A REVIEW OF THE PITT RIVER WATERSHED

Compiled by

M.S. Elson
Northern Natural Resource Services Ltd.
Vancouver, B.C.

For

New Projects Unit
Salmonid Enhancement Program
Department of Fisheries and Oceans
1090 West Pender Street
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ABSTRACT

The glacial upper Pitt River rises at an elevation of 1710 m in the Coast Mountains and flows southerly 52 km to the head of Pitt Lake (27 m long), at sea level. The tidally influenced lower Pitt River flows 20 km to a confluence with Fraser River at Douglas Island, approximately 30 km inland from Vancouver. The Alouette River, a major tributary system to the Pitt, flows 25 km westerly from Alouette Lake to a confluence with lower Pitt River 7.0 km upstream of the Fraser-Pitt confluence.

The watershed lies in the West Coast Climatic Region, characterized by heavy mean annual precipitation. The topography is rugged, and elevations range from sea level to 2925 m above sea level (ASL). Less than 10% of the upper watershed is below 300 m ASL. Approximately 80% of the rocks are intrusive varieties of Coast Range granites.

The economy is dominated by logging and agriculture. Population in the watershed is approximately 80,000 people (less than 100 in the upper watershed) and expected rates of population growth in settled areas to 1990 are approximately 3% per annum.

There are violent fluctuations in streamflow in many streams in the watershed resulting from heavy precipitation and snowmelt. Flows of the S. Alouette River have been controlled since 1925.

Historically, the Pitt system supported all five species of east coast Pacific salmon plus sea-run trout and char species. Pink salmon are no longer present; chinook salmon are in serious decline. Upper Pitt River is among the largest coho producers in the Fraser drainage. Spawning salmon may be in the system from July to February. Little specific information exists concerning the biology of juvenile salmon in the system, except for sockeye in the upper Pitt River and chum salmon in some Alouette River tributaries. The International Pacific Salmon Fisheries Commission (IPSFC), and the Department of Fisheries and Oceans (DFO), conduct annual estimates of abundance of salmon spawning in the Pitt River system. DFO has conducted surveys of adult chum and coho salmon in some lower Pitt River tributaries, usually in conjunction with enhancement activities in the Alouette River system. The enhancement of lower Pitt River

system steelhead and cutthroat trout has been investigated by the B.C. Ministry of Environment, Fish and Wildlife Branch*.

Multi-disciplinary baseline data collection in the lower watershed has been extensive but unintegrated. This report includes descriptions of existing salmonid enhancement facilities in the watershed, and summarizes their past production.

Surface water quality in the lower Pitt River system is characterized by extreme softness, and low alkalinity and ionic strength. Non-filterable residue (NFR) often exceeds recommended fish culture limits (RFCL), and may require filtration prior to use in an enhancement facility, particularly in periods of extreme discharge. Concentrations of iron, copper, lead, and zinc which often exceed RFCL may be associated with high concentrations of non-filterable residue. High nutrient levels and relatively low oxygen concentrations in the Alouette River system are attributable to agricultural and residential pollution. The tidally influenced reversing flows of the lower Pitt River modify many water quality characteristics by mixing with Fraser River water, and potential pollution of Fraser River will be reflected in the lower Pitt system. Surface water quality of the upper Pitt River has not been monitored. During peak discharge periods, the levels of suspended material are high.

The limited groundwater quality data available indicate potential fish culture problems. In lowland areas adjoining lower Pitt River, saltwater has often been encountered in test drilling. In upland areas, and in unconfined aquifers in the lowlands, groundwater is often characterized by high concentrations of iron, manganese and nitrate, and high bacterial counts. The pH is often low. Upland groundwater is usually higher than surface water in calcium, hardness and alkalinity. There has been only cursory investigation of the groundwater potential of the upper Pitt watershed.

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*Now separated into Fisheries Branch and Wildlife Branch, but referred to in this report by the old name, because the bulk of data referred to were collected by that department.

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ACKNOWLEDGMENTS

It is not possible to acknowledge the support of everyone who contributed to this report, but the assistance of certain contributors was invaluable. M. Waldron and P. Westlake at the Fisheries Regional Library in Vancouver made library resources readily available and responded quickly to literature requests.

T. Bakos of B.C. Forest Products, D. Dodic of the UBC Research Forest, and L. Leroux and K. Langdale of the B.C. Ministry of Forests all provided logging and forestry information. Water use, quality and streamflow data were supplied promptly by P. Whitfield, H. Liebscher, O. Nagy, B. Tassone, E. Halstead, and J. Dotzler. L. MacLeod and G. Gough with the Waste Management Branch provided much of the water quality data.

Staff of the B.C. Fish and Wildlife Branch, notably T. Burgess, T. Evans, R. Hahn, and P. Caverhill, provided ready access to their files and prompt replies to specific requests. Special thanks go to J. Woodey of the International Pacific Salmon Fisheries Commission (IPSFC) for his efforts in assembling data on upper Pitt River salmon. Without exception, staff of the Department of Fisheries and Oceans (DFO) in Vancouver and New Westminster responded promptly to requests for information. In particular, thanks go to B. Shepherd, D. Mackinlay, G. Bonnell, M. Farwell, N. Schubert, R. Harrison, S. Carruthers, J. Arsenault, and Fishery Officers at the New Westminster office.

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INTRODUCTION

This is the fourth in a continuing series of reports intended to summarize available biophysical data for use by the New Projects Unit of the Enhancement Operations Division in assessment of the suitability of various river systems for the design and construction of federal salmon enhancement facilities. Previous reports have described the Quesnel (Helm *et al.*, MS 1980a), Nechako (Helm *et al.*, MS 1980b), and Kitimat (MacDonald and Shepherd, MS 1983) watersheds.

This report reviews the Pitt River watershed including its major tributary system, the Alouette, and compiles DFO and other fisheries data in combination with relevant background information from additional sources. The summary of biophysical data presented here is intended as a review of readily accessible information for DFO internal reference only. Conclusions and recommendations generated by the data are offered as guidance by the authors, and do not necessarily reflect the policy of the Department of Fisheries and Oceans.

ENHANCEMENT RATIONALE

In late 1984, agreement was reached between Canada and the United States for implementation of a new coast-wide treaty for dealing equitably with interceptions by fishermen of each country of salmon stocks destined for streams in the other country. The treaty was signed in March 1985, and conditions are now expected to be much more favourable for enhancement of Fraser River salmon.

Fraser River annual average sockeye abundance has ranged from pre-1913 levels of approximately 10.5 million to current levels of approximately 5.5 million. Most of the original productive capacity of the system remains intact and current abundance could be approximately doubled (Vernon, 1982). Enhancement of upper Pitt River sockeye stocks by a strategy of spawning channel construction (to upgrade fry production from an existing facility) combined with experimental enrichment of Pitt Lake has been suggested as a contribution to total Fraser River salmonid enhancement (Vernon, 1982; Lill *et al.*, 1985).

Pink salmon have not been recorded from the Pitt River system since the mid-1950's. Experiments were initiated by the IPSFC in 1984 to reintroduce this species to parts of the lower watershed.

The total return of chinook salmon to the mouth of the Fraser River (escapement plus terminal catch) has declined from approximately 230,000 in 1970 to 116,000 in 1980 (Fraser *et al.*, 1982). Pitt River chinook salmon are approaching extinction, and immediate rehabilitation of this stock has been advocated (Schubert, 1982). DFO investigations of upper Pitt River chinook are described in appropriate sections of this report. Lill *et al.* (MS 1985) recommend stream improvement of Blue Creek combined with use of the existing IPSFC hatchery on Corbold Creek to protect and enhance upper Pitt River chinook salmon.

The total return of coho to the mouth of the Fraser River shows little discernible pattern, although some evidence exists that there is a gradual overall decline. Escapement trends of upper Pitt River coho are unclear, as there have been large variations in the estimated annual abundance. There is an apparent increase in abundance since 1977, but full reliance cannot be placed on the return estimates for coho or on their terminal exploitation rates. Within the Pitt River watershed, further study is required to determine actual carrying capacities, limitations to production, and the most effective rehabilitative techniques applicable to coho salmon.

The Alouette River watershed has received considerable salmonid enhancement effort to date. Past production and enhancement goals of existing facilities are described in appropriate sections of this report. In general, the major enhancement effort has been toward restoring Alouette River system coho and chum salmon populations to historic levels, and existing facilities are probably capable of attaining these goals.

The formulation of an integrated management and enhancement strategy for the Pitt and Alouette River systems, and the effective implementation of such a strategy, will require constructive input from the IPSFC, DFO, the B.C. Ministry of Environment, and from the various levels of local and regional government having jurisdiction in the area.

CLIMATE

The entire Pitt River watershed (Figure 1) lies in the "West Coast Maritime Climatic" classification of the West Coast Climatic Region (Chapman *et al.*, 1956; Department of Environment, Atmospheric Environment Service, 1980). This classification implies heavy winter precipitation, dry and cool summers, and mild and wet winters. Elevations in the watershed range from sea level to 2900 m and therefore there is substantial variation in local conditions, related to moderating maritime influences and the effects of the mountains. At higher elevations, more of the precipitation is in the form of snow.

Atmospheric Environment Service does not compile meteorological data from the upper Pitt River watershed. Meteorological data are presented here for two sites in the lower Pitt River system with a range in elevation from 2 m ASL (Pitt Polder) to 373 m (Haney UBC Research Forest) (Figures 2 and 3, Appendices 1, 1a, and 1b). At both sites there is very heavy mean annual precipitation (2276.2 mm - 2285.2 mm) with the higher level reached at the lower elevations. Of these totals, 7.6% falls as snow at Haney UBC and 2.4% as snow at Pitt Polder. For comparative purposes, at Alta Lake* (elev. 668 m), approximately 46% of the total precipitation falls as snow, and similar percentages could be expected in areas of similar elevation in the upper Pitt River watershed. Seasonally, for both lower Pitt River sites, autumn is wettest and spring driest; monthly, July is driest and December is wettest. Mean daily temperatures are lowest in January and highest in July at both stations. There are four months (June, July, August, September) in an average year at Pitt Polder that are completely frost-free, and the frost-free period is slightly less at the Haney UBC station.

Rainfall is measured in the summer months at Alvin in the upper Pitt River watershed. From these data, Schubert (MS in prep.) has estimated that the mean annual precipitation ranges from 1900-3050 mm. Roddick (1965) estimates that precipitation in mountainous areas of the watershed ranges up to 5000 mm/yr, with very heavy rainfall in the autumn.

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*Outside Pitt River watershed, but geographically similar to upper Pitt watershed.

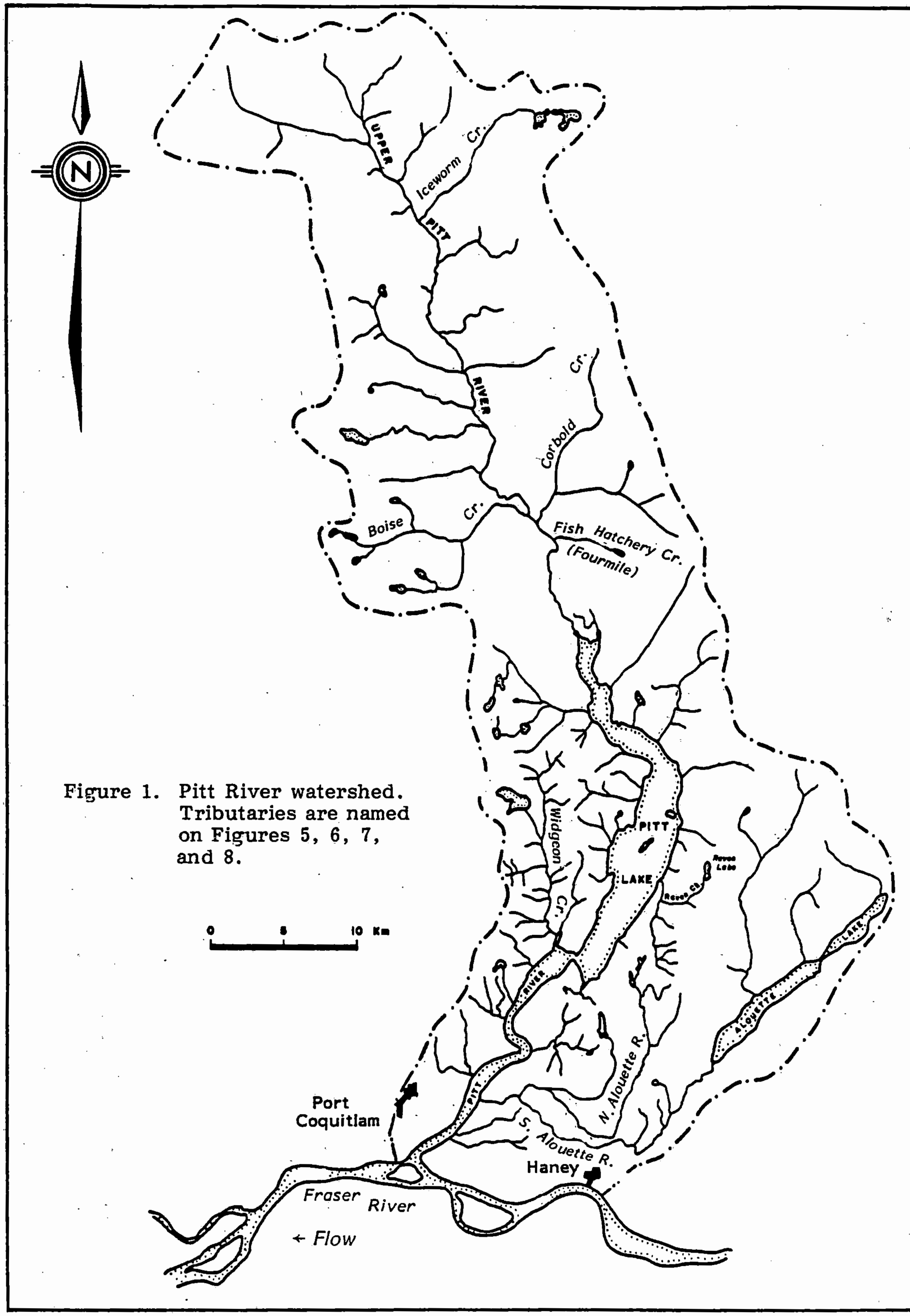


Figure 1. Pitt River watershed. Tributaries are named on Figures 5, 6, 7, and 8.

Figure 2. Weather for Pitt Polder. Daily means of air temperature, precipitation, and number of days with frost (1954-1980) (data from Department of Environment, 1980).

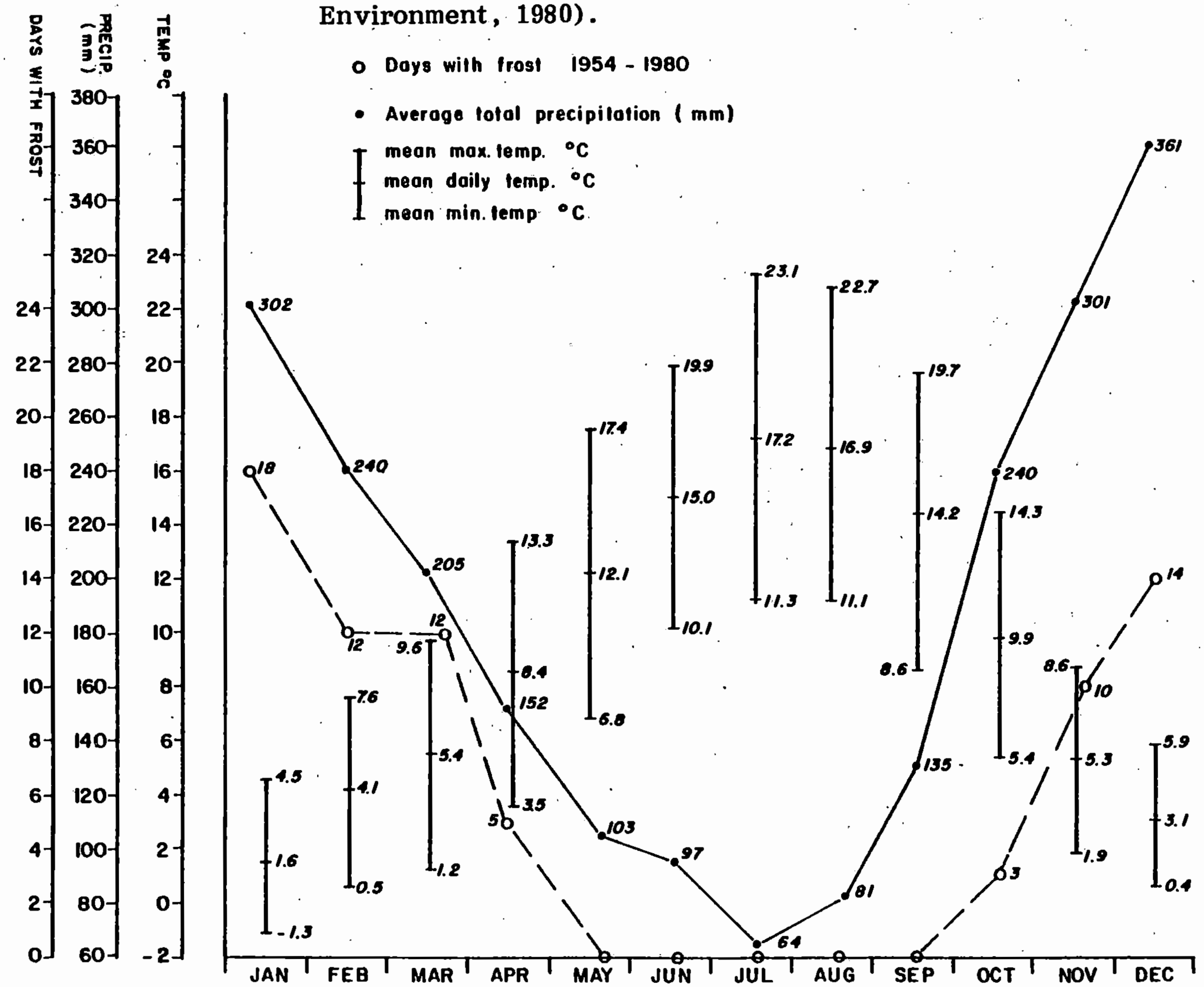
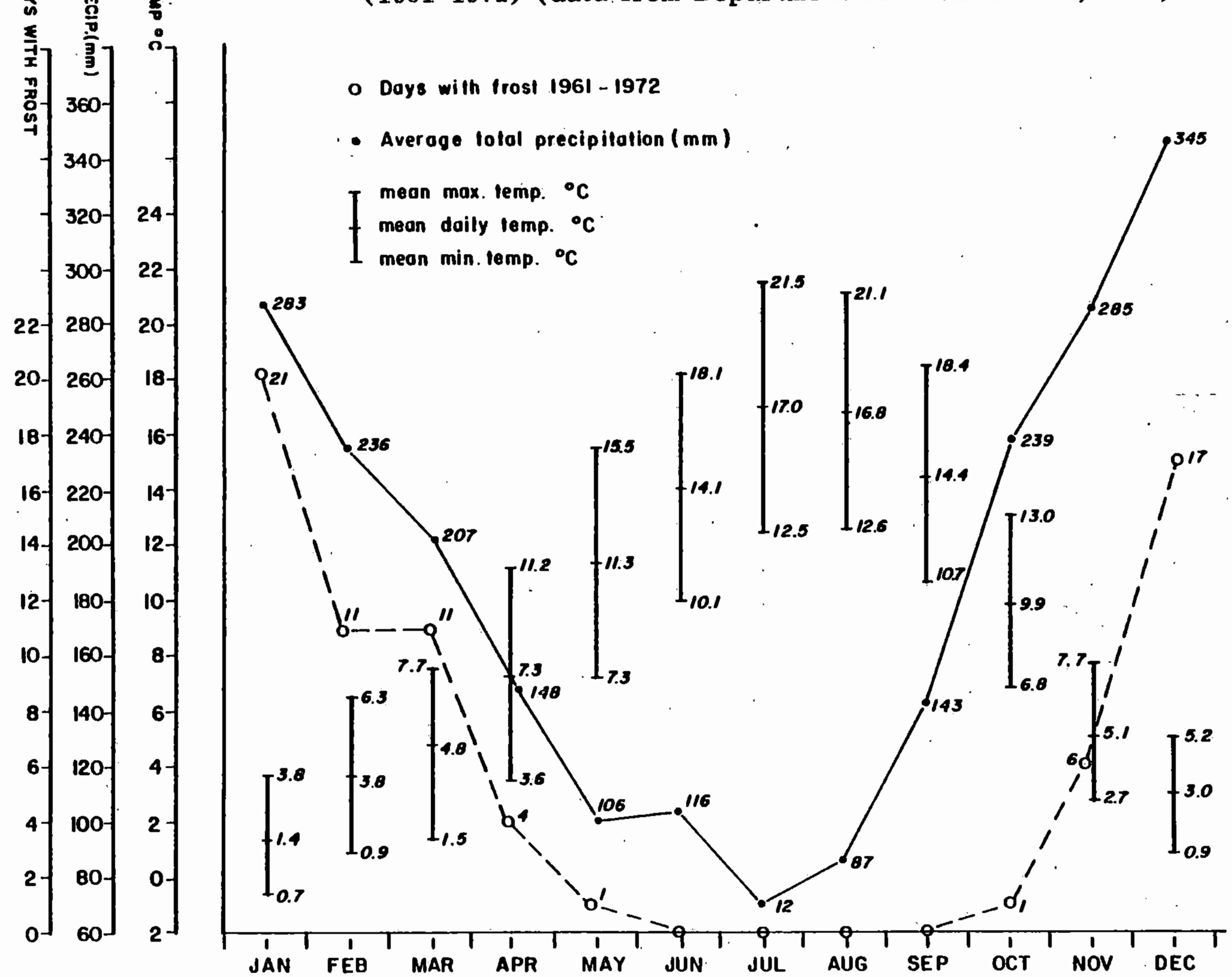


Figure 3. Weather for Haney UBC Research Forest. Daily means of air temperature, precipitation and number of days with frost (1961-1972) (data from Department of Environment, 1980).



GEOLOGY AND TOPOGRAPHY

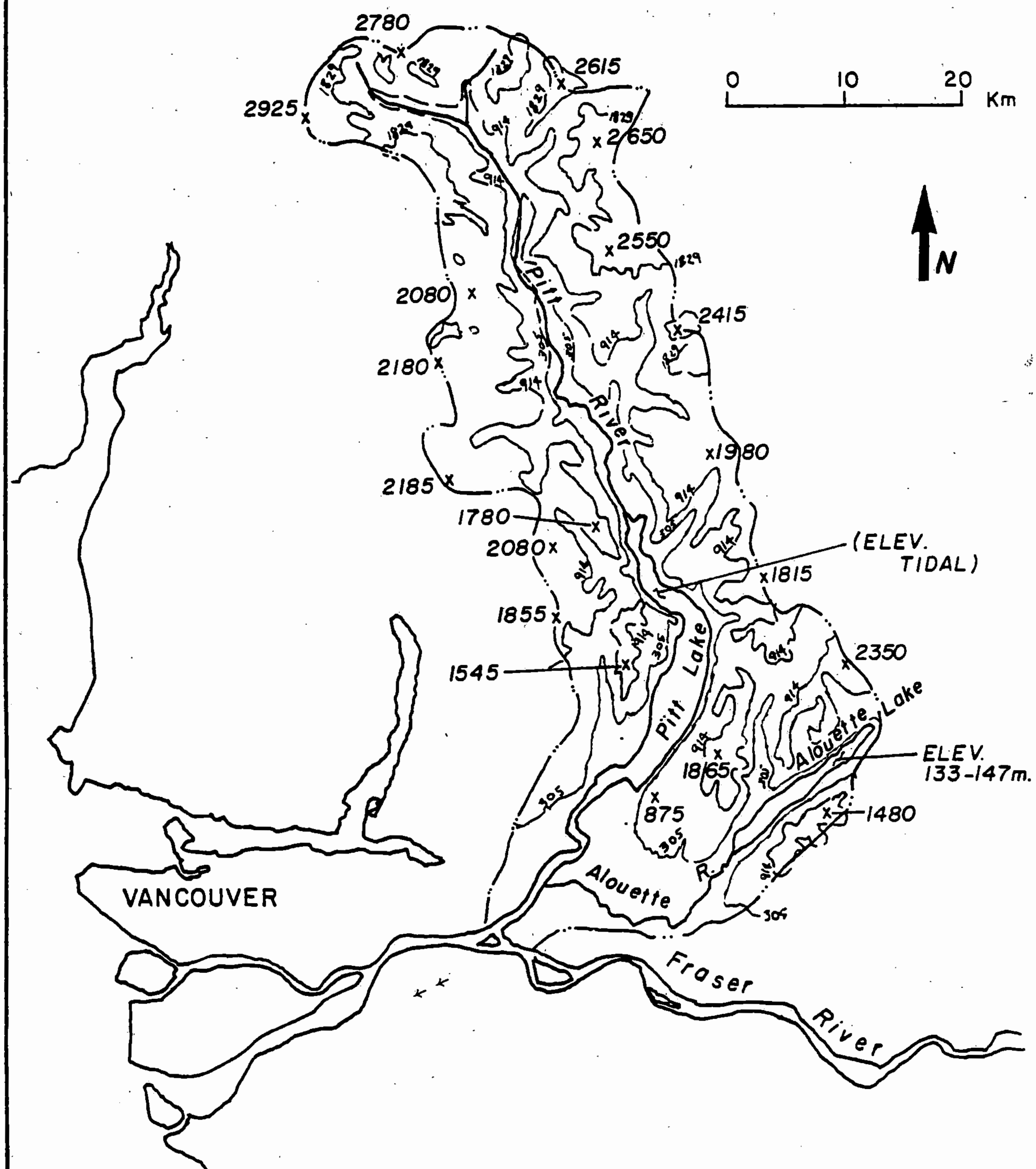
The following observations are condensed from Roddick (1965). The Fraser River lowlands and the Coast Mountains comprise the two major physiographic units in the Pitt River watershed. The lowlands, extending from the Fraser River to the southern ends of Pitt and Alouette lakes, are underlain by unconsolidated fluvial and glacio-fluvial silts, sands and gravels. These marine and glacial deposits extend into upper Pitt River valley for approximately 20 km north of the head of Pitt Lake, and approximately 5 km into the Widgeon Creek valley.

The Coast Mountains in the upper Pitt River area consist of uneven, craggy ridges interrupted by deep transverse saddles and steep-walled, narrow valleys. Topographical relief* in the region averages about 2100 m. Less than 10% of the upper region is under 300 m in elevation, and several peaks exceed 2500 m in elevation (Figure 4). Upper Pitt River valley is U-shaped with a steep average gradient of approximately 2.3%, and many of the tributaries have gradients exceeding 70%. The headwaters of upper Pitt River are bordered by several large glaciers and most tributary streams are cirque-headed, reflecting previous glaciation.

Approximately 80% of the mountainous area of the watershed is underlain by plutonic rocks consisting of granite, granodiorite, quartz diorite, diorite, gabbro and migmatite. Pendants of sedimentary, volcanic and metamorphic rock (comprising less than 10% of the total visible rock) are engulfed in the plutonic rocks. These pendants outcrop in the headwaters of Corbold, Iceworm and Pinecone creeks, on the southeast shore of Pitt Lake, and between Pitt and Alouette lakes.

*Average elevation differential between high and low points on a land plain.

Figure 4. Topography of Pitt River watershed (contours at 305, 914, and 1829 m).



ACCESS

An extensive network of main highways and roads provides access to most areas of the lower Pitt River watershed. The main branch of the CPR crosses lower Pitt River near its confluence with the Fraser River. Figure 5 shows the boundaries of District Municipalities in the watershed (all serviced by excellent road systems) and the main access routes through the lower areas. The boundaries of major land use divisions referred to in this report are shown in Figure 5a. Logging roads of variable quality (Figure 6) extend northward from the head of Pitt Lake, but do not connect with roads of the metropolitan areas to the south. Access to the head of Pitt Lake (Figure 7) is restricted to boat or aircraft.

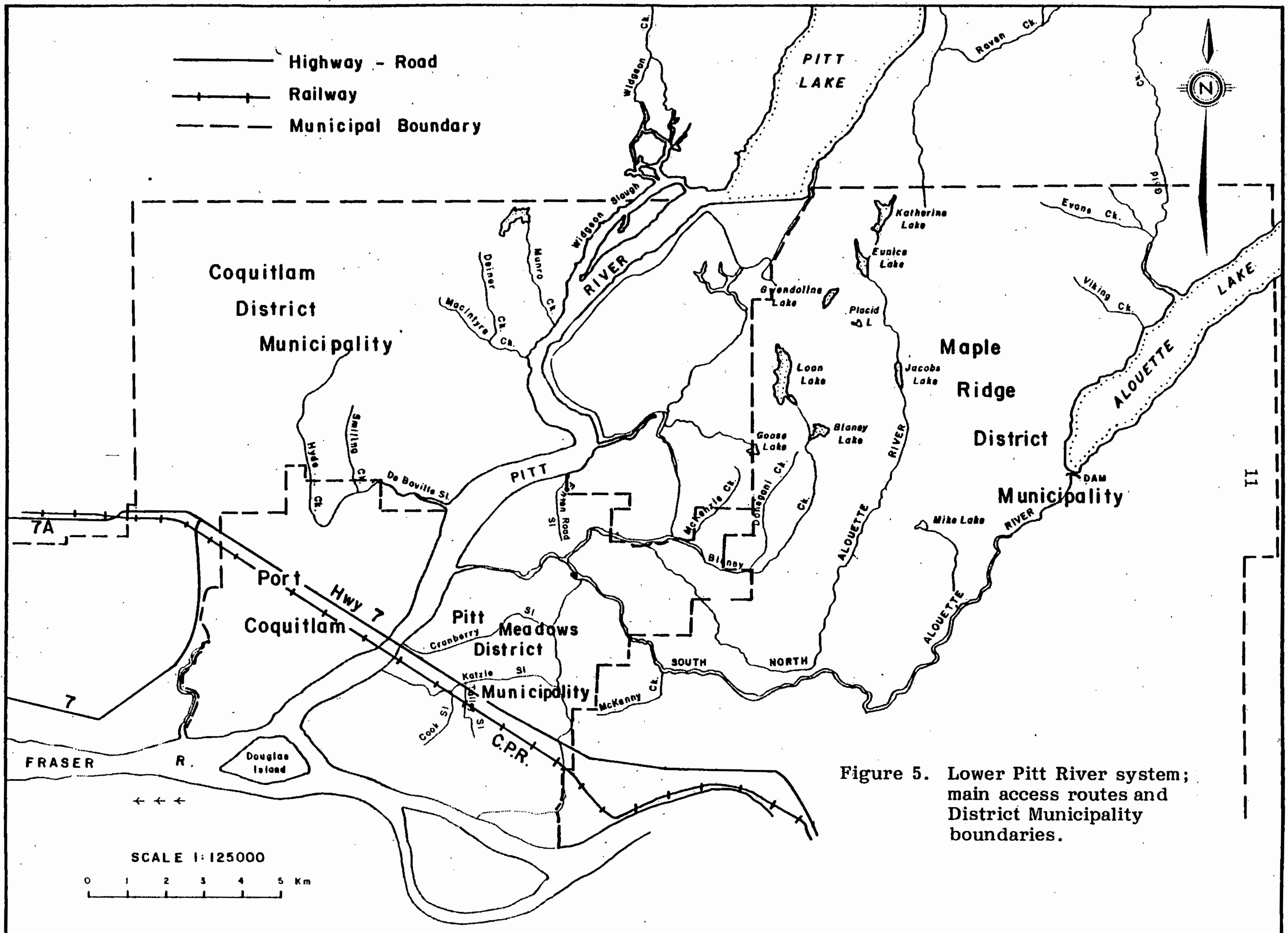


Figure 5. Lower Pitt River system; main access routes and District Municipality boundaries.

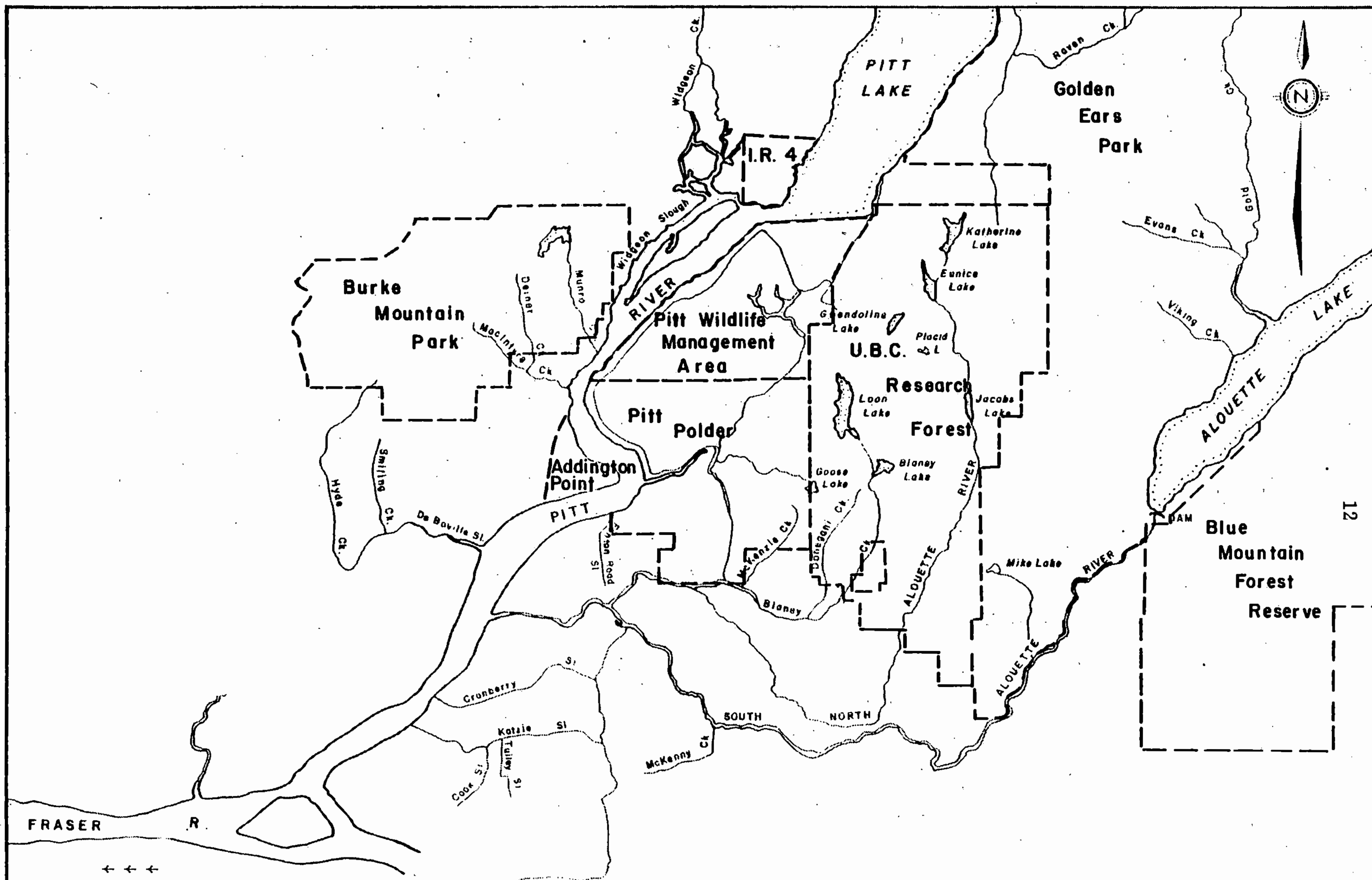


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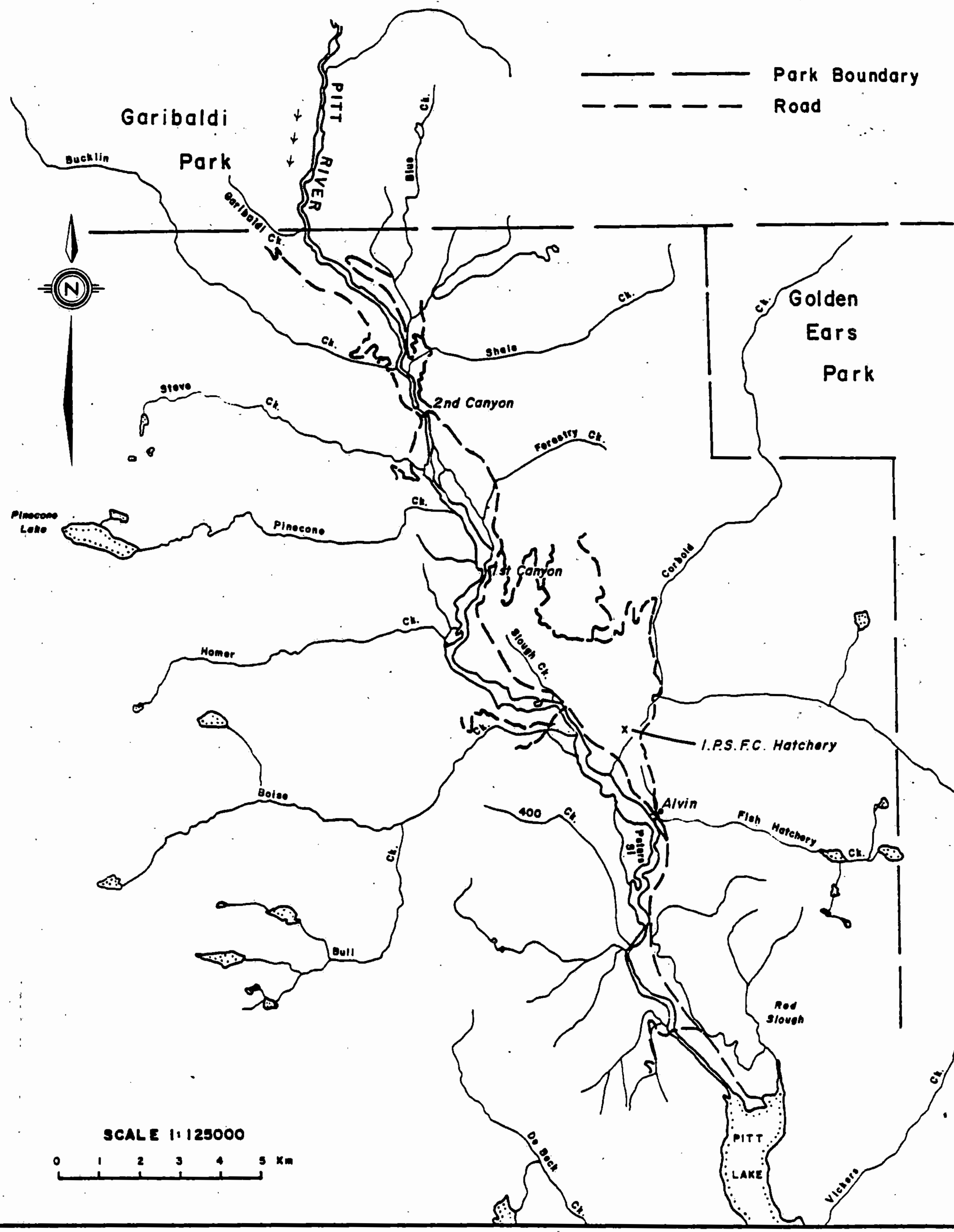
Figure 5a. Major land use areas referred to in this report.

.Figure 6. Upper Pttt River system; main logging roads, Provincial Park boundaries.



