry release.

c) Fishways:

Fishways break a waterfall into a number of steps which the fish can negotiate. They are used to circumvent natural or man-made barriers in streams so that spawning areas upstream can be utilized. The four Fraser River fishways (including Hell's Gate) have returned salmon with a total catch value of $60 million in the first 20 years, for a capital outlay of $2.3 million in the late 1940's.

d) Incubation Boxes:

An incubation box is a unit filled with alternating layers of salmonid eggs and gravel. Water flows through gravel in the box, and emergent fry are allowed to return directly to the natural system.

e) Japanese-style Hatcheries:

Hatcheries for chum salmon in Japan have been very successful and recently, Canadian scientists have applied the Asian technology to eastern Pacific chum stocks. The technique uses warm groundwater (rather than surface water) to accelerate eggs and alevin (larva) development. The emergent fish are then reared for about four weeks and are several times larger than stream fry and experience higher survival to the adult stage.

f) Lake Enrichment:

Lake enrichment involves controlled nutrient additions to a lake, causing increases in the phytoplankton and later zooplankton populations which are in turn used as food by young sockeye. Larger and more abundant sockeye smolts produce an excess escapement and the carcasses thereafter fertilize the lake naturally and the cycle is maintained. Therefore, by artificially fertilizing the lake, SEP can elevate the total stock and increase the numbers of sockeye available to the fishery.

g) Obstruction Removal:

Many streams have an assortment of log jams, beaver dams, waterfalls, etc. that hamper the upstream migration of salmonids. To ensure that adults have access to all possible spawning areas as many of these as possible are removed.

Obstruction removal has been practised for decades, and the benefits associated with this work are clear; however, certain obstructions are now recognized as beneficial to salmonids. Beaver dams, for instance, obstruct spawners but provide good rearing area for young coho, requiring selective dismantling of dams. Falls can be reshaped with explosives so that fish can negotiate the rise; however, resultant flow patterns must not wash out spawning areas or impede migrating fish. Fisheries authorities direct stream clearance but, through SEP, are now able to mobilize community groups and much of this work is now undertaken on a wider scale.

h) Stream Improvement:

Salmonid production can be improved on most streams, whether pristine or affected by man. Spawning can be improved by controlling bank erosion, adding gravel, removing small obstructions and clearing debris and garbage from the stream. Ensuring that enough cover and instream backwaters and eddies remain can improve juvenile production of such species as coho and trout. This kind of enhancement requires little equipment, some labour and a practical, common-sense knowledge of what salmonids need.

Project Flow

Each salmonid species has a different niche in the aquatic ecosystem and must be studied, approached and handled individually. Different stocks or "runs" of each species (that is, populations returning to spawn in a certain river) have also been shown to be genetically unique, and necessitate a stream-by-stream approach to protection, management and enhancement possibilities. Thus, the operating mechanism of the Salmonid Enhancement Program must identify and study individual salmonid stocks before fish production technology can be applied.

SEP fish production activities have been divided into three geographic areas; the Fraser River and west coast of Vancouver Island, Georgia and Johnstone Straits and

In 1910 this Fisheries Service crew was transplanting eggs near Chilco Lake.

the north coast of British Columbia and the Yukon. The planning for each area is the responsibility of the Federal-Provincial Geographic Working Group. The fish inhabiting each stream in each area are adapted to their environment as closely as a lock and key: since no two rivers are exactly alike, SEP examines each river on a site-specific basis.

SEP is flexible enough to allow for the incorporation of new discoveries into its long-term development plans. Research investigations range from the study of incubation and juvenile production units to migration of marine salmon, genetics and transplants, and the approach and analyses of complete systems. This work is aimed at developing new, and improving existing techniques to increase salmonid production in relation to regional goals.

SEP projects are organized so that a standard "flow" of activities can be followed. Manageability, reconnaissance, feasibility, design, construction, operations and maintenance, and evaluation are carried out for each major facility, although not necessarily in that order.

a) Manageability:

Stocks to be enhanced must be able to:

i) be harvested without over-exploitation of other stocks;

ii) not detrimentally interact with other valuable stocks (by predation, competition, etc.,); and

iii) not exceed the carrying capacity of freshwater or estuarine environments.

Management of the salmonid resource is a complex undertaking, and involves the selection of individual runs as they enter the fishery. Juvenile and adult tagging studies are important in providing the means to identify different stocks and examine their marine survival, distributions, times of migration and fishery contribution. However, fishery management officials recognize that perfect exploitation cannot be achieved and have incorporated a multi-species, total-system approach to enhancement and harvesting; that is, by identifying a group of stocks that are jointly fished, in the same or neighbouring streams, enhancement can be undertaken as a unit.

b) Reconnaissance and Feasibility:

Reconnaissance includes broad geographic overview studies to identify potential enhancement sites and stock opportunities. Feasibility activities are conducted to test and "prove up" those sites and stocks identified as enhancement candidates by reconnaissance. Feasibility studies (or baseline studies) quantify pertinent information so that specific enhancement plans can be formulated. For example, determining that in nature, juvenile chinook salmon leave the river system after 90 days of rearing instead of a full year, may eliminate the need for winter-operating fish culture facilities. The feasibility requirement of "manageability" (manageable in the fishery), "enhanceability" (biologically and technically possible to enhance), and "desirability" (economically, technically and socially desirable) must be met before enhancement can be undertaken.

c) Design and Construction:

Design is the development of detailed plans, specifications, and costing for the proposed enhancement facility and its operations, maintenance and evaluation. The design of the enhancement facilities for a selected project is specific to the site and stock.

Construction is the physical assembly of a facility to enhance salmonids. This term is limited to activities which create a physical capital asset, but in general usage, construction may be used to include some facets of small stream work or obstruction

removal.

d) Operations and Maintenance:

"Operations" is the term used to describe the activities necessary to run the fish production facility. Efforts directed into operations vary considerably with the type of facility, season and target species — most hatcheries require a year-round fish culture staff and spawning channels a seasonal crew, whereas fishways virtually operate themselves. Lake fertilization is also considered in operations.

Maintenance activities are necessary to maintain the value of the investment and ensure continued fish production; that is, the upkeep, improvement or renovation of an enhancement facility, including buildings, grounds and other works or structures.

e) Evaluation:

The broad purpose of evaluation is knowledge generation to maintain or improve fish production. Engineering evaluation is initially aimed at fine-tuning physical operations and, over the longer term, at evaluating the technology in search of improvements. Similarly, the biological evaluation is to fine-tune the operation of the facility to optimize production and over the long haul, evaluate technology. The biological evaluation, because of fish life cycles and high natural variability, may last over a number of years whereas the engineering feasibility may take only months.

Five Account System

The impacts of salmonid enhancement projects are analysed on the basis of their contribution to:

i) national income;

ii) employment;

iii) regional development;

iv) native people; and

v) resource and environmental preservation.

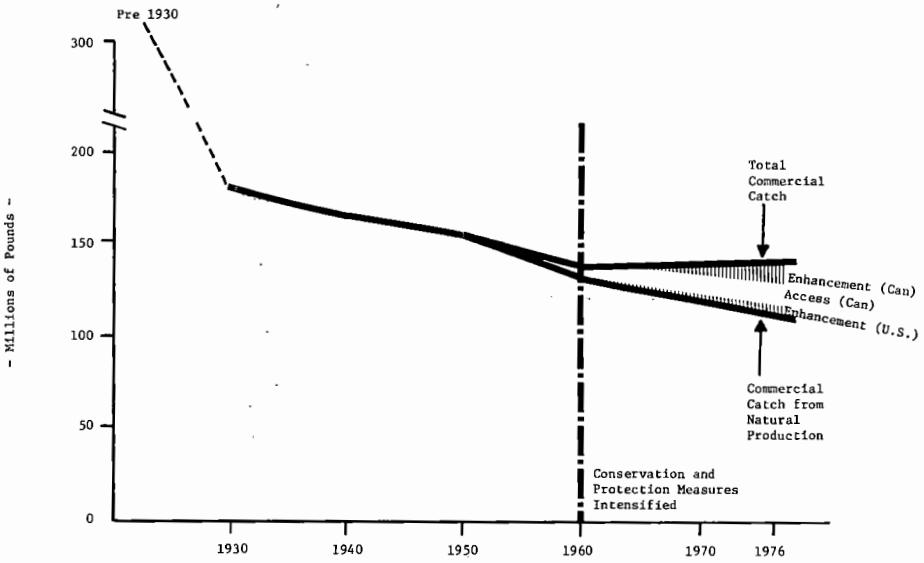
This "Five Account System" was designed to recognize that society has a multiplicity of goals and that not all are measureable in national income dollars. Through the Five Account System, the trade-off among objectives involved with any SEP plan becomes explicit to the decision-makers, resulting in an appropriate balance of the social and economic objectives of government.

Special Projects

The protection of small streams is now recognized as an important SEP management concern. Some salmonid species, such as coho and steelhead, reproduce in literally hundreds of small stream systems rather than in a few large runs. The importance of these streams is often overlooked; they are frequently first to be affected by the encroachment of man and are also very fragile in ecological terms. The Special Projects Unit (SPU) works to alleviate such resource management problems by undertaking projects involving the protection and rehabilitation of small streams.

Figure 1

Long-Term Trends in the Commercial Catch



Summary of Progress in Year I

Although the program has encountered some financial and administrative problems in its first year, much progress has been made. The following account is a summary of work done in various sectors:

a) Administration:

Significant progress has been made in the following areas:

i) development of a cost-recovery plan acceptable to the federal government;

ii) planning (program and project) in which a specified aim has been to harmonize biological, engineering and economic objectives;

iii) development of an educational program and tools for it;

iv) development of public Advisory and Participation mechanism;

v) work on the Native Project Pilot program; and

vi) development of closer ties between Federal departments for future work on the program.

Although Federal and Provincial government people have been working together on many parts of the program, a formal agreement between the two governments has not yet been signed. The program has encountered difficulties in acquiring adequate staff, and this particular problem could have a major impact on progress over the next two years. It will also, certainly, require the intensified use of private contractors for nearly all aspects of program work.

The Federal-Provincial steering group continues to give the program leadership, but progress toward the setting up of a Management Board has been slow. The major advisory body to the program in its first years has been the B.C. Task Group, a body made up of representatives from all aspects of the salmonid resource. This group has been growing in effectiveness ever since it came into being.

A new unit — the Enhancement Services Branch — was built into the Federal Fisheries and Marine Service during the year. This unit brings together, under one organizational roof, the engineering, biological, economic and planning services involved in this multiple-objective program.

Also, a Special Projects Unit was formed within this new Branch and assigned specific responsibility for SEP economic development work for small stream improvement and restoration projects, and for public involvement activities. Much of the work done under this heading is funded jointly by SEP and by the Canada Employment and Immigration Commission.

b) Research:

Research projects supported by SEP covered a wide front during the first year. Areas touched included stock manageability, studies of the biological feasibility of future work, establishment of design parameters and work aimed at building the highest possible degree of efficiency into future operations. All projects launched during the year went ahead on schedule. These first-year projects will themselves come under a searching economic assessment — as will all other SEP projects in the years ahead.

Dramatic success has been achieved in the lake fertilization projects — making it entirely realistic to hope for a significant boost in the production of sockeye early in the program. Two hundred and fifteen metric tons of fertilizer were distributed in Great Central, Long, Hobiton, Henderson and Mohun Lakes from early May to late October. Results were good in every case. An additional 33 lakes were surveyed this summer, and 14 of them were found to have good potential for development by the lake enrichment technique.

Set against this success has been the buildup of heavy, commercial fishing in Barclay Sound this year, taking relatively large numbers of summer steelhead. This has created a conservation problem, and dramatizes the need to assess stocks carefully before going ahead with new enhancement projects.

Program experts are also studying the response of the fishing fleet — and other "stock management" complications of the rapid increase in stocks of sockeye, resulting from the successful fertilization of Great Central and Henderson Lakes.

c) Stock Management:

Significant new knowledge about the manageability of various salmonid stocks was acquired in the course of studies made during the first year. Projects of this kind included the marking of juvenile fish, recovery of adult fish and sampling of the catch. Although some fish marking projects did not achieve their targets (Docee River and Goose Bay, for example), others, such as the Chilco tagging project, did even better than expected. Also, many wild chinook and coho were marked, along with fish from hatcheries.

At Cowichan, fish that had been tagged as adults were recovered. Studies, including catch samplings, were made to determine the proportion of steelhead in the commercial catch. This was done on the Skeena, at Barclay Sound, Johnstone Strait and on the Fraser River, under supervision of Provincial government officials.

Work funded by SEP and supervised by Provincial government staff members has progressed well. This work has been particularly useful in setting long-term targets for the production of steelhead and cutthroat stocks, about which information is badly needed.

d) Reconnaissance and Feasibility:

Biological studies made directly by Federal staff have, in general, proceeded successfully, although the scope of this effort has been narrowed through administrative difficulties. Staffing and funding problems also curtailed some engineering feasibility studies — specifically, Fraser River headwaters, Kitimat and Kalum. However, good progress has been made at Vedder-Chilliwack, Tlupana, Bella Coola and Little Qualicum. Feasibility and reconnaissance studies made during the year led to the following adjustment of schedule:

i) speeding-up of plans for a Japanese-style chum hatchery at Bella Coola;

ii the probable deferment of the building of a major facility at Deadman;

iii indefinite postponement of a chum spawning channel at Vedder; and

iv) acceleration of a hatchery on the Chilliwack.

Other changes in the long-range plan can be expected as feasibility studies are completed.

e) Design and Construction:

By the end of the first year, design will have been essentially done for the following proposed SEP installations:

i) Inches Creek Japanese-style hatchery;

ii) Wolfe/Tsolum incubation boxes;

iii) Puntledge River hatchery expansions;

iv) Big Qualicum spawning channel no. 3;

v) Embly Falls fishway;

vi) Tlupana and Bella Coola chum hatcheries — stage I work;

vii) Little Qualicum spawning channel; and

viii) Pallant Creek Japanese-style hatchery.

At the Puntledge River hatchery, construction at the Upper River site is complete and also the rebuilding of the rearing facilities at Big Qualicum. The new chum facility at Pallant Creek is also well on its way.

The major construction job of the year was completion of renovations to the Pinkut Creek spawning channel — at a cost of about $1.5 million (half a million dollars of which was funded by SEP). It was decided to delay construction of the chum facility at Inches Creek. Here, however, the necessary land has been purchased and cleared, wells have been completed and designs revamped. This means that the project will be postponed and is ready to be implemented in 78/79 or in 79/80, according to the way priorities are arranged.

f) Operations and Maintenance:

During the year, 11 major fish culture facilities were in operation — all of them assigned to SEP. These operations produced a total of 260 million fry and smolts during the year. This adds up to a total potential yield of more than 1.5 million adult fish destined for the fisheries. Fifteen additional fishways now operated by SEP are expected to contribute another half million fish to the catch.

g) Direction:

A shortage of experienced biologists has severely impeded the planning and design of new salmon enhancement facilities. Management will be exploring all avenues for filling this gap in biological and engineering help from the private sector.

SEP is working closely with the Federal Environmental Protection Service and the Habitat Protection Branch of the Federal Fisheries to make sure that the habitat of the salmonids gets careful attention in all its plans. It will also work with these groups to set adequate environmental standards for major SEP fish culture operations.

Future Projections

Of the SEP funds for 1978/79, $8 million will go for major capital projects. Construction will begin on a new fishway at Embly Falls in Johnstone Strait and on three new chum hatcheries at Pallant and possibly Mathers Creeks on the Queen Charlotte Islands and at Bella Coola River in the central coast. At Kitimat on the north coast, the pilot operation will be expanded, and design work will begin for a multi-million dollar hatchery. On the west coast of Vancouver Island, a new chum and chinook hatchery at Tlupana, off Nootka Sound, will be under construction, and design work for another hatchery farther south at Nitinat River is under consideration. In Georgia Strait, a spawning channel at the Little Qualicum River, near Parksville, will be under construction, and a $2.2 million spawning channel is also being designed for inclusion in the Big Qualicum River project. At Courtenay, construction will continue on a major, new hatchery at Puntledge River for chinook, coho and steelhead. For the Chilliwack-Vedder system in the Fraser, design plans will be complete for a multi-million dollar hatchery and spawning channel complex while habitat restoration programs in the area are also undertaken. Finally, plans for incubation boxes at Inches Creek in the Fraser are being examined for possible

construction. Over the next four years, SEP intends to build about 60 of these major projects.

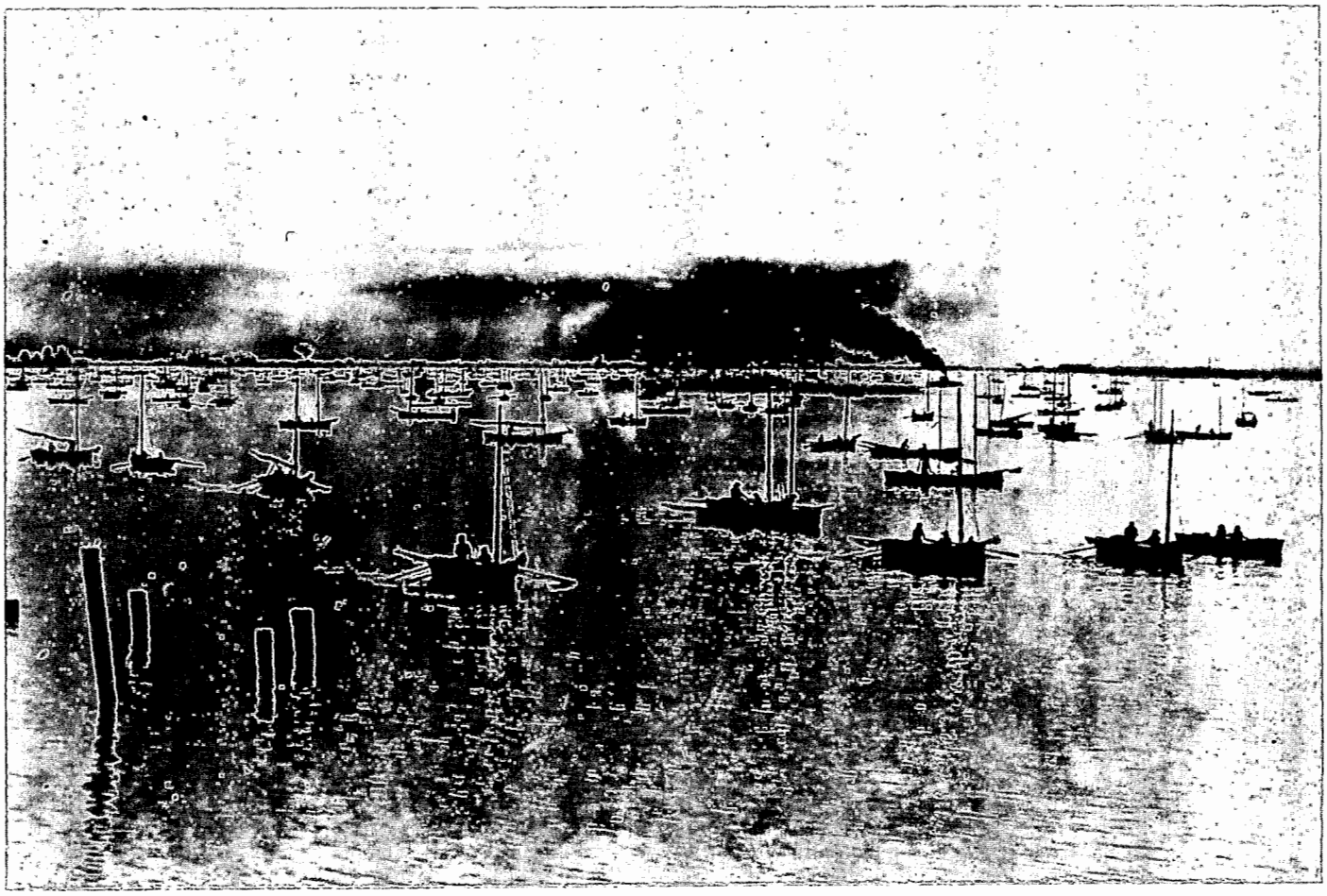
Hatcheries and other big construction projects consume less than half of this year's total budget for salmonid enhancement. The promising work on lake fertilization is expected in the long term to increase sockeye production by 1.5 million fish annually from the projects now underway. Increasing work in small stream rehabilitation and stock management is being undertaken. Other projects include prototype work in hatcheries, rearing channels, pen rearing and estuary rehabilitation. Clearing log jams, cleaning out silt, digging channels, improving culverts and controlling beaver dams are ongoing fisheries programs also concerned with salmonids.

This year, $1 million of SEP funds and $2.5 million from the Department of Employment and Immigration will be used for community development projects. In this program, a contract is let with a community group, Fisheries personnel provide supervision and training, and, as skills and interest develop, the group can progress from simple stream clearance to the construction of fish production facilities. Last year, there were seven of these community development projects — this year, there will be about 23. These projects are seen as one of the best things about the Salmonid Enhancement Program, and a sizeable increase in the number of public projects is planned this year.

The British Columbia public will be actively involved, not only in field projects, but in the direction of the program. Members of a new Salmonid Enhancement Board will be announced and will represent, along with government representatives, diverse sectors of the public, including commercial fishing and processing, recreational fishing, native Indians, the public at large and a competing water resource user such as logging.

Of this year's total enhancement budget of $20 million, $14.5 million is allocated to the projects mentioned above, including the $2.5 million from Employment and Immigration. The remaining $5.5 million is for bio-engineering studies for proposed projects, evaluation and econonomic studies, operating enhancement facilities built in the last two years' program such as those at Atnarko, Thornton Creek and Kitimat, ensuring public involvement and for administration of the Salmonid Enhancement Program.

The Salmon fishing fleet in the Fraser River, circa 1900, consisted of thousands of small boats. A steamship (background) towed the vessels onto the fishing grounds.



II Development Areas

A. Fraser River and West Coast of Vancouver Island

International Pacific Salmon Fisheries Commission Proposals:

In order to realize coordinated enhancement goals concerning all salmonids, the IPSFC Fraser River sockeye and pink enhancement proposals have been reviewed in detail. The preliminary assessment is now complete, major impact areas have been identified, and the first working draft of a report is in the final stages of completion (F. Fraser, 1978).

Serpentine and Nicomekl

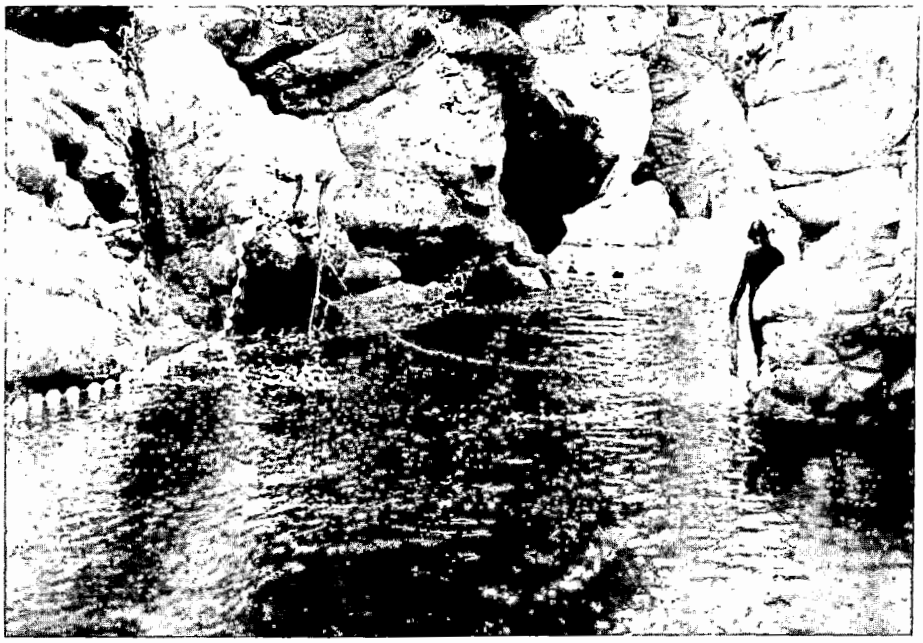
In this project, the present state of the fish habitats and populations in the Serpentine and Nicomekl systems were examined. Although this investigation was part of a larger, overall study by ARDA (Agricultural & Rural Development), SEP concerns were directed towards the protection and enhancement of cutthroat and steelhead trout, and coho salmon. The study area included not only the upper watershed but the lower agricultural flatlands as well.

During May and June 1977, habitat reconnaissance began on the Serpentine and Nicomekl Rivers. Juveniles were captured by electroshocking and, flows permitting, minnow traps, butterfly traps and seines were also used. Since the smolt migration corresponded with spring freshets, it was difficult to quantify numbers or timing; however, a definite downstream migration of juvenile searun cutthroat was noted and steelhead were migrating in smaller numbers. The study also suggests that parts of the system are underutilized and that others have insufficient flows.

A creel census began in October and catches of cutthroat, steelhead, and coho, both this year and last year, are being evaluated. The survey is extending to neighbouring streams such as the Little Campbell and Salmon Rivers. Sampling continued until April 1 and it appears that cutthroat catches predominate, while coho and steelhead catches are less significant. The overall results of the creel census were: 779 anglers interviewed, 1,828 angler-days, 250 steelhead killed and 39 released, and 760 cutthroat killed and 442 released.

Fraser Valley Trout Hatchery

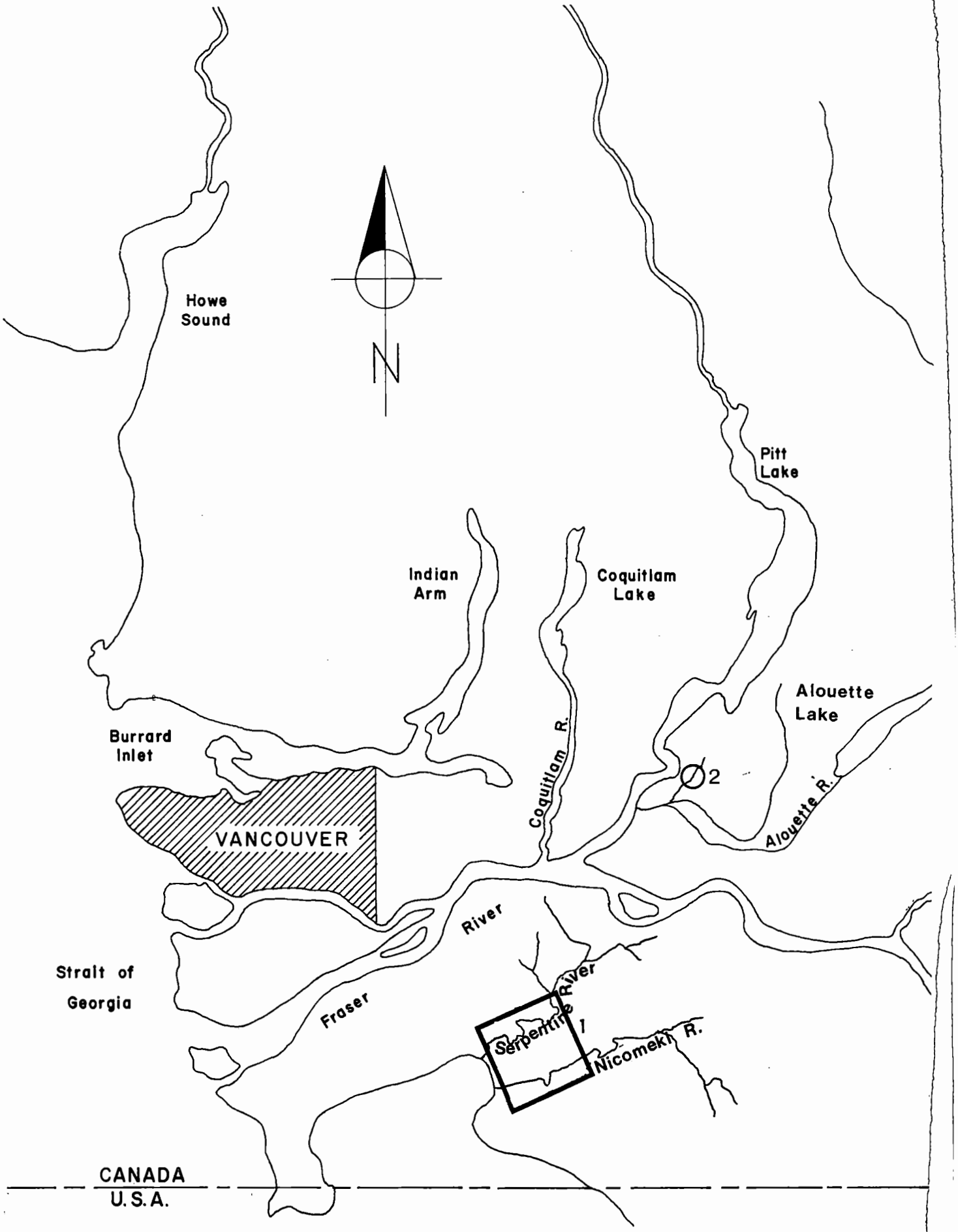
Although not SEP funded, the provincially-operated Fraser Valley Trout Hatchery in Abbotsford is a successful and prominent contributor to realizing salmonid enhancement goals of increased fish production, scientific research, and public information and education. The hatchery was built in 1976/77 as a replacement for an old, privately-run hatchery which was bought by the Province of British Columbia in 1965. Since April 1977, operations were gradually moved to the new facility and on November 4, the new Abbotsford Trout Hatchery was officially opened. Phase I of the hatchery has been completed at a cost of 7.5 million dollars and plans for expansion of the fish production facilities (Phases II, III and IV) are underway.



Recovering steelhead for tagging purposes requires careful seining in difficult areas.

The hatchery features a complete public information gallery including photos, models and aquaria in an attractive indoor setting as well as guided tours and a theatre/projection room. A research wing and complete offices, laboratories, shop and storage areas are also included in the main building. Fish culture facilities include 32 stacks of Heath trays, 108 rearing troughs and 11 circular, self-cleaning rearing ponds (7.6 m diameter). The hatchery is groundwater-fed and uses a recirculating water system with sand biological filters. Additional ponds for holding brood stock and quarantined fish are operated on separate water supplies.

At present, the number of fish on hand indoors is approximately 58,000 rainbow fry, 200,000 steelhead eggs and 31,000 coastal cutthroat eggs. The outside rearing ponds contain approximately 150,000 fish, mostly rainbow trout. Steelhead culture operations have produced approximately 22,000 Coquihalla River smolts, to be released this spring after only one year of rearing.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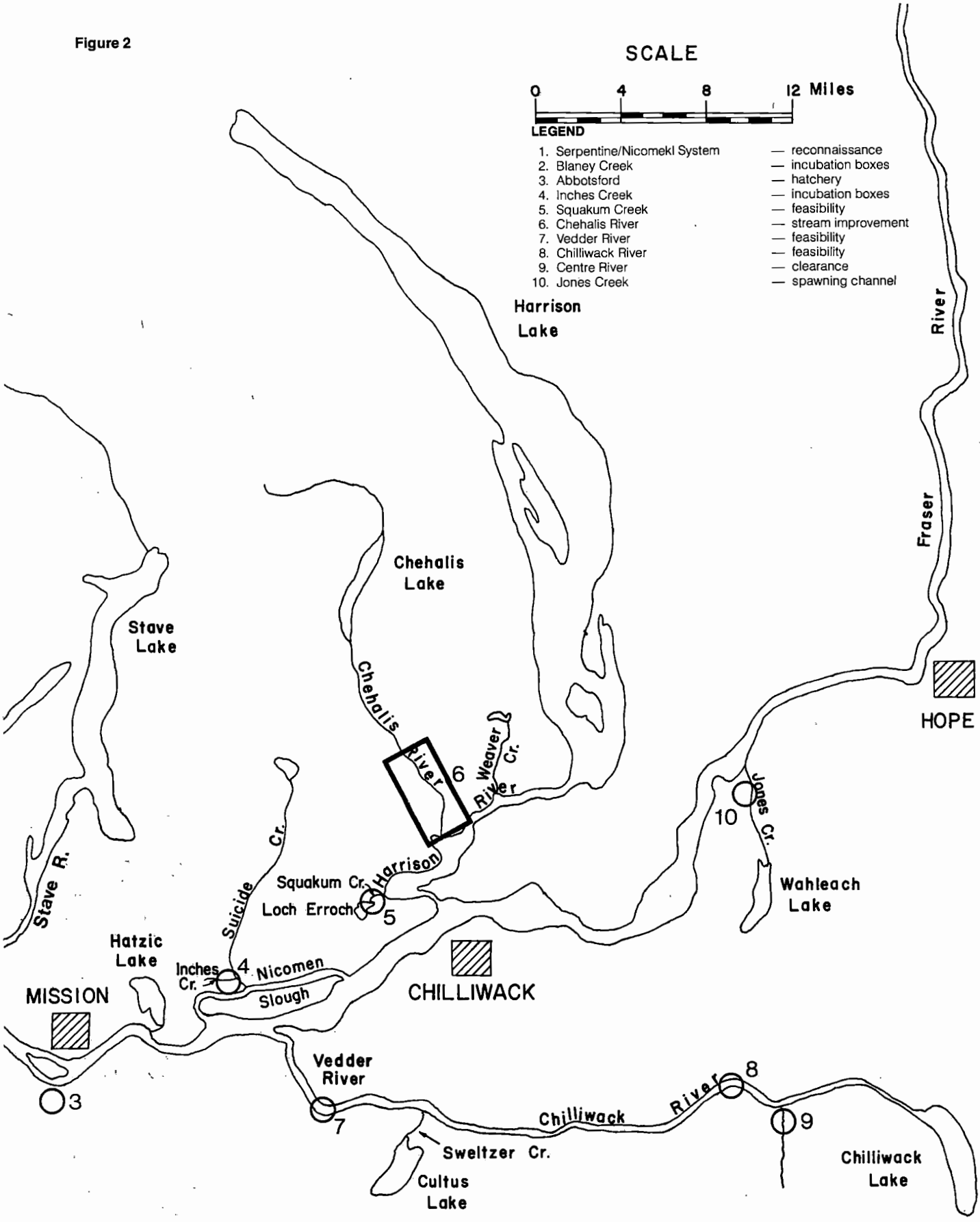
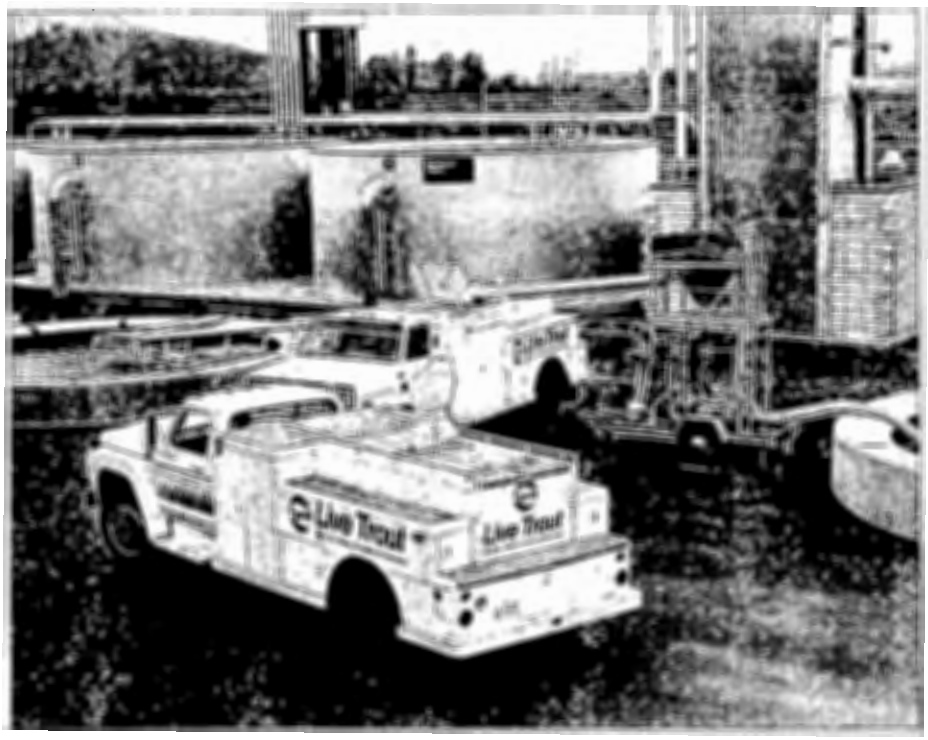
Lower Fraser River

Figure 2





In addition to SEP activities related to steelhead and cutthroat trout enhancement, the Fraser Valley Trout Hatchery in Abbotsford routinely transports live trout to many lakes in southern B.C.

Blaney Creek Production

Objectives of the Blaney Creek project are to enhance, by the incubation box technique, chum salmon stock to an economically significant size of 50,000 adults. Furthermore, the timing, abundance and survival of these returns in the fishery and on the spawning grounds will be identified and the incubation box technique will be further refined and evaluated.

The 1976 brood fry migration from the Blaney Creek incubation boxes produces 158,800 chum fry for an egg-to-fry survival of 91 percent. Due to the mild winter in 1976/77, fry migration peaked approximately 2 weeks earlier than usual.

A total of 1.7 million eggs were planted between October 20 and November 8, 1977 in the three incubation boxes. A total of 647 females were used for an average fecundity of 2,645 eggs per female. In addition, approximately 280,000 eggs were planted in a screen tray in the top of a 50,000 egg incubation box, to be transplanted to Mossum and Musqueam Creeks. These did not develop properly and died at the eyed stage when shocked.

Dead recoveries indicate that returns to Blaney Creek in 1977 are 97 percent from the 1973 brood release of 1.3 million fry. Total returns are estimated at about 6,500 adults. With a 50 percent mark mortality and 40 percent fishery exploitation, this is a fry-to-adult survival rate of 0.5 percent. Sampling of the fishery in the week ending September 24 showed 3 marks out of 9,000 sampled in Area 12 and 3 marks out of 8,528 sampled in Area 13, indicating the peak of adult migration. Almost 50 percent of the incubation box returns strayed to and spawned in the North Alouette River.

Inches Creek

a) Production:
A pilot chum salmon facility utilizing two 500,000 egg capacity incubation boxes has been in operation on this small groundwater fed stream since 1970. Egg-to-fry survival in this facility has averaged 82 percent in seven years of operation. Adult escapements have increased from a 1964 to 1973 average of 2,100 pieces (250-3,500) to an average of 6,700 pieces in the last four years.

Continuing operations at the Inches Creek site will evaluate and refine incubation box techniques using a groundwater source for chum salmon.

Timing, abundance and survival of the incubation box fry will be assessed by recoveries of fin-clipped adults in the fishery and on the spawning grounds.

A total of 1.2 million chum fry were produced from the 1976 brood egg deposition, representing a survival rate of 88.1 percent. A total of 275,300 of these fry were marked with fin clips. Experiments were carried out with a screen tray plant and soft egg plant in two 50,000 egg incubation boxes. Survivals were 95 and 97 percent, respectively.

A total of 1.7 million eggs were planted in four egg takes between December 7 and 28, 1977. In addition to normal production, screen tray plants were made in two modified 50,000 egg incubation boxes to test the effects of variations in egg densities and flow in terms of survival, timing and size of fry. In addition, eggs were planted in a hatchery tray and alevins planted in an incubation box at various times to determine optimal timing of alevin plants from trays (Table 2).

Estimates of timing, numbers and age compositions of the adult migration into Inches Creek were made by fence counts and dead pitches.

b) Design and Construction:
Inches Creek, a tributary of Norrish Creek, which discharges into Nicomen Slough near Mission, B.C., was selected for the first major chum salmon enhancement facility in the lower Fraser Valley.

The proposed facility will be located on 3.8 acres of recently acquired property upstream of the pilot facility and will utilize the incubation box technique to incubate 7.8 million chum eggs, and 1.5 million coho eggs.

The chum fry will be reared in a 122 m long by 10 m wide rearing channel for approximately 30 days, then released. The coho fry will be reared in a 30.5 m by 6.1 m raceway also for 30 days at which time they will be transferred to underutilized rearing areas such as Nicomen Slough.

The total adult production is estimated to be 100,000 chum and 14,500 coho salmon. As an additional benefit of the project, water released from the facility into the upstream portion of Inches Creek should increase the natural production of the system.

The estimated capital cost of the proposed facility is $725,000 including $25,000 for land acquisition. Annual operating costs

Table 2.

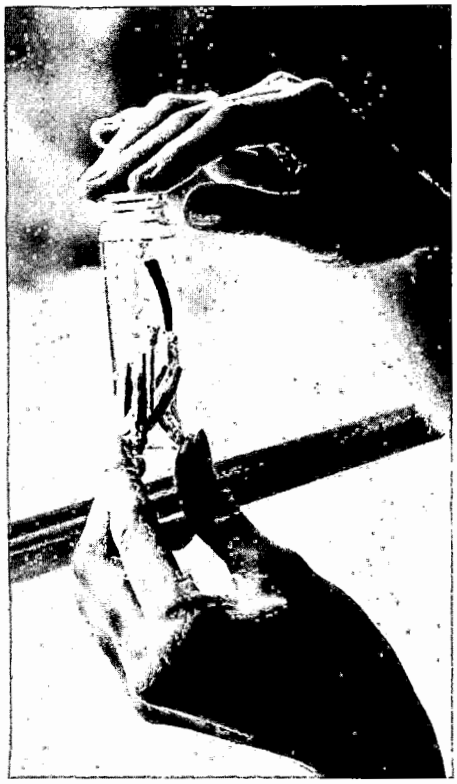
Summary of experimental incubation box egg plants at Inches Creek in 1977.

	Incubation Boxes		Screen Trays			Heath Tray
	1	2	3	4	5	
No. of Eggs/ Plant	695,712	283,188 422,368	16,161 29,512 42,792	16,161 29,512 42,792	50,293	50,241
Flow (US gpm)	7.5	7.5	15	7.5	7.5	4
Gravel	Crushed	Round	Round	Round	Round	Round

Table 3.

Numbers of coho smolts tagged in the Chilliwack River system in 1977.

Salwein Cr.	9469
Hopedale Cr.	4208
Little Hopedale Cr.	1563
Ryder Cr.	3943
15 Mile Cr.	1260
Post Cr.	1255
Chilliwack R. (at lake outlet)	111
Total	21,809



Chum and pink salmon are too small to accept coded wire tags and are usually marked by fin-clipping. These anesthetized chum fry from Inches Creek are being examined for fin-clip quality.

are estimated at $110,000. An economic analysis of the project indicates a benefit-cost ratio of 2.06:1 based on a 40 year operating life span of the facility.

The proposed facility will consist of a groundwater development system including wells, a pumphouse, pumps and aeration facilities; incubation units with a capacity for incubating up to 9.4 million eggs; a rearing channel, a combined adult holding and juvenile rearing pond; a fence for adult capture; pollution abatement facilities; access road, warehouse and workshop, office and residence; counting area and laboratory and a public display area.

Tentative design plans for the facilities were completed in 1977/78 and in addition the property was acquired, cleared and stripped of overburden in preparation for construction of the proposed facilities which is scheduled for 1979/80.

A well development program was also undertaken and pump tests have ascertained that the two 50 cm diameter wells will yield approximately 8,100 litres/min. The tests also revealed that the water temperature of the developed wells is 10.5 C (51°F) which is warmer than the water temperature of the existing operating well which is 8° C (46.5°F).

Vedder/Chilliwack Enhancement Feasibility

Establishing enhancement facilities on the Vedder/Chilliwack system requires biological baseline studies on the local enhancement stocks of chum and coho. This project is in the second year of a three-year study and consists of a two-phase juvenile tagging program and an adult dead recovery.

Phase I was completed on June 7, 1977 and a total of 21,809 coho smolts were tagged with binary nose tags. The fish were captured by means of converging throat weir traps and a 4 x 4 inclined plane trap. The fish were taken from six tributary streams and in the mainstem Chilliwack river near the Chilliwack Lake outlet (Table 3).

Phase II commenced in mid-October 1977 and involved trapping coho juveniles in Chilliwack Lake using baited minnow traps. Tagging was completed on December 6, 1977 and a total of 5,390 coho juveniles averaging 9 fish/gram were marked with adipose fin clips.

Tagging and dead recovery of adult chum and coho salmon was undertaken to determine the abundance, timing, distribution and interception by the Chilliwack/Vedder sport fishery (coho). Tagging of chum and coho salmon continued from November to January, 1978. Fish were captured by beach seining and a total of 1,933 chum and 234 coho were marked with 2.2 cm disc tags and released. In January, the dead recovery was nearing completion with 35,080 chum and 1,369 coho carcasses recovered.

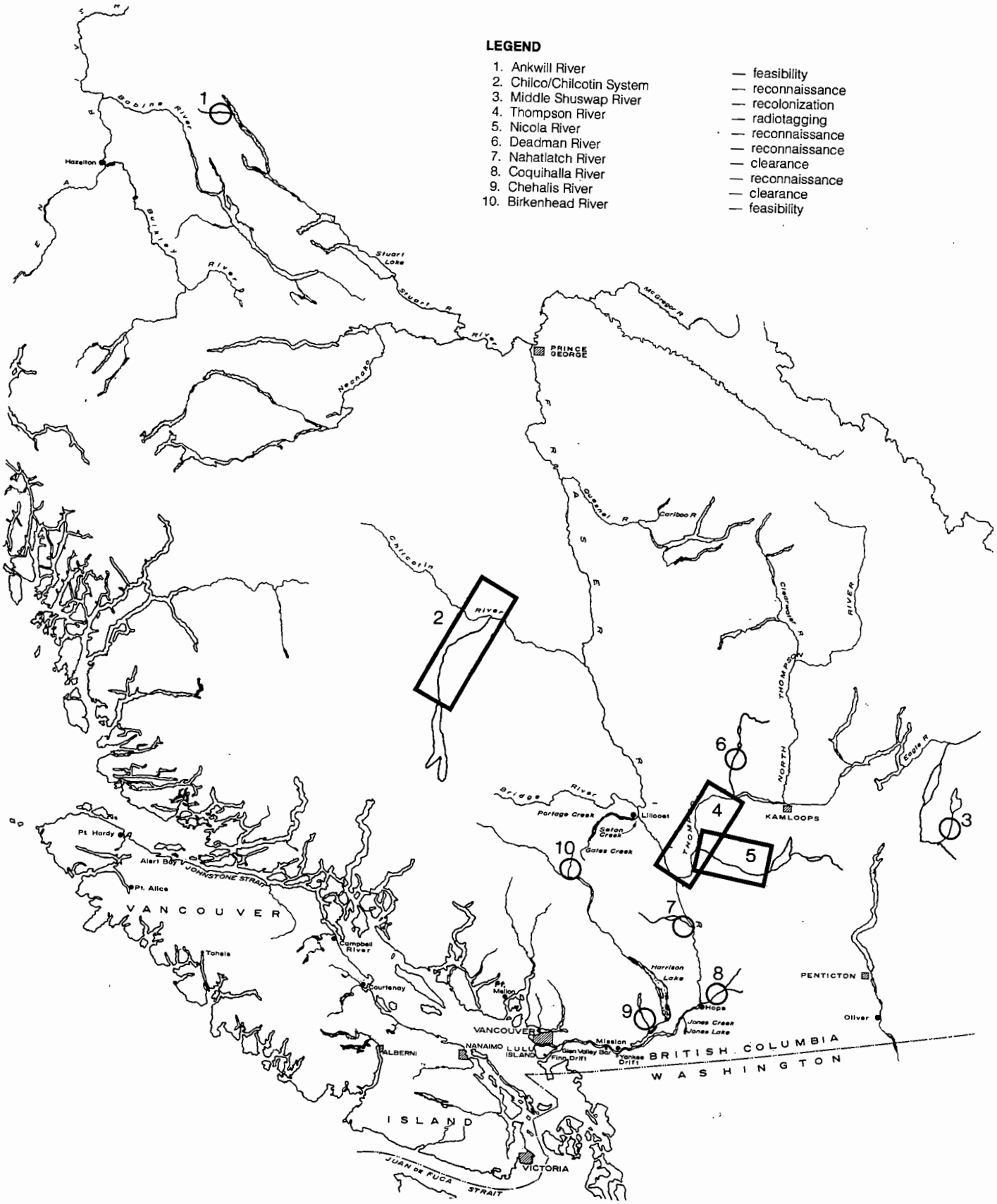
Vedder River Steelhead

Section of the mainstem Vedder River and Slesse, Foley and Post Creeks were sampled for juvenile population abundance and distribution. Sections of the rivers were scuba-floated, and seining, netting and electrofishing were used to recover fish in more accessible areas. Slesse and Foley Creeks were found to be underseeded so they recently received 4,900 (Slesse) and 3,800 (Foley) steelhead smolts introduced from Vedder River brood stock held at the Abbotsford Hatchery.