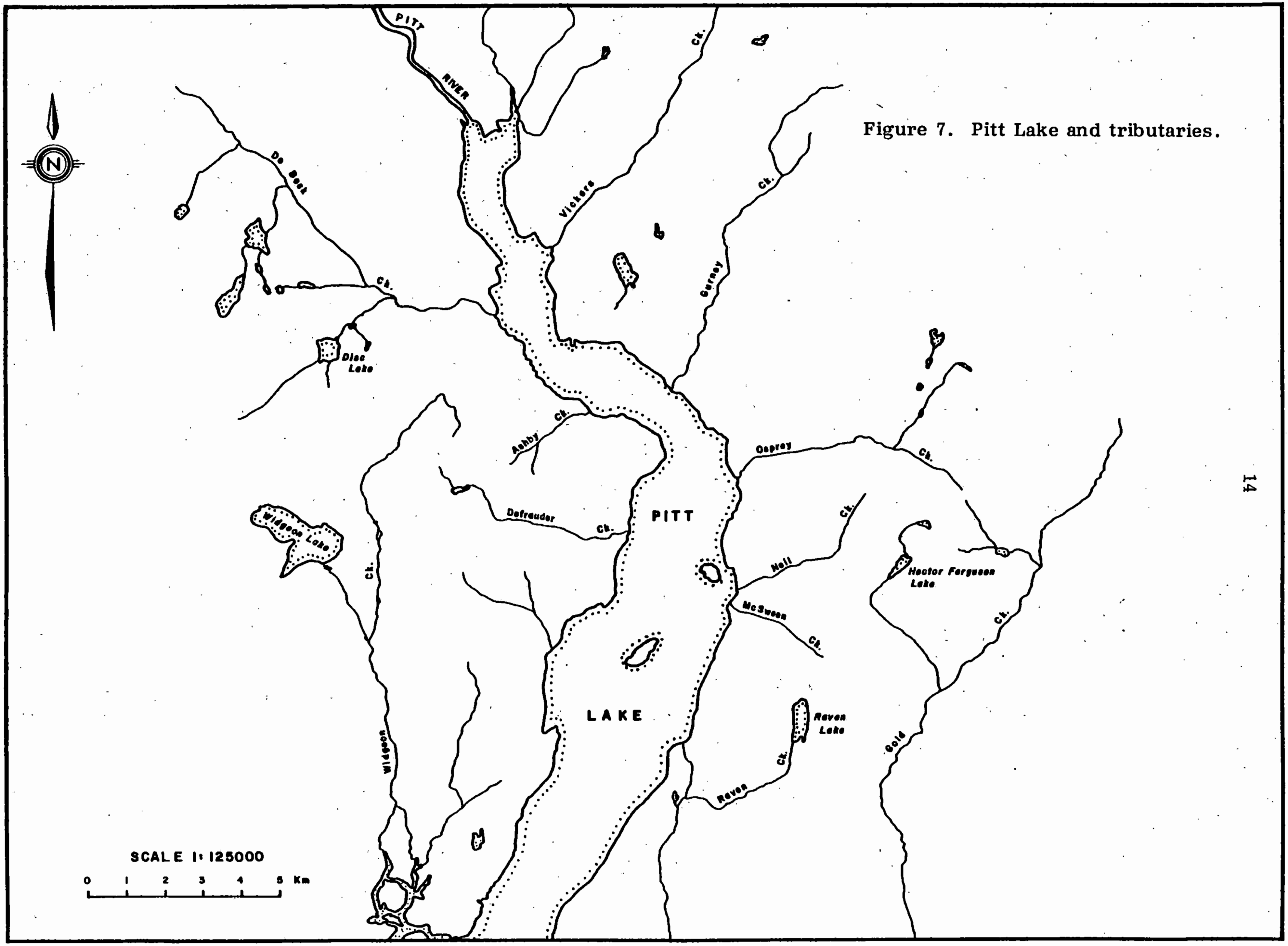


Figure 7. Pitt Lake and tributaries.

DRAINAGE

Mapped tributaries to the Pitt River (from National Topographic Series maps, scale 1:50,000) are represented diagrammatically in Figure 8. The glacial upper Pitt River system drains an area of approximately 780 m^2. The river rises near Isosceles Peak at an elevation of 1710 m and flows 52 km in a southerly direction into the head of Pitt Lake. The river flows for much of its length in a braided, shifting channel through a U-shaped valley approximately 1000 m wide. The overall gradient is 3.2%. Gradients in the 20 km section upstream of the lake average 1.95% which is steep compared to other sockeye salmon spawning grounds (1.2% in Adams River). Cooper (MS 1967) estimated the rate of bedload transport at 45 times that of Adams River. All tributaries to upper Pitt River enter from steep side valleys with short, flat, delta areas in the Pitt River floodplain. The major tributaries (Figures 6 and 8) to upper Pitt River are:

Tributary	Length in km
Iceworm Creek	12.0
Blue Creek	5.0
Bucklin Creek	10.0
Shale Creek	7.5
Steve Creek	7.5
Pinecone Creek	8.0
Forestry Creek	4.0
Homer Creek	9.0
Boise Creek	14.0
Corbold Creek	17.0
Fish Hatchery Creek	8.0

Pitt Lake (Figures 7 and 8) is a warm, monomictic lake 27 km in length, 54 km^2 in area, with a mean depth of 46 m, and a water residence time* of 0.77 (compared to 10.5 in Adams Lake) and a tidal fluctuation of 0.6 m.

Lower Pitt River, 30 km inland from Vancouver, links Pitt Lake to the Fraser River. Salt water seldom extends to within 10 km of the Fraser-Pitt confluence,

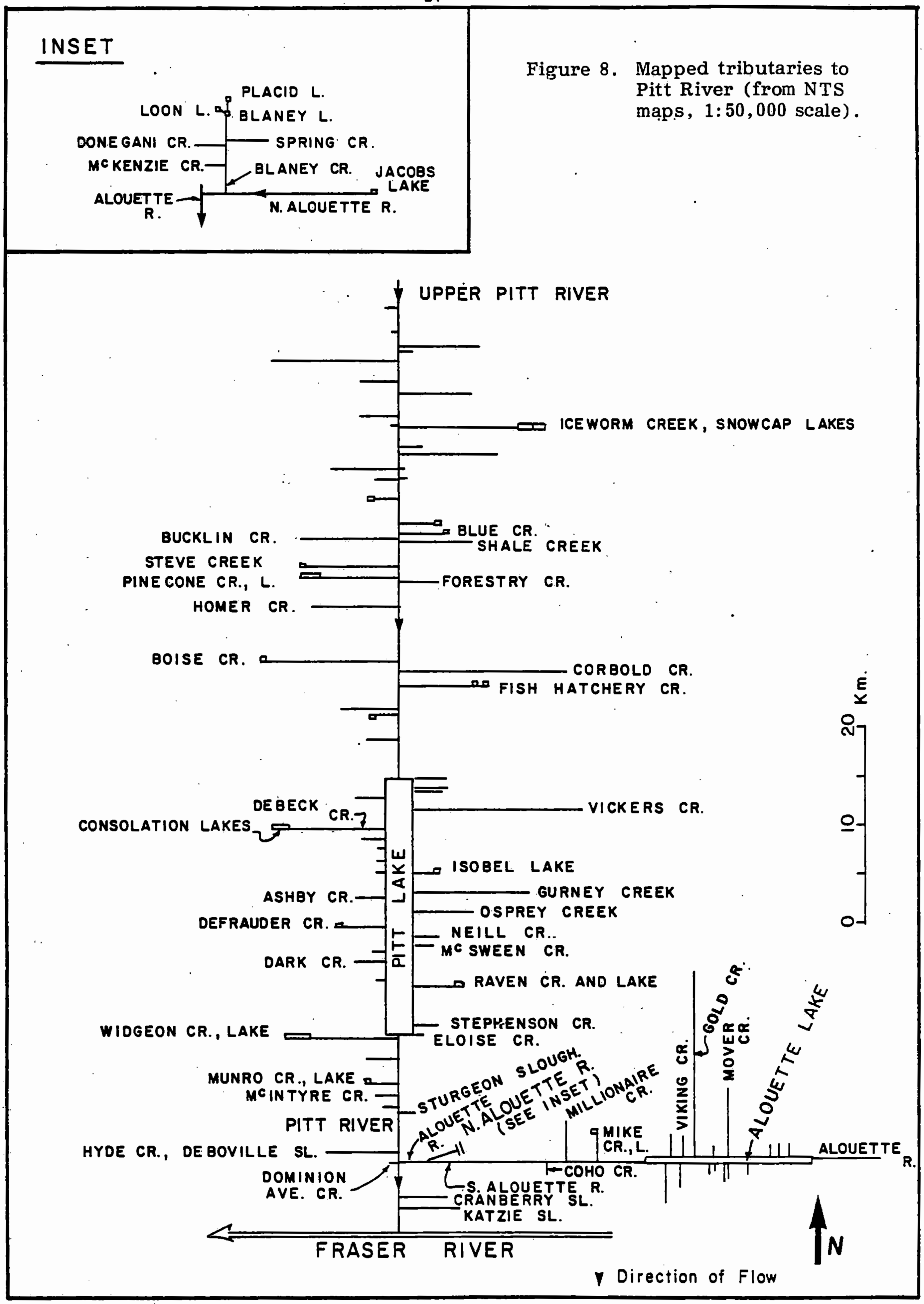
*Pitt Lake is flushed in 0.77 years, Adams Lake in 10.5 years (J. Woodey, pers. comm.).

but tides modulate Fraser River flow and cause lower Pitt River to fluctuate up to 2 m. There is an upstream movement of sediment in lower Pitt River from Fraser River. Lower Pitt River (20.7 km in length) is only slightly longer than its floodplain, resulting in a low sinuosity of 1.2 (Ashley, MS 1977). Dyking for flood control has altered the drainage of parts of the lower Pitt River watershed (tributaries on Figures 5 and 8).

The Alouette River system, the major tributary to lower Pitt River and located on the east side, drains a watershed of 335 km^2. Major watercourses in the Alouette system are the South Alouette River (24 km to Alouette Lake), North Alouette River (25.4 km), and Blaney Creek (8.3 km). A dam built in 1925-26 at the outlet of Alouette Lake is a barrier to upstream migration of fish. Alouette Lake has a length of 17 km, an area of 16.5 km^2, and a mean depth of 64 m. The lake is oligotrophic. Lake elevation varies from 133-147 m ASL due to drawdown for hydroelectric purposes. Average gradient of the South Alouette River is 0.55% downstream of the dam; the lower 7.5 km is tidal and flows through a dyked channel. North Alouette River is tidal in the lower 6 km.

Major west side tributaries to lower Pitt River are Widgeon Creek, Munroe Creek, McIntyre Creek, and Hyde Creek (Figures 5 and 8).

Figure 8. Mapped tributaries to Pitt River (from NTS maps, 1:50,000 scale).



WATERSHED UTILIZATION

History

The following information was compiled from Barnard (MS 1975), Cooper (MS 1967), Roddick (1965), and files of the Fish and Wildlife Branch at Surrey, B.C. (B.C. Ministry of Environment, 1984a).

The Katzie Indians, a Coast Salish group, were the first inhabitants of the Pitt River system. They established temporary fishing and hunting villages adjacent to the lower Pitt River. The earliest white men to occupy the area were fur traders from the Columbia River system, and Pitt River* was first mentioned by name in Hudson's Bay Company journals in 1827. Settlement of the lower Fraser River Valley area and the lower Pitt River was greatly stimulated by the Fraser River gold rush of 1858, and the settlement of Haney was founded in 1860. Maple Ridge was formed when people from Langley extended their land settlement across the Fraser River. Early settlement was linked to resource extraction from predominantly single-family pre-emptions on higher ground adjoining lower Pitt River. Dates of incorporation of municipalities (Figure 5) in the lower Pitt River area are as follows:

	Year of Incorporation
Maple Ridge	1874
Coquitlam	1891
Port Coquitlam (City)	1913
Pitt Meadows	1914

Since the early part of this century there have been continuing efforts to reclaim the extensive area of freshwater marsh, bog, stream, low knoll and wooded piedmont adjoining the lower Pitt River for agricultural purposes. Dyking was initiated in 1913 and efforts to reclaim the land continued with variable success. Reclamation was not completely successful until 1964, and was finally accomplished by the ingenuity and persistence of Dutch settlers who have now transformed parts of the area into useful agricultural land. Most of the lowlands adjoining

*Named for William Pitt the Younger (1759-1806), British Prime Minister.

lower Pitt River are now dyked and isolated from the tidally influenced Pitt and lower Alouette rivers.

Exploration of the upper Pitt River was initiated by prospectors before the turn of the century. There have been abortive attempts at farming, but the recent history of the area is connected with logging activities which were begun in the 1930's (Cooper, MS 1967). The community of Alvin (Figure 6) is the hub of logging activity in the area, which is conducted by British Columbia Forest Products Ltd. (BCFP).

Logging

Logging in the Pitt River watershed is managed by the Ministry of Forests within the Fraser Timber Supply Area (TSA). Private lands and parks are not included. The Maple Ridge and upper Pitt River supply blocks within the Fraser TSA may be logged at the rate of 142 ha/yr, but the annual exploitation rate is not always attained. The Maple Ridge supply block extends to the south end of Pitt Lake, and the upper Pitt block extends north to the southern boundary of Garibaldi Park.

Logging in upper Pitt River watershed has been continuous since the 1930's BCFP has logged approximately 80,000-95,000 m^3/yr in the period 1967-1984 from an area of 120-140 ha/yr. Logging is conducted on privately owned timber leases and on vacant crown land in the Fraser TSA portion of the upper watershed. The marketable timber is found below approximately 1000 m in elevation. BCFP plans to continue operations for the next 25 years at a production rate of 120,000 m^3/yr. Logs are trucked to the head of Pitt Lake, sorted and bundled, and towed to Lower Mainland markets. The lower Pitt River is used extensively as a log storage area by BCFP and other timber operations. The species logged by BCFP are as follows (T. Bakos, BCFP, pers. comm.):

Species	Percentage
Hemlock	38%
Balsam	25%
Red cedar	18%
Douglas fir	13%
Yellow cedar	5%
Cottonwood and maple	1%

Extensive long-term logging activity in upper Pitt River watershed has no doubt contributed to the instability of the river channel, but Cooper (MS 1967) describes channel instability upstream of the logged areas, and cites extremes of discharge and bank instability as additional contributing factors.

Most of the accessible mature timber adjacent to Pitt Lake has been logged by various operators over the past 40 years. Some timber, inaccessible by conventional logging methods, is taken out by helicopter. Approximately 21,000 m^3 has been removed by helicopter in the last three years and 30,000 m^3 is expected to be removed in 1985 (L. Leroux, Ministry of Forests, pers. comm.).

Much of the accessible mature timber in the Maple Ridge supply block has been logged at least once since early settlement of the area. For example, parts of the upper Alouette River watershed (now in Golden Ears Park) were logged between 1919 and 1929. The Widgeon Creek watershed has been logged intermittently since 1940. Whonnock Industries Ltd. logs approximately 3,000 m^3/yr from the Blue Mountain Forest Reserve (a provincial forest, status undeclared). Approximately 5,000 m^3/yr are logged from the UBC Research Forest. This area was intensively logged between 1924 and 1931 by railway logging operations, and much of the present forest is second growth. An insignificant amount of timber is taken to supply several shake mills operating in the Maple Ridge area.

Mining

There are no metalliferous mines in the Pitt River watershed. A large number of mineral claims have been staked and restaked in this century, but few show sufficient mineralization to qualify as legitimate mining prospects. The more promising occurrences have been explored sporadically, and although this has involved some underground work, none have been proved economic (Roddick, 1965).

The revised Mineral Inventory Maps (B.C. Ministry of Energy, Mines and Petroleum Resources, 1984) list four mineral occurrences in the upper Pitt River whatershed, nine adjacent to Pitt Lake, and two in the UBC Research Forest. Of these, Roddick (1965) describes four with the most potential.

1. The Golden Ears group near the southeast shore of Pitt Lake. Mineralization consists of gold, copper and silver.

2. The Standard group located on the southwest shore of Pitt Lake. Mineralization consists of galena and chalcopyrite, with low values in gold and silver.

3. The Maple Leaf group on Vickers Creek (Pitt Lake). Mineralization consists of pyrite and chalcopyrite.

4. The Cox group on Corbold Creek, 8 km upstream from upper Pitt River. Mineralization consists of pyrite and molybdenite with minor values in gold.

There are presently several groups of mineral claims in the watershed held in good standing, but the level of current exploration has been preliminary, and mineral production is not anticipated at current metal prices. Active mining in the watershed has been limited to sporadic production of granitic building stone quarried adjacent to lower Pitt River, and to production of sand and gravel at several locations in the lower watershed.

Interest in placer mining has been occasionally generated by rumour. Placer claims have been staked and held in good standing for variable periods (e.g., in Widgeon Creek, De Beck Creek, Corbold Creek), but only preliminary development work has been done and production has not been achieved. Corbold Creek watershed has recently (1984) been opened for the legal location of placer claims.

Population

The Pitt River watershed is located in the Lower Mainland Region as catalogued by the B.C. Regional Index* (B.C. Ministry of Economic Development, 1978). The area comprises parts of three district municipalities and the City of Port Coquitlam, and unincorporated land to the north of the municipal boundaries within the Greater Vancouver and Dewdney-Alouette Census Divisions. Rapid population growth was experienced from 1971-1976 throughout the lower Pitt River area (25% in Pitt Meadows and Maple Ridge), attributable to greatly increased residential development. The total population of the Municipalities and Coquitlam City in 1984 was 82,640**. Rates of population increase have been variable and related to housing demand. The average annual percentage population increase in Maple Ridge to 1991 is expected to range between 2.4% and 3.6% (Maple Ridge planning department, pers. comm.). Similar rates of population increase are expected in the other municipalities.

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*Most recent publication, 1978.

**Includes northeast part of District of Coquitlam, plus total of other Municipalities and Coquitlam City.

There are approximately 100 leased lots adjoining Pitt Lake (mostly seasonally occupied), and there are approximately 80 permanent residents in the upper Pitt watershed, all employees of BCFP and the IPSFC.

Industry and Farming

The only industry in the upper Pitt River watershed is the logging operation of BCFP. Forestry and agriculture are the leading industries in the Pitt Meadows and Maple Ridge areas. Dairy farming is the principal agricultural enterprise in Pitt Meadows and mixed farming predominates in Maple Ridge. Other farming in Pitt Meadows includes cattle, poultry, greenhouse and nursery operations. The higher land in Maple Ridge supports many mixed farms, and products include sheep, pigs, tree fruits, furs and flowers. Residential developments near Haney and Pitt Meadows have resulted in substantial reductions in farm land.

Several sand and gravel pits and quarries produce structural materials for the construction industry. Tourism is of minor importance to the economy of the area, and most recreational facilities cater mainly to Lower Mainland residents. There are several operating shake and shingle mills in the lower Pitt watershed. Log-booming and storage is a major activity in lower Pitt River. Port Coquitlam is the major freight terminus of the CPR.

Minor industry throughout the lower watershed includes warehousing and small manufacturing, commercial enterprises and small business enterprises. In Maple Ridge, the Berryland cannery is a major employer. There are several industrial parks with limited development.

Water Licences

Table 1 summarizes licenced water use within the Pitt River watershed. There have been a total of 141 water licences issued, of which 111 are for use within the lower Pitt and Alouette river systems. Priority of users is determined by date of licence approval, not by licence classification (approval dates are not listed in this report).

In the Alouette River system, the major water use is for power generation and storage by B.C. Hydro in Alouette Lake (four licences). There have been nine licences issued in the lower Alouette system and Pitt Polder for irrigation and

Table 1. Summary of licenced water removal from the Pitt River system (B.C. Ministry of Environment, 1984c, Water Investigations Branch).

	No. of Licences	Storage	Power Generation	Industrial	Land Improvement	Conservation	Domestic	Irrigation	Waterworks
1. Alouette River System, Pitt Polder, and Pitt Wildlife Management Area									
	1	5.906 m^3/s (151000 afa)							
	3		28.515 m^3/s (1007 cfs)						
	1								$5.262x10^{-4} m^3/s$ (10000 gd)
	5				$2.631x10^{-4} m^3/s$ (5000 gd)				
	1				$58.083x10^{-5} m^3/s$ (14.85 afa)				
	1					$1.052x10^{-4} m^3/s$ (2000 gd)			
	2					$14.158x10^{-2} m^3/s$ (5 cfs)			
	1					$66.493x10^{-3} m^3/s$ (1700 afa)			
	9							$68.057x10^{-4} m^3/s$ (174 afa)	
	2			$54.759x10^{-5} m^3/s$ (14 afa)					
	1			$1.416x10^{-2} m^3/s$ (.5 cfs)					
	30						$60.509x10^{-4} m^3/s$ (115000 gd)		
Total:	57								
2. Pitt Lake									
	3								$17.890x10^{-4} m^3/s$ (34000 gd)
	23						$2.631x10^{-4} m^3/s$ (5000 gd)		
Total:	26								
3. Upper Pitt River									
	2		$18.689x10^{-2} m^3/s$ (6.6 cfs)						
	1					$79.287x10^{-2} m^3/s$ (28 cfs)			
	1								$2.631x10^{-4} m^3/s$ (5000 gd)
Total:	4								

Table 1 (cont.)

	No. of Licences	Storage	Power Generation	Industrial	Land Improvement	Conservation	Domestic	Irrigation	Waterworks
4. Lower Pitt River and tributaries (excluding Alouette system)									
	1					$910.271 \times 10^{-4} m^3/s$ (1230000 gd)			
	1					$52.803 \times 10^{-3} m^3/s$ (1350 afa)			
	9							$48.403 \times 10^{-4} m^3/s$ (123.75 afa)	
	1			$3.911 \times 10^{-3} m^3/s$ (100 afa)					
	1			$4.248 \times 10^{-2} m^3/s$ (1.5 cfs)					
	6			$1.368 \times 10^{-4} m^3/s$ (2600 gd)					
	3			$10.789 \times 10^{-4} m^3/s$ (1500 gd)					
	19						$10.655 \times 10^{-4} m^3/s$ (20250 gd)		
	1								$0.526 \times 10^{-4} m^3/s$ (1000 gd)
	2		$15.574 \times 10^{-2} m^3/s$ (5.5 cfs)						
Total:	54								

afa = acre feet/annum
cfs = cubic feet/second
gd = gallons/day
m^3/s = cubic metres/second

30 licences issued in the Alouette system for domestic use of water. Other usage includes water for land improvement, conservation, and usually unspecified waterworks and industrial purposes.

Licenced water use from Pitt Lake is mainly for domestic purposes (23 licences) associated with leased lots adjacent to the lake.

In the upper Pitt River, four licences have been issued for conservation, power generation and waterworks at the IPSFC facility and at the BCFP community of Alvin.

Licenced water usage from lower Pitt River and tributaries (excluding the Alouette system) is primarily for irrigation and domestic purposes (total 28 licences). Water for unspecified industrial and waterworks purposes is available to nine licence holders.

PITT RIVER CAPABILITY STUDY

Published maps of the Canada Land Inventory (CLI) series (Department of Environment, 1975) describe the inherent productive capacity of Pitt River watershed in terms of ungulates and waterfowl, and capability for recreation. Where possible, generalizations from these maps have been supplemented by more specific data collected during biophysical surveys in the area. Published maps describing agricultural and forestry capacities in the watershed are not available, but manuscript maps (B.C. Ministry of Environment, MS 1966) describe these capabilities for the lower watershed only.

Agriculture

The manuscript maps describe most of the lower Pitt River watershed as having low agricultural capacity. Much of the dyked areas adjoining lower Pitt River are subject to periodic inundation resulting from heavy precipitation combined with the high water table. These factors, concurrent with the presence of mainly unsuitable soils result in low agricultural capability. Much of the land in existing agricultural use is classed as either forage or permanent pasture. Dairy farming is the principal agricultural use in Pitt Meadows and much of Pitt Polder. Higher, more productive agricultural land in Maple Ridge supports mixed farming with variable products.

The upper Pitt River watershed and the mountainous areas from Fraser River to the head of Pitt Lake are essentially unsuitable for agriculture because of extreme steepness of slopes, lack of soil, shorter growing seasons, and large areas of exposed bedrock.

Forestry

The manuscript maps indicate wide variability in forestry capacity for the lower Pitt River watershed. Forest capability ratings range from very poor (0-2.1 m^3/hectare/year) in wetland habitat to excellent (7.7-9.1 m^3/hectare/year) in parts of Maple Ridge, the UBC Research Forest and the Blue Mountain Forest Reserve. Most of the lowland area adjoining the lower Pitt River has very low productive capacity because of excessive soil moisture.

Much of the following information has been condensed from Burgess (MS 1981a,b).

Vegetation characteristics of the lower Pitt and Alouette River watersheds are largely determined by the interaction of topography and climate. In the watershed, there is heavy annual precipitation, winters are mild and summers are moderate to cool. Habitat types in the watershed are mainly forested lands, wetlands and agricultural land. Forested land is the dominant habitat type and there are three basic forest vegetation zones in the watershed, governed largely by elevation. These biogeoclimatic zones are summarized in the following table.

Zone	Elevation (m)	Precipitation (mm)	Snowfall (% of precipitation)	Dominant Tree Species
1) Coastal Western Hemlock	0-1070	1600-6300	0-40%	Douglas Fir Western Hemlock Red Cedar Grand Fir Lodgepole Pine
2) Low Mountain Hemlock Sub-Zone	1000-1370	1750-4250	20-70%	Mountain Hemlock Amabilis Fir Yellow Cedar
3) High Mountain Hemlock Sub-Zone (sub-alpine parkland)	Above 1370	Up to 5000	70%	Mountain Hemlock Amabilis Fir

There are a number of different seral stages within these zones, as a result of logging and fires. In these areas are heavy growths of alder, maple and occasional white birch. Where the forest canopy is open, common shrubs are vine maple, huckleberry, salal, willow, and sword fern.

Dominant tree species found in wetlands habitat (Pitt Wildlife Management Area, Addington Point) include alder, cottonwood, crab apples and hawthorn (Barnard, MS 1975).

In the upper Pitt River watershed, lack of soil and tremendous accumulations of snow above elevations of approximately 1700 m restrict growth to scattered pockets (Roddick, 1965). Dominant tree species at lower elevations are balsam fir western hemlock, Douglas fir, red cedar, yellow cedar, cottonwood and maple (BCFP, pers. comm.). Cooper (MS 1967) describes the forest on the valley floor of upper Pitt River as deciduous, interspersed with immature conifers in previously logged areas.

Reforestation in logged areas of the upper watershed has been undertaken by both the Ministry of Forests and by BCFP. Approximately 50,000-60,000 trees per year have been planted in the last five years. Species have included red cedar and Douglas fir below elevations of 700 m, and hemlock and balsam above 700 m (Ministry of Forests, pers. comm.). Other activities have included tree-spacing programs conducted from a Corrections Service camp upstream of Alvin. Up to 350 ha/yr of mixed stands of 15-40 yr old timber have been spaced in each year since 1975.

Ungulates

The CLI maps class almost the entire lower Pitt watershed and lands adjoining Pitt Lake as having moderate to moderately severe limitations to the production of ungulates. Limitations are usually due to a combination of two or more of adverse climate, soil moisture, soil fertility, depth to bedrock, topography, flooding, exposure and adverse soil characteristics. Excessive snow depth at higher elevations often reduces mobility of ungulates and availability of food. Burgess (MS 1981b) describes parts of the lower Pitt watershed: "...due to the concurrence of a favorable mix of climate, elevation, topography, and vegetation type" as "home to an amazing array of wildlife (235 species) including 202 bird species and 32 mammalian species". The lower elevation areas have a greater proportion of both species and individuals than higher ground. Coastal blacktail deer and mountain goat are the only species of ungulate found in the lower watershed. Goats have been observed on the northern edge of UBC Research Forest and are scarce. Deer winter below about 700 m.

In the upper Pitt watershed, lands above about 1500 m usually have limitations so severe that there is no ungulate population. The limitations are due to a combination of severe climatic conditions and exposed bedrock. Lands below about 1500 m are described as having moderately severe limitations to ungulate production due to climatic factors and limited food supply. There are four small areas adjacent to upper Pitt River that are important winter range for coastal blacktail deer and mountain goat.

Waterfowl

The CLI maps describe all dyked lands adjacent to lower Pitt River as having moderately high capabilities for waterfowl production, but production may be reduced in some years by occasional drought. Favourable characteristics are a high proportion of both temporary and semi-permanent marsh poorly interspersed with deep marsh. In upland areas, adverse topography severely restricts the development of wetlands, and therefore the production of waterfowl. Lands adjoining Pitt Lake have severe limitations to waterfowl production, related to very steep topography. Excessively deep or shallow waters in Pitt and Alouette lakes also severely limit waterfowl production. Burgess (MS 1981b) reports substantial populations of ducks and geese in the wetland areas south of Pitt Lake, primarily during the migrational and wintering periods. Geese are present throughout the year. Twenty-four duck species have been observed. There are approximately 800 permanently resident Canada geese in the lower Pitt watershed. Whistling and Trumpeter swans winter in these wetlands as well. There are several pairs of greater sandhill cranes in the area, and approximately 24 species of wetland birds (e.g., herons, bitterns, coots).

The mouth of upper Pitt River has a moderately high capability for waterfowl production. The remainder of upper Pitt watershed is described by the CLI maps as having almost no capability for waterfowl production because of extremes of topography which preclude the development of wetlands.

Recreation

The Pitt River watershed, as described in the CLI maps, affords an extremely varied outdoor recreational potential. These lands, including lowland areas of lower Pitt River and most of upper Pitt valley have a moderate capability for outdoor recreation based on dispersed activities. The Coquitlam Area Mountain Study (B.C. Ministry of Municipal Affairs, MS 1981) ranks existing and potential major and minor recreational activities in several land units in lower Pitt River watershed and Pitt Lake area, relating these activities to habitat types and elevation differentials. The activities described include hiking, camping, nature study, cross-country skiing, snowshoeing, downhill skiing, snowmobiling, powerboating, canoeing, horseback riding, fishing, hunting, four-wheel driving, trailbike riding, and cottage development.

Sport-fishing is a very popular recreational activity in the Alouette River and Lake system, and in Pitt Lake.

STREAMFLOWS

Water Survey of Canada has monitored discharges of some streams in the Pitt River watershed for various periods of record. Figure 9 identifies discharge locations (and temperature monitoring sites) discussed in this report, and Table 2 lists mean monthly discharges of some of these stations, the range in discharge for N. and S. Alouette rivers in 1983, and pre- and post-dam construction flows of S. Alouette River. Appendices 2 through 2g list mean monthly discharges from each station by year of record and maximum and minimum recorded discharges in some years of record. Severe flow reductions in the S. Alouette River have resulted from construction of a dam at the outlet of Alouette Lake and diversion of water from Alouette Lake into the Stave River system. Mean annual flows in S. Alouette River in 1983 represent only 11.5% of the mean annual flow in the pre-dam construction period 1916-1925 (Table 2).

Streamflows of upper Pitt River near Alvin were monitored from 1952-1965. Figure 10 depicts the means of maximum and minimum discharge and the mean monthly discharge of upper Pitt River. In general, the hydrograph reflects a dominant summer glacial melt, with low flows from December to March due to freezing temperatures at higher elevations. Monthly means show an increase from 14.0 m^3/sec in March to 115.0 m^3/sec in July (a rate of increase of 0.84 m^3/sec/day). There is a decrease in discharge from July (115.0 m^3/sec) to November (40.0 m^3/sec) for an average decrease of 0.6 m^3/sec/day. There is wide variation in daily discharge in the autumn, associated with the frequent heavy rainfalls. The maximum recorded daily discharge occurred in early November 1955 (597 m^3/sec) and discharges exceeding 400 m^3/sec have been recorded in September. These extreme discharges, combined with the limited buffering capacity of the upper watershed (exacerbated by the effects of clear-cut logging) result in violent flow fluctuations, scouring and shifts in the channel in the autumn period. Minimum recorded discharge was 5.1 m^3/sec on February 18, 1956.

Figure 11 depicts the means of maximum and minimum discharge and the mean monthly discharge of S. Alouette River in 1983. In 1983, highest mean monthly flows (6.5 m^3/sec) occurred in January and lowest flows (0.6 m^3/sec) occurred in August. There has been continuing discussion between B.C. Hydro and various fisheries managers concerning acceptable flows in the S. Alouette River since construction of the dam at Alouette Lake outlet. B.C. Hydro may produce sudden,

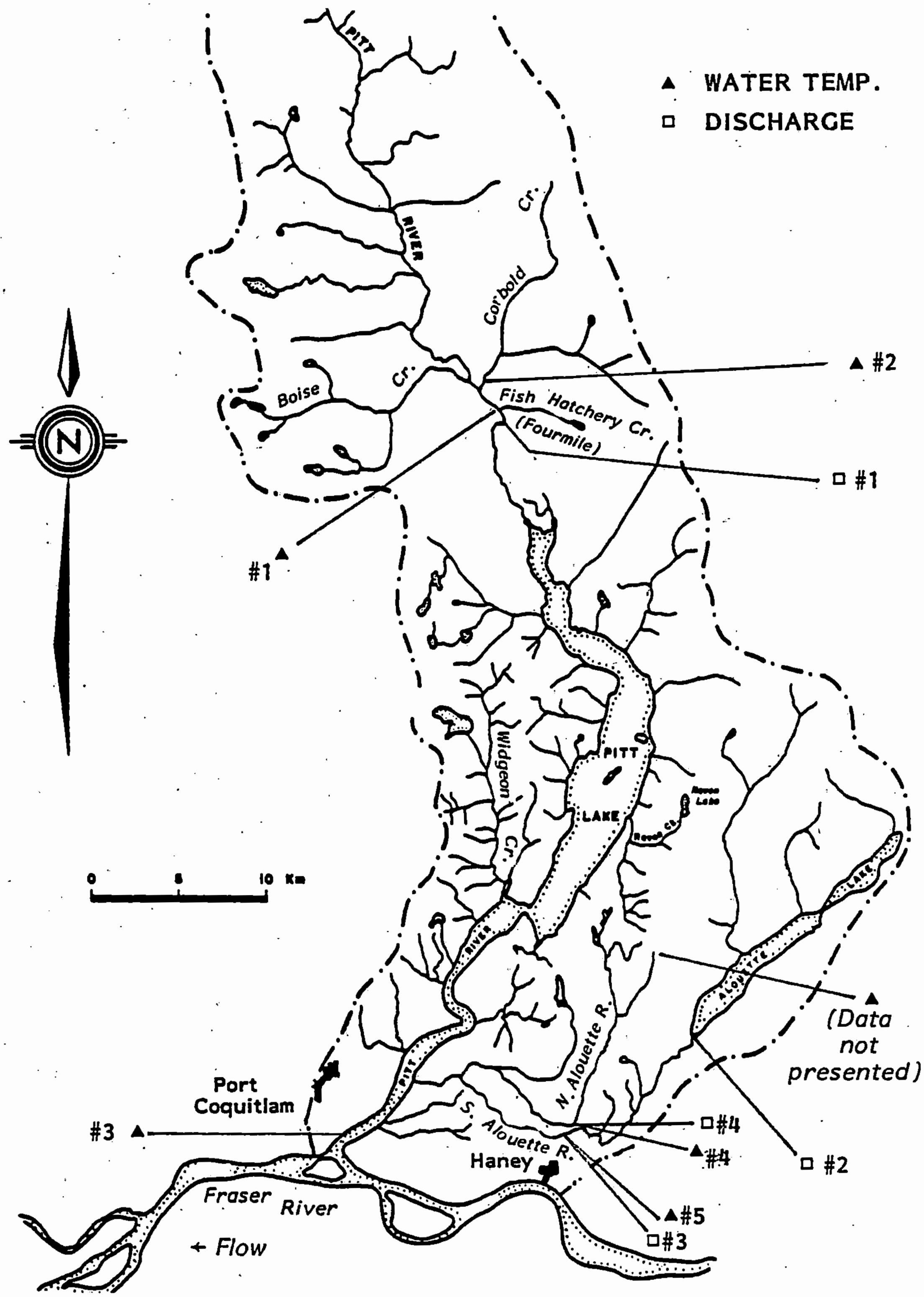


Figure 9. Discharge and water temperature monitoring sites in the Pitt River watershed. (Discharge sample site numbers are explained in Table 2; water temperature sample site numbers refer to data presented in Appendices 4 through 6b.)

Table 2. Monthly mean discharges of some streams in the Pitt River watershed. Sites identified on Figure 9 (data from Water Survey of Canada, 1983, 1984).

Sample Site	Location	Date		Monthly Mean Discharges (m^3/sec) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	Pitt R. (Alvin)	1952-1965		21.1	22.9	14.0	27.8	65.5	107.0	115.0	83.9	67.1	51.6	40.1	26.3
2	Alouette L. (Outlet)	1916-1925*		27.2	29.9	18.7	22.9	26.7	22.8	11.9	5.8	12.5	25.1	28.6	39.7
3	S. Alouette (Haney)	1960-1976**		4.2	2.8	2.3	1.7	1.3	1.1	1.2	1.8	0.8	1.8	4.9	5.9
3	S. Alouette (Haney)	1983	Mean	6.5	3.3	4.6	1.3	1.4	1.0	2.4	0.6	1.5	1.2	5.5	2.1
			(Max.)	(28.9)	(7.5)	(27.6)	(3.9)	(3.3)	(3.3)	(18.1)	(1.1)	(4.3)	(4.6)	(17.4)	(3.5)
			(Min.)	(1.2)	(1.3)	(0.8)	(0.6)	(0.5)	(0.5)	(0.6)	(0.5)	(0.9)	(0.5)	(2.9)	(1.1)
4	N. Alouette (Haney)	1911-1982		4.2	4.3	3.0	2.9	2.5	2.0	1.4	0.8	1.4	3.3	4.5	5.0
4	N. Alouette (Haney)	1983	Mean	5.6	4.4	2.4	2.1	1.7	2.0	4.8	0.2	1.7	1.7	8.6	1.4
			(Max.)	(38.0)	(11.8)	(11.8)	(6.2)	(4.8)	(7.7)	(38.7)	(0.5)	(13.1)	(10.2)	(40.1)	(6.5)
			(Min.)	(0.7)	(0.7)	(0.8)	(0.8)	(1.0)	(0.7)	(0.4)	(0.1)	(0.2)	(0.2)	(1.7)	(0.3)

**Pre-dam construction*
***Post-dam construction*

M.A.
22.7 = 89% reducti
2.5
33

Figure 10. Means of maximum and minimum discharge and monthly mean discharge (m^3/sec) of upper Pitt River near Alvin (data from Water Survey of Canada, 1983).

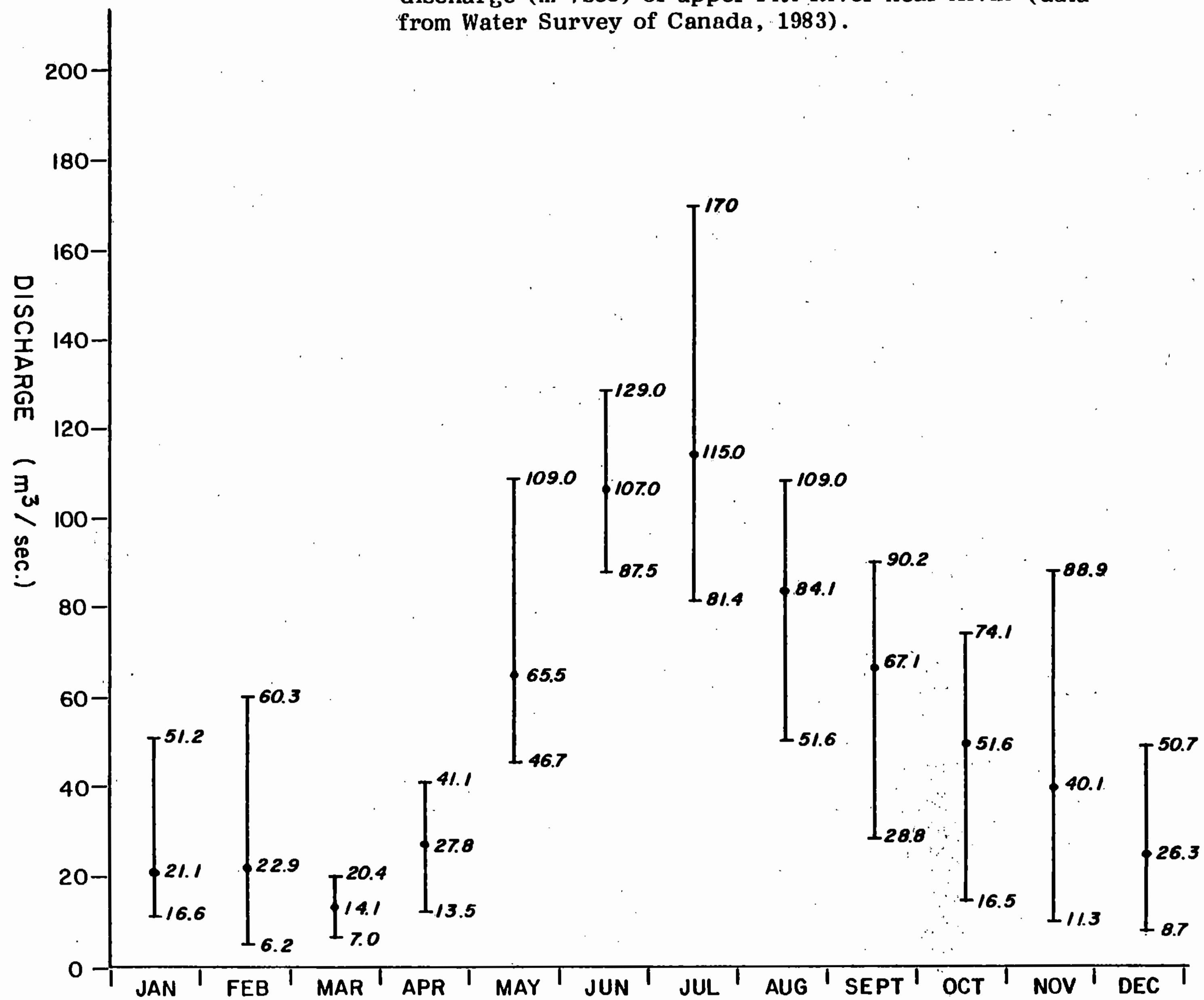
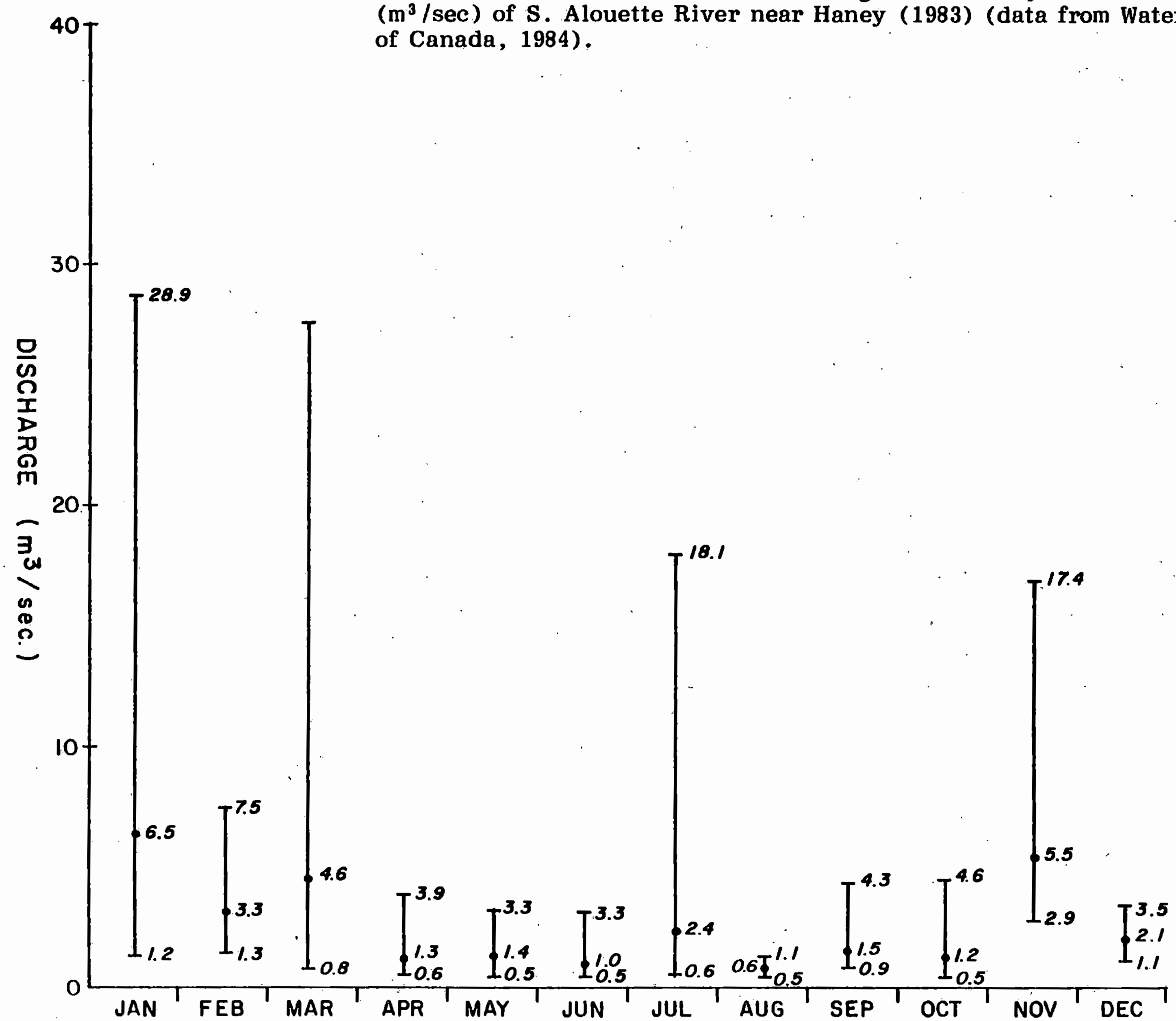


Figure 11. Means of maximum and minimum discharge and monthly means of discharge (m^3/sec) of S. Alouette River near Haney (1983) (data from Water Survey of Canada, 1984).



instantaneous releases of up to 70.8 m^3/sec to the river by opening gates in the dam, and there have been sudden increases in flows during the critical low flow summer periods. In 1971 discharge rose from 1.56 m^3/sec to 33.13 m^3/sec on June 25, and on July 12, 1972 there was an increase from 1.47 m^3/sec to 38.79 m^3/sec (data from Griffith and Russell, 1980; Water Survey of Canada, 1983). These floods result in scouring of the channel and abrupt temperature change. Some progress has been made in controlling these sudden releases, but the problem of low flows in the S. Alouette River is not yet completely resolved.

The flow regime of the N. Alouette River shows peak flows in the period November to February with a gradually declining discharge (0.03 m^3/sec/day) in the period February to August. The maximum and minimum recorded discharge of N. Alouette River occurred on December 23, 1963 (76.2 m^3/sec) and on August 30, 1961 (0.071 m^3/sec) respectively.

Ashley (MS 1977), from a study of the tidal characteristics and gauge heights in lower Pitt River, describes the flow mechanics of the system. Rising water in the Strait of Georgia retards flows in the Fraser River until water levels at the Fraser-Pitt confluence are higher than in Pitt River. Flow in Pitt River then reverses and water flows up lower Pitt River into Pitt Lake. Water Survey of Canada does not monitor the discharges of lower Pitt River because of the reversing flows which prevent accurate discharge calculations. The percentage of lower Pitt River discharge contributed by the Pitt drainage basin has not been accurately calculated, and is dependent on a combination of tidal and discharge conditions beyond the scope of this report.

WATER QUALITY

Surface Water

Surface water sampling sites are identified on Figure 12 and described in Table 3. Water quality analyses from these sites are expressed as averages* in Table 4, often of measurements obtained over a period of years. Analytical methods and detection limits were variable among testing agencies and over time. Data collected prior to 1973 are less comprehensive than subsequent information available from EQUIS (B.C. Ministry of Environment, 1983).

A. Lower Pitt River system

Levels of filterable residue, conductivity, alkalinity, hardness and calcium are usually lower than RFCL (Appendix 3). Low values of these parameters, typical of coastal regions of B.C., result from heavy precipitation, rapid run-off, and from the generally insoluble nature of the granitic substrate. Analyses often show levels of iron, non-filterable residue and colour exceeding RFCL. Data presented in Table 4 show that all the above parameters tend to increase with distance downstream from Pitt and Alouette lakes (sites 4 and 14, respectively) to Fraser River (site 1). Regular downstream increases in parameter levels indicate that contributing sources are regularly distributed along the system.

In lower Pitt River, an increasing gradient for many parameters from Pitt Lake (site 4) to Fraser River (site 1) is largely a result of tidal mixing of Fraser and Pitt River waters. Analyses from sites 4 through 1 show filterable residue increasing from 17 to 104 mg/L. Conductivity increases, but is higher in Pitt River (104 mg/L at site 2) than in Fraser River (site 1). Alkalinity, hardness and calcium increase regularly from site 4 to 1, average values of all three parameters are below RFCL in Pitt Lake (site 4), and range extremities of each parameter are below RFCL in Pitt Lake (site 3).

Total iron increases from 0.19 mg/L in Pitt Lake (site 4) to 1.79 mg/L in Fraser River (site 1). Much of this iron is probably in a bound form, as dissolved iron concentrations (0.03 to 0.2 mg/L) are much lower than total

*Ranges are provided when averages are not available from the raw data.

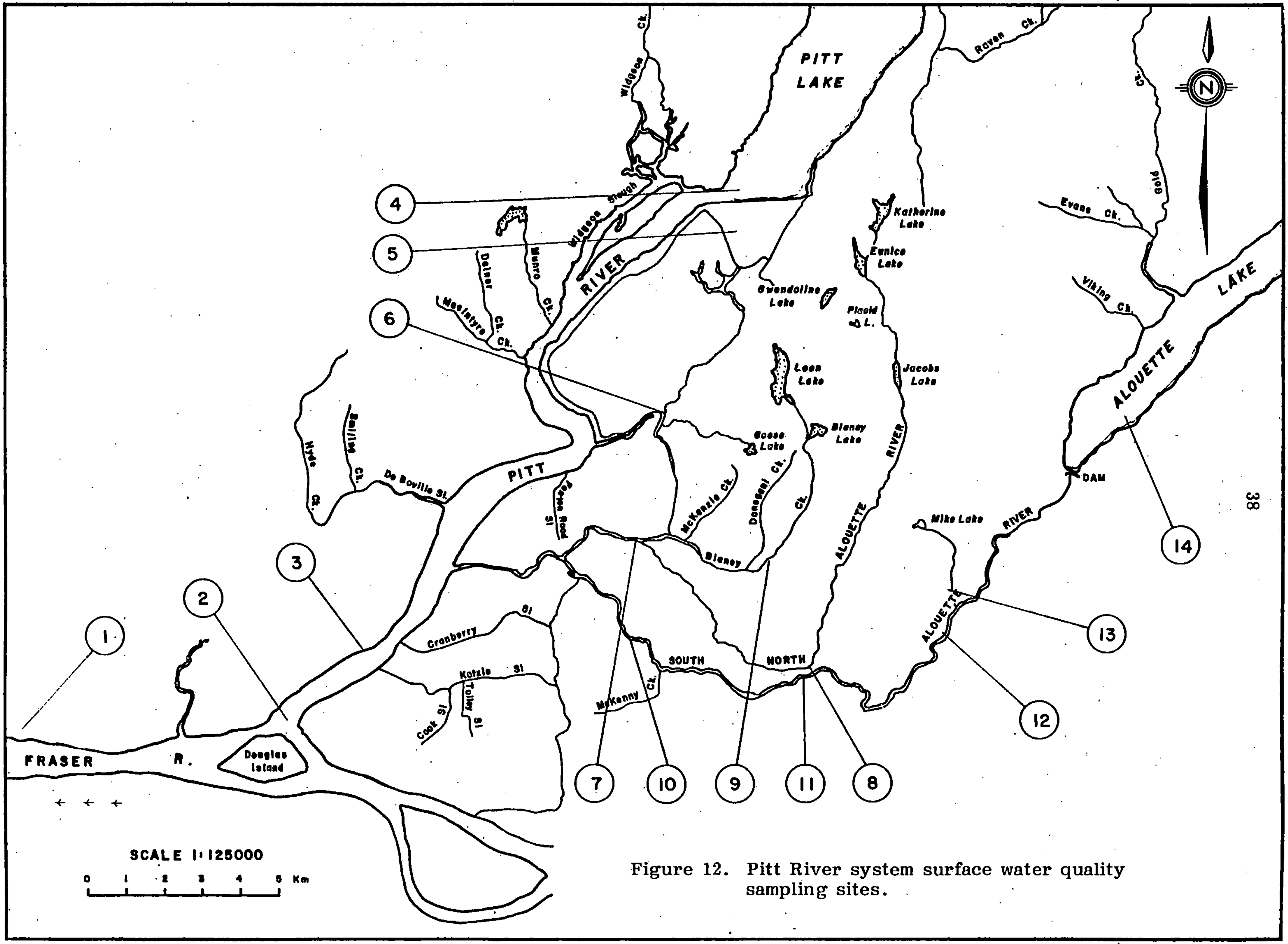


Figure 12. Pitt River system surface water quality sampling sites.

Table 3. Pitt River system surface water quality sampling sites and data sources.

Site	Location	Data Source	Sampling Date(s)
1	Fraser R., Patullo Bridge	B.C. Ministry of Environment (1983), EQUIS; Benedict *et al.* (1973)	1972-1983 (approx.);
2	Mouth of Pitt R. (Douglas Island)	Department of Environment (1973), NAQUADAT	Mar. 28, 1973; Sept. 13, 1971
3	Pitt R. at Lougheed Bridge	B.C. Ministry of Environment (1983), EQUIS; B.C. Research (1971); Benedict *et al.* (1973)	1972-1973; Sept. 13, 1971; 1973
4	Pitt Lake near south end	B.C. Ministry of Environment (1983), EQUIS	1972-1983
5	Pitt Wildlife Management Area	B.C. Ministry of Environment (1979)	Oct. 16, 1978; Apr. 25, 1979
6	Sturgeon Slough area	B.C. Ministry of Environment (1979); Pitt Waterfowl Management Assoc. (MS 1972)	Oct. 16, 1978 & Apr. 25, 1979; May, Jul. 1972; Feb., May, 1973
7	N. Alouette R. at 232nd Street	B.C. Ministry of Environment (1983), EQUIS	1972-1983
8	N. Alouette R.	B.C. Ministry of Environment (1983), EQUIS	1972-1983
9	Blaney Cr.	Dept. of Fisheries & Oceans/EPS Chemistry Laboratory (1984); Pitt Waterfowl Management Assoc. (MS 1972)	1974-1984; May, Jul. 1972; Feb., May 1973
10	S. Alouette R. at 208th Street	B.C. Ministry of Environment (1982), EQUIS	1972-1983
11	S. Alouette R. at 232nd Street	B.C. Ministry of Environment (1983), EQUIS; Department of Environment (1973), NAQUADAT	1972-1983; Jun. 20, 1971
12	S. Alouette R. at 248th Street	B.C. Ministry of Environment (1983), EQUIS	1972-1983
13	Mike Lake Cr.	Dept. of Fisheries & Oceans/EPS Chemistry Laboratory (1984)	Jul. 10, 1984
14	Alouette Lake	B.C. Ministry of Environment (1983), EQUIS	1972-1983

Table 4. Pitt River system groundwater quality measurements.

Water Quality Parameter (mg/L)*	RFCL**	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		Site Number													
Colour (TCU)	<15	12.5	15	15	5			23.8	17.5		20	12.5			5
pH - Field	6.8-8.5	7.49	7.6	7.5	7.37	6.23	6.7	7.27	7.30	7.1	7.1	7.4	7.7		6.98
- Lab	6.8-8.5			7.4	6.86			6.48	6.46		6.9	7	7.0	6.2	6.41
Residue - Total	<2000	120		79	19			37.2	47		84	232	28		12.1
- F	90-400	104		46	17			29.5	18		58	49		22	12.8
- NF	<3	55		46	3			5.7	2.3	5	17	3.8	1.4	<5	1.26
Conductance (µmho/cm)	150-2000	81	105	93	60	104Lab	102Lab	48	33		83	71	30	15Lab	32
Temperature (°C)	4-18	9.2	1.7	8.8	9.9			11.5	8.7	8	11.9	11.4	7.9		9.2
DO (mg/L)	>6-8	11.54	12.1	11.4	11.6	10	12	10.06	11.2	14	9.89	10.7	10.3		11.3
(%)	95-100			96											
Turbidity (JTU)	1-60	19.2NTU	15	32	2NTU			6.35NTU	4.2NTU		12.8NTU	26NTU		<0.1FTU	0.9NTU
Alkalinity	20-300T	39T	41	30.8T	6.0T	6.3 T		6.59T	4.4T	37	16.3T	14.47		4.0	3.8T
TOC	-	1.7	3.4	5.1							2	5.0			1
Chloride	<170U	2.1	2.7	1.8D	1.2D			3.53D	0.86D		9.68D	8.0D		0.8U	0.72D
Fluoride				<0.05T								0.11D		<0.03U	
Hardness	75-400	38	46Calc	34 D	6.6 D	7	40	8.4D	5.0D	7	21.1D	17.7D		5.29T	3.9D
NH_3-Total (D)	<0.05U	0.02		0.022	0.007	0.054U		0.033	0.009	0.015U	0.049	0.01	0.011	<0.005U	0.011
(T)	<0.05U			0.022	0.012			0.03	0.02		0.042	0.01			0.02
NO_2/NO_3 (D)		0.11		0.101	0.095	0.044U	0.4U	0.10	0.14		0.51	0.17	0.25		0.14
NO_3 (D)	<0.12U	0.1		0.10	0.067	0.04U	0.4U	0.092	0.10	0.035U	0.3	0.17	0.1	0.10U	0.10
(T)	<0.12U			0.10	0.095			0.18	0.14		0.31	0.17			0.13
NO_2 (D)	<0.012	<0.005		<0.005	<0.005	0.006U	0.007U	<0.005	<0.005	0.013U	0.0053	<0.005	<0.005	<0.005U	0.008
Organic-N (T)	-	0.16		0.13	0.082			0.17	0.05		0.22	0.11	0.12		0.084
Kjeldahl-N (T)	-	0.18	<0.5	0.19	0.073	1.05U	0.66U	0.23	0.11		0.27	0.13	0.09		0.93
BOD	-	<1-4	0	1.4									<10		
COD	-	5-17		1-4							12				<10
PO_4-Total (T)	<0.05U	0.06	0.028U	0.055	0.008	0.105U	0.043U	0.07	0.006	<0.005	0.03	0.01	0.01U	0.007U	0.006
Silica	<10-60U	5.14		5.8D	2.35D			3.2D	3.2D		7.2D	7.2D		2E	2.8D
SO_4	<90U	6.8D		6.69D	5D			5D	5D		5D	5D		3U	<5D
Tan/Lig (T)	-	0.43		0.38							0.6				
C-Inorganic	-		9	7.72								12			1
Phenols	<0.001	0.4-3.2													
Oils, Grease		1.8													
Pesticide - Var				<Det.Lim.											
Coliform (#/0.1L) - Total		11950	4900	4025	15			322	38		2930	864	30		17
- Fecal		1438	500	802	11			284	18		1096	493	45		12
CO_2	2-5	0.7-7.7		4-6	Res.										
Ag	<0.0001D	<0.002T		<0.002											
Al	<0.1T	1.53U				0.12T								0.6E	
As (T)	<0.5U	0.05		0.005	0.006	<0.26								<0.05E	0.007
Ba	<1U													0.003E	
Bo (D)				0.17	0.15			0.17	0.17		<0.2	0.17			0.15
Cd x 10^3	<0.3µgD	<0.5D		0.9		<0.5		<0.5			<0.5			<0.5E	<0.5
Ca	4-150U	11.3	10.2	10.8	2.22	1.6T		2.5	1.6		6.44	5.65		1.6E	1.22

Table 4 (cont.)

Water Quality Parameter (mg/L)*	RFCL**	Site Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cr (T)	<.01U, <.04T	0.007		0.007	0.005	<0.005		0.005	<0.005		0.005	<0.005		<0.005E	<0.005
CN	<0.005U	<0.01													
Co		<0.1U				<0.01								<0.005E	
Cu (T)	<0.001U	<0.001D		0.004	0.002	0.002		0.002	0.001	<0.01D	0.004	0.003		<0.001E	0.002
Fe (T)	<0.3T	1.79(.1)		1.36(.2)	0.19(.03)	1.0		0.57(.2)	0.233(.05)	<0.03D	0.93(.2)	0.4(.05)		0.051E	0.13(.05)
Hg x 10^3	<0.05μg T	0.06T		<0.05T						0.8D		0.12E			
K (D)	≪50U	0.7		0.55	0.29	0.18		0.37	0.27		0.77	0.57		0.6U	0.12
Mg (T)	<10U	2.56	1.8U	0.95	0.20	0.84		0.4	0.21		0.95	0.73		0.2E	0.125
Mn (T)	<0.05T	0.044		0.056	0.02	0.05		0.02	0.033		0.028	0.06		<0.001E	0.017
Mo (T)		0.003				<0.01								<0.005E	
Na (D)	≪500U	4.9	1.3U	2.07	1.33			3.25	1.05		4.95	3.9		0.9E	0.67
Ni (T)	<0.045T	<0.02		0.011	0.01	<0.01		<0.01	<0.01		<0.01	<0.01		<0.02E	<0.01
Pb (T)	<0.01U	0.02		<0.002	0.003	0.003		0.005	0.002	<0.02D	0.003	0.006		<0.001E	<0.002
Zn (T)	<0.005U	<0.005		0.008	0.02	0.005		0.006	0.005		0.01	0.013		<0.002E	0.009
Se	<0.05T													<0.05E	
Sr															

*Unless specified otherwise.
**Recommended Fish Culture Limits (RFCL) (Appendix 8).
___ - Average values exceed RFCL.
--- - Range extremities are outside RFCL.
T,E,D,U - Total, extractable, dissolved, or unspecified fraction.
NTU, JTU, FTU - Jackson Condle, Nephelometric, or Formazin Turbidity Units.
TNTC - Too numerous to count.
Lab - Laboratory measurement.

concentrations. Non-filterable residue (NFR) increases from 3 to 55 mg/L from site 4 to site 1. Average values of iron and NFR exceed RFCL at sites 1 and 3, while range extremities of both parameters exceed RFCL in Pitt Lake (site 4). Time series of water quality at site 3 in lower Pitt River (Department of Environment, 1973) show parallel increases in extractable iron, turbidity and sediment loading during the 1973 spring freshet. Levels of NFR and associated iron (and probably other minerals) vary with discharge in lower Pitt River, but it should be noted that water at this site includes an unknown proportion of Fraser River water. Total manganese also increases downstream of Pitt Lake, and range extremities are greater than RFCL at sites 1 and 3. Total copper and zinc are marginally higher in Pitt River and Lake (sites 3 and 4) than in Fraser River (site 1). Total cadmium levels beyond RFCL have been recorded at site 3. Total metal measurements include an unknown proportion bound to NFR.

Nutrient levels (nitrate, phosphate and total nitrogen) and coliform bacteria counts increase from site 4 to site 1, and dissolved oxygen (DO) levels as low as 4.4 mg/L have been recorded in Fraser River (site 1).

Sites 5 and 6 represent marshy areas. The pH is low (6.2 to 6.7), likely the result of growth and decay of bog plant material (Barnard, MS 1975). Alkalinity, hardness and calcium are all below RFCL at site 6. At site 5, average values of total aluminum, copper and iron exceed RFCL, while range extremities of manganese, lead and zinc exceed RFCL. Water quality in areas represented by these samples is not subject to Fraser River influence.

Analysis of data from the North Alouette system (sites 7-9) and the South Alouette system (sites 10-14) shows downstream increases in filterable residues and conductivity, and average values of both lie below RFCL at all the above sites. Calcium, alkalinity and hardness increase with distance downstream, and values are usually below RFCL, increasing in lower stations of the S. Alouette River (sites 10, 11). Contributions to these parameters include erosion and leaching of surrounding surficial sediments, and leaching of lime applied for agricultural purposes (Pitt Waterfowl Management Association, MS 1972). Barnard (MS 1975) presented data (Table 5) showing increased calcium, alkalinity and total dissolved solids (filterable residue) in surface water from agricultural areas compared to surface water from non-agricultural areas, indicating that liming probably contributes to these parameters.

Table 5. Surface water quality meansurements (mg/l) of differing habitat types in lower Pitt River system (Barnard, MS 1975).

Sample Site	Habitat Descriptions	pH	Alkalinity	Ca^{++}	T.D.S.	NO_3-N	Total-N	PO_4-P
36	Type 1 - Agric. Habitat	6.8	38.7	4.46	345.4	0.090	1.022	0.015
37	Type 2 - Agric. Habitat	6.5	30.8	5.94	254.8	0.250	1.112	0.013
38	Open Wildlife Habitat	6.3	8.6	1.20	35.9	0.020	0.606	0.007
39	Dense Wildlife Habitat	6.2	13.3	1.77	48.1	0.050	0.908	0.005
40	Sturgeon Slough Marsh	6.7	11.7	2.99	62.2	<0.020	0.458	0.007
41	Public Shooting Marsh	6.7	13.6	2.16	37.3	<0.020	0.389	0.006

Total and fecal coliform counts, and levels of nitrate, phosphate, ammonia, total nitrogen and chloride increase downstream from the headwaters of N. and S. Alouette rivers. Some residential areas adjoining these rivers are without municipal sewer facilities, and septic seepage is a contributing source of these pollutants (F.F. Slaney and Company Ltd., 1973). Analysis of water from sites 10 and 11 shows that the S. Alouette River is particularly affected, with levels of ammonia (0.05 mg/L) and nitrate (0.81 mg/L) exceeding RFCL. A similar but less severe situation exists in N. Alouette River (sites 7-9). Other potential sources of ammonia and nutrients are animal excreta and farm fertilizer. Barnard (MS 1975) detected elevated levels of nitrate, total nitrogen and phosphate in surface water from agricultural areas compared to surface water from non-agricultural areas (Table 5). As a result of pollution, DO levels are reduced, with lower extremes sometimes falling below RFCL in the lower reaches of S. Alouette River (6.3 mg/L at site 10) and of N. Alouette River (5.3 mg/L at site 7). Limited sampling indicates a nitrite level slightly exceeding RFCL in Blaney Creek (site 9). Both N. and S. Alouette rivers tend to be slightly acidic, with lower extremities of pH ranging below RFCL.

Levels of NFR also increase with distance downstream in N. and S. Alouette rivers, often marginally greater than RFCL in the lower reaches (sites 7, 8, 10, and 11). Total iron concentration follows the same pattern, and is probably largely composed of iron bound to NFR, as dissolved iron concentrations are much less (sites 7-14). Total copper, zinc and lead concentrations tend to follow the same pattern, but downstream increases are small. Potential sources of metals include erosion and leaching of sediments, septic seepage and storm sewer discharge (Dorcey, 1976). Other anomalous metal concentrations in Alouette system include an elevated total manganese concentration in N. Alouette River (site 8), a dissolved mercury concentration of 0.8 μg/L exceeding RFCL in Blaney Creek (site 9), and both high extractable mercury and high total manganese concentrations exceeding RFCL in S. Alouette River (site 11). Unknown proportions of total metals could be bound to NFR.

B. Upper Pitt River

Little surface water quality information exists for the upper Pitt River system. The Geological Survey of Canada (GSC) has not conducted stream sampling, and the IPSFC does not monitor water quality in the system. Water from Corbold Creek is supersaturated with oxygen and nitrogen as a result of very steep gradients in the stream. Surface water from most high-gradient tributaries to upper Pitt River would probably also be supersaturated. Cooper (MS 1967) describes a high rate of bedload transport (and associated suspended material) in upper Pitt River. Surface water would require filtration prior to use in a salmonid enhancement facility. Continued clear-cut logging practices in the area will no doubt continue to affect surface water quality of upper Pitt River.

Pollution Potential

Future pollution of Pitt River system surface water is possible from a variety of sources. Ongoing residential expansion adjacent to N. and S. Alouette rivers will exacerbate existing risks of pollution from septic seepage and siltation from construction sites. Expansion of storm drainage systems might result in sudden large-volume increments to streamflows and increased introduction of some metals, including lead (Dorcey, 1976). Storm sewer discharge from Port Coquitlam could similarly affect water quality in De Boville Slough.

Agricultural wastes will continue to contribute to high nutrient levels found in Alouette system. Controlled flows of S. Alouette River will result in concentration of pollutants and elevated water temperatures, which will reduce DO levels (F.F. Slaney & Co. Ltd., 1973).

Residential and industrial growth will increase the risks of accidental pollution. In 1971, a chemical spill in S. Alouette River was responsible for a fish kill (Sigma Resource Consultants, 1983).

At present there is limited industrial activity in the area and limited discharge of industrial effluent to the system. Existing industrial effluent permits issued by the Waste Management Branch allow discharge from a hotel on the west side of lower Pitt River at site 3, from a trailer park at the confluence of Pitt and Alouette rivers, and from a provincial recreational development at the outlet of Alouette Lake in Golden Ears Park. Water quality of outfalls at site 3 and at Alouette Lake outlet is summarized in the following table.

Water quality parameters measured at outfalls at site 3
and in Golden Ears Park (mg/L)

Site	pH	Filterable Residue	Non-Filterable Residue	Dissolved Ammonia	Dissolved Nitrate	Dissolved Nitrite	Dissolved Phosphate
Hotel, site 3	4.2		110	1.7	7.0	0.008	
Golden Ears Park	5.9	80	2	1.1	7.4	0.02	0.1

The analyses reveal very acidic conditions with ammonia and nitrate levels far above RFCL. Nitrite and phosphate exceed RFCL at the Golden Ears Park outfall.

Increased exploration of gravel deposits lying west of lower Pitt River (Hora and Basham, 1980) and adjoining N. and S. Alouette rivers, where extensive production is proposed, are a potential source of suspended materials (Griffith and Russell, 1980). An industrial park is also proposed in the Alouette system. Pesticide use is minimal (B.C. Ministry of Environment, pers. comm.). Herbicides are used to control plant growth on rights-of-way and to kill broad leaf plants on dairy farms. Aerial spraying of insecticides and fungicides is conducted in blueberry growing areas of Pitt Polder. There is a proposal to use herbicides to control blackberry growth near De Boville Slough. Insecticides are used to control mosquitoes and can be used in forestry for control of insect pests. The B.C. Ministry of Environment has little control of private use of pesticides, unless a specific misuse has occurred. Little monitoring is done. Data from a single sample from site 3 (Department of Environment, 1973) showed no detectable levels of pesticides or their breakdown products. Extensive use of lower Pitt River as a log-storage and booming ground has been identified as a potential source of pollution, but the effects have not been specifically identified.

The effects of potential pollution of Fraser River will be reflected in tidally influenced areas of lower Pitt River.

Groundwater

A. Lower Pitt River

Figure 13 shows groundwater investigation sites in the lower watershed. Site descriptions, locations, sampling dates, and sources of data are listed in Table 6; Table 7 describes groundwater quality of some sites shown on Figure 13.

Much of the information on groundwater quality in the area has come from sources unrelated to fisheries investigations. In 1961 the Greater Vancouver Regional District (GVRD) drilled test wells for aquifer potential in the lowland areas of Alouette system (sites 6, 9, and 10, Figure 13). The results of this drilling revealed low potential for a local municipal groundwater supply (Department of Environment, 1984). Flow rates were very low (but unspecified) and were probably retarded by a high silt content in the sediments (Halstead, GSC, pers. comm.).

At present, the area is largely supplied by municipal water, and domestic wells are not common. Chemical analysis of water from domestic wells is compulory in most areas and analysis is done by the Central Fraser Valley Health Unit (CFVHU) (B.C. Ministry of Health, 1985). In the lowland areas, domestic wells are often shallow, undrilled surface wells (sites 5, 8). Site 9 was drilled to a depth of 13 m. High bacterial counts in water from sites 5 and 8 (Table 7) reflect an oxygenated environment. Low pH, alkalinity, hardness, calcium, manganese and conductivity (sites 5, 8, 9) may result from an unknown proportion of surface water in the wells, and from biological degradation of and adsorption to organic material (Barnard, MS 1975). Nitrate levels tend to be high as measured by nitrate plus nitrite (nitrite assumed to be minimal). Dissolved iron and manganese exceeding RFCL are found in water from site 8.

Salt water is commonly found (sites 1, 2, 7) at depths from 25-250 m. At site 1, salty artesian water flowed from a depth of 250 m (drilling done in search for oil). At site 2 a test well for domestic purposes produced salty water at 25 m. At site 7 a commercial test well encountered alternating salty layers within the sedimentary strata from 60-100 m. Other references to salty groundwater include Ashley (MS 1977) in reference to unpublished data from drilling done by the GSC, and Halstead (pers. comm.) regarding shallow wells near the Pitt Meadows Airport. Chemical analyses are not available for water from these wells.

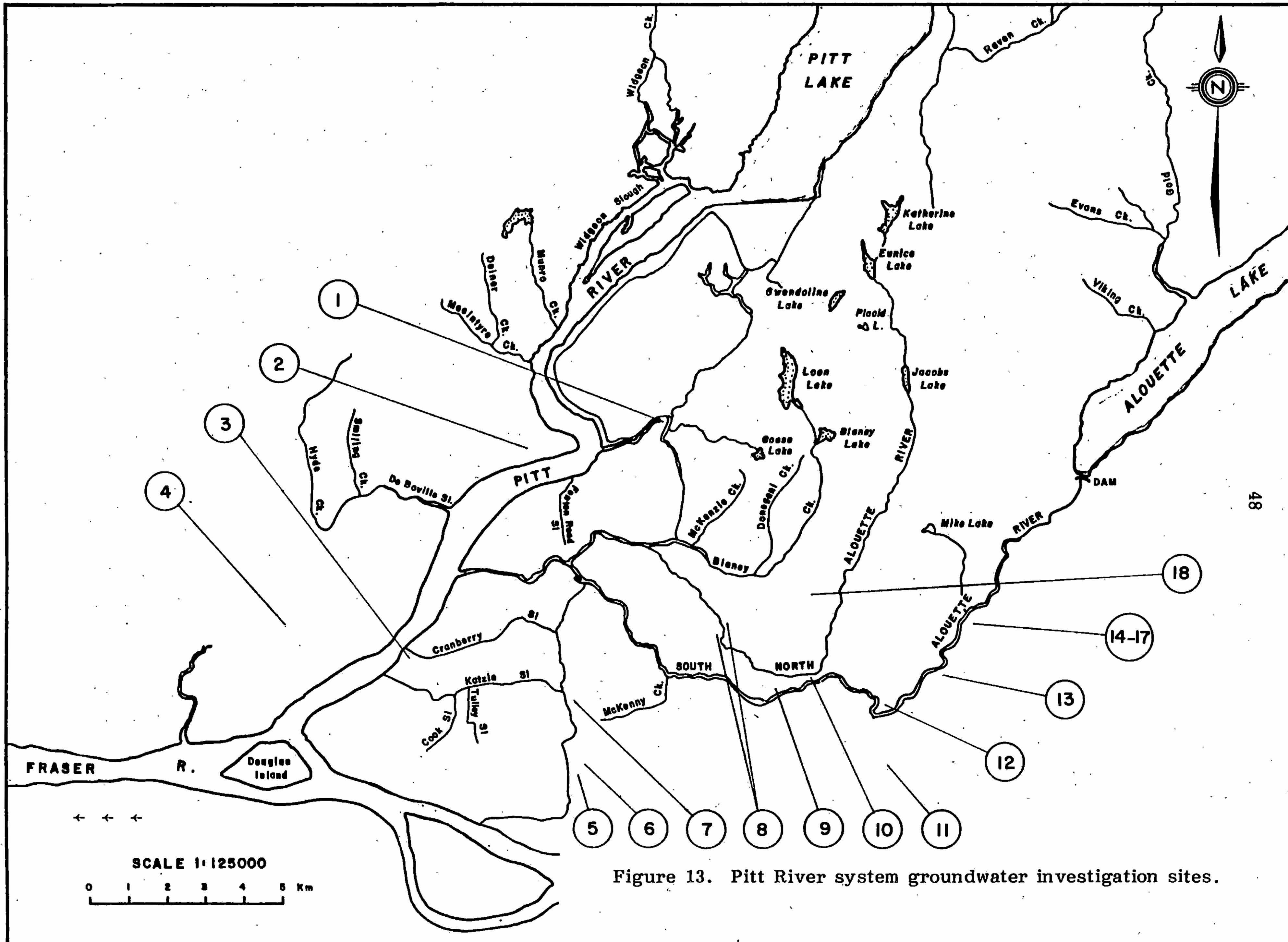


Figure 13. Pitt River system groundwater investigation sites.

Table 6. Pitt River system groundwater investigation sites and data sources.

Site	Description	Location	Data Source	Sampling Date(s)
1	Oil well	Pitt Polder	Department of Environment (1984); B.C. Ministry of Energy, Mines and Petroleum Resources (1966)	
2	Domestic well	Addington Pt.	Department of Environment (1984)	
3	GSC bore hole	East of Pitt River near Lougheed Br.	Ashley (1977)	
4	Industrial well	Esco Foundry, Coquitlam	Department of Environment (1984); (Spicer, pers. comm.)	
5	Domestic well	Maple Ridge	B.C. Ministry of Health (1985)	1982
6	GVRD test well	Maple Ridge	Robinson, Roberts, and Brown Ltd. (1961)	
7	Agricultural well	Maple Ridge	Department of Environment (1984)	
8	Two domestic wells	N. Alouette River	B.C. Ministry of Health (1985)	1980, 1981
9	Domestic/ GVRD wells	S. Alouette River	B.C. Ministry of Health (1985); Robinson, Roberts, and Brown Ltd. (1961)	1982
10	GVRD test	S. Alouette River	Robinson, Roberts, and Brown Ltd. (1961)	
11	Domestic well	Maple Ridge	B.C. Ministry of Health (1985)	1983
12	Domestic well	S. Alouette River	B.C. Ministry of Health (1985); Department of Environment (1984)	1981
13	Institutional well	Pacific Voc. Inst.	B.C. Ministry of Health (1985)	1983
14	Well #1	ARCC fish hatchery	Dept. of Fisheries & Oceans/EPS Chemistry Laboratory (1984)	July 17, 1981
15	Well #2	"	"	1982
16	Test well	"	Piteau and Associates (1982)	1982
17	Spring	"	Dept. of Fisheries & Oceans/EPS Chemistry Laboratory (1984)	1981
18	Three domestic wells	Silver Valley	B.C. Ministry of Health (1985)	1980-1983
19	Two hot springs	Upper Pitt River	B.C. Hydro & Power Authority (1984)	

Table 7. Pitt River system groundwater quality measurements.

Water Quality Parameter (mg/L)*	RFCL**	Site Number 5	8	9	11	12	13	14	15	16	17	18	19
Colour (TCU)	<15	<5	<5	<5									
pH - Field	6.8-8.5												
- Lab	6.8-8.5	6.6	6.2	5.7	8.1	7.4	6.0	7.5	6.5	7.75	6.5	5.3-7.6	
Residue - Total	<2000											72-	
- F	70-4000	42	54	114	164	91	82	104			39	34-222	1500
- NF	<3 inc.		50					<5			<5		
Conductance (µmho/cm)	150-2000	30	42	140	274		98	141		92	40	28-375	
Temperature (°C)	4-18							8-10	8.5		7.5F		56
DO (mg/L)	>6-8												
(%)	95-100							75		50			
Turbidity (JTU)	1-60	12 NTU	3 U	0.25 NTU	1.1 NTU			1 FTU			<1 FTU	1.5 NTU	
Alkalinity	20-300T	7	20	18	132	67	43 T	52.7		36 TD	14.8	0.7-188	
TOC								1.3	1.0				
Chloride	<170	3.8	3.3	17	11.1	<1	3.83	17.2 T		10 D	1.5T	0.4-10	
Fluoride		<0.1		<0.1	0.25		0.043					<0.1	
Hardness	20-400	13	22	27	80	46	31	52 T	24 E		14.8E	16-64	
NH_3-Total (D)	<0.05 U										<0.005T		
(T)	"							0.056 T					
NO_2/NO_3 (D)		0.7 U	0.04-0.32	0.6		0.04	0.96					0.5-0.6 U	
NO_3 (D)	<0.12 U				<0.02 U							0.03 U	
(T)	"							0.46		0.57	0.57		
NO_2 (D)	<0.012 U				<0.005 U			0.013 T	<0.005 T		<0.005 T	<0.005 U	
Organic-N (T)													
Kjeldahl-N (T)													
BOD													
COD													
PO_4-Total (T)	<0.05 U							0.056	<0.01		0.012		
Silica	10-60 U							10.7 T	8.8 E		5.28 T		73.5 U
SO_4	<90 U	1.5		1.2	<2	7		6.2 T		2.50	<1 T	<1	395 U
Tan/Lig (T)													
C-Inorganic													
Phenols	<0.001												
Oils, Grease													
Pesticide - Var													
Coliform (#/0.1 L) - Total		TNTC	TNTC	<1	<2	<1	<2					<1->16	
- Fecal							<2						
CO_2	2-5												
Ag^2	<0.00010												
Al	<0.1 T							<0.05 T	<0.05 E		<0.09 E		
As (T)	<0.5 U								<0.05 E		<0.15 E		
Ba	<1 U				<0.01 U			0.003 T	0.001 E		<0.03 E	<0.01	
B (D)					0.02				0.012 E			<0.01	
Cd x 10^3	<0.3 µgD							<0.004 T	<0.002 E		<0.01 E		
Ca	4-150 U	4 T	6.7 T	8 T	0.5 T	11 T	8.98 D	16.1 T	8.3 E	9.9 D	4.99 E	5-52	107.5U

Table 7 (cont.)