The research section of the Fish and Wildlife Branch will be concerned in future with evaluating the quality of the smolt output in terms of adult returns to the system. Assessments of other tributaries will also be undertaken before enhancement plans are finalized.

Figure 3.

Upper Fraser River



Jones Creek

The controlled-flow spawning channel, built in 1954 as mitigation for a dam built by B.C. Hydro, is the first spawning channel ever constructed and continues to provide odd-year pink salmon production. The Jones Creek spawning channel is in its twelfth year of enumeration to be made in the dominant pink cycle year. Chum, coho and steelhead also utilize the system and both coho and steelhead juveniles use the channel and creek for rearing.

Maintenance operations at Jones Creek are largely related to silt removal. Gravel cleaning and settling pond enlargement and cleaning have recently been completed; however, silt accumulation is seen as an ongoing problem.

A counting fence was operated to October 18, 1977 and a summary of the pink and chum escapements are listed in Table 4.

The fry migration will be monitored during April and May using a mesh/Wolf trap arrangement. A Fyke net with dyed fish releases will also be employed to estimate fry production downstream. Approximately 700,000 pink fry are expected to emerge.

Table 4.

Jones Creek spawning escapement summary for 1977.

Species	No. of Fish	% Male	Egg Deposition
Pink	1907	47.4	1.8 million
Chum	142	47.5	N/A

Table 5.

Lengths and ages of adult chinook salmon sampled in the Birkenhead River in 1977.

AGE		3		4		5	
	2_1	3_1	3_2	4_1	4_2	5_1	5_2
Percent age composition	2.5	59.9	1.6	15.6	18.0	.8	1.6
$\bar{x}$	2.5	61.5		33.6		2.4	
Hypural length (cm) males	52.1	69.9	57.0	84.1	76.3	89.8	-
$\bar{x}$				74.6			
Females		69.4	59.8	76.4	70.9	-	76.1
$\bar{x}$				70.8			

Lower Fraser Engineering Feasibility

The following engineering feasibility studies were undertaken on the Lower Fraser River system:

a) Chilliwack/Vedder River:
Topographical surveys were undertaken and plans were prepared of proposed chum salmon rehabilitation projects on the Chilliwack/Vedder River system including Barret and Ryder Creeks. The proposed work would be an extension of the sidechannel development pilot program that was initiated on the left bank of the Vedder River upstream of the B.C. Hydro Bridge in 1977/78.

b) Chilliwack River:
Preliminary designs were undertaken on a proposed salmonid hatchery located near the confluence of Slesse Creek and the Chilliwack River. The total adult production objectives of this facility are 100,000 chums, 150,000 coho, 10,000 chinook and 12,000 steelhead. Final design and construction of the facility is scheduled for 1978/79 and 1979/80 respectively.

c) Squakum Creek:
Topographical surveys were undertaken and preliminary plans were prepared of a proposed chum salmon rehabilitation project on Squakum Creek. The proposal envisages the replacement of the existing gravel and the construction of gabion drop structures on the main channel to control stream velocity and erosion during high discharge conditions. It is anticipated that the proposed project will make a significant increase in chum salmon production in that system and will be relatively low capital and maintenance free as the source of the water is from Lake Erroch which acts as a large settling basin.

Birkenhead River Biological Feasibility

A hatchery program was devised to increase depressed stocks in the Birkenhead and Lower Lillooet River systems. Chinook eggs were loaded in an incubation box and the fry reared, marked and released; wild juveniles were trapped and sampled; and adult chinook and coho were enumerated and sampled.

An extensive program of juvenile sampling was begun in March, 1977. Chinook, coho, and sockeye salmon as well as rainbow and cutthroat trout were recovered in minnow traps, inclined plane traps, and by beach seining. Dye mark releases were used to determine inclined plane trap efficiency. A predator study in which 274 predators were examined was also carried out on Tenas and Lillooet Lakes, using a monofilament gillnet.

Thirty adult chinook were captured by angling and held until early September; however, due to high water temperatures only 5 females were retained for spawning. Approximately 18,000 eggs were planted in a screen tray on the surface of a 50,000 egg incubation box. Estimated mortality is approximately 22 percent and the fry emerged about March 31. They will be reared in a rearing trough for three months and tagged before release.

Approximately 250 chinook were observed in the Birkenhead River, and a subsequent dead recovery produced the age and length breakdown in Table 5.

Coquihalla River

Efforts in 1977/78 were directed to identifying enhancement options in Sowaqua Creek, and specifically above a fish obstruction (log jam) located in 1973. SEP field work began by identifying habitat types and spawning grounds, by aerial and walking surveys, in nearly 24 km of this watercourse. Subsequently, representa-

tive sites were chosen and juvenile trapping by means of angling, scuba floating, electroshocking, and seining were implemented. Apparently, the rearing habitat in Sowaqua Creek is underutilized and future enhancement plans will probably include colonization of the area. Continuation of this program in 1978/79 will involve other tributaries of the Coquihalla system.

A steelhead rearing pond in the Coquihalla River system has been operable prior to SEP; however, a proper evaluation was needed before further enhancement work could be undertaken. In the 1977/78 fiscal year, funds were provided to complete this report (Sebastian, 1977). Preliminary results indicate that the rearing ponds may be ineffective and should be abandoned in favour of hatchery production.

A special "no-kill" fishery attracted 158 anglers who caught 21 steelhead and 516 trout.

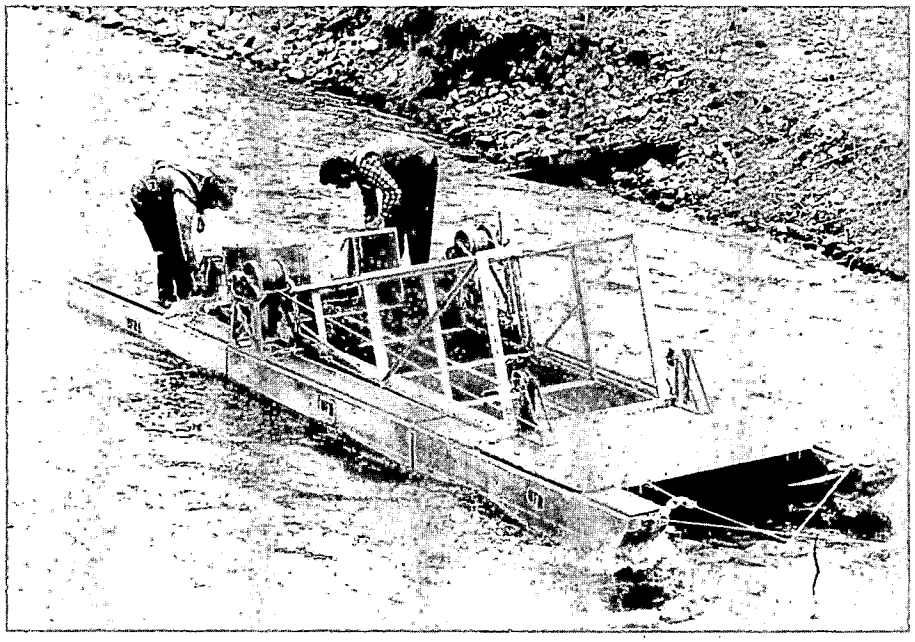
Upper Fraser River Reconnaissance

Reconnaissance activities in the Upper Fraser River watershed were undertaken for the third consecutive year to identify potential salmonid enhancement opportunities, collect basic biological data on stocks, and ascertain the feasibility of undertaking nose-tagging programs for juvenile chinook.

Reconnaissance continued from August 24 to October 19, 1977 with a crew of two to three men working a total of thirty-three field days. Due to time constraints, surveys were restricted mainly to chinook salmon spawning areas. Emphasis was given to the Quesnel River and to the possible need for stream improvement to enhance pink salmon in the river. Available pink salmon spawning area and the feasibility of improvement was investigated.

Systems were surveyed by means of aircraft, boat, and foot. Biological and physical parameters of spawning and rearing areas were described on stream survey forms. Adult numbers, timing, and spawning distribution were recorded. A total of 435 adult chinook carcasses were sampled on the spawning grounds for sex, age, and length. Juvenile rearing areas were determined by seining and minnow trapping. All fish captured were recorded as to method, species, numbers and location. Chinook juveniles were sampled for length and age. Suitable locations for downstream migrant traps were determined on the Nechako, mainstem Fraser (Tete Jaune), and Lower Shuswap Rivers.

A major portion of the field data collected has been analyzed and a summary draft report containing the results and recommendations is nearing completion.



A "4x4" downstream trap floats on the surface and is held in place by guy lines. This trap was installed on the Chilco River to sample fry and smolt migrations in early spring.

Upper Fraser Engineering Feasibility

Bio-engineering reconnaissance surveys were undertaken on several streams located on the Takla, Trembleur and Stuart Lake systems to ascertain the feasibility of constructing sockeye salmon spawning channels. The surveys revealed that Ankwill Creek which was originally proposed for construction, did not appear to have adequate discharge for the operation of the channel during winter months. The construction of sockeye spawning channels did, however, appear to be feasible on Driftwood River, Kazchek Creek and Tachie River.

It is proposed to obtain hydrological data on several of these systems in 1978/79.

This fish is a rainbow trout juvenile from the Chilcotin River system.

Chilco/Chilcotin Biological Reconnaissance

Biological reconnaissance was initiated in 1977 for a proposed chinook and steelhead rearing facility on the Chilco/Chilcotin system. The indigenous stocks of chinook salmon were examined in order to assess adult and juvenile biological parameters, determine locations of rearing and spawning areas, and suggest possible enhancement sites.

Chinook salmon escapements to the Chilcotin River system in 1976 were estimated to be approximately 7,500. In order to obtain adult biological data, fishery contributions, growth rates and other parameters, an attempt was made to capture, rear, mark and release chinook and rainbow juveniles.

Fish were captured by a combination of downstream migrant traps, beach seining, and minnow traps. A total of 50,000 chinook fry, 800 chinook smolts and 400 rainbow trout were marked with coded wire nose-tags and released. Juvenile timing and rearing areas were identified.

Several tributaries of the Chilco/Chilcotin system were surveyed to varying degrees during late August and September. Adult chinook numbers, timing and distribution were recorded. A total of 223 adult chinook carcasses were sampled for age, sex, and length.

Chilco/Chilcotin Steelhead

A creel census was conducted to determine steelhead angler characteristics, effort and success, as well as to facilitate gathering biological information by adult tagging and scale sample analyses. Juveniles were also marked with coded wire nose-tags. It was found that between 1972 and 1977, spring angling pressure nearly doubled (655 to 1,202 angler days) while fall angling effort was approximately the same in 1972 as in 1977 (344 and 368 angler days). Of 161 steelhead caught in fall 1977, 87 were released. From scale readings, the most common age class was 3.2+, which has accounted for 60 to 80 percent of the readings over a twenty-year period, and only 1.4 percent of the adults sampled were repeat spawners. A total of 34 adult and 424 juvenile steelhead were tagged in 1977. Aerial counts of spawners have shown an overall decline in stock size from a high of 299 in 1973 to a low of 103 in 1977.

Thompson River Radio Tagging

Although the Thompson River is well known for its trophy steelhead, angler catches have been declining over the last 10 years. Using a questionnaire system, it was determined that catches have ranged from a high of 3,500 fish to a low of 700. Pollution problems such as urban sewage, pulp mill effluents, and logging activities in some of the tributaries are believed to have aggravated this situation.

In an effort to gather biological baseline data on the spawning population, especially with respect to distribution and timing, a radio tagging program was implemented. Adult steelhead, averaging 7 kg, are caught by angling, held, tagged, held again, and released. The tag measures approximately 5 cm x 2.5 cm, is shaped like a small padlock, and is inserted into the stomach by hand. Each tag emits a unique signal, so that the movements of each fish can be monitored by an on-shore receiver; spaghetti tags are also used for visual identification. Twenty-five summer-run steelhead were tagged in October and November and fifteen winter run fish will be tagged shortly. So far the fish have not moved more than 25 to 30 km; however, as temperatures increase, more movement is expected into the spawning grounds. The radio tag batteries have a six-month life span and the population will be monitored during their entire stay in the system.

A reward system has been formulated so that tagged fish will not be removed by anglers. For each tagged adult that is returned alive to the system, a $100.00 reward will be paid. Each claimant must quote the tag number and confirm the location of the fish within the stream. For those fish that are killed by anglers, a $25.00 reward will be paid for return of the radio and spaghetti tags. From an estimated winter angler catch of more than 1,000 steelhead, two tagged fish were released and one was killed.

Middle Shuswap Recolonization

The Middle Shuswap River is located between Sugar and Mabel Lakes and drains into the North Thompson River system. An existing dam at the Sugar Lake outlet provides flow control over the Middle Shuswap River which historically supported a population of spawning chinook salmon. A second dam, designed for power production, is situated at Shuswap Falls, 32 km downstream from the affected area and is a total barrier to anadramous fish. A recolonization study was initiated to demonstrate the suitability of the watercourse for fish production.

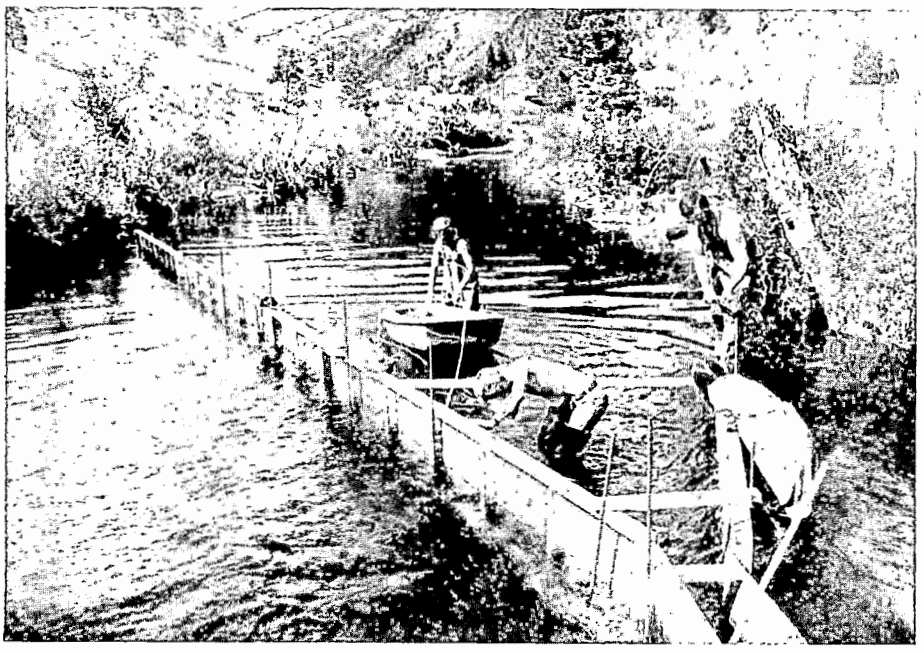
During August and September, Fisheries staff captured 71 adult chinooks (37 females) by a combination of sport angling and beach seining. These were transported above the power dam, tagged and released. The colonized area was subsequently swam and walked repeatedly to locate spawners and redds. Due to the length of the spawning areas very few adults were recovered although 23 redds were identified. Evidently, the population spawned successfully and the river is suitable for natural chinook spawning. A spring program will be implemented to estimate fry numbers, quality and timing.

Continuing discussions with B.C. Hydro have led to the recommendations that either the power project be removed or a fishway installed to facilitate spawning chinook salmon.

Deadman River

a) Biological Feasibility:
Salmonid stocks in the Deadman River have declined since 1960 after historically supporting moderate sized runs of chinook and coho as well as smaller runs of steelhead and pinks. Flow control works at the outlet of Snohoosh Lake were constructed in 1976 and a guaranteed flow for fisheries purposes was incorporated into the design. The purpose of this study was to determine the feasibility of rehabilitating the salmonid stocks in Deadman River as well as to provide biological baseline data necessary for the planning and implementation of an enhancement facility.

Adult migrants were monitored by a counting fence on the Deadman River from mid-July to late November, and focused on chinook and coho migrants. Redds and spawners were systematically surveyed and subsequent dead recoveries were implemented. Escapements in 1977 were approximately 146 chinook, 25 coho, and 132 pinks. Within the chinook population the fish were small (fecundity approximately 3,000 eggs), over half the males were jacks, and the migration timing was fairly long.



In order to monitor juvenile downstream migrations, a converging throat weir was constructed on the Deadman River system. This type of weir is light, portable, easy to assemble, and is especially suitable for small streams.

A converging throat weir trap was erected and maintained from mid-July to mid-October. All salmonids were enumerated and chinook pre-smolts and yearling rainbows were retained for coded wire nose-tagging before release. Systematic minnow trapping was also done to determine relative fish densities within the watercourse and Fyke nets were operating throughout the program. It was found that 98 percent of the juvenile chinook were yearling rather than 90-day fish, and that Deadman River could probably support a much larger smolt population without seriously stressing the rearing capacity of the stream.

Three thermographs continuously recorded air and water temperatures. Four locations were selected for biweekly water sampling and extensive analytical tests were conducted at the Cypress Creek Water Quality Lab. Stream descriptions, including streambed, bank, vegetation, rearing and spawning area data were systematically gathered in conjunction with other activities. Removal of an old timber crib dam 26 km upstream from the mouth, is recommended, as it is partial obstruction to chinook and steelhead and a total block to coho salmon.

b) Engineering Reconnaissance and Feasibility:

Reconnaissance surveys undertaken on Deadman Creek revealed the location of several sites that appeared to be feasible for the proposed construction of salmonid enhancement facilities on that system for chinook and coho salmon and steelhead trout.

The most promising site was located near the outlet of Snohoosh Lake in which the outflow is controlled by a storage dam that was recently constructed under the Agriculture Rehabilitation and Development Act.

This site is located on Crown Land approximately 610 m below the dam and the water supply to the facility would be provided by a pipeline from the reservoir. The reservoir would act as a settling basin and, in addition, it may be feasible to provide temperature control.

Several other sites are located on the lower reaches of this system and these would be considered for any proposed pilot enhancement facility that would be constructed to "build up" the escapements to the system to ensure the availability of adequate brood stock prior to the construction of permanent facilities.

Topographical and hydrological surveys were undertaken on the above sites to ascertain the feasibility of construction of salmonid enhancement facilities.

Additional engineering studies are scheduled for 1978/79. Design and construction of the facilities are scheduled for 1979/80 and 1980/81 respectively.

Tlupana Inlet Design

Chum stocks on the west coast of Vancouver Island will be the subject of a major enhancement project at Tlupana Inlet. This project will be an opportunity to examine Japanese-style hatcheries as production facilities in a climate similar to that in Japan. Furthermore, through the incorporation of an offsite incubation system, it is possible to enhance all the spawning streams in the inlet and facilitate their harvesting as a group. Concern for potential overfishing of chinook stocks has led to their incorporation into the hatchery facilities.

Design criteria have been completed for a Japanese-style chum hatchery with a total incubating capacity of 25 million eggs. Donor stock will be taken from the Conuma River (chum and chinook), Tlupana-Nesook River, Sucowa River, Canton Creek and Deserted River using removable fences. Conuma River will be the main site and will have incubation facilities, keeper and rearing channels, office, lab, shops and residences for year-round operation. All incubation will take place at Conuma River and the buttoned-up alevins will be transported by tank truck to rearing channels at the original sites. These four streams will each have rearing channels and a portable trailer for accommodating one person during the spring rearing and fall adult holding periods.

Construction of the facilities will be underway over the next two years. The Conuma River site will be completed by November, 1978, and the Tlupana-Nesook, Sucowa, and Canton sites by October 1979. The Deserted River installations will be completed sometime later.

Robertson Creek Hatchery

a) Production:

The Robertson Creek project was originally built as a spawning channel, but in recent years has become a research, hatchery-style facility. Activities at Robertson Creek described in Figure 5 include adult trapping, egg-taking, incubation, ponding, rearing and release of coho, chinook and steelhead.

In connection with the fertilization of Great Central Lake, 40,000 sockeye smolts were trapped, coded wire tagged and released between April and July 1, 1977. An electronic fish counter was installed at the Stamp River outlet between June 1 and November 1, 1977, and 240,000 sockeye and 1,200 coho adults were counted.

This female chinook weighed approximately 16 kg and was one of the returning brood fish to the Robertson Creek hatchery.

Experiments were conducted to assess the applicability of the Japanese free-style incubation methods to production hatchery techniques. If successful, substantial reductions in both space requirements and costs of incubation will be realized. Chinook and coho eggs were successfully incubated in hatchery trays, wooden and plastic free-style boxes, and wooden and plastic modified Atkins incubators.

In cooperation with the Provincial Fish and Wildlife Branch, steelhead eggs are being incubated in hatchery trays with constant temperature well water, and ambient river water to overcome early ponding problems. As well, eggs and fry will be regularly examined for evidence of pathogens. Successful techniques will be applied to future steelhead culture activities.

b) Native Involvement:

The Sheshaht Indian Band was awarded a contract to undertake an enumeration and tagging program in Great Central Lake and Robertson Creek. Although tagging operations were foregone due to a late start in the program, the Band was involved in operations and maintenance activities at the Robertson Creek hatchery site.

Five people were employed from July 4 to September 1, 1977. Band members were involved in adult enumeration using an electronic counter and on-going fish culture consisting of feeding and records maintenance for .75 million coho. Good returns of fish to the hatchery and Great Central Lake required accelerated maintenance and preparation for the fall program, including painting three raceways with anti-fouling paint and dip and seine net mending.

Figure 4.

West Coast of Vancouver Island

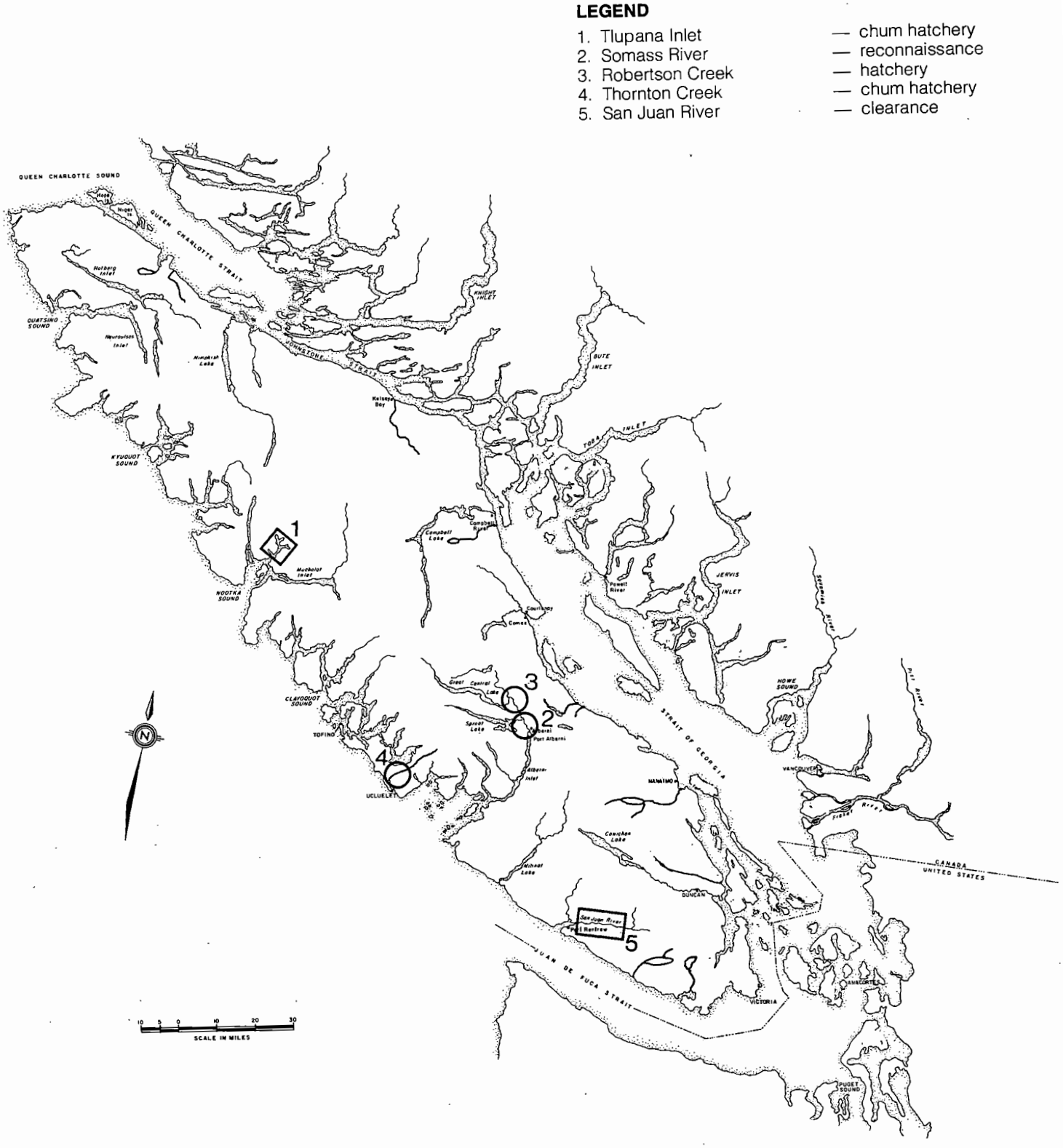
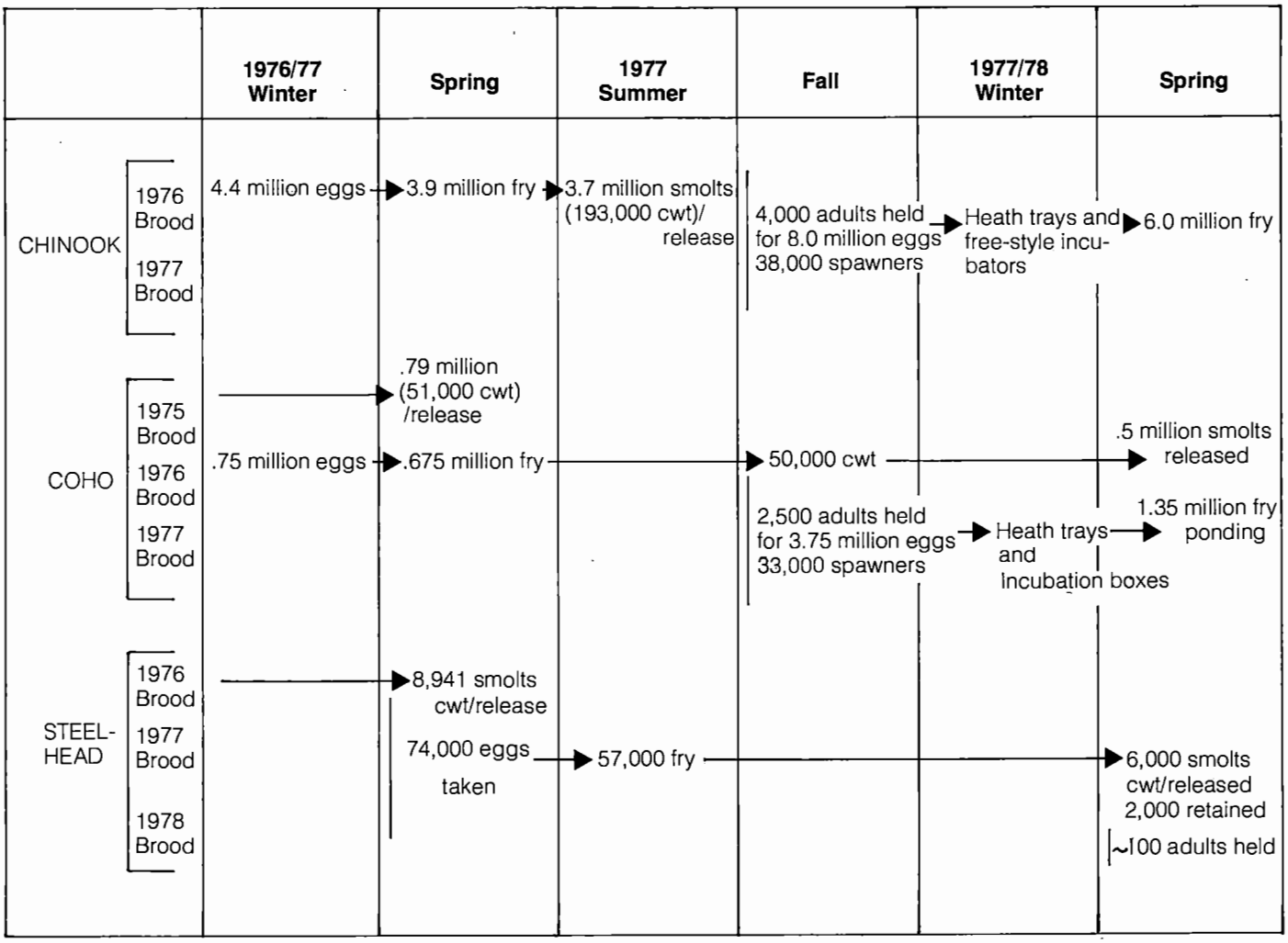


Figure 5:

Breakdown of fish culture activities at the Robertson Creek hatchery during the 1977/78 fiscal year.



Somass River Reconnaissance

Creel censuses on the Somass and Lower Stamp Rivers over the past two winters have helped to identify angler use of the systems and overall steelhead catch with respect to the Robertson Creek enhancement project. Results obtained from 130 interviewed fishermen in 1976/77 and initial reports in 1977/78 indicate that these rivers have rebounded from previous poor escapements.

From June to October, 1977, a complete inventory of the streams flowing into Great Central Lake was done. Using walking, aerial, jet boat and swimming techniques, potential juvenile rearing areas were identified. A subjective evaluation determined that unutilized rearing areas exist in the Ash River and Stamp River tributaries (G. Horncastle, 1977, 1978).

Adult summer steelhead were also enumerated throughout the Somass, Nahmint, South Sarita and Franklin Rivers and China Creek. Swimming surveys indicate that nearly 500 summer steelhead were present in September/October 1977, mainly in the Somass system. Initial comparisons between escapement and incidental commercial catches show that Alberni Inlet steelhead in general may be severely overfished.

Nitinat Lake Biological Feasibility

Nitinat Lake, an anoxic fjord, with historically high chum production levels and currently a target for fish enhancement was surveyed from 1975 to 1977. Proposed enhancement goals are to increase and stabilize chum fry input into the lake and produce 300,000 chum salmon annually, as well as to produce 100,000 coho, 50,000 chinook and 2,500 steelhead using hatchery methods. Major components studied were water quality, benthos, zooplankton and fish. The top zone in Nitinat Lake is characterized by a strong halocline from 0 to 5 m depth and a continuous thermocline down to 10 m depth. Waters below 10 m are isothermal at 10° C and isohaline at 30 parts per thousand. Except for the top 0 to 30 m depth, 74 percent of the Nitinat water mass is anoxic.

A cursory survey of benthos revealed considerable interstation variation in abundance, with annelids and amphipods being the two major components. Copepods were the main planktonic group. Significant variation in zooplankton abundance and composition along both the vertical (0 to 30 m) and the horizontal (stations 1 to 6) axes occured within and between years. These variations could not be related to the measured water quality parameters.

Table 6.

Summary of rearing and marking data at Thornton Creek Japanese chum hatchery.

No. of Fry	Days of Rearing	Release Date	Average Weight	Water	Egg-to-Fry Survival	Rearing Mortality (Percent)	Mark
813,600	38	April 12	1.1g	Filtered	94	14	LV
60,500	17	April 13	.7g	Filtered	79	.4	RV
				Unfiltered	62	1.5	

Chum and chinook fry left Nitinat River in April and May, and reared one to two months in Nitinat Lake before entering the ocean. Lack of oxygen may limit vertical fry distribution to 5 m depth at lakehead and to 20 m depth at lake outlet.

Nitinat fry grew at rates comparable to fry from other areas, with chum outgrowing chinooks by 0.5 to 1.4 percent per day. There was some yearly variation in fish diets. Planktonic prey were important to juvenile chum, chinook, sockeye, herring and to adult sticklebacks. Benthos was important to chinook and coho. Chum, chinook, and coho also preyed to some extent on small fish. Because of diet similarity among species, considerable competition for food may occur in years of high fish production.

Potentially negative influences on salmonid fry rearing in Nitinat Lake appear to be the presence of hydrogen sulfide, non-salmonid competitors for fry food and space, and piscivorous predators. However, lake productivity is much higher than the present rate of utilization by chum fry and installation of a hatchery may result in significantly increased fry production.

Thornton Creek Production

The Japanese incubation and rearing method is being used in a pilot project at Thornton Creek to increase the chum population. This technique is being tested in a typical west coast of Vancouver Island stream; that is, flow fluctuations with each rainfall, warm water (2 to 10° C), stained water flowing from a cedar swamp often with a high level of organic silt.

Nearly 900,000 1976 brood chum fry were released after a short period of rearing and fin clipping (Table 6).

In mid-October 1977 the adult trapping fence was installed on Salmon Creek. Commencing on October 22, a total of 1.1 million eggs were planted at the hatchery in a free-style incubator and modified Atkins incubator. An additional 100,000 eggs were planted, half in a screen tray plant and half in layer planting, in two unfiltered incubation boxes.

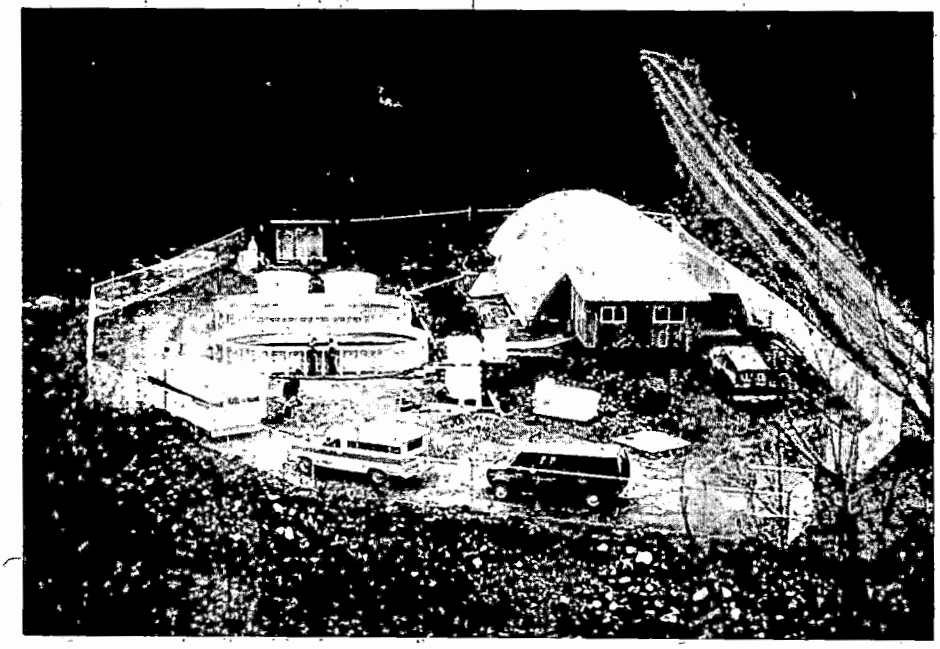
Table 7.

Age and length data of chum spawners in Thornton and Salmon Creeks.

	Age Composition			Orbital-Hypural Lengths (cm)		
% Age:	3	4	5	3	4	5
Thornton Creek	62	38	0	52.4	55.0	-
Salmon Creek	36	64	0	53.1	55.5	-

Dead pitches indicate that age composition and orbitalhypural lengths were different for Thornton Creek and Salmon Creek spawners, indicating that separate populations may exist (Table 7).

The Thornton Creek chum hatchery, near Ucluelet, is a pilot facility which has been a successful fish production project.



B. Georgia and Johnstone Straits

General Reconnaissance

Preliminary biological/engineering data is being gathered as a first step in identification of river systems, stocks and sites for enhancement of chinook, coho, chum and pink salmon.

a) Squamish:
General reconnaissance operations in the Squamish River system have been continuing for four years to provide baseline data for possible enhancement work to various side channels in the Squamish River watershed. Technical data were compiled on spawning salmon, with particular emphasis on chum, pink and chinook. Specific phases of the survey determined spawner distribution and abundance; age, length and fecundity; and temperature regimes.

Escapements to some of the areas were determined by dead pitches and estimates were also derived from foot, helicopter and jet boat surveys. Hypural lengths and scale samples were taken and chum salmon were gillnetted to obtain females for fecundity samples. A summary of the results is shown in Table 8.

Table 8.

Summary of lengths, ages and fecundities of chum salmon in the Squamish River system in 1977.

	Mean Hypural Length(cm)		Percent Age				Mean Fecundity
	M	F	3 yr	4 yr	5 yr	unknown	
Paradise Upper Channel	61.5	60.1	8	75	4	13	-
Gillnet Slough	62.5	61.2	7	76	6	11	3684
Mallard Slough	62.6	61.8	17	51	0	32	3461
Judd Slough	63.1	60.2	10	67	4	19	2826

b) Jervis Inlet:
Pink salmon escapements to Jervis Inlet have gone from historic levels of 200,000 to a 1977 return of 22,000. Reconnaissance activities were initiated to determine the cause(s) of this decline and to assess the enhancement potential of the area. Adult numbers, timing, and distribution were examined by using ground and aerial surveys. Predicted escapement based on 1975 brood year criteria was 24,000 fish and 22,000 fish actually returned: 10,000 to Deserted River and 12,000 to Skakwa River. No isolated cause for the decline was evident and reconnaissance is continuing.

c) Kakweiken:
A set of double falls 3.2 km from tidewater on Kakweiken River in Thompson Sound form an obstruction to migrating pink salmon. There are 24 km of good spawning area above the falls and odd year escapements range from 35,000 to 100,000 fish; even year escapements to 75,000.

Previous field activities have determined that one attempt at facilitating fish passage, a steep pass fishway, is not effective at certain water levels, although during favourable water conditions it has proven to be very effective. A proposal was therefore formulated to construct a new, concrete fishway which will function at all water levels.

d) Embly:
Falls on the Embly River form a velocity barrier at tidewater. Even year pink salmon runs of up to 100,000 return to the Embly system, although in 1976 only 7,000 were able to pass the falls and 30,000 to 40,000 died in the lagoon. A fishway has been designed using a blasting technique called "pre-shearing" where a flume is blasted in the surrounding rock with precast concrete baffles installed inside.

A report is in preparation (Barrett, 1978) describing the Embly and Kakweiken projects in greater detail.

Kakweiken Design

A steep pass fishway surmounting falls on the Kakweiken River is slated for replacement by a vertical slot fishway which will ensure successful passage of fish at all water levels. The new design has been formulated for several years; however, SEP funds have made its construction imminent and an updated review of these plans was undertaken.

The use of explosives to form vertical rock faces (pre-shearing) is being considered as a replacement for some concrete work, as the remote location of the site creates logistic problems for construction operations. It is expected that the fishway will be completed and operable by year III of SEP.

Salmon River Reconnaissance

In the past decade, anadromous and nonanadromous sport fish have declined by a factor of 50 percent in the Salmon River, representing the highest rate of decline of sport fish stocks on Vancouver Island. For this reason, reconnaissance work was conducted throughout the watershed with the broad objectives of determining the amount of habitat that is not being used by anadromous fish, the natural carrying capacity, and enhancement options from a biological viewpoint.

The Salmon River is located north of Campbell River on Vancouver Island, is approximately 205 km in length, and is accessible to anadromous fish for 39 km. Rainbow trout are the predominant fish species and its population is supported entirely by natural reproduction. Also present are sockeye salmon, cutthroat trout, and Dolly Varden char. Most of the river was walked or snorkeled to determine species distribution and describe general stream environments. In-stream fish habitat assessments on representative river sections included water quality, stream temperatures, sedimentation and substrate compaction, channel stability, bottom material, bank type, and overall habitat complexity. The principal methods of capturing salmonids for sampling were

Figure 6.

Georgia and Johnstone Straits

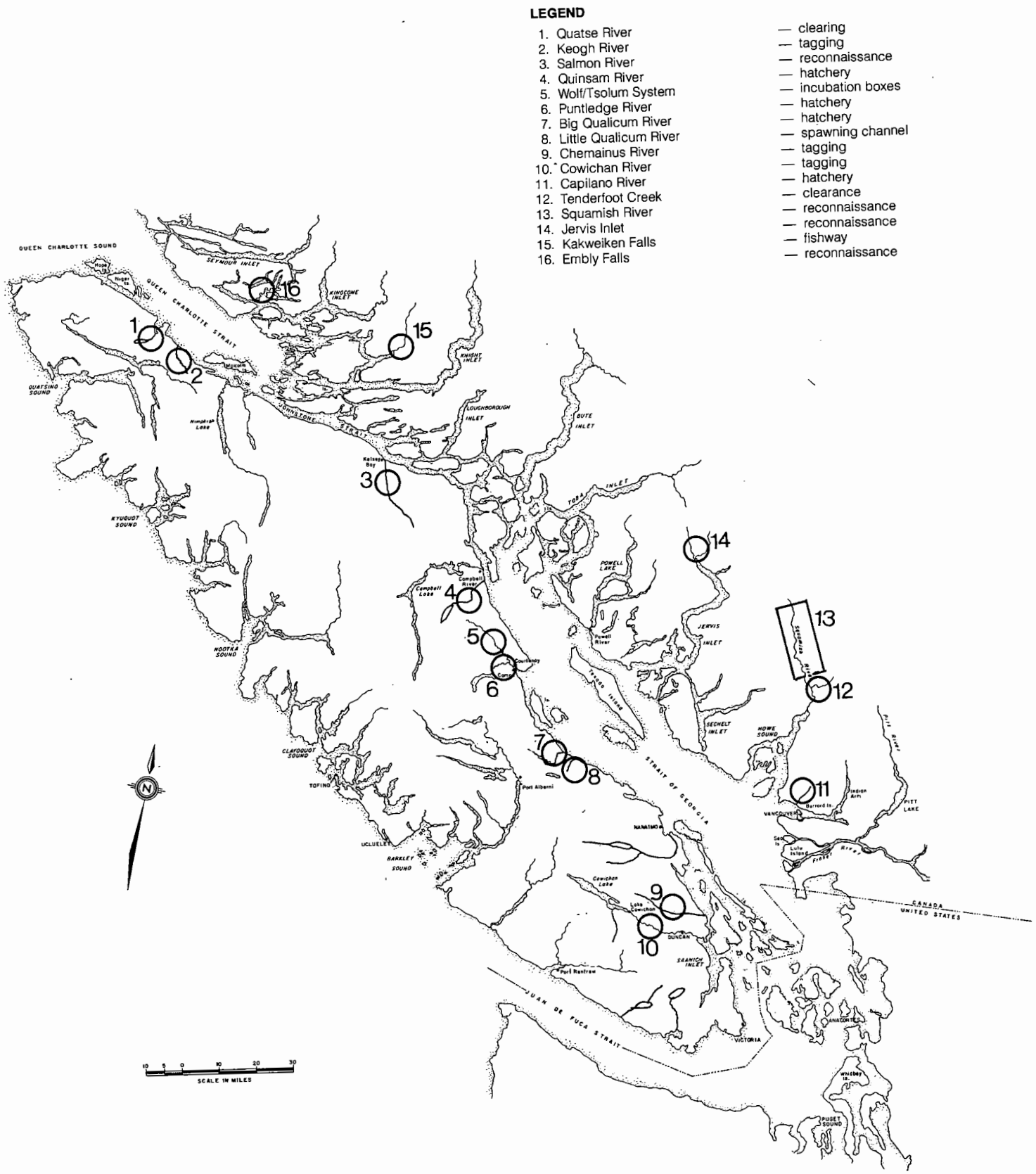
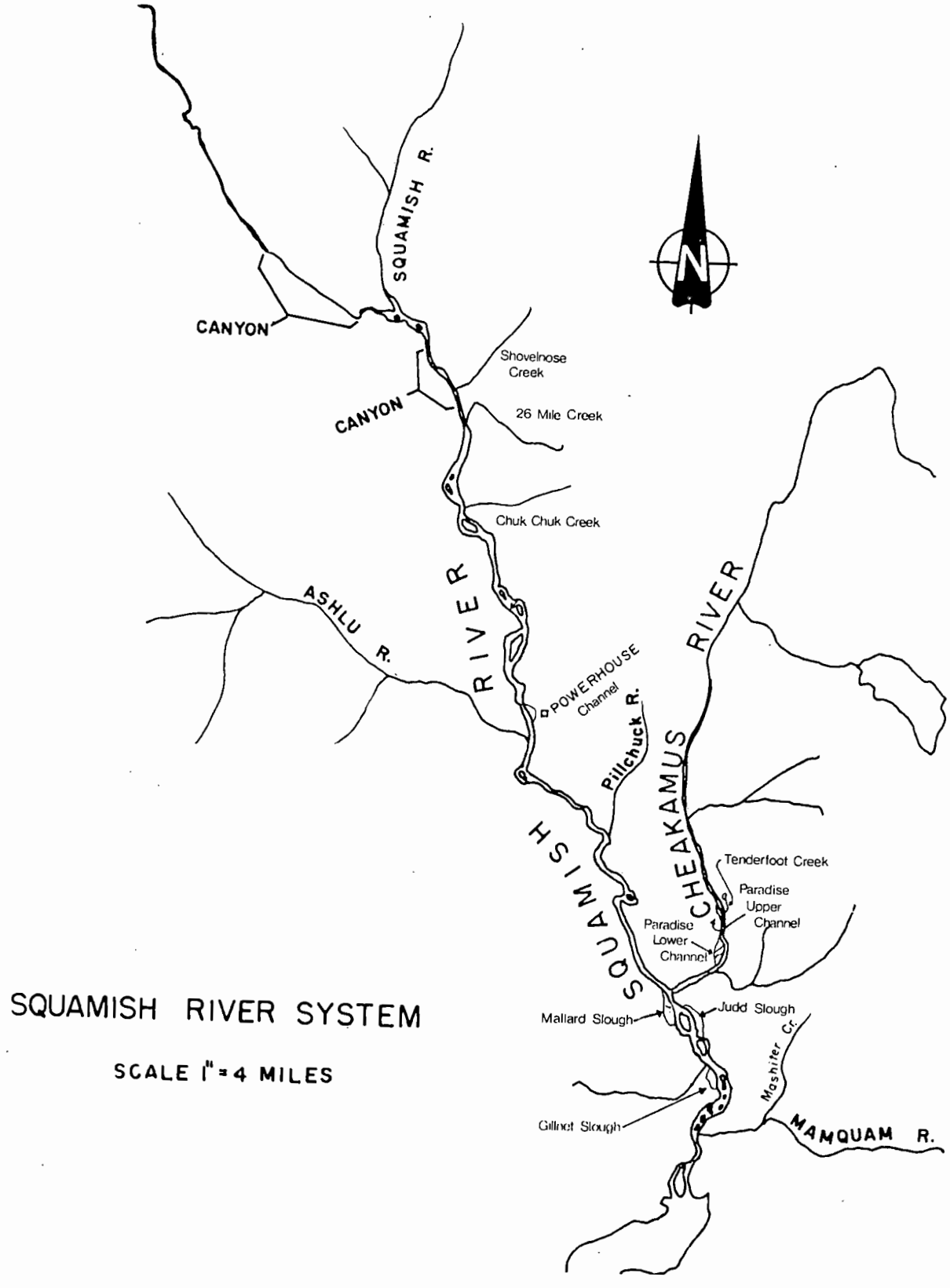


Figure 7.

Sketch of Squamish River System, 1977.



angling, seining, trapping, and electrofishing. Estimates of population size were accomplished utilizing swim surveys in the mainstem and the removal methods in the smaller streams.

A total of 26 tributaries and the mainstem river were examined, a total of 24 problem areas or obstruction sites and associated enhancement options were identified (Table 9). Late summer salmonid estimates displayed a range from .19 to 1.67 fish/m^2. In most sites, the relative abundance of salmonid juveniles were of steelhead, coho, Dolly Varden and cutthroat respectively. There was no significant difference in growth rates between streams in the watershed. Current natural production, as determined by biomass estimates, account for 630 to 940 steelhead and 3,260 coho escapements. The Memekay River and its tributary, Cooper Creek, contribute 50 percent of the total steelhead smolt production for the Salmon River.

Table 9.

Enhancement Options in the Salmon River Watershed. The projects described have a benefit-cost ratio of 1.1:1.

	Location	Enhancement Prescription
1.	Salmon River	[1]Blasting obstruction
2.	Salmon River	Fishway at Hydro diversion
3.	Sachts Creek	Obstruction removal/stream clearance
4.	Springer Creek	In-stream habitat and cover introduction
5.	Spirit Creek	Stream clearance
6.	Cooper Creek	Stream clearance
7.	Blandy Creek	Limited stream clearance
8.	Ruth Creek	Stream clearance
9.	Dalrymple Creek	Modify culvert for fish passage

[1]Undertaken in 1977/78.

Hatchery trays operate in stacks for maximum water and space efficiency. In 1977, the Quinsam hatchery incubated more than three million chinook and coho eggs — not yet capacity.

The Quinsam River hatchery uses approximately 70 tons of fish food per year for its chinook and coho rearing operations.

Quinsam River Hatchery Production

The Quinsam Hatchery began operation in the fall of 1974. Since then, 1 million chinook fingerlings, 2 million coho smolts, 236 thousand chum fingerlings and 35 thousand steelhead yearling smolts have been released. At the present time, 549 thousand coho and 36 thousand steelhead are being reared (Table 10).

Eggs taken from the 1977 brood adults were 4.180 million coho and 1.099 million chinook (Table 11). Sixteen winter run steelhead captured by angling in December are presently being held. In conjunction with the hatchery program, enumeration of adults on both the Campbell and Quinsam Rivers and enumeration of juveniles of all species from the Quinsam River continues. Marking of Quinsam River coho migrants has been carried out annually since 1974 (Table 12) in an effort to determine marine survival, distribution and fishery contribution rates.

Puntledge River

a) Production:
Fish production activities at the Puntledge River Hatchery and spawning channels are summarized in Figure 8.

Secondary biological activities at the Puntledge project include a disease diagnostic service provided by the Nanaimo Biological Station. Periodic samples of adults and juveniles of all species are analyzed for disease. Also, it is believed that pinheads develop as a result of a diet deficiency of one or more of the B-complex vitamins. Since pinhead mortality has been significant at Puntledge River, a study is planned to assess the effectiveness of a double vitamin pack in addition to the regular OMP diet on the rate of pinhead mortality in summer chinook fry.

b) Design and construction:
The Puntledge River spawning channel presently supports a potentially very valuable chinook stock. In order to increase production without interfering in the manageability of the run, hatchery production will be implemented. Adult production targets of 75,000 chinook, 7,500 steelhead, 80,000 coho (reared), and 50,000 coho (colonized in Upper Puntledge River) will be met by the construction of complete hatchery facilities. The project is to be constructed in two phases: Phase I, the upper hatchery site, is virtually completed while Phase II, downstream, is undergoing design considerations.

When a female is ready for stripping, the eggs are loose inside the body cavity: chinook fecundity averages about 5,000 eggs per female. This fish is from the Puntledge hatchery brood stock.

Table 10.

Quinsam Hatchery fish production summary

	Brood Year	Species	No. Released	Fish/lb.	Fish/kg.	% Marks	% Tag Loss
Releases	1974	Chinook	163,000	94	206	46.5	13.0
	1975	Chinook	425,000	105	231	24	2.5
	1976	Chinook	376,000	48.5	106	26	1.0
	1974	Coho	1,440,000	16.5	36	13.1	14.3
	1975	Coho	662,000	13.3	29	12.3	10.0
	1975	Steelhead	20,000	8.0	17.6	100	8.0
	1976	Steelhead	16,000	5.9	12.9	100	N/A
	1974	Chum	237,000	369	812	28.7	AD only
On Hand	1976	Coho	549,000	33.5	73	27.3	4.0
	1977	Steelhead	36,000	35.1	77	100	N/A

Figure 8:

Breakdown of production activities at the Puntledge River hatchery and spawning channels during the 1977/78 fiscal year.

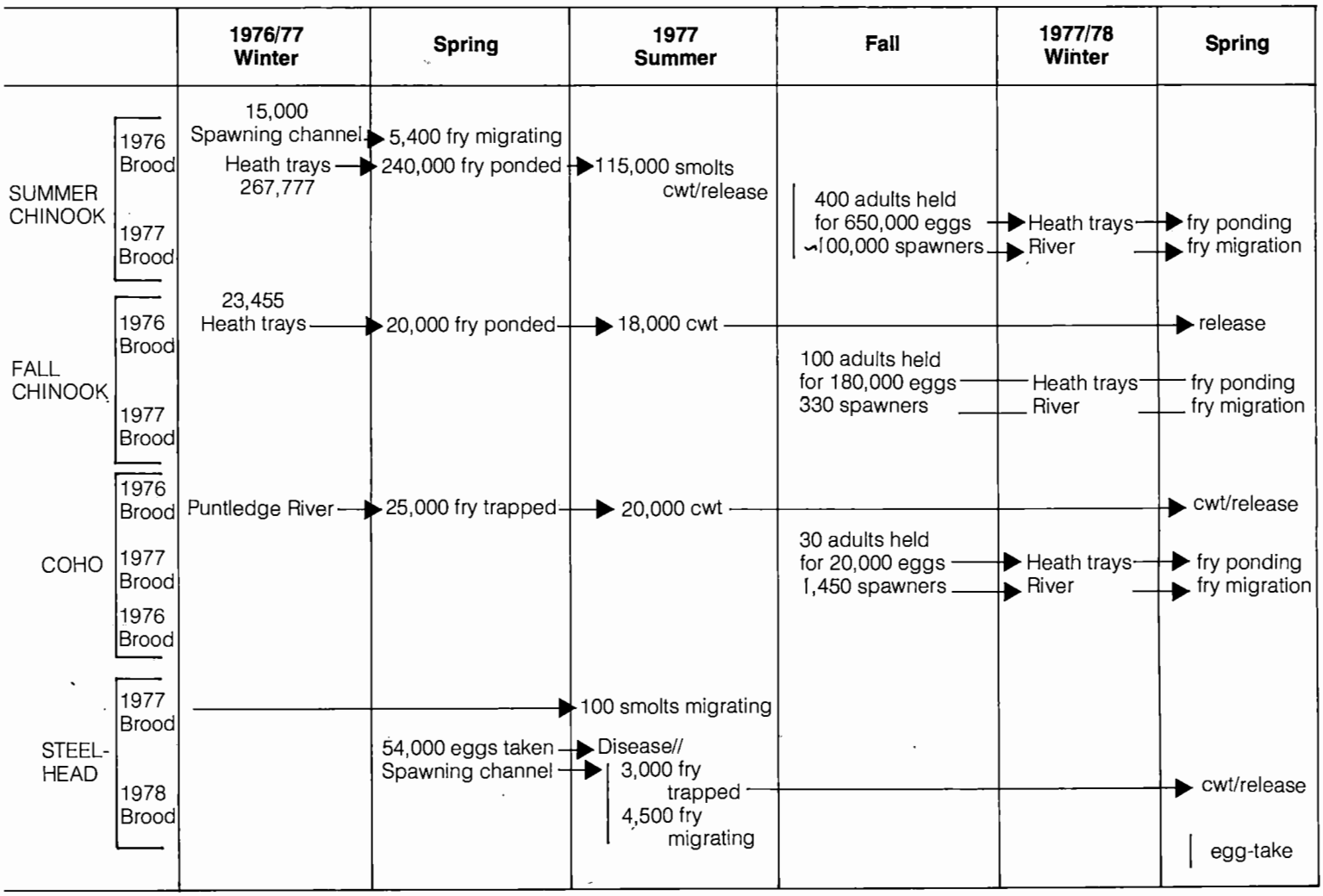


Table 11.

Quinsam Hatchery egg incubation — 1977 brood

Species	Eggs Taken (millions)	Mortality to Eyed (millions)	Percent Mortality
Coho	4.2	1.3 (of 3.1 handled)	42.1
Chinook	1.1	.25	22.5

Table 12.

Quinsam River wild fry marking (coded-wire tags)

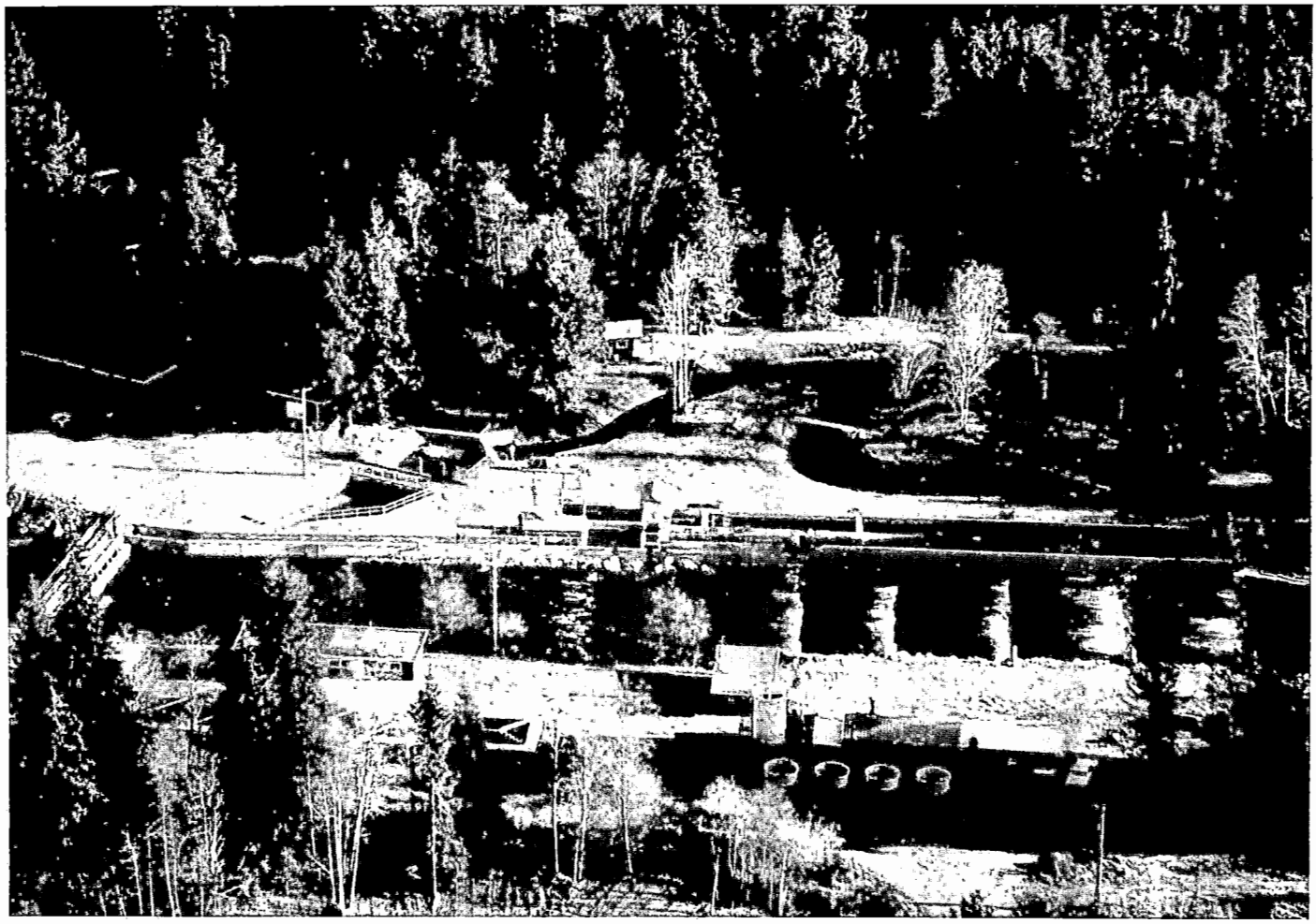
Species	Brood Year	No. Marked
Coho	1972	2,384
Coho	1973	8,465
Coho	1974	8,614
Coho	1975	24,118

The upper site hatchery is in final construction stages and contains five 3.1 m diameter rearing tubs and six rearing troughs (with plumbing for 12). Water for these facilities is taken from Puntledge River, supplied by a pumphouse at the fishway. A rearing area was also completed; rectangular, gravel-lined channel, 174 m x 6.1 m, divided into four separate sections with three diffusers and 16 feeder stations. Concrete inlet works divert water from the spawning channel and a fishway connects it to the river. Eggs were incubated at B.C. Hydro facilities while rearing installations were under construction.

Design studies have been completed for a holding/rearing facility with two bays, a fishway with an adjoining viewing room, and a river water supply. Plans for a hatchery building and fence are underway and purchase/lease agreements are under consideration by B.C. Hydro.

Construction will continue in 1978/79 and all buildings, services and equipment should be operable by 1979/80.

The Big Qualicum River has hatchery, rearing channel and spawning channel facilities. Plans for the construction of a third spawning channel are underway.



Big Qualicum River Hatchery

a) Production:
The past year has been one of change and success at the Big Qualicum project. A new fish ladder and adult trap, and two combination adult holding and juvenile rearing raceways were completed during the fall. The earthen rearing channel was split into two channels, one for coho and one for chinook, and the total length increased by 50 percent. Increased escapements were noted in the chinook and coho runs, and in the return of steelhead now occurring.

A total of 1.58 million chinook, coho and steelhead smolts were released into Big Qualicum River in 1977. Prior to release, numbers of fish adequate to assess fishery contribution were coded wire tagged (Table 13).

Approximately 180,000 adult salmonids escaped to the river in 1977/78 (Table 14). Returns of hatchery-reared coho and chinook continued to be excellent. Preliminary data indicate that marine survival of 1974 brood coho is 25 percent, and that survival of 1974 brook chinook will be in excess of 10 percent.

The steelhead run will continue through April, but already appears to be the highest recorded in at least a decade. Angling pressure has been very high, particularly in holding pools created in the river just downstream from the counting fence. Seventy percent of the steelhead examined are of hatchery origin.

Current status of the hatchery is summarized in Table 15. Most remarkable is the expected record release of 2.5 million 1977 brood chinook smolts. These smolts will comprise two differentially tagged groups. One tag code will represent fish reared in a semi-natural earthen channel, whereas the other will represent those reared in a concrete raceway in order to assess the influence, if any, of these two different rearing environments on smolt quality and survival.

Table 13.

Big Qualicum hatchery smolt releases in 1977.

Species	Brood	cwt Code	No. cwt+Ad	No.Ad Only	No. Unmarked	Total Release	Date	Size (g)
Chinook	1976	2/17/16	101,474	1,232	669,519	772,225	Jun 1	6.3
Coho	1975	2/10/3	90,520	5,016	687,545	783,018	May 5-18	25.8
Steelhead	1976	12/1/10	23,384	723	0	24,107	Apr 22	63.1

Table 14.

Big Qualicum project returns in 1977.

Species	Escapement (Fence Count)	Females Spawned	Current No. in Holding	River Sports Catch[1]
Coho adults	37,500	1,750	-	?
Coho jacks	36,614	-	-	?
Chinook adults	2,462	731	-	0
Chinook jacks	724	-	-	0
Chum	93,062[2]	-	-	0
Steelhead	409	-	60	400-600

[1]Additional fence count.

[2]Below fence estimate for chums 10,729.

Table 15.

Big Qualicum hatchery status — March, 1978.

Species	Brood	Stage	No. On Hand	Expected Spawning Date	Expected Release Date	Expected Release No.[1]
Chinook	1977	Egg/fry	2.7 mill.	-	Jun 1978	2.5 mill.
Coho	1976	Pre-smolt	900,000	-	May 1978	800,000
Coho	1977	Egg	2.0 mill.	-	May 1979	1.0 mill.
Steelhead	1977	Pre-smolt	40,000	-	May 1978	10,000
	1978	Egg	20,000	-	May 1979	
		Adult	60	Apr 1978		10,000

[1]Release in Big Qualicum. Plans are to transplant 30,000 steelhead pre-smolts each year.

In April 1977, 735,746 chum fry were marked, originating from Channel #2 and the river. An estimated total of 50 million fry migrated down the river, 20 to 22 million from Channel #2, with the balance from the river. Peak output occurred in 1971 when 67 million chum fry migrated from the Big Qualicum system. In 1978 it is proposed to fin-clip one million fry.

The purpose of fry marking is to assess the existing chum production, both from Channel #2 and from the river itself, prior to construction of Channel #3.

b) Construction:
Renovations and expansions at the Big Qualicum Project have been underway since 1976. Construction and design of a channel inlet, fish transportation channel, river work and fences were completed in 1977/78 in order to produce an additional 50,000 coho and to maintain the integrity of the facility.

A new counting fence was built in 1976, using conrete and galvanized steel. It replaces the former wooden structure.

A concrete holding/rearing structure was recently completed, having two sections each 68.6 m x 4.6 m. A 42.7 m long fishway connects it to the river and it will be used for rearing 90-day chinook fry.

The existing rearing channel was restructured to provide an extra leg of watercourse. New diffusers were installed at the upstream and downstream ends of each leg. The channel is presently accommodating steelhead yearlings and the extra leg will be used for coho rearing.

In order to meet the increased water requirements for the expanded rearing channel and additional facilities, a new water intake was constructed. This installation utilizes river water, operates at a higher capacity, and will be less affected by debris.

Hatchery Steelhead Evaluations

In order to evaluate the hatchery steelhead program at the Big Qualicum and Quinsam Rivers, the Fish and Wildlife Branch has undertaken creel census, life history, and adult steelhead distribution and spawning studies on those rivers.

On the Big Qualicum River, steelhead anglers were requested to obtain a numbered survey card and submit information such as time fished, catch number of fish killed, and the area of river fished. A randomized creel census was also conducted on the Quinsam and Campbell rivers to estimate the total angler effort and catch of winter steelhead, proportion of hatchery-reared fish contributing to the catch and the quality of those fish. On the Big Qualicum River, from December 1, 1976 through April 3, 1977, 447 cards were completed and returned, and hatchery steelhead comprised 73 percent of the total catch. On the Quinsam/Campbell Rivers, first returns of hatchery steelhead are expected this year. The results of the surveys are summarized in Table 16.

Scale samples were taken from steelhead on the Big Qualicum, Campbell, and Quinsam Rivers. Big Qualicum steelhead revealed 6 total age groups for maiden wild steelhead and 3 for maiden hatchery fish. Fish of total age 2.1+ or 3.1+ comprised 78 percent of total age 1+. Repeat spawners comprised 8.6 percent of the wild steelhead and 2.4 percent of the hatchery steelhead. Juvenile life history studies were carried out on the Quinsam River and the results are summarized in Table 17.

Juvenile steelhead population estimates were conducted on the Quinsam River and a total of four 50 m sections of stream, two upstream and two downstream of the hatchery fence, were sampled by electrofishing (Table 18). A fence and trap was operated on the Big Qualicum River to determine adult populations estimates for that river.

Table 16.

Total estimated angler catch and effort for Steelhead from Big Qualicum, Quinsam and Campbell Rivers, 1976/77.

River	Total Effort (hours)	Total Catch	Total Kept
Big Qualicum	1,477	275	137
Campbell	3,360	379	227
Quinsam	2,465	174	105

Table 17.

Lengths by age of juvenile steelhead in the Quinsam River in 1977.

Age Class	Mean Length (mm)	Range (mm)
0	47	30-85
1+	112	80-145
2+	158	140-180

Table 18.

Number of trout of each age collected at census sites on the Quinsam River, September, 1977.

Site	Age Class 0+	1+	2+
1	90	43	13
2	34	23	9
3	168	21	0
4	302	41	0

On the Big Qualicum River, the hatchery program has been underway for four years, with steelhead returning for the past two. Between November 8, 1976 and April 25, 1977, 601 steelhead ascended the Big Qualicum River to points upstream of the hatchery. Catch and escapement figures, when added to this total, revealed a total steelhead return of approximately 800. Sixty-five percent of these fish were estimated to be of hatchery origin.

Survival of Big Qualicum 1974 brood hatchery smolts could not be accurately determined. Estimates based on different smolt sizes and life histories ranged from 1.7 to 2.5 percent. Returns of Quinsam Hatchery fish are not expected until the 1977/78 season.

Little Qualicum River

a) Biological Feasibility:
The Little Qualicum River chum stock, among the largest on Vancouver Island, has declined in recent years. Chums returning to the river are closely aligned in timing with those of the neighbouring Big Qualicum River. The terminal net fishery harvesting the enhanced Big Qualicum stock at the final stage of their ocean migration appears to be depleting the Little Qualicum chums. To conserve the run and to augment chum production to the terminal fishery a spawning channel has been proposed for the Little Qualicum River.

The Little Qualicum is also an important steelhead angling stream and to protect this stock from potential overfishing, enhanced production of steelhead is included in the long term plans for the system. For Phase II of the Salmonid Enhancement Program (commencing in 1982/83) a moderate scale production facility is envisaged which will be integrated with spawning channel operations.

Field studies in 1976 and 1977 focused on chum spawning distribution, analysis of land and water use in the system as they affect water quantity and quality and on the selection of a suitable spawning channel site.

A manuscript report is in preparation which outlines background information on the Little Qualicum system (obtained from files, reports and from personnel with local knowledge), including the results of field surveys, and recommendations regarding development of the site.

b) Design:
Design criteria have been established for a spawning channel on the Little Qualicum River to produce 300,000 adult chum salmon. This project is in keeping with the "systems" approach of enhancement and management coordination.

The spawning channel will be located approximately 3 km from the tidewater and will be approximately 4.2 km long and 7.6 m wide and involve some 65 ha of river bench land. It will have 14 legs of varying lengths and graded spawning gravel as well as settling basin, cleaning culvert and diffuser installations. The water intake will be located in the Little Qualicum River and will supply both a spawning channel and proposed rearing channel.

Two fish entrances with floating fences will be used to load the channel, instead of a loading leg and gate structures. "Splitters" will be located at the lower end for fry enumeration.

The final design specifications are being prepared and water licence and property purchase are also underway. Construction is slated for completion in 1980/81.

Cowichan Side Channels

On most flood and drought-prone coastal rivers without large headwaters lakes to buffer flows, endemic chum populations utilize side channels extensively for spawning. A typical side channel has a log jam or gravel bar at its head which acts as a valve and moderates flood flows. Spawning beds are thus protected from gravel deposition, erosion or shifting of river course. A typical side channel also exhibits groundwater flow which is less subject to rise and fall than surface runoff. Spawning beds are thus also protected from receding water levels and subsequent stranding of fry or freezing and desiccation of eggs and alevins during low flow conditions.

The key to chum productivity in unstable systems is the protected spawning and incubation environment commonly found in side channels. On the Cowichan River, reconnaissance conducted in 1976 and 1977 focused on opportunities to increase production by improving existing side channels utilized by spawners or by creating new side channels by restoring flow in former channels that have been isolated from the mainstem.

Reconnaissance was carried out on foot and boat with the aid of a helicopter on one occasion to obtain an overview of the system. Sixteen side channels were explored, each being measured for length, appraised with regard to development potential, and mapped. Two sites, both ground water fed, were selected for development consideration: one in the "Riverbottom Road" area, approximately 12.9 km from the mouth, and one near the Duncan townsite, approximately 2.4 km from the mouth. A topographical survey was conducted at the former site.

Reconnaissance also included surveys of the abundance and distribution of chum spawners in the Cowichan system. An estimated 25,000 chums spawned in the system in 1976/77 and 75,000 in 1977/78. The surveys confirm that the selected side channel development sites are located within the range of chum upstream migration and in areas of spawning abundance.

Samples of the chum spawning stock were obtained for age and size determination and for fecundity of female spawners. Tissue samples of adult chum were also obtained for disease analysis, laboratory studies being carried out by staff of the Fisheries Research Board at the Pacific Biological Station.

Emphasis on chum enhancement on the Cowichan stems from the unique manageability of this stock. Chum returning to the system congregate in Satellite Channel near the mouth of the Cowichan River where a terminal net fishery exploiting the stock has operated for many seasons. The timing and location of the fishery results in a negligible capture of other species and other chum stocks returning to streams in the area.

Wolf/Tsolum System Design

In order to enhance the depressed pink salmon stocks on south-east Vancouver Island, an incubation box facility has been designed for installation on the Wolf/Tsolum system. The project will involve two phases, each producing 50,000 adult pinks, and using a total of 12 fibre glass-type incubation boxes. A diversion fence with an attached holding area as well as various on-site operational facilities are planned. Water will be supplied by a gravity-feed system from Wolf Lake. This facility will probably be operated from the Puntledge Hatchery and is slated for construction in Phase I of SEP.

Headwater Tagging

Since 1974, SEP has funded coded wire tagging of chinook and coho juveniles from several major river systems in Georgia and Johnstone Straits: Squamish, Cowichan, Chemainus, Keogh, and Kakweiken Rivers. Wild stock tagging will provide baseline data on ocean migration routes, migration timing, fishery contributions and marine survival. These data will aid in pinpointing the "best" sites and stocks for future enhancement, from a biological viewpoint, and will allow development of management and enhancement strategies that minimize impacts on wild stocks and maximize returns to fishermen from enhanced stocks.

a) Keogh River:
In conjunction with the Provincial Fish and Wildlife Branch, Fisheries tagged 41,500 coho smolts between April and June on the Keogh River. Tagging took place at the

enumeration fence which is located approximately one-half mile above the estuary. Tagging in 1978 will complete assessment of Keogh River coho salmon. Upstream enumerations will be conducted in the fall of 1978 and 1979.

Operations are set up in the field to facilitate marking of wild fry. The fish are fin-clipped, mechanically nose-tagged, and held before release.

b) Chemainus River:
In 1977, a fence trap was installed on Miller Creek, a very small tributary of the Chemainus River. In addition, experimental traps were installed on the main Chemainus River and Bonsall Creek to evaluate future trapping sites. Both traps were fishing for a very short duration and catches were small. During April and May, 1977, 5,700 coho smolts were tagged and released. With three trap sites, numbers tagged in 1978 should exceed 20,000. Upstream surveys will be conducted in the fall of 1978 and 1979.

c) Kakweiken River:
Only 2,960 coho smolts were tagged during April and May using four fence trap sites and minnow traps. There was evidence that cutthroat trout and Dolly Varden char prey extensively on coho smolts. Coho smolt tagging will not be attempted in 1978.

It was planned to take eggs from chinook salmon and summer steelhead during August, 1977; incubate eggs to the eyed stage at the Kakweiken site; complete incubation, rearing and tagging of juveniles at the Big Qualicum hatchery; then return tagged juveniles to the Kakweiken River for release. Unfortunately, so few adult chinook and steelhead were observed after one and one-half months of repeated swim surveys and visual observations that this aspect of the Kakweiken study was abandoned.

A pilot incubation system was established at the Weldwood Canada Ltd. camp and was tested with 50,000 eggs from pink salmon. Eggs were incubated to the eyed stage (98 percent survival) and then were planted in the Kakweiken River. If funds permit, a chinook egg take will be attempted in the late summer of 1978.

Spawning ground surveys demonstrated that odd year pink salmon spawn in large numbers up to 19 km above the present fishway. Even year pink salmon distribution will be surveyed in 1978 during the chinook egg take program.

The adipose fin is removed from juvenile fish to denote the presence of a coded wire tag in the head.

d) Cowichan River:
During the fall and winter of 1977/78 adult coho and chinook salmon were enumerated and sampled for coded wire tags and age/size composition. Escapement populations were estimated by tower counts, swim surveys and tag and recapture surveys. The 1977 coho escapement was approximately 60,000; chinook 8,000; and an estimated 3 percent (preliminary) of the coded wire tagged 1974 brood coho smolts returned to spawn. Chinook coded wire tag returns and age/size composition data have not yet been analyzed. A reduced escapement survey will be necessary in 1978/79 to enumerate and recover tags from 1974 and 1975 brood chinook salmon.

e) General:
Analysis and reporting is virtually complete for 1972 and 1973 brood coho smolt tagging in the Squamish River; for spawning ground recovery of tagged Squamish coho salmon; for 1973 brood coho smolt and 1974 brood chinook smolt tagging in the Cowichan River; and for spawning ground recovery of tagged 1973 brood coho salmon on the Cowichan River.

Capilano River Hatchery Production

Over 1.7 million salmon smolts were released from Capilano Hatchery in June, 1977, with a biomass of 16,500 kg (Table 19). This represents almost 90 percent of production capacity.

There were several experimental groups within the coho and chinook juvenile populations, each of which was marked with a unique wire tag code as a means to compare survival and fishery contributions between groups. These data will provide a guide for fish culture programs at Capilano and other facilities.

The early ponded, 1976 brood chinook averaged 6.3 g at release, the largest ever produced at Capilano. The late chinook at 3.1 g were, on the other hand, the smallest ever released. Contributions from these two groups may differ in age composition, numbers, biomass yield and ocean distribution.

Two major groups of 1975 brood coho were produced:

1. Native Capilano stock. These fish are the progeny of the adults which escaped in the 1975 fish kill. All the smolts were multiple fin-clipped (adipose-left ventral) so returning adults might easily be separated for spawning from transplanted Big Qualicum stocks.
2. Big Qualicum stock. Following the fish kill, 1975 brood Big Qualicum coho eggs were transplanted to Capilano in order that the hatchery would operate at capacity and continue to make significant contributions to the fishery. Within this population, experimental groups included those juveniles fed a diet containing anabolic steroids to promote growth, and those reared at four different loading densities.

Adult returns in 1977 were extremely low as a result of complete loss of hatchery production in 1975 (Table 20). To conserve females for brood stock, the river and estuary were closed to sport and native fishing. All female fish surviving to maturity were spawned yielding approximately 1.0 million coho and 1.2 million chinook eggs.

The Capilano River in North Vancouver is one of the few remaining urban water systems supporting anadromous salmonid stocks.

Table 19.

Capilano hatchery smolt releases in 1977.

Species	Group	Brood	cwt Code	No. cwt+Ad	No.Ad only	No. Unmarked	Total Release	Date	Size (g)
Chinook	Early	1976	2/16/23	71,993	3,900	693,377	769,270	June 6	6.3
Chinook	Late	1976	2/16/24	73,809	3,885	337,338	415,032	June 21	3.1
TOTAL CHINOOK							1,184,302		
Coho	Capilano stock	1975	2/12/17 2/16/16	34,083*	-	0	34,083	June 6	19.6
Coho (BQ)	Hormone Control	1975	2/16/22	18,886	1,110	56,324	76,320	May 30	22.3
Coho (BQ)	Testosterone	1975	-	0	0	38,636	38,636	May 30	22.8
Coho (BQ)	17-d-CH_3 Test	1975	2/16/21	18,843	738	47,477	67,058	May 30	22.7
Coho (BQ)	Density 1	1975	2/16/17	18,575	947	36,575	56,097	June 7	15.6
Coho (BQ)	Density 2	1975	2/16/18	19,090	733	54,699	74,522	June 7	19.0
Coho (BQ)	Density 3	1975	2/16/19	24,768	766	56,568	82,102	June 6	19.2
Coho (BQ)	Density 4	1975	2/16/20	23,241	232	77,703	101,176	June 6	14.5
TOTAL COHO							529,994		
Steelhead		1976	12/1/11	11,819	640	0	12,459	May 19	21.6

*Multiple fin-clipped: adipose and left ventral.

Table 20.

Capilano hatchery returns in 1977/78

Species	Escapement	Females Spawned	On Hand
Coho adults	1,861	493	0
Coho jacks	18,052	-	0
Chinook adults	660	338	0
Chinook jacks	507	-	0
Chinook jimmies	58	-	0
Summer Steelhead	52	0	35
Winter Steelhead[1]	0	0	0

[1]In progress.

Table 21.

Capilano hatchery status — March 1978.

Species	Brood	Group	Stage	No. On Hand	Expected Spawning Date	Expected Release Date	Expected Release No.
Chinook	1977	Early	Pre-smolt	800,000	-	Jun 1978	750,000
Chinook	1977	Late	Egg/fry	450,000		Jun 1978	420,000
Coho	1976		Pre-smolt	700,000	-	Jun 1978	675,000
Coho	1977		Egg	950,000[1]	-	Jun 1979	500,000
Steelhead	1977		Pre-smolt	12,000	-	May 1978	11,500
Summer Sthd.	1978		Adult	35	May 1978	May 1979	10,000
Winter Sthd.	1978		Adult	0	May 1978	May 1979	10,000

[1]Approximately 300,000 coho fry will be transported to Capilano River above the reservoir.

This year smolts released will total approximately 1.8 million (Table 21). Several experiments are in progress. Anabolic steroids are being tested on the 1977 brood early chinook and the 1976 brood coho. In an independent experiment with the coho, the effect on smolt quality of different feeding rates during the cold temperature period is being examined.

Approximately 900,000 coho fry will be ponded this spring. Of these, some 300,000 will be transported to the Upper Capilano River to provide a coho reservoir additional to the hatchery. Usually adults rather than fry are transported but insufficient numbers of adults were available last fall.

Steelhead returns continue at a low level; 52 summer run steelhead were trapped, with 35 now being held. Steelhead from the 1978 winter run have yet to arrive at the hatchery.

Squamish River Steelhead Investigations

The Squamish River system is highly valued by anglers for salmon, Dolly Varden char, rainbow, cutthroat and especially steelhead trout. Like many other steelhead rivers in this province, the watershed is suffering from the combined effects of habitat degradation and exploitation by native-food and sport fisheries, reflected by downward angling use and catch trends. In 1977, funds were made available under SEP to increase the level of steelhead investigations within the Squamish system. The primary objective is to obtain enough information to develop a long-term management plan for the Squamish River's anadromous trout and char. Work done this fiscal year included a creel census, a steelhead angler questionnaire, and preliminary studies of juvenile steelhead (numbers and habitat).

Two census takers worked from March to June, interviewing steelhead anglers in order to obtain a close estimate of the sports catch (Figure 9). Based on 1,234 interviews, steelhead anglers reported catching a total of 1,334 steelhead. Of these fish, 531 were killed and 803 were released. Further analysis is underway.

The 613 steelhead anglers contacted during the spring creel census were mailed questionnaires that requested their opinion on management options and specific angling regulations. There was a 56 percent (338 anglers) response to the questionnaire and many anglers (about 20 percent) felt strongly enough about Squamish steelhead management to supply comments in excess of just answering the questions. A summary of the questionnaire results is being prepared and will be mailed to these anglers who returned questionnaires.

Beginning in August, 1977, a field crew began electrofishing, minnow trapping, and seine netting on five major rivers and fifteen small tributaries. Data was recorded on juvenile steelhead habitat preference, population numbers, age class distribution and length frequency.

During March, 1978 and into the new fiscal year, a 3-man crew will determine relative numbers and distribution of adult steelhead. This will be done by snorkel-equipped swimmers and by walking small tributaries and side channels.

Figure 9.

Reproduction of a creel census form.

CREEL FORM - SQUAMISH RIVER SYSTEM

River_____ Date_____

Wx_____ Interviewer_____

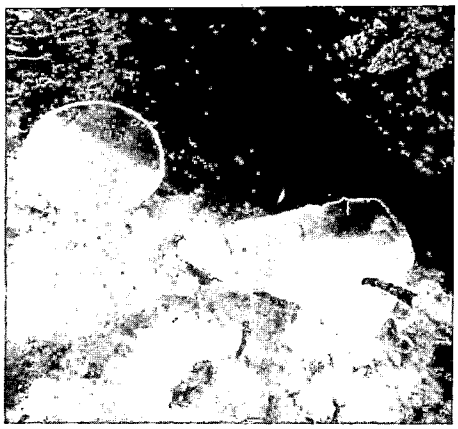
SH - Steelhead
CT - Cutthroat
DV - Dolly Varden

K - Killed
R - Released

Angler and Time	River Location	'A' Success-Apr-June/76 S.H.	'B' Success on Check Day SH(plus area)	'B' Success on Check Day Other(plus area)	'C' Success in 1977 prior to check day or from last time checked SH(plus area)	'C' Mo.	'C' Other(plus area)	'C' Mo.	Check (✓) if new Angler	Name, Address, Telephone Number

Sections "A," "B," and "C" can be combined to give run year and fiscal year steelhead catch totals.

Areas: #1 - Cheakamus (B.C. Hydro - confl.)
#2 - Confl. area
#3 - Lower Squamish (Judd - Howe Sd.)
#4 - Upper Squamish (Wildon - Elaho)
#5 - Upper Squamish (Elaho upstream)
#6 - Elaho R.
#7 - Ashlu R.
#8 - Mamquam R.



Electroshocking is used to examine juvenile salmonid populations. The fry are temporarily stunned, recovered, sampled and held before release.

The diver is showing the location of two steelhead underwater. Spaghetti tags are attached to the dorsal fins of both fish.

C. NORTH COAST OF B.C. AND THE YUKON

Atnarko River

a) Pink Station:

The Atnarko pilot incubation box facility was designed to rehabilitate the odd-year pink salmon runs to the Atnarko River, which have returned at less than 5 percent of historic levels since 1965.

Approximately 1,355,300 pink salmon fry and 6,000 chinook fry were produced from the Atnarko incubation boxes in 1977. This represents overall egg-to-fry survivals of 50 and 70 percent respectively.

A broom handle weir for counting migrant spawners and trapping hatchery donor stock was installed in the Atnarko River on August 20, 1977. The pink salmon spawning migration peaked between August 27 and September 8. The estimated pink salmon escapement was 150,000; up from an average of 30,000 over the last five cycles. If spawning escapements continue at this level, the Atnarko pink station will have exceeded its major objective of increasing the run to 100,000 pieces. Data from hydraulic sampling and fry trapping indicate that fry production is continuing at a high level and, unless an unfavourable marine environment intervenes, further good returns are expected.

Adult pinks for the egg-take were trapped at the weir, sexually segregated and transferred to 2.7 m diameter, 2.7 m deep holding pens. Of 5,057 fish held, 2,237 females and 866 males were used for spawning. The fecundity of Atnarko River pink salmon in 1977 was approximately 1,900 eggs per female, and the recovery rate upon spawning approximately 1,800 eggs per female. The eggs from five females were placed in a dry plastic pail and fertilized with the milt from three males. The eggs were then washed, left to water-harden for two hours and planted in the incubation boxes. Approximately four million eggs were planted and preliminary estimates indicate that the success of fertilization exceeded 90 percent.

From September 4 to 14, 118 males and 26 female chinook salmon were taken from the Atnarko River spawning grounds. Ripe fish were either spawned immediately or at the Atnarko facility after being transported downstream by jet boat. A total of 72,520 eggs were taken from 16 females and fertilized with milt from 38 males. The fertilized eggs were washed, water-hardened for 2 hours, and placed in a stack of Heath incubators situated inside the filter building. These eggs were shocked and picked on October 5. As a result of algal fouling of the Heath incubators, only 20-25,000 remained alive at that time.

A major landscaping project was undertaken in 1977, with labourers supplied by the Bella Coola Chamber of Commerce through a Local Initiatives Program grant. Improvements included clearing of rocks and log debris, levelling, seeding and irrigating in the immediate camp vicinity. Supervision, materials and equipment were provided by the Department of Fisheries and the Environment and technical advice by the Parks Branch.

b) Headwater tagging:

The Atnarko incubation box facility has been expanded to include ponds for rearing chinook fry and holding coho smolts for coded wire nose-tagging. Tagging studies are expected to provide information on stock distribution and exploitation of Atnarko River chinooks and Atnarko and Bella Coola River coho. Some marked three-year-old fish, released in 1977, are expected to return in the fall of 1978.

The 6,000 chinook fry from the incubation boxes were supplemented with 55,000 wild chinook fry from the Atnarko River and reared in oval fibreglass tubs. By June 20, 1977, these fish had grown to 311 fish/kg and were large enough to accept coded wire nose-tags. Approximately 55,000 fish were released at dusk on June 24. The approximate overall mortality during rearing and nose-tagging was 3.5 percent and nearly 4,000 undersized fish were released unmarked.

Approximately 23,200 juvenile coho were trapped from tributaries of the Bella Coola and Atnarko Rivers during April and May. These fish were transported to the Atnarko incubation box site and tagged with coded wire nose-tags. The mortality from marking and handling was 1.9 percent therefore approximately 23,000 marked coho smolts were released from the Atnarko facility in 1977.

Bella Coola Public Involvement

Enhancement Services Branch personnel supervised and coordinated the activities of several citizens groups involved in the Salmonid Enhancement Program in the Bella Coola area. The Bella Coola River is the site of a major chum enhancement facility and detailed information on the system will aid in its operation and maintenance. Furthermore, by employing local labour in SEP activities, a trained manpower source is developed which can be used to staff the project.

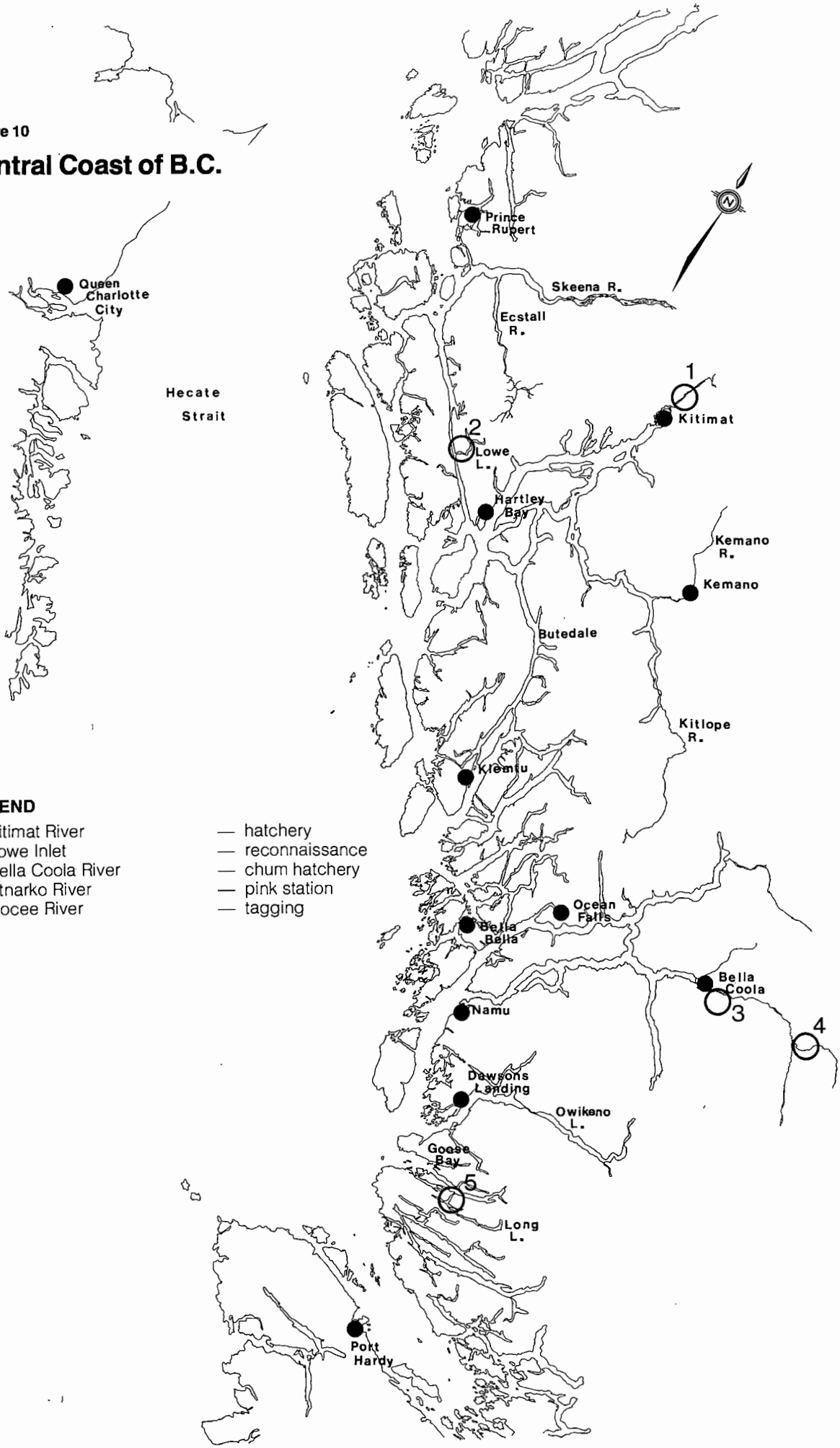
The Bella Coola Chamber of Commerce was awarded a Local Initiatives Program grant, through which the following projects were funded:

i) Trail cutting and log-jam removal on the Necleetsconnay River.

ii) Landscaping and gravel cleaning at the Atnarko Pilot Incubation Box Facility.

Figure 10

Central Coast of B.C.



LEGEND

1. Kitimat River — hatchery
2. Lowe Inlet — reconnaissance
3. Bella Coola River — chum hatchery
4. Atnarko River — pink station
5. Docee River — tagging

iii) Stream clearance and log-jam removal to improve spawning access in the lower Bella Coola Valley and upgrade the rearing environment for fry and juveniles. Tributaries of the Bella Coola River from Thorson Creek to the Noosgultch River, including the Salloompt River and its tributaries, were included (Figure 10).

iv) Weir construction and spawner enumeration at Fish Creek.

The Bella Coola Indian Band conducted a biophysical inventory of Tatsquan Creek under the terms of a contract with the Department of Fisheries and the Environment. Tatsquan Creek was mapped, gradients established, flows recorded, temperatures monitored and the abundance and distribution of juvenile and adult salmon studied. A juvenile trapping survey of the Necleetsconnay River and several smaller streams on the reserve was also carried out. Trails were cut and streams cleared to improve spawner access as required.

Part of a Young Canada Works grant administered by the Bella Coola Fish and Game Protective Association was applied to Salmonid Enhancement related projects in the Hagensborg and Firvale areas. The work included a biophysical survey encompassing tributaries and side channels of the Bella Coola River, stream clearance and habitat improvement. A report summarizing the activities of the Young Canada Works crew, including all data collected, was sent to the Enhancement Services Branch.

Bella Coola Chum Hatchery

The Bella Coola chum hatchery program is planned using the design of the Tlupana Inlet project. Using the Japanese hatchery technique and 5 million eggs taken from four sites, it is expected that 120,000 adult chum salmon will be produced.

The central site, Snootli Creek, will have modified Atkins plastic incubation boxes, groundwater-fed, to accommodate 5 million eggs. Four keeper channels will accommodate 5 million alevins and will be fed by a mixture of surface and groundwater. All the sites, Snootli Creek, Saloompt River, Fish Creek, and Thorsen Creek, will have a dirt rearing channel for 1 to 1.25 million fry to be reared to approximately 1 g each. Other facilities at Snootli Creek will include a 186 m^2 hatchery building providing an incubation room, office, lab, washrooms, locker and shop area. Caretaker and crew residences, and a security fence and fish collection system are also planned.

The facility will be operable by late summer 1978; however, full production will not be met immediately due to an expected shortage of donor stock.

This angler was interviewed during a creel census near Bella Coola. The steelhead has a spaghetti tag on the dorsal fin.

Bella Coola/Atnarko Steelhead

In 1977/78 SEP funds were made available to gather basic data on the steelhead populations of the Bella Coola/Atnarko River systems for the purpose of completing the information gaps as pertain to these systems.

Data collected during the winter/spring creel census of 1976/77 estimated that 3,613 angler days were accumulated between November and May and that more than 80 percent of the angling effort occurred during April and May. An estimated 783 steelhead were killed and 270 released, and an additional 425 were caught by the Indian net fishery between March and July. Eighty-six adult steelhead have been tagged and released; four have been recaptured and some major spawning areas were identified.

During September and October, 1977, stream studies have been carried out on most of the Atnarko/Bella Coola system. Systematic sampling, using minnow traps, was undertaken to determine distribution and density of steelhead juveniles. A detailed fisheries inventory was completed on the Talchako River and its east side tributaries. Preliminary results indicate that although the mainstem exhibited very little fisheries potential, the backwater, side channels and tributaries contained excellent steelhead spawning and rearing areas.

Goose Bay Enhancement

The Rivers and Smith Inlet chinook salmon support a major recreational and commercial fishery in their home waters. Further information is required on the overall migratory patterns of these fish and their contribution to the various fisheries. With this need in mind and the poor success potential in obtaining fry from natural waters it was decided to establish an incubation facility for Rivers Inlet chinook and thereby have some 50,000 juveniles of a size large enough to mark; in the spring of 1978.

A hatchery tray incubation system was established in cooperation with the Canadian Fishing Co. Ltd. at their Goose Bay camp using unfiltered creek water. The egg take aimed at 100,000 eggs but after two attempts only 50,000 eggs were obtained. This was caused by abnormally low numbers of male chinook salmon on the spawning grounds and a high incidence of unripe female spawners.

Severe algal formations were experienced quite quickly at the incubation site and this resulted in a virtually total loss of eggs prior to the eyed stage. The facility was therefore shut down in December of 1977.