Water Quality Parameter (mg/L)*	RFCL**	Site Number 5	8	9	11	12	13	14	15	16	17	18	19
Cr (T)	<0.01 U				<0.01U			<0.009T	<0.005E		<0.015E	<0.01	
CN	<0.005 U												
Co									<0.005E		<0.015		
Cu (T)	<0.001 U				<0.01			0.1T	<0.005E		<0.01E	<0.01T	
Fe (T)	<0.3 T	<0.10T	0.02-0.80	<0.1	0.34	0.05	<0.03D	0.18D	<0.005E	0.043D	<0.01E	<0.1-0.2T	
Hg x 10^3	<0.05 µg T										<0.2U		
K (D)	≪50 U							1.45U		3.72D	0.27U		6.9
Mg (T)	<10 U	0.7	1.3	1.7	11	4.5	2.02T	2.7T		1.47D	0.571E	0.8-8T	0.22
Mn (T)	<0.05 T	<0.02	0.04-0.070	<0.03	0.12	<0.05	<0.003T	0.143T	<0.001E	0.10D	<0.003E	0.2T	
Mo (T)								<0.02T	<0.005E		<0.15E		
Na (D)	<<500	2.1	2.2	19	18	5	4.9T	7.45T	3.0E	8.8D	1.72E	3.2	235
Ni (T)	<0.045 U							0.129T	<0.02E		<0.08E		
Pb (T)	<0.01							<0.04T	<0.02E	0.012D	<0.08E		
Zn (T)	<0.005 U				0.02			0.11T	<0.002	0.03D	<0.02E	<0.01T	
Se									<0.05E		<0.15E		
Sr									0.036E				

*Unless specified otherwise.
**Recommended Fish Culture Limits (RFCL) (Appendix 8).
___ - Average values exceed RFCL.
--- - Range extremities are outside RFCL.
T,E,D,U - Total, extractable, dissolved, or unspecified fraction.
NTU, JTU, FTU - Jackson Condle, Nephelometric, or Formazin Turbidity Units.
TNTC - Too numerous to count.
Lab - Laboratory measurement.

In the upland areas, groundwater quality is best documented by analyses available from ARCC* wells. The first well (site 14), drilled to a depth of 70 m in 1980, developed a serious bacterial infestation six months after completion. The concentration of bacteria plugged well screens and reduced pumping efficiency. Elevated levels of nutrients (nitrate and phosphate) and an ample oxygen supply in the water (site 14, Table 7) may have enhanced the growth of bacteria. High dissolved iron in the water (up to 0.35 mg/L) was also related to bacterial growth. Use of this water in fish culture at ARCC ultimately coated gill surfaces, resulting in fish mortality by suffocation (Piteau and Associates, 1982). The well was abandoned and another drilled (site 15) to a depth of 48 m. Finer sediments at some levels in the new well contained elevated iron concentrations and high bacterial counts, but water from coarse sedimentary strata in the well is satisfactory after two years of production. Microbial blooms tend not to occur in water from coarse sedimentary strata in these wells (Dakin, pers. comm.).

Chemical analysis of water from the first well (site 14) revealed high iron, manganese, copper, zinc, nickel, ammonia and nitrate concentrations exceeding RFCL. It should be noted that analyses were done after a period of disuse of the well. Calcium, alkalinity and hardness were higher than in water from the second well or from water from a spring source (sites 15, 17).

Analysis of water from the second well showed a pH lower than RFCL. Hardness, alkalinity, and filterable residues were lower than RFCL in water from a spring source (site 17); nitrate exceeded RFCL.

A third shallow test well (site 16) produced water of similar quality to the first well although the data are less comprehensive, and metal concentrations were measured as dissolved, rather than as extractable as in the other samples.

Measurements of dissolved gases at sites 14-17 are high. A DO measurement of 80% saturation was recorded from the spring water. Similar values from the first well were recorded in hatchery notes dated January 1981 (Bonnell, pers. comm.). At another time, total gas pressure (TGP) from this well exceeded RFCL (103%) even after passing through an aerator. The high DO measurements indicate an oxygenated source (Piteau and Associates, 1982), probably from nearby surface water or unconfined portions of the aquifer. Temperature of groundwater from the second well remained constant at 8.5°C over a test period of several days and was

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1.5°C lower than water temperatures of the first well. Piteau and Associates concluded that the aquifer tapped by the second well should sustain a yield of 150 L/sec.

A well at site 13 has been serving the Pacific Vocational Institute for several years and no bacterial problems have been encountered. Analysis of water from this well done in 1983 indicated pH and nitrate levels outside RFCL (CFVHU; pers. comm.).

Domestic wells in upland areas of the Alouette system (sites 12, 13, 18) exhibit higher values for alkalinity, hardness, specific conductivity and calcium than the same measurements from domestic lowland wells or from surface water. Iron, manganese and nitrate levels are often above RFCL. Fluorine may occur up to 0.25 mg/L (site 13). Bacterial problems are not believed present, but pH may be low (5.3 at site 18) compared to RFCL. The wells are usually drilled (in contrast to lowland wells) up to depths of 70 m (site 13). Flows of up to 4 lps were recorded, but these data are not the result of formal pump-testing.

To the west of lower Pitt River in Port Coquitlam, Esco Ltd. drilled a test well (site 4) 40 m through coarse sediments (Spicer, pers. comm.). The well yielded 34 lps, but was fouled within three months by iron bacteria and corrosion, and was abandoned. It is not known if other levels of the well were tested.

Descriptions of the surficial geology of the lower watershed provide limited clues to groundwater potential in the area. The lowlands adjoining lower Pitt River are underlain by marine and alluvial sediments, mainly clays and silts interspersed with beds of sand (Armstrong, 1984; Ashley, MS 1977), providing limited aquifer potential. Barnard (MS 1975) describes, as a general model for the lowlands, approximately 15 m of marine and non-marine sand (a potential aquifer) underlying 4 m of clay and silt. A GSC borehole near the Pitt River bridge, site 3 (Armstrong, 1984), corroborates this model, but test wells at sites 6 and 7 encountered only limited sand.

Deposits of coarser sediments adjoining Alouette River, illustrated by drill logs from GVRD test wells at sites 9 and 10, provide existing aquifers for producing domestic wells (sites 8-13). Gravel deposits occur in Pitt Meadows (Hora and Basham, 1980), and, because of relatively impermeable sediments underlying the gravel, these deposits may be potential aquifers. Gravel deposits are also found west of lower Pitt River.

Granitic bedrock which generally underlies the area is probably a poor source of groundwater (Halstead, pers. comm.), although faults and fractures may be potential aquifers (Armstrong, 1984).

In summary, available flow data from drilled wells suggest that coarser, predominantly glacio-fluvial deposits of the upland areas are better potential groundwater sources than marine and alluvial deposits of the lowlands. The widespread occurrence of salt water probably further limits the suitability of potential lowland aquifers for fish culture. Both highland and unconfined lowland aquifers have potential fish culture problems related to elevated levels of iron and manganese, and the potential for bacterial growth supported by oxygen and nutrients. Elevated nitrate levels may be attributable to septic seepage in areas outside sewer service, or to agricultural wastes and fertilizers. In view of these problems, the potential for locating acceptable groundwater sources in the lower Pitt River watershed may be poor, and test drilling and development costs will be high. Low hardness, alkalinity, pH and calcium could further limit potential groundwater quality, although in the groundwater analysed they usually lie within RFCL and are higher than the same levels in surface water.

Continuing agricultural, rural and housing developments in the area may affect potential groundwater sources. Nutrients from fertilizers, animal excreta and septic seepage may contaminate near-surface aquifers, but probably will not affect confined aquifers underlying impermeable clays and silts (Armstrong, 1984). Increases in nutrients would enhance the potential for microbial blooms. Elevated nitrates, thought to be from fertilizers, are found in some wells in Langley (CFVHU). Calcium increases resulting from liming in agricultural areas could also affect groundwater.

Increased competition for available groundwater can be expected from domestic, agricultural and/or industrial users.

B. Upper Pitt River

Little specific information exists on groundwater potential or quality in the upper watershed. Schubert (1982) estimates that there is sufficient groundwater available for construction of a major facility, but provides no detail. Schubert (MS, in prep.) suggests, on the basis of stable water temperatures, that Slough Creek may be augmented by a significant groundwater flow. The IPSFC does not monitor groundwater in the upper Pitt system. It is possible that past depositional environments were similar to those which concentrated iron and manganese in sediments of the lower watershed, and there is a possibility that similar fish cultural problems may be inherent in potential aquifers in the upper watershed.

There are two hotsprings flowing into upper Pitt River approximately 21 km north of the head of Pitt Lake. Water at 57°C flows at the rate of 0.5 lps from the most northerly springs (McDonald *et al.*, 1978). Analysis of water from the two springs (site 19) by B.C. Hydro shows very high total dissolved solids, including calcium, sodium, chlorine, sulphate and silicon. Magnesium is not elevated. B.C. Hydro does not release data on the yield or development potential of the hotsprings.

WATERSHED TEMPERATURES

Water temperatures have been monitored by Water Survey of Canada, by the IPSFC, and by other investigators at several locations in the Pitt River watershed. Locations at which continuous records have been kept are shown in Figure 9 (Streamflow section).

Upper Pitt River

In the upper Pitt River (site 1 on Figure 9), water temperatures were monitored by Water Survey of Canada (1952-1965). Spot observations of water temperature by month over the period of record (Appendix 4) ranged from 0°C-14.8°C, with an average upper temperature of approximately 9°C in late May, June, July and August. In the months of November, December, January and February, minimum and maximum temperatures range between 0°C and 5°C. Monthly water temperatures are within RFCL (2°-18°C) from February through December, and approach the lower limits only in January and February. In general, upper Pitt River water temperatures are low in comparison to other coastal systems (Schubert, MS in prep.).

There is considerable variation in water temperature between mainstem upper Pitt River and some tributaries, reflecting differences in watershed characteristics. The following table lists mean weekly water temperatures in °C at four sites in upper Pitt River system in the period September-November, 1979 (Schubert, MS in prep.).

Week Ending	Mainstem	Boise Creek	Slough Creek	Corbold Creek
Sept. 15	9.3	10.3	10.3	9.3
29	9.1	10.8	9.6	8.7
Oct. 6	8.9	10.0	9.5	8.3
29	8.2	8.7	9.0	7.6
Nov. 3	7.7	6.7	8.6	6.1

Slough Creek temperatures varied least and were generally warmer than the mainstem, indicating a possible groundwater source. Boise Creek temperatures were correlated with ambient air temperatures, reflecting an incomplete forest canopy (result of logging), and the low Corbold Creek temperatures reflect its glacial origin. Water temperatures of Corbold Creek (monitored at site 2 on Figure 9) in an average year are shown in Appendix 5. Annually, the range of temperature is between 2° and 10°C, and during the period of sockeye spawning (September), temperatures range between approximately 8.5° and 9.0°C (IPSFC, 1984b).

Pitt Lake

The following table lists the range of surface water temperature (°C) in Pitt Lake from April-November 1979 (Johnson, MS 1981).

Month	Surface Water Temperature Range (°C)
April	6.5 - 9.5
May	6.5 - 12.5
June	12.5 - 18.5
July	13.5 - 19.0
August	17.5 - 19.5
September	13.5 - 17.0
October	- -
November	7.0 - 7.5

Lower Pitt River

In the lower Pitt River watershed, Water Survey of Canada has monitored water temperatures in the lower Pitt River near Port Coquitlam (site 3 on Figure 9), in the North Alouette River near Haney (site 4 on Figure 9), in the South Alouette River near Haney (site 5 on Figure 9), and in Jacobs Creek*

*Data not presented.

above Jacobs Lake (a N. Alouette River tributary). Appendices 6, (lower Pitt River), 6a (N. Alouette River), and 6b (S. Alouette River) present spot water temperatures for each site over the period of record.

Water temperatures range from 0°C to 20°C in the lower Pitt River near Port Coquitlam. Summer peaks are reached in July and August, and January and February temperatures range from 0°C to 7.0°C with the lowest recording in January. Average monthly temperatures are within RFCL.

Water temperatures in the N. Alouette River range from a low of 0°C in December and January to 18°C in June, July and August over the period of record. Average monthly water temperatures are within RFCL.

Spot observations of water temperature in S. Alouette River range from 1°C in January to 20.2°C in July. Highest water temperatures (and coliform counts) typically occur during low flow periods in S. Alouette River and could result in unacceptable increases in biological oxygen demand. Average monthly temperatures in July and August approach the upper limits for RFC, and temperatures higher than those recorded by Water Survey of Canada have been documented (Griffith and Russell, 1980).

PAST BIOPHYSICAL STUDIES

A. *Upper Pitt River System, Pitt Lake*

Aro (1979) described the first biophysical studies of the upper watershed in his summary of activities of the Pitt Lake hatchery from 1916 to 1936. Operated by the federal government, the facility was located near Alvin. Eggs and juveniles of Pacific salmon were distributed from this and other hatcheries to various locations in the Pitt River system.

The bulk of salmonid biological information has been collected by the IPSFC in their investigations (since 1947) and enhancement (since 1960) of sockeye salmon in upper Pitt River. Cooper (MS 1967), in an unpublished report, presented the results of an examination of the spawning grounds, with emphasis on discharge, bedload transport and the effects of logging and bank instability on the stream channel. Cooper (1977) evaluated the production of sockeye from the IPSFC facility on Corbold Creek. Harvey and Cooper (1962) described the origin and treatment of supersaturated water in Corbold Creek. Johnson (MS 1981), in an unpublished report, described the migrational behaviour of juvenile sockeye during lacustrine residence in Pitt Lake. Stockner and Shortreed (1983) compared the limnology of Pitt Lake to 18 other sockeye nursery lakes. Progress and annual reports of the IPSFC (1984a) contain references to upper Pitt River sockeye salmon biology and production. The results of these investigations will be summarized in appropriate sections of this report.

DFO investigations of the upper watershed, apart from information contained in the F381 files, have been sparse. Schubert (MS in prep.) investigated the spawning and rearing potential of upper Pitt River for species other than sockeye. Segments of his work have been published (Schubert, 1982); the results of juvenile salmonid biological investigations and coded wire tagging are in preparation. DFO personnel have monitored the declining chinook salmon population in Blue Creek since 1980 (DFO memoranda 5903-85-P165, May 15, 1981 and October 29, 1981).

The Fish and Wildlife Branch (B.C. Ministry of Environment, MS 1981) conducted a brief survey of trout habitat potential in upper Pitt River. B.C. Hydro has investigated the geothermal potential of Pitt River as part of a regional program; the results are unpublished.

B. *Lower Pitt River and Tributaries*

Baseline biophysical data collection in the lower watershed has been extensive but haphazard and unintegrated. Numerous ecological research projects have been conducted in lowland areas adjoining lower Pitt River, with emphasis on waterfowl, aquatic mammals, fish habitat and botanical studies. These projects were usually jointly funded by universities and the Fish and Wildlife Branch. Over 350 research projects have been initiated in the UBC Research Forest, with emphasis on the forest services, but including fisheries and ungulate biology, lake and stream ecology, soil studies, small mammal ecology, and microclimatology. Lists of these studies are available from the UBC Research Forestry office.

The B.C. Fish and Wildlife Branch has conducted extensive surveys of the Alouette River and Widgeon Creek watersheds, with emphasis on trout habitat. Hartman (1968) investigated growth rates of steelhead and coho salmon in S. Alouette River. Griffith and Russell (1980) investigated enhancement opportunities for trout and the potential for co-operative management in the Alouette watershed. De Leeuw and Stuart (MS 1981) studied small-stream enhancement possibilities for sea-run cutthroat trout in several lower Pitt River tributaries.

DFO studies in the lower watershed have been mainly directed to salmonid enhancement projects. Banford and Bailey (1979) describe the results of chum salmon incubation at Blaney Creek (tributary to N. Alouette River). Schubert (1982) studied adult salmon spawning in Alouette River, McIntyre Creek and Widgeon Creek. F.F. Slaney and Co. Ltd. (1978) and Sookachoff (MS 1984) studied minimum flow requirements in S. Alouette River, and Carpenter (1927) described water power developments of the Alouette-Stave lakes region. D.B. Lister and Associates Ltd. (1983) evaluated the performance of the ARCC enhancement project as part of the Small Projects Program of SEP.

There have been no formal biological studies of lower Pitt River mainstem. The status of environmental knowledge to 1974 of the Fraser River Estuary is described by Hoos and Packman (1974), with occasional references to lower Pitt River.

Conservation and recreational issues have been addressed by several groups in the lower Pitt watershed, and most notably documented by the Coquitlam Area

Mountain Study (B.C. Ministry of Municipal Affairs, MS 1981), and by the Coquitlam River Management Study (B.C. Ministry of Environment, 1978).

Ashley (MS 1977) studied sedimentology and flow mechanics in lower Pitt River and Pitt Lake.

SPECIES COMPOSITION AND PREDATORS

Table 8 summarizes the species composition of fish in areas of the Pitt River watershed (data from Hartman, 1968; Carl *et al.*, 1967; Fish and Wildlife Branch files). In addition to those species listed, there is an unconfirmed report (B.C. Fish and Wildlife Branch) of stocking of eastern brook trout in Monroe Lake.

Predators on Pitt River salmon as identified in the F381 files (Department of Fisheries and Oceans, 1984) include man, seals (to Pitt Lake), river otters, black bear, eagles, mink, and marten. Mergansers and other aquatic birds feed on juvenile salmon in Pitt Lake and upper Pitt River. Dolly Varden char and other fish species probably feed on salmon fry.

Table 8. Species of fish present or recorded from the Pitt River watershed.

Common Name	Scientific Name	Lower Pitt River, Pitt Lake	Upper Pitt River & Tributaries	Alouette River System	Alouette Lake
Kokanee	*Oncorhynchus nerka*	X	X	X	X
Sockeye Salmon	*Oncorhynchus nerka*	X	X		X*
Pink Salmon	*Oncorhynchus gorbuscha*	<u>X</u>	<u>X</u>	<u>X</u>	
Chum Salmon	*Oncorhynchus keta*	X	X	X	X*
Coho Salmon	*Oncorhynchus kisutch*	X	X	X	X*
Chinook Salmon	*Oncorhynchus tshawytscha*	X	X		X*
Rainbow Trout	*Salmo gairdneri*	X	X		X
Steelhead	*Salmo gairdneri*	X	X		
Cutthroat Trout	*Salmo clarki clarki*	X	X		X
Dolly Varden Char	*Salvelinus malma*	X	X		X
Lake Trout	*Salvelinus namaycush*				X**
Stickleback	*Gasterosteus* spp.	X	X	X	X
Mountain Whitefish	*Prosopium williamsoni*	X	X	X	
Sculpin	*Cottus* spp.	X	X	X	X
Largescale Sucker	*Catostomus macrocheilus*	X		X	X
Longnose sucker	*Catostomus catostomus*	X		X	X
Northern squawfish	*Plychocheilus oregonensis*	X		X	X
Peamouth Chub	*Mylocheilus caurinus*	X		X	X
Longnose Dace	*Rhinichthys cataractae*	X		X	
Redside Shiner	*Richardeonius balteatus*	X		X	X
Black Crappie	*Pomoxis nigromaculatus*	X		X	
Brown Bullhead or Catfish	*Ictalurus nebulosus*	X		X	
White Sturgeon	*Acipenser transmontanus*	X			
Longfin Smelt	*Spirinchus thaleichthys*	X			
Lamprey	*Lampetra* spp.	X	X	X	
Common Carp	*Cyprinus carpio*	X			
Starry Flounder	*Platichthys stellatus*	X			
Brassy Minnow	*Hybognathus hankinsoni*	X		X	

X* - *Isolated after dam construction (1925), extinct.*

X** - *Stocked.*

<u>X</u> - *Pink salmon are extinct in the Pitt River system.*

WATERSHED RECONNAISSANCE

Overview reconnaissance of Pitt River watershed by SEP personnel has been extremely limited. SEP engineers conducted a one-day inspection of upper Pitt River with emphasis on Blue Creek (G. Neilsen, pers. comm.) in 1981. Observations of the system have been made in conjunction with other investigations (e.g., Schubert, 1982; IPSFC; B.C. Hydro), and by DFO surveys of Blue Creek (e.g., aerial survey, September 1984), and during chinook salmon broodstock collections on Blue Creek by Chilliwack Hatchery staff in 1981 (DFO memorandum, 5903-85-P165, Oct. 29, 1981).

SALMON RESOURCE

Escapement and Spawning

Much of the information in this section has been summarized from the F381 files, which contain repeated references (Appendix 15a,b) to unfavourable enumeration conditions prevailing in the upper Pitt River related to the glacial nature of the stream and extreme fluctuations in discharge during the spawning period. The necessarily infrequent observations by DFO personnel, frequent personnel changes, and time constraints regarding submission of reports (December 31 of each year) further limit the validity of their estimates. In this report, information from the F381 files has been supplemented where available with data collected by the IPSFC and from baseline biological studies conducted by DFO (in the Alouette system) and by the Fish and Wildlife Branch.

A. Upper Pitt River

Timing

Historically, the upper Pitt River has supported all five species of eastern Pacific coast salmon, and populations of steelhead, cutthroat trout and Dolly Varden char. Pink salmon have not been observed since 1961, and chums have been observed only infrequently in recent years. Table 9A summarizes the timing of upper Pitt River spawners and shows the usual times of arrival of each species on the spawning grounds. This information is also included in Figure 14, which illustrates the approximate migration timing of Pitt River salmon through the commercial fishery, their arrival in particular spawning streams, and the duration of the spawning period in each stream.

Chinook salmon usually enter the upper Pitt River in late July, followed by sockeye in August, coho in September, and chum salmon in October. Steelhead probably arrive in November and are present until late February. Spawners of all species usually hold in pools and side channels prior to moving on to the spawning grounds. Early coho spawners enter the tributary spawning areas in mid-November, but the main run remains in the river through December with migration into the tributaries and peak spawning occurring in late December. In

Table 9. Summary of usual spawner timing in the Pitt River system.

A. Upper Pitt River (F381 files; Schubert, 1982; IPSFC annual reports).

Species	Period	Usual First Arrival	Start Earliest	Start Latest	Peak Average	End Average	End Latest
Sockeye	1925-1983	Aug. 15-20	Aug. 20	Sept. 5	Sept. 10-12	Sept. 30	Oct. 20
Coho	1925-1978	Sept. 15	Sept. 15	Nov. 15	Dec. 20-Jan. 1	Jan. 20	Feb. 15
Chinook	1925-1983	July 20	July 30	Sept. 1	Aug. 20	Sept. 15	Sept. 30
Chum	1925-1983	Oct. 1	Oct. 1	Oct. 31	Oct. 20	Nov. 1	Dec. 15
Steelhead		Nov. 15	Dec. 1	Jan. 1	Jan. 1		Feb. 28

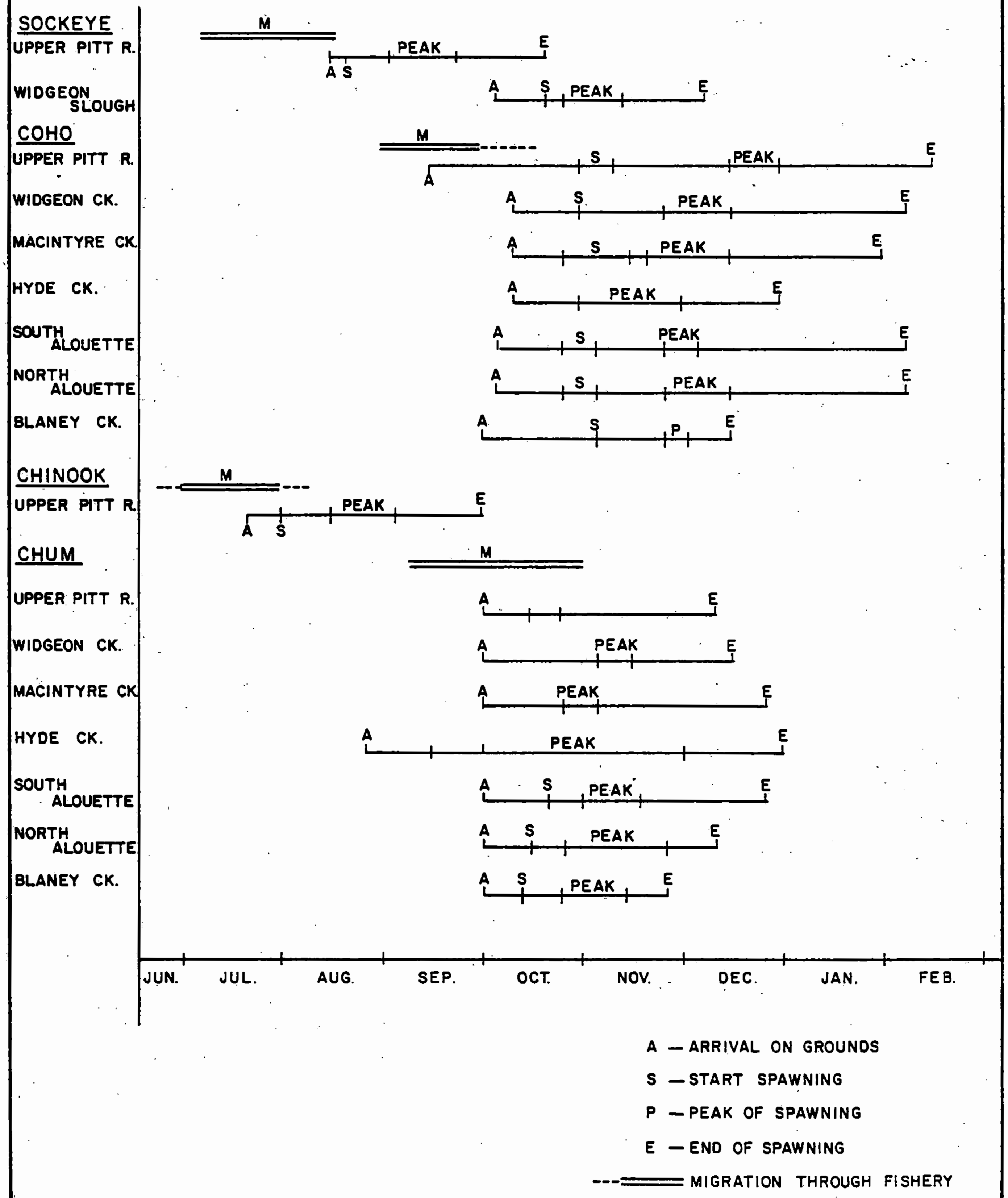
B. Alouette River System (F381 files; Schubert, 1982; Banford and Bailey, 1979).

Species	Period	Usual First Arrival	Start Earliest	Start Latest	Peak Average	End Average	End Latest
Coho							
S. Alouette	1925-1983	Oct. 5	Oct. 15	Nov. 5	Nov. 30	Dec. 30	Feb. 10
N. Alouette	1925-1983	Oct. 5	Oct. 15	Nov. 5	Nov. 30	Jan. 10	Feb. 10
Blaney Creek	1925-1983	Oct. 5	Nov. 1		Nov. 30	Dec. 15	
Chum							
S. Alouette	1925-1983	Oct. 1	Oct. 20	Nov. 20	Nov. 10	Dec. 15	Dec. 30
N. Alouette	1925-1983	Oct. 1	Oct. 15	Oct. 30	Nov. 10	Nov. 15	Dec. 10
Blaney Creek	1972-1977	Oct. 1	Oct. 11	Oct. 16	Nov. 4	Nov. 12	Nov. 25
Steelhead			Dec. 1		Dec. 30	Feb. 15	

C. Lower Pitt River west side tributaries (F381 files; Schubert, 1982; IPSFC annual reports).

Species	Period	Usual First Arrival	Start Earliest	Start Latest	Peak Average	End Average	End Latest
Sockeye							
Widgeon Creek (Slough)	1941-1982	Oct. 10	Oct. 20	Nov. 5	Nov. 2	Dec. 1	Dec. 7
Coho							
Widgeon Creek	1931-1982	Oct. 10	Nov. 1	Nov. 15	Dec. 1	Jan. 10	Feb. 5
McIntyre Creek	1970-1978	Oct. 10	Oct. 31	Nov. 15	Nov. 30	Dec. 20	Feb. 1
Hyde Creek	1981-1982	Oct. 10	Oct. 15		Nov. 15	Dec. 1	Dec. 31
Chum							
Widgeon Creek	1931-1982	Oct. 1	Oct. 1	Oct. 20	Nov. 15	Nov. 30	Dec. 15
MacIntyre Creek	1970-1978	Oct. 5	Oct. 15	Oct. 31	Nov. 15	Nov. 20	Dec. 10
Hyde Creek	1981-1982	Sept. 30	Sept. 30	Nov. 1	Oct. 30	Dec. 10	

Figure 14. Approximate migration timing through the Area 29 commercial fishery, and duration of the spawning period of salmon spawners in the Pitt River and tributaries. (Migration estimates from IPSFC, 1984a; Schubert, pers. comm.; Palmer, 1972; M. Farwell, pers. comm.; J. Woodey, pers. comm.)



some years, a second group of coho arrives in upper Pitt River in late January and spawns during February (Schubert, MS in prep.).

Sockeye usually begin spawning in early September and peak spawning occurs about mid-September. In most years the spawning period ends about September 30. Chum salmon spawning is complete by early November.

Distribution

Salmon spawning in the upper Pitt River watershed is generally confined to the lower reaches of tributaries and to side channels of the mainstem. There are no obstructions to adult migration in the lower 40 km of the mainstem, but obstructions are usually present within 2 km of the mouths of most tributaries. Scattered spawning (coho) has been observed in the lower reaches of Iceworm Creek, but the main concentrations of spawners (all species) are located between the mouths of 400 Creek and Garibaldi Creek (approx. 20 km).

Figures 15, 16, and 17 illustrate the normal distribution of sockeye, coho, chum and chinook spawners in upper Pitt River and tributaries (data from IPSFC, 1984b; Schubert, MS in prep.; F381 files).

The majority of sockeye spawners utilize the mainstem of the river downstream of the First Canyon, and there is considerable variation in percent utilizing particular tributaries from year to year. The lower reaches of Fish Hatchery, Corbold and Boise creeks are the next most preferred sockeye spawning areas.

Blue Creek is now the only major chinook salmon spawning area in the upper Pitt system. Smaller numbers of chinook have been observed spawning in side channels near the mouth of Homer Creek (Schubert, MS in prep.), and scattered spawning occurred in the mainstem between First Canyon and Boise Creek. Corbold Creek supported spawners in some years and lower Boise Creek was utilized by chinook spawners prior to intensive logging activities in that area.

Coho spawning distributions are based on observations by Schubert (MS in prep.). Spawning densities are highest in the lower flood plain reaches of several tributaries, but low density spawning occurs in many mainstem side channels and in protected reaches of the mainstem itself. The major spawning areas are in the lower reaches of Blue Creek, Boise Creek, Fish Hatchery Creek, Slough Creek, Forestry Creek, Homer Creek, Peters Slough, Garibaldi Creek, Red Slough Creek

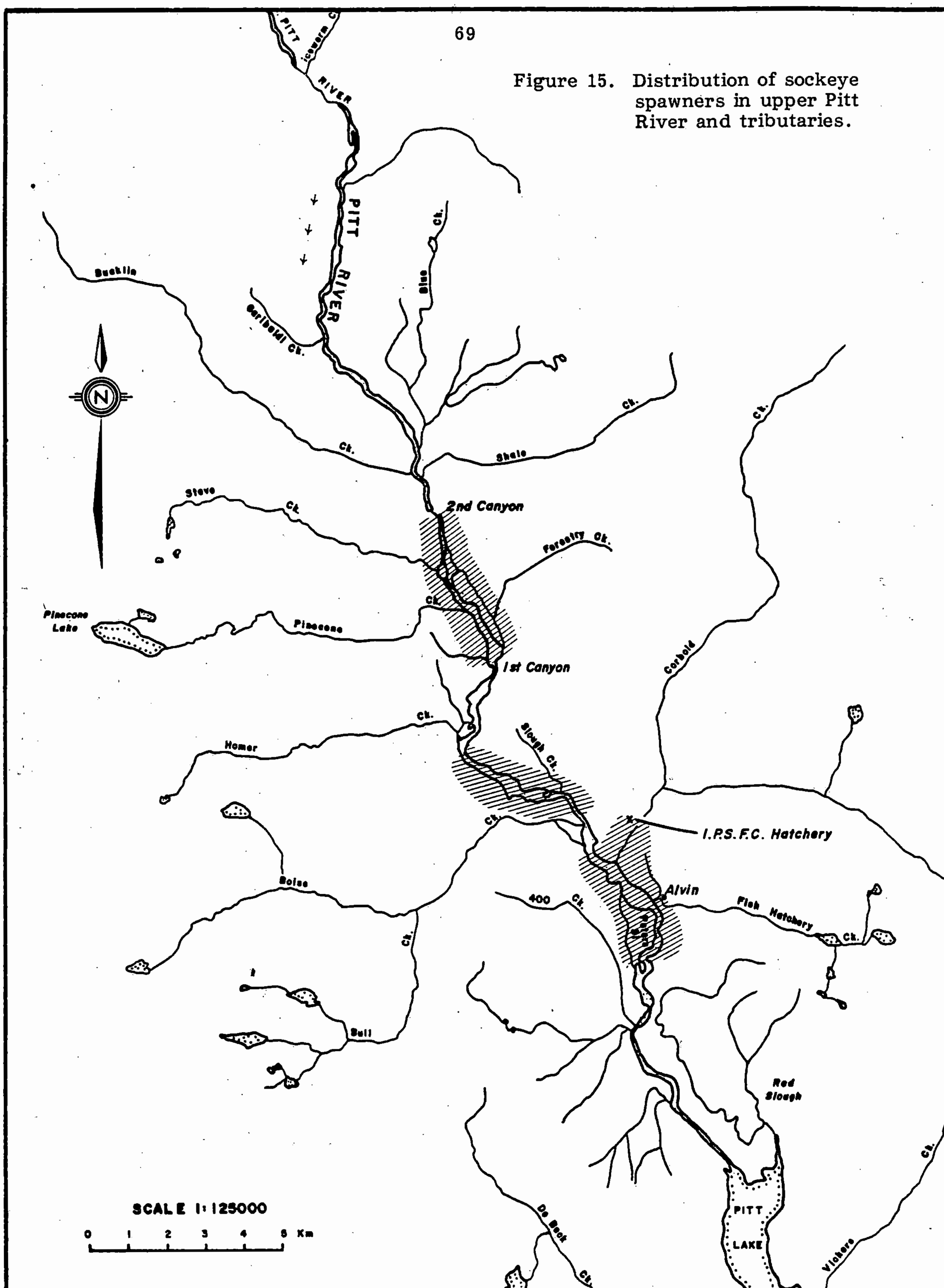
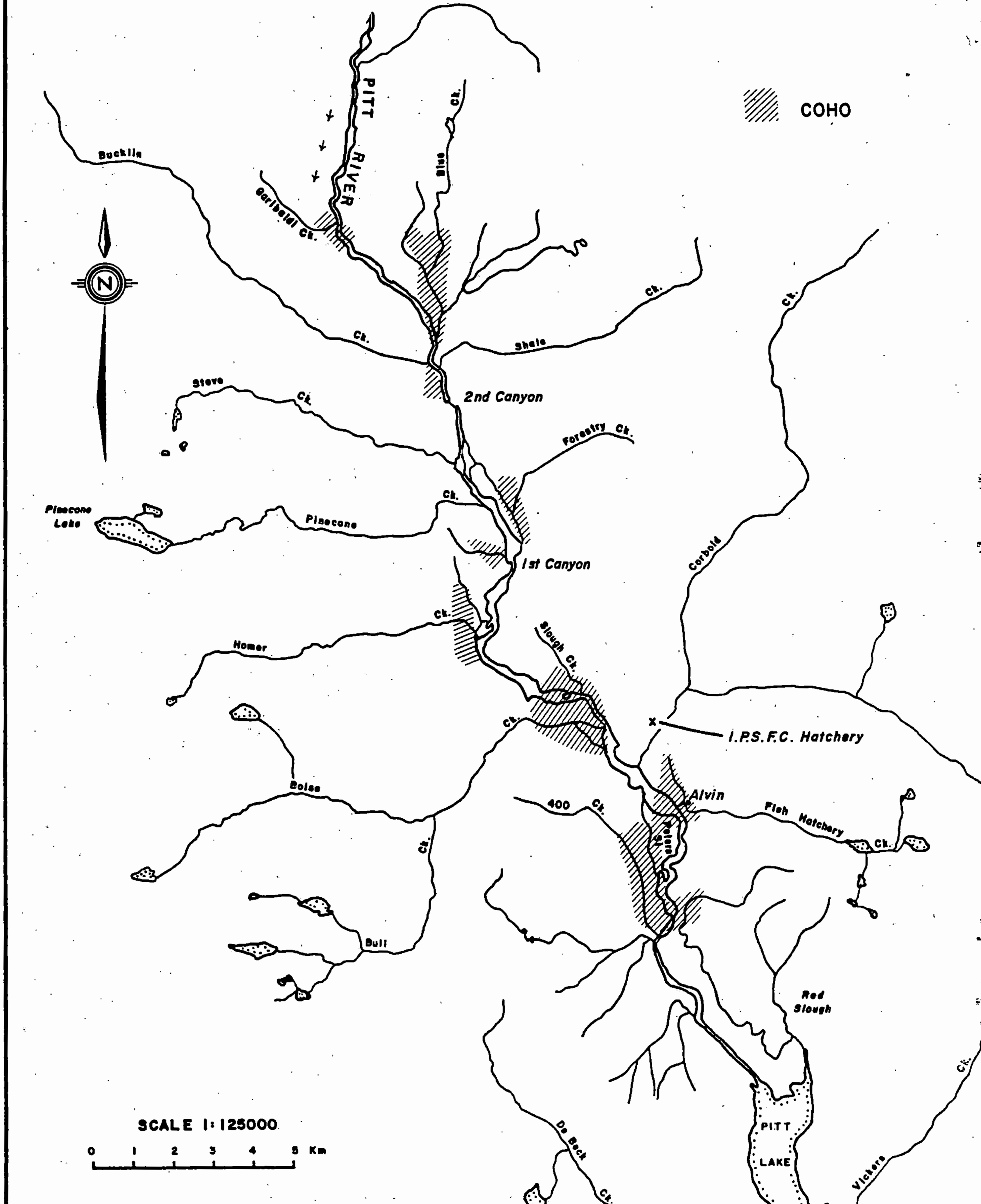


Figure 15. Distribution of sockeye spawners in upper Pitt River and tributaries.

Figure 16. Distribution of coho spawners in upper Pitt River and tributaries.



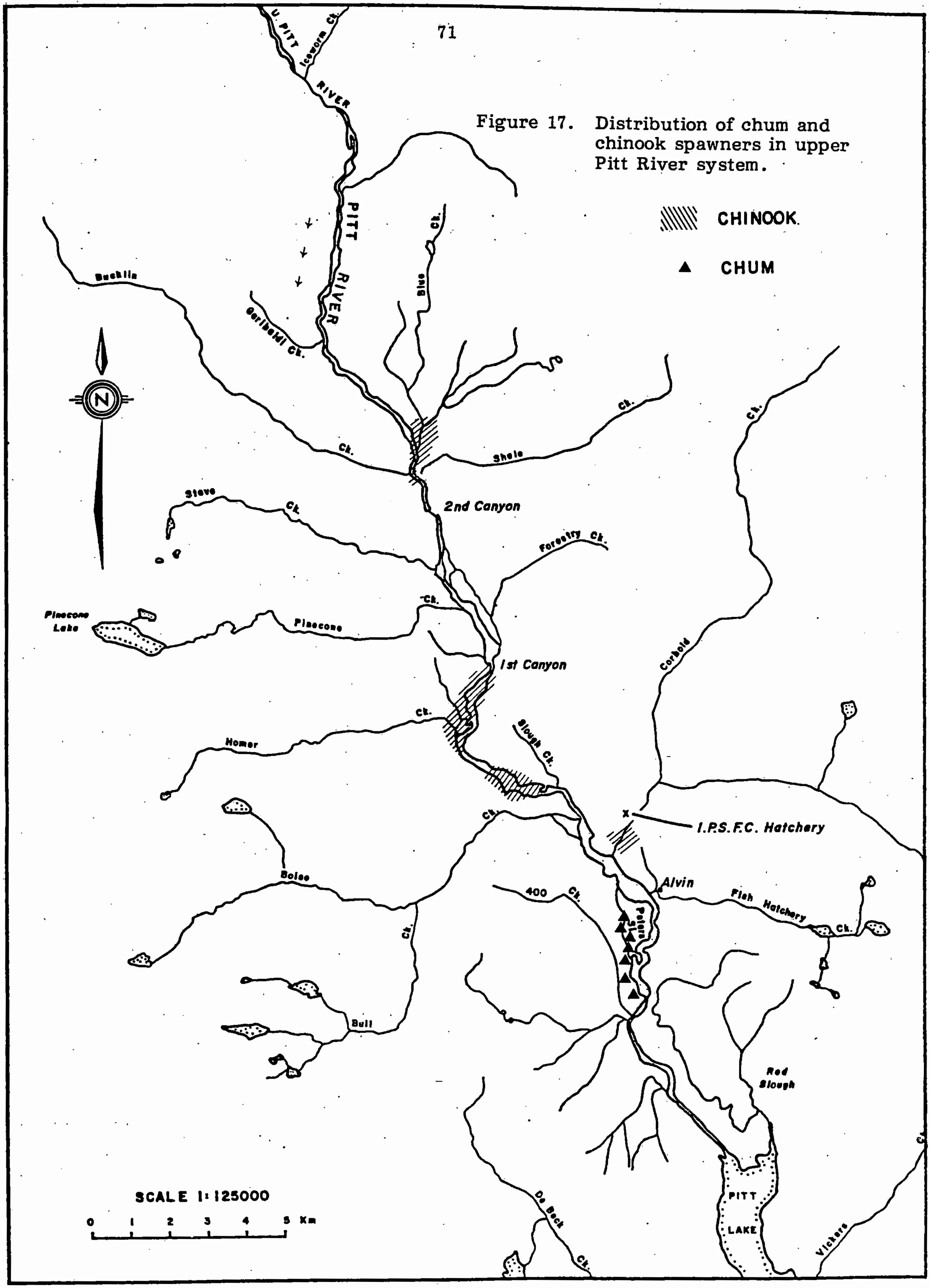


Figure 17. Distribution of chum and chinook spawners in upper Pitt River system.

and Corbold Creek (descending order of importance from Blue Creek to Corbold Creek).

Chum salmon spawn only in a mainstem side channel known as Peters Slough near Alvin. The F381 files indicate that pinks spawned in October in side channels near Alvin.

Abundance

The estimated escapements of salmon and steelhead to upper Pitt River (1947-1984) are listed in Table 10. Figures 18a,b,c,d and e present the same information graphically for sockeye, chinook, coho, chum and pink salmon, respectively. Over the period of record, sockeye escapements have ranged from a low of 6642 in 1970 to a high of 55380 in 1948. Average escapements from 1948-1984 are as follows:

Period	Average
1948-54	32537
1955-64	16717
1965-74	14813
1975-84	23641

There has been an increase in adult escapement since construction of the hatchery and incubation channel in the early 1960's, but low recent escapements (8725 in 1982) are of concern to the IPSFC.

Upper Pitt River chinook escapements have ranged from a high of 3500 in 1962 to a low of 120 in 1980. Average escapements from 1948-1984 are as follows:

Period	Average
1948-54	530
1955-64	2105
1965-74	1425
1975-84	304

There has been a drastic decline in chinook salmon escapements to upper Pitt River. Overharvesting probably accounts for some of this decline, but destabilization of the spawning grounds as a result of clear-cut logging practices has also had an effect. Only Blue Creek presently supports concentrated chinook spawning. Blue Creek

Table 10. Escapement of sockeye, chinook, coho, chum, pink and steelhead to the upper Pitt River, 1947-1984.

Year	Sockeye	Chinook	Coho	Chum	Pink	Steelhead
1947	91,000			Unknown		
1948	55,380	25		Unknown		
1949	9,290	25				
1950	40,061	750	400	750	25	Unknown
1951	37,837	750	400	1,500	750	200
1952	48,899	1,500	7,500	3,500		400
1953	18,693	1,500	3,500	1,500	7,500	750
1954	17,624	750	400	750		Unknown
1955	17,950	750	3,500	750	1,500	750
1956	32,094	1,500	400	200		400
1957	12,338	1,500	1,500	25	25	400
1958	10,385	3,500	3,500	200		
1959	15,740	750	400	400		
1960	24,510	400	400	N/O		
1961	11,162	400	3,500	25	2	
1962	16,385	3,500	7,500	1,500		
1963	12,680	750	400	N/O		
1964	13,804	1,500	7,500	N/O		
1965	6,981	400	1,500			
1966	20,867	1,500	3,500	75		
1967	10,300	750	1,500	N/O		
1968	16,988	400	750	N/O		
1969	25,084	200	750			
1970	6,657	1,500	1,500			
1971	15,469	7,500	35,000			
1972	13,412	750	1,500			
1973	11,928	750	3,500			
1974	20,792	500	3,500			
1975	39,942	300	3,000			
1976	36,530	750	3,500	400		
1977	13,887	700	8,000			
1978	24,835	150	40,000			
1979	37,558	250	5,000			
1980	17,135	120	2,500	25		
1981	25,327	325	3,500	-		
1982	8,725	300	7,500	N/O		
1983	16,858	N/O	3,500	10		
1984	15,797					

Figure 18a. Estimated escapement of upper Pitt River sockeye (1947-1983).

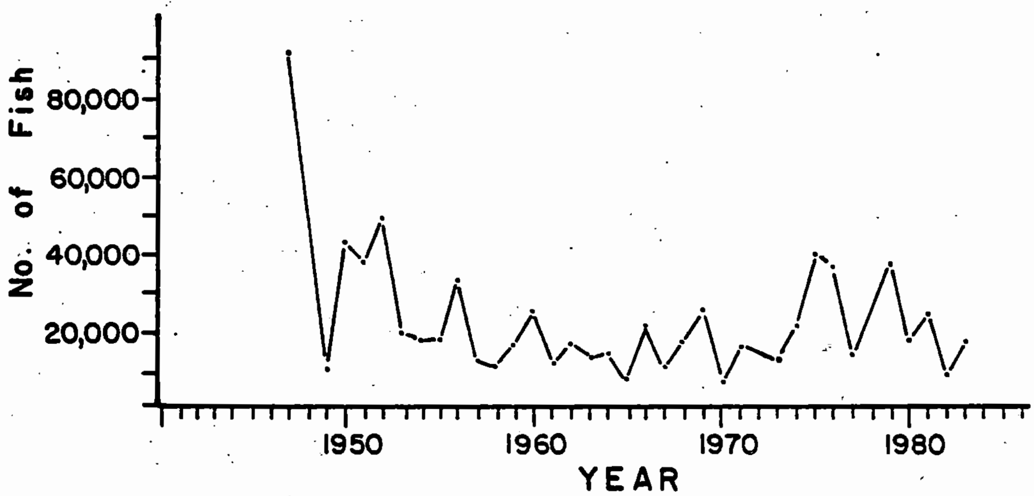


Figure 18b. Estimated escapement of upper Pitt River chinook (1948-1982).

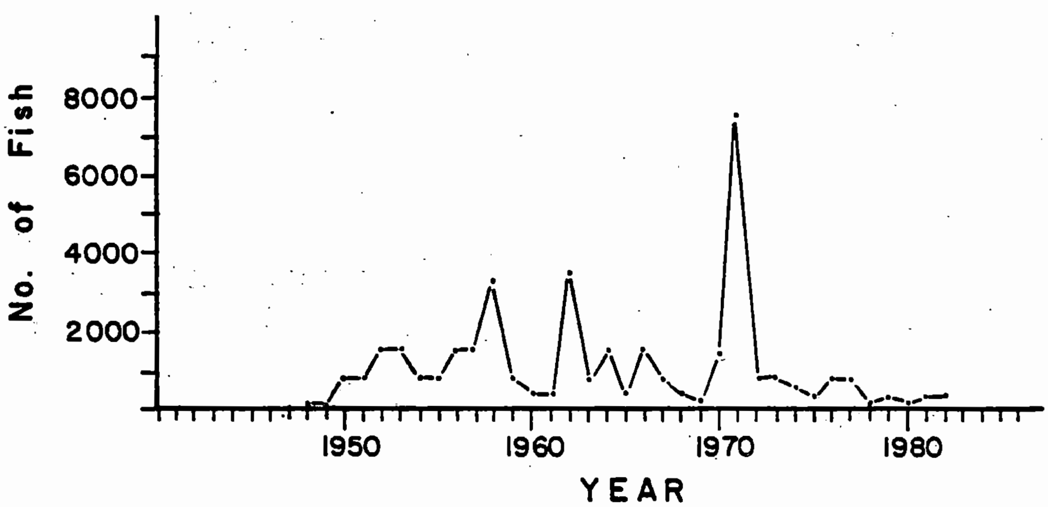


Figure 18c. Estimated escapement of upper Pitt River coho (1950-1983).

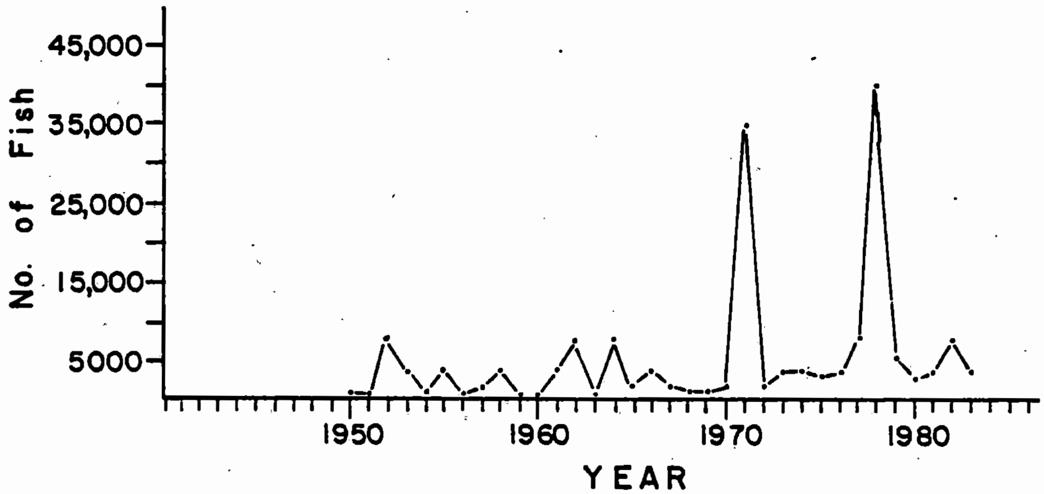


Figure 18d. Estimated escapement of upper Pitt River chum (1950-1983).

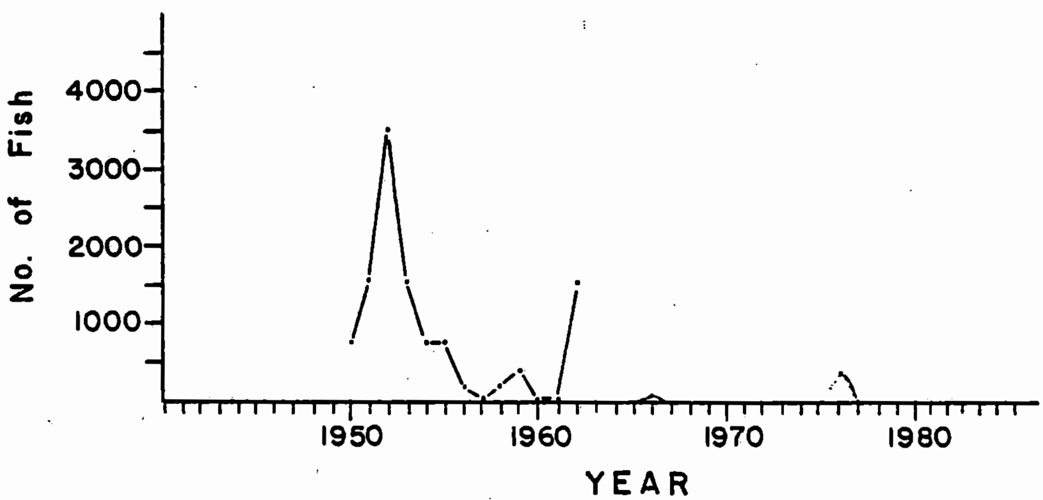
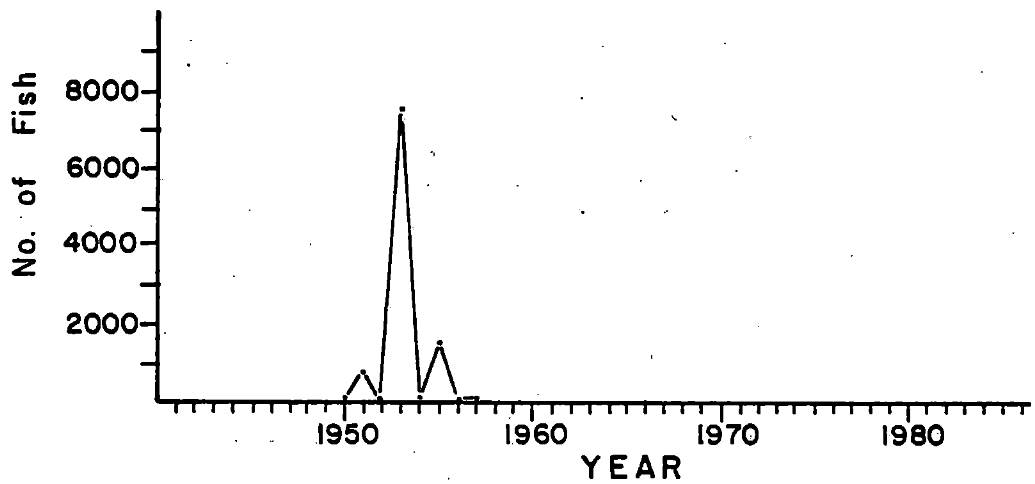


Figure 18e. Estimated escapement of upper Pitt River pinks.



is a stable stream at present (Lill *et al.*, 1985), but the chinook population has no doubt suffered from the effects of past logging and road construction activities.

Coho escapements have ranged from 40,000 in 1978 to approximately 400 annually in 1950 and 1951. Average escapements in the period 1950-1983 are as follows:

Period	Average
1950-54	2440
1955-64	2860
1965-74	5300
1975-83	7650

Coho escapement estimates made by Schubert in the period 1977-1979 were at variance with escapements reported in the F381 files. For example, in 1978 the F381 estimate was 40,000 spawners, and Schubert's estimate was 17,500, based on a more accurate survey of the spawning grounds. These results reflect the difficulty of accurate enumeration of spawners in upper Pitt River.

Chum salmon escapements to upper Pitt have ranged from 25 to 3500 in the period 1950-1965, with an average of approximately 850 in years when fish were observed (to 1965). The escapement was estimated at 400 in 1975 and at less than 100 in 1979 (Schubert, MS in prep.). There has been a substantial decline in chum salmon escapements to upper Pitt River since the early 1950's.

The F381 files indicate both odd and even year* pink salmon escapements to upper Pitt River between 1950 and 1961. Odd year escapements were much larger than even year, and ranged from 2-7500. Pinks have not been observed since 1961.

Steelhead have not been enumerated since 1957. Escapements have ranged from 200 in 1951 to 750 in 1955.

B. Alouette River System

The Alouette River system historically supported all five species of salmon plus populations of sea-run cutthroat trout and steelhead. The dam constructed at the outlet of Alouette Lake has had two major lasting effects on salmon populations in the South Alouette River. Because no provision for fish passage was called for in construction of the dam, spawning populations of sockeye, chinook.

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*25 fish in 1950.

coho and chum salmon were prevented from entering historical spawning grounds in Alouette Lake and tributaries (Griffith and Russell, 1980). The second lasting impact has been the severe reduction of flows, with attendant potential impacts on fish populations. There has also been extensive channelization and dyking in the lower reaches of the system, and gravel removal from the streambeds of both the North and South Alouette rivers. Gravel removal was curtailed by legislation in 1956, and in 1971 a minimum flow agreement was reached with B.C. Hydro establishing a continuous flow of 0.06 m^3/sec below the dam site and a minimum flow of 0.71 m^3/sec further downstream. Total lengths of streams useful to anadromous fish in the Alouette River system (i.e., up to barriers) are 25 km in S. Alouette, 12 km in N. Alouette, and 5 km in Blaney Creek.

Timing

Table 9B summarizes the timing of salmon spawning in the Alouette River system, and shows the usual times of arrival of each species on the spawning grounds. This information is included in Figure 14, which also illustrates the approximate migration timing through the fishery. The system now supports spawning populations of only chum and coho salmon, with smaller populations of sea-run cutthroat and steelhead. Early arrivals of both chum and coho salmon may be present in both North and South Alouette rivers and Blaney Creek as early as October 1. Spawning for both species in the system begins about mid-October. The peak of chum spawning usually occurs in early November, and coho peak spawning occurs in late November with some spawners being present until early February in most years. Chum salmon spawning is usually complete by late December in North and South Alouette rivers, and by early December in Blaney Creek.

The peak of spawning for steelhead occurs in late December and early January.

Distribution

Figure 19 illustrates the normal distribution of coho and chum salmon spawners in the Alouette River system and the location of the Blaney Creek incubation site and ARCC hatchery. In South Alouette River, chum salmon spawn in the

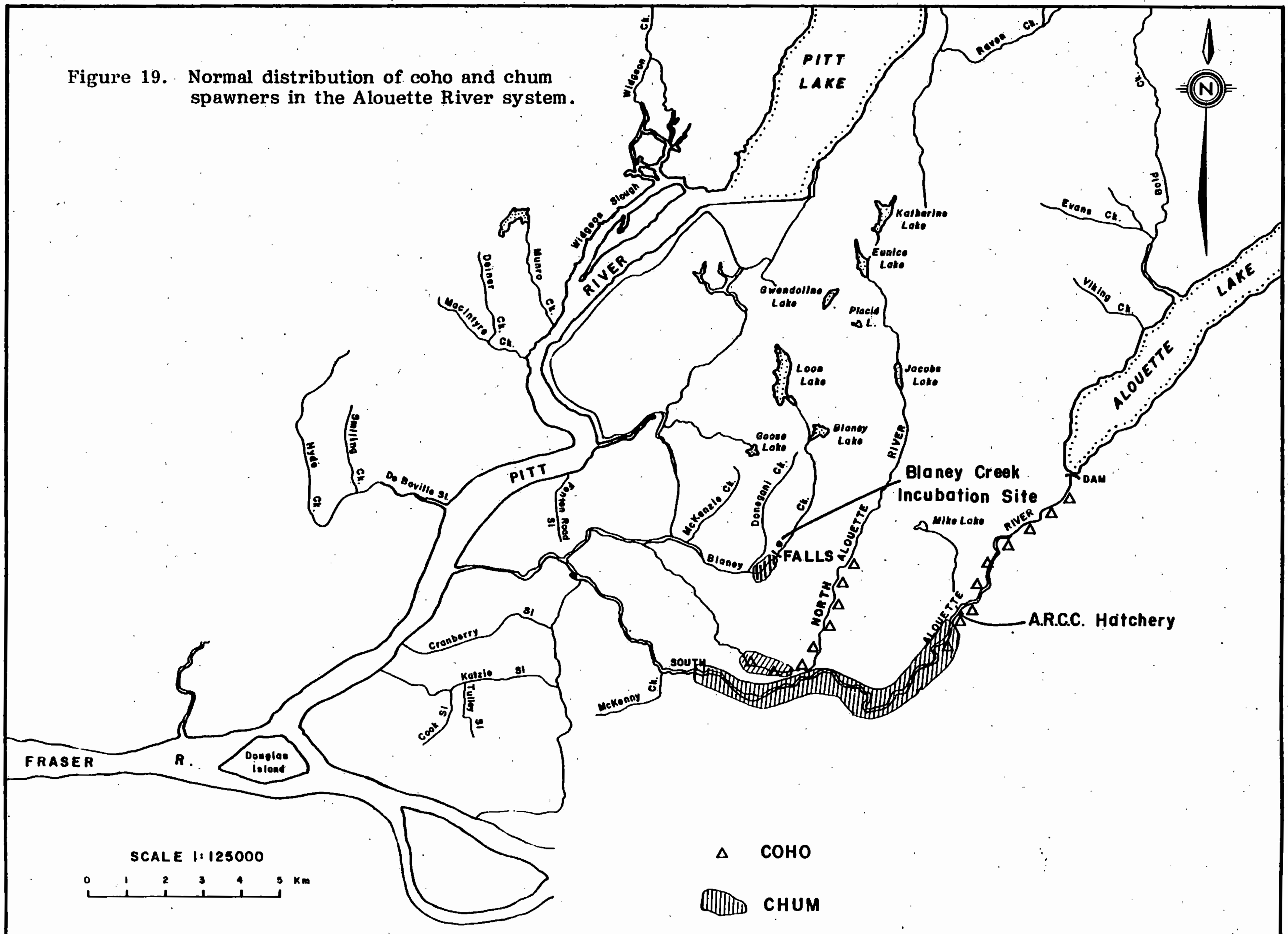


Figure 19. Normal distribution of coho and chum spawners in the Alouette River system.

middle section of the stream between 8 km upstream to 15 km upstream. In North Alouette River, chum salmon spawn primarily in that section of the stream between 6 and 7 km upstream. In Blaney Creek, chum salmon spawn in a 1000 m^2 area of the stream downstream of the falls.

Coho spawn in scattered groups in S. Alouette River in that section of the river between 14 km upstream and the dam at Alouette Lake outlet. On N. Alouette River coho spawn mainly in a 5 km reach of the river between 6 and 11 km from its confluence with Alouette River.

Steelhead spawn in North and South Alouette rivers, but probably not in Blaney Creek (Griffith and Russell, 1980).

Abundance

The estimated escapements of salmon and steelhead to the Alouette River system for the period 1947-1983 are listed in Tables 11a,b, and c. Figures 20a to 20h present the same information graphically for S. Alouette River, N. Alouette River and Blaney Creek. Average escapements for the period of record are shown in the following table (from F381 estimates):

	Chum			Coho		
Period	S. Alouette River	N. Alouette River	Blaney Creek	S. Alouette River	N. Alouette River	Blaney Creek
1947-54	2320	2268	400	593	334	170
1955-64	830	730	245	242	205	62
1965-74	2975	797	630	385	317	105
1975-83	7980	1536	685	425	282	52

Chum salmon escapements have ranged from 200 (in 1954) to 18500 (in 1982) in S. Alouette River. The recent substantial increases in escapement are partly due to returns from ARCC hatchery releases. Much higher returns of N. Alouette chum salmon in recent years (5000 in 1977, 5500 in 1981) are in part due to returns from the Blaney Creek incubation facility. Average coho escapements to the N. and S. Alouette rivers have been stable over the period of record. Blaney Creek supports a small population of coho (range 25 to 200) and an enhanced

Table 11a. Escapement of coho, chum, pink and steelhead to the South Alouette River, 1947-1983.

Year	Coho	Chum	Pink	Steelhead
1947	200	750	15,000	
1948	750	750		Unknown
1949	200	3,500	3,500	
1950	400	3,500		
1951	750	7,500	1,500	75
1952	1,500	3,500		400
1953	750	3,500	3,500	400
1054	200	200		
1955	750	3,500	3,500	200
1956	400	200		200
1957	400	750	25	200
1958	400	400		200
1959	25	750		200
1960	200	750		
1961	25	400		
1962	75	400		
1963	75	400		
1964	75	750		
1965	75	200		
1966	200	3,500		
1967	75	400		
1968	75	3,500		
1969	25	400		
1970	750	750		
1971	750	1,500		
1972	400	7,500		
1973	750	7,500		
1974	750	4,500		
1975	700	2,800		
1976	400	7,500		
1977	650	7,000		
1978	250	6,000		
1979	400	4,500		
1980	400	8,500		
1981	750	10,000		
1982	600	18,500		
1983	100	15,000		

Table 11b. Escapement of coho, chum, pink and steelhead to the North Alouette River, 1947-1983.

Year	Coho	Chum	Pink	Steelhead
1947	75	1,500	3,500	
1948	25	400		25
1949	75	3,500	1,500	
1950	400	1,500		Unknown
1951	400	3,500	1,500	75
1952	750	3,500		400
1953	750	3,500	3,500	400
1954	200	750		
1955	400	3,500	3,500	75
1956	200	200		200
1957	200	750	25	200
1958	200	200		75
1959	25	750	0	25
1960	200	400		
1961	25	400		
1962	200	400		
1963	200	400		
1964	400	400		
1965	75	200		
1966	200	400		
1967	200	75		
1968	25	400		
1969	25	200		
1970	750	400		
1971	750	750		
1972	400	750		
1973	750	3,500		
1974	350	1,300		
1975	600	750		
1976	25	25		
1977	450	5,000		
1978	250	240		
1979	50	350		
1980	300	500		
1981	400	5,500		
1982	250	1,500		
1983	150	1,500		

Table 11c. Escapement of coho, chum and pink salmon to Blaney Creek, 1948-1982.

Year	Coho	Chum	Pink
1948		200	
1949	25	750	75
1950	200	750	NR
1951	200	750	400
1952	200	400	NR
1953	200	750	200
1954	200	400	NR
1955	75	750	75
1956	25	25	
1957	75	200	
1958	25	75	
1959	25	25	
1960	75	400	
1961	25	750	
1962	75	25	
1963	25	200	
1964	200	750	
1965	75	400	
1966	75	400	
1967	25	200	
1968	25	750	
1969	25	400	
1970	200	400	
1971	200	750	
1972	200	750	
1973	75	1,500	
1974	150	450	
1975	100	200	
1976	25	200	
1977	30	3,000	
1978	60	240	
1979	30		
1980	100		
1981	100	3,200	
1982	100	1,000	

NR = none recorded

Figure 20a. Estimated escapement of S. Alouette River coho (1947-1983).

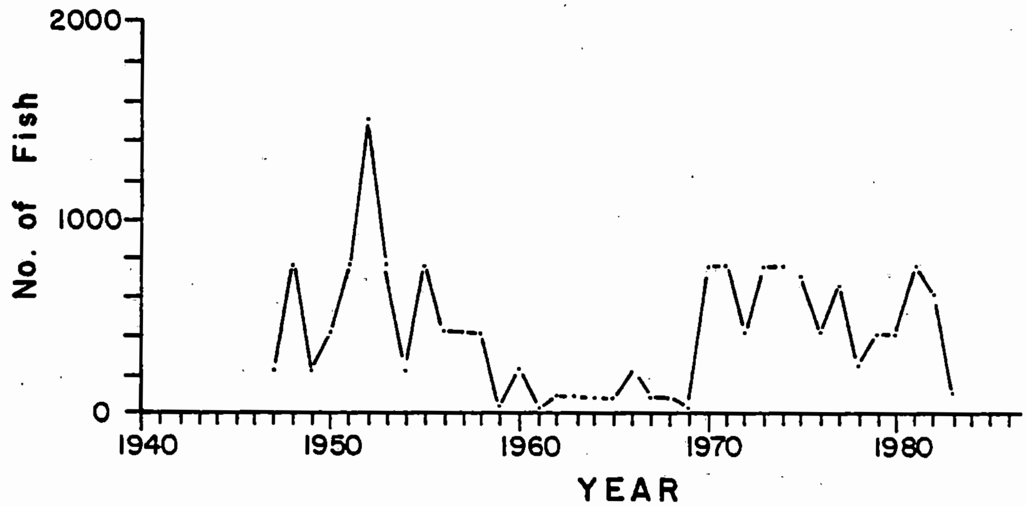


Figure 20b. Estimated escapement of S. Alouette River chum (1947-1983).

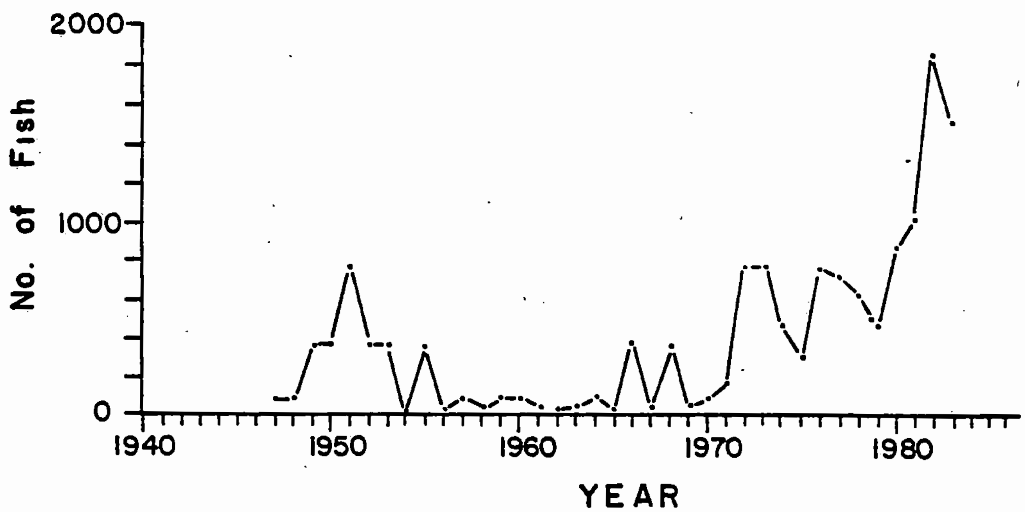


Figure 20c. Estimated escapement of S. Alouette River pinks (F381 files).

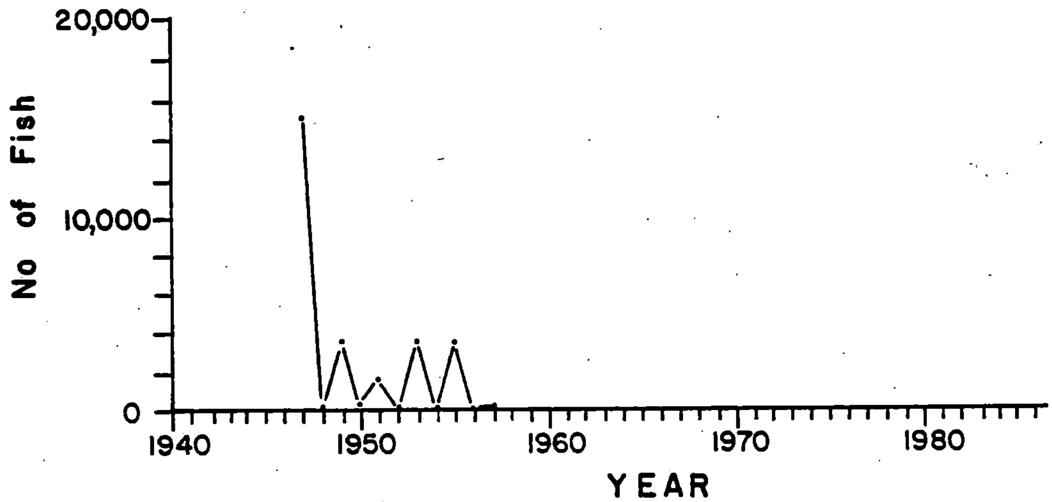


Figure 20d. Estimated escapement of N. Alouette River coho (1947-1983).

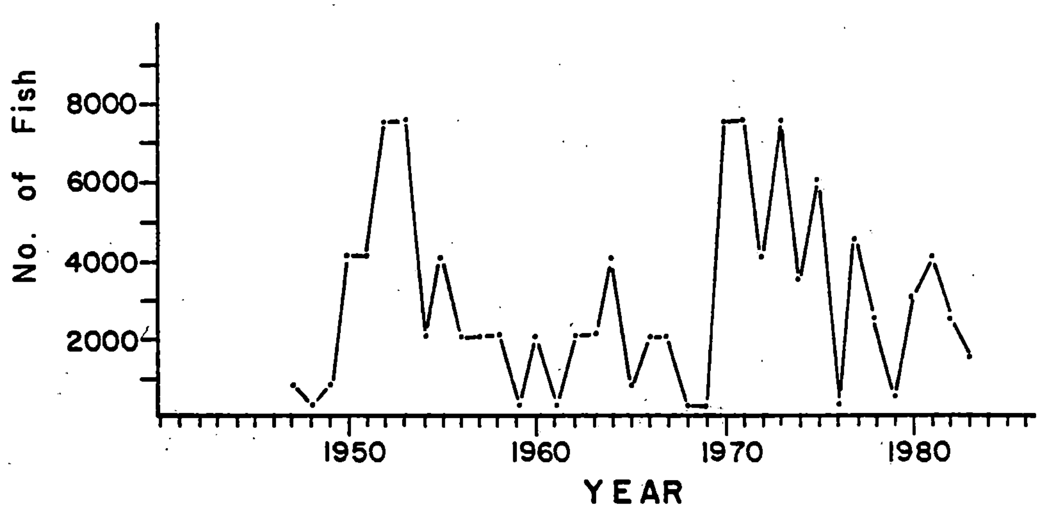


Figure 20e. Estimated escapement of N. Alouette River chum (1947-1983).

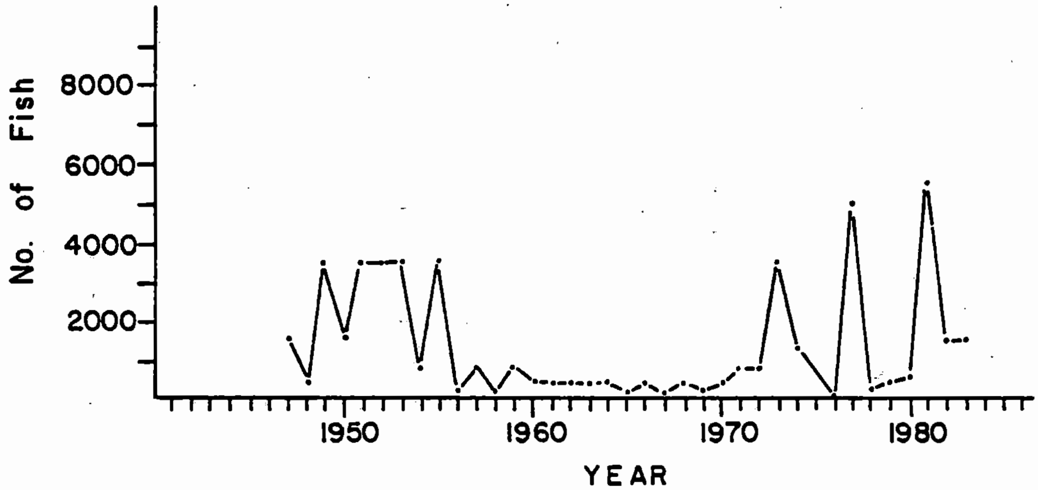


Figure 20f. Estimated escapement of N. Alouette River odd-year pinks (F381 files).

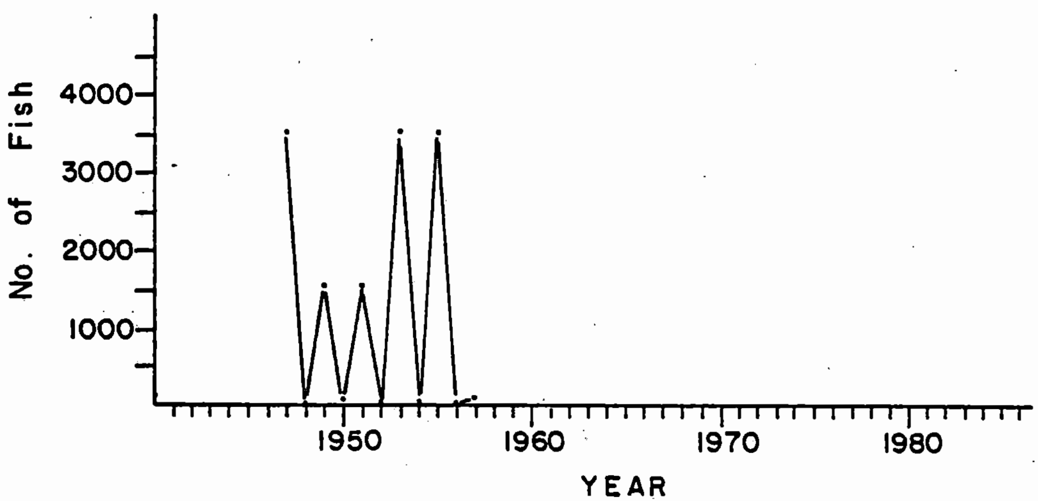


Figure 20g. Estimated escapement of Blaney Creek coho (1949-1982).

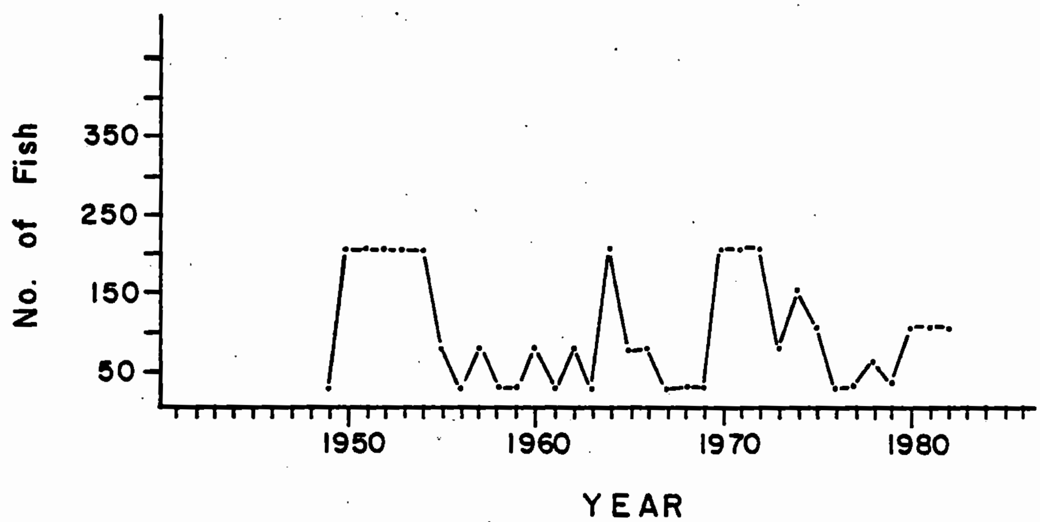
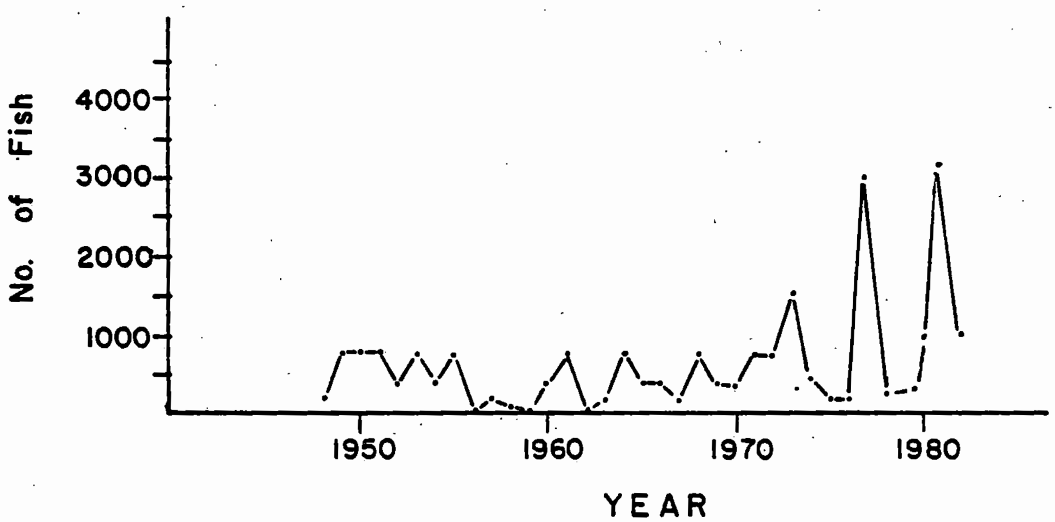


Figure 20h. Estimated escapement of Blaney Creek chum (1948-1982).



population of chum salmon. The average escapement prior to 1977 (year of first adult return from incubation facility) was 400 chum (range 25-750). The largest escapement of 2764 in 1977 included the 1973 brood incubator returns of four-year-old chum salmon (Banford and Bailey, 1979).

In 1977 and 1978, chum salmon escapements to the S. Alouette River, as estimated by F381 reports and by mark-and-recovery surveys, varied as follows:

Year	F381	Mark-and-Recovery (DFO)
1977	7000	15900
1978	6000	10900

Pink salmon have not been recorded in the S. Alouette River since 1957. Populations ranged from 15000 in 1947 to 25 in 1957. Pinks in the N. Alouette River ranged from 3500 to 25 in the last year of record (1957). Odd-year pink salmon escapement to Blaney Creek ranged from 75 to 400 in the period 1949 to 1955 (last year of record). Prior to extinction, pink salmon spawned in October and early November, in areas now utilized by chum salmon (F381 files).

Griffith and Russell (1980) estimate the annual steelhead escapement to S. Alouette River at 200-238, and at 28-34 in N. Alouette River. Sea-run cutthroat escapement is estimated at 500 to the S. Alouette River and its tributaries.

C. Lower Pitt River West Side Tributaries

Widgeon Creek drains a watershed of approximately 80 km^2 (Schubert, 1982). The lower 2 km are marshy and there is an impassable falls (9 m high) approximately 6 km upstream. The creek drains Widgeon Lake and flows south 16 km to enter Widgeon Slough, a lower Pitt River side channel. The system supports spawning populations of sockeye, coho and chum salmon as well as steelhead and cutthroat trout; pink salmon have not been recorded from the system since 1957.