There are no plans to make another attempt using this facility and at present budget limits do not allow for any other attempts to get tagged chinooks out of this area of the coast.

In areas with heavy rainfall and dense forest growth, debris and washouts are serious maintenance problems for counting fences. In this case, the Docee River fence (central coast) has panels which are raised except during the spawning migration.

Docee River Tagging

Docee River in Smith Inlet was one of the few areas where juvenile chinook salmon could be obtained for tagging purposes in the southern part of the central coast. An early start was made in 1977 to trap juvenile chinook and prepare for rearing them to a tagable size. The trapping soon indicated that very few fish would be captured and the project was terminated. There are no plans to try again in 1978.

Figure 11

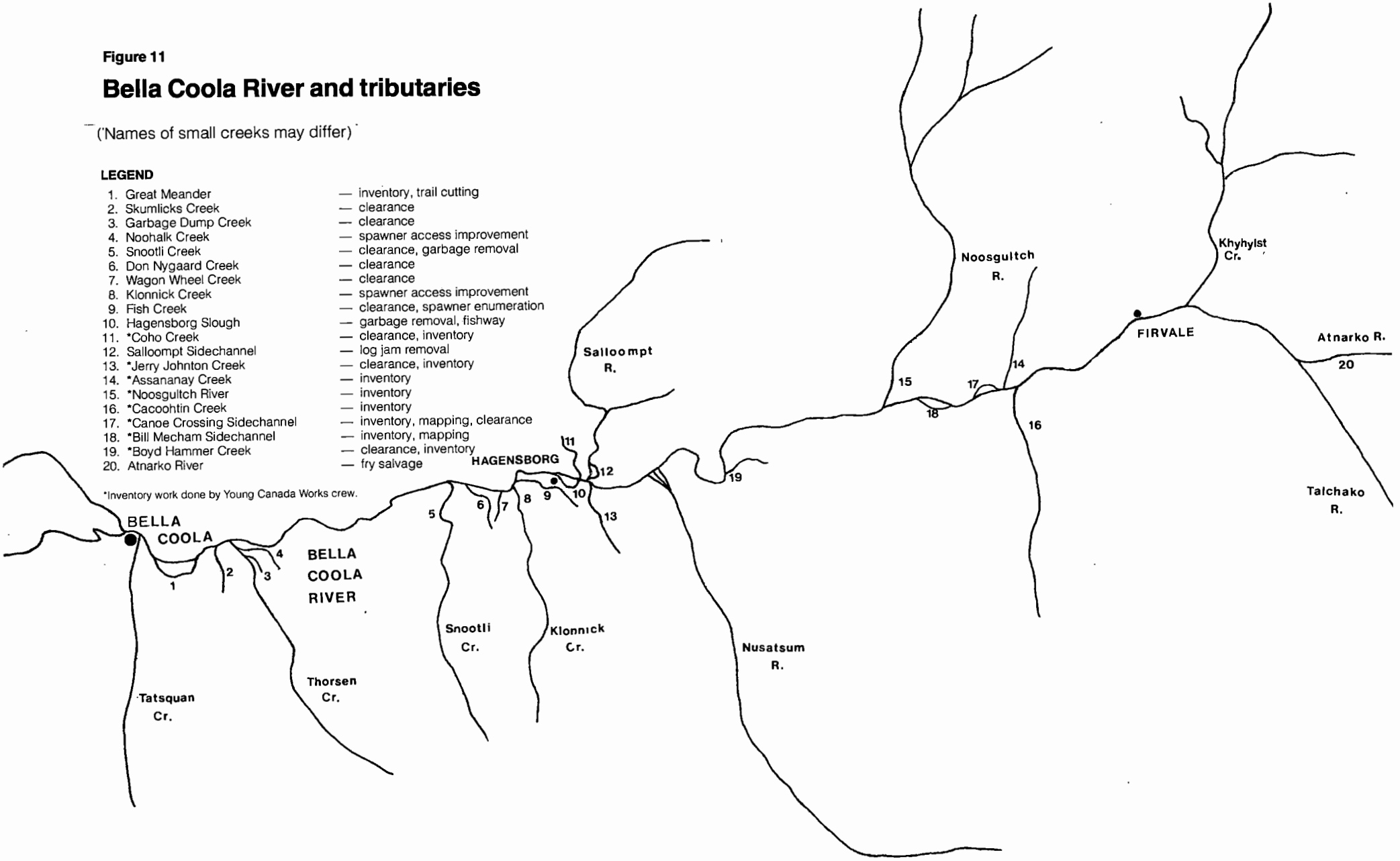
Bella Coola River and tributaries

('Names of small creeks may differ)

LEGEND

1.	Great Meander	— inventory, trail cutting
2.	Skumlicks Creek	— clearance
3.	Garbage Dump Creek	— clearance
4.	Noohalk Creek	— spawner access improvement
5.	Snootli Creek	— clearance, garbage removal
6.	Don Nygaard Creek	— clearance
7.	Wagon Wheel Creek	— clearance
8.	Klonnick Creek	— spawner access improvement
9.	Fish Creek	— clearance, spawner enumeration
10.	Hagensborg Slough	— garbage removal, fishway
11.	*Coho Creek	— clearance, inventory
12.	Salloompt Sidechannel	— log jam removal
13.	*Jerry Johnton Creek	— clearance, inventory
14.	*Assananay Creek	— inventory
15.	*Noosgultch River	— inventory
16.	*Cacoohtin Creek	— inventory
17.	*Canoe Crossing Sidechannel	— inventory, mapping, clearance
18.	*Bill Mecham Sidechannel	— inventory, mapping
19.	*Boyd Hammer Creek	— clearance, inventory
20.	Atnarko River	— fry salvage

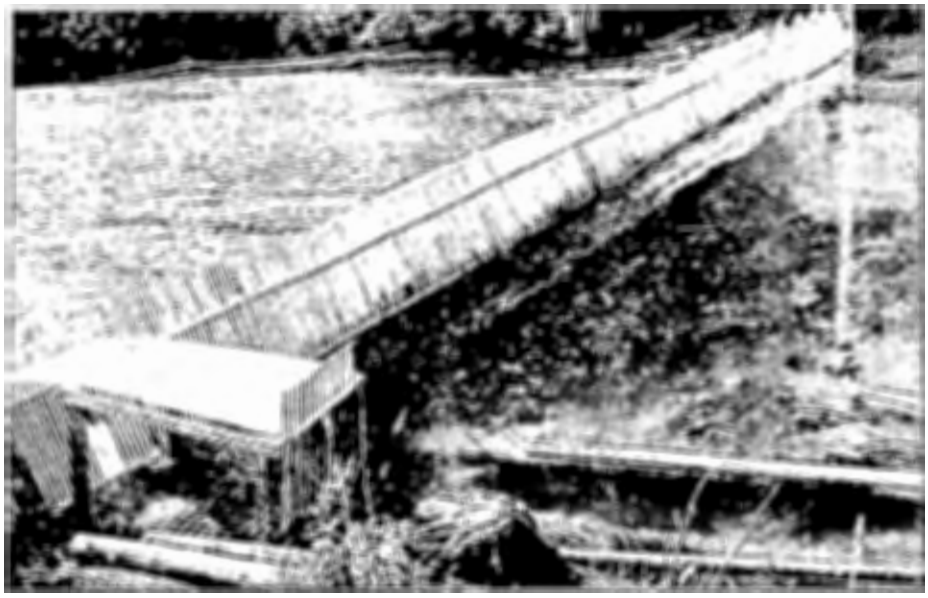
*Inventory work done by Young Canada Works crew.



Lowe Inlet Reconnaissance

Lowe Inlet, located on the eastern side of Grenville Channel, drains a watershed of approximately 85 square miles and has a partial obstruction (Verney Falls) at its confluence with the Lowe Lake system. Although historic escapements of sockeye have been very high (a cannery was once located on Lowe Inlet), present escapements into Lowe Lake number from 2,000 to 5,000 fish. Preliminary surveys conducted in the 1950's included a biological reconnaissance of the lake and falls. Eventually the commercial fishing boundary was moved downstream to the inlet entrance.

Reconnaissance activities in 1977 were undertaken to examine the feasibility of blasting a fishway around Verney Falls. An on-site examination of the rock structure has led to tentative design studies for a verticle slot fishway, which would be operable under a wider range of discharge and tide conditions than the existing situation allows. Construction of the fishway is slated for Phase I of SEP.



Adult pink salmon are directed through a counting fence in the Little Wedeene River.

Kitimat River

a) Biological Feasibility:

Biological work on the Kitimat River in 1977 concentrated on the chinook stock with some minor work on the coho and chum spawners. Funding problems did not allow a spring program on juveniles to take place and all effort was on the adult migrants. The objective of the adult program was to obtain basic biological information on the adult chinook salmon and to demonstrate the feasibility of procuring brood fish for hatchery use.

In an attempt to determine more fully the spawning stock size and spawning distribution of the Kitimat chinooks, a mark recapture study was undertaken. In all, 131 chinook were marked in the river but very few recaptures were made. The small population spread over some 48 km of the river area made this estimate technique futile.

Excellent weather conditions with low clear water in late August allowed for the determination of most chinook spawning areas on the Kitimat and visual estimation of run size was possible. Official estimate of chinook escapement to the river in 1977 was 1,400 fish.

Part of the effort this year was to determine the timing and numbers of fish entering the tributaries of the Kitimat. The Kitimat Rod and Gun Club was contracted to count and sample the fish passing the fences with funding from the Department and from Alcan Smelters and Chemicals Ltd. The dry summer experienced in 1977 affected the tributaries and very few fish were enumerated. The most promising fence for chinook enumeration was on the Little Weedeene River but the installation was completed too late to enumerate chinook and the fence later washed out removing the possibility of counting other species.

A pilot project for beginning "enhancement" of the Kitimat chinooks was investigated in 1977. A tray incubation facility was established in cooperation with Eurocan Pulp and Paper Co. Ltd. within one of the company's buildings and utilizing the company's potable water supply. In conjunction with this a large holding pen was placed in the Kitimat River and 24 "green" chinook were seined and held in the pen. There were no mortalities and the lack of brood stock available at the enumeration fences necessitated obtaining fish off the redds. After 10 days the goal of 100,000 eggs in the incubation trays was obtained.

Survivals have gone very well with 91 percent surviving to the eyed stage and 86 percent to the time of first feeding in early January. The warm (7° C) groundwater supplying the incubation facility caused an early ponding time and a trailer was equipped with two troughs to provide covered, controlled rearing.

The first month of feeding is past with the fish already doubling their weight. The fish will be tagged and released in the spring, and should produce approximately 1,200 fish for the commercial, Indian and recreational harvesters and return 400 fish to the river for escapement. The tag returns from these fish will be valuable in determining their migration and fishery utilization patterns.

b) Hatchery Construction:

Conceptual work on the major fish production facilities for the Kitimat watershed has been slow because of budget limitations. However, in the winter of 1977, a concerted effort by both Field and Enhancement Services established some basic decisions of the first phase of enhancement facilities.

The aim of the enhancement program is to restore all stocks to their historic levels and then add to these levels. Production goals for final total stock in the Kitimat River are 110,000 chinook, 400,000 coho, 600,000 chum, and 1,400,000 pink salmon. Also to be enhanced and maintained at a level of 10,000 fish are steelhead trout.

The present aim of enhancement is primarily for the hatchery production of depressed chinook stocks. Initially, brood limitations will keep the chinook production to less than 1 million eggs. Final production goals are for 5 million chinook eggs to produce some 3.5 million underyearling smolts.

Also to be included in the hatchery operation are capacities for 2 million coho eggs to produce 1.5 million reared smolts, and 100,000 steelhead eggs to produce some 60,000 smolts.

The pink and chum biological and engineering feasibility work is at present incomplete and there thus remains some question as to facility type for these species. Spawning channels were suggested and would have capacities for 25,000 female chum salmon and 37,000 female pink salmon.

Site work on the hatchery is presently underway with design and construction of the hatchery facility to be done in 1978/79 with

Scale samples are taken from salmonids to determine age structure and life history patterns. Thin, closely spaced bands denote winter growth; wide, dark bands are summer growth.

an aim of having the chinook rearing facility available for the spring of 1979 and the remainder of the hatchery ready for the summer of 1979. Concept decisions and design work on the pink and chum facilities will begin in 1979.

The existing temporary incubation system on Eurocan Pulp and Paper Company property will hopefully be expanded so a larger egg-take can be done in 1978. These fish will be reared at the permanent hatchery site.

Kitimat River Steelhead

During April, May and June of 1977, a creel census was conducted on Kitimat River, placing the emphasis of the study on a continuation of angler use, steelhead life history and spawning habitat surveys initiated in 1976.

From interviews with more than 750 steelhead anglers, it was determined that the Kitimat fishery is of very short duration (two months) and consists almost entirely of Kitimat residents. The average angler was described as casual and inexperienced and an exploitation rate of only 10 percent was assumed. Artificial steelhead enhancement will become necessary only if the social and environmental conditions in the Kitimat area change drastically in the near future.

From creel censuses in 1976 and 1977, 125 biological samples were obtained. Fourteen age groups were identified and all fish spent three or four years in fresh water before migrating to the ocean. A relatively high percentage of repeat spawners (32 percent) in the Kitimat sample is noted and appears to be characteristic of short-run, spring migrant steelhead populations.

In 1977 investigations were directed towards determining the distribution and extent of spawning habitat throughout the Kitimat River system by observations made by walking, drifting by boat and from a helicopter. Initial work in 1976 in which suspected spawning habitat was documented laid the groundwork for this study. The majority of steelhead spawning sites were located along the mainstem for about 65 km; however, many tributary streams also contained spawners. Qualitative factors such as size of redd and water conditions were also noted.

During April, May and June of 1977, a creel census was conducted on Kitimat River. Over 750 steelhead anglers were interviewed. Success rate of the Kitimat angler (about 90 percent of the anglers were Kitimat residents) was extremely low. Scale samples and other biological information from landed steelhead were also obtained.

Steelhead spawning areas were located and mapped using routine survey methods to determine location and distribution of spawners.

Mathers and Pallant Biological Feasibility

Recent evidence indicates that the Queen Charlotte Islands chum stocks, which form an important part of the local commercial fishery, are below optimum. Biological baseline studies were therefore initiated on two of the most important and accessible areas, Mathers and Pallant Creeks.

Together with relevant background data, the results of SEP studies of the water quality and chum spawning populations of these creeks from August to December, 1977, were examined. A wide range of water quality parameters were sampled for and most were within an acceptable range for fish culture facilities. Suspended solids loadings indicated potential problems for Mathers Creek. Substrate inventories were made of most of both systems and predicted potentials were verified by subsequent spawner distribution in Pallant Creek. Timings, distributions, and abundances of chum spawners were estimated using temporary counting fences and aerial and walking surveys. Spawner characteristics as determined by live and dead sampling of 469 chums at Pallant and 37 chums at Mathers are recorded below (Table 22).

Table 22

Summary of chum spawner characteristics in Mathers and Pallant Creeks in 1977.

	Pallant	Mathers
% Male	49%	35%
Total Age: 3	35%	12%
4	64%	82%
Hypural Length:		
Males	570 mm	603 mm
Females	561 mm	578 mm
Fecundity	2732 eggs	2919 eggs
Egg Retention	2.3%	1.5%

Pallant Creek Construction

Site preparation for the Pallant Creek chum hatchery project began in the summer of 1976 with the clearing and ballasting of approximately 550 m of access road as well as hatchery and accommodation sites, the hatchery site was enlarged, and the access roads and sites were surfaced with gravel. Sluffs along the access had occurred the previous winter and were removed.

A reinforced concrete intake was constructed to be connected to a 30 cm diameter pipeline feeding the hatchery building. The streambed required drilling and blasting before the intake could be built. The structure contained 15.3 m^3 of concrete and was dowelled to the bedrock. The trash racks and other metal work required will be contained in a later contract.

The water supply consists of 150 m plastic pipeline, 30 cm in diameter providing gravity feed from the intake structure to the hatchery building. The 120 m^2 hatchery building is on a reinforced concrete slab and is a metal self-framing building. At present, eggs are incubating and construction will be completed in 1978/79.

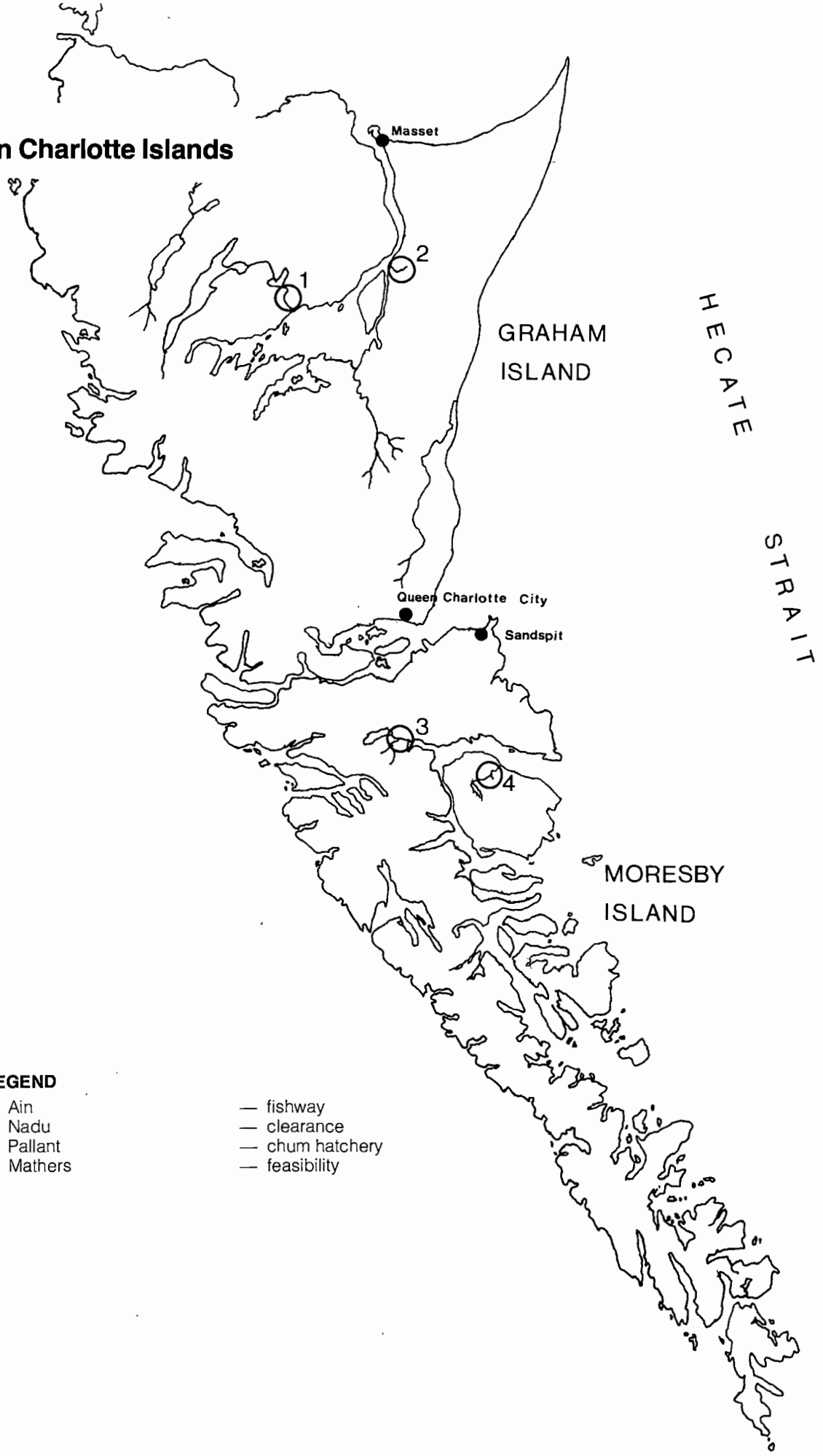
Skeena River Steelhead Identification

a) Babine River:

On the Babine River, over 100 adult steelhead spawners were captured in a nine month period near the Nilkitkwa-outlet

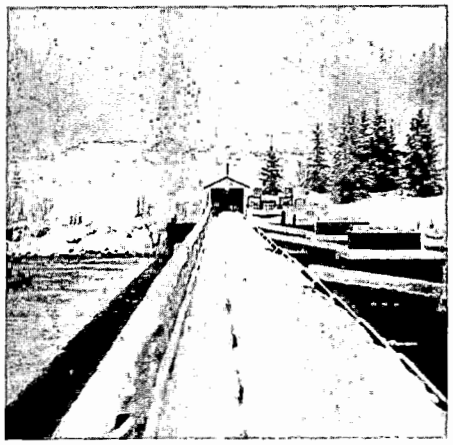
Figure 12

Queen Charlotte Islands



LEGEND

1. Ain — fishway
2. Nadu — clearance
3. Pallant — chum hatchery
4. Mathers — feasibility



The Babine River fence enumerates smolt and adult migrations at Babine Lake and is one of the northernmost winter-operating facilities. Eggs from winter-run steelhead were obtained here for incubation at the Fulton River camp, 100 km southeast.

spawning grounds. Fifty fish (30 female and 20 males) were retained for stripping (April 15 to May 20). Approximately 120,000 eggs were taken during the week of May 18 to 25, transported to the Fulton River site, fertilized and placed in hatchery trays.

b) Kispiox River:

As water levels permitted, some additional steelhead spawning ground reconnaissance in upstream tributaries of the Kispiox River was conducted in June. During the spring and summer of 1976, more detailed studies were undertaken on the adult and juvenile populations.

c) Suskwa River:

During July and August of 1977, the Suskwa/Harold Price system was surveyed to establish a habitat and fish inventory preparatory to a barrier removal project on this system. Adult steelhead were tagged, movements monitored and anglers censussed.

Morice River Steelhead

During the periods September through December, 1976 and August through November 1977, a creel survey and catch sampling program was conducted on the Morice River to gather information on the steelhead fishery including angler origin, effort, methods used and success.

Anglers were found to be primarily British Columbia residents and expended nearly 2,000 angler days annually to catch approximately 400 to 600 steelhead in the Morice River. Among 518 readable scale samples collected over the two-year period, 15 age groups were identified. The majority of Morice steelhead spent four years in freshwater prior to seaward migration, remained in the ocean for one year, and returned as first-time spawners, averaging about 1.7 kg in weight.

Table 23

Comparison of average smolt lengths of steelhead trout within the Skeena system.

	Fork length in mm		
	3 yr	4 yr	5 yr
Morice	145	178	200
Kispiox	163	195	241
Babine	187	203	246

Juvenile steelhead were collected during the summers of 1976 and 1977 by means of minnow traps and angling. Lengths and scale sample readings were correlated and the relationship was used to back calculate smolt length from freshwater radius of adult scales. It was found, through comparison with other Skeena systems, that there is wide variation in those factors affecting freshwater growth (Table 23).

Kitsumkalum River Biological Feasibility

The 1977 Kitsumkalum River study is a continuation of the 1976 study to determine the feasibility of enhancing the Kitsumkalum chinook and coho stocks. In 1977, the majority of the work was directed towards chinook studies.

During the downstream studies, 28,734 chinook fry and 2,467 coho juveniles were captured below the lake using dipnets, fyke nets, traps, beach seines and minnow traps. Above the lake, 822 chinook fry and 1,325 coho juveniles were captured by using minnow traps. The chinook fry were reared, and 25,517 chinook fry and 3,744 coho juveniles marked with coded-wire tags and released to provide information on fishery contribution, migratory routes, migration timing and possible U.S. interception of these stocks.

In the Kitsum Kalum River, chinook salmon were seined, tagged, measured and released from a jet-boat.

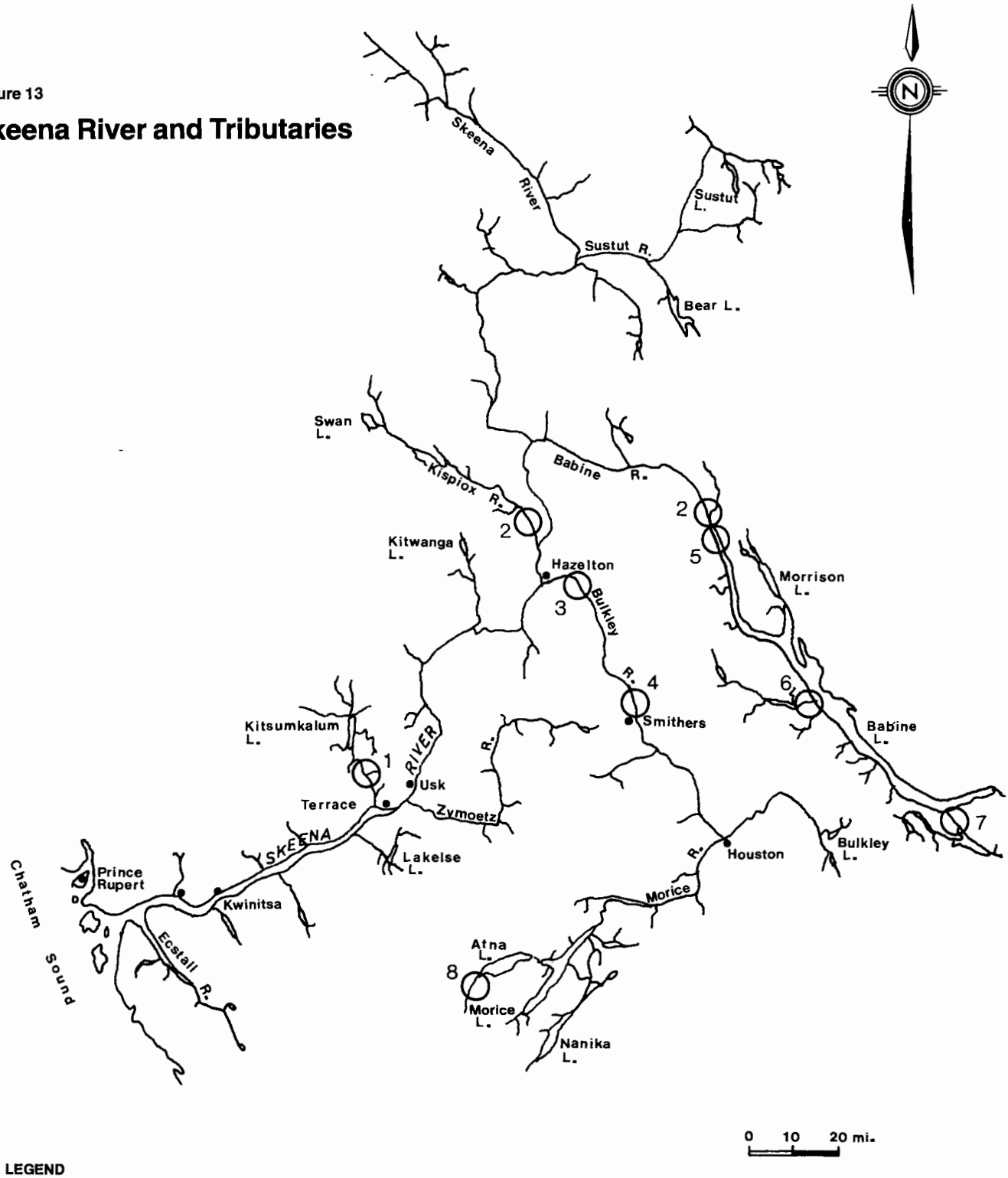
The adult chinook program was also divided into the upper system (Cedar River, Clear Creek) and the lower system (Kitsumkalum River below the lake). On the upper system, an adult chinook tag and release program was conducted using a gillnet at the top end of Kitsumkalum Lake. A total of 185 adult chinook were tagged, length and scale sampled, and then released. Due to poor river conditions and shortage of manpower, an adequate dead recovery program could not be initiated, therefore chinook escapements into the upper system were determined from aerial flights and on-site inspection. The estimated chinook spawners were 4,000 in the Cedar River and 200 in Clear Creek. On the lower system, an adult chinook tag and dead recovery program was conducted by the use of a beach seine. A total of 100 chinook were tagged, length and scale sampled, and released. A total of 7 tagged chinook were recovered from 725 dead chinooks examined. The estimated escapement for the lower river was calculated to be 9,000 chinook salmon.

In November, a survey was conducted to determine which streams in the Kitsumkalum River system support spawning stocks of coho salmon and, at the same time, identify stream obstructions and determine the spawning potential of each stream. In the Kitsumkalum system, 12 streams currently support coho spawners, 6 of these have good spawning potential, and 8 have obstructions such as beaver dams, log jams and windfalls. Surveys for coho escapements in this system were not undertaken due to ice and snow coverage during the spawning season.

A water sampling program was initiated this year to evaluate the water quality in the Kitsumkalum River system. Water samples were taken monthly, at two locations, and these samples are being analysed for residues (FR/NFR), nutrients (TPO_4, NO_3, NO_2, SiO_2, SO_4, F-), extractable dissolved

Figure 13

Skeena River and Tributaries



LEGEND

1. Kitsumkalum River	— biological feasibility
2. Kispiox and Babine Rivers	— steelhead identification
3. Moricetown Falls	— clearance
4. Toboggan and Cathlyn Creeks	— clearance
5. Babine River	— fence
6. Fulton River	— spawning channels
7. Pinkut Creek	— spawning channels
8. Atna River	— clearance

metals (Ca, Cu, Fe, K, Mg, Mn, Na, Pb, Zn) and algal.

The Kitsumkalum bio-feasibility study is proposed to continue in the 1978/79 fiscal year. Some of the proposed activities are: a downstream study for fry and smolt timing, nose tagging of chinook and coho juveniles, visual estimates of adult chinook and coho spawners, dead sampling of adult chinook and coho for age, length and sex data.

Fulton River

a) Spawning channel production:

A large deposition and good survival rate combined to produce a record 209.8 million fry, proving 1977 to be an exceptional year. River production was the highest since 1961, when assessment began; Channel No. 1 survival was well above average; and Channel No. 2 production, at 141.8 million fry is well above the 1971/76 average of 81.0 million.

b) Sockeye fry enumeration:

Corrected production estimates from the Babine enhancement facilities are required before additional research is conducted on Babine Lake to determine the cause(s) of fry mortality. Although most of these estimates are accurate, there are indications that the convergent throat traps used in Fulton River and Fulton Channel No. 2 need to be re-evaluated.

The accuracy of the traps was tested by using a mark/release/recapture method involving dye-marked sockeye fry released upstream from the fence during the regular migration period. It appears that trap efficiency is related to the effects of river level on the pattern of water flow through the channel exit. Standard calculations may have been underestimating fry production and further data analysis is underway (Figure 14).

c) Steelhead and chinook enhancement:

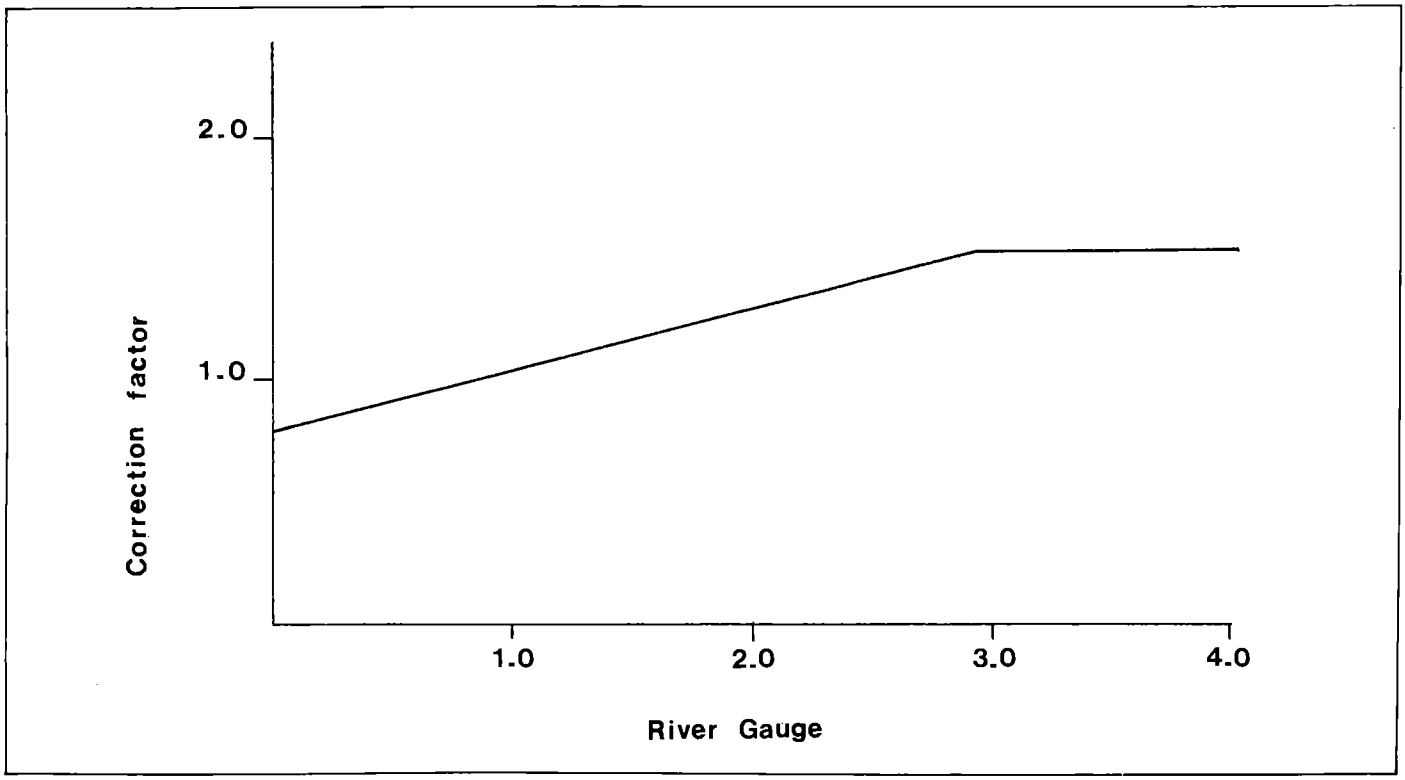
The continual decline of chinook salmon to the Skeena River system, after increased sport and commercial fishing restrictions, emphasized the need for implementing further measures to rehabilitate the stock. Similarly, steelhead trout are heavily utilized and appear to be in danger of severe overfishing. Furthermore, there is a lack of biological information on migration timing, commercial fishery contribution and commercial and sport interception of individual Skeena stocks. Appropriately, chinook and steelhead enhancement was initiated at the Fulton River site, using Babine River donor stock. The application of coded wire nose-tags to the juveniles will provide valuable information concerning adult survival, timing, and patterns of migration and interception. Fry reared at Fulton River will be returned to the Babine River for release and are expected to return as adults only as far as the Babine River.

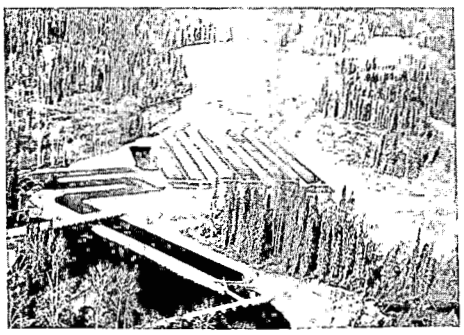
In early 1977, 50 steelhead trout were collected and retained in the Babine River. On May 18 to 24, 120,000 eggs and sperm were taken and flown 100 km southeast to Fulton River, fertilized, and incubated in hatchery trays. At emergence, in July, survival was 47 percent and 53,375 fry were transferred to circular tanks for rearing. To date, there are 31,000 steelhead fry being reared and in April of 1978 the fish were marked with coded wire nose-tags, and will be released as two-year-old smolts in 1979.

Chinook salmon eggs and sperm were, for the second year in 1976, taken from the Babine River stock; 18 males and 30 females were stripped between September 22 and October 1, producing approximately 200,000 eggs. Fertilization was delayed until the eggs and sperm were flown to the Fulton River Project. The eggs were planted in a gravel incubation box and in April, 1977, approximately 135,000 fry emerged. These fish were reared to smolts under hatchery conditions, and 111,039 were tagged and airlifted to the Babine River where they were released in July, 1977.

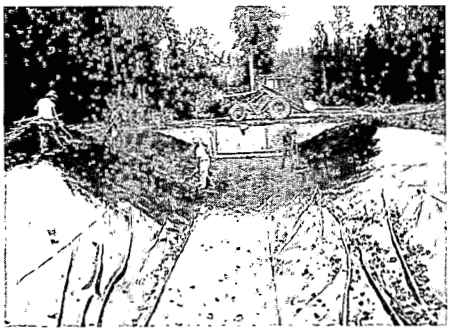
Figure 14.

Correction factor for estimating fry production at Fulton River.





Spawning channel no. 2 at the Fulton River site can accommodate 110,000 sockeye spawners and produced 142 million fry in 1977.



Rearing pond construction required the installation of a heavy plastic liner before laying a sand and gravel bottom.

The Fulton River laboratory building was expanded to accommodate rearing tubs, troughs and hatchery trays for chinook and steelhead incubation and rearing.

d) Construction:

The rearing potential of the Fulton River site is being expanded through the installation of permanent incubation and rearing facilities. Constructon began in March with the excavation of a laboratory extension. Due to the harsh winter climate in this area, the frozen ground had to be broken with heavy equipment and the concrete heated to prevent it from freezing. Supply and drain lines for five 3.1 m diameter rearing tubs, two rearing troughs and 30 hatchery trays were installed. The supply line was temporarily connected to an existing incubation box pump, capable of producing 580 1/min. by early May, the 6 m x 9.2 m extension was complete, the water was running, and chinook and steelhead production had begun.

Warm water temperatures in mid-summer caused reduced oxygen levels in the water supply and a second incubation box pump was connected to provide higher flows. Low oxygen levels continued to be a problem, especially during the spawning season, while the temporary water supply was utilized. An 5.5 m x 1.8 m diameter well was installed and connected, via two 20 cm pipes, to a 2.4 m x 2.4 m fry-proof intake box 23 m away in the river bed. Three 20 hp submersible pumps with an output of approximately 3785 1/min. each were installed in the well. Two pumps will supply water for all the rearing installations and the third is reserved for standby purposes.

A 24.4 m x 9.8 m rearing channel was built outside the laboratory building to accommodate steelhead fry in their second year. A 3 mm PVC (plastic) liner was laid on bedding sand between concrete intake and outlet structures. It was covered with 7.5 cm of sand and 15 cm of gravel and is surrounded by a chain-link fence.

Pinkut Creek Spawning Channel

a) Production:

Traps were washed out by high water levels during the fry migration and fry production estimates are based on a combination of fry trapping and hydraulic sampling. The channel has been under reconstruction for nearly two years and therefore has no 1976 brood stock (Table 24).

Table 25 shows a technical comparison of all the spawning channels in British Columbia.

b) Construction:

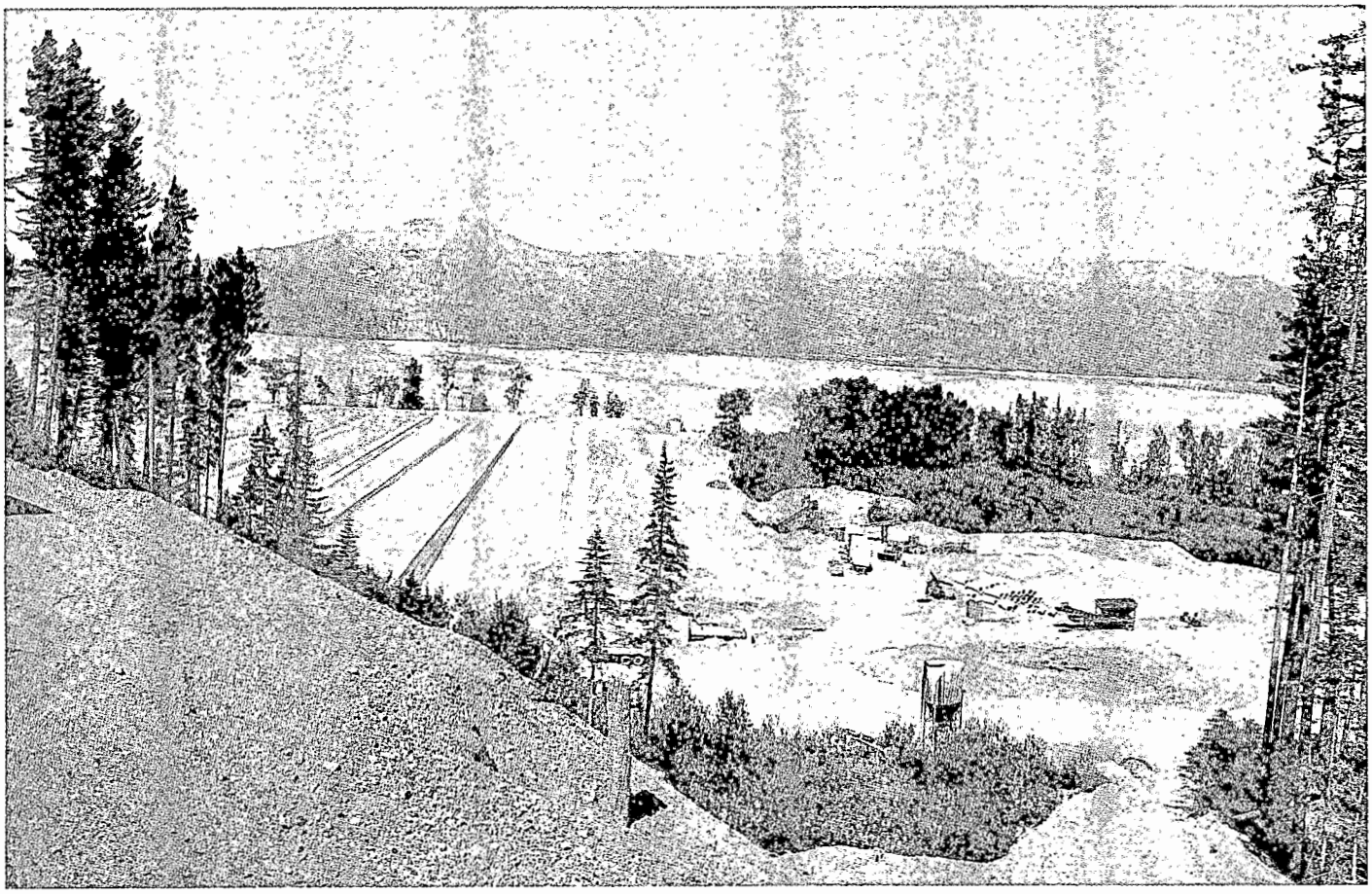
The Pinkut Creek spawning channel in the Babine Lake development project has been subject to several major operational problems. Silt has persistently accumulated in the gravel due to unstable berms and inefficient settling ponds, adult density control is not well achieved and icing problems occur in the channel itself. These factors combine to produce poorer survival rates and low production, although Pinkut Creek is known to be an important sockeye salmon producer. A 1.3 million dollar construction contract was awarded to rehabilitate the spawning channel.

In 1976/77, new adult control works were constructed, consisting of a new diversion weir and new diffuser structures. Channel work began by removing the spawning gravel and preloading the site to prevent shifting.

Table 24

Summary of sockeye salmon production in the Babine Lake development project in 1977.

Location	1975 brood smolts (millions)	1976 brood No. of fry (millions)	1976 brood % Survival (egg-to-fry)	1977 brood escapement
Fulton Ch. 1		17.8	58.9	19,079
Ch. 2		141.8	66.6	127,548
River		50.2	17.3	355,403
Pinkut Ch.				20,201
River		8.1	22.5	64,556
Babine River	61.04			



Reconstruction of the Pinkut Creek spawning channel involved major renovations in the channel itself (left) and the settling ponds (right)

In 1977, channel repairs were fully underway. The berms were trimmed of the existing material and wire mesh was placed over the slopes and shotcreted. Ten channel legs were constructed in this manner.

The spawning gravel was rewashed using a conveyor belt and jet method. Riprap and frozen particles had to be broken and thawed before washing and clay contamination necessitated manipulating the water jets and gravel movement for efficient washing. Baffles were installed in order to fight size gradation of the finished product. Some gravel was also manufactured on the site, washed and used to supplement the old material.

Three new settling basins and collection ditches were also constructed. The existing basin was cleaned and excavated and the sides and bottom trimmed. Pipework was installed so that water pours out central manhope pipes. An impervious clay/silt material was laid on the bottom, weir beams were poured and the sides were laid with mesh and shotcrete.

Northern B.C. And Yukon

a) Tatchun-Michie Outmigrations:

Tatchun and Michie Creeks are both tributaries of the Upper Yukon River supporting chinook salmon spawners. Tatchun Creek enters the Yukon River approximately 363 km downstream of Whitehorse whereas Michie Creek drains via McClintock River into Marsh Lake approximately 72 km above the Whitehorse power facilities. Work was done in 1975 and 1976 on Tatchun Creek with limited effort on Michie in 1976.

Initial results indicated a dwindling chinook stock and further studies were initiated. The program for both creeks was designed to study the outmigration timing, residency and size composition of juvenile chinook salmon. Fyke nets were used for the capture of 152 chinook fry and smolts in Tatchun Creek along with incidental catches of arctic grayling, whitefish and sculpins. Michie Creek surveys were modified to enumeration by swim counts. Numbers of fry average 1,500 (25 smolts) until mid-October when counts decreased to zero.

b) Upper Yukon reconnaissance:

The Yukon River has its source in the several large lakes on the Yukon-B.C. border; from the outlet of Marsh Lake it runs over 1,900 miles through both Yukon and Alaska to its outlet in the Bering Sea. In 1959 the Whitehorse Hydro Power Dam was completed and a fishway installed. Chinook numbers have steadily decreased from an average of 1,600 to a low of 121 in 1976. A slight increase to 277 occurred this year.

Negotiations over the past several years have resulted in the Northern Canada Power Commission being advised of its responsibility for construction and operation of a mitigation hatchery for chinook salmon. The program was carried out to determine numbers, distribution, and timing of adult and juvenile chinook to provide an information base for the operational direction of the proposed Whitehorse hatchery.

The program was sectioned into three aspects: adults, juveniles, and physical-chemical parameters. Chinook migrants were enumerated and a percentage live sampled in the Whitehorse hatchery.

A total of 55 of 277 adult chinook were sampled (19.9 percent). Of those sampled the M/F sex ratio was .89 with an age com-

Table 25.

A Technical comparison of Federal spawning channels in British Columbia.

Channel	Species	Year	Width (m)	Area (m^2)	Gradient	Gravel Size (cm)	Depth (cm)	Vel. (m/sec)	Water Depth (cm)	Q (l/sec)	Settling Basin (m)	Spawners ($X10^3$)	Eggs ($X10^6$)	Egg-to-Fry Survival (%)	Remarks
Jones Creek	Pink	1954	4.6	2,200	.001	2-10	45	.61	45	700-850	4.6x61	2.2	1.7	37	Original gravel +4", settling increased, vel. range .31 to .76m/sec.
Robertson Creek	Pink Chinook	1960	10.7	8,400	.0012	2-10	40-50	.46	45	2800	Lake	—	—	—	Not in production, depth controllable.
Big Qualicum #1	Chum	1963	6.1	2,600	.0009	2-10	60	.61	45	1700	None	9.1	N/A	18.2	Not used, slope changed but no improvement, had holding ponds. Vel. range .52 to .64m/sec.
Fulton #1	Sockeye	1965	9.2	10,800	.0009	2-10	45	.55	40	2100	None	22	35.8	48.7	
Big Qualicum #2	Chum	1967	12.2	14,100	.002	2-15	60	.73	30	2300-2800		20	30.5	78.5	Holding pools filled, fish widened channel, vel. range .46 to 1.07m/sec.
Pinkut	Sockeye	1968 1977	12.2	33,000	.0009	2-10	45	.55	40	1300-1600	7,600 x 11,900	63	61.4	35.4	Rebuilt in 1977, settling basin now 32,600 m^2, total of 3 pools center-fed.
Fulton #2	Sockeye	1971	15.3	73,100	.002	2-10	45	.64	30	2800	Lake	130	195.0	44.5	

position of 4, 6.7 percent; 5, 57.8 percent; 6, 35.5 percent (11 reabsorbed scales). Areas above and below the Whitehorse Power Dam were surveyed for spawners. From this data, Michie Creek appears to spawn approximately 20 percent of all migrants.

A converging throat inclined plane trap was fished in the Yukon River a mile below the hydro dam to ascertain outmigration timing. Several hundred sculpins, burbot, round and humpback whitefish, ciscos and arctic grayling were caught; however, no chinook were recorded (July to October).