McIntyre Creek flows easterly for approximately 3 km entering Pitt River north of Port Coquitlam. The stream drains a watershed of approximately 8 km^2, and supports spawning populations of coho and chum salmon. Pink salmon have not been reported from the system since 1955.

Hyde Creek (and Cedar Ditch) flow into the head of De Boville Slough. Dyking has altered the drainage pattern of Cedar Ditch, which previously flowed into lower Pitt River near the mouth of De Boville Slough. The system supports spawning populations of chum and coho salmon.

Timing

Table 9C summarizes the timing of salmon spawning in McIntyre and Hyde creeks and the Widgeon Creek system, and shows the usual timing of arrival of salmon on the spawning grounds. This information is included in Figure 14, which also shows the approximate migration timing through the fishery.

In Widgeon Slough and Creek, sockeye spawners are enumerated by the IPSFC. The spawning period extends through November, with a usual peak in mid-November. Chum salmon spawning peaks in mid-November and extends to early December, while coho spawners are present in the system from early November to early February, with a usual peak spawning period in early December.

In McIntyre Creek, chum salmon spawn through November, with a peak period of approximately mid-November. The peak of spawning for coho occurs in late November and extends through December. The F381 files report chum salmon spawning in Hyde Creek over a wider time period, with a peak in late October. Coho peak spawning in Hyde Creek usually occurs in mid-November.

Distribution

The normal distributions of salmon spawners in Widgeon Creek, McIntyre Creek and Hyde Creek (including Cedar Ditch) are shown in Figures 21, 22a and 22b, respectively.

In the Widgeon system, sockeye spawn mainly in the Slough itself. Coho spawn from 3.5 to 5.5 km upstream in both branches of the Creek, and chum salmon spawn from 2.5 km to 4.0 km upstream in west Widgeon Creek and from 2.0 km to 3.0 km upstream in east Widgeon Creek.

In McIntyre Creek, coho spawn between 0.4 km and 1.6 km upstream, and chum salmon spawn in the lower 1 km. The stream can support a larger chum population than has been evident in recent years, but appears to be fully utilized by coho salmon (Schubert, 1982).

In Hyde Creek, chum salmon spawn in approximately the lower 3 km of the stream and coho are scattered through the same area. Chum spawning in Cedar

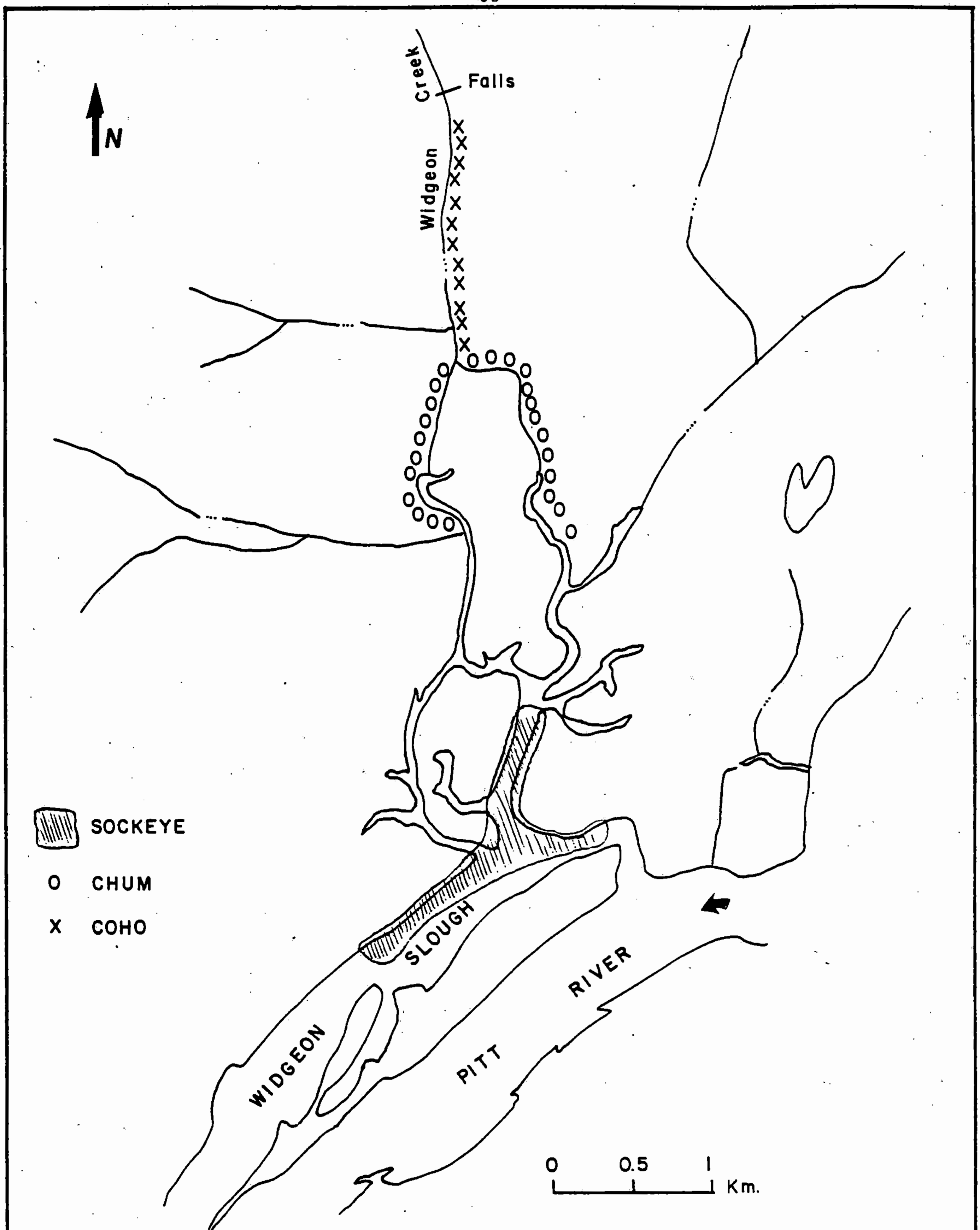


Figure 21. Normal distribution of sockeye, chum and coho spawners in Widgeon Creek and Slough.

Figure 22a. Normal distribution of coho and chum salmon in McIntyre Creek.

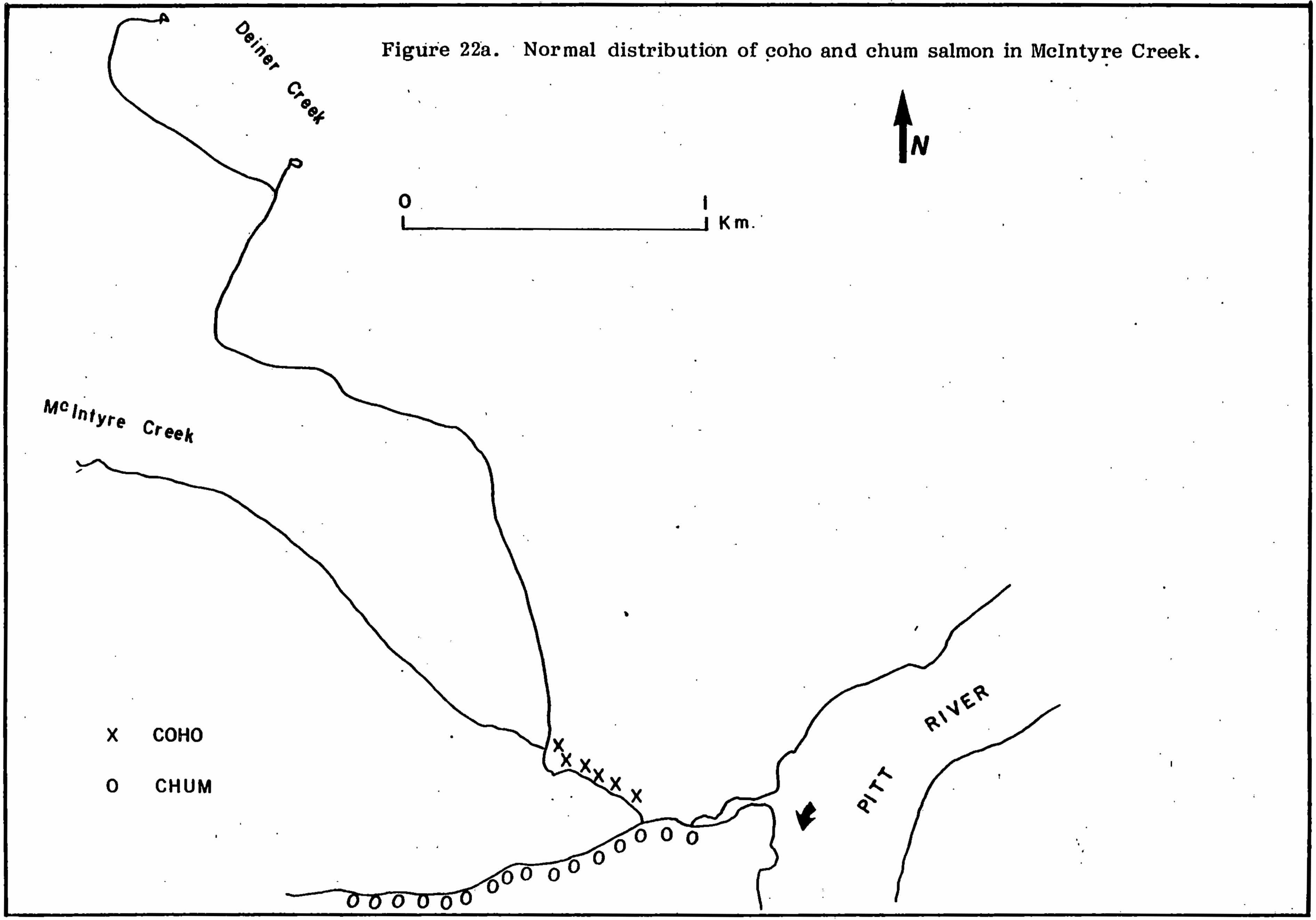
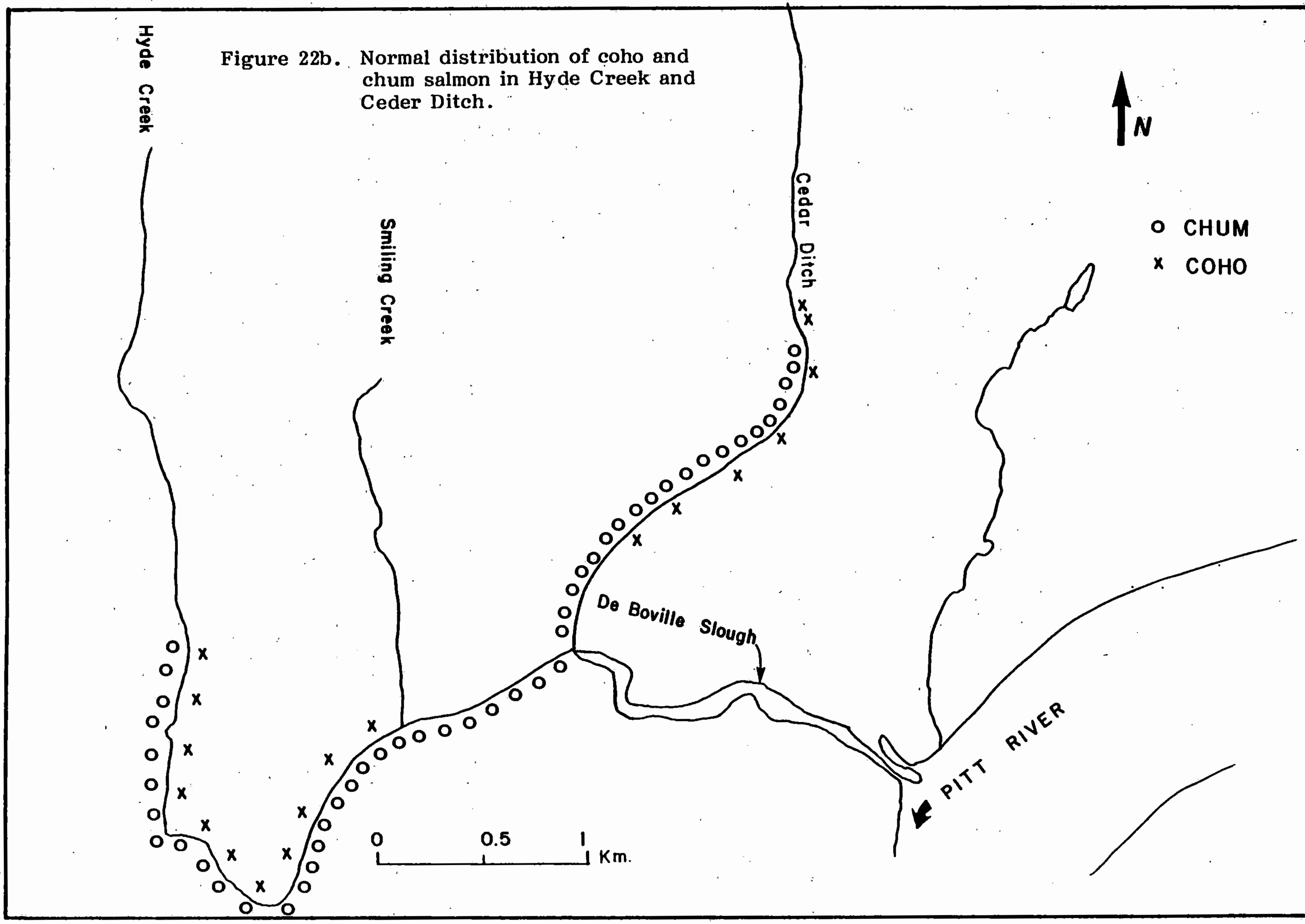


Figure 22b. Normal distribution of coho and chum salmon in Hyde Creek and Ceder Ditch.



Ditch is concentrated in the lower 2 km of the stream; coho spawning extends slightly farther upstream and is scattered throughout the chum spawning areas.

Abundance

The estimated escapements of salmon and steelhead to Widgeon Creek and of salmon to McIntyre and Hyde creeks are listed in Tables 12 and 13a,b, respectively. Hyde Creek F381 records are available only from 1980 to the present. Figures 23a-g present the same information graphically for Widgeon and McIntyre creeks (F381 files; IPSFC, 1984a). Average escapements since 1962 to Widgeon Creek and McIntyre Creek are summarized in the following table:

	Chum		Coho		Sockeye
Period	Widgeon Creek	McIntyre Creek	Widgeon Creek	McIntyre Creek	Widgeon Slough
1947-54	1860	2730	785	500	985
1955-64	450	177	372	172	760
1965-74	455	175	550	175	658
1975-83	990	150	355	150	787

The averages indicate relative stability for most populations. Widgeon Creek chum escapements have ranged from 25 in 1959 to 3000 in 1977, and there is an apparent recent increase in the population. Sockeye escapements to Widgeon Slough have ranged from a high of 1643 to a low of 389. Odd-year pink salmon escapements in Widgeon Creek ranged from 3500 to 200 in the last year of observation (1957), and McIntyre Creek supported a small population of pink spawners (average 250) till the last year of observation (1955). Steelhead are present in Widgeon Creek but the small population (approximately 150) has not been enumerated since 1956.

In Hyde Creek system over the brief period of record, approximately two-thirds of the chum population spawns in Cedar Ditch. The population has shown an apparent increase since 1980 (Table 13b), but this is probably related to lower exploitation rates in the commercial fishery (K. Tatoosh, fishery officer, pers. comm.).

Table 12. Escapement of sockeye (1942-1983), coho, chum, pink and steelhead (1947-1983) to Widgeon Creek.

Year	Sockeye	Coho	Chum	Pink	Steelhead
1942	529				
1943	293				
1944	1,100				
1945	1,200				
1946	1,404				
1947	750	400	750	3,500	
1948	Present	200	750		
1949	650	400	3,500	1,500	
1950	600	750	1,500		
1951	745	1,500	3,500	1,500	75
1952	1,648	1,500	1,500		400
1953	1,518	750	1,500	7,500	
1954	1,000	750	750		N/O
1955	Present	400	750	750	75
1956	1,000	200	200		75
1957	1,200	400	1,500	200	Unknown
1958	1,152	400	200		
1959	637	25	25		
1960	400	200	75		
1961	1,293	200	75		
1962	599	1,500	750		
1963	353	400	75		
1964	667	750	75		
1965	275	750	200		
1966	884	750	750		
1967	1,006	200	200		
1968	1,552	400	400		
1969	715	400	400		
1970	364	750	400		
1971	394	1,500	750		
1972	302	400	400		
1973	427	400	750		
1974	1,643	250	450		
1975	936	400	350		
1976	1,391	400	200		
1977	427	300	3,000		
1978	1,600	1,000	935		
1979	599	400	1,200		
1980	389	350	1,000		
1981	572	300	1,700		
1982	515	400	1,500		
1983	943	N/O	600		

Table 13a. Escapement of coho, chum and pink salmon to McIntyre Creek, 1947-1984.

Year	Coho	Chum	Pink
1947	200	750	
1948	75	75	
1949	200	750	400
1950	200	750	
1951	200	750	400
1952	200	200	
1953	200	200	200
1954	75	75	
1955	75	75	75
1956	25	25	
1957	25	200	
1958	25	25	
1959	25	750	
1960	25	75	
1961	25	200	
1962	25	200	
1963	25	75	
1964	200	75	
1965	75	400	
1966	75	75	
1967	75	75	
1968	75	200	
1969	25	200	
1970	200	200	
1971	200	200	
1972	75	200	
1973	75	200	
1974	50	100	
1975	75	100	
1976	25	75	
1977	35	500	
1978	25	50	
1979	50	20	
1980	50	100	
1981	40	150	
1982	30	100	
1983	15	400	
1984	15	400	

Table 13b. Escapement of coho and chum salmon to Hyde Creek and Cedar Ditch, 1980-1984.

Year	Coho	Chum
1980		300
1981	20	700
1982	109	1300
1983	12	1000
1984	80	1859

Figure 23a. Escapement of sockeye to Widgeon Slough (1942-1983).

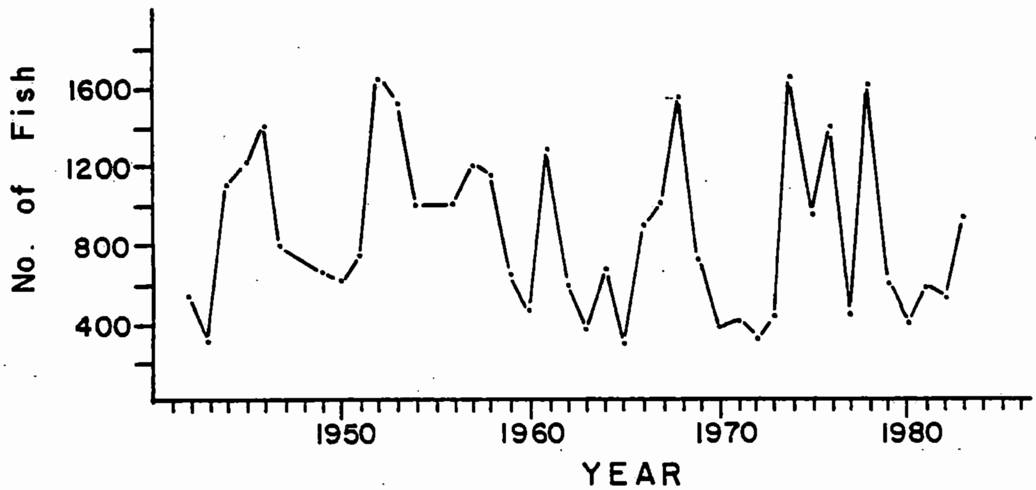


Figure 23b. Escapement of coho to Widgeon Creek (1947-1982).

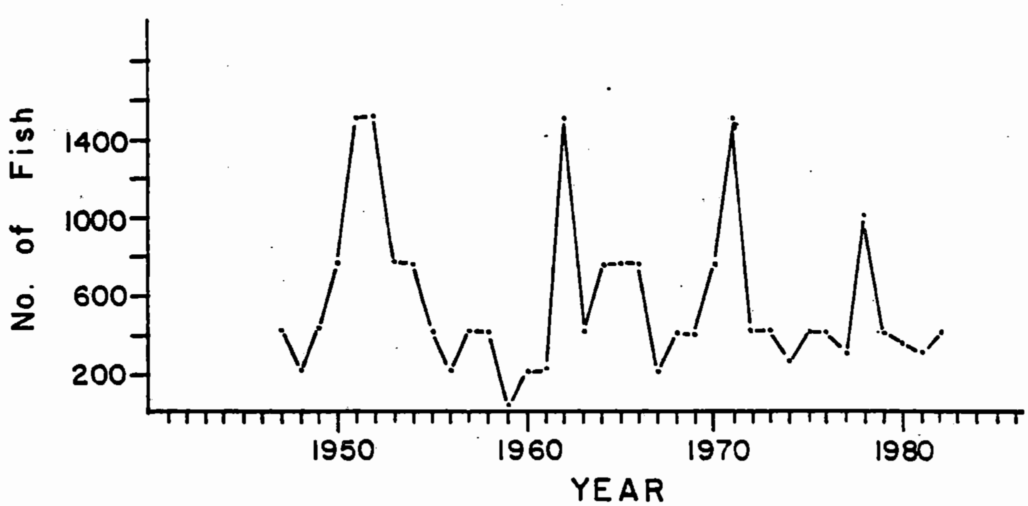


Figure 23c. Escapement of chum to Widgeon Creek (1947-1983).

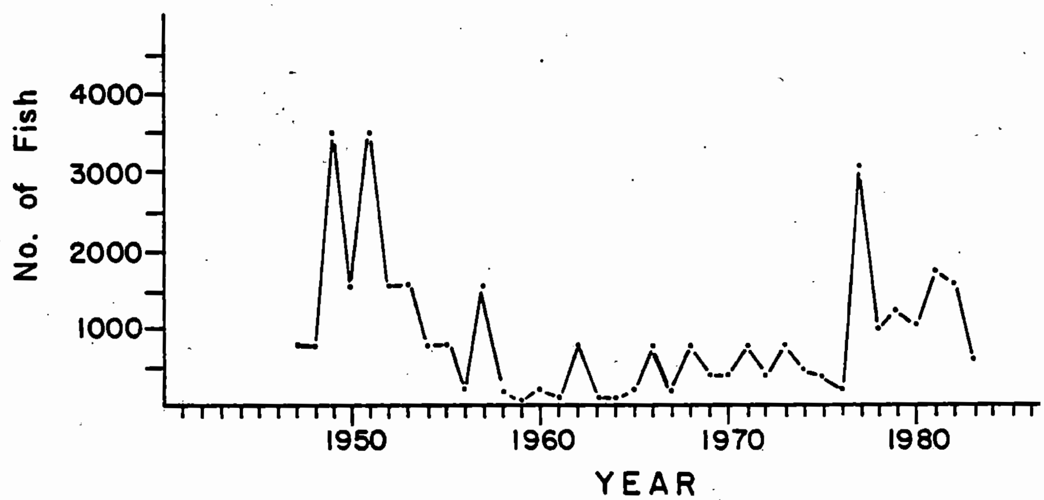


Figure 23d. Escapement of odd-year pinks to Widgeon Creek (1947-1957).

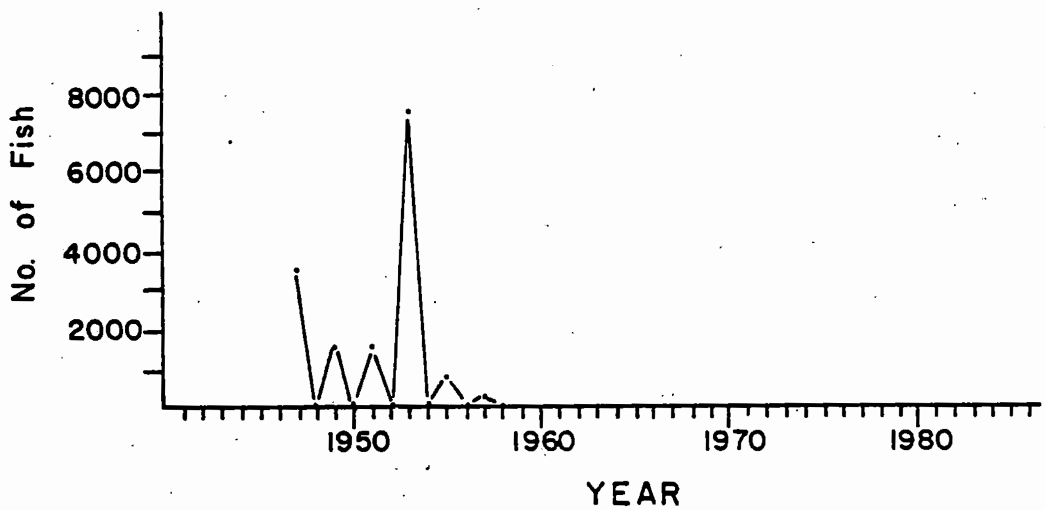


Figure 23e. Escapement of chum to McIntyre Creek (1947-1983).

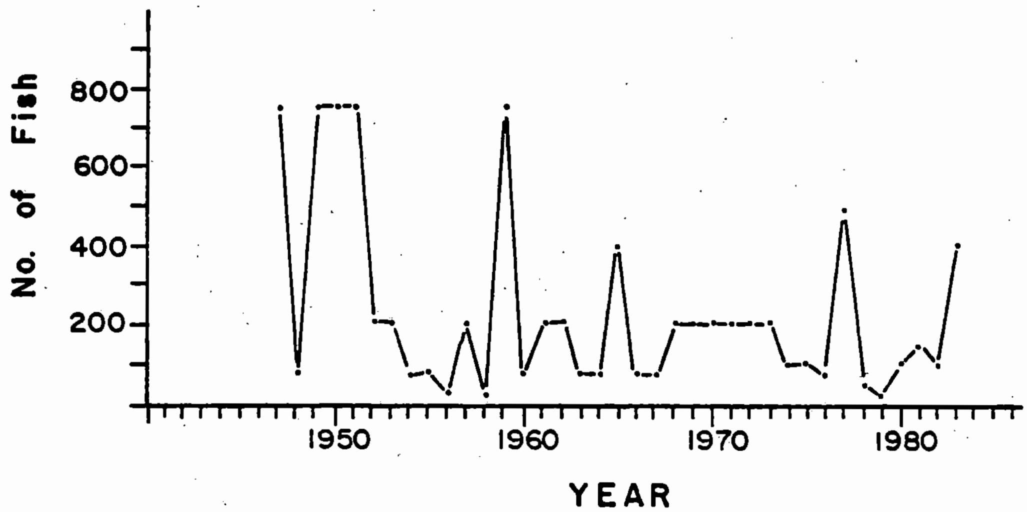


Figure 23f. Escapement of odd-year pinks to McIntyre Creek (1949-1955).

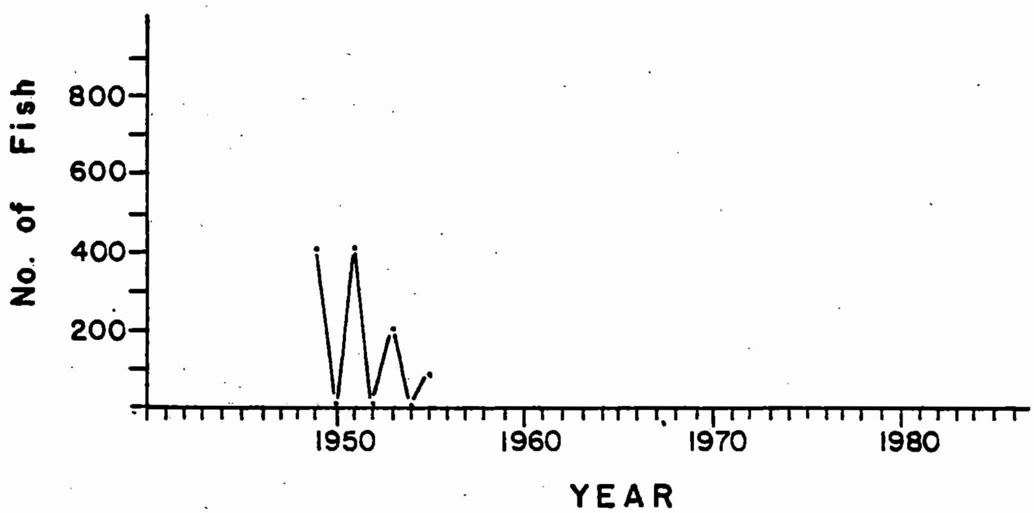
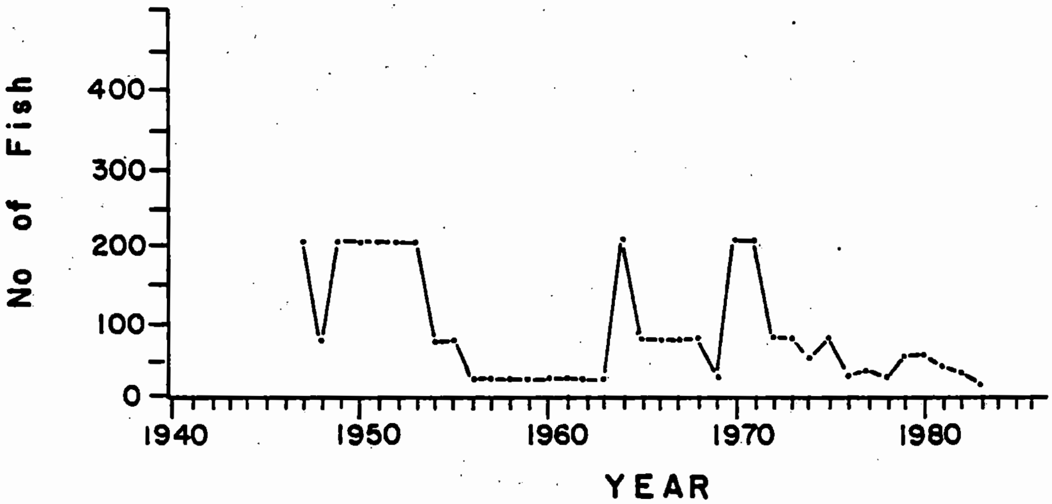


Figure 23g. Escapement of coho to McIntyre Creek (1947-1983).



ANNUAL CATCH

Commercial and Indian Food Catch

The IPSFC is responsible for managing Fraser River sockeye and pink salmon and for dividing the total sockeye and pink catch from the Convention Area (which includes Areas 29 A-C) evenly between fishermen of both Canada and the United States. Within the lower Fraser River area, the IPSFC regulates the late June to October fishing period which accounts for approximately 90% of the total commercial catch of all salmon species in some years. The fishing season prior to and after IPSFC control is managed by DFO (Fraser *et al.*, 1982). Salmon returning to spawn in the Pitt River system that are caught commercially are partially represented in the Area 29 commercial catch, but it is not possible to determine with accuracy the percentage of Area 29 catches of coho, chum and chinook salmon represented by Pitt River fish. The IPSFC conducts detailed sampling of commercial catches of sockeye and estimates that proportion of the commercial catch of sockeye attributable to specific Fraser River stocks, including Pitt River.

Sockeye

Appendix 7* lists catch (commercial, 1948-1978; Indian food, 1975-1983) and escapement (1948-1984) of upper Pitt River sockeye. The commercial catch has ranged from 5808 in 1978 to 202000 in 1971, and has averaged approximately 63650 per year over the period of record. The Indian food catch was estimated at 152 sockeye per year from 1975-1983, and the greatest number taken was 521 in 1979.

Estimated adult sockeye production from Pitt River and from the IPSFC incubation channel is represented in Appendix 8. IPSFC methods of estimating the contribution of the incubation channel to the total upper Pitt River sockeye run are described by Cooper (1977). In 1983, the IPSFC estimated the contribution of the incubation channel as 9000 sockeye from a total production (catch plus escapement) of 28000 fish. Continued low returns of Pitt River sockeye are of concern to the IPSFC, and suggested reasons may relate to post-lake juvenile survival rates and age of fish at return (IPSFC annual report, 1983).

*Appendix 7 includes additional information which will be referred to in appropriate sections of this report.

Chinook and Coho

Table 14 lists the 5-year average commercial troll and gillnet catches of coho and chinook salmon in Area 29 from 1966-1980. It is not possible to determine accurately what percentage of the total catches are represented by Pitt River fish. The annual exploitation rate of upper Pitt River chinook salmon may be as high as 80% in some years (R. Harrison, pers. comm.).

The upper Pitt River contributed 10.4% in 1977 and 22.5% in 1978 to the total Fraser River coho populatoin, and is among the largest coho producers in the Fraser drainage (Schubert, 1982). Within Area 29, coho are taken incidentally in the late sockeye, pink and chum fisheries. If the concurrently migrating stocks of other species are weak, the commercial fishery is restricted and the coho catch is small. There are variable harvesting strategies imposed from year to year. The total exploitation rate of Pitt River coho may be as high as 80% in some years (Schubert, pers. comm.).

Coded wire tagging (CWT) data (S. Carruthers, pers. comm.) show that Pitt River coho and chinook salmon are not unique to the Area 29 fishery. Of an estimated 1339 tags recovered in 1981 from upper Pitt River coho (1977 and 1978 brood years), areas of major recovery were as follows:

Catch Region	Statistical Area	No. Recovered
SW Vancouver Island Troll	21,23,24	611
NW Vancouver Island Troll	25-27	180
Juan de Fuca Net	20	176
Johnstone Strait Net	12,13	90
Georgia Strait Troll	13-18,29A,B,C	69
Fraser River Net	29A,B,C,D,E	4
Central Net	6-11	3
SW Vancouver Island Net	21-24	2

Chum Salmon

Exploitation rates of chum salmon in Area 29 vary from year to year (M. Farwell, pers. comm.). The long-term average exploitation rate (1967-1983) has been

Table 14. Average commercial troll and gillnet catches of coho and chinook salmon in Area 29, 1966-1980 (from Fraser *et al.*, 1982).

Period	Gear	Coho	Chinook
1966-1970	Net	54898	105020
	Troll	169	3938
	Total	55067	108958
1971-1975	Net	54684	97895
	Troll	533	10816
	Total	55217	108711
1976-1980	Net	29690	63070
	Troll	1831	4064
	Total	31521	67134

36% and has ranged from 7% in 1981 to 63% in 1973. It is not possible to determine the representation of Pitt River chum salmon in these catches. Palmer (1972) describes the Fraser River chum salmon fishery to 1969. The average annual catch in the period 1951-1960 was 259000 fish, and 63745 fish in the period 1961-1969. Catches have declined over the period of record.

Schubert (1983) summarizes the Indian Food Fishery of the Fraser River from 1951-1982. Pitt River fish are taken in this fishery in the Canoe Pass reach of the Steveston area. The average annual Indian Food Fishery catch by species in the Steveston area is as follows:

Period	Chinook	Coho	Chum	Sockeye	Steelhead
1978-82	739	2169	2118	13596	63

It is not possible to determine the representation of Pitt River fish in these catches, but the numbers are probably very low. The IPSFC estimates an average Indian catch of only 152 Pitt River sockeye in the Steveston area, or approximately 1% of the total sockeye catch (13596). Other Pitt River species are probably represented in similar low percentages of the total Indian Food Fishery catches.

Sport Catch

Within the boundaries of Pitt River watershed, sport fishing is conducted with varying intensity for coho salmon, steelhead and cutthroat trout. Total catches are unknown.

Upper Pitt River coho salmon are subjected to a small but intensive sports fishery for cutthroat trout and large, sea-run Dolly Varden char. Sport fishing for steelhead has been closed within Garibaldi Park since 1982 to protect spawners (R. Hahn, Fish and Wildlife Branch, pers. comm.). Pitt Lake provides sport-fishing opportunity, but the catch per unit effort is low.

In the Alouette River system, Griffith and Russell (1980) described an intensive sport fishery for steelhead and cutthroat trout. A creel census conducted in 1977 reported 277 cutthroat caught in S. Alouette River and 16 in N. Alouette

River. Fishing is not allowed in lakes within the UBC Research Forest, and the B.C. Sport Fishing regulations (B.C. Ministry of Environment, 1984b) define closures in portions of the Alouette River system.

CWT data indicate that upper Pitt River coho and chinook contribute to the sport catch of these species in Georgia Strait. A total of 66 tags were recovered in the Georgia Strait sport fishery in 1981 from coho tagged in upper Pitt River in 1977 and 1978.

JUVENILE SUMMARIES

(Emergence, Migration Timing, Growth, Distribution, Abundance)

Baseline biological data collection relating to juvenile salmonid biology is inadequate in the Pitt River system. Very little specific information is available on hatching and emergence timing, migration and growth, and periods of freshwater residence of juveniles of species other than sockeye in upper pitt River and chum salmon in Blaney Creek. After emigration from Pitt Lake or from the Alouette River system, no information exists as to the subsequent freshwater biology of Pitt River system salmonid juveniles.

This section includes brief descriptions and production summaries of enhancement activities in the system.

A. *Upper Pitt River*

Juvenile coho, chum, chinook and sockeye salmon remain in freshwater for variable time periods in upper Pitt River and in Pitt Lake.

Coho

Schubert (DFO memorandum, 5903-85-P165, Feb. 3, 1982) conducted a CWT of coho juveniles, and recovery of tagged adult carcasses in the period 1979-1982. A total of 62379 under-yearling and 19045 yearling coho were tagged and released in 1979. A formal report describing the CWT program is in preparation and will include some data concerning times of emergence, distribution, abundance and growth of coho juveniles in the system. The available data suggest that upper Pitt coho emerge in early June and grow slowly. As many as 30% may remain in the system for two years, returning as 4_3 adults, and 70% leave after one year and return as 3_2 adults (Schubert, pers. comm.). Rearing densities were similar in the two years of the study despite radically different brood year escapements, suggesting that the primary rearing areas are fully utilized at low brood year escapement levels.

Chum

The biology of chum salmon fry in upper Pitt River is not known. In other systems, chum fry emerge in April and migrate out of the natal system almost immediately. It is possible that chum fry may rear in Pitt Lake prior to emigration out of the Pitt system.

Chinook

Hatching and emergence timing of chinook salmon fry in upper Pitt River are unknown. Analysis of scale patterns shows that the population includes both "ocean-type" (8% of 95 fish sampled) and "stream-type" individuals (92% of 95 fish sampled). "Ocean-type" fry rear in freshwater for a period of from 60-150 days and migrate out of the system in the period June to September in other systems. "Stream-type" fry migrate to sea in their second spring. The scale pattern of Pitt River chinook reflects a life cycle with rapid and constant freshwater growth, possibly indicating a period of residence in Pitt Lake (Schubert, 1982).

Chinook fry have been captured incidentally during sockeye fry trapping conducted by the IPSFC in upper Pitt River. The absolute numbers of emigrants are not known because the trapping efficiency was not indexed to chinook fry. The limited data suggest that the 50% level of migration was complete by May 7 in all years.

Sockeye

The IPSFC began operation of a sockeye salmon hatchery in 1960 on Corbold Creek. The purpose of the facility was to supplement production of sockeye fry from the natural spawning grounds in an attempt to halt the observed decline of the run (Cooper, 1977). Fry produced from the hatchery were smaller than natural fry (Mead and Woodall, 1968), and, in 1963, two upwelling-flow gravel incubation channels were put into operation which produced fry of comparable size to natural fry. The incubation channels have a capacity of 4 million eggs. Appendix 9 summarizes sockeye fry production from the hatchery and Pitt River for the period 1960-1980, and reference will be made to these data where appropriate in this report.

Fry emergence

Sockeye fry produced in the incubation channel have slightly earlier emergence timings, as expressed in the following table (IPSFC, 1984b).

	Emergence Dates (Average)		
	10%	50%	90%
Wild Fry (1960-1977)	April 12	April 27	May 12
Channel (1963-1983)	April 17	April 25	May 7

Differing emergence timing may be related to when the channel is loaded, and to the timing of natural spawning. The 10% level of emergence has been reached as early as March 26 in the wild and February 25 in the channel, and 90% emergence has been reached as late as May 23 in the wild and May 20 in the channel. Emergence occurs in water temperatures ranging from 3.3 to 7.2°C, and fry migrate nocturnally 11 km to Pitt Lake in a few hours. Thus, the 10%, 50% and 90% migration dates are approximately the same as the emergence dates.

Post emergent fry distribution, growth and abundance

Johnson (MS 1981) describes migration patterns of sockeye fry in Pitt Lake in 1979. There is a strong migration toward the outlet end of the lake in late June and early July. Sockeye were found throughout the lake in August and September, with movement toward the outlet again in November. The mean length of juvenile sockeye in Pitt Lake in 1979 ranged from 29-31 mm from the end of April to mid-June. Growth rates then accelerated, and sockeye fry averaged 70 mm by the end of July. In the period July 30-November 15, mean lengths ranged from 70 mm to 75 mm.