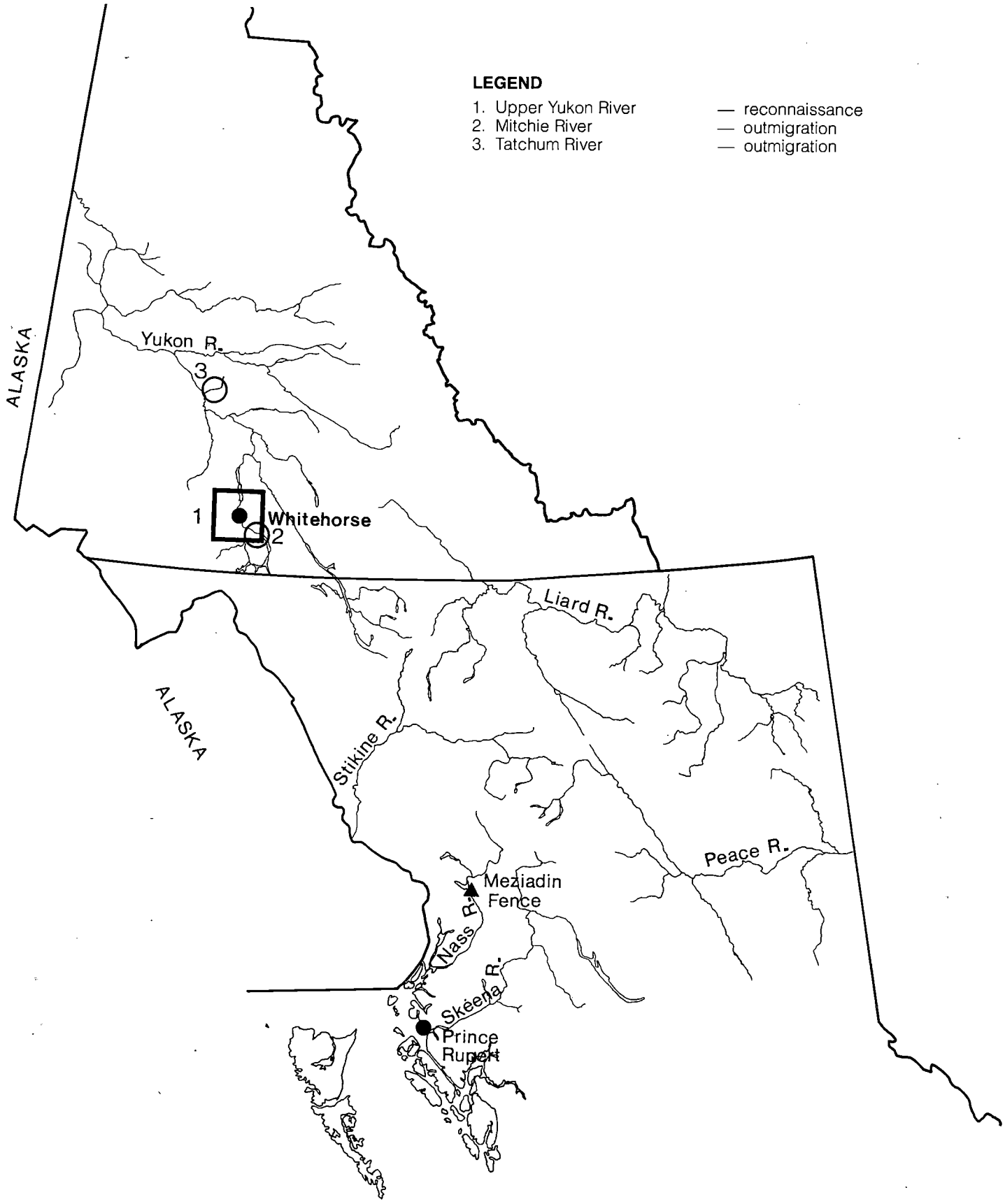
Surveys of all tributaries to the Yukon River between Laberge and Marsh Lakes were completed for biophysical characteristics as well as chinook juveniles. Minnow traps, pole and beach seines, modified Wolf traps were used for capture. Most creeks were identified as having chinook fry. Based on these observations a theory for a summer rearing dispersal mechanism was postulated.

A water chemistry survey was initiated in conjunction with the Water Quality Branch of DIANA. Two sites were chosen above the Whitehorse Hydro Dam and samples taken twice weekly.

Plans for 1978 include expanded effort in Upper Yukon spawning ground determinations. the study will attempt to zero in on two small creeks to analyze rearing potential, habitat and food organism preferences, migrational movements and causal factors.

Figure 15

Northern B.C. and the Yukon



III RESEARCH

A. FEDERAL

Stock Identification (Marking System)

Two studies were conducted as part of a program to develop the capability of marking large numbers of chum, pink and sockeye fry. The objective is to mechanize part of the process so that a high production rate at low mortality can be obtained with a minimum of operator skills.

a) Coded Wire Tagging:

A study at Rosewall Creek last summer determined that fry as small as 30 mm could be marked with half-length coded wire tags. If coded wire tags could be used for pink and chum fry marking, our knowledge of their marine habits would be greatly increased. Using tags of a .255 mm diameter and 0.5 mm long, approximately 300 fish were tagged, held for 4 months, and killed for lab examinations. The delayed mortality and tag loss rates were low. The smaller tags can be identified even in adult heads. A high-resolution X-ray technique now in regular use by the Mark Recovery Program to locate "missing" tags was developed to assess the placement accuracy of the half length tags in the small fish and as a double check on the reliability of the tag detection system. A report is in preparation for 1978.

Development of a small-diameter (.20 mm) wire tag for special fry-marking operations is now underway.

b) Electrosurgery:

Electrosurgery is being examined as an alternative to adipose fin-clipping coded wire tagged fish. By cauterizing the fin, tissue regrowth, common to the snip method, may be eliminated. The cauterization method is also faster, more efficient, more amenable to mechanization and may even be performed underwater. Work is continuing on this project and a report has been prepared by the contractor.

Enumeration/Monitoring Technology

a) Adult Counter:

A low-cost, portable fence was developed and installed on the Cowichan River, near Duncan. Although the design needs further work, the feasibility of developing a light-weight fence is clearly indicated.

b) Juvenile Counters:

A prototype of a lightweight fence with electronic adult counters was developed and installed in the Cowichan River.

Two echocounters were built for use in the lake enrichment program in areas where conventional fry trapping and counting is not practical. These counters have a number of built-in self-checking features designed to function as quality controls for surveys performed by contractors using this equipment. In 1977, a total count of Great Central Lake juveniles was done using echocounters; however, the degree of accuracy is uncertain. At present, Cultus Lake juvenile populations are being estimated using both echocounters and fence counts in order to arrive at an error factor which can be applied to the Great Central Lake situation.

Bioengineering Studies

a) Gravel/Salmon Egg Hydraulics:

A study is underway to examine the hydraulics of flows through gravel and to develop basic data essential to the design of salmon egg hatchery cells. Tests include permeability, void ratio and egg capacity in different types of round gravel. The results did not fit existing hydraulic theory. A report has been prepared by the consultant and is being reviewed by UBC.

b) Gravel Cleaner:

A gravel cleaner was developed for cleaning spawning channel beds, using the Salmon Commission's prototype. The new design consists of a self-contained gas-powered unit, with 50 pipes extending 23 cm into the gravel and using a venturi system to force down air and water. The unit is pulled along on skids by a crane or winch, has dimensions of 7.6 m x 2.4 m x 1.5 m high and weighs approximately 3,200 kg. There are three units to be field tested in the Babine spawning channels in 1978.

c) Intake Design:

A study was completed examining the designs of infiltration galleries at hatcheries and incubation boxes. From information obtained from a review of the literature and investigations of existing systems, some general guidelines are presented. Apparently, successful development of streambed infiltration galleries is mainly dependant on satisfying certain stream flow conditions at each specific site.

d) Automatic Sexing and Maturity Testing:

Automatic sexing and maturity testing could be used to permit controlled loading of salmon into enhancement facilities, to reject excess males for harvest, and to reduce overspawning in sockeye channels.

A contract was let to test optical techniques for the identification of male coho salmon returning to the Capilano hatchery. A proportion of these could then be harvested by the local Indian band. Although the optical method performs no better than experienced hatchery personnel, it is simple to use, inexpensive, and frees skilled technicians for other work.

The maturity testing investigation has been dropped; however, a spin-off technique for detecting parasites in fresh fish fillets is continuing using non-SEP funds.

Babine Sockeye Studies

a) Echo Sounding:

Echo sounding techniques were used on Babine Lake in 1977 to estimate the dispersal, distribution and abundance of under-yearling sockeye. This study had two objectives, firstly, to determine why fry-to-smolt survival in 1975 and 1976 was much lower than expected, and secondly, to identify and maximize the accuracy and precision of echo sounding in estimating the abundance of lacustrine sockeye populations in general.

The field program started in June, was completed in January and the data are now being analyzed. Horizontal movements of juvenile sockeye were more rapid and frequent than expected, although the general seasonal pattern was consistent with J. McDonald's earlier results. By using an upward facing transducer, it was confirmed that sockeye were virtually absent in the top 5 m, except at dusk and occasionally at dawn. A total abundance estimate will probably be impossible because, at any given time, parts of the lake had targets which were too dense to count.

Pursuing the second objective, estimates of accuracy were obtained by echo sounding in conjunction with seining and midwater trawling. Within-sample variation was estimated by repeatedly sounding the same transect. A field procedure for calculating beam dimensions (necessary to obtain abundance estimate) was developed.

b) Production:

The operation of artificial spawning chan-

nels at Babine Lake began in 1966. As the channels reached full production, sockeye fry output increased annually and, by 1972, reached a level three times the previous one. Smolt outputs increased accordingly except in 1975 and 1976 when fewer smolts were produced than would be expected from observed fry outputs. A study was begun in 1977 to see if reduced smolt production may have resulted from factors associated with the greatly increased numbers and density of fry in the lake. The program was designed specifically to determine:

i) if the distribution, abundance, growth and age composition of juvenile sockeye in the lake had changed from that observed in previous years;

ii) if the number of kokanee, the non-anadromous form of sockeye, exceeded former levels resulting in decreased production of seaward-migrating smolts and also greater competition for food; and

iii) if the larger prey population of sockeye fry had resulted in more and larger predator fishes.

Juvenile sockeye and other fishes were caught in the lake from July through October following a standardized purse seining procedure used during 1966-68 and again during 1971-73. Comparisons of catch per unit effort (as estimates of density) revealed little change in the seasonal distribution of the sockeye in 1977 from that observed previously. Processing of samples and analysis of data to indicate changes in the growth, size and age composition of juvenile sockeye, kokanee, and trout was started in 1977, and will be completed in 1978.

Other studies included:

i) a test of the copper sensitivity of Babine Lake sockeye fry. Results, which are now being analysed, indicate that pesent copper levels in the lake pose no acute toxicity threat to young salmon,

ii) observations in the spring of 1977 indicate that some simple, inexpensive modificatons to the present fry by-pass and provision of some shelter among one part of the lower Babine River may substantially improve fry survival, and

iii) a check on the accuracy of fry production estimates from Fulton Channel No. 2 using mark-recapture methods indicated that previous production estimates may have been too low.

Disease Surveys

This sub-program has continued to see a growing demand for its services since its inception in May 1974. Approximately 320 cases were processed in 1977 compared to 260 in 1976. This demand is not expected to increase to any great extent in 1978 since the availability of the service is now widely known and utilized.

The health status of fish stocks in Federal rearing facilities continues to be monitored. Furunculosis and bacterial kidney disease remain major infectious disease problems within these facilities. Examination of adults returning to the Capilano and Quinsam River hatcheries has revealed infections by *Ceratomyxa shasta*, an internal parasite responsible for substantial losses among rainbow trout in Oregon and Northern California. The prevalence of this organism at both hatcheries should be closely monitored. It is hoped that monitoring of disease agents at all Federal facilities can be carried out on a more regular and frequent basis in 1978/79.

Surveillance and monitoring of river systems of salmon enhancement potential have been completed at approximately 12 sites and a fairly complete picture of the occurrence of infectious diseases in the southern third of the Province has emerged. All data collected have been incorporated into a generalized data-base computer system. The system has proven useful for rapid data retrieval and determination of geographical disease patterns.

A major survey on the Horsefly River migrant adult sockeye was conducted in an attempt to determine the role of infectious diseases in prespawning mortalities in this system. Laboratory work on the samples collected will not, however, be completed until early 1978, after which a report will be prepared.

The new Fish Health Protection Regulations, which came into effect January 1, 1977, have had considerable impact on this sub-program. Although responsibility for inspection and certification of private culture facilities under the regulations has been assumed by the Provincial Government, the Diagnostic Service remains responsible for the Federal hatcheries and for monitoring international shipments of live fish into this Region.

Consultation and reporting to users of the Service continued to be an important aspect of this sub-program. A manuscript is in preparation describing the computerized data-base program currently used by the Diagnostic Service.

Vaccine Development

A vaccine designed to prevent vibriosis, furunculosis, and bacterial kidney disease (KD), was evaluated between July, 1976 and July, 1977. Although some degree of protection against vibriosis and furunculosis was obtained, no protection against bacterial KD was achieved using either injection, oral, or immersion techniques.

In 1977, experiments were initiated to determine if antigens could be released from the furunculosis and KD pathogens and whether the convenient immersion technique could be used for their administration. A new "spray vaccination" technique was also briefly tested. Crude laboratory challenges based on injecting fish with graded doses of living furunculosis bacteria suggested that none of the extracts conferred any protection to the fish; spray-vaccination also proved ineffective. Similar evaluations of the anti-KD vaccines were not possible at this stage.

In an attempt to develop an anti-KD vaccine that could be produced in quantity, an attempt was made to locate fast-growing bacteria similar to the KD bacterium. Three cultures were selected and tested in coho salmon; however, the level of antibody production was very low compared to the levels produced against the KD bacterium. The results suggest that studies on substitute vaccines be suspended and that heat-treated KD cells were more antigenic than any of several other forms.

Experiments in growing the kidney disease bacterium in mass liquid culture revealed that growth yields are considerably less than those attainable with other fish pathogens. Some refinements have been identified which may make mass production of the KD vaccine possible, but it will always be relatively expensive. Observations suggest that the source of the virus responsible for piscine erythrocytic necrosis (PEN) of seawater-cultured chum and pink salmon may be a marine fish. Pacific herring, for example, appear to suffer from a similar disease caused by a virus indistinguishable from the salmon virus. The herring and salmon viruses are similar in size, morphology, and heat liability, and when the former was injected into the five species of Pacific salmon, infections were established in all five species, with chum and pink salmon suffering the severest infections. Whether the viruses are the same entity remains to be determined.

Ocean Survival Studies

Ocean survival studies of fish populations involve examining data in order to assess past and present conditions of the ocean environment. Biological statistics of fish populations are also included so that ocean effects may be separated from biological and freshwater environmental effects.

The provision of technical assistance has allowed data series of the following items to be compiled, computed or graphed as appropriate:

i) Monthly discharges of three major rivers to December, 1976;

ii) monthly mean sea levels for four stations to be put on tape, graphed and smoothed for publication in the Data Report Series; and

iii) monthly mean temperatures, salinity, nutrients and chlorophyll at Station "P" for 0 and 150 metre depths.

Computed monthly mean Ekman, total and vertical transports from 1946 to 1977 for the North Pacific Ocean, have been transferred to tape for ease of data retrieval. Daily pressure data on a grid over the Gulf of Alaska are on tape for 1954 to 1977. There are a few months data missing for summers previous to 1963. Data Reports No. 34 and 35 on 1976 transport and 1960-1977 mean transport values have been published.

An analysis and report on the catches of chum salmon in the Johnstone Strait areas was given to regional management biologists of the Fisheries and Marine Service.

Nutrition and Applied Endocrinology Program

a) Fish nutrition:

The Resource Services Branch, in cooperation with several other agencies, routinely analyses diet ingredients and finished feeds. The analytical results are assembled at the Pacific Biological Station and forwarded to the parties concerned.

Two experiments on coho salmon were completed. Duplicate groups of underyearling coho and coho fry were each fed one of several dry diets based upon the Abernathy formulation. Poultry by-product meal, (PBM), low-glucosinolate rapeseed meal (RSM), and feather meal (FM) were used in various substitutions or simplifications of the dry diet, usually involving the reduction or omission of herring meal. These two experiments indicate that PBM together with FM is an excellent source of protein for coho salmon; however, more investigations on RSM are warranted because of the effects noted on the thyroid and the importance of this endocrine gland in early growth and smoltification.

A similar experiment was conducted on chinook salmon; this was not completely successful as some coho alevins were inadvertently mixed with chinook alevins in the main stock tank. Nevertheless some positive findings were obtained. These were as follows:

i) general order of the growth responses of coho in the mixed species situation mirrored that of coho in the above experiments;

ii) a large incidence of pinheads was noted in the groups of chinook salmon fed the simplified formulations indicating that soybean meal is probably not a good source of protein for this species; and

iii) several unsimplified formulations appeared to equal Abernathy in producing growth. More effort will go into the development of practical dry diets for chinook salmon in the future.

A large diet experiment involving 200,000 juvenile coho salmon has been in progress since June, 1977 at the Quinsam Hatchery. Growth responses of fish fed West Van 1 and West Van 2 experimental dry diet formulations have been equivalent to fish fed commercial OMP or Abernathy. Fish are routinely sampled for fish health and histopathological examinations and prior to release will be sampled for determination of flesh lipid characteristics.

The returns of these experimental groups to the fishery will be monitored. In addition, routine proximate analyses are performed on both diets and fish. The two diets being tested at the Quinsam Hatchery were initially manufactured in the laboratory and subsequently on a pilot scale at a commercial B.C. feed mill.
A manuscript entitled "Development of Practical Dry Diets for Coho Salmon (*Oncorhynchus kisutch*) Using Poultry By-Product Meal, Feather Meal, Soybean Meal and Rapeseed Meal as Major Protein Sources", has been prepared for presentation at the EIFAC Symposium on Fish Nutrition and Feed Technology.

b) Diet enrichment with anabolic hormones:

Commencing in 1976, groups of underyearling coho salmon received diets supplemented with 1 ppm 17∝-methyltestosterone and 5 ppm testosterone for 98 days. Terminal weights of 17∝-methyltestosterone and testosterone-treated fish on satiation rations were 41.8 and 13.2 percent greater than those of controls, respectively. Lower increases were noted in fish on restricted rations. Feeding of 17-∝-methyltestosterone and testosterone increased voluntary food intake of fish by 16.8 and 6.2 percent respectively. The ratio of weight gained to food consumed in groups on satiation and restricted rations containing 17∝-methyltestosterone increased by 10.0 and 22.1 percent respectively. Corresponding values for testosterone-fed groups were 2.6 and 8.8 percent.

Feeding a diet containing 17-∝methyltestosterone for 125 days to steelhead originating from Qualicum River did not affect growth, food consumption or food conversions. This contrasts with previous tests with Oregon steelhead in which steroid-fed fish grew at an increased rate.

Rainbow trout (mean wt 1.6 g) were obtained from a local trout farm. After 169 days of feeding to satiation, fish which received 1 or .5 ppm of 17-∝methyltestosterone in the diet weighed 19.8 percent and 15 percent more than controls. When hormone feeding was continued for another 63 days weight increments of hormone-fed fish decreased gradually to 13.5 and 8.7 percent, respectively. Histological examination after 232 days indicated that the hormone affected testis development in this species. No changes occurred in food consumption or food conversion efficiency.

Commencing in 1976, groups of underyearling coho salmon were fed Oregon Moist Pellets supplemented with L-thyroxine (T_4) or 3,5,3′—triiodi-L-thyronone (T_3) for 98 days. Control groups received OMP containing solvent. Administration of T_3 significantly enhanced growth in length than in weight in certain groups of fish led to a decline in condition factor. Voluntary food intake was increased by low doses of T_3 and T_4 but decreased by high doses of T_3.

17∝-methyltestosterone was mixed in doses of .2 and 1 mg/kg into the diet of Atlantic salmon (Salmo salar) parr. During 106 days of feeding, both doses enhanced growth in weight and length significantly. The greatest gain in weight (23.6 percent over control) and length (6.6 percent) was produced by the lower dose. Protein and lipid composition of the muscle was not affected by the treatment, but the 1 ppm dose caused a small but significant decrease in moisture content. Some changes in the structure of the testes occurred in androgen-treated fish, but ovaries were not affected.

In another experiment, groups of 75,000 coho parr received experimental diets consisting of OMP supplemented with 1 ppm 17∝-methyltestosterone, 5 ppm testosterone or no supplement. The diets were fed at 125 percent of recommended OMP feeding level intermittently for 9 months commencing in May 1976. After this time the groups were fed for 3 months at a restricted level because of exceptionally high temperatures of the river water. This restriction of food intake caused initial large gains in weight and length of hormone treated groups to be reduced. Weight gains over the control group at time of release were 17.1 percent in the 17-∝methyltestosterone group and 28.3 percent in the testosterone group. Histological examination showed that gonads were unaffected by the treatment. In March 1977 1,000 fish from each of the hormone treated and control groups were transfer-

red to Nanaimo Biolooical Station, where salt-water challenge was performed in order to determine readiness for saltwater transfer. In June the three groups were gradually introduced to sea water. Growth rate was monitored during the following four months and was found to be satisfactory. Twenty thousand fish from each group were tagged (CWT) before release from the Capilano hatchery in order to determine ocean survival.

Finally, groups of 75,000 coho hatched in 1977 and ponded at normal density were fed a diet supplemented with 17-∝-methyltestosterone. Rate of feeding was either 100 or 125 percent of recommended OMP level. This feeding schedule will be continued until the fish are tagged (CWT) and released in 1978.

c) Controlled Reproduction:

Investigations into inducing final maturation and ovulation in salmonids were undertaken with the following objectives:

i) to permit the controlled spawning of salmonids in the hatchery environment,

ii) to induce earlier spawning in hatchery stocks of chinook salmon prone to prespawning mortality, and

iii) to reduce the holding time of male and female salmon captured in the field from natural runs for egg taking followed by off-site or on-site incubation.

Experiments were conducted on coho and chinook salmon and cutthroat and steelhead trout at the Capilano hatchery, Abbotsford hatchery and RSB West Vancouver during 1976 and 1977. Injections of varying doses and types of hormone preparations were administered and the time of ovulation compared with control groups. Fertilization rates and survival to hatching were excellent providing treatments were within a month of normal spawning. For example, survivals of eyed chinook eggs at the Capilano Hatchery were 240 to 310 percent higher in treated groups than in control goups. Salmon gonadotropin preparations were provided to the North American Salmon Research Centre in St. Andrews for a co-operative project on induced spawning in Atlantic salmon.

Photoperiod control of spawning season in salmon is being tested on pink and coho salmon (Table 26) and three-year old pink adults may be used to obtain 1976 Bear river run were transferred to the West Vancouver site and five treatment groups were initiated. A second experiment involving the advancement or retardation of spawning coho was successfully completed in 1977 with the spawning of 4-month delayed fish on May 5. The fertilized ova from this experiment were used in one of the sex reversal experiments described below.

Table 26.

Summary of photoperiod treatments and expected maturation times of pink salmon from the Bear River 1976 brood stock.

Group	Treatment	Expected Spawning Time
1	Extended photoperiod simulating 6, 90-day seasons	Oct/79
2	Extended photoperiod until Aug/78 Normal photoperiod until Oct/79	Oct/79
3	Extended photoperiod until Dec/78 Normal photoperiod until Oct/79[1]	Oct/79
4	Salt water control — normal photoperiod	Oct/78
5	Fresh water control — normal photoperiod	Oct/78

[1] Previous attempts using this approach has produced three-year old fish.

Studies on controlled sex differentiation have been undertaken to allow the alteration of sex ratios or sterilization of salmon. An increase in the ratio of female salmon in the commercial catch would increase its landed value. It would also permit a larger egg take where there is a need to build up hatchery populations or would permit a lower hatchery escapement where the egg requirement is stable. The stocking of selected lakes with sterile salmonids could result in trophy sized sports fish. Sex ratio control or sterilization would also be of considerable value in the aquaculture of Pacific salmonids.

Coho eggs, alevins and fry were treated with various doses and combinations of estrogens and androgens in 1977 (Table 27). Clear evidence for transformation to females was observed in the estrogen-treated groups while, in the androgen-treated groups, only testes were seen with evidence of sterilization at the higher dosages. Controlled sex differentiation studies were initiated on chinook and pinks early in 1978.

The Bibliography of Fish Reproduction 1963-1974 was completed during this year.

Salmon Incubation Requirements

Investigative work for 1976/77 consisted of an extensive series of tests on eggs and larvae of chum, sockeye, and coho incubated in different gravel media. The objective of the study is to establish favourable ranges of certain environmental parameters for incubation. This was done by investigating relationships between different gravel types or mixtures and several larval responses. Some responses are alevin distributions in gravel bodies throughout their development, growth and yolk utilization rates, timing characteristics of fry emergence, and differences between species. Analysis is incomplete, but there are noteworthy differences in several responses and a first approximation of certain gravel parameters appears feasible. The goal is to define gravel mixtures that will prevent extensive downward movement of alevins while not impeding their out-migration.

The test series was continued for the 1977/78 season so that favourable ranges and possible optima can be defined more precisely. In addition, a series of tests were initiated to evaluate performance (in terms of fry survival, size, and timing characteristics) of a number of incubation systems, including different versions of a shallow matrix incubator and a new artificial incubation substrate developed by the Oregon Aqua-Foods Corporation.

Most of the investigation's effort was directed toward sample and data processing, and reporting of earlier work. A manuscript was completed reporting the final Headquarters Creek Hatchery evaluation test (1972-1974). It should appear as a Fisheries and Marine Tech. Rep. early in 1978.

A paper was completed reporting the results of a literature survey covering the salmonid literature from 1965 to 1976. It deals primarily with developmental requirements of eggs and larvae and contains several indices to some 1,700 titles, including a comprehensive subject index. A program, called WINDOW, can search the computerized list following a 5-point

Table 27.

Summary of sex reversal experiments on coho salmon in 1977, using hormone treatments at the early life stages.

Brood Stock	Eyed Eggs and Alevins	Fry	Analysis
Jan/77 — eyed 1976 brood stock	immersed in: 17α-methyltestosterone 17B-estradiol 17B-estradiol $NaSO_4$	fed Abernathy formula containing: 17α-methyltestosterone 17B-estradiol	histological examination of gonads
May/77 — eyed delayed 1976 brood stock	immersed in: 17α-methyltestosterone 17B-estradiol	"	histological examination of gonads
"	"	"	maintained for analysis of long-term effects
"	control	control	"

instruction of the general form, "Effect of (factor, condition) A, at stage a, on (response, process) B, at stage b, in species S." Even though subject coding cannot be entirely objective, the system seems to have produced satisfactory results in several trials.

Size and Time at Release Experiment

An experiment was initiated to determine the effect of time and size at release of juvenile hatchery-reared coho salmon upon their distribution, growth, survival, age at maturity, and accuracy of homing. In the spring of 1975 three releases (April, May, and June) of juvenile coho salmon of Big Qualicum origin, each containing three major size groups, were released from Rosewall Creek, representing a combined total of 122,013 marked and tagged fish. In the fall of 1975, 1,417 jack coho (all precocious males) originating from these releases were recovered at Rosewall Creek. In general, the results indicated there was a positive correlation between smolt size at release and the percent that returned as jacks. Also, for smolts of any specific size, their return as jacks decreased the later they were released. Jack size was positively correlated with the size of the smolts at release.

In the fall of 1976, 3,341 marked adults were recovered of which 2,885 were tagged. The percent return of adults was lowest from smolts released in April (0.82 percent), intermediate from those released in May (1.82 percent) and highest from those released in June (4.40 percent). The largest percent returns as adults came from the smaller smolts of each release. Adults from the May release were largest and those from the June release were smallest. Larger smolts produced larger adults. There was also a highly significant and positive correlation between jack and male adult size. Hence, smolt size, jack size, and adult size were all positively correlated to each other.

In summary, a high production of jacks was not followed by a high production of adults. The production of jacks reduced the potential for an adult production. Estimates of adult biomass produced from smolts of different sizes released at different times indicated that maximum production was achieved when smolts were released at a moderate size of around 19 g and late, in early June. Hence, future production facilities should be built on sites having cooler water supplies, which would produce later releases of fish at a smaller size. A preliminary report will be published in the form of a Technical Report in the near future.

Accelerated Growth Studies

In the fall of 1976 we began acceleration of 50,000 Big Qualicum fall chinook fry, in an attempt to produce significantly larger smolts (15 g as opposed to 6 or 7 g) than those produced in the production rearing channel. Fry were reared throughout the winter at elevated temperatures (10 - 12°C), and all were marked and nose tagged in early April.

Unfortunately, neither the planned size nor time of release of these fry was achieved. Many of the accelerated fry began exhibiting a strong migratory behaviour in April at a size of approximately 6 g average weight, and we were obliged to release them into the river at half the desired size and 2 months earlier than the production fry. Beginning on April 18, 1977, a total of 42,085, 6 g fry were given access out into the river. By April 26, all fry had moved into the river and many of these were recovered in the downstream trap located near the river mouth. As a result, the experiment will provide us with information on the effects of time at release rather than size at release. Age at maturity, survival, growth, etc., of both groups will be determined on their return as adults in subsequent years. In the fall of 1977, another lot of 50,000 Big Qualicum fall chinook eggs were collected and are currently being incubated. These fry were accelerated last winter and will be released this spring as tagged smolting fry (weighing on the average at least 15 g) at the same time as the production rearing channel fry. Age at maturity, survival, growth, etc., of both groups will be determined on their return as adults in subsequent years.

A second attempt to rear coho to the smolt stage in 6 months rather than the usual 14 months through control of temperature, food, and photoperiod, was initiated during the winter of 1976/77. The progeny of 16,000 eggs (1976 brood) from the Rosewall coho stock were reared at 10 to 15°C to a mean release weight of 10 g. Fourteen thousand and eight smolts were tagged, and on June 22, 1977, were allowed to migrate. In the fall of 1977, nine jacks originating from this release were recovered at Rosewall Creek. Returning adults will be recovered in the fall of 1978.

Currently, a normally reared group of 15,000 fry from the same stock and brood year (1976) as the accelerated smolts is being reared at ambient temperatures for 14 months at Rosewall Creek. These will be released as tagged smolts in the spring of

1978 at the same size and on the same date as the accelerated smolts released in 1977.

A third group will also be released at this time. Eggs from coho (1977 brood) from Rosewall Creek hatchery stock were incubated at 10°C. Resultant fry from these eggs were accelerated during the winter of 1977/78 and will be released this spring as tagged smolts at the same size and on the same date as the normally reared smolts. Age at maturity, survival, growth, etc., of the returns from the two accelerated groups and the normal group will be compared.

Lake Enrichment

In 1977, on the basis of the apparent positive effects of controlled nutrient additions to Great Central Lake (1970 to 1973) on adult sockeye production, the Lake Enrichment subprogram was expanded into a pilot-scale treatment.

The Lake Enrichment group fertilized three lakes on Vancouver Island (Great Central, Henderson, and Hobiton) and one on the mainland near Smith Inlet (Long Lake) with 206 metric tons of nitrogen and phosphorus at an N:P ratio of 10:1. In addition, it supervised the fertilization of Mohun Lake near Campbell River by the B.C. Fish and Wildlife Branch. Concurrent with the fertilization was an intensive twice-monthly sampling program on the five fertilized lakes and on Kennedy Lake, a priority candidate for future fertilization. Results indicate that primary and secondary production in all fertilized areas increased by up to 20 times. Deleterious changes in phytoplankton and zooplankton species composition were avoided. In decreasing order of annual productivity, the lakes are Long, Mohun, Henderson, Great Central and Hobiton. Amounts of lake periphyton (littoral attached algae) within lakes differed between fertilized and unfertilized areas, by as much as a factor of 15, indicating considerable uptake of nutrients by benthic algae. For all lakes, algal species composition was similar within fertilized and unfertilized areas. Zooplankton populations in fertilized lakes responded with biomass increases ranging from a low of 200 mg ash free dry wt/m^3 in Hobiton Lake to over 1 g in Long Lake. A comparable biomass figure for untreated Kennedy Lake was 80 mg. The results indicate that production in fertilized areas of the lakes increased significantly while the overall trophic status of each lake was maintained.

A total of 35 lakes in British Columbia and 3 in the Yukon were surveyed as a preliminary step in identifying candidate lakes for fertilization (Figure 16). Final selection of lakes to be fertilized will depend on further limnological and fisheries ecology studies, on international and social factors, and on the management problems caused by enhanced stocks. Lakes which at present appear to be prime candidates for fertilization are Nimpkish on Vancouver Island; Morice, Meziadin, Alastair, Fred Wright, Swan, Kitlope and Owikeno and the Northwest arm of Takla Lake in the central interior of the Province; Mathers, Awan and Ian Lakes on the Queen Charlotte Islands; Tahltan Lake in Northern B.C., and Klukshu in the Yukon. These lakes are nutrient poor, have favorable light climates, have low populations of anadromous sockeye which are considerably below historic levels.

Short sediment cores (≤50 cm) were taken from all treated lakes, except Long and Kennedy Lakes. The cores were analyzed quantitatively for diatom microfossil abundance, A/C ratio (diatom frustule ratio between the Araphidae and Centrales families) and organic content. Mohun Lake had the greatest paleoproductivity with an average of 302 x 10^7 , main arm of Kennedy (51 x 10^7), Henderson (42 x 10^7), and Hobiton (38 x 10^7). *Cyclotella stelligera* was the dominant diatom in all lakes and its abundance along with very low A/C ratios (0.01-.30) indicate ultraoligotrophic conditions, historically and currently. Counts from Henderson Lake cores show an abundance of marine diatoms, suggesting saltwater intrusions have occurred frequently over the past few centuries.

The specific objective of the fish ecology unit was to determine the effects of controlled artificial enrichment of nursery lakes on growth, production and feeding of resident fish populations, with particular emphasis on juvenile sockeye salmon and on their return as adults. Attempts to obtain samples of migrating smolts from each lake before enrichment began were moderately successful, except for Henderson and Kennedy Lakes. Smolts from Long Lake were the smallest and the proportion of 2-year-olds was greatest of all stocks sampled and approximately one-third exhibited growth on their scales. The significance of the observed differences in smolt size and circulus number is not known, but factors such as population density, available food resource, temperature during lake residence, and sampling times, either individually or in combination, could have influenced the size (and growth) date.

Great Central (2), Kennedy (3), Henderson (1), Hobiton (1) and Mohun (1) Lakes were surveyed acoustically on one to three occasions, using a 200 kH echo-sounder, from late July to early November. The number of surveys are indicated in parentheses. In all lakes but Hobiton midwater trawling and plankton tows were made in association with sounding surveys to provide information on the composition characteristics of the pelagic fish population and the available food resource, respectively. Preliminary estimates for the sockeye population in millions of fish for the different lakes were: Great Central, 6.2-8.7; Kennedy, 4.5 - 2.0; Henderson, 1.1; and Hobiton, 0.4. Population estimates for Great Central and Hobiton are believed reliable to within 25 percent. Estimates for Kennedy and Henderson may be less reliable due to the interaction of young sockeye and sticklebacks, as indicated by mid-water trawl catches. The kokanee population in Mohun Lake in late July was estimated to be 125,000, consisting of 100,000 age 0, 22,000 1 and 3,000 2 (adults).

All sockeye caught in Kennedy Lake were 0+ (1976 brood year). Fish were distributed vertically according to size, with the smallest individuals closest to the surface. Also, smaller fish were taken in Clayoquot Arm than in the main basin. *Bosmina* was important as food for young sockeye in both arms of the lake in August. In September the copepodite stages of *Cyclops bicuspidatus* appeared in the diet of fish in both basins, and *Bosmina* was lacking in the diet of sockeye in the main basin.

Ancillary experiments on gear associated with increasing the reliability of population estimates were conducted as opportunity and time permitted. These included development of an inflatable fishing and sounding platform, measuring and calibrating the beam widths of the echo-sounders, and determining the selectivity of the various mid-water trawls.

The study on the Great Central Lake sockeye in relation to the initial lake fertilization experiment was continued in 1977. Preliminary estimates of the total run to GCL make it the largest on record: approximately 1 million fish, consisting of 82 percent 4-year-olds, 17 percent 5-year-olds, and 1 percent other ages. The return per spawner of 4-year-olds was 4.0 (progeny: brood) for an untreated year class. This relatively high return may reflect either the positive relationship between number of parents (216,000 in 1973) and resulting progeny, or nutrient input to the lake from decayed carcasses following spawning. Estimates of the Sproat Lake stock, which is being used as a "control" indicates a continued increase in the size of the stock in the absence of treatment. This supports the hypothesis that survival of Sproat juveniles is increased by increased production of young GCL sockeye. The correlation between the number of GCL smolts in a given year (as indicated by estimates of the pre-migrant population) and the number of adults returning to Sproat Lake three years later was significant ($r = 0.881$).

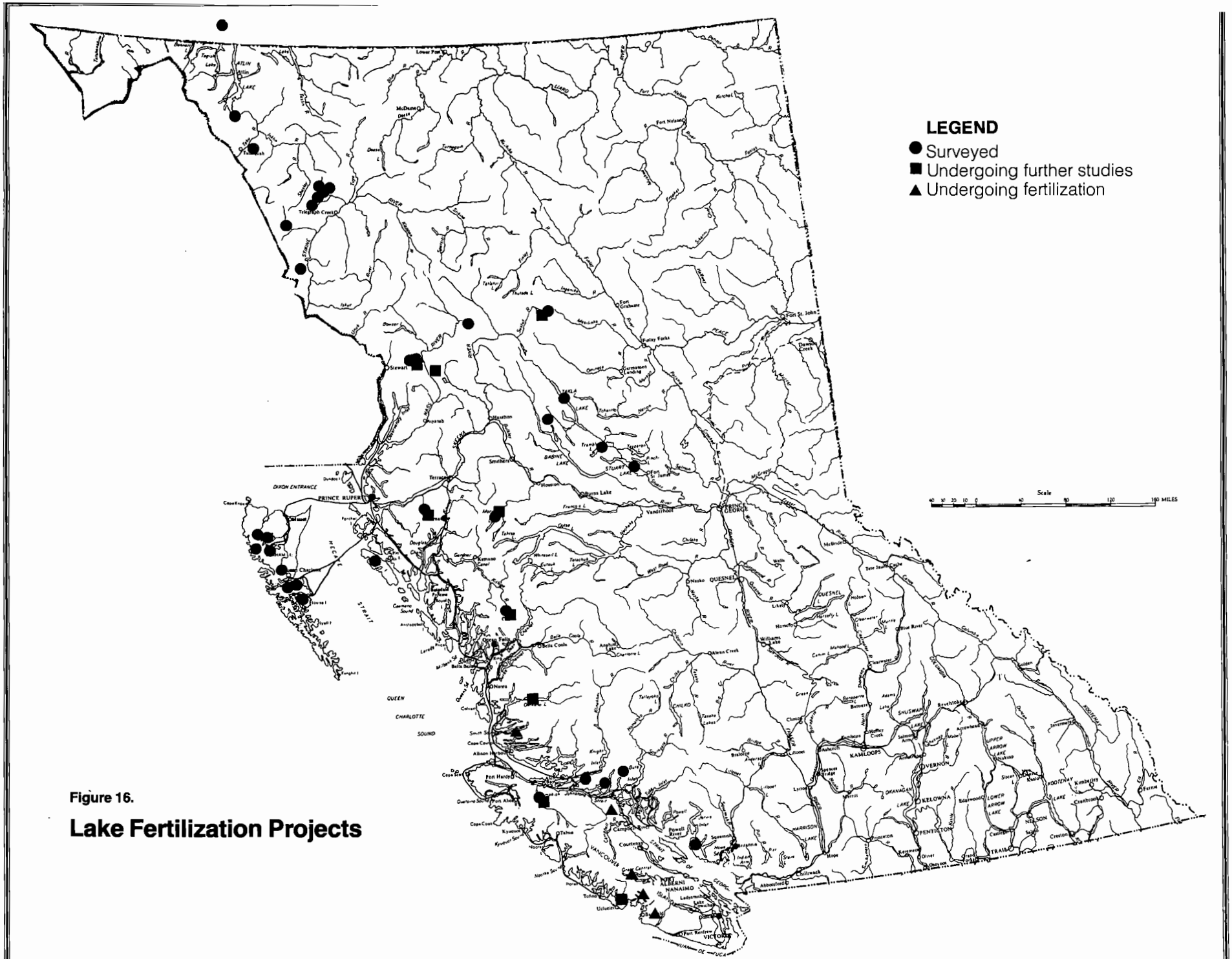
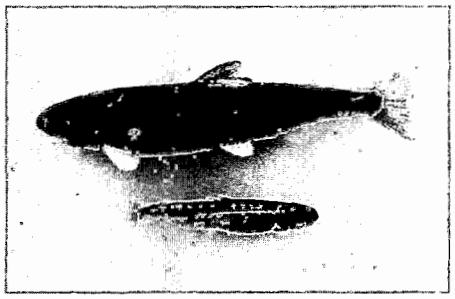


Figure 16.

Lake Fertilization Projects



Fed and unfed chum fry from Rosewall Creek have a difference in weight of approximately six-fold.

Japanese-Style Chum Hatchery and Plankton Watch

To test the applicability of the Japanese-style chum hatchery technique and to test the hypothesis that this technique results in higher survival rates than the Bams' incubation box method, one million chum salmon eggs from the Big Qualicum River were raised at the Rosewall Creek Hatchery under two conditions:

i) Lot A — One-half of the eggs were incubated with groundwater (temperature 7-8°C) following the Japanese technique. Two days before hatching, the eggs were spread out on screens (15,000 per m) in keeper ponds. Fry were marked with an adipose-left pectoral clip before entering the holding ponds and fry were fed for 8 weeks until release. Weight of fry at time of release was more than 2 g per fish.

ii) Lot B — The other half of the eggs were incubated with river water (ambient temperature). Shortly before hatching these eggs were put in two Bams gravel incubation boxes for further development and upon emergence the fry were all marked with an adipose-right pectoral clip.

The incubation box fry (lot B) were released in the evening with an equal number of Japanese-style fry (lot A). In total, 430,000 Japanese-style fry (weighing more than 2 g each) and 430,000 incubation box fry (weighing about 0.35 g) were released to the ocean in May, 1977. Returns of mature salmon (4- and 5-year-olds) are expected in 1981 and 1982.

Weekly samples of zooplankton were taken off Rosewall and Thornton Creek chum hatchery sites in nearshore areas to determine food availability at time of saltwater entry of fry.

Stock Establishment and Improvement

a) Test of Gene-pool Transfer Technique:

Attempts to establish pink salmon runs in the off-year of streams only producing pink salmon in alternate years have been in the past based on transfer of spawning stock or fertilized eggs from donor streams. Such attempts have generally failed to produce self-sustaining new runs. In 1975 an experiment began at Bear River on Vancouver Island to test the theory that infusion of the male component of the Bear River on-year gene pool into eggs transferred from a donor stream (Glendale River) during the 1975 Bear River off-year cycle would significantly increase adult returns to the river.

In April, 1976, marked fry of three types were released from the Bear River Hatchery (Table 28).

In addition, approximately 1,000,000 unmarked Glendale fry resulting from other experiments were released as buffers against predators.

Examination in 1977 of 667,000 fish (approximately 50 percent of the total catch for Johnstone Strait) recovered the following marks:

AdLV:48 (Glendale ♀ x Glendale ♂ — control group)

AdRV:31 (Glendale ♀ x Bear River ♂ — frozen sperm)

DV:37 (Glendale ♀ x Bear River ♂ — accelerated male)

Recoveries were approximately one-quarter of those expected. (Returns of all stocks in the Johnstone Strait area were far below normal.)

Chi-square tests between AdLV and AdRV are not quite significant at the 5 percent level ($P < .07$) indicating statistically equal returns to the fishery. The DV group is not included in comparisons due to the high likelihood of this mark occurring naturally in such a large sample. No marks were recovered from less extensively sampled catches taken in other areas except for 8 AdLV marks in samples totalling 62,114 from the Juan de Fuca fishery. If these are added to Johnstone Strait recoveries, totals become 56 AdLV and 31 AdRV which are statistically different ($P < .01$). It is interesting to note that the AdLV group would be expected to have a higher likelihood of straying to areas other than Johnstone Strait under the hypothesis of poorer homing propensity. Examination of recovery sites for marked fish in Johnstone Strait also suggest AdRV and DV marked fish were present in greatest numbers in areas adjacent to Bear River, whereas recovery sites for AdLV (control) were more variable. Other observations based on commercial fisheries recoveries include the following:

i) Timing of entry to the fishery was similar for all groups; however, recoveries of the AdLV (control) group occurred over a prolonged period.

ii) Length-weight measurements were taken on all marked fish recovered Females of the AdLV (control) group were found to be significantly heavier (about 15 percent) and longer (7 percent) than the AdRV group. No differences were found amongst males of these two groups. The differences observed related well to size of male parent. Glendale male parents were about 6 percent longer than Bear River males. The DV group was intermediate in size as might be expected if some of these marks were due to natural causes.

iii) Female:male ratios amongst groups were similar — approximately 2♀: 1♂ not unusual in commercial catches for the area.

Glendale River, the source of the donor

Table 28.

Summary of marked pink fry released from the Bear River hatchery in 1976 testing genepool transfer techniques.

Group	Number	Mark
Glendale ♀ Bear River ♂ (sperm from 1974 Bear River run, frozen for 1 yr. in liquid nitrogen)	136,047	AdRV
Glendale ♀ Bear River ♂ (sperm from accelerated 1-year-old males, derived from 1974 Bear River run)	136,026	DV[1]
Glendale ♀ Glendale ♂ (control group, sperm from 1975 Glendale run)	135,564	AdLV

[1]Double ventral.

eggs, was surveyed on several occasions and a total of 3,662 carcasses were examined from an estimated escapement of 20,000 to 25,000. No valid marks were recovered. Surveys of a number of streams in the vicinity of Bear River also failed to uncover any marked fish.

A fence was operated at the mouth of the Bear River from July 8 to October 23, at which time it was washed out. During this period only one (unmarked) pink entered the river.

Although it cannot be stated with certainty that no other pinks entered, the conclusion is that virtually no pinks returned. A number of theories have been proposed to explain the lack of returns to the river, including:

i) Genetic incompatability between year classes of pink salmon or genetic aberrations due to damage to sperm cells during the freezing or acceleration processes.

ii) Unsuitability of donor stock.

iii) Imprinting of the fry to "green" concrete in the newly constructed hatchery. It is possible that since the hatchery was not operated in 1977 returning fish lacked the necessary olfactory cue to home to the river after returning to the general area.

Observations on the fry and on adults returning to the fishery provide no support for the first theory and transplants to date generally show some returns regardless of donor stock. It is felt the last theory is most plausible.

The test, while demonstrating the feasibility of crossing year classes of pinks, is inconclusive in regard to the original hypothesis of increased homing propensity for donor stocks containing the male component of the homestream gene pool.

b) Examination of Loading Density and Flow Effects in Upwelling Gravel Boxes:

Eyed pink eggs from the 1975 Bear River run were loaded at six different density/flow combinations in twelve 1.2 m x 1.2 m "Bams-type" gravel boxes in the hatchery at Bear River. The test was designed in conjunction with R. Bams to test the incubation capacity of his units (Figure 17).

Analysis of data is in progress; fry samples have yet to be weighed and measured. Initial observations are as follows:

i) estimates of eyed egg to emergent fry survivals ranged from 84 to 106 percent (mean 95.6). Taking into account the estimation methods used for counts and variation between replicates it is concluded there were no detectable differences in survival between treatments;

ii) final conclusions on fry quality will depend on analysis of length-weight measurements. However, no gross differences in fry size, quality, or stage of development were observed visually;

iii) emergence timing patterns were similar for all boxes. Median emergence for all boxes occurred within a 2-day period. However, there was a suggestion that fish emerged slightly earlier from boxes with higher flows or densities;

iv) levels of 0_2, CO_2, and ammonia remained well within tolerable limits in all boxes. However, there were clear relationships between the levels observed and the flow/density combinations. On the basis of these it should be possible to predict O_2 demand and CO_2 and ammonia production for a given situation; and

v) while an upper limit for loading capacity of "Bams-type" incubation boxes was apparently not achieved, these initial observations indicate the maximum capacity is far greater than originally believed.

Figure 17.

Summary of egg densities and flow rates in experimental gravel boxes at Bear River.