The period of lake residence of sockeye juveniles is not completely understood. Johnson (MS 1981) suggests that in some years some Pitt Lake fingerlings may rear in the lower Pitt River or in Fraser River estuary. Appendix 10 summarizes the age of return of upper Pitt River sockeye and other data which will be referred to where appropriate. The data indicate that over the period of record, approximately 99% of sockeye smolts rear in freshwater (Pitt Lake) for one year (sub-2 return), and approximately 1% (sub-3 return) remain in the lake for two years. The probable dates of smolt outmigration from Pitt Lake are between April 15–May 15 (IPSFC estimate).

Total (wild and channel) sockeye fry production from upper Pitt River as derived from preliminary IPSFC data (Appendix 10) has ranged from a low of 2.9 million in 1970 to 13.2 million in 1974. Average fry production has ranged from approximately 4.6 million per year in the period 1960–1970, to 7.7 million per year in the period 1971–1975, and 12.4 million in the period 1976–1980. Fry produced in the system in the late 1970's and early 1980's have approached or exceeded earlier IPSFC estimates of the optimum carrying capacity of Pitt Lake (10 million fry). In recent years, adult returns from higher fry production have not increased proportionately. Pitt Lake is considered by the IPSFC as one of the least suitable sockeye environments in Fraser River watershed, based on comparisons of mean zooplankton volumes (0.11 in 1979 in Pitt Lake, 1.85 in 1979 in Cultus Lake) (Johnson, MS 1981; Stockner and Shortreed, 1983). The lake is given a high priority ranking for limnetic fertilization because of its low productivity, its stable supply of fry from the Corbold Creek hatchery, and its accessibility for sampling and treatment. Vernon (1982) discusses possible increased enhancement of upper Pitt River sockeye, and suggests the construction of improved spawning facilities at Corbold Creek to improve fry production, combined with experimental enrichment of Pitt Lake. He cautions that large numbers of long-finned smelt resident in Pitt Lake may also benefit from expected higher zooplankton abundance resulting from lake enrichment.

B. *Alouette River System*

There is very little published information describing the biology of juvenile salmonids in Alouette River system. Banford and Bailey (1979) provide the best information available on chum salmon fry emergence timing and migration, from studies conducted in Blaney Creek. Hartman (1968) describes growth rates and distribution of coho salmon in the Alouette River. Griffith and Russell (1980) provide limited information on coho salmon juvenile distribution in S. Alouette River, and extensive data on steelhead and cutthroat trout juvenile biology in the system. Wild fry emergence and migration timing have not been monitored by DFO in N. and S. Alouette rivers. Coho fry and smolt production from the ARCC hatchery on the S. Alouette River is available from SEP Special Projects computer printouts, and Banford and Bailey provide fry production figures for the Blaney Creek incubation facility. Files of the B.C. Ministry of Environment (1984a) summarize production of steelhead smolts at ARCC.

Chum Salmon

1) From 1972-1980, upwelling gravel incubators were used at Blaney Creek for the propagation of chum salmon (Banford and Bailey, 1979). The project was designed to enhance minor spawning runs (25-750 adults/yr) to a production target of 14000 returning adults. Appendix 11 summarizes chum salmon fry production from Blaney Creek brood stock (incubation has been conducted at Inches Creek since 1980).

Fry emergence, migration and growth (Blaney Creek)

In the period 1972-1977 the average incubation period was 179 days from planting to emergence at a mean temperature of 5°C. Chum fry produced in the incubator and in the wild exhibited differing migrational timing as expressed in the following table:

	Migration		
	10%	50%	90%
Wild Fry	April 18	April 25	May 3
Incubator Fry	April 25	May 2	May 10

Wild fry migrated approximately one week earlier than incubator fry in Blaney Creek. The outmigration of Blaney Creek chum salmon fry (average of incubator and wild) occurs eleven days later than Fraser River wild fry migration at the 10%, 50% and 90% levels of migration.

Fry quality for Blaney Creek chum salmon compares well with that determined for chum fry from five other incubation facilities in B.C., as indicated in the following table:

		Mean Length (mm)	Mean Weight (mg)	Developmental Index (K_D)
Average (5 locations)	- Incubation box	38.5	399	1.9
	- Wild	39.2	386	1.9
Blaney Creek	- Incubation box	38.8	358	1.9
	- Wild	39.3	373	1.8

2) The SEP-funded Alouette River Project was initiated in 1979 and is operated by the staff and inmates of the Alouette River Corrections Centre (ARCC). The goal of the project is to rehabilitate depressed salmonid stocks in the Alouette River system. Adult production targets for the ARCC are 20000 chum, 14000 coho, 1000 steelhead and 3000 cutthroat trout (Bonnell, MS 1984). The project was begun in 1979 with incubation boxes. Expansion since then has included the drilling of two production wells and the construction of rearing ponds and incubation facilities. Appendix 12 summarizes production and release of juvenile salmon from the facility from 1979-1983. The number of chum salmon fry released to Alouette River ranged from 60290 in 1979 to 250000 in 1983.

There is no information available for wild chum salmon fry emergence, migration timing or growth rates in either S. or N. Alouette rivers. McIvor (DFO memorandum, 5903-85-A26, Oct. 1, 1980) discussed the results of incubation and rearing of chum salmon eggs and fry at ARCC in 1979, and equated spawner characteristics of S. Alouette River chum salmon to Blaney Creek chum on the basis of geographic proximity. He recommended the initiation of a downstream juvenile trapping program so that hatchery releases can mirror natural chum salmon migration periods. The peaks of chum salmon spawning in N. and S. Alouette rivers are slightly later than in Blaney Creek, and on this basis the 10%, 50% and 90% levels of emergence and timing of migration of wild chum fry may be later in N. and S. Alouette rivers.

Coho Salmon, Steelhead Trout

Coho salmon fry emergence and migration timing have not been monitored by DFO in the Alouette River system. Hartman (1968) suggests that coho fry emerge in late March and early April in the S. Alouette River, and migrate from the stream approximately 14 months later in late May. The peak of outmigration of coho smolts in the Fraser River is approximately mid-May, but the timing of entry of Alouette coho smolts to the Fraser River is unknown. Hartman (1968) reports mean lengths of coho in S. Alouette River as 35 mm in late March, 40 mm in late May, and 60 mm in October. Most smolts left the river at a mean length of approximately 90 mm. Schubert (1982) reported 92% of returning adults were sub-2 fish, but data were limited (n=15). Hartman (1968) observed that rearing coho segregated during summer into pool-type habitat, while steelhead were present in riffle areas. The rearing capacity of S. Alouette River has been severely limited by high temperatures associated with low summer flows (F.F. Slaney and Co. Ltd., 1973).

3) There has been increased trout stocking in the Alouette River system by the B.C. Ministry of Environment since construction of the SEP-funded ARCC facility. The program is presently in the sixth year of wild native steelhead brood stock capture and smolt stocking. The eggs are incubated at Fraser Valley Trout Hatchery and fry are reared there and at the ARCC facility. Approximately 25000 steelhead smolts per year are released in the S. Alouette River. Appendix 13 summarizes trout and char stocking programs by the Fish and Wildlife Branch in the Pitt River system (1933-1984). Lake trout were stocked in Alouette Lake in 1968-1969; all other fish stocked were juveniles or eggs of steelhead, rainbow trout or cutthroat trout.

Hartman (1968) observed steelhead emergence in late June in S. Alouette River. Steelhead juveniles grew faster than coho. Approximately 80% of the steelhead juveniles sampled were 0+, 19% were 1+, and the remainder were 2+ and 3+ fish.

C. Lower Pitt River West Side Tributaries

The biology of juvenile salmonids in Widgeon Creek (Widgeon Slough), McIntyre Creek and Hyde Creek has not been studied. The IPSFC conducts enumeration of sockeye spawners in Widgeon Slough, but DFO has not undertaken baseline biological data collection in these streams. Widgeon Slough sockeye spawners are smaller than upper Pitt River sockeye, and the IPSFC suggest that fry from this stock may be 0+ migrants.

SPAWNER CHARACTERISTICS

Except for upper Pitt River sockeye and Blaney Creek chum salmon, the characteristics of spawning salmon in the Pitt River watershed have usually been established from small samples taken during brief surveys of the various tributaries, and are probably not representative of the total spawning populations.

A. *Upper Pitt River*

Sex Ratios

Sockeye

Sex composition of upper Pitt River sockeye by year is included in Appendix 7. There is considerable variability by year in the sex composition of the run; the percentage of males has ranged from 35% in 1958 to 61% in 1948. In the period 1975-1984 the percentage of females has averaged approximately 56% of the annual spawning population, while in the period 1965-1974 females averaged 46% of the fish sampled.

Coho

Table 15 summarizes some characteristics of spawning coho salmon in upper Pitt River (data summarized by Schubert, DFO memorandum, 5903-85-P165, 1982). Of 264 fish sampled, 44% were male and 56% were female. Schubert (1982) observed that the sex ratio of coho salmon sampled from 30 lower Fraser Valley streams, including upper Pitt River, Widgeon Creek and S. Alouette River, approximated 50% male:50% female.

Table 15. Age, length, and sex composition of upper Pitt River coho salmon, 1981.

Age	Sex	Sample Size	Mean Post Orbital Hypural Plate Length (mm)	%age
4_3	Male	26	426	11.5
	Female	35	503	15.5
3_2	Male	70	423	31.0
	Female	94	490	41.6
Combined	Male	115	420	43.6
	Female	149	494	56.4
Total		264		

Chum

Sex ratios of chum salmon in the upper Pitt River have not been established. Schubert (1982) calculated sex ratios of 56% female and 44% male from spawning ground recoveries from 30 lower Fraser Valley streams.

Chinook

Table 16 summarizes some characteristics of chinook spawners in upper Pitt River in 1981. Measurements were taken by DFO Chilliwack Hatchery personnel who operated a counting fence on Blue Creek from July to September in conjunction with an egg-taking operation. The eggs were eyed at the IPSFC facility on Corbold Creek, then transferred to Chilliwack Hatchery. Approximately 49000 coded wire tagged 3-gm fry were released in Blue Creek in April 1982 (D. Buxton, pers. comm.). Most were released into the Chilliwack River in an attempt to rebuild the Chilliwack chinook population through transplant.

Table 16. Age, mean length, and sex composition of upper Pitt River chinook salmon.

Age Class	n M	n F	% of Total M	% of Total F	% of Total Total	Male Mean POHL (mm)	SD	Female Mean POHL (mm)	SD
3_1	4	0	4	0	4	591	69.8	-	-
3_2	24	0	25	0	25	370	29.1	-	-
4_1	2	2	2	2	4	772	77.1	706	5.6
4_2	15	2	16	2	18	572	50.2	615	29.0
5_1	0	0	-	-	-	-	-	-	-
5_2	12	30	13	32	45	760	65.5	744	30.2
6_1	0	0	-	-	-	-	-	-	-
6_2	1	3	1	3	4	845	-	788	72.1
	58	37	61	39	100				

The overall sex composition of 95 chinook salmon was approximately 39% female and 61% male.

Age Composition

Sockeye

Appendix 10 summarizes the age composition of the upper Pitt River sockeye run by year (1948-1978). Over the period of record, 99% of returning adults were sub-2 fish. Of these, 60% were aged 5_2, 39% were 4_2, and less than 1% were age 3_2 "jacks". Approximately 1% of returning adults were sub-3 fish, age 5_3 and rarely age 6_3.

Coho

Of 264 coho sampled in 1981 from the upper Pitt River (Table 15), 27% were 4_3, 72% were age 3_2, and less than 1% were age 2_2 fish. All 13 coho sampled in 1978 were age 3_2 fish.

Chinook

There is wide variability in the age class composition of upper Pitt River chinook (Table 16). Of 95 fish sampled, 25% were age 3_2, 18% were age 4_2, and 45% were age 5_2 fish. Age 3_1, 4_1, and 6_2 fish were represented in lower proportions. There is a high proportion (41%) of young (3_2 and 4_2) males among the breeding individuals of this small chinook stock. Overall, of 95 fish sampled, 92% were sub-2 ocean-type fish.

Chum

Four chum salmon sampled by Schubert in upper Pitt River in 1978 and 1979 were age 4 (Schubert, MS in prep.).

Length

Sockeye

Appendix 14 lists mean standard lengths (tip of snout to end of hypural plate) of upper Pitt River sockeye (1948-1980). Mean lengths of age 4_2 males ranged from 568 mm (1980) to 625 mm (1957), and averaged 599 mm over the period of record. Age 5_2 males ranged from 639 mm (1956) to 689 mm (1948) and averaged 662 mm over the period of record.

Age 4_2 females ranged from 512 mm (1976) to 573 mm (1957) and averaged 535 mm over the period of record. Age 5_2 females ranged from 578 mm (1980) to 620 mm (1957) and averaged 597 mm over the period of record. Average length of males was greater than females within the same age class.

Coho

Mean postorbital-hypural plate lengths (POHL) of 264 coho salmon sampled in upper Pitt River in 1981 are listed in Table 15. Mean POHL ranged from 233-426 mm for males and from 490-503 mm for females. Females were larger than males.

Chinook

Mean POHLs by age of a sample of 95 chinook salmon from Blue Creek are listed in Table 16. Mean POHL ranged from 370 mm (age 3_2) to 845 mm (age 6_2) for males and from 615 mm (age 4_2) to 788 mm (age 6_2) for females. Males were larger than females in the 4_1, 5_2 and 6_2 age classes, but smaller than females in the 4_2 age class.

Chum

POHLs of four chum salmon from upper Pitt River ranged from 510 mm to 678 mm, and averaged 602 mm.

Fecundity

Sockeye

Mean fecundity by year (1960-1983) of upper Pitt River age 4_2 and 5_2 sockeye is listed in Appendix 7. The average for the period of record is 4663, and the means have ranged from 4174 to 5004. Variability is a function of the annual proportions of 4- and 5-year-old females. The IPSFC estimates the success of spawning by an examination of spawned carcasses for egg retention and pre-spawning mortality. In the period 1948-1984, egg retention and pre-spawning mortality estimates have ranged from 0.3%-27.1% and averaged 3.5%.

Coho

Fecundities of upper Pitt River coho were determined from eight fish obtained by angling in 1980. The samples were from intact skeins. The data are listed in the following table (Schubert, DFO memorandum, 5903-85-P165, Nov. 2, 1981):

Sample No.	POHL (mm)	Fork Length (mm)	Fecundity	Age
1	579	729	3177	3_2
2	516	661	3565	3_2
3	473	586	2949	3_2
4	460	568	2510	3_2
5	598	788	3860	3_2
6	533	693	2845	3_2
7	524	683	3945	3_2
8	453	540	3369	4_3
Mean	520	656	3278	

The average fecundity of coho salmon from eight other B.C. streams was 2623. The average egg retention of coho in 1978 was 7.2% for carcass samples from 30 lower Fraser Valley tributaries (Schubert, 1982).

Chinook

An estimated 120000 eggs were taken from 31 chinook salmon in Blue Creek in 1981, yielding an average egg take fecundity of 3870.

B. *Alouette River System*

Sex Ratios

Chum

The overall sex composition of Blaney Creek chum salmon (1973-1977) was 49% male and 51% female from a sample of approximately 3500 fish (Banford and Bailey, 1979).

In South Alouette River in 1978 the sex ratio of a sample of 183 chum was 50% male:50% female (Schubert, 1982).

In North Alouette River in 1977 the sex ratio of a sample of 52 chum salmon was 48% male:52% female (Schubert, 1982).

Coho

Of 22 coho sampled in N. and S. Alouette River in 1977, 45% were male and 54% were female (Schubert, 1982). The sex ratio of lower Fraser Valley coho salmon approximates 50% male:50% female (Schubert, 1982).

Age Composition

Chum

The overall age composition of Blaney Creek chum salmon (1973-1977) from a total sample of approximately 3500 fish was 16% age 3, 78% age 4, and 6% age 5. There was considerable annual variability in percentage composition over the period of record. Age 4 fish always predominated, and ranged from 56% to 98%. Age 3 fish ranged from 1% to 39%, and age five fish ranged from 0% to 22%.

The following table summarizes the age composition of a sample of 179 chum salmon from spawning grounds in S. Alouette River in 1978 (Schubert, 1982):

	Age 5 (sample size)	Age 4 (sample size)	Age 3 (sample size)
Male	2.8% (5)	40.2% (72)	7.3% (13)
Female	2.2% (4)	39.6% (71)	7.8% (14)

In S. Alouette River, approximately 30% of chum salmon are age 3, 65% are age 4, and 5% are age 5. These ages were determined from samples taken during annual egg-take operations to supply the ARCC facility, and from carcass recoveries. The data have not been completely analysed (G. Bonnell, pers. comm.).

Coho

Of 15 coho salmon sampled from S. Alouette River in 1977, 93% were age 3_2 fish and 7% were age 4_3. Schubert (1982) observed that age 3_2 coho were dominant in 30 lower Fraser Valley streams, including S. Alouette River.

Lengths

Chum

The following table lists the range and average POHLs of Blaney Creek chum salmon (age 3, 4, 5) from 1972-1977 from a sample of approximately 3500 fish (Banford and Bailey, 1979).

		POHL (mm)		
Period		Age 3	Age 4	Age 5
1972-1977	Range:	527-581	572-593	572-600
	Average:	550	580	587

Mean POHL and range for each age class of a sample of 179 chum salmon from S. Alouette River in 1978 are listed in the following table (from Schubert, 1982):

	POHL in mm (sample size)					
	Age 3		Age 4		Age 5	
	Male	Female	Male	Female	Male	Female
Range:	537-567	523-551	583-600	559-576	590-664	567-611
Mean Length:	552(13)	537(14)	592(72)	568(71)	627(5)	589(4)

The average length of older fish was greater than that of younger fish, and the average lengths of males were greater than females within each age class.

Coho

The following table lists mean POHL and range for each age class of a sample of 15 coho salmon sampled in S. Alouette River in 1977.

	POHL (mm)			
	Age 3_2 (sample size)		Age 4_3 (sample size)	
	Male	Female	Male	Female
Range:	433-611	465-561	-	-
Mean Length:	522(6)	513(8)	575(1)	-(0)

From sampling of coho in 30 lower Fraser Valley streams including the Alouette system, Schubert (1982) noted that there was no significant difference in lengths ($p = 0.05$) between age 4_3 and 3_2 coho, each with a minimum of one marine year, or between age 3_3 and 2_2 coho, which spend only a few months in the ocean.

Fecundity

Chum

Mean fecundity of chum salmon in Blaney Creek ranged from 2391 to 3261 and averaged 2644 from 1972-1977. The average fecundity of chum salmon from 11 other B.C. streams averaged 2765 (Banford and Bailey, 1979).

Coho

No data could be found on the fecundity of coho salmon in the Alouette River system.

C. *Lower Pitt River West Side Tributaries*

Baseline biological data collections from spawning salmon in Widgeon Creek and Slough, McIntyre Creek and Hyde Creek are inadequate. The IPSFC conducts only limited surveys of sockeye spawning in Widgeon Slough, and is primarily interested in spawner enumeration, but some data exist on sex composition. Schubert (1982) describes the results of spawning ground surveys of chum and coho salmon in 1977 and 1978 in McIntyre and Widgeon creeks, and presents some information on the characteristics of salmon spawners, but sample sizes are small.

Sex Ratios

Sockeye
(sex ratios and age composition)

Sockeye spawners in Widgeon Creek and Slough are age 4 and 5 fish. Sex ratios are variable from year to year; in the period 1970-1982, females represented 54% of the spawning population, and 52% in the period 1960-1969. In 1983, sex composition of the run was 41% male:59% female (IPSFC, 1984a).

Chum

The following sex ratios were established from small samples of chum salmon spawners in Widgeon and McIntyre creeks in 1977 (from Schubert, 1982).

Location	Male Number (%)	Female Number (%)
Widgeon Creek	37 (42%)	52 (58%)
McIntyre Creek	39 (38%)	65 (62%)

Coho

Statistically valid sex ratios of coho salmon in Widgeon and McIntyre creeks cannot be established from the small sample sizes (n=10 in Widgeon Creek, n=17 in McIntyre Creek in 1977). The sex ratios probably approximate 50% male:50% female (Schubert, 1982).

Age Composition

Chum

The age compositions of chum salmon sampled in Widgeon and McIntyre creeks in 1977 are listed in the following table (from Schubert, 1982).

	Age 3		Age 4		Age 5	
	Male	Female	Male	Female	Male	Female
Widgeon Creek (n=87)	3.4%	1.1%	37.0%	57.4%	1.1%	0.0%
McIntyre Creek (n=104)	0.9%	1.9%	35.6%	57.7%	0.9%	2.9%

Coho

Sample sizes of Widgeon and McIntyre creek coho salmon are not large enough to establish valid estimates of the age composition of the total population. The following table lists percentage age composition of small samples of coho from Widgeon Creek in 1977 and 1978:

Year	Age 2_2		Age 3_3		Age 4_3	
(sample size)	M	F	M	F	M	F
1977(n=9)	-	-	56%	22%	-	22%
1978(n=24)	25%	-	25%	38%	4%	8%

Age 3_2 coho were dominant (82%) in McIntyre Creek, but age 2_2 males comprised 12% of the total sample of 39 fish. The remaining 6% were age 4_3 fish.

Lengths

Chum

The following table summarizes POHLs of samples of chum salmon from Widgeon Creek and McIntyre Creek in 1977 (from Schubert, 1982).

	Age 3 (n) Male	Age 3 (n) Female	Age 4 (n) Male	Age 4 (n) Female	Age 5 (n) Male	Age 5 (n) Female
Widgeon Creek						
- Mean	603(3)	585(1)	623(32)	588(50)	645(1)	
- Range	427-780	-	614-632	579-597	-	
McIntyre Creek						
- Mean	540(1)	530(2)	601(37)	571(60)	620(1)	600(3)
- Range	-	-	590-612	564-578	-	510-690

Coho

The following table summarizes POHLs of small samples of coho salmon from Widgeon Creek and McIntyre Creek in 1978 (from Schubert, 1982).

	Mean POH Length in mm (sample size)				
	Age 2_2	Age 3_2		Age 4_3	
	Male	Male	Female	Male	Female
Widgeon Creek					
- Mean	266(6)	414(6)	522(9)	375(1)	494(2)
- Range	238-294	328-500	499-545	-	-
McIntyre Creek					
- Mean	225(2)	385(8)	496(16)	359(1)	508(2)
- Range	-	338-432	471-521	-	-

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APPENDICES

Appendix 1. Temperature and precipitation coding referred to in Appendices 1a and 1b (data from Department of Environment, Atmospheric Environment Service, 1980).

Type of Normal Code

1. 30 years between 1951 and 1980
2. 25 to 29 years between 1951 and 1980
3. 20 to 24 years between 1951 and 1980
4. 15 to 19 years between 1951 and 1980
5. 10 to 14 years between 1951 and 1980
6. less than 10 years
7. combined data from 2 or more stations
8. adjusted
9. estimated

Appendix 1a. Means of temperature and precipitation for Pitt Polder, latitude 49°18'N, longitude 122°38'W, elevation 2 m ASL, 1954-1980 (data from Department of Environment, Atmospheric Environment Service, 1980.)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year	Code
PITT POLDER (Elevation 2 m)														
Daily Maximum Temperature (°C)	4.5	7.6	9.6	13.3	17.4	19.9	23.1	22.7	19.7	14.3	8.6	5.9	13.9	2
Daily Minimum Temperature (°C)	-1.3	0.5	1.2	3.5	6.8	10.1	11.3	11.1	8.6	5.4	1.9	0.4	5.0	2
Mean Daily Temperature (°C)	1.6	4.1	5.4	8.4	12.1	15.0	17.2	16.9	14.2	9.9	5.3	3.1	9.4	2
Standard Deviation, Daily Temperature	2.2	1.6	1.1	1.0	1.3	1.4	1.1	1.2	1.2	0.9	1.4	1.7	0.6	2
Extreme Maximum Temperature (°C)	14.4	18.3	20.0	26.1	32.2	33.9	36.1	35.0	31.1	28.0	19.4	17.0	36.1	
Years of Record	*27*	*27*	*27*	*27*	*27*	*27*	*27*	*27*	*27*	*26*	*26*	*27*		
Extreme Minimum Temperature (°C)	-23.3	-16.7	-11.7	-4.4	-2.2	1.7	4.4	2.8	-1.7	-5.6	-14.4	-17.8	-23.3	
Years of Record	*27*	*27*	*27*	*27*	*27*	*27*	*27*	*27*	*27*	*26*	*27*	*27*		
Rainfall (mm)	277.1	233.5	201.6	152.2	103.5	97.0	64.6	81.0	135.5	240.9	296.1	344.9	2229.9	2
Snowfall (cm)	25.3	6.7	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	16.0	55.1	2
Average Total Precipitation (mm)	302.4	240.3	205.5	152.2	103.5	97.0	64.6	81.0	135.5	240.9	301.3	361.0	2285.2	2
Standard Deviation, Total Precipitation	133.1	101.3	81.6	59.8	47.2	47.9	49.1	58.4	70.8	130.0	115.6	122.9	364.2	2
Greatest Rainfall in 24 Hours	134.1	89.9	67.1	98.0	47.5	55.0	82.3	56.1	119.6	111.3	143.8	126.0	143.8	
Years of Record	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*30*		
Greatest Snowfall in 24 Hours	45.0	21.8	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.8	33.0	45.0	
Years of Record	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*30*		
Greatest Precipitation in 24 Hours	134.1	89.9	67.1	98.0	46.5	55.0	82.3	56.1	119.6	111.3	143.8	126.0	143.8	
Years of Record	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*29*	*30*		
Days with Rain	18	17	18	16	13	12	8	10	11	16	19	20	178	2
Days with Snow	4	1	1	0	0	0	0	0	0	0	–	2	8	2
Days with Precipitation	20	18	18	16	13	12	8	10	11	16	19	22	183	2

Appendix 1b. Means of temperature and precipitation for Haney UBC Research Forest Spur 17, latitude 49° 18'N, longitude 122° 33'W, elevation 373 m ASL, 1961-1972 (data from Department of Environment, Atmospheric Environment Service, 1980).

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year	Code
HANEY UBC RF SPUR 17 (Elev. 373 m)														
Daily Maximu Temperature (°C)	3.8	6.3	7.7	11.2	15.5	18.1	21.5	21.1	18.4	13.0	7.7	5.2	12.5	8
Daily Minimum Temperature (°C)	-0.7	0.9	1.5	3.6	7.3	10.1	12.5	12.6	10.7	6.8	2.7	0.9	5.7	8
Mean Daily Temperature (°C)	1.4	3.8	4.8	7.3	11.3	14.0	17.0	16.8	14.4	9.9	5.1	3.0	9.1	8
Standard Deviation, Daily Temperature	2.2	1.9	1.1	1.1	1.5	1.9	1.4	2.0	1.6	1.2	1.0	2.1	0.5	5
Extreme Maximum Temperature (°C)	14.4	19.4	20.6	23.9	31.7	33.3	35.0	33.3	31.1	26.1	20.0	14.4	35.0	
Years of Record	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*10*	*10*	*11*	*10*	*11*		
Extreme Minimum Temperature (°C)	-15.6	-8.9	-6.7	-2.2	-0.6	3.3	6.1	7.2	3.3	-2.2	-8.3	-20.0	-20.0	
Years of Record	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*10*	*10*	*10*	*11*	*11*		
Rainfall (mm)	224.3	216.8	189.4	141.3	106.3	116.1	71.9	88.3	143.6	232.3	272.4	294.2	2096.9	8
Snowfall (cm)	56.4	28.5	20.3	7.0	0.6	0.0	0.0	0.0	0.0	0.1	14.1	46.4	173.4	8
Average Total Precipitation (mm)	288.8	236.7	207.4	148.7	106.7	118.1	71.9	87.0	143.6	239.0	285.7	344.6	2276.2	8
Standard Deviation, Total Precipitation	115.2	111.3	91.6	50.2	26.6	53.5	60.1	67.7	75.0	103.6	66.2	100.7	292.0	5
Greatest Rainfall in 24 Hours	113.3	65.0	65.0	75.7	35.3	55.9	75.7	42.9	81.0	61.2	79.2	103.6	113.3	
Years of Record	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*10*	*9*	*10*	*11*	*11*		
Greatest Snowfall in 24 Hours	32.5	24.1	17.8	10.2	4.6	0.0	0.0	0.0	0.0	0.8	35.8	40.6	40.6	
Years of Record	*11*	*11*	*11*	*10*	*11*	*11*	*11*	*10*	*9*	*10*	*11*	*11*		
Greatest Precipitation in 24 Hours	113.3	65.0	65.0	75.7	35.3	55.9	75.7	42.9	81.0	61.2	79.2	103.6	113.3	
Years of Record	*11*	*11*	*11*	*11*	*11*	*11*	*11*	*10*	*9*	*10*	*11*	*11*		
Days with Rain	15	16	17	16	13	14	8	9	12	16	19	18	173	8
Days with Snow	8	5	4	1	0	0	0	0	0	0	2	5	25	8
Days with Precipitation	20	18	19	16	13	14	8	10	12	16	20	22	188	8

Appendix 2. Monthly and annual mean discharges in cubic metres per second for the period of record, Pitt River near Alvin, Station No. 08MH017 (Water Survey of Canada, 1983).

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1952	----	----	----	----	----	----	----	----	----	34.9	32.5	29.5	----
1953	51.2	22.6	19.1	31.6	76.2	87.6	127	106	78.8	55.5	51.3	31.2	61.8
1954	14.3	41.2	16.8	21.1	77.8	104	128	106	90.2	68.6	68.9	26.5	65.4
1955	10.6	9.54	7.01	16.4	54.0	124	133	90.1	63.8	65.1	56.0	16.7	54.1
1956	17.9	6.16	11.2	35.9	83.7	110	121	81.8	67.2	53.4	30.6	22.5	53.6
1957	11.0	----	10.8	33.1	109	129	117	75.1	56.4	31.1	16.4	20.8	----
1958	23.4	30.7	13.4	20.1	80.1	124	99.1	72.2	90.2	----	----	40.0	----
1959	26.3	8.72	11.1	28.1	49.0	94.7	98.2	61.5	59.5	44.9	25.8	23.7	44.5
1960	15.3	19.7	19.8	41.1	60.3	102	115	74.8	59.1	57.6	36.8	25.1	52.2
1961	38.7	26.5	14.7	13.5	46.7	102	81.4	51.6	28.8	16.5	11.3	8.73	36.7
1962	11.8	19.3	8.41	37.4	48.6	107	107	104	60.0	74.1	58.5	50.7	57.4
1963	19.3	60.3	20.4	25.3	58.3	87.5	99.0	75.0	66.6	----	----	----	----
1964	19.2	13.5	11.6	23.2	52.4	119	170	109	84.4	66.1	32.5	20.0	60.3
1965	14.7	16.4	17.6	34.0	55.0	105	98.0	84.1	----	----	----	----	----
Mean	21.1	22.9	14.0	27.8	65.5	107	115	83.9	67.1	51.6	40.1	26.3	54.0

Location: Lat. 49° 39'50"N Long. 122° 41'10"W

Drainage Area 515 km^2
Natural Flow

Appendix 2a. Annual extremes of discharge and annual total discharge for the period of record, Pitt River near Alvin, Station No. 08MH017 (Water Survey of Canada, 1983).

Year	Maximum Instantaneous Discharge (m^3/s)	Maximum Daily Discharge (m^3/s)	Minimum Daily Discharge (m^3/s)	Total Discharge (dam^3)
1952	----	----	----	----
1953	----	206 on Jul. 13	8.50(E) on Oct. 15	1 950 000
1954	----	217 on Oct. 8	7.08 on Jan. 29	2 060 000
1955	----	597(E) on Nov. 3*	5.86(E) on Mar. 25	1 700 000
1956	----	201 on Sep. 26	5.10 on Feb. 18*	1 700 000
1957	----	210(E) on Sep. 6	----	----
1958	----	453(E) on Sep. 17	----	----
1959	----	171 on Apr. 29	7.79 on Feb. 18	1 400 000
1960	----	165 on Jun. 16	7.05(E) on Jan. 10	1 650 000
1961	----	232(E) on Jan. 15	7.65 on Sep. 26	1 160 000
1962	----	231 on Aug. 20	5.80(E) on Feb. 27	1 810 000
1963	----	309 on Oct. 13	----	----
1964	----	326 on Jul. 15	9.85 on Mar. 9	1 910 000
1965	----	----	----	----
			Mean:	1 700 000

(E) - Estimated   *Extreme recorded for the period of record

Appendix 2b. Monthly and annual mean discharges in cubic metres per second for the period of record, South Alouette River near Haney, Station No. 08MH005 (Water Survey of Canada, 1983).

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1911	----	----	----	----	----	----	----	----	----	----	45.0	35.8	----
1912	40.0	39.5	5.94	12.9	22.7	23.1	11.0	14.7	15.1	21.6	59.8	30.1	24.6
1913	16.8	33.4	19.7	24.7	35.0	31.0	21.5	8.59	14.9	28.9	57.7	25.5	26.3
1914	41.0	15.1	29.4	29.2	16.8	10.4	4.55	3.06	18.6	34.2	64.5	11.0	23.1
1915	21.0	16.5	24.3	39.6	13.9	6.37	3.97	3.08	2.96	27.5	25.0	38.7	18.6
1960	----	----	----	2.35	1.73	1.08	0.395	0.579	0.752	1.89	2.42	2.14	----
1961	9.76	5.25	3.09	1.59	1.26	0.584	0.391	0.348	0.377	2.16	3.51	6.96	2.94
1962	5.21	2.14	1.14	1.49	1.56	0.916	0.516	1.08	0.811	1.63	3.65	3.65	1.98
1963	1.69	2.16	1.50	1.80	1.01	0.428	0.757	0.360	0.305	1.31	6.20	9.40	2.25
1964	5.44	2.18	3.17	2.25	1.64	1.78	1.33	----	----	----	----	----	----
1971	----	----	----	----	----	2.43	1.10	1.02	1.13	2.88	3.26	2.07	----
1972	2.92	4.74	4.22	2.29	1.22	0.984	5.36	0.836	1.03	0.787	1.66	4.03	2.51
1973	2.27	1.41	1.70	0.903	0.907	1.02	0.605	0.535	0.596	1.32	2.46	5.47	1.61
1975	2.65	2.00	2.07	1.05	0.912	0.655	0.498	0.849	0.734	2.53	19.4	17.2	4.22
1976	3.52	2.33	1.83	1.90	1.15	1.35	1.17	1.51	1.46	1.17	1.54	2.25	1.76
1977	2.28	1.80	1.98	1.15	0.989	1.29	1.15	1.09	1.18	1.47	3.34	12.7	2.55
1978	1.58	1.92	1.24	1.23	1.20	1.01	0.932	0.962	1.79	1.04	2.08	1.58	1.37
1979	0.981	3.18	2.20	1.26	0.731	0.778	0.835	0.732	0.784	1.02	0.887	7.35	1.72
1980	1.50	2.69	2.35	1.55	0.859	1.43	1.19	0.850	1.14	0.915	10.0	21.0	3.80
1981	2.02	3.16	1.79	3.31	1.41	2.20	0.888	0.589	0.747	7.40	7.15	3.32	2.82
1982	4.17	12.2	1.90	1.96	0.985	0.814	1.30	0.959	0.974	1.37	2.89	3.01	2.64
Mean	9.16	8.43	6.08	6.97	5.58	4.48	2.97	2.20	3.44	7.43	16.1	12.2	7.34

Location: Lat. 49° 14'21"N Drainage Area 234 km²
Long. 122° 34'42"W Regulated Since 1925

Appendix 2c. Annual extremes of discharge and annual total discharge for the period of record, South Alouette River near Haney, Station No. 08MH005 (Water Survey of Canada, 1983).

Year	Maximum Instantaneous Discharge (m^3/s)	Maximum Daily Discharge (m^3/s)	Minimum Daily Discharge (m^3/s)	Total Discharge (dam^3)
1911	----	----	----	----
1912	----	175 on Nov. 21	3.68 on Mar. 12	777 000
1913	----	168 on Feb. 17	3.40 on Sep. 27	831 000
1914	----	236 on Jan. 6*	2.83 on Aug. 15	730 000
1915	----	140 on Apr. 3	2.69 on Sep. 30	587 000
1960	----	----	----	----
1961	----	95.4(E) on Jan. 15	0.212 on Sep. 14	92 600
1962	----	32.0 on Nov. 19	0.357 on Jul. 15	62 600
1963	----	28.9 on Dec. 23	0.184 on Jun. 17*	70 900
1964	----	----	----	----
1971	----	----	----	----
1972	----	68.0 on Jul. 13	0.487 on Dec. 14	79 300
1973	----	31.4 on Dec. 15	0.413 on Sep. 10	50 700
1975	134 at 05:00 PST on Dec. 4	93.2(E) on Dec. 4	0.467(A) on Jul. 22	133 000
1976	10.2 at 05:19 PST on Jan. 15	7.93(A) on Jan. 15	0.745(A) on Nov. 11	55 800
1977	69.9 at 16:09 PST on Dec. 14	68.5 on Dec. 14	0.765 on Jan. 9	80 300
1978	20.0 at 20:17 PST on Nov. 17	9.37 on Nov. 7	0.566(E) on Dec. 2	43 300
1979	68.2 at 19:36 PST on Dec. 19	33.1 on Dec. 20	0.612 on May 17	54 400
1980	158 at 17:26 PST on Dec. 26*	126 on Dec. 27	0.536 on Sep. 18	120 000
1981	62.8 at 07:27 PST on Nov. 1	57.3 on Nov. 1	0.529 on Aug. 11	89 000
1982	36.1 at 16:57 PST on Feb. 20	32.8 on Feb. 20	0.624 on Jun. 10	83 400
			Mean:	232 000

(A) - Manual gauge (see reference index)
(E) - Estimated

*Extreme recorded for the period of record

Appendix 2d. Monthly and annual mean discharges in cubic metres per second for the period of record, Alouette River at outlet of Alouette Lake, Station No. 08MH014 (Water Survey of Canada, 1983).

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1916	11.3	38.8	46.0	29.6	29.6	26.1	24.7	8.80	3.44	3.28	27.7	15.1	21.9
1917	18.5	19.1	8.54	27.0	34.8	39.2	22.3	7.81	8.04	17.8	24.6	59.5	24.0
1918	51.9	28.8	29.5	25.6	19.4	16.5	6.90	10.0	3.12	30.1	30.2	39.2	24.3
1919	27.4	24.2	16.0	36.4	36.5	20.9	14.5	5.59	3.29	2.64	52.2	39.6	23.2
1920	32.0	20.2	13.6	11.2	15.6	21.0	6.25	2.18	39.4	40.5	23.6	30.0	21.3
1921	36.7	39.8	19.3	19.8	28.8	30.5	15.6	8.03	32.5	62.2	34.7	41.5	30.7
1922	8.67	10.4	7.99	18.5	33.5	30.9	10.3	5.67	14.6	21.8	13.7	43.0	18.3
1923	33.7	8.74	13.1	20.9	22.7	17.5	7.57	2.07	2.80	7.57	19.5	45.3	16.9
1924	21.5	66.7	12.5	15.0	17.2	10.4	3.70	2.85	15.2	40.3	31.2	44.3	23.2
1925	29.9	42.4	20.6	24.7	28.8	15.4	7.29	4.45	2.65	----	----	----	----
Mean	27.2	29.9	18.7	22.9	26.7	22.8	11.9	5.75	12.5	25.1	28.6	39.7	22.6

Location: Lat. 49° 17'12"N
Long. 122° 29'12"W   Regulated Since 1925

Data Contributed By:
British Columbia Electric Railway Company

Remarks: Monthly mean discharges representing natural inflow to Alouette Lake have been computed by B.C. Hydro.

Appendix 2e. Annual extremes of discharge and annual total discharge for the period of record, Alouette River at outlet of Alouette Lake, Station No. 08MH014 (Water Survey of Canada, 1983).

Year	Maximum Instantaneous Discharge (m^3/s)	Maximum Daily Discharge (m^3/s)	Minimum Daily Discharge (m^3/s)	Total Discharge (dam^3)
1916	----	193 on Feb. 16	1.42 on Oct. 24	694 000
1917	----	212 on Dec. 16	3.88 on Sep. 6	756 000
1918	----	212 on Jan. 1	1.70 on Oct. 4	766 000
1919	----	326 on Nov. 16	1.98 on Oct. 27	731 000
1920	----	129 on Jan. 18	1.42 on Aug. 18	672 000
1921	----	425 on Oct. 29*	3.88 on Aug. 15	969 000
1922	----	173 on Dec. 25	3.37 on Aug. 9	577 000
1923	----	125 on Dec. 16	1.19 on Sep. 14	532 000
1924	----	243 on Dec. 12	1.27 on Sep. 15	735 000
1925	----	133 on Feb. 3	0.821 on Aug. 19*	----
			Mean:	715 000

*Extreme recorded for the period of record

Appendix 2f. Monthly and annual mean discharges in cubic metres per second for the period of record, North Alouette River at 232nd Street, Maple Ridge, Station No. 08MH006 (Water Survey of Canada, 1983).