Egg density (1000's)	Flow (1pm) 60	120	240
120	2 boxes		
240	2 boxes	2 boxes	
480	2 boxes	2 boxes	2 boxes

Stream Juvenile Production

The specific objective of the current subprogram is to maximize, at minimum cost, numbers of coho and chinook fry in natural streams by control of physical factors and by increasing available food. The Big Qualicum Experimental Rearing Channel was constructed for this purpose. Essential aspects are control of discharge, high density rearing of coho, provision of artificial food, and recycling of wastes into edible benthos. Since the fish are raised in series, the downstream gradient in water quality might result in differences in health and survival of fry and smolts. The hypothesis was proposed, therefore, that there would be no differences among numbers of returning adults derived from smolts raised in different regions of the channel. To test this, 30,000 fry from each of four sections in the channel were clipped and tagged in February. Smolt release was in mid-May.

Mean weight of smolts were: section 5 (downstream), 21.5 g; section 4, 18.0 g; section 3, 17.0 g, section 2, 13.5 g. Section 1 had no fish in it until April, when it received the 1976 brood swim-up fry.

Attempts to count accurately the out-going smolts failed. Recapture after tagging, however, indicated a 40 percent loss of fish since ponding. This is attributed to predation from birds and mink. Cannibalism was not significant. A net was put over the channel in December to reduce predation.

The large size of the downstream fish suggests that the basic hypothesis is wrong. With a discharge of 425 litres/sec, oxygen demand and metabolic products did not impair water quality significantly, whereas channel enrichment resulted in the downstream fish obtaining more natural food than the upstream. Chemically, therefore, the channel could support more fish. Pool size, however, presents a limitation. This could be best overcome by an increase in channel length.

This portion of the Big Qualicum experimental rearing channel shows riffle-pool arrangements, shelters and predator nets.

About 75 percent of the upstream fish, and 95 percent of the downstream, had natural food in them at anytime between June and October. About a third had at least 25 percent of the stomach full of natural food. The most available items were chironomid pupae and larvae. Although the pool benthos responded most to enrichment (a 20-fold increase in biomass after 11 months), the riffle benthos provided most of the food. Detailed studies determined the response of benthos to fish wastes, the rate of recolonization of gravel after cropping, and the optimum gravel size for riffle benthos.

After the exodus of smolts, the channel was cleaned with a fire hose, the quality of the effluent being controlled by the rate of cleaning. Recolonization by benthos took 3 weeks.

In the fall, 176 jacks reached the channel outlet; 23 percent were tagged. Some, but not all, originated from the channel. Most jacks were captured at the mouth of the Qualicum River.

As in 1976, the new brood was ponded into four pens. In addition, however, 33,000 were placed directly in the channel after the water velocity in section 1 had been reduced by means of a shallow weir. In consequence, it was found that swim-up fry can be reared directly in the channel and the pens can be dispensed with.

The 1976 brood of fish was transferred to sections 2 to 5 of the channel in June. Screens were removed to reduce mortalities from mink, which chased fish onto them. A lower summer temperature and reduced rations resulted in fry in November being half the weight of the previous year's fish at that time. This should allow comparison of effects of size on adult returns.

In the second half of summer, the fish were fed, by hand, three times a day, every second day, to encourage consumption of natural food. Comparison is being made of diets under the two conditions.

From a managerial viewpoint, this project is showing that 0.5 million smolts can be raised without hydropower, with at least 75 percent less commercial food than would be used in a traditional hatchery, and with a labour demand of about 1.5 man-years.

B. PROVINCIAL

Marine Steelhead Interceptions

Steelhead trout are highly vulnerable to salmon fishing gear, and many B.C. populations of this valuable sports fish are believed to be declining due to a combination of environmental and harvesting pressures. There is some concern that the increased salmon fishing created by successful salmon enhancement projects will endanger steelhead stocks. The Marine Resources Branch of the B.C. Department of Recreation and Conservation undertook a project to estimate the numbers of steelhead that are currently being caught in Canadian commercial salmon fisheries. In addition to determining the magnitude of commercial interceptions, a variety of data on the timing and distribution of the catch were collected in order to assist in the prediction of potential impacts on steelhead stocks from proposed salmon enhancement projects.

Information was collected in four different study areas by interviewing gillnet and seine fishermen at the time of the delivery of their salmon catch. The data included the location and duration of fishing effort, the salmonid catch, and the times and places of steelhead catches. In addition, biological samples were taken of most of the steelhead caught by interviewed fishermen. The reader is referred to "Incidental Catches of Steelhead Trout in the Commercial Salmon Fisheries of Barkley Sound, Johnstone Strait, Skeena River and Fraser River", available from the Marine Resources Branch.

a) Fraser River (Federal Fisheries Area 29 A, B, and D):

The 1977 commercial catch was estimated to be 800 ± 300 steelhead. (The 1976 catch was estimated to be 1,000± 200; this greater catch was probably due to longer and more intensive chum fishery of that year.) The timing of the catch and biological sampling indicate tht these were primarily Thompson River fish. Although the catch is substantial compared to estimates of the sports catches and spawners on the Thompson, it represents such a minute portion of the total commercial salmonid catch that no control or regulation of the commercial fleet would be cost-effective for their protection. Declining steelhead stocks on the Fraser system appear to be in need of enhancement to maintain themselves against current harvesting and environmental pressures; enhancement of late Fraser chum stocks could create additional pressure on these populations.

b) Barkley Sound (Federal Fisheries Area 23):

Approximately 800 ± 150 summer run steelhead from several Alberni Inlet stocks were caught during the harvesting of enhanced sockeye stocks from Great Central Lake. Again, the number is large compared to estimated escapement, but small compared to the $5 million salmon fishery. The valuable steelhead sport fishery in the Alberni Inlet area will clearly require enhancement of natural stocks if the lake fertilization program (sockeye enhancement) continues.

c) Skeena River (Federal Fisheries Area 4):

This area had the largest steelhead catch of the areas studied, with an estimated 10,000 ± 1,000 steelhead caught during the brief but intense 1977 fishery for sockeye and pink salmon. (The 1976 catch was estimated to be 5,000 ± 500; this smaller catch was probably due primarily to reduced fishing effort due to poor salmon returns.) Timing and biological data indicate that the steelhead caught are primarily Babine and Kispiox stocks. These stocks appear to be fairly strong despite a history of intense fishing at the mouth of the Skeena River. The recent enhancement of Babine Lake sockeye which is just beginning to effect fishing effort in this area, may create excessive steelhead harvesting rates. Data on time and place of catch are analysed to determine if a modification in the length and frequency of fishing openings would reduce steelhead catches without a reduction in salmon harvesting efficiency.

d) Johnstone Strait (Federal Fisheries Areas 12 and 13):

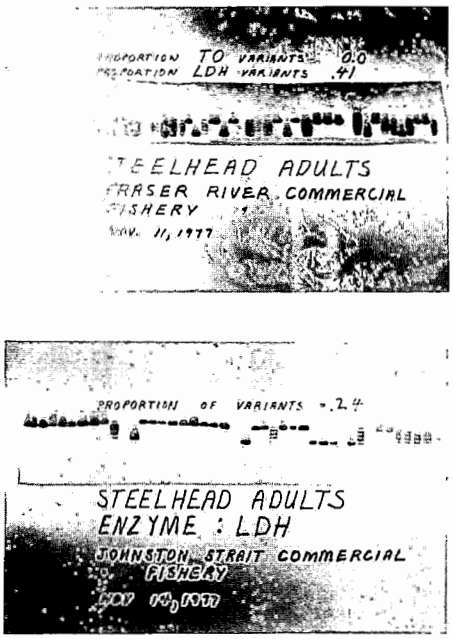
An estimated 3,000 ± 500 steelhead were caught by gillnets and seines in this extensive and highly mixed fishery. It is not possible at this time to determine what portions of the catch were mainland Fraser, Vancouver Island and Puget Sound fish. Fishing was fairly poor in 1977 in this area, especially the later runs; 1978 may show an increased steelhead catch with increased salmon fishing.

The restoration and maintenance of historic levels of natural steelhead stocks is probably incompatible with current salmon fishing effort, and increases in the salmon stocks and fishing effort will unavoidably increase the harvesting pressure on the remaining steelhead stocks. Steelhead enhancement projects will be required to prevent extinctions of some populations and to supply numbers adequate for a healthy sports fishery.

Stock Identification (Enzyme Analysis)

Stock identification of steelhead has become an important research area for SEP due to the high level of commercial interception of these fish and increasing enhancement and management interests.

By identifying characteristic isotopes of the enzymes in steelhead tissues, stock identification can be assumed through the inference of genetic continuity. Tissue samples are required primarily from liver en-



Electrophoretic plates separate different chemical structures of the same enzyme and are used to identify genetically-related steelhead in the commercial fishery.

zymes; however, muscle and eye samples are also used. Electrophoretic patterns of enzymes from fish originating in a certain stream can be correlated with samples from marine steelhead catches to help identify fishery utilization of the different stocks.

Beginning last year, tissue samples have been tested from steelhead taken from a number of different streams and life stages. There are approximately 1,600 fry, 400 smolt and 250 adult samples taken from the entire Fraser system, Upper Skeena tributaries, and some streams in the Georgia/Johnstone Straits area. About 810 samples were obtained from the commercial fisheries in the Skeena River, Fraser River, Johnstone Strait, and Barkley Sound areas.

The main focus of this year's work has been to look at whether or not geographic patterns of enzyme variability are stable from year to year and consistent through the fry to adult life history stages. Such stability is essential if enzyme variability is to be used for stock identification. As a consequence, much of the sampling this year has consisted of intensive sampling of a few river systems rather than looking at province wide patterns of variability. The results of this work look promising in that the within river variability is much less than the between river variability. Some of next year's sampling program will be designed to confirm this conclusion but most of next year's samples will be used to fill in gaps in the large scale geographic pattern.

The accompanying photos show the contrast between the patterns of interior steelhead and coastal steelhead for LDH (Lactic Dehydrogenase). Another enzyme which shows a similar but opposite pattern is TO (Tetrazollum Oxydase). The separation of interior and coastal fish in the commercial fishery is definitely possible at present but it remains to be seen if stocks within Barkley Sound, for example, will be separable from each other.

Preliminary results show that 100 percent of the Fraser River and 30 percent of the Johnstone Strait commercial steelhead catches are returning to the Thompson/Chilco system. A more complete report on this is forthcoming in 1978/79.

Stream Enhancement Research

a) Freshwater Carrying Capacity:

Studies on the Keogh River are attempting to develop techniques for predicting the production capacity of coastal rivers for anadromous gamefish, particularly steelhead trout. Currently, there is no reliable method for the determination of smolt output and expected numbers of adult returns (adjusted for variable annual survival in the ocean); presently only gross estimates can be obtained from expansion of steelhead catch data from the punch card questionnaire.

Test areas throughout the Keogh River are censused for fish densities and a habitat classification system developed. With the assistance of low level aerial photography the entire river is classified according to specific habitat types and the abundance of pre-smolts estimated. Each test area consists of 20 m of stream enclosed by stop seine nets. All fish including juvenile coho, steelhead, cutthroat, Dolly Varden, sculpins, lamprey and stickleback are removed by a combination of minnow trapping, electroshocking, river seining and pole seining. Fish are counted, measured, weighed and a sample aged from scale collections. Physical factors of each section are recorded including flow, depths, velocities, length and width, temperature, upstream hydraulics, and detailed quantification of cover characteristics (e.g. surface vegetation, over-stream debris, in-stream debris, surface turbulence, and substrate). Several subclasses of pools, runs and riffles are typical areas and knowledge gained from their analysis relative to fish abundance was rapidly applied to the experimental evaluations of in-stream devices. During June to July in 1976 and 1977 more than 80 sections were examined and most of the data is still in the analysis stages.

A 44 m fish counting fence, constructed of wooden timbers, steel screens with rotating panels and 15 wolfe smolt traps, has been utilized to enumerate anadromous gamefish migration in the river. Problems with high water in 1976 and trapping efficiency in 1977 have made it difficult to obtain accurate production data on smolt output. A novel smolt trap comprised of 75 m^2 of submerged horizontal screen and 18 m^2 of vertical screen has been added to increase reliability of smolt enumerations. This data is mainly required to test the accuracy of the predictions of smolt output derived from the juvenile census plus habitat classification.

Adults are also enumerated at the fence by using a mark/recapture method based on recovery of fish in the sport fishery and as kelts migrating seaward. The steelhead run was 920 and 650 in 1975/76 and 1976/77 respectively, and the Dolly Varden 2,000 annually.

Preliminary results indicate that production of steelhead in the Keogh River is limited by the amount of total dissolved solids (TDS — particularly phosphorus) and the amount of stable in-stream cover such as logs, root-wads and boulders.

Unfavorable flow conditions such as major freshets are also considered to affect juvenile production because the lowest percentage of pre-smolt parr has moved out of the river in the spring after a winter associated with a major freshet. Such freshets frequently cause extensive movement of the streambed and move in-stream cover of fish.

Hopefully, habitat descriptions in relation to fish density can be developed into a predictive model for deriving reliable estimates of gamefish production for typically fluctuating coastal rivers.

	Approx. TDS	Productivity
Keogh River (coastal)	25 mg/1	low
Fraser Valley	50-60 mg/1	↓
B.C. Interior	approx. 125 mg/1	higher

b) Evaluation of In-stream Devices:

Although British Columbia is becoming increasingly involved with improvement of the natural stream habitat, limited information is available to provide guidance on the utility and installation of various habitat improvement devices. Eastern Canada and

the eastern United States have examined several in-stream aids to the production of salmonids and these have largely proven successful. In an attempt to quantify and evaluate the effects of several designs of gabions, rip-rap and cabled log structures on the survival and growth (summer and winter) of juvenile steelhead trout and coho salmon, experiments were conducted in 1977 at the Keogh River on northern Vancouver Island.

Gabions (wire baskets filled with rocks) were tested in three arrangements; V-notch weirs, deflector without cover, deflector with cover. Rip-rap (large, angular pieces of rock) were placed in four patterns: V-notch, deflector without cover, deflector with cover, and a random grouping. A preliminary assessment of logs secured into the stream banks with cables was also conducted. Altogether there are 38 structures, including replicates (plus controls) and further work is planned to involve other devices such as I-deflectors, log cribs, and a fifth design of rip-rap placement. Assessments of durability and cost are major objectives of this research.

Experimental enhancement of sea-run cutthroat and coho production using rock and root wad arrangements in four treatment zones is also underway on Colquitz Creek near Victoria. A novel design of a "reverse gravel platform" is also being evaluated for spawning of these species, because spawning gravel in urban streams is of poor quality.

Cutthroat Culture Development

The Abbotsford hatchery is the location of a research project developing sea run cutthroat culture techniques for SEP. Enhancement goals include supplementing depressed stocks in the Chilliwack area using hatchery techniques, and subsequent expansion of the program to other areas of the province.

Approximately 20,000 eggs were taken from 18 females in February and March of 1977 (average fecundity was 1,100 eggs/female). After a one-year period of successful incubation and rearing, 15,500 juveniles are presently on hand. Different size groups of fish will be released in April, after fin-clip marking, with the largest group being 90 grams. A fence will be installed at Gravelly Slough and both adult and juvenile migrations will be monitored.

The success of this project to date indicates some potential for sea run cutthroat enhancement using hatchery methods. A very high survival rate of approximately 75 percent from egg to pre-smolt stage demonstrates the hardiness of this stock. It is hoped that cutthroat will imprint like steelhead, at the smolt stage, and that reliable homing can be expected. A second egg take is being mobilized, although a shortage of adults may necessitate a reduction in numbers to be reared.

Semi-Natural Steelhead Rearing

To evaluate alternative methods of culturing steelhead, experiments were conducted at the Abbotsford hatchery. In this study, steelhead fry from the same brood stock were divided into two groups: one exposed to hatchery conditions and the other reared in "semi-natural" net pens (ie., exposure to a natural water, temperature and light regime).

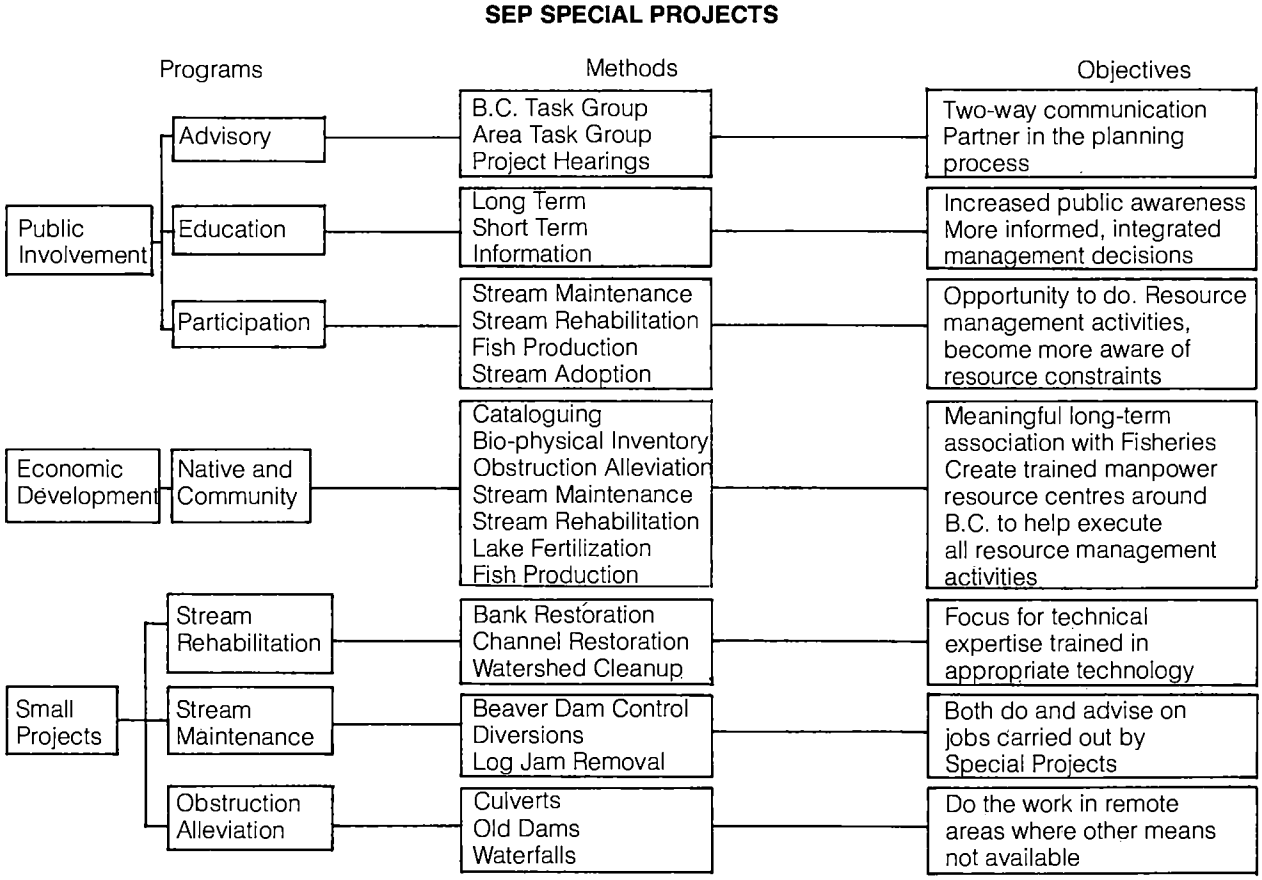
Chilliwack River brood stock, consisting of four females and two males were treated with gonadotrophin. Subsequently, ovulation was achieved approximately 2½ weeks earlier than usual and 29,000 eggs were successfully fertilized. The females were of above average fecundity and ranged in size from 13 to 16 lbs.

The semi-natural rearing area was constructed in a 4.9 m x 7.3 m building floating on a pond off the Chilliwack River. The building has interior walkways and is divided into two 2.4 m x 2.4 m x 1.2 m marquisette-lined pens. The outer pen structure is made of one inch steel mesh for aquatic predator control. The fry are fed automatically, with some natural food supplements. The second group is being reared under standard hatchery conditions.

Approximately 24,500 fry were ponded and, at present a total of 15,000 pre-smolts (9,000 at the hatchery and 6,000 in the rearing pens) are on hand. The fish are approximately 40 g each and will be reared for another month before the nose-tagged, fin-clipped fish are released into Upper Chilliwack River tributaries. A 1978 brood egg take is underway and 20,000 eggs are presently incubating.

Figure 18.

Special Projects Unit Organization



IV SPECIAL PROJECTS UNIT

A. PUBLIC INVOLVEMENT

Program Development

Due to a late start in Year I (mid-summer of 1977), the Public Involvement Program (PIP) has not progressed as extensively as had been hoped. Final budget allocations were not recommended until the November meeting of the working group, thus allowing basically only four months of concentrated activity in Year I. Nevertheless, PIP has not stood still.

The B.C. Task Group progresses, and has expanded its membership to better reflect a cross-sectional mosaic of the B.C. community. Four full group sessions have been held this year (total of eight since its inception in 1976) plus four special subcommittee meetings. In addition, its elected executive has met once or twice a month. The one local Area Task Committee remains on "hold" in the Bella Coola Valley, although indications are that it may soon be reactivated.

The Public Involvement Working Group has been reformulated and is evolving a more assertive role in the direction of PIP program policies, activities, and budgets and meets bi-monthly. Its membership continues to reflect the diversity of disciplines involved in SEP from both the federal and provincial perspectives.

A series of community discussions, to follow the "Public Inquiries", will be conducted in the original 17 communities in 1978/79. This time the team will include all key components of SEP.

Joint field-staff Workshops are being designed to help improve the sensitivity and managerial ability of public involvement at the local level. Such workshops are essential if the long-term successful integration of public involvement within SEP is to be assured. This is one aspect that should continue to receive high priority from the PIP leadership.

Special research, investigating new avenues to more adequately involve the citizens in large urban communities, will con-

tinue until spring when a more comprehensive plan will be presented for review. Similarly, the role of native involvement in SEP is being thoroughly examined from many perspectives. Physical participation in small stream projects already has been absorbed within the Special Projects Unit.

Numerous informal and formal discussions have been conducted with key personnel within both the Fisheries & Marine Service and the Fish & Wildlife Branch. A growing appreciation of the importance of PIP is apparent, yet, much more energy must be devoted to this particular role. Professional assistance should lead to more productive, cooperative efforts through the remainder of Year I, into 1978/79, and beyond. Specific consultation with the SEP Director and his Directorate continues as requested.

Unregulated activities have had a significant adverse impact on the environment and ecology of the Fraser River and it is recognized that public support of SEP goals is an important factor in dealing with the situation. In order to aid in PIP policy planning, a report was prepared (W.B. Paulik, 1978) identifying ways and means to encourage active public involvement toward conservation of the Fraser River. The report summarizes and evaluates present mechanisms and impacts of public involvement such as formal hearings, information meetings, existing groups, etc., and identifies 22 new, specific opportunities for public involvement.

Education

a) Educators' Package:

Public inquiries on SEP in 1976 indicated that there was a need for young people's education on this subject. Several educators in British Columbia are already involved in field studies and the idea of SEP involvement in the schools has been fully supported. In order to provide a mechanism for teachers to incorporate the program into their curricula, an educators' package has been developed.

In overview, the package is divided into four units. The lessons of Unit I provide a perspective for viewing the salmonids. Since every aspect of their habit is important, a full orientation is necessary. The emphasis in Unit I shifts gradually from the entire B.C. community to the vital watershed areas to the nurturing streams. Unit II describes the characteristics and traits of each of the salmonid species, compares their anatomy to the human's and speculates as to the stimuli causing the spawning response. The lessons of Unit III focus on the many aspects of the fishing experience. The commercial fishing industry — its development, the techniques employed and its people are dealt with in the context of B.C. and the salmonids. Likewise, the recreational aspects of salmonid fishing are examined. In Unit IV, the lifestyles of British Columbians are brought to the fore: problems, choices, potential solutions loom in the background, challenging the student to reflect upon his values. Among the issues to be considered is the dilemma of fish versus hydro-electric power.

The material will be available in two levels: the junior high school section for grade nines; and the elementary school section, for grade sixes. The package can be adapted either up or down and could be used by kindergarten teachers. Each lesson is supplemented with visual aids and can be used in social studies, language arts and science classes. The package is presently in its second draft and under review by SEP managers. It is hoped that it will be available for use in the schools by September, 1979.

b) Educational program on Fishing Regulations:

Between May 1977 and March 1978, 98 percent of all public and private schools between Mill Bay and Kelsey Bay in the east coast of Vancouver Island were approached on the subject of developing an educational program on responsible attitudes towards fish and fishing regulations. Approximately 38,500 students ranging from kindergarten to grade twelve, together with 1,700 teachers were involved in this program during the contract period. Each school district was approached separately with a view to the fishery problems of the locale and pupils were involved by seeing films, slide shows and attending a series of lectures.

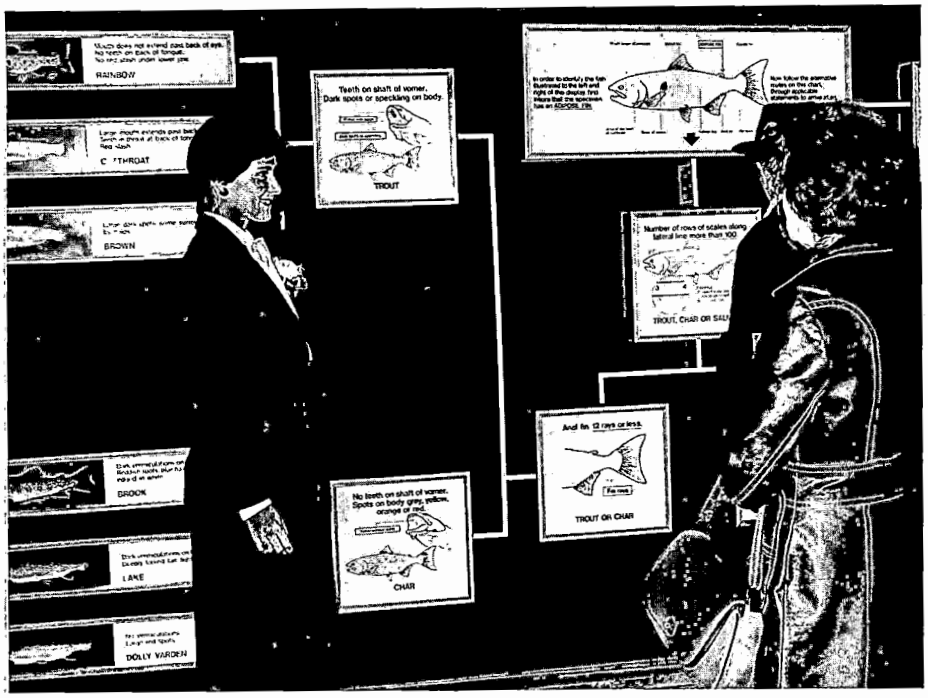
The program analysis recognized different attitudes toward authority in general among different ages of students and reflected the need for information on rules about fishing. Basically, the student body was approached and confronted with fishery and resource laws and discussion forums were initiated with the young uninformed person on the need for correct attitudes toward the environment and the law.

Information

a) Public Displays:

The PNE display in 1977 consisted of aquaria and rearing tubs filled with salmonid fry, smolts and adults incorporated into a covered area lined with photographic displays. A 3.1 m x 6.1 m information panel described SEP and its intergovernmental involvement and the photos described fishing methods in the early 1900's, conventional methods, and futuristic ideas. Personnel were in attendance at all times and the entire display was dismantled for possible re-use.

Next year, the information section hopes to



The Fraser Valley Trout Hatchery incorporates high-level public displays into the hatchery design and is a popular spot for both tourists and community members.

construct a simulated river, 60 m long, complete with all the salmonid species and heavily landscaped with natural plants, ferns, and trees for a total immersion effect.

Permanent public information display boards were erected at the Fulton River, Pinkut Creek and Babine River camps. The displays contain maps of salmon spawning areas in B.C., sketches of the Babine facilities, and photos describing salmonids at every stage and many fishing activities.

As part of a general updating and refinement of the Capilano hatchery public display works, a scale model of the hatchery was developed. The new model is actually an update of a previous structure that was completed in 1971. The model will be approximately 1.2 m x 2.5 m and will be installed on the site this spring. Further improvements of the Capilano hatchery public display area are planned for 1978/79.

b) Audio-Visual Material:

A slide/tape package, approximately 15 minutes long, is being produced in an attempt to explain SEP to the public using audio-visual material. The narrative begins by outlining the life cycle of salmon, the first contact with man with associated economic and social impacts, and progressing to modern civilization and the problems it creates for salmonid species. SEP in its present form is discussed in terms of intent, expectations and participants.

The package is for use with a single or double slide projector and sound system and can be adapted for broadcast on local television stations. It will be available in various SEP-associated offices throughout the province and is designed for use at public meetings, rod and gun clubs, etc.; hopefully, to be used in conjunction with informative literature.

"Tomorrow's Salmon" is a 24 minute documentary film setting SEP in clear perspective. The film features commentary by Peter Larkin, fisherman Jimmy Sewid, businessman Bill Harrison and late author-naturalist Roderick Haig-Brown. It is available at the Information Centre's film library (NFB 106C 0176 563).

SEP funds allowed the purchase of three copies of the film, "Damned Forever", produced by American sport fishing organizations. The film is approximately 30 minutes long and presents a dramatic description of the permanent, far-reaching environmental effects of power dams. Interviews with Washington State fisheries biologists bring indirect problems associated with dams and reservoirs into focus; for example, the effects of coarse fish proliferation and nitrogen supersaturation on salmonid populations. The Columbia River is taken as a case study where the effects of many high damming projects have all but eradicated anadromous stocks. Copies of the film are available from the Information desk at the Fisheries Service.

c) Publications:

In order to aid in facilitating public support and involvement in SEP, funds were made available for two specifically SEP-oriented background publications, the "Salmonid" bulletins and fact sheets. The "Salmonid" bulletin is published bi-monthly and includes current information on enhancement activities. The fact sheets focus on modern salmonid enhancement techniques such as fishways, lake enrichment and hatcheries. Aproximately 15,000 copies of each document are delivered by mail and additional copies are delivered in bulk to fisheries offices in many locations. To date, 14 bulletins and 3 fact sheets are in circulation.

"Where and When to See Salmon" is a booklet produced this year describing 7 of the most accessible enhancement projects in B.C. and when fish can be seen there. The text will be frequently updated to include both natural and artificial sites.

Three brochures describing the Salmonid Enhancement Program in general have been prepared. At present, they are awaiting French translations and will be published at a later date.

Recognizing a need for a technical manual for stream studies, enhancement projects and classroom studies, a handbook, "Small Streams and Salmonids", has been written. It is a product of joint funding between SEP, the B.C. Fish and Wildlife Branch, the B.C. Ministry of Education, the Seattle Municipality, and Washington State education groups.

The manual has been locally field tested to meet the needs of community groups and of teachers in upper elementary and secondary levels. It consists of the following sections:

i) small stream study with community and school;

ii) biology of salmon;

iii) small stream enhancement projects; and

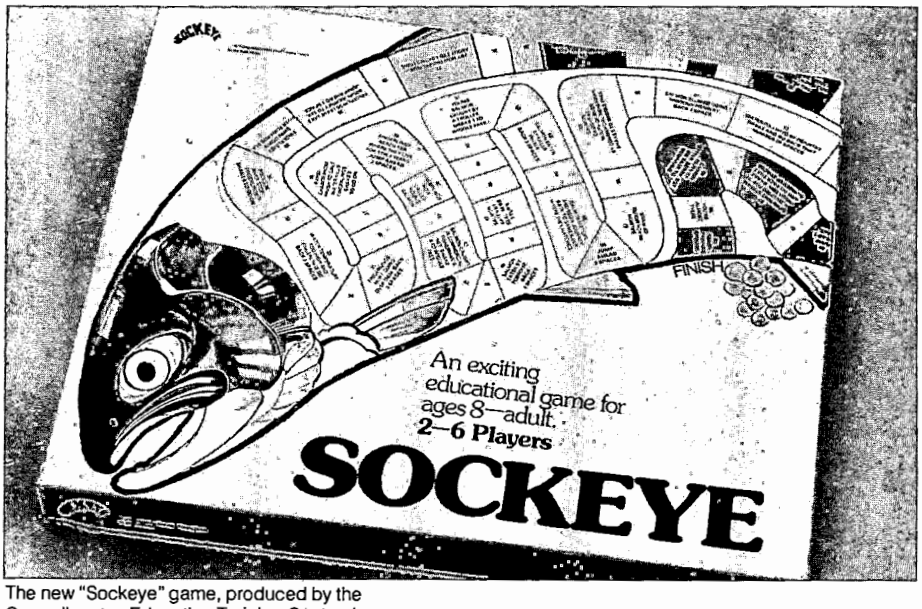
iv) salmon culture.

The manual consists of more than 200 pages of detailed technical instruction and is appendixed with suggested activities, bibliography and recommended reading, opportunities for employment, and a lab procedure for the Winkler oxygen sampling technique.

A book dealing with salmonid enhancement, along the lines of the TIME-LIFE Science Series is nearing the final draft stage. The book will include material on salmonid biology, life history and habitat. It will deal with a number of forms of salmonid enhancement: stream improvement, lake enrichment, transplants, fishways, spawning channels, hatcheries. It will also deal with aquaculture and salmon management. The book is planned to have a generous number of photographs and artwork. A target printing date is in 1978, hopefully in time for school opening.

d) Game:

A game, "Sockeye", has been produced for use in the elementary schools' Social Studies curricula. It is played similar to "Snakes and Ladders": if a player lands on the "eaten by otter" square, he must return to the beginning; if he is caught in a com-



The new "Sockeye" game, produced by the Coqualleeetza Education Training Centre, is now being field-tested.

mercial fisherman's gillnet, he must shake "2" to wiggle free; etc. Ideally, the game is played with six people, each representing 50,000 eggs, and usually no more than one player will reach the end.

The game was published in September, 1977 after nearly a year of preparation, and is currently being field-tested in Chilliwack. At this point, it is not available for commercial sale; however, negotiations concerning mass production and publishing rights are being considered.

e) Provincial Information Centre:

To help facilitate the Fish and Wildlife Branch to develop educational and informative material on their aspects of SEP, funds were directed through the Information and Education Branch.

A workshop was held in January 1977 to coordinate and educate information officers. Representatives of the television and newspaper media were also included. A folder of SEP informative material is being assembled and will be for community use. Copies of films and publications were also purchased to be readily available in various offices.

Interpretive on-site signs will be produced and erected in approximately 30 to 40 locations. These will describe fisheries activities in areas where SEP involvement is not always visible, for example, stream clearance. A general copy for these will be developed and sign erection will continue as new projects emerge.

Displays are also being prepared for use in the two major ferry runs. Arrangements and negotiations for these are underway.

Participation

a) Madeira Park Students:

A project to cut trails along spawning streams tributary to Sakinaw Lake in the Pender Harbour area was undertaken in the summer of 1977. Spawning gravel was also added to the streams where necessary. The work was carried out by students under the supervision of the local Fishery Officer. The Young Canada Works program paid for the labour and Fisheries Service funds purchased hand tools.

b) Pacific Salmon Society:

An inventory of salmonid spawning streams in the Pender Harbour/Jervis Inlet areas is presently underway. Activities will include:

i) interviewing local residents to collect information on spawning areas and suggestions for improvement:

ii) assembling and summarizing Fisheries Service data on local streams, their production levels and problems; and

iii) field visits to help select and recommend streams for improvement.

To date, questionnaires have been distributed and the statistics will be compiled in 1978/79. Stream surveys will be commencing shortly.

c) Pacific Trollers Association:

The coho spawning population in the Pachena River, near Bamfield, has gone from approximately 3,400 thirty years ago, to 400 in 1977. In order to gain information on the stock and to increase the number of spawners, the Pacific Trollers Association has built a 50,000 egg incubation box to be installed on the river. Although an egg take was planned for 1977, a combination of high water, mudslides, bridge washouts, and other technical problems have forced a postponement until 1978.

d) Cowichan Fish and Game Association:

The main objective of the Association was to formulate plans and organize the public in localized sport fish enhancement projects. Projects of natural or semi-natural content were undertaken with an emphasis on educational involvement.

Ten schools participated in feeding coho fry in Rotary Park Creek, a groundwater-fed sidechannel of the Cowichan river. Initial surveys and habitat sampling were conducted during February, 1977, using an electroshocker and upstream/downstream seines to determine fish numbers and condition. The feed site was fenced off and after four weeks of feeding and trapping, mean lengths of the fed and unfed fish were 120 mm and 70 mm respectively.

On Glenora Creek, a log jam was successfully notched to allow passage of more than 125 coho into several miles of excellent spawning and rearing area. Falls on Bear Creek were modified to form a fishway using blasting and cement wall construction in a very difficult location. Water was diverted around falls on Averill Creek using an old low-level dam site just upstream. Three other streams were assessed for obstruction removal and will be worked on by group volunteers in order of priority in 1978.

e) Port Hardy Secondary School:

The Biology 11 class at the school has been working towards improving the salmon stocks in a tributary of the Tsulquate River near Port Hardy.

Preliminary work in September and October, 1977, included removal of garbage and debris from the creek and removal of log jams to improve access for fish. At this time, there wre a few coho fry in the stream. Apparently this small stream which runs through Port Hardy had supported a larger coho and pink run than the rest of the Tsulquate River system. However, previous land clearing has resulted in silting of several spawning beds and apparent mistreatment of spawning fish has reduced the population.

Currently the Construction 11 class is starting work on a 50,000 egg upwelling incubation box to place in the stream. Hopefully, coho eggs will be incubated in the fall of 1978 and the condition of the box will be closely monitored by biology students.

If the project is successful, fry feeding programs will follow. It is hoped to involve all ages of students in the program at that time. The school regards the program as primarily educational in nature, and any long term involvement of the salmon stock in the stream will be an added benefit.

f) Prince Rupert Secondary School:

This project is designed to maintain a stock of approximately 4,000 coho fry in plywood rearing boxes until they reach smolt size. The boxes are presently being constructed in the school shop by students, and completion is expected in early April.

The fry will be collected from the creek in May after hatching. From then until release, they will be fed standard hatchery feed, hopefully from a Department of Fisheries source.

An improved location for the boxes appears to be the City of Prince Rupert Public Works yard. This site is much nearer the source of water, is securely fenced and a watchman is on duty throughout the night. It is in close proximity to Oldfield Creek and effluent water from the boxes can be discharged into the creek. Although not officially approved, problems with relocation are not anticipated.

Observations of the creek have been an ongoing activity of classes in the school. Attention has been focused on determining how many fish are spawning and when it takes place. In spot checks, a total of 10 fish were observed. Three carcasses were obtained and checked for spawning. All were female and had spawned completely with virtually no egg retention. Spawners were observed at the end of October and throughout November, and an adequate hatch of fry is anticipated.

Recently, checks of the creek have been made to attempt to determine when smolts leave to go to sea. A student has reported seeing a concentration of 100 to 200 10 to 15 cm fish, suggesting the smolts are going to sea about mid-March. This means the fish may have to be reared for a full year

unless rearing conditions make them develop more quickly.

Although the boxes are expected to be completed and operable in time for the fry migration a source of food and basic rearing information is still required. Teachers hope to visit the Capilano Hatchery and the Pacific Biological Station to discuss details with experienced personnel.

g) Colquitz/Craigflower Enhancement:

Activities on the Colquitz and Craigflower systems are primarily concerned with urban watershed management. Working with officials from every level of government and several outside agencies, concerns such as storm water drainage, channelization and water licenses are being considered with a view to integration with environmental requirements for fish production. Considerable habitat improvement has been implemented in the form of creating new spawning areas, improving shoreline vegetation, and ensuring adequate water levels in certain areas.

Present escapements of searun cutthroat trout and coho salmon are very low and enhancement using incubation boxes aims to produce additional adults for the urban sport fishery. The biology of searun cutthroat is not well understood, therefore the first two years of enhancement have dealt with life history and population studies as well as physical assessments of the streams. Two fences in each creek monitor adult and juvenile numbers and density while scale sample and creel census analyses provide biological information.

At present, there are 18,000 cutthroat and 5,000 coho eggs in incubation boxes which are gravity fed from the Goldstream reservoir. A proposal to rear the fry in fresh water has been forwarded.

h) North Island Steelhead Society:

The Steelhead Society of B.C., North Island Committee, has been attempting for nearly 2 years to mobilize an incubation box project. This spring, under SEP, members obtained blueprints for a 50,000 egg incubation box and initial survey activities are underway. The Society plans to construct the box on the Goodspeed River, on the Canadian Armed Forces Base at Holberg. The box will be gravity-fed with water from Mud Lake and will contain coho eggs by fall, 1978. Public involvement in this project is stressed; the site will be tended by individuals from the CAFB, summer work will be done by work clubs, and students will prepare rearing pens on floats in Mud Lake. The Society also hopes to implement a stream improvement project in the future, involving one section of the Keogh River that can be protected on a long-term basis.

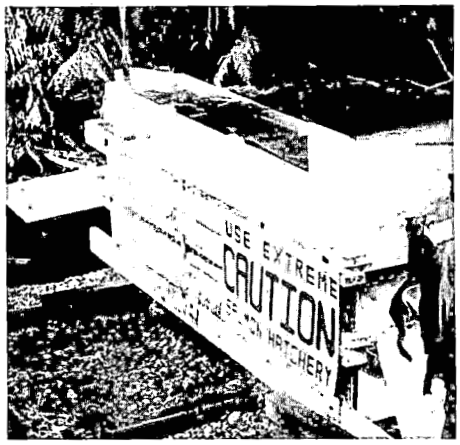
i) Sooke Conservation Society:

The main project in 1977 was the repair of a dam on Brantford swamp (DeMamiel system). After vandalism in 1976, the Water Resources Branch identified the need for a major repair operation. With SEP funding and Sooke Conservation Society (SCS) labour the dam was fully operable in late summer when flow control was most needed.

A small concrete storage dam on Matheson Lake was installed to supply salmonid rearing areas downstream on Matheson Creek. Labour was supplied by the SCS and the Young Canada Works Program (YCW), with funds from SEP.

The seven YCW students, under SCS supervision, also implemented a feeding program on Matheson, Tugwell and DeMamiel Creeks. Streams were fed three times per week and food was supplied by the Fish and Wildlife Branch. Considerable fry salvaging took place during low water levels. Stream clearance was carried out using power saws and also baffles were built to create pools. The students counted and measured coho fry at certain time intervals and recorded and adjusted water levels at three dams.

The SCS is responsible for two incubation boxes operating on Mary Vine Creek (Sooke River system). At present, a total of 130,000 coho eggs are incubating. This is the fourth year of operation for these boxes. Egg-to-fry survivals have been from 80 to 92 percent. The Society is now concerned with high losses of fry in the streams, particularly through predation, and future SEP applications will be submitted.



These incubation boxes were built and maintained by the Sooke Conservation Society (upper) and Port Renfrew Community Salmonid Enhancement Program (lower). They have an incubation capacity of approximately 50,000 eggs each.

j) Port Renfrew Community:

The San Juan River enhancement program began unofficially four years ago with coordination between the free labour of the Jordan River Correctional Camp Inmates and various volunteer groups. Stream clearance programs were initiated and log jams and debris were cleared from local rivers and creeks.

SEP involvement began in the winter of 1976/77 when the first incubation box was built. The whole of the 1977 summer was spent preparing a site for the box. Again, many private donations of time, labour and materials were made and by the fall of 1977 it was ready for operation. The unit now contains 48,000 chum eggs and indications are that the incubation period has been successful.

k) Serpentine Watershed Improvement:

From a series of springs at the corner of 140th Street and 60th Avenue in Surrey flows a small stream supporting coho salmon, steelhead and rainbow trout. A section of creek was cleared in 1962/63 and since that time, efforts have been made to increase the coho spawning potential. Logging debris has caused the stream to change course many times and in order to develop spawning beds it was necessary to control erosion, deposit gravel and erect weirs in likely spawning areas. Government funding was provided for the first time in 1977 through SEP, at a cost of less than $90.00. The lower 80 feet of the stream has been preserved as a rearing area and contains pool and riffle areas overhung by alders and salmonberries. This year approximately 15 fish spawned in this area and it is felt that the stream could ideally accommodate 100 or more pairs.

l) B.C.I.T. Training Centre:

Since its inception, the British Columbia Institute of Technology has strived to provide realistic and practical education and training at the technical level for a variety of vocations. The Fisheries, Wildlife and Recreation management program was able to develop fish culture facilities below the

Seymour dam within the watershed area. With the cooperation of the Greater Vancouver Water District, SEP funding, and much student and faculty input, this teaching facility became operational last year.

Specifically, the project site consists of a 122 m long semi-natural rearing channel equipped with four concrete weirs for water flow control and debris control. Associated with the channel are additional rearing and adult holding facilities. Also installed on the site are two 50,000 egg upwelling gravel incubators and one bank of hatchery incubation trays. The site has been enclosed with a chain link fence and a trailer for office and laboratory functions has been placed on the site.

Fish propagation on the site began in late spring of 1977 when two female steelhead were obtained from the Seymour River. To date there are approximately two thousand offspring from this small beginning being reared at the site. In addition, eggs from 12 female coho were fertilized in the fall of 1977 and presently there are 35,000 coho fry being reared. Production objectives for 1978/79 include 20,000 summer run and 20,000 winter run steelhead trout juveniles and 35,000 to 50,000 coho salmon juveniles. Although the initial returns will be small, the desire is to enhance coho stocks by 2,500 adults and the winter and summer run steelhead stocks by 2,000 each.

m) Squaretailers Rod and Reel Club:

During the year, several clean-up activities, including log jam removal and debris cleaning, were undertaken on Hastings Creek in North Vancouver. In mid-December, six adult coho were captured and placed above the culvert at Hoskins Road. Members have continued to keep a close watch on the creek: pollution problems, log jams, and returning fish in particular.

The club was represented at the B.C. Wildlife Federation Lower Mainland Conference in Chilliwack and did an information slide presentation of Hastings Creek. This presentation was repeated at the Vancouver International Boat Show.

In early February, a fishway was built and installation is scheduled for April, 1978, on Hastings Creek.

n) Centennial Secondary School:

Mossum Creek which is fed by rainwater and groundwater, flows approximately 8 km through dense bush to empty into Burrard Inlet and supports small populations of coho and cutthroat. Teachers at the Centennial High School in Coquitlam submitted a proposal to SEP to build an incubation box in order to provide an ongoing biological project as well as summer work for some of the students.

The students constructed a 50,000 egg incubation box beside the stream and installed gravity-feed intake works upstream. The school planned to incubate 25,000 chum eggs from an enhancement project in the Fraser Valley until the first returning adults could be harvested.

Unfortunately, land fill dumped upstream of the box silted the water badly enough to necessitate moving it upstream and postponing egg incubation until 1978/79. Stream cleanup and grass planting activities began immediately and temperature and flow records are now being monitored at the new incubation box site.

o) South Vancouver Island Aid the Fish Society:

The Society was formed in July, 1977 when a group of volunteers began visiting various facilities in Port Alberni, Qualicum, Bamfield and the Pacific Biological Station. After applying for a permit as well as SEP and Canada Works funding, a workshop was organized to build incubation boxes and walk the proposed streams with fisheries officers and volunteers. The streams in the Sooke area originally had good runs of chum salmon as late as thirty years ago. Today, due to logging and industry, they have been clogged with slash, log jams, silt, etc., totally depleting the runs.

In November, 1977, the crew worked a 7-day week in order to be prepared for the salmon run. Problems were encountered with the intake filters due to clogging from leaves; however, a new triangle-shaped filter was designed to remedy the problem. At Cole Creek, aproximately 90 m of road was built to haul materials in and at Tugwell Creek, 120 m of ditch was dug to properly elevate the incubation box pipe. Eventually, intakes and locations were changed at both creeks. Near a stream at Beecher Bay, approximately 60 m of trail was built to carry gravel, the incubation box and equipment to the stream.

Chums were taken on November 9 by seining and placed in 19 m x 1.2 m x 1.8 m holding pens made of vinyl-coated wire mesh. The eggs were taken on November 15 and December 5 and 30,500 and 116,000 eggs were obtained, respectively. Many freshets and poor weather conditions hampered the biological activities; however, the Society feels that future undertakings will benefit by having better preparations and experience.

B. NATIVE AND COMMUNITY INVOLVEMENT

Native Pilot Projects

a) Sliammon:

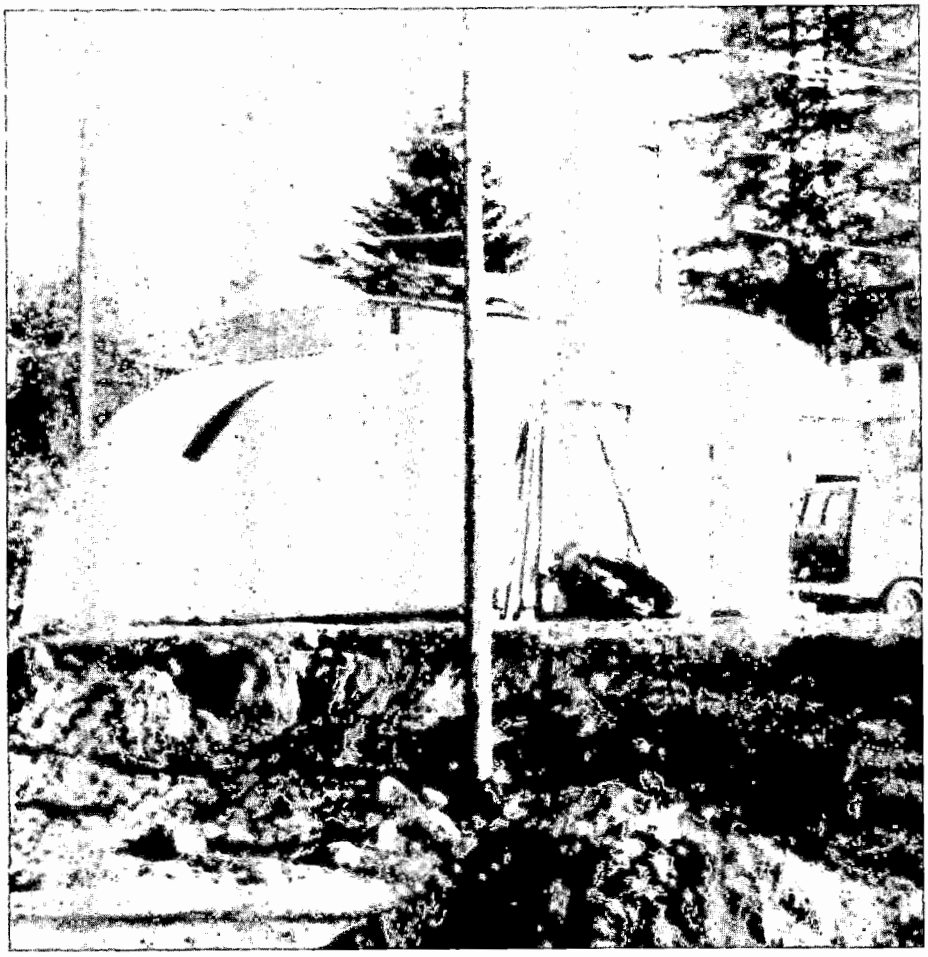
The Sliammon Band had done some stream clearing work in 1976 to the satisfaction of both the Fisheries and Marine Service and the Band. Early in 1977 the possibility of building a hatchery was discussed and the Band received funding from both the FMS and the Canadian Employment and Immigration Commission (CEIC) for its construction, operation, and related staff training. Therefore, the 1977/78 Sliammon project consists of two separate phases. Phase I involved stream clearing and improvement of the upper reaches of the Sliammon River, as well as surveying and repairing cleared streams from last year's stream improvement project. Phase II involves the construction and operation of a prototype incubation and rearing facility, similar in design to the Japanese chum hatchery system.

The Sliammon River and several smaller streams were inspected for the effect of last year's clearance operations; however, no remedial work was required. An existing, major log jam was removed on the Sliammon River and Okeover, Whittle, and Myrtle Creeks were cleared of beaver dams and other minor obstructions.

Construction and maintenance of the hatchery was done by the Band with the help of construction and biological consultants. In late August, site clearing and construction began on the Sliammon Reserve. The new facilities include a pipeline from Sliammon Lake, incubation building and tanks, keeper ponds, and holding/rearing ponds. The hatchery is designed to operate more for training than production and training of crew in fish culturing techniques has been mainly an informal, on-the-job undertaking. In late November 1977, 220,000 chum eggs were obtained from the Sliammon River by seining and gillnetting and are presently incubating at the hatchery.

b) Bella Bella:

The Bella Bella Band Council was granted a joint contract between the Canada Manpower Job Creation Branch and the Federal Fisheries Service as one of the five Native Pilot Projects of SEP. The objectives



The Sliammon Indian Band's chum hatchery is located on native land and is operating primarily as a training facility.

of this contract were to conduct a preliminary survey of streams surrounding Bella Bella as a basis for determining the potential spawning area of these streams and to train some local residents in salmon enhancement related work. These trainees may staff future enhancement facility sites on the central B.C. coast.

The stream inventory project started on June 6, 1977 with a four day on-site training course and was suspended on October 14, 1977 until more favourable weather conditions returned in the spring months. During the six month period, 80 streams including some lake systems were surveyed. This is less than one-half of the total number of small streams in Statistical Areas 6, 7, and 8.

Data collected included:

i) quantitative estimates for streambed/bank interface composition, bank stability, juvenile fish rearing habitat, water colour, water temperature, and physical obstructions to salmon migration;

ii) a rough map indicating areas of good spawning gravel, obstructions, important tributaries, secondary and flood channels, and the type of terrain surrounding the stream bank;

iii) the length of each stream section, the dry and wet widths, and the average stream gradient were measured using an optical tape measure and a clinometer, respectively; and

iv) photographs of the general watershed, typical stretches of each stream section, gravel composition, obstructions; the latter two using an object or a person as a scale for comparison.

Estimated potential spawning area for Statistical Areas 6, 7, and 8 was over 2 million m^2. Twenty-five streams were considered as candidates for future stream clearance or improvement projects and fourteen streams were similarly considered for potential enhancement sites.

A winter stream monitoring program began October 17, 1977, and will continue until sufficient data is taken. The objective of this program was to determine the egg-to-fry survival rate, to measure the stream flow rate and to record the minimum and maximum temperature on a bi-weekly basis. Five streams considered representative of the central coast streams were monitored over the fall and winter months.

Five men (two men on rotation) were selected for the winter monitoring program. These men were given instructions on how to use a hydraulic gravel sampler, a max/min thermometer and a simple flow rate measure technique by a Federal Fisheries technician.

The crew was to take three or four gravel samples from each stream. One sample was to be taken after the eyed egg stage. The stream flow and max/min readings were to be taken every field trip.

The five representative streams were visited once every two weeks for samples i.e., a six day field trip/two weeks. The remaining four days of that period were spent in the office where the crew were taught how to use the data collected from the stream inventory and the winter monitoring program. Literature on various aspects of their jobs and the Salmonid Enhancement Program was also provided for the crew.

The data from the winter monitoring program is being assembled and a report will be forthcoming.

c) Chehalis:

In September 1977, the Chehalis Indian Band agreed to approach the Fisheries and Marine Service with a plan for stream clearing and tagging/dead recovery of chum salmon. The Harrison/Chehalis River system, the Stave River, and several streams in the Mission and Chilliwack area would be involved in the project. FMS agreed to supply a technical advisor who would be present at the project daily; in addition, FMS would supply all equipment. The Band administered all funds and was responsible for the direct supervision of manpower and work allocations.

There were two crews operating and each site was visited once every 10 to 14 days. Dead recovery and biological sampling programs were also carried out in conjunction with the tagging operation. There were 5,666 fish marked with disc tags and 107,700 marked and unmarked carcasses were recovered. Total numbers in each of the Stave, Harrison/Chehalis, and Squakum systems have not yet been determined.

Beaver dam control was also implemented throughout the spawning period. Several of these dams were a considerable block to migrating spawners in that they occur-

red at the mouths of streams. Of 15 dams removed, 10 required repeated treatment throughout the fall program.

Chums in the Harrison River (upper) and pinks in the Kispiox River (lower) were disc-tagged and recovered to gather information on spawner numbers and distribution.

d) Kispiox:

Early in 1977, the Job Creation Branch of Canada Manpower and the Kispiox Indian Band approached Fisheries with a proposal for the Band to do stream clearance work on the Kispiox River, with partial financing from the Canada Works Program. The Kispiox project, in its final form, extended from the beginning of August to the end of October and, in addition to some stream clearance work, included two inventory studies, a pink salmon spawner enumeration and the employment of a Fisheries Officer. The Band, as contractor, was responsible for providing the workers, supervising their work and handling personnel problems. Fisheries staff trained the crews, drafted work schedules and made certain that technical standards were maintained.

The stream clearance work came under the supervision of Fisheries' engineers. A major partial obstruction to fish migration at Kitwangulf Canyon was blasted, beaver dams were opened to allow migrating fish to reach spawning areas, and some log jams, which were considered potentially harmful, were removed.

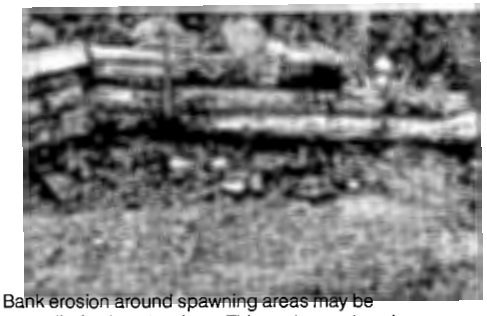
Inventory crews completed standard, waterproof inventory forms designed for the project to get maximum information with a minimum of training. One side of the form dealt with a physical description of the stream at the sampling site and the immediate vicinity. This was the prime concern of the upper river inventory crew. The emphasis on the lower river was on trapping juveniles in the tributaries and mainstem, using the reverse side of the standard form.

Pink salmon spawners were enumerated by a Peterson mark-recapture estimate. Migrating pink salmon were captured by beach seines, tagged with 7/8 inch disc tags held on by nickel pins and released to continue their migration. The tag recovery crew floated sections of the river in rubber rafts, stopping to count all dead encountered and to remove any attached tags. A total of 1,126 tags were applied to pink salmon between August 3 and August 25, 1977. Of this total, 120 (10.7 percent) were recovered from the 31,249 dead pink salmon examined. The estimate of the spawning population of pink salmon was 190,400.

e) Nanaimo:

At the beginning of June, 1977, an ambitious project was started in Nanaimo to assist the recovery of salmon populations in the local area. The project is called "Community Fisheries Enhancement" and is operated by the Central Island Community Development Corporation under the terms of a contract with three federal agencies. The Community Employment Strategy and Job Creation Branch sections of the Canada Employment and Immigration Commission as well as the Fisheries and Marine Service contributed jointly to fund a project involving stream clearance and improvement work. Public involvement and education have also been major concerns of the project. Secondary activities included stream monitoring, escapement estimates and the construction of chum incubation boxes. Approximately half of the crew were hired from the Nanaimo Indian Band.

Stream improvement work began June 6, 1977 and several techniques were used to improve nearly 40 creeks in the Nanaimo area. Streams were walked and cleared of major debris such as log jams. Recognizing that some debris is desireable habitat for juvenile salmonids, this work was done with judgement and restraint. In-stream devices, including digger logs, root wads, gabions, small rock weirs and floating logs were applied in selected areas. These



Bank erosion around spawning areas may be controlled using stop-logs. This work was done by a Nanaimo citizens group.

techniques are expected to have a positive impact on the productive capacities of the streams.

A number of areas had problems relating to urban development, including ditching by local residents and accumulation of garbage in the streambed. The garbage was simply removed and taken to the dump; however, one stream was improved with gravel and had structures installed along the bank to prevent erosion.

Excursions along the streams also furnished very useful data on basic biological reconnaissance. Most streams had water temperatures and flows measured at regular intervals all year round and fry salvage operations were conducted in several areas threatened by summer dry-ups. Several streams were electroshocked in order to determine populations of fry in certain areas. Several crews were involved in the fall and winter with walking streams, counting fish and collecting scale samples.

Counting fences were erected on four major creeks: Chase, Bonell, Nanoose, and Whitehorse. These were installed from late September to early December and were used to assess escapement stocks of coho and chum salmon in these locations. Also, two chum incubation boxes were installed on a side channel to Haslam Creek and were fully operable and supplied with eggs by December.

At this writing, a new winter program has been initiated until April 1, 1978. Winter work includes stream improvement at higher elevations, lake surveys and public liason and education.

f) Little Chilliwack:

In 1977, SEP officials approached the Shulkayn and Yakweakwioos Bands to undertake stream rehabilitative work on the Little Chilliwack. Using funds from the Job Creation Branch and initial technical help from the Fisheries and Marine service, stream clearance and brush removal of approximately 1 km of watercourse has been completed. Work will continue on this project pending clarification of administrative and funding issues.

g) Chemainus:

A side channel to the Chemainus River, near Nanaimo, historically supported large numbers of spawning chum salmon. In recent years, gravel had been deposited at the side channel exit, completely blocking fish passage and water eventually was diverted around the channel.

It was proposed to restore the sidechannel inlet, dredge the outlet and prepare the channel for spawners. The Hallalt Band was contracted to do this work, using funds from the Job Creation Branch of the Canada Employment and Immigration Commission and technical input from the Fisheries and Marine Service. Since the fall of 1977, the channel has been cleared and prepared and further restoration is forthcoming.

h) Cowichan:

A pilot project involving a "Netarts-bay"-type incubator facility is being conducted on the Cowichan Indian Reserve. This facility, constructed on the Cowichan Indian Farm Co-op land in the fall of 1976, is operated under contract between the FMS and the Cowichan Indian Hatchery Company Ltd. An estimated 317,000 chum eggs were obtained by a FMS field crew during December, 1976 to commence operations. After a successful year of incubation, chum eggs were again taken in mid-December of 1977. Of 1.6 million eggs incubated, approximately .5 million were lost at ponding due to unknown causes; however, fish production is continuing as planned and another egg-take is scheduled for 1978.

C. SMALL PROJECTS

Fraser River and West Coast of Vancouver Island

a) Nahatlatch River:

A massive log jam approximately 300 m long and 45 m wide has been in existence for a number of years on the Nahatlatch River approximately .8 km above Nahatlatch Lake. The jam was considered to be an almost impenetrable barrier to upstream migrating salmonids and in fact a number of dead unspawned chinook salmon have been observed in recent years below the obstruction.

The jam was of such a magnitude that the costs of removing it by conventional methods would have been exorbitant. It was, therefore, decided to excavate a bypass channel approximately 245 m long around the jam in order to provide an alternate route for upstream migrating salmonids.

The project commenced in January, 1977 and was completed in October, 1977.

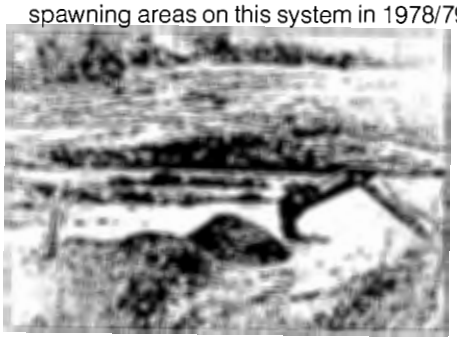
Bypass channels may be constructed around large obstructions, like this one around a log jam on the Nahatlatch River.

b) Vedder River:

Dyking projects undertaken on the Vedder River have inadvertently produced very favourable chum salmon spawning areas. These areas are located behind the dykes and are supplied with groundwater flows. The flood that occurred on the system in 1975; however, resulted in large accummulations of sand and silt being deposited over a large portion of these areas, considerably reducing their productivity.

In October, 1977 a pilot project was undertaken to rehabilitate one of these areas which is located on the left bank of the Vedder River approximately 450 m upstream of the B.C. Hydro bridge. The project involved the stripping of approximately three feet of overburden material and the subsequent placement of graded spawning gravel approximately 50 cm deep in this area. This work resulted in about 1,700 m^2 of prime spawning area that was subsequently utilized by approximately 3,000 chum salmon.

In view of the highly successful result of this project it is proposed to undertake extensive rehabilitation of other chum salmon spawning areas on this system in 1978/79.



After severe flooding and silting, this spawning area near the Vedder River was rehabilitated for spawning chum salmon.

c) Chehalis River:

Several groundwater-supplied channels immediately adjacent to the Harrison River were improved for chum salmon spawning by the removal of sand and silt deposits. In addition, beaver dams were removed utilizing heavy equipment in order to provide unobstructed access to spawning areas.

It is proposed to rehabilitate a portion of these areas in 1978/79 by utilizing techniques similar to that used to rehabilitate chum salmon spawning areas on the Vedder River. This would involve the removal of silt and sand deposits from the channels and the subsequent placement of graded spawning gravel in hese areas.

d) Nicola River:

A log jam was removed on the Nicola River approximately two miles upstream from Merritt, B.C. Although the jam was not considered to be an obstruction to upstream migrating salmon it was considered that large numbers of fry were being diverted and subsequently stranded on adjacent farm land as a result of water being diverted by the jam during spring freshets.

e) Centre River:

The removal, which was funded by a L.I.P. grant, of a large log jam on the Centre River, a tributary of the Chilliwack River, resulted in the serious reduction in discharge to several side channels.

Rock gabions were constructed across the main stream bed in the immediate vicinity of the top end of the side channels to eliminate the possibility of these areas becoming dried up as a result of a channel degradation anticipated in this relatively high gradient reach of river.

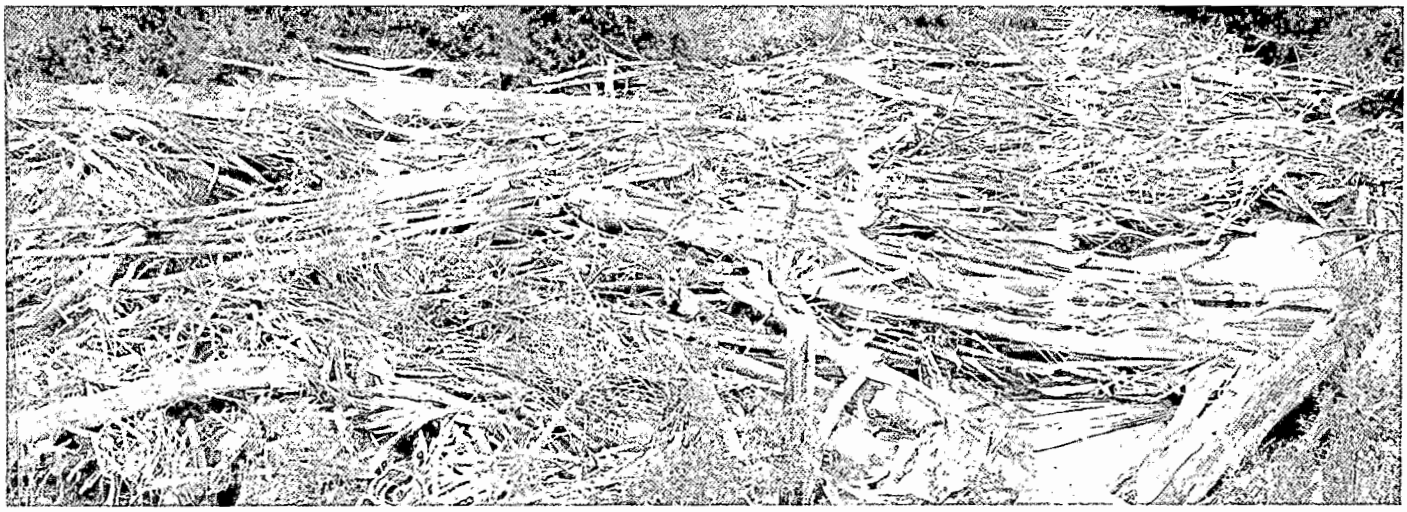
f) Chilliwack River:

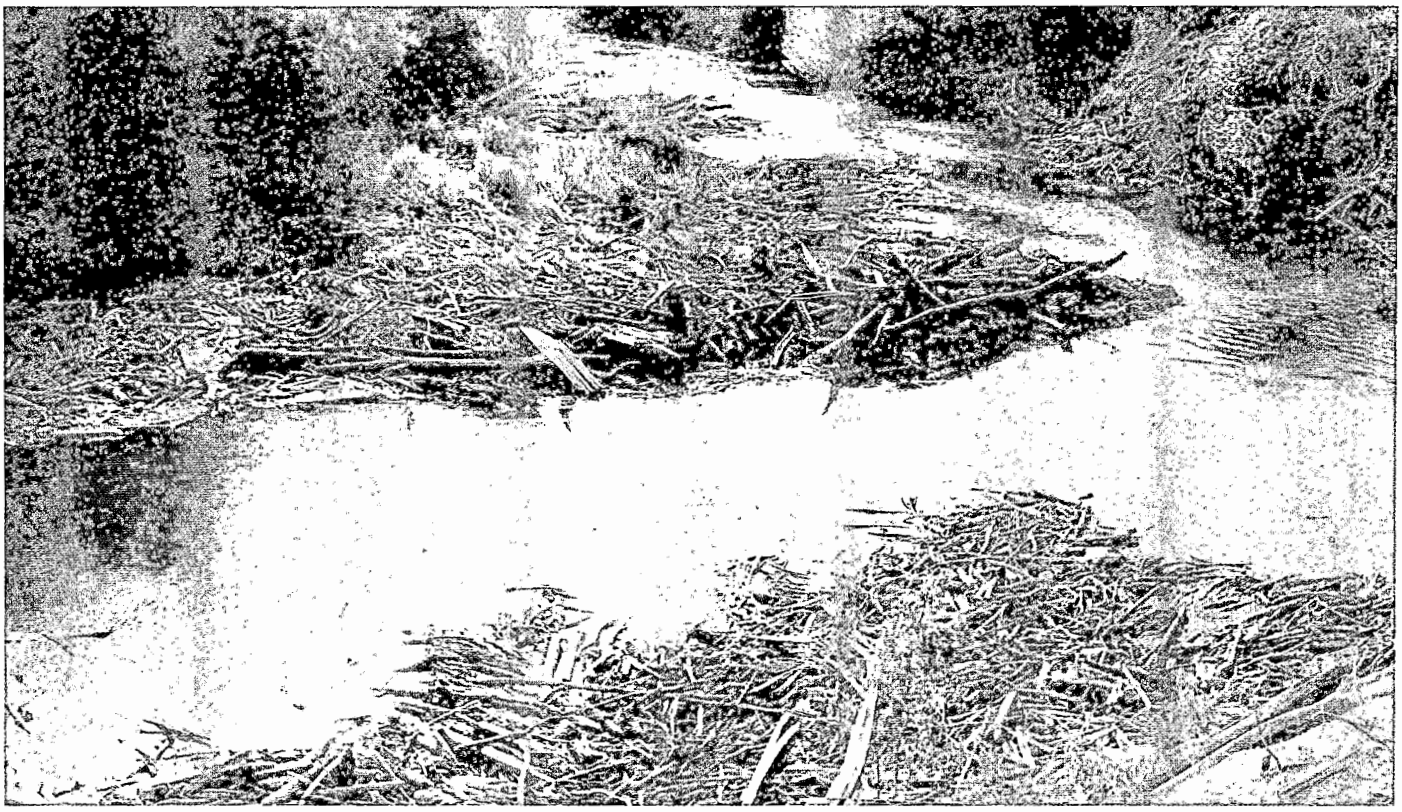
Maintenance work was undertaken at a dyke and a settling basin that was constructed in 1975 at the base of a potential slide area on the Chilliwack River. The dyke was originally constructed to prevent erosion of the toe of the slide and to settle out sand, silt and clay that was being continuously discharged into the Chilliwack River.

Georgia and Johnstone Straits

a) Nib Falls:

Nib Falls is a partial obstruction to fish in the Puntledge River, downstream from the spawning channel. The falls drop 15 m in 300 m and consist of two separate cascades interconnected by approximately 300 m of rapids. Salmon migrating up the left bank channel are often delayed or injured and excessive pre-spawning mortalities may occur. Therefore, a pool-and-weir type fishway was constructed during August and September, 1977.





Log jams can often be significant barriers to migrating salmonids. On the Nicola River, cleanup work was especially effective.

The fishway design required a flume cut out of the Nib Falls ledge with concrete verticle slot baffles. A temporary coffer dam was constructed to dewater the site and the rock area was broken by drilling and blasting. The walls were pre-sheared by blasting a line of closely spaced holes along the wall lines of the flume before the main part of the excavation was removed. This procedure produced straight, smooth rock faces which could be used as sidewalls for the fishway. Subsequent drilling and blasting was required to break up the rock before it could be removed from the excavation. Approximately 300 m was removed from the excavation and piled on the small island at the lower end of Nib Falls. The completed flume was 25 m x 4.6 m into which four steel-reinforced concrete baffles with verticles slots were set. The fishway was first operational on October 3.

b) Quatse River:

A large log jam on the Quatse River was thought to be a total obstruction to spawning salmon. In the spring of 1977, a small crew entered the area, cut a trail to the log jam site, and almost completely removed it by blasting. Access to five miles of river was obtained for sockeye salmon.

c) Tenderfoot Creek:

Mosely Lake and Tenderfoot Creek are tributaries of the Cheakamus River and have spawning populations of several species. Some time ago, a railway bridge over Tenderfoot Creek was replaced with culverts too small and high for fish to negotiate, except at high water levels. To facilitate migrating spawners at lesser flows, a new culvert was installed approximately 60 m upstream from the existing ones. Also, a small earthfill dam and four holding pools were constructed near the culvert entrance to further improve access. This system is an important salmon spawning and rearing area in the District of Squamish and the culvert replacement project allowed approximately 2,500 chum salmon to spawn above the railway.

The Nib Falls vertical-slot fishway was partly constructed using explosives to create smooth rock faces.

North Coast

a) Nadu River:

Between July 26 and August 5, 1977, work was done on the Nadu Creek culvert which, due to improper installation and scouring at the outlet, prevented fish from migrating up Nadu Creek.

The road around the culvert was excavated and a trench was dug, reaching the streambed level. The culvert was then rolled into the trench and sandbagged at both ends to present scouring. The operation provided access to approximately 16 km of watercourse for coho salmon.

b) Bella Coola River:

Hagensborg Slough in the Bella Coola River was obstructed at two 122 cm culverts with floodgates on the downstream ends. Fish passage is impeded by a drop of approximately 60 cm to the river level at low water; the floodgates being closed; and water from the slough running under and around the culverts.

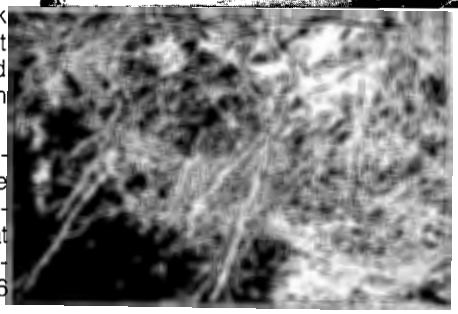
To rectify this situation, a weir was constructed around the lower ends of the culverts using sand/cement sandbags with metal reinforcing bars. The floor of the pool was cemented to prevent leakage. At the upstream end of the culverts, 6 ml polyethylene was secured on the bed of the slough in order to control leakage. Finally, the floodgates were propped open by inserting a block of wood under the hinge.

The project was completed on October 2 and allowed the passage of 200 coho salmon into Hagensborg Slough.

c) Ain River:

Waterfalls on the Ain River are impassable at certain water levels and form a partial obstruction to sockeye and coho stocks migrating to Ain Lake, and beyond. In order to minimize prespawning mortalities and delayed migrations, remedial work was undertaken.

The problem areas were treated as three separate obstructions: the lower, middle and upper falls. The lower falls were bypassed by a fishway, drilled and blasted from solid rock. The middle falls were restructured by blasting to form two "steps" of pools, to minimize the drop. The upper area was widened to reduce the velocity of water and three side pools were blasted in the rock for resting areas.



Beaver dam removal requires special care so that spawners can continue upstream while retaining rearing areas for juveniles. In this case, fish passage was achieved past a dam on Toboggan Creek using light explosives.

d) Toboggan and Cathlyn Creeks:

On both of these streams, beaver dams totally blocked the spawning migration. To alleviate the situation, a crew entered the area in October and partially dismantled the dams, two by blasting and eight by hand. By allowing the dams to be rebuilt in a matter of hours several thousand fish gained access to the stream while the beaver ponds could still function as potential rearing areas for juvenile coho.

c) Moricetown Fishway:

A collapsed grating was blocking fish passage through the Moricetown Falls fishway, and salmon were accumulating at the base of the falls. Immediate removal of the grating was necessary to prevent overharvesting by the native food fishery.

f) Pallant Creek:

Adjacent to the hatchery site on Pallant Creek is a 2 m waterfall which has been a partial obstruction to spawning chum salmon. In mid-summer of 1977, the top ledge of the drop was blasted to restructure the falls and create easier access for fish.

g) Atna River:

In September, 1977, work began on blasting a fishway around falls in the Atna River which was a partial obstruction to sockeye salmon. A bypass was blasted in the rock face adjacent to the falls. To control flows within the flume, several pools were also blasted in the bypass watercourse.

V. ECONOMIC DEVELOPMENT

Economic and Social Goals of SEP

The objective of the Salmonid Enhancement Program is "to maximize net social and economic benefits from salmonid enhancement subject to budgetary and technical constraints". Canada and the Province agree to work toward the achievement of the following government goals:

i) to augment National and Provincial income:

ii) to foster development of economically disadvantaged communities or regions:

iii) to improve the economic well-being of the Native Indian peoples, consistent with the need to preserve their social and cultural heritages;

iv) to create employment opportunities for Canadians; and

v) to preserve, rehabilitate, and/or enhance natural salmonid habitats, and to maintain and/or rehabilitate vestigal salmonid stocks of local, regional, or national significance.

The progress of the Salmonid Enhancement Program toward the above goals is presented in the following pages.

National Income

The National Income Account estimates the benefits of increased commercial, recreational and native food fish production and measures these against the costs of their development and management in terms of "national income dollars". SEP projects and fisheries management policies which maximize the net National Income benefits of increased commercial, recreational and native food fish production are placed in the National Income Maximization Plan. A planning process has been developed which assumes the technical interdependance of candidate projects and identifies the national income trade-offs inherent in pursuing multiple objective plans.

a) Commercial Fishing:

Continuing work on salmon price projections is underway in studies evaluating demand analyses and estimating demand equations for the commercial salmon industry. A paper, "An Evaluation of Data Requirements and Data Availability for a Multi-market Salmon Demand Analysis", deals mainly with the feasibility of further detailed demand work. A forthcoming report (D. DeVoretz, 1978) estimates demand equations of species/product specific markets in the U.S., Canada, and Europe.

Two reports were prepared dealing with the question of investment policy in the commercial fishing industry (M. Shaffer, 1978). The overcapitalization of the fleet and processing sectors (i.e. more catch capacity than it utilized) is a primary concern.

Basic data were gathered and analysed for use in developing a cost/income model for the B.C. salmon fishery industry. These data will be used to forecast economic impacts of cost recovery mechanism alternatives (i.e. license, landing fee possibilities, etc.) on fishermen and processors. A licensing review of the entire B.C. Fishing Industry is now underway and will also be coordinated with recent cost recovery mechanism studies for SEP.

Workshops with the Institute of Animal Resource Ecology at UBC have included fleet mobility analyses of the seine fleet and sport fishermen. Models are being developed to examine intra- and extra-seasonal behaviour of the fleet from an economic viewpoint.

Commercial fishermen in 1977 received up to $2.60 per pound for chinook salmon. This price varies widely and is dependent on many factors, including size and condition of fish as well as location and season of catch.

b) Recreational Fishing:

A field survey was carried out this summer at Campbell River to examine the relationship between fish abundance and recreational demand. The purpose of the survey was to gather data on angler participation, distance travelled by anglers, and various factors likely to affect angler participation during discrete periods over the season (e.g. weather conditions), catch per unit effort, average weight of fish caught, etc.). This data has been organized and compiled in the computer but analysis has been delayed due to other priorities.

Another study was initiated this year to examine the relationship between fish availability and sport fishing demand. This is an innovative study using video tape equipment and echo sounders to determine fish abundance in given areas at given times. This will be correlated with information on angler activity gathered simultaneously from boat counts. A survey questionnaire will also be used to test angler preferences and attitudes.

Data has been gathered to summarize the present income and employment level in the sport fishing related tourist industry on a region by region basis. A report (P. Loftus, 1978) is forthcoming. This work is the first phase of studies designed to forecast the effects of SEP projects on the regional distribution of tourist income and employment, and to monitor SEP for testing those forecasts.

The Honourable Roméo Le Blanc and his son caught these chinook salmon near Campbell River in August, 1976.

c) Food Fishing:

Data on food fish catches is being assembled in order to examine the valuation of the food fishery benefits of SEP. Areas of the Province where food fish demand is not fully met will be identified, and the report will be completed in 1978.

Native food fishermen on the Fraser River, near Yale, still use aboriginal methods.

Regional Development

For the purpose of SEP project assessment, the Department of Regional Economic Expansion has defined the coastal area of British Columbia north of a line from Bamfield to Powell River as a less developed region of the Province. Within the Regional Development Account the potential impact of SEP in terms of long term employment and income generation to this area is measured.

A program and project ranking system has been devised based upon three criteria:

i) the relative size of the primary fishing revenue impact;

ii) the probable geographic distribution of that impact throughout the less developed region; and

iii) the socio-economic conditions in the areas of impact.

On the basis of this ranking a preliminary Regional Development Maximization Plan for Phase I (W. McKay, 1977) has been developed as one enhancement option.

Although considerable progress was made in 1977 in predicting the geographic distribution of primary fishing revenue impacts, considerable work is still required. This work is currently on-going through further analysis of historic fishing patterns, and will be extended in the future to fleet mobility analysis.

Also, progress is being made in expanding the Regional Development ranking criteria to assess and evaluate impacts in the fish processing sector and in facility operations. In 1977/78 preliminary estimates of the impact of these factors indicated that they were significant. A more accurate assessment of their relative weight is being pursued through a product end use survey.

Further work completed in 1977/78 included a study of the impact of cost recovery on regional income and employment. This was submitted as an Annex to the Cost Recovery cabinet document. Also, in order to collect and summarize existing statistical data for remote communities, a community handbook was developed. This handbook gives a basic socio-economic profile for all coastal regions in British Columbia. Information listed includes topography, labour force, number of unemployed, and main employers: fishing, forestry, mining, construction, etc.

Native People

The Native People Account uses a rating system which allows for the consideration of all important project impacts on Native people. The impacts considered were as follows:

i) annual incremental catch to the Native commercial fleet;

ii) employment implications of each project, including incremental processing employment as well as on-site construction or operations employment;

iii) food fishing implications; and

iv) the implications of other factors such as social impacts (e.g. band attitude towards the project).

These four factors are combined to determine the final rating of project or program proposals in terms of the Native People Account. Under the procedures developed during this year, project ratings can be based directly on the proportion of project benefits expected to accrue to native people.

A Native People Account assessment of all potential Phase I projects was carried out in February, 1978, together with an analysis of four alternative Phase I program plans.

Development of a data base for the Native People Account is in progress. This includes up-to-date commercial catch statistics, refinements of the catch distribution model using mobility analyses, as well as basic information on communities.

A study of the impact on native people of cost recovery proposals was prepared as an Annex to the cost recovery cabinet document.

A revised version of the study "Impact of the Salmonid Enhancement Program on Native People" was prepared and distributed to Indian Bands, native organizations, and people involved in the planning and implementation of SEP. The report considers impacts arising from incremental fish and construction and operation of facilities, as well as information, consultation, and involvement aspects.

Facilitation of the Native Project Pilot Program continued throughout the fiscal year, and an evaluation of the program is being carried out. Projects at Nanaimo, Kispiox, Bella Bella, Sliammon and Chehalis are included. The evaluation includes objectives and outcomes related to employment, skills and personal development, future aspirations, community effects, Band-Fisheries relations, and enhancement aspects. An Interim Report was prepared in January, 1978, and a Final Report is due in 1977/78.

Assistance was provided in organizing the Native Program Working Group (NPWG), finalizing the NPWG workplan, and preparing the basic documentation objectives of the Native Program, terms of reference for the NPWG, etc.

Background research on affirmative action programs elsewhere and legal implications has been completed. A paper is due in 1978, identifying policy options regarding employment of native people in technical and professional positions, as well as labouring positions and construction work.

A working paper, "Background Information on Native Indian Training", compared 27 native training programs within and without British Columbia and the Fisheries Service. This paper was distributed to those who will be involved and/or affected by these training programs.

Assistance was provided in organizing the Native Participation Program (NPP) for 1978-79. This included preparation of a general organizational framework for the NPP, preparation of an information sheet on the NPP, development of draft selection criteria, preparation of background papers on the rationale for the program, and assistance with program implementation.

Employment

Although full employment is assumed for the National Income Account presentation, in the coastal areas of British Columbia, high rates of unemployment are common. The Employment Account attempts to consider the fact that the use of unemployed labour resources entails zero social cost in terms of foregone national income. Its objectives are:

i) to rank SEP proposals on the basis of primary employment generated (including fishing and processing employment); and

ii) to estimate on a project by project basis, the probability of hiring labour resources which would otherwise be unemployed.

In an effort to determine unemployment rates by trade and region, collaborations with the Canada Employment Centre (Insurance) are continuing. It has been proposed to cooperate further with the Canada Employment and Immigration Commission in order to refine the data and its implication. Also, a paper on the consideration of

"make or buy" alternatives evaluated in projects and program planning has been completed and the possibility of a paper, "Buy Canadian" has been discussed.

Environmental and Resource Preservation:

A contract has been let to start making operational the environmental account. A report due in 1978 will recommend a framework for assessing the environmental impacts of SEP project proposals. In addition, the methodology will be applied as a test case on the Chilliwack/Vedder hatchery proposal.

Policy Issues

a) Cost Recovery:

In November, 1977 the Federal Government approved cost recovery as an integral part of the Salmonid Enhancement Program. The recommended Federal cost recovery elements were a commercial and recreational fishing license fee and a levy on salmon landings at the processor level. The view was to prepare the necessary infrastructure for these fees to be implemented by January 1, 1979. In addition, the Minister of Fisheries was to discuss any cooperative arrangements with the Government of British Columbia in order to further the program, and to announce publicly the government's plan for cost recovery at an appropriate time.

The present status of cost recovery is that the final details of the mechanisms and their public announcement are awaiting the outcome of informal discussions with client groups and a Federal-Provincial agreement. The Minister of Fisheries has made clear the Federal Government commitment to a cost recovery plan and implementation of the final plan by January, 1979, is on schedule.

b) Federal and Provincial Agreement:

The first draft of Federal/Provincial agreement on joint involvement in SEP has been prepared and consultations are in progress. Economic management, cost recovery, and resource interactions are primary factors under consideration.

The Environment and Land Use Committee, responsible for examining resource issues in B.C., is collaborating with the Federal government in an attempt to coordinate SEP with Provincial agency processes. If both the beneficial and adverse impacts of SEP projects on other resource users could be identified, negative resource use interactions could be minimized and positive interactions enhanced through the project planning process.

A case study was completed on the magnitude of the fish/forest interaction. "A Preliminary Economic Analysis of the Interaction Between Fish and Forest Sectors in British Columbia", describes the problems associated with conflicting Federal/Provincial jurisdictions, site-specific considerations and the economic and intangible values of fish habitat protection.

Project Analyses

Economic feasibility analyses have been conducted on a candidate list of Phase I SEP projects. Some detailed benefit/cost analyses of proposed capital projects in years 1 and 2 were completed. A summary of the national income and distributional effects of selected projects are presented in Table 29. The reader is reminded that these figures are based on data available in 1977/78 and are considered forecasts.

Table 29.

Summary of economic feasibility studies on selected projects for years 1 and 2.

	Little Qualicum	Tlupana Inlet	Puntledge River	Bella Coola	Pallant Creek
Development	Spawning Channel	Japanese Hatcheries	Hatchery	Japanese Hatchery	Japanese Hatchery
Positive Net Benefits	$16.0 m.	$14.6 m.	$7.9 m.	$3.0 m.	$3.2 m.
Benefit/cost Ratio	2.1 : 1	2.1 : 1	1.8 : 1	1.5 : 1	1.5 : 1
Native Impact	Medium	Low	Low	High	High
Regional Impact	Low	Medium	Medium	High	High
Short Term M/Y Constr./Assess.	89.8	42.2	104.2	23.6	42.9
Annual M/Y Operations	3.5	4.5	7.0	5.0	5.0
Annual Man/days Output	13,560	14,400	2,560	4,900	4,124

VI SEP OVERVIEW STUDIES

Bioreconnaissance and Feasibility Studies Standardization

The Federal Provincial Salmonid Enhancement Program requires bioreconnaissance and feasibility studies in various areas to provide a basis for planning and implementation of enhancement studies. It is anticipated that a portion of these studies will be contracted to the private sector. A document has been prepared to assist in developing a suitable format for the terms of reference governing contract bioreconnaissance studies.

SEP Cabinet Document

From March, 1975 when the concept of a Salmonid Enhancement Program was first announced, until May, 1977, the Fisheries and Marine Service conducted an extensive series of studies and pilot projects directed towards the preparation of a comprehensive and geographically diverse enhancement package. A document "The Salmonid Enhancement Program" was prepared, outlining the background and description of the program, technical and economic rationale, Federal/Provincial relations and public participation factors that were developed during the two-year study period. The report was originally prepared as a cabinet document, but was edited for readability and will be supplied to concerned public groups with the intention of fostering a two-way exchange of information between the public and their government.

Stream Catalogues

Previous to the Salmonid Enhancement Program, publications of stream

catalogues had been undertaken by the Fisheries and Marine Service as time and resources permitted. These reports have become a major data base for salmonid enhancement as well as important reference material for outside agencies. To ensure their continued development on a regular basis, funding was provided by SEP.

At present, spawning escapements and stream characteristics are being updated and collated largely from existing data. Streams in statistical areas 15, 16, 17, 18, and 28 were catalogued in 1976; 12, 13, 14, 19, and 20 in 1977; and 2W, 2E, 22, 23, and 24 are currently underway.

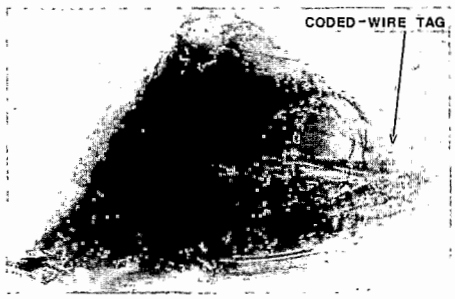
UBC SEP Modeling

The Institute of Animal Resource Ecology at UBC under contract to SEP continues to provide a number of workshops and studies related to the Salmonid Enhancement Program. The major project of this past year has been a simulation model of the chinook and coho fisheries of the Strait of Georgia area. The model showed that many of the probable/possible regulations were of little value in increasing escapement: in particular phasing out the commercial fishery would do little to help the recreational fishery. The model, in dealing with fishery management of this area, highlighted the importance of immediate action on the number of threatened chinook stocks fished in the area.

Other studies underway include an analysis of commercial seine fleet movements to develop a predictive model which will permit exploration of the impacts of enhancement on fleet distribution. A study on salmonid population dynamics, with specific reference to the severely depressed Atnarko odd-year pinks was completed (Peterman, 1977). This study suggests the potential for short term enhancement to elevate populations to higher stability levels at which, if managed carefully, they will stay without enhancement.

Mark Recovery Program

In order to facilitate the recovery of increasing numbers of coded wire tagged juvenile salmonids as adults, the need for an extensive recovery program became evident. The first Mark Recovery Program (MRP) began in 1973 in response to American fisheries biologists' requests for recovery information on their stocks in exchange for similar data on Canadian fish. The project was limited to gathering sport and commercial catch data in the Gulf of Georgia; however, the 1974 MRP was expanded to include the entire B.C. coast. As fishery managers dealing with Canadian and international stocks became more concerned with this data, the MRP has been expanded and improved and the data recovery system refined. In 1977, SEP contributed to the funding of the MRP and it is now instrumental in planning stock management and enhancement on a long term, as well as seasonal, basis.



Coded wire nose-tags, inserted in juvenile fish, can be recovered in adult heads. This method of marking provides detailed fishery information with minimal stress on the individual fish.

The MRP employs a head recovery crew of 18 to 27 people spread through fish packing plants in locations such as Prince Rupert, Namu, Tofino, Ucluelet, Victoria, Steveston and Vancouver. Fish heads are recovered from adipose fin-clipped (coded wire tagged) coho, chinook and steelhead from sport and commercial fisheries and returned heads and log books are exchanged for informative literature and a MRP lottery draw. The heads are shipped frozen to the Fisheries Service warehouse in North Vancouver where a crew of 4 to 7 technicians recover and decode the tags.

The data are gathered and collated at the

Table 30.

List of annual and in-season reports published by the Mark Recovery Program; their titles, status' and purposes.

Title	Status	Purpose
1973 Annual Report	Completed, published, distributed	General
1974 Annual Report	Completed, published, distributed	General
1975 Annual Report	Completed	General
1976 Annual Report	In preparation	General
1977 Annual Report	In preparation	General
Georgia Strait Head Recovery Bulletin	Monthly	Feedback to sport fishermen, sport log book participants, and interested parties.
U.S. List	Monthly	Canadian recoveries of U.S. - originating salmon. Exchanged with U.S. agencies.
Canadian List	Monthly	Canadian recoveries of salmon of Canadian origin. For in-house users of all descriptions.
Log Book Newsletter	Monthly from April to October	Feedback to participating commercial trollers.

Fisheries Service for release in several publications (Table 30). Retrieval from computer data banks is available to users such as other fisheries agencies, hatcheries, fisheries managers and research scientists. The information may be correlated with exploitation and migration data from other sources, such as the Provincial Government's creel census and marine steelhead interception programs.

Tagging report

A report is in progress to present an overview of the Pacific salmon tagging programs in the northeast Pacific. The document compiles, extracts and reviews existing information to aid in formulating stock management policies. A final report is expected in 1978/79.

General Reconnaissance: Geothermal Groundwater

A report was prepared by a group of geological consultants cataloguing 47 hotsprings in British Columbia to assess the potential for using low-cost, geothermal heat for use in fish culture operations. Temperatures, chemical composition, discharge rate, terrain, ownership status, proximity to other freshwater supplies and local fish stocks are reported for each spring. Likely areas for field investigations are also outlined. Assuming salmonid tolerances of the chemical characteristics of thermal waters could be assessed and site specific considerations could be met; it was felt that further work on developing geothermal energy sources could be successful.

Cutthroat Enhancement

Sea run cutthroat are regarded as a very enhanceable renewable resource; they utilize small stream environments which are easily modified for spawning and freshwater development and they stay close to shore in their marine development phase, making them easily available for recreational fishing. A report has been prepared describing the opportunities for increasing the support capabilities of Victoria area streams for sea run cutthroat. For each stream in the study area, that could or does support this species, the environmental condition of the stream, limiting factors and enhancement opportunities are outlined. Marine and stream fishability as well as enhancement suggestions for regulatory measures are also included.

Habitat Protection Unit

The Habitat Protection Unit (HPU) has been involved with SEP primarily through administrative input at the committee and working group level. The HPU is represented on each of the GWGs, on the Public Involvement working group, and in the Special Projects Unit. Programs concerned with habitat protection have been proposed to the Research working group and the HPU will be represented there in future. In addition, within the Federal/Provincial Estuary Study on the Lower Fraser, HPU personnel who form a key role in that study have been funded by SEP to formulate program direction and inventory critical habitats. The HPU has also been involved in the B.C. Task Group, discussing such issues as estuary protection, hydro-electric projects and fisheries' habitat problems in general. Proposed public relations activities of SEP, such as brochures on SEP habitat protection and the fisheries resource, have received a significant degree of input from the HPU. There have been numerous appearances ranging from schoolroom lectures to meetings with the industry in which the HPU and SEP have appeared on a joint basis discussing the relationship between their interests.

During the 1978/79 fiscal year, it is anticipated that the role of the Habitat Protection Unit within SEP will continue to expand. Involvement in the GWGs, the Public Involvement working group, and the Research working group will grow in future years and it is also anticipated that Special Projects will rely increasingly on liason with HPU members for projects arising at a regional, local and district level. In addition to all of these activities, Habitat Protection will serve in a referral capacity for most of the SEP projects that have implications to environmental disturbance. For the coming fiscal year, Habitat Protection has been funded to undertake:

i) additional Lower Fraser River inventory and computer programming of resource base;

ii) a major research program, to be supervised by Habitat into receiving water standards for hatcheries;

iii) supervision by Habitat personnel of the Nicola Valley minimum flow study and installation of fish screens; and,

iv) a preliminary research project on the Lower Fraser investigating the possibility of establishing marsh areas in formerly degraded zones.

Minimum Flow Inventory

The Habitat Protection Branch has undertaken an inventory of a number of river systems. Using data in existing stream correspondence, spawning files and fishery officers' comments, a list of rivers with or requiring "Fishery Resource Maintenance Flow" agreements was compiled. Problems were identified (Table 31) and solutions suggested: e.g., low flow studies, priorization of such studies, or possible contribution of SEP by way of funding or technical support. Specialized information on SEP projects is also included, and funding for additional work is suggested. A complete account of the status inventory of Low Flow Agreements on B.C. rivers with detailed recommendations for future studies and implementation is in preparation and will be available from the Water Use Division of the Habitat Protection Branch.

Kootenay lake Ecology

A contract was let to prepare a report on an ecology-based production study of Kootenay Lake. The study was undertaken during the 1964 to 1971 period for the purpose of determining climactic, edaphic (physical and chemical) and biological parameters of the lake. It is planned that the report will be completed and published as a technical report in the 1978/79 fiscal year.

Table 31:

Inventory of rivers, by protection district, with or requiring maximum-minimum flow agreements, and abbreviated comments.

District	River	F.R.M.F.[1] in effect	Comments
New Westminster	Alouette	yes	flows too high
	Chehalis	no	chum enhancement
	Coquitlam	no	study underway
	Hicks	no	low flows
	Jones	yes	spawning channel
	Norrish-Suicide	no	recommendations made
	Seymour	yes	not maintained
	Stave	no	enhancement
Victoria	Goldstream	yes	flows monitored
	Jordan	yes	fish stocks reduced
	Leech	no	report in preparation
	Sooke	no	report in preparation
Nanaimo	Black	no	report in preparation
	Cheakamus	yes	monitoring required
	Chemainus	no	summer low flows
	Cowichan	yes	storage reservoir
	Deadman	yes	enhancement
	Headquarters	no	enhancement
	Little Qualicum	no	enhancement
	Nanaimo	yes	low flows
	Puntledge	yes	enhancement
	Rainy	no	low flows
	Salmon	yes	low flows
	Theodosia	yes	not effective
	Tsolum	no	extreme flows
Port Alberni	Ash	yes	—
	Heber	yes	—
	Marble	incomplete	unstable flows
	Somass	no	—
Campbell River	Quinsam	yes	low flows
Lillooet	Bridge	no	existing dam
	Seton	yes	powerhouse
Kamloops	Bessett	incomplete	low flows
	Duteau	yes	not well monitored
	Nicola	incomplete	low flows
	Shuswap	no	study underway
Prince George	Nechako	no	report in preparation
Kitimat	Kemano	no	enhancement
Prince Rupert	Nanika	no	natural state
	Morice	no	guidelines established

[1]Fishery Resource Maintenance Flows.

APPENDIX I

Appendix I describes the numbers, locations, and months of recovery of coded-wire-tagged chinook salmon originating from the following hatcheries:

i) Robertson Creek (Figure 1),

ii) Puntledge River (Figure 2),

iii) Big Qualicum River (Figure 3), and

iv) Capilano River (Figure 4)

as determined by commercial and recreational fisheries in Canadian waters in 1975. This data does not indicate the fishery contributions of hatchery stocks.

The tagged chinook represented in Figures 1 to 4 were progeny of several different brood years. Appendix Table 1 presents the overall proportions of recoveries from the different brood years.

Appendix Table 1.

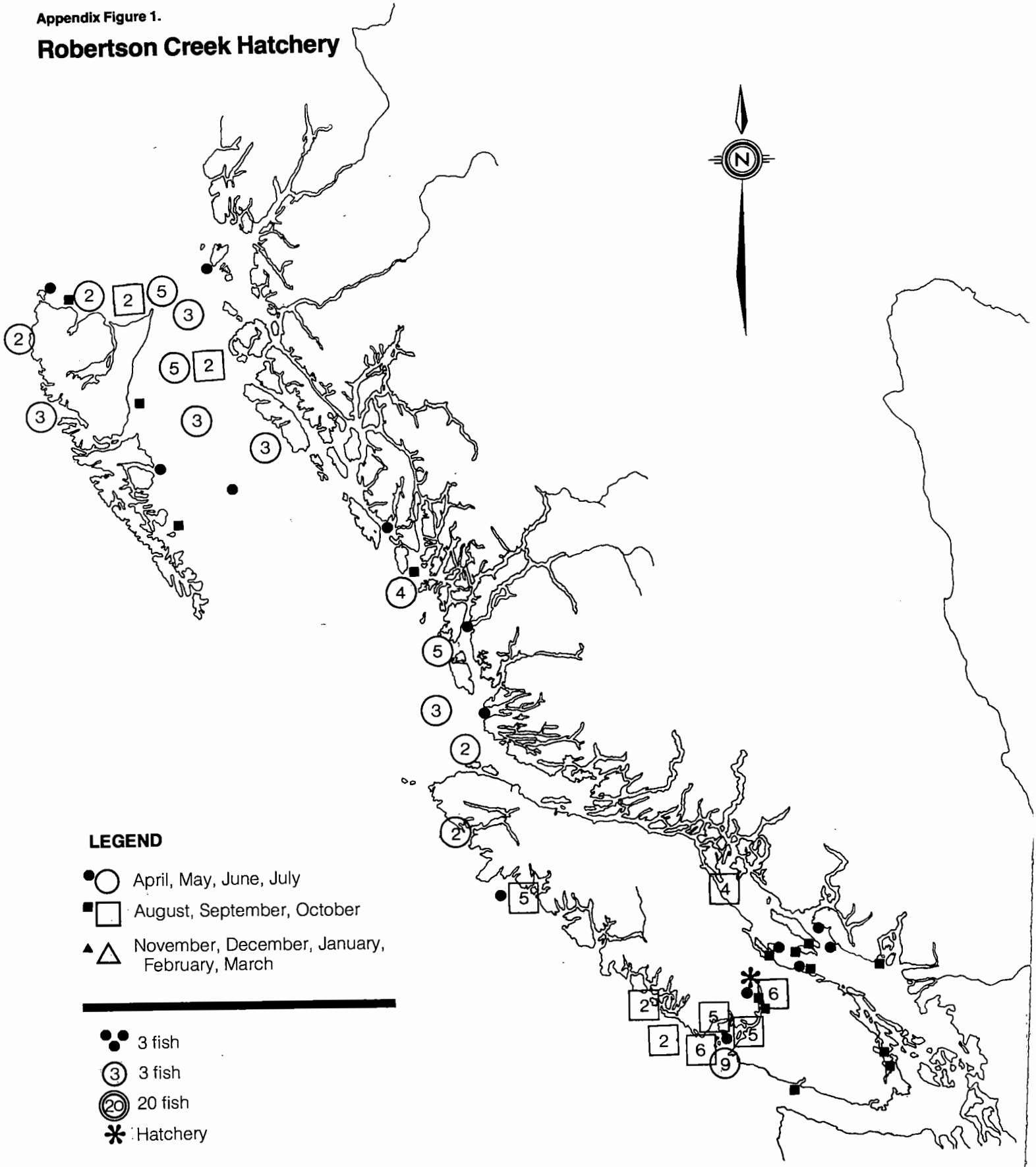
Breakdown of tagged chinook by hatchery and brood year recovered in 1975.

Hatchery		Brood Year				
		1970	1971	1972	1973	Total
Robertson Creek	R*	—	—	108	23	131
	T**	—	—	107,440	142,105	149,545
Puntledge River	R	—	10	120	524	654
	T	—	5,070	46,110	52,778	103,958
Big Qualicum River	R	11	156	311	712	1,109
	T	30,425	176,975	158,469	96,165	462,034
Capilano River	R	—	23	248	671	942
	T	—	138,216	80,945	100,503	319,664

* tagged chinook recovered
** total tagged chinook

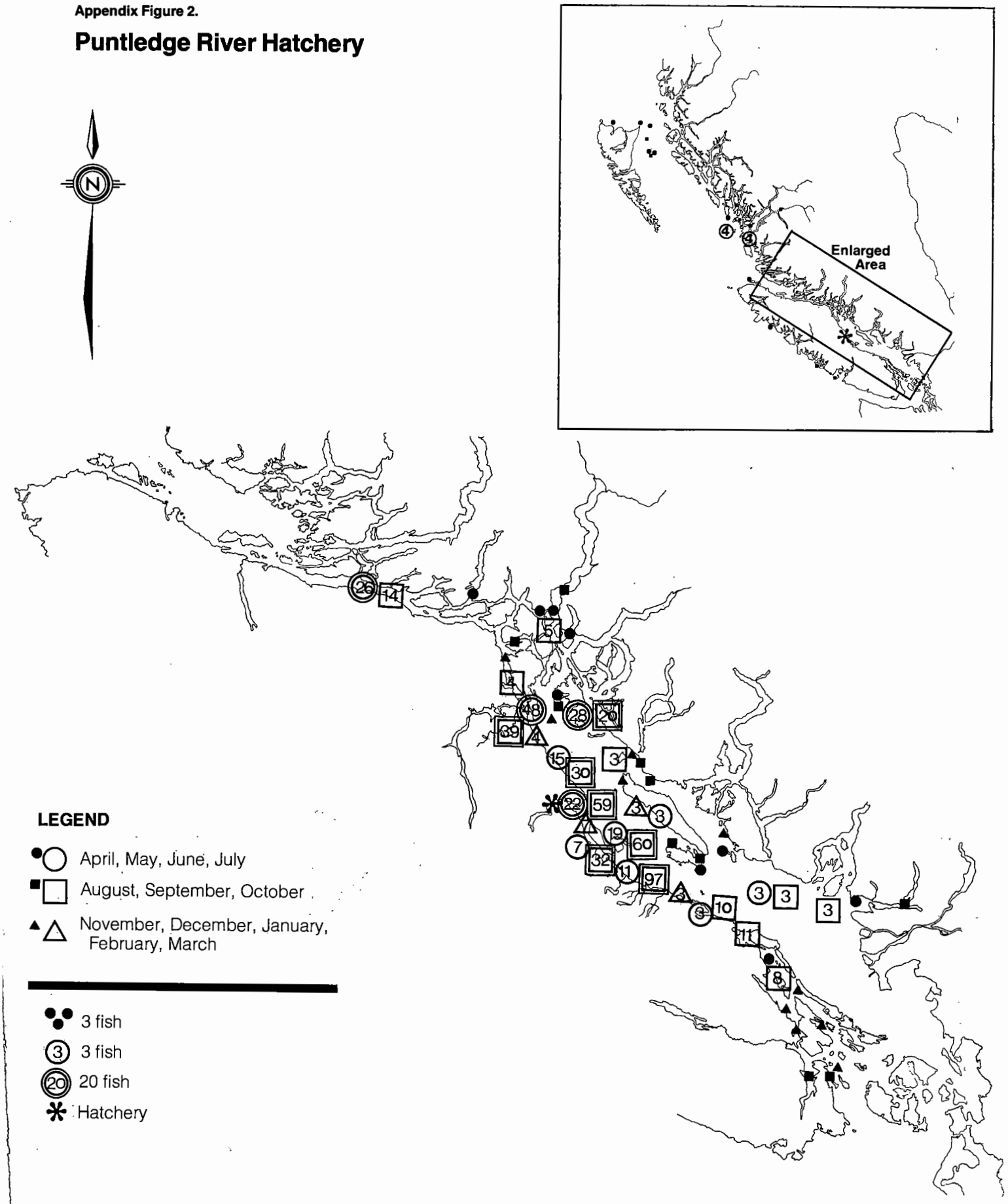
Appendix Figure 1.

Robertson Creek Hatchery



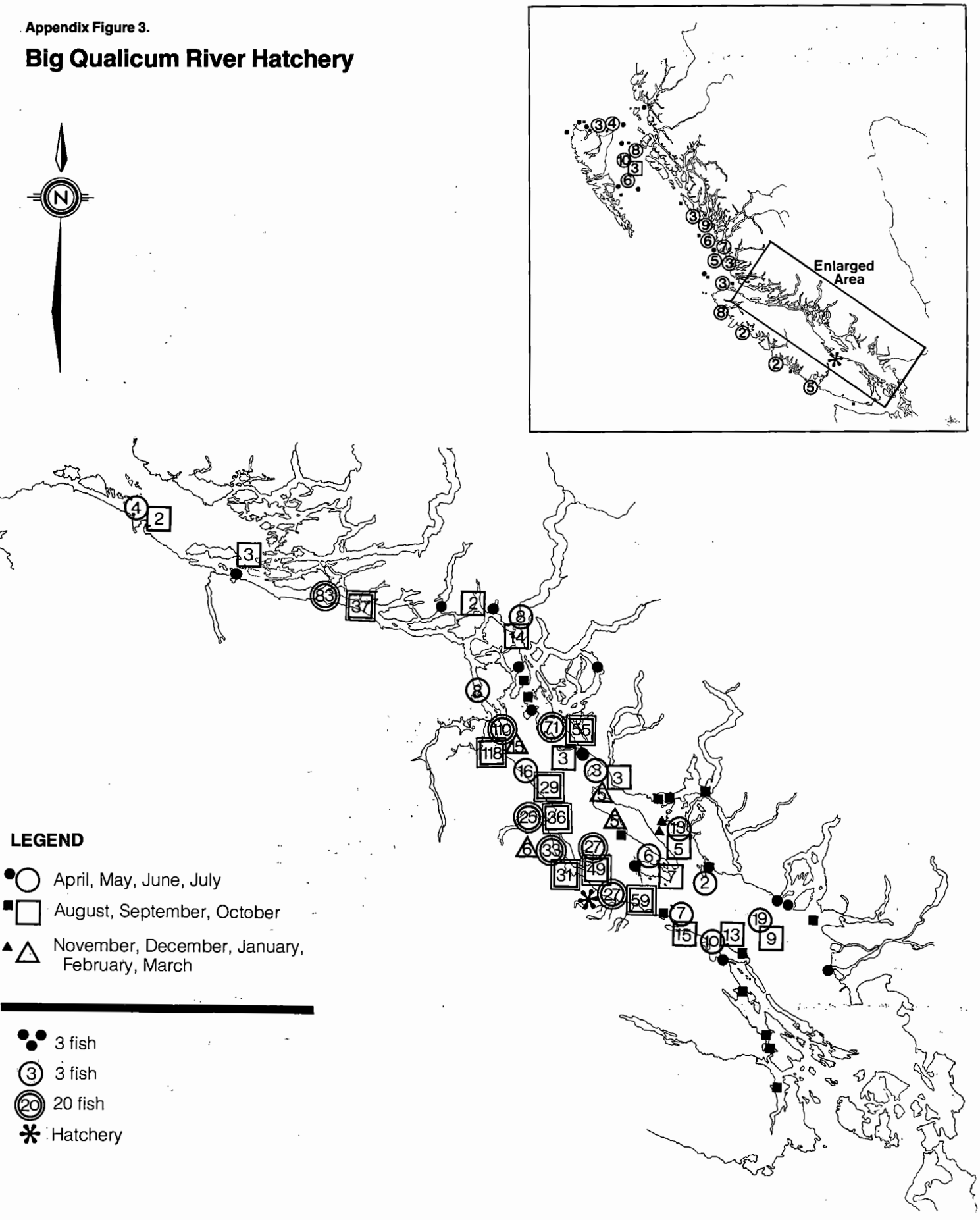
Appendix Figure 2.

Puntledge River Hatchery



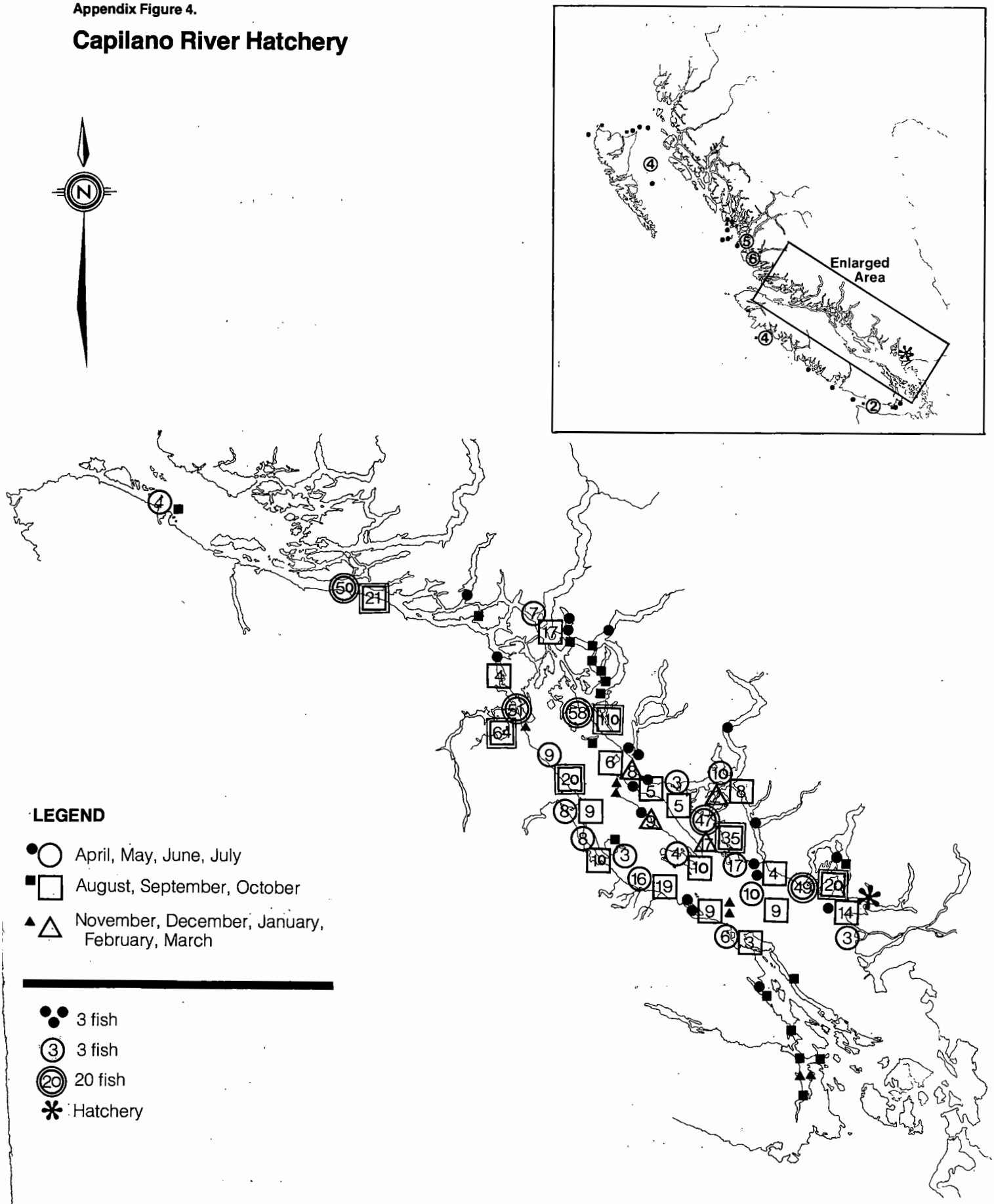
Appendix Figure 3.

Big Qualicum River Hatchery



Appendix Figure 4.

Capilano River Hatchery



APPENDIX II

Appendix II describes, in tabular form, the preliminary expenditures of Year I of the Salmonid Enhancement Program on a project-by-project basis.

Year I Expenditures

Administration	Expenditures
Administration	$ 272,376.61
Program Development and Project Management	210,830.04
Management Board	4,204.99
Resource Consultants	5,542.72
	$ 492,954.36

Economics	
Indust. Study	24,386.84
Recrn. Study	35,601.03
Native Impt. Study	130,893.71
Regn. Impt. Study	25,063.97
Benefit Cost Study	32,108.82
Policy Issues Study	22,585.32
Program Support	15,683.51
Inter Resce. Impct.	17,000.00
Economic Nanaimo	69,907.97
Econ. Bella Bella	104,251.99
Econ. Sliammon	116,452.39
Kispiox	30,628.71
Econ. Chehalis	32,938.33
	657,502.59

Public Involvement	
Salary & Government Costs	2,588.70
Indian Trainees	1,117.98
Info. Centre	54,976.33
Public Education	82,314.78
Native Project	20,103.55
Task Forces	1,543.30
Inquiries	70.80
Public Participation Project	21,016.71
Workshops	13,974.10
Consultants	291,682.95
Information Service	11,539.92
	500,929.12

Steelhead Studies	
Steelhead ID. Skeena Kit. Bella Coola	103,863.37
Georgia Johnstone Strait Steelhead Study	73,009.63
Serpentn. Nicmkl. Salm. Study	16,842.49
Somass River Sum. Steelhead Study	13,709.89
Fresh Water Salmon Prod. Study	102,420.76
Assmt. Study Steelhead Comm. Fishry.	102,740.67
Fraser River Steelhead	67,858.14
	408,444.95

Sp. Projects Administration	6,159.00

Enhancement Facilities

Pinkut Cr. Assessment	9,562.33
Pinkut Cr. Operations	93,716.92
Fulton River Asses.	41,129.98
Fulton River Ops.	47,221.14
Pinkut Cr. Airlift	3,058.21
	194,688.58

Georgia-Johnstone Strait

Headwater Tagging	93,796.37
BQR Chum Marking	10,812.77
Stream Catalogue	23,135.79
General Reconn.	40,386.36
Cowichan Side Chan. Native Project	32,464.08
Wolf Tsolum Design	574.49
B.Q.R. Rear Channel & Proj. Improvement	284,695.80
Small Stream Study	26,186.79
Program Support	30,499.86
Little Qualicum Sp. Ch. Design	23,401.68
Puntledge Design	5,285.23
Puntledge Construction	332,665.45
Cowichan Bio. Eng. Baseline	11,586.21
Mark Recovery	301,824.99
Little Qualicum Property	1,930.50
Small Stream	66,834.53
Bio Study & Mtnce.	179,570.84
	1,465,651.74

Fraser - W.C.V.I.

Birkenhead Feas.	55,733.53
Chilliwack Headwater Tag.	106,819.24
Chilco Headwater Tag.	68,013.92
Blaney Operations	27,826.20
Inches (Barnes) Operations	41,362.47
Thornton Operations	73,847.86
Vedder Feas.	18,346.48
Shuswap Feas.	11,124.94
General Reconn.	8,969.07
Reconn. Fraser	46,214.88
Engineering Reconn.	10,532.15
Small Stream Improv.	27,650.37
Reconn. W.C.V.I.	76,488.83
Program Support	38,471.76
Inches Design	22,007.31
Tlupana Inlet Eng. Feas.	67,348.53
Deadman Biol. Feas.	24,339.63
Inches Construction	84,404.48
Deadman Engineering	18,984.69
Lower Fraser Biology	37,650.70
Tlupana Bio Feas.	449.17
	866,586.21

North - Central Coast

Bella Coola Feas.	20,040.52
Kalum Feas.	116,660.73
Kitimat Feas.	148,241.85
Mathers Feas.	65,251.32
Atnarko Operations	129,735.63
Docee Feas.	7,187.47
Fulton Operations	69,301.10
Q.C.I. General Reconn.	15,133.51
Mathers Design	6,509.09
Program Support	64,117.07
Pallant Bio.	51,457.40
Pallant Design	20,704.54
Fulton Construction	77,488.17
Small Stream Improvement	49,673.67
Pallant Construction	243,781.83
Pallant Operations	690.00
Lowe Lake Fishway Surv.	388.80
Bella Coola Public	10,393.60
Bio Eng. Reconn.	32,784.74
Kitimat Feas.	4,649.15
Pinkut Channel	475,000.00
Babine Fence Rpr.	59,437.94
Yukon River Feas.	17,734.03
	1,686,362.16
Enhancement Engineering	67,703.79

Enhancement & Facilities

Program Management	11,414.70
Quinsam Hatch Ops.	218,162.46
Big Qualicum Ops.	98,532.29
Capilano Operations	108,536.26
Capilano Maintenance	59.25
Puntledge Operations	22,912.72
Robertson Cr. Ops.	84,877.69
Robertson Cr. Maint.	4,017.52
Jones Creek Sp. Ch.	231.00
	548,743.89

Resource Services

Bio-Engineering Studies	1,344.31
Stock ID. Marking Systems	16,065.84
Enumeration/Monitor Tech.	74,683.97
	92,094.12
Total Expenditures	**$7,059,820.51**

APPENDIX III

Appendix III lists the reference material for the projects described in the annual report text. The reports are not listed in proper bibliographic form as many are still in the preparatory stages, others are in-house documents, and several levels of report-writing are represented. For example, technical, data, and manuscript reports, branch publications, publications in scientific journals, press releases, etc. are all combined in the following pages.

The purpose of this appendix is to indicate the level of knowledge available on relevant SEP subjects and to identify the authorities for reference purposes. The references are listed first by working group and then alphabetically:

I Geographic Working Groups
Fraser River and West Coast of Vancouver Island
Georgia and Johnstone Straits
North Coast of B.C. and the Yukon

II Research Working Group
Federal
Provincial

III Economics Working Group

IV Miscellaneous

I. Geographic Working Groups

Fraser River and West Coast of Vancouver Island

Bailey, D.D.	Blaney and Inches Creeks Incubation Box Operations 1976 Brood	in preparation
Bailey, D.D.	Thornton Creek Chum Hatchery Operations 1976 Brood	in preparation
Burns, M.	Sport Fishery April 1976 to April 1977 Creel Census on the Serpentine, Nicomekl, Salmon and Little Campbell Rivers	in preparation
Buxton J.D. F.J. Fraser	Report on the Middle Shuswap River Chinook Program — 1977	in preparation
Caverly, A.	Life History of Steelhead Trout in: Coquihalla River South Alouette River Vedder River Capilano River Seymour River Based on Anglers' catches	complete
Caverhill, P.	Squamish River Steelhead Investigations — Angler Questionnaire	in preparation
Fedorenko, A.Y. D.T. Lightly F.J. Fraser	Nitinat Lake Biological Surveys, 1975 - 1977	in preparation
Fraser, F.J.	International Pacific Salmon Fisheries Commission Enhancement Plan Assessment and Impact Statement	in preparation
Fraser, F.J.	Jones Creek Spawning Channel Progress Report	in preparation

Fraser, F.J.	Selected Fraser River Watershed Folios	in preparation
Fraser, F.J.	West Coast of Vancouver Island Enhancement Possibilities and Management Strategies	in preparation
Fraser, F.J., C.L. Cross L.C. Goodman	The Chinook and Coho Salmon of the Fraser River Past, Present, Future	in preparation
Godin, R. D.D. Bailey	Birkenhead River Feasibility Survey 1977-1978	in preparation
Kahl, A.L. F.J. Fraser	Chilcotin River Reconnaissance — 1977	in preparation
Kahl, A.L. F.J. Fraser	Upper Fraser River Reconnaissance	in preparation
Mitchell, B. F.J. Fraser	Chilliwack River Enhancement Feasibility Studies — 1976-1978	in preparation
Sebastian, D.	Habitat and Juvenile Steelhead Studies in Sowaqua Creek	in preparation
Sebastian, D.	Patterns of Smolt Outmigration from Watercress Creek Rearing Pond	in preparation
Spence, C.	Salmonid Enhancement Program Chilco/ Chilcotin Steelhead Survey	complete
Tutty, B.D. Y. Yole	Evidence of Substantial Natural Production of Overwintering Stream-type Chinook in the Upper Fraser system	complete
Wersta, E.A.	Creel Census and Questionnaire of Steelhead Anglers on Seymour River 1976-1977	complete
Williamson, D.	Physical and Legal Access on the Coquihalla, Siverhope, Vedder, South Alouette, Coquitlam, Seymour, Lynne and Cheakamous Rivers	in preparation

Georgia and Johnstone Straits

Argue, A.W. R.W. Armstrong	Coho Smolt Coded-wire Tagging of Wild Coho and Chinook Juveniles from the Cowichan River System — 1975	complete
Argue, A.W. J. Coursley	Preliminary Revision of Georgia Strait and Juan de Fuca Strait Tidal Salmon Sport catch Statistics — 1972-1976 Based on Georgia Strait Head Recovery Program Data	complete
Argue, A.W. D.E. Marshall	Size and Age of Chinook and Coho Salmon in the Strait of Georgia Troll Fishery, 1976	complete
Argue A.W. C.C. Wilson	Squamish River Spawning Ground Recovery of 1973 Brood Coded-wire-tagged Coho Salmon	in preparation
Argue, A.E. R.W. Armstrong L. Patterson B. Lewis	Enumeration and Coded-wire-tag Recovery from Cowichan River Coho and Chinook Salmon Escapements in 1976 and 1977	in preparation
Armstrong, R.W. A.W. Argue	Coho Smolt Coded-wire-tagging and Enumeration Broods on Three Small Tributaries of the Squamish River System	in preparation
Armstrong, R.W. A.W. Argue	Trapping and Coded-wire-tagging of Wild Coho and Chinook Juveniles from the Cowichan River System, 1975	complete
Barrett, D.	A Preliminary Reconnaissance of Pink and Chum Salmon in Jervis and Sechelt Inlets	in preparation
Barrett, D.	Baseline Information for Proposed Projects on Kakweiken River, Embly River and Wolf Lake/Tsolum River	in preparation
Brown, R.F. V.D. Chaley D.G. Demontier	Preliminary Catalogue of Salmon Streams and Spawning Escapements of Statistical Area 14 (Comox-Parksville)	complete
Chaley, V.D. R.F. Brown	Preliminary Catalogue of Salmon Streams and Spawning Escapements of Statistical Areas 17 and 18 (Nanaimo, Ladysmith Duncan).	complete
deHruccoczywirth, V.C. R.W. Armstrong A.W. Argue	A Preliminary Salmonid Reconnaissance of the Toba River System — 1976	complete
Fraser F.J. D.D. Bailey M.J. Wood	Big Qualicum River Salmon Development Project (Vol. II): Hatchery Operations 1967-1972	complete

Heizer, S.R. A.W. Argue	Basic Catch Sampling and Coded-wire-tag Recovery Data for Georgia Strait Chinook and Coho Fisheries in 1973	complete
McLean, W.E.	Quinsam Salmon Hatchery Background Water Quality Data 1972-1978	complete
McLean W.E. C.M. Spicer	Performance of Water Quality Treatment Facilities at the Quinsam Salmon Hatchery 1975-1977	complete
Marshall, D.E. R.F. Brown V.D. Chaley D.G. Demontier	Preliminary Catalogue of Salmon Streams Spawning Escapement of Statistical Area 11 (Seymour-Belize Inlets)	complete
Marshall, D.E. R.F. Brown V.D. Chaley D.G. Demontier	Preliminary Catalogue of Salmon Streams and Spawning Escapement of Statistical Area 13 (Campbell River)	complete
Marshall, D.E. R.F. Brown V.D. Chaley D.G. Demontier	Preliminary Catalogue of Salmonid Streams and Spawning Escapements of Statistical Areas 19 and 20 (Victoria-Sooke)	complete
Wilson, C.C. R.W. Armstrong A.W. Argue	The 1975 Upstream Squamish River Spawning Grounds Recovery of 1972 Brood Coded-wire-tagged Coho Salmon	complete

North Coast of B.C. and the Yukon

Banford, C.	Gravel Incubation and Fry-to-smolt Rearing of Chinook Salmon (Oncorhynchus tshawytscha) at Fulton River	complete
Banford, C.	Heath Tray Incubation and Rearing of Steelhead Trout (Salmo Gairdneri) at Fulton River	complete
Chudyk W.E.	Suskwa River Steelhead Trout — 1977 Inventory Creel Survey and Life History Characteristics — Study leading to the Removal of a Barrier on Harold-Price Creek	complete
Chudyk, W.E. M.R. Whately M.C. Morris	Life History of Kitimat River Steelhead Trout from Anglers' Catches in 1976-1977	complete
Chudyk, W.E. M.R. Whately	Some Notes on the Habit and Habitat of Steelhead Trout in Kispiox River with Particular Reference to Cullon Creek	complete
Cleugh, T.R.	Bibliography of Fisheries and Fish Related Studies in the Yukon	complete
Eccles, B.M. M.C. Morris	Preliminary Survey of Steelhead Spawning Habitat, Kitimat River, B.C.	complete
Eccles, B.M. M.C. Morris M.R. Whately	Kitimat River Steelhead Sport Fishery — April 6 to May, 1977	complete
Ginetz, R.M.J.	A Review of the Babine Lake Development Project	complete
Hilland, R.T.	The Effect of Density, Substrate, Water Quality and Egg-take Procedures on Pink Salmon (O gorbuscha) Production from the Atnarko River Incubation Boxes.	complete
Hooton, R.S.	Big Qualicum River Steelhead Investigations — Progress During 1976-1977	complete
McDonald, J.E.	A Comparison of Loading Densities for Sockeye Salmon in a Gravel Incubator	complete
McDonald, J.E. R.M.J. Ginetz	Gravel Incubation and Fry-to-smolt Rearing of Chinook Salmon (Oncorhynchus tshawytscha) at Fulton River	complete
Marchall, D.E. R.F. Brown V.D. Chaley D.G. Demontier	Preliminary Catalogue of Salmon Streams and Spawning Escapements of Statistical Area 2W (Queen Charlotte Islands)	complete
Morris, M.C. B.M. Eccles	A Report on the Distribution of Spawning Steelhead Trout in Kitimat River	complete
Morris, M.C. B.M. Eccles	Preliminary Survey of Juvenile Salmonid Rearing Habitat, Kitimat River, B.C.	complete

Morris, M.C. B.M. Eccles	Preliminary Survey of Juvenile Salmonid Rearing Habitat, Summer 1976, Upper Kitsumkalum River and Tributaries	complete
Shepherd, B.G.	Biological Reconnaissance of Mathers and Pallant Creeks to December, 1977	complete
Shepard, C. J. Algard	A Preliminary Survey of Juvenile Steelhead /Rainbow Trout Distribution and Rearing Habitat in the Morice River System	complete
Steigenburger, L.W. M.S. Elson	Northern Yukon Fisheries Studies, 1972-1974 Volume 3	complete
Whately, M.R.	The Babine Steelhead Project	complete
Whately, M.R. M.C. Morris W.E. Chudyk	Morice River Steelhead Trout — the 1976 and 1977 Sport Fishery and Life History Characteristics from Anglers' Catches	complete
Wilkinson, T.	Salmonid Enhancement Program, Atnarko Bella Coola Steelhead Study 1976-1977	complete

II Research Working Group

Federal

Alderdice, D.F.	Environment Stresses and Biological Hazards	complete
Alderdice, D.F.	The Salmonid Enhancement Program: Assessing the State of the Art. Physiological Requirements — Knowns, Unknowns, and Risks to the Enterprise.	complete
Alderdice, D.F. F.P.J. Velsen	Relation Between Temperature and Incubation Time for Eggs of Chinook Salmon (O. tshawytscha).	complete
Alderdice, D.F. R.A. Bams F.P.J. Velsen	Factors Affecting Deposition, Development and Survival of Salmonid Eggs and Alevins. A Bibliography 1965-1975	complete
Ballantyne, A.	Graphs of Sea Levels at Four B.C. Stations: Alert Bay, Tofino, Point Atkinson, Prince Rupert	complete
Bams, E.A. K.S. Simpson	Substrate Incubators Workshop — 1976 Report on Current State of the Art	complete
Bilton, H.T.	The Return of Coho Salmon (O.kisutch) to Rosewall Creek Vancouver Island, B.C. from Smolts of Different Sizes Released in April, May, June, and July, 1975.	in preparation
Donaldson, E.M.	Bibliography of Fish Reproduction 1963-1974	complete
Donaldson, E.M. G. Hunter H.M. Dye	Induced Ovulation in the Coho Salmon (O. kisutch) Using Salmon Pituitary Preparations, Gonadotropin, Releasing Hormones and an Antiestrogen	complete
Donaldson, E.M. H.M. Dye B.F. Wright	The Effect of Storage Conditions on the Biological Conditions on Activity of Salmon Gonadotropin	in preparation
Donaldson, E.M. F.W. Goetz B. Jalabert C.N. MacKinnon D.W. MacQuarrie	Applied Studies on Controlled Reproduction of Pacific Salmon	completed
Fagerlund, U.H.M. J.R. McBride	Distribution and Disappearance of Radioactivity in Blood and Tissues of Coho Salmon (O kisutch) After Oral Administration of 3H Testosterone	in preparation
Fagerlund, U.H.M. J.R. McBride	Effect of 17α-methyltestosterone on Growth, Gonad Development, External Features and Proximate Composition of Muscle of Steelhead Trout, Coho and Pink Salmon	complete
Fagerlund, U.H.M. D.A. Higgs J.R. McBride	Influence of Feeding a Diet Conating 17-α methyltestosterone or Testosterone at Two Ration Levels on Growth, Appetite and Food Conversion Efficiency of Underyearling Coho Salmon (O. kisutch).	in preparation

Goetz, F.W. E.M. Donaldson, G.A. Hunter and H.M. Dye	The Effects of Estradiol-17B and 17α-methyl-testosterone on Early gonadal Differentiation in the Coho Salmon (O.kisutch).	in preparation
Higgs, D.A. J.R. Markert D.W. Quarrie J.R. McBride B.S. Dosanjh C. Nichols G.E. Hoskins	Development of Practical Dry Diets for Coho Salmon (O.kisutch) Using Poultry-by-product meal, Feather meal, Soybean Meal, and Rapeseed Meal as Major Protein Sources.	in preparation
Higgs, D.A. J.R. Markert D.W. McQuarrie	Diet Development	complete
Higgs, D.A. U.H.M. Fagerlund J.R. McBride H.M. Dye E.M. Donaldson	Influence of Combinations of Bovine Growth Hormone 17α-methyltestosterone and L-thyroxine on Growth of Yearling Coho Salmon (O.kisutch).	complete
Higgs, D.A. U.H.M. Fagerlund J.R. McBride J.G. Eales	Influence of Orally Administered L-thyroxine and 3,5,3'-triiodo-L-Thyronine on Growth, Appetite, and Food Conversion of Under-yearling Coho Salmon (Oncorhynchus kisutch)	complete
Hoskins, G.E. L.P. Hulstein	Annual Report of the Diagnostic Service of the Fisheries and Marine Service, Pacific Region for 1975.	in preparation
Ker, Priestman and Associates	Salmonid Enhancement Design Study of In-filtration Galleries and Hatcheries and Incubation Boxes.	complete
Ludwig, B. D.A. Higgs U.H.M. Fagerlund J.R. McBride	A preliminary Study of Insulin Participation in the Growth Regulation of Coho Salmon (O. kisutch)	complete
McBride, J.R. U.H.M. Fagerlund	Studies with Anabolic Steroids	complete
MacKinnon, C.N. E.M. Donaldson	Comparison of the Effect of Salmon Gonadotropin Administered by Pellet Implantation or Injection on Sexual Development of Juvenile Male Pink Salmon (O. gorbuscha)	complete
MacQuaries, D.W. J.R. Markert W.E. Vanstone	Photoperiod Induced Off-season Spawning of Coho Salmon (O. kisutch)	in preparation
Markert, J.R. D.A. Higgs H.M. Dye D.W. McQuarries	Influence of Bovine Growth Hormone on Growth Rate, Apetite and Food Conversion of Yearling Coho Salmon (O. kistutch) Fed Two Diets of Different Composition	complete
Mauzer, J.I. W.E. Barraclough R.J. LeBrasseur C.D. McAllister	Preliminary Information on Some Ecological Relationships Resulting from Artificial Enrichment of an Oligotrophic Sockeye Salmon Nursery Lake	in preparation
Mundie, J.H. D.E. Mounce	The Application of Stream Ecology to Raising Salmon Smolts in High Density	in preparation
O'Brien, R.N. S. Visaisouk R. Raine D.F. Alderdice	Natural Convection — A Mechanism for Transporting Oxygen to Incubating Salmon Eggs.	complete
Saunders, R.L. U.H.M. Fagerlund J.R. McBride E.B. Henderson	17α-Methyltestosterone. A Potential Anabolic Hormone in Atlantic Salmon Culture	complete
Shortreed, K.S. J.G. Stockner	Response of Attached Algae to Whole-lake Fertilization Experiments in Five B.C. Coastal Lakes	in preparation
Stockner, J.G.	Lake Fertilization as a Means of Enhancing Sockeye Salmon Populations: the State of the Art in the Pacific Northwest	complete
Stockner, J.G. K.S. Shortreed	Limnological Inventory of 35 Nursery Lakes in B.C.	in preparation

Stockner, J.G. K. Stephens K.S. Shortreed	Artificially Induced Upwelling in Great Central Lake, B.C.	in preparation	
Wickett, W.P.	Relationship of Coastal Oceanographic Factors to the Migration of Fraser River Sockeye Salmon (O. nerka)	complete	
Wickett, W.P. J.A. Thomson A. Ballantyne	Transportation Computations for the North Pacific Ocean 1960-1975, 16-year Means by Months	complete	
Wickett, W.P. J.A. Thomson A. Ballantyne	Transport Computations for the North Pacific Ocean, 1976	complete	
Williams, D.D. J.H. Mundie	Substrate Size Selection by Stream Invertebrates, and the Influence of Sand	in preparation	
Williams, D.D. J.H. Mundie D.E. Mounce	Some Effects of Benthic Production in a Salmonid Rearing Channel	complete	
Wright Engineers Ltd.	Permeability of Gravel and Gravel-Synthetic Fish Egg Mixtures	complete	

Provincial

Halsey, G. E. Oguss	Incidental Catches of Steelhead Trout in the Commercial Salmon Fisheries of the Barkley Sound, Johnstone Strait, Skeena and Fraser Rivers	complete	
Slaney, P.A.	Estimating Production Capabilities of Coastal Rivers for Anadromous Game Fish Utilizing Habitat Classification	in preparation	
Slaney, P.A. W. Harrower	Research and Development on Rearing of Steelhead Smolts in Lake Pens	complete	
Slaney, P.A. E.A. Parkinson H.A. Smith	Evaluation of Headwater Stocking of Anadromous Gamefish in Coastal British Columbia	complete	
Smith, H.A. P.A. Slaney	Life History Characteristics of Searun Dolly Varden Char in the Keogh River	in preparation	
Tautz, A.F. R.W. Land	Development of Searun Cutthroat Culture	in preparation	
Tautz, A.F. R.W. Land	Evaluation of Steelhead Culture Techniques Involving Hatchery and Satellite Rearing Pens	in preparation	
Ward, B.R. P.A. Slaney	Evaluation of In-Stream Devices for the Production of Steelhead Trout and Coho Salmon in a Coastal Stream	in preparation	

III ECONOMICS WORKING GROUP

* Annexes to the Cabinet Document on Cost Recovery

Acres Consulting Services Ltd.	* Economic Impacts Associated with the Salmon Industry in British Columbia	complete	✓
Barclay, J.C.	* An Ex-Post Benefit Cost Analysis of the Big Qualicum River Development Project	complete	
Barclay, J.C.	* Benefit-cost Analysis of Example Phase I Plan of the Salmonid Enhancement Program	complete	✓
Barclay, J.C.	* Estimation of Commercial Fishery Benefits and Associated Costs for the National Income Account	complete	✓
Barclay, J.C.	* Impact of the Salmonid Enhancement Program (Including Cost Recovery) on Industry Costs and Revenues	complete	✓
Barclay, J.C.	Report of the Economics Working Group on the Salmonid Enhancement Program Plan	complete	✓
Barclay, J.C.	Treasury Board Submission for the Little Qualicum, Puntledge, Tlupana, Bella Coola Projects	complete	
Department of Regional Economic Expansion	* Potential Regional Impact of the Salmonid Enhancement Program	complete	✓

	DeVoretz, D.J.	An Evaluation of Data Requirement and Data Availability for a Multi-Market Salmon Demand Analysis	complete	
	De Voretz, D.J. R. Holmes	* An Outline of On-Going Studies on the Demand for Salmon	complete	✓
	Economic Working Group	List of Members of the Cost Recovery Working Group	complete	
	Economic Working Group	* The Economic Rationale for Salmonid Enhancement	complete	✓
	Edwin, Reid and Associates, Ltd.	* Impact of the Salmonid Enhancement Program on Native People	complete	
	Fraser, C.A.	License Limitation in British Columbia Salmon Fishery	complete	
	Fraser, C.A. N. McIlroy M. Friedlaender	* Native People/Regional Development Impacts of Cost Recovery	complete	
	Johnstone, R.S. D.H. Wang	* Markets for Canadian Salmon: an Economic Analysis of Market Demand	complete	✓
	Loose, V.	* Policy Paper on Resource Interactions	complete	
	McDaniels	Evaluation of Freshwater Sport Fishery Benefits from Selected Enhancement Projects	complete	
	McIlroy, V.N.	B.C. Community Profiles Handbook	complete	
	McKay, W.	* Evaluation of Incremental Indian Food Fish Benefits from Salmonid Enhancement	complete	
	McKay, W.	Socio-Economic Analysis of Native Indian Participation in the B.C. Salmon Fishery Proposed Salmonid Enhancement Program	complete	
	Masse, W.D.	* Evaluation of Incremental Recreational Benefits from Salmonid Enhancement	complete	
	Masse, W.D.	* Review of Cost Recovery Mechanisms — Recreational Fishery	complete	
	Morley, R.W.	* Incidence of Cost Recovery Charges — The Organizational Structure of the B.C. Salmon Industry	complete	
	Morley, R.W. C.A. Fraser	* Current Distribution of Rents in the Commercial Fishing Industry	complete	✓
	Rank, A.D.M. M.J. Friedlaender D. Williams	Interim and Final Assessment Reports of the Native People Project Pilot Program.	complete	
	Reid, D.J. R.W. Morley	Review of Cost Recovery Mechanisms — Commercial Fishing Industry	complete	✓
	Robinson, G.	* An Estimate of the Opportunity Costs of a Salmonid Enhancement Facility	complete	
	Shaffer, M.	* Economic Impacts Associated with the Salmonid Enhancement Program in British Columbia	complete	✓
	Shaffer, M.	* Existing and Potential Demand for B.C. Commercial Salmon Production	complete	✓
	Shaffer, M.	* Policy Paper of Fishing Fleet Size	complete	✓
	Shaffer, M.	* Policy Paper on Processing Capacity	complete	✓
	Shaffer, M.	Social Cost-Benefit of Increased Participation and Investment in the Primary and Secondary Sectors of the B.C. Salmon Industry	complete	
	Shaffer, M.	The Economic of Increased Participation in the Salmon Fleet	complete	
	Shaffer, M.	* The Employment Impact of Salmonid Enhancement Proposals and the Social Cost of Labour	complete	
	Shaffer, M.	* The Impact of Salmonid Enhancement on the Government Account	complete	
	Underwood, McLellan and Associates Ltd.	* Supply and Demand Characteristics for British Columbia Salmon	complete	✓

Underwood, McLellan and Associates Ltd. Edwin, Reid and Associates Ltd.	* Competitiveness and Efficiency of the British Columbia Salmon Industry (two volumes)	complete
Urion, H.	Cost-Income Model of the British Columbia Salmon Fishing Industry	complete

IV MISCELLANEOUS

Acara, A.H.	Production Ecology of Kootenay Lake	complete
Envirocon Ltd.	Study to Develop Guidelines for Standardized Bio-Reconnaissance and Feasibility Studies for S.E.P.	complete
Goodbrand, D.W. J.T. Crandall	Study of the Potential Use of Geothermal Springs for Fish Culture in the Pacific Drainage of British Columbia	complete
Hamilton, R.	Inventory and Assessment of "Fisheries Resource Maintenance Flows."	in preparation
Heizer, S.T. J.C. Beukema	Basic Data for the 1974 Canadian Chinook and Coho Catch Sampling and Mark Recovery Program	complete
Heizer, S.R. R.J. Cook A.W. Argue	Basic Data for the 1975 Canadian Chinook and Coho Catch Sampling and Mark Recovery Program. Volume I: Catch, Sample Size, Observed and Estimated Mark Recoveries for 20 Catch Regions Volume II: Observed and Estimated Mark Recoveries for Each Tag Code Volume III: Basic Data for Each Chinook Mark Recovered Volume IV: Basic Data for Each Coho Mark Recovered	complete
Heizer, S.R. R.J. Cook A.W. Argue	Basic Data for the 1976 Canadian Chinook and Coho Catch Sampling and Mark Recovery Program. Volume I: Catch, Sample Size, Observed and Estimated Mark Recoveries for 20 Catch Regions Volume II: Observed and Estimated Recoveries for Each Tag Code Volume III: Basic Data for Each Chinook Mark Recovered Volume IV: Basic Data for Each Coho Mark Recovered	complete
Paulik, W.B.	Opportunities and Strategies to Transform Community Behaviour Toward Conservation of the Fraser River	complete