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1911	----	----	----	----	----	----	----	----	----	----	7.05	4.59	----
1912	4.88	4.35	0.625	1.39	1.69	1.69	0.970	1.74	1.48	2.28	7.34	3.85	2.68
1913	2.18	4.94	3.36	3.91	4.28	2.35	1.73	0.805	1.11	4.30	6.46	2.21	3.12
1960	----	----	2.11	3.35	3.10	1.98	0.628	1.15	1.51	4.44	2.97	3.01	----
1961	8.27	9.03	3.74	2.83	2.27	1.12	0.372	0.254	1.04	4.04	2.57	5.03	3.35
1962	3.79	2.49	0.957	2.18	2.14	1.82	0.854	1.96	1.24	2.46	5.32	5.78	2.58
1963	2.01	3.23	1.94	2.24	1.40	0.846	1.34	0.275	0.129	3.38	7.31	5.89	2.49
1964	5.41	2.78	2.85	3.96	3.58	3.94	3.08	1.60	3.38	2.85	4.87	4.89	3.60
1965	4.52	8.12	1.78	3.21	3.33	1.03	0.517	0.526	0.261	3.21	3.72	2.94	2.73
1966	4.88	2.51	3.12	2.59	2.26	2.00	2.91	0.964	1.05	6.03	3.40	9.39	3.45
1967	7.48	5.34	2.84	1.49	2.50	2.13	0.842	0.321	0.313	8.07	3.78	5.85	3.41
1968	8.08	4.35	4.08	2.53	2.09	1.74	0.960	1.16	3.48	4.29	4.13	3.69	3.38
1969	----	----	3.59	4.71	2.18	1.45	1.11	0.763	3.29	2.93	2.53	2.82	----
1970	3.10	3.15	1.87	3.67	1.34	1.51	1.19	0.323	1.85	1.87	2.92	3.44	2.18
1971	6.49	5.77	3.36	2.57	2.86	3.01	2.00	0.295	1.46	5.10	4.98	1.89	3.30
1972	3.86	5.50	9.11	4.13	3.15	2.10	4.18	0.434	1.87	0.532	3.68	8.54	3.93
1973	3.51	2.29	2.18	1.28	1.98	2.17	0.798	0.241	0.614	3.81	4.94	6.42	2.52
1974	6.69	5.48	5.14	3.32	4.25	2.89	2.70	0.680	0.423	0.367	4.48	4.72	3.42
1975	3.06	2.02	2.99	1.84	2.96	1.96	0.794	1.49	0.429	5.59	6.65	7.28	3.10
1976	4.56	2.43	2.65	2.86	3.31	2.68	2.15	2.00	1.74	1.32	2.60	5.01	2.78
1977	3.38	2.56	2.77	2.11	1.72	1.50	0.689	0.446	1.39	2.24	5.84	5.23	2.49
1978	2.03	2.55	1.93	1.78	2.14	1.06	0.334	0.901	2.19	0.966	2.77	1.76	1.69
1979	0.721	4.17	4.43	2.24	1.63	1.13	0.717	0.155	1.01	1.90	1.35	9.84	2.44
1980	1.48	4.62	2.75	2.61	1.60	1.96	1.43	0.854	2.43	0.906	7.49	9.24	3.10
1981	1.27	4.82	2.53	6.05	2.30	3.93	0.838	0.213	1.00	6.15	4.38	3.31	3.04
1982	4.05	7.11	1.95	2.83	2.39	2.05	2.22	0.902	0.839	2.67	3.73	3.94	2.86
Mean	4.16	4.33	2.99	2.87	2.50	2.00	1.41	0.818	1.42	3.27	4.51	5.02	2.94

Location: Lat. 49°14'34"N Long. 122°34'42"W

Drainage Area 37.3 km^2
Natural Flow

Appendix 2g. Annual extremes of discharge and annual total discharge for the period of record, North Alouette River at 232nd Street, Maple Ridge, Station No. 08MH006 (Water Survey of Canada, 1983).

Year	Maximum Instantaneous Discharge (m^3/s)	Maximum Daily Discharge (m^3/s)	Minimum Daily Discharge (m^3/s)	Total Discharge (dam^3)
1911	----	----	----	----
1912	----	36.8 on Nov. 21	0.340 on Sep. 27	84 700
1913	----	44.7 on Nov. 24	0.227 on Sep. 27	98 300
1960	----	20.4(E) on Dec. 12	----	----
1961	----	56.6(E) on Jan. 15	0.071 on Aug. 30*	106 000
1962	----	23.2(E) on Jan. 2	0.252 on Aug. 2	81 400
1963	----	76.2 on Dec. 23*	0.079 on Sep. 29	78 500
1964	----	58.6 on Nov. 10	0.425 on Oct. 29	114 000
1965	----	29.4 on Feb. 17	0.176 on Sep. 25	86 000
1966	----	64.3 on Oct. 23	0.232 on Sep. 4	109 000
1967	----	29.7 on Feb. 4	0.204 on Sep. 26	108 000
1968	----	55.2 on Jan. 20	0.198 on Aug. 8	107 000
1969	60.6 at 16:16 PST on Jan. 4	34.8 on Jan. 4	----	----
1970	36.8 at 23:16 PST on Apr. 5	23.3 on Apr. 6	0.079 on Aug. 30	68 600
1971	62.9 at 20:32 PST on Oct. 25	29.4 on Jan. 26	0.076 on Aug. 18	104 000
1972	103 at 13:42 PST on Jul. 12	58.3 on Jul. 12	0.193 on Oct. 18	124 000
1973	64.3 at 05:00 PST on Oct. 13	39.6(E) on Nov. 28	0.113 on Sep. 5	79 000
1974	53.8 at 00:48 PST on Dec. 21	39.9 on Feb. 3	0.178 on Sep. 30	108 000
1975	92.0 at 14:33 PST on Nov. 3	45.6 on Dec. 2	0.153 on Oct. 1	97 800
1976	51.0(RE) at 09:02 PST on Nov. 17	26.9 on Dec. 26	0.238 on Oct. 22	87 900
1977	71.4 at 20:17 PST on Jan. 17	39.4 on Jan. 18	0.193 on Aug. 20	78 400
1978	77.0 at 17:39 PST on Nov. 7	31.1 on Nov. 7	0.187 on Aug. 8	53 300
1979	107 at 17:40 PST on Dec. 17	57.8 on Dec. 14	0.108 on Aug. 31	77 000
1980	118 at 09:44 PST on Dec. 26*	64.6 on Dec. 26	0.180 on Aug. 16	98 000
1981	107 at 13:24 PST on Oct. 31	73.1 on Oct. 31	0.139 on Sep. 17	96 100
1982	80.4 at 12:01 PST on Dec. 3	40.0 on Dec. 3	0.327 on Aug. 29	90 200
			Mean:	92 900

*Extreme recorded for the period of record (E) - Estimated (R) - Revised since January 1980

Appendix 3. Recommended Fish Culture Limits (RFCL) (values in mg/L unless otherwise specified).

Water Quality Parameter	Recommended Levels	Toxic Levels	Source
Alkalinity, Total	20-300	not lethal to pH 9.0	1
Ammonia (as NH_3)	<0.002 incubation	>0.08	1
	<0.005 rearing		1
Total (as N)	<0.05		3
CO_2	2-5	>20	2
Chloride (Cl^-)	<170	>400	1,2
Chlorine Residue	<0.002	>0.006	1
CN	< 0.005		3
Colour (TCU)	< 15		1
Conductivity (μmhos/cm)	150-2000		1
Dissolved Gases:			
Total	< 103%	> 110%	1
N_2 + Ar	< 100%	> 110%	1
DO: mg/l	> 6-8	< 4	2
% sat.	95-100%		1
Hardness (as $CaCO_3$)	20-400		1
H_2S	<0.002	>0.004	2,3
Nitrite	<0.012	0.2	2
Nitrate	<0.12		2
pH	6.8-8.5	<5, >9	2
Phenols	<0.001		3
Phosphate, Total	<0.05	0.01-0.05 allows plankton blooms	1
Residue:			
Total	<2000		2
Filterable	70-400	2000	1
Non-Filterable	<3 incubation	1000	1
	<25 rearing		1
Silica (as Si)	10-60	diatom growth inhibited <0.05	1
Sulphate	<90	5000-7000	1

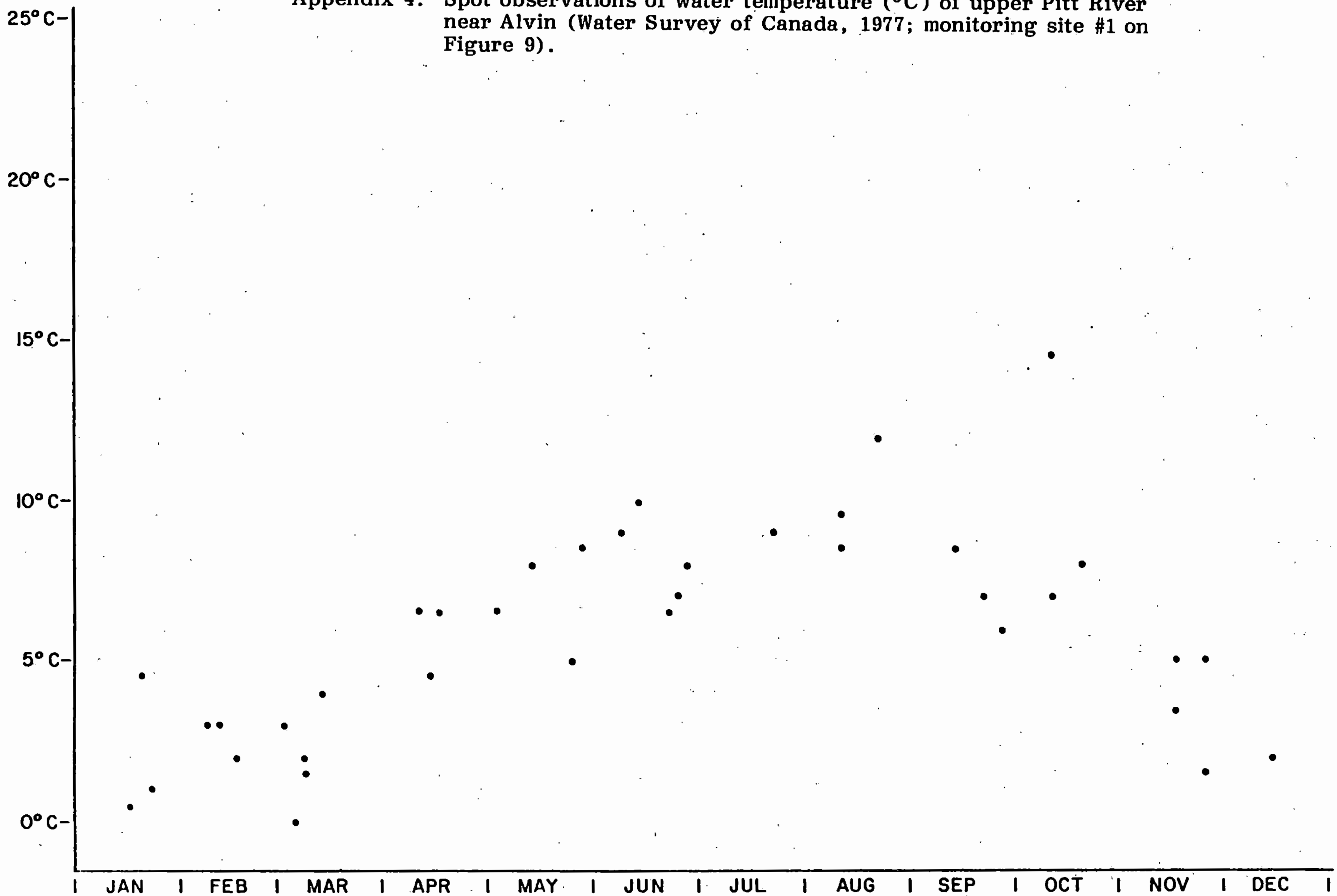
Appendix 3 (cont.)

Water Quality Parameter	Recommended Levels	Toxic Levels	Source
Taste	OK		2
Temperature °C	4-18	<2, >25	2
Turbidity (JTU)	1-60	1000	1
Metals:			
Ag Diss.	<0.0001		3
Al Total	<0.1	5	1,3
As	<0.5	>1	2,3
Ba	<1.0		2
Cd Diss.	<0.3 μg/l		3
Ca	4-150	300	1
Cr	<0.01		2
*Cu: with Zn	<0.001		1
soft H_2O	<0.006		1
hard H_2O	<0.03		1
Fe, Total	<0.3	1-2 @ pH 5-6.7	1,3
Hg	<0.05 μg/l	0.2 μg/l	1
K		>50	2
Mg	<10	>100	2
Mn, Total	<0.05	>15	1,3
Na		>500	2
Ni, Total	0.045		3
Pb	<0.01	0.1	1
*Zn: soft H_2O	<0.005	0.01-4 kills salmonids	1
hard H_2O	<2		1
Se, Total	<0.05	>2.5	2,3

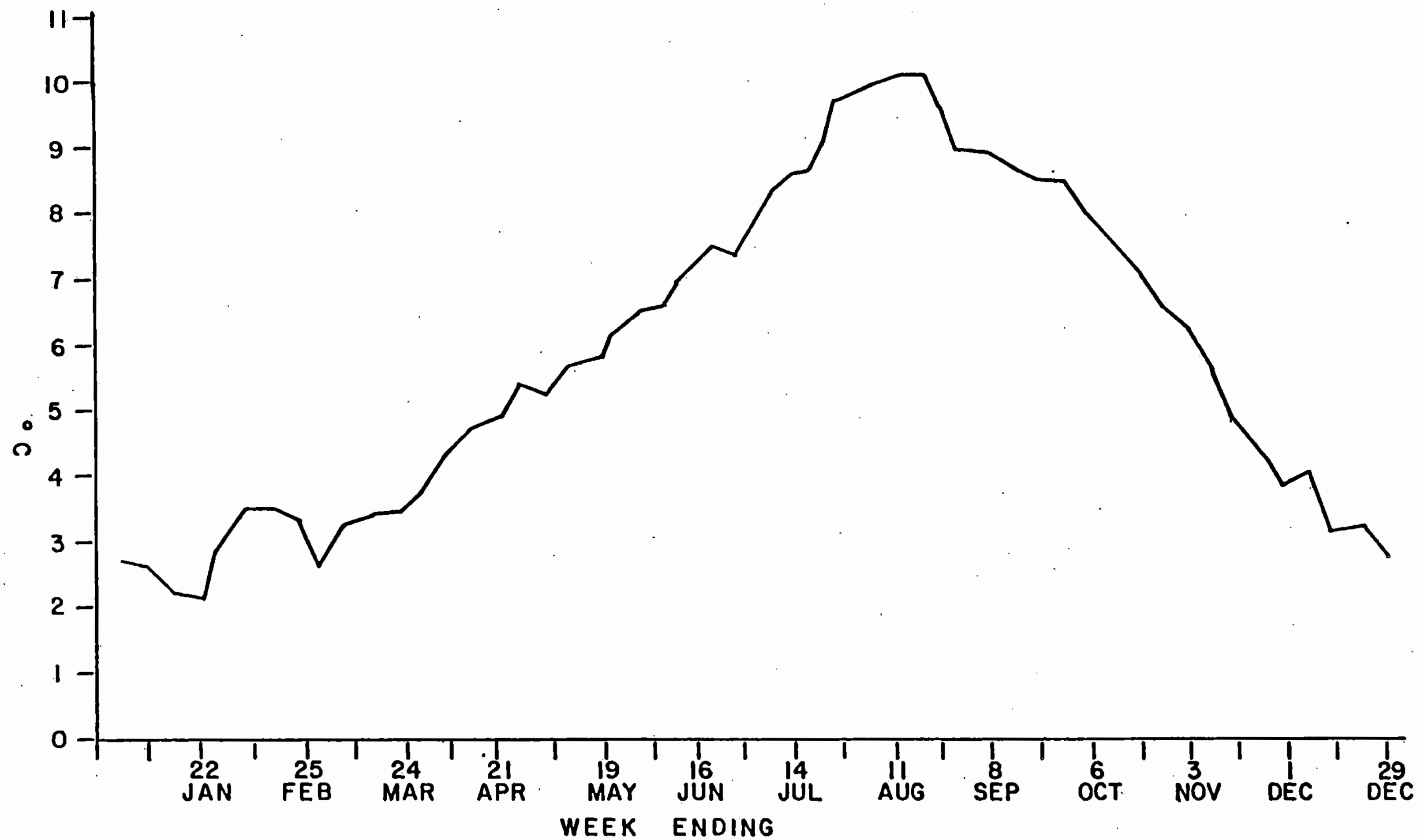
*Copper and zinc should not exceed 0.001 and 0.01 respectively when they appear together. Cu at 0.005 mg/l may suppress gill ATPase and compromise smoltification in anadromous salmonids.

Sources:
1. MacDonald and Shepherd (MS 1983)
2. Mackinlay (1984)
3. Sigma Resource Consultants Ltd. (1983)

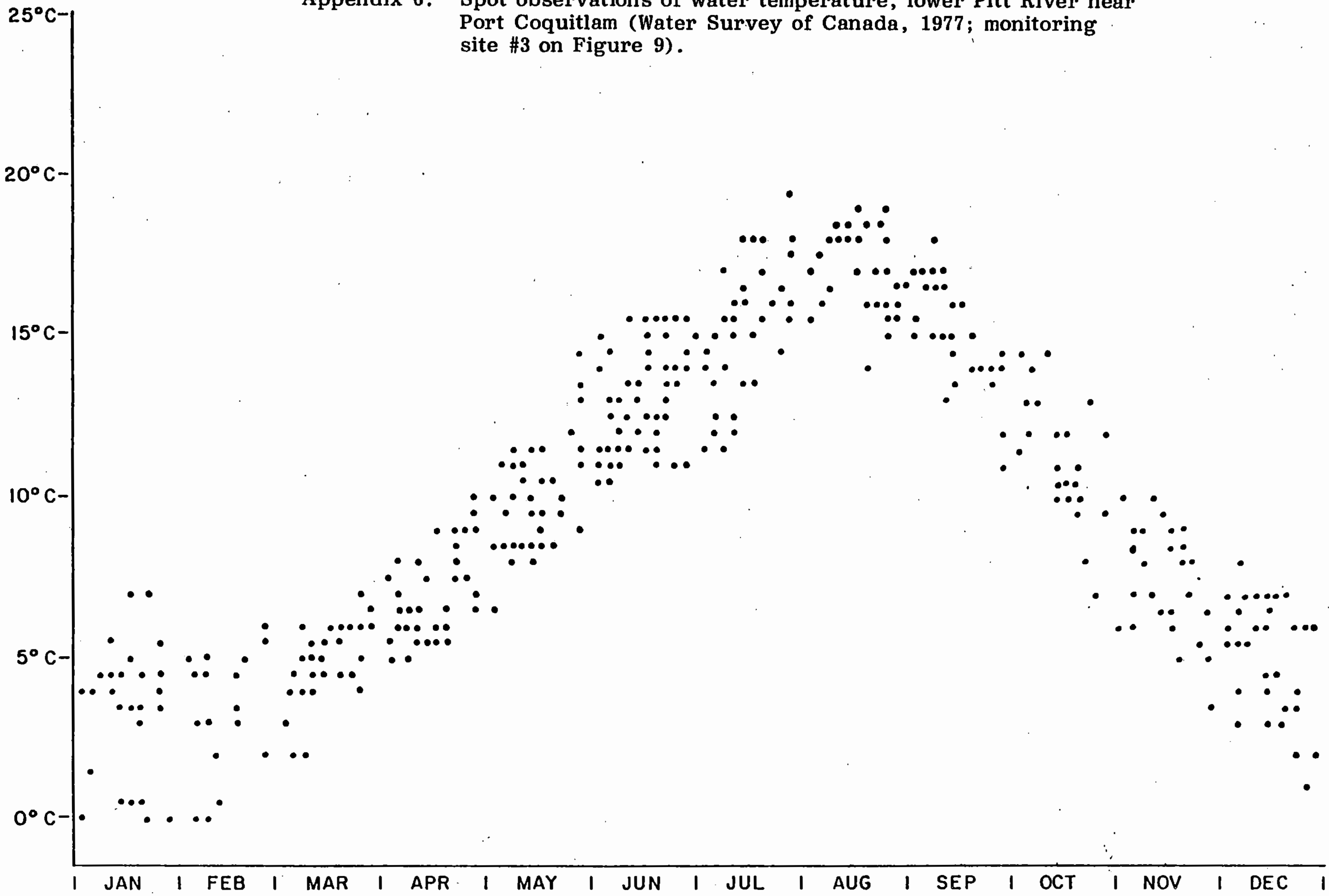
Appendix 4. Spot observations of water temperature (°C) of upper Pitt River near Alvin (Water Survey of Canada, 1977; monitoring site #1 on Figure 9).



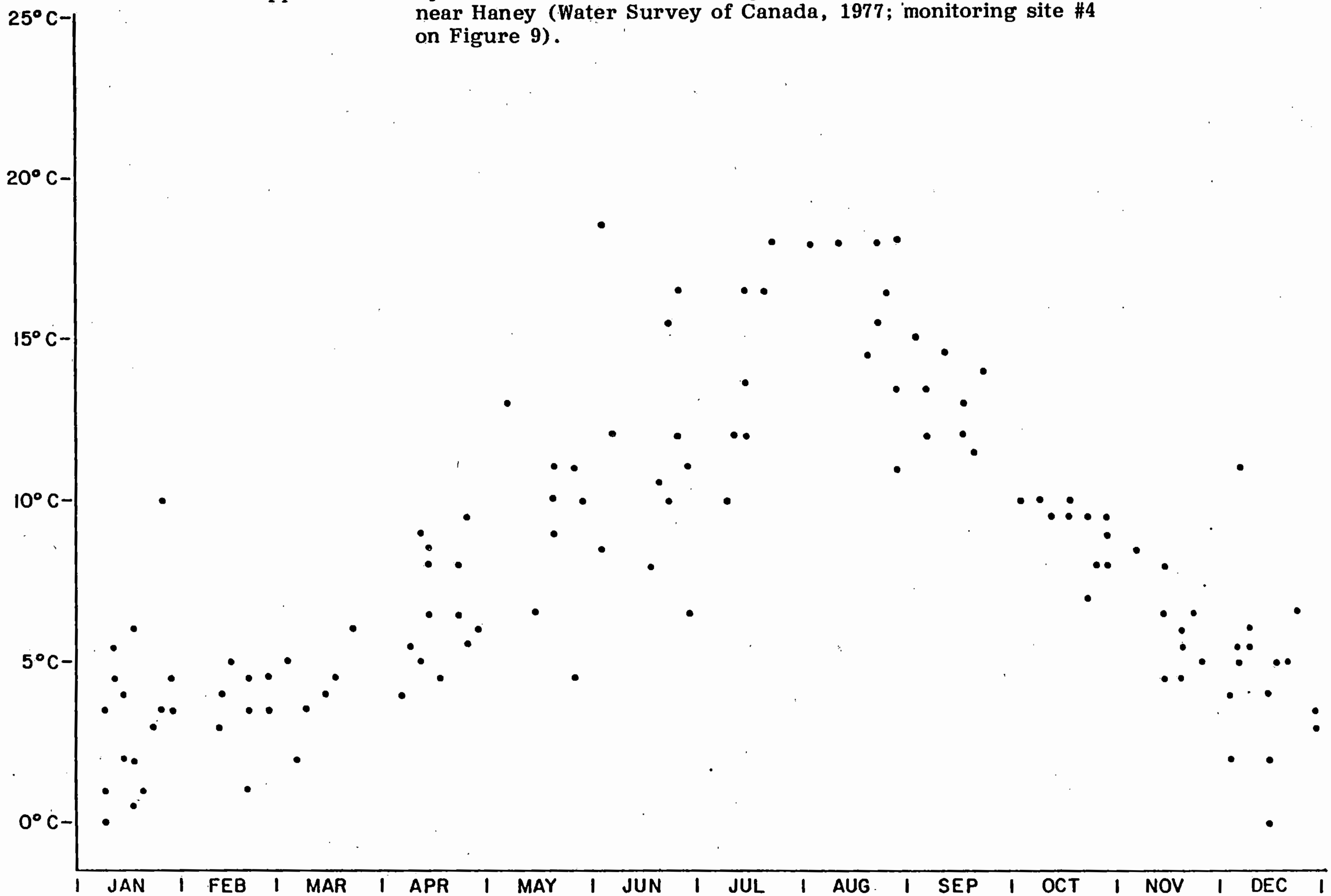
Appendix 5. Average water temperatures on Corbold Creek (IPSFC, 1984b; monitoring site #2 on Figure 9).



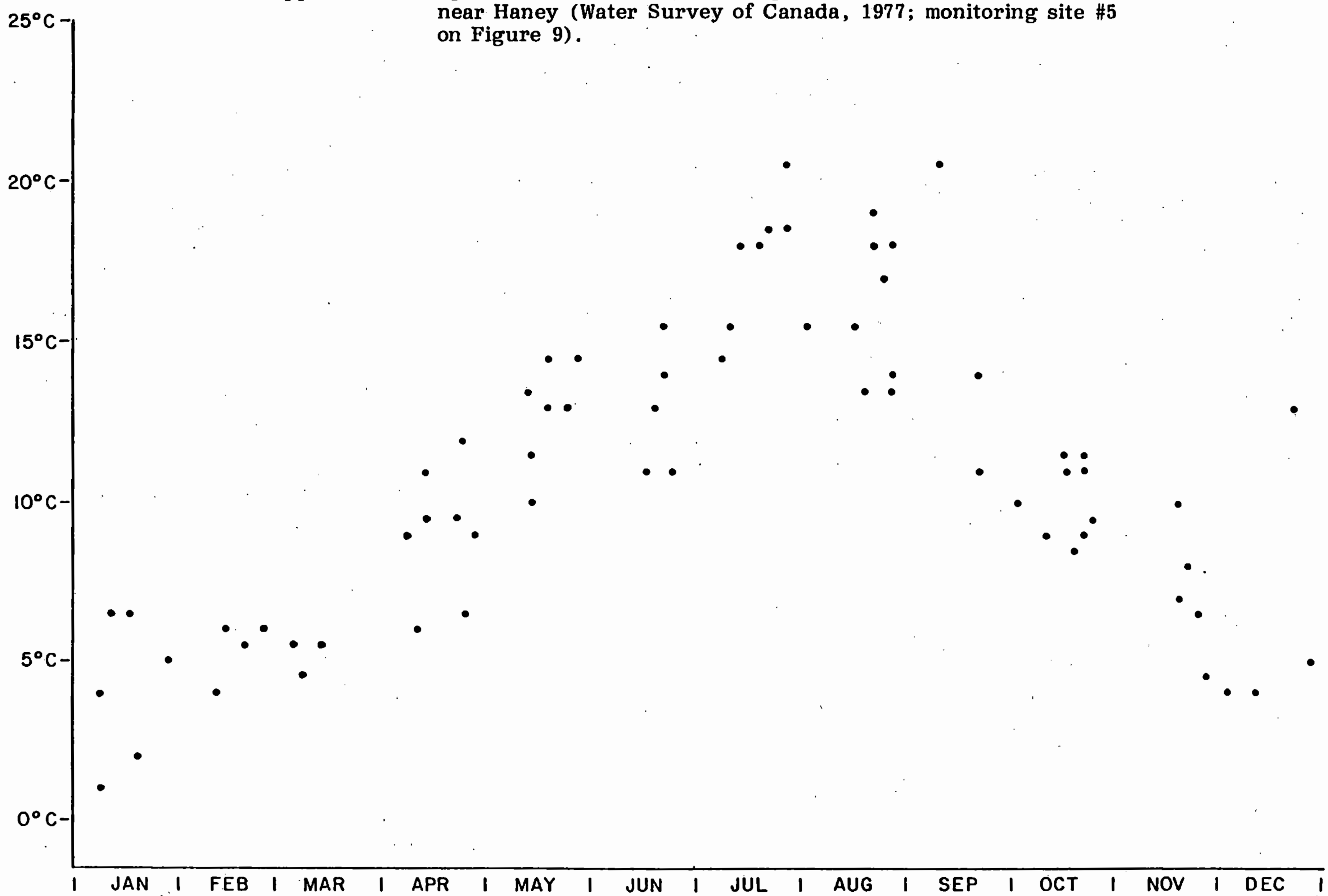
Appendix 6. Spot observations of water temperature, lower Pitt River near Port Coquitlam (Water Survey of Canada, 1977; monitoring site #3 on Figure 9).



Appendix 6a. Spot observations of water temperature (°C), N. Alouette River near Haney (Water Survey of Canada, 1977; monitoring site #4 on Figure 9).



Appendix 6b. Spot observations of water temperature (°C), S. Alouette River near Haney (Water Survey of Canada, 1977; monitoring site #5 on Figure 9).

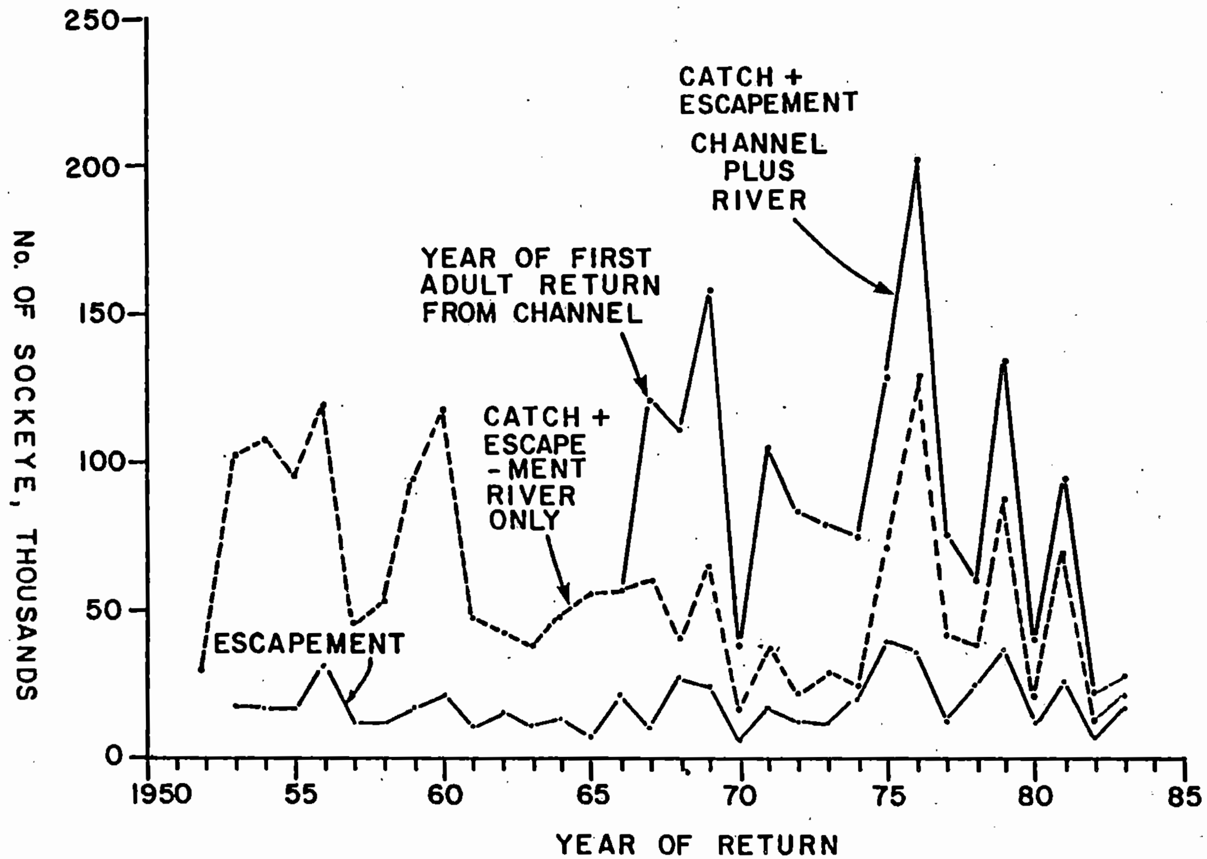


Appendix 7. Catch and escapement of upper Pitt River sockeye for some years of record from 1948-1984; sex composition of the run, and mean fecundities for some years (data from IPSFC, 1984b).

Brood Year	*Adult Escapement	Male Escapement n(%)	Female Escapement n(%)	Effective Females	Mean Fecundity	Catch	Indian Catch
1947	-	-	-	-	-	-	-
1948	55,380	34,050(61.48)	21,330(38.52)	20,340		67,340	-
1949	9,290	4,624(49.77)	4,666(50.23)	4,449	-	11,488	-
1950	40,061	21,806(54.43)	18,255(45.57)	13,312	-	106,276	-
1951	37,837	19,043(50.33)	18,794(49.67)	17,922	-	82,465	-
1952	48,899	25,842(52.85)	23,057(47.15)	21,904	-	23,279	-
1953	18,673	8,472(45.37)	10,201(54.63)	9,303	-	7,114	-
1954	17,624	8,928(50.66)	8,696(49.38)	8,332	-	33,470	-
1955	17,950	6,138(34.19)	11,812(65.81)	11,221	-	148,987	-
1956	32,094	20,595(69.17)	11,499(35.85)	11,107	-	38,229	-
1957	12,335	6,654(53.94)	5,681(46.06)	5,130	-	16,869	-
1958	10,381	3,663(35.29)	6,718(69.71)	6,658	-	6,150	-
1959	15,731	9,554(60.73)	6,177(39.27)	6,096	-	96,753	-
1960	24,510	11,611(47.32)	12,899(52.63)	12,493	4,803	8,804	
1961	11,158	4,540(40.69)	6,618(59.31)	6,525	4,935	91,873	-
1962	16,580	7,753(46.25)	8,827(53.24)	8,460	4,713	40,690	
1963	12,680	6,654(52.98)	6,026(47.52)	5,749	4,174	130,255	-
1964	13,756	7,399(53.79)	6,357(46.21)	6,313	4,843	178,290	-
1965	6,966	3,515(50.46)	3,451(49.54)	3,368	4,556	32,003	-
1966	20,842	10,011(48.03)	10,831(51.97)	10,723	4,853	56,834	-
1967	10,282	5,030(48.92)	5,252(51.08)	5,236	4,453	57,480	-
1968	16,988	8,761(51.57)	8,227(98.43)	8,189	4,420	88,600	
1969	25,073	13,114(52.30)	11,959(47.70)	11,710	4,916	35,999	-
1970	6,642	3,414(51.40)	3,228(48.60)	3,098	4,558	48,721	-
1971	15,452	8,490(54.94)	6,962(45.06)	6,663	4,774	202,005	-
1972	13,412	6,810(50.73)	6,602(49.22)	6,569	4,472	124,745	-
1973	11,895	7,039(59.18)	4,856(40.82)	4,744	5,004	31,235	-
1974	20,581	11,681(56.76)	8,900(43.24)	8,854	4,813	97,345	-
1975	39,920	18,469(46.27)	21,451(53.73)	21,369	4,227	25,791	3
1976	36,525	16,946(46.40)	19,579(53.60)	19,467	4,668	62,571	0
1977	13,852	6,021(43.47)	7,831(56.53)	7,791	4,806	15,933	88
1978	24,786	10,609(42.80)	14,177(57.20)	14,109	4,512	5,808	48
1979	37,542	15,877(42.30)	21,665(57.71)	20,307	4,726	-	521
1980	17,101	7,788(45.54)	9,313(54.46)	9,169	4.555	-	71
1981	25,327	11,355(44.83)	13,972(55.17)	13,224	4,701	-	226
1982	8,708*	3,599(41.33)	5,109(58.67)	5,086	4,550	-	274
1983	16,852	6,645(39.43)	10,207(60.57)	10,074	4,902	-	137
1984	15,797	7,014(49.90)	8,783(55.60)	-	-	-	-
Averages:							
1948-54	32,537	(52.13)	(47.87)	13,651			
1955-64	16,717	(48.94)	(51.06)	7,975			
1965-74	14,813	(52.43)	(47.57)	7,546			
1975-84	23,641	(43.68)	(56.32)	12,059**			
1960-83					4,663		

**1975-1983

Appendix 8. Sockeye production from upper Pitt River and IPSFC incubation channel (IPSFC, 1984a; adapted from 1983 annual report).



Appendix 9. Summary of upper Pitt River wild and channel sockeye egg deposition, egg-to-fry survival rates, and fry production 1960-1980 (IPSFC, 1984b; estimates of total fry production and egg-to-fry survival rates are preliminary).

Brood Year	Channel Only Eggs Spawned (millions)	Channel Only Eggs Planted (millions)	Egg Deposition Wild Only (millions)	Egg Deposition Total (millions)	Fry Produced in Channel Only (millions)	Spawned Egg to Fry Survival Channel Only (%)	Fry Produced in Wild Only (millions)	Egg to Fry Survival Wild Only (%)	Total Fry Production (millions)
1960	3.257	-	56.750	60.007	2.508	77.01	2.109	3.72	4.617
1961	4.060	-	28.141	32.201	3.022	74.44	4.006	14.23	7.028
1962	1.357	-	38.511	39.868	1.163	85.68	2.297	5.97	3.460
1963	3.189	2.967	20.806	23.995	2.250	70.56	1.187	5.71	3.437
1964	3.700	3.465	26.872	30.572	3.074	83.08	2.260	8.41	5.334
1965	2.133	1.987	13.245	15.378	1.654	77.56	1.773	13.39	3.427
1966	3.658	3.260	48.378	52.036	2.868	78.41	2.314	4.78	5.182
1967	4.529	3.842	18.788	23.317	3.300	72.87	0.656	3.49	3.956
1968	3.163	2.870	33.034	36.197	2.673	84.52	1.970	5.96	4.643
1969	4.881	4.547	52.686	57.567	4.192	85.88	2.764	5.25	6.956
1970	2.151	1.997	11.969	14.120	1.744	81.08	1.200	10.03	2.944
1971	2.652	2.408	29.155	31.807	2.291	86.37	4.353	14.93	6.644
1972	3.792	3.359	25.586	29.378	2.998	79.06	4.111	16.07	7.109
1973	2.366	2.107	21.373	23.739	1.793	75.79	1.959	9.17	3.752
1974	3.437	3.196	39.176	42.613	2.622	76.29	10.632	27.14	13.254
1975	4.554	4.192	85.783	90.337	4.119	90.44	3.790	4.42	7.909
1976	4.648	4.310	86.247	90.895	3.861	83.07	15.067	17.47	18.928
1977	4.909	4.270	32.535	37.444	3.648	74.33	7.013	21.56	10.661
1978	4.953	4.531	58.707	63.660	3.543	71.53	7.162	12.20	10.705
1979	4.559	4.138	91.413	95.972	3.397	74.51	6.392	6.99	9.789
1980	4.863	4.563	36.898	41.761	3.908	80.37	7.811	21.17	11.719
1981	4.618	4.270	57.544	62.162	3.818	82.67	-	-	-
1982	2.657	2.397	20.404	23.141	2.137	80.43	-	-	-
1983	4.789	4.319	44.598	49.387	3.738	78.05	-	-	-
Averages:									
1960-65					2.279				4.551
1966-70					2.955				4.736
1971-75					2.765				7.734
1976-80					3.671				12.360
Average (1960-1980)								11.05	
Average (1960-1983)						79.33			

Appendix 10. Age composition of upper Pitt River sockeye 1948-1978 (IPSFC, 1984b).

Brood Year	Jack 3_2 Return	Adult 4_2 Return	Adult 5_2 Return	Total Sub-2 Return	Adult 5_3 Return	Adult 6_3 Return	Total Sub-3 Return	Total Adult Return	Total Return (catch + escapement)
1948		26,803	95,917	122,720	0	0	0	122,720	122,720
1949	0	6,085	13,251	19,336	1,442	0	1,442	20,778	20,778
1950	62	91,231	55,044	146,337	0	0	0	146,275	146,337
1951	0	41,761	78,541	120,302	0	0	0	120,302	120,302
1952	0	39,952	31,890	71,842	0	336	336	72,178	72,178
1953	0	12,688	12,372	35,060	747	0	747	25,807	25,807
1954	42	37,926	13,126	51,094	0	0	0	51,052	51,094
1955	5	78,394	85,616	164,015	976	1,946	2,922	166,932	166,937
1956	15	28,169	38,686	66,870	1,900	1,553	3,453	70,308	70,323
1957	0	3,474	24,544	28,018	1,189	0	1,189	29,207	29,207
1958	12	12,978	3,157	16,147	0	388	388	16,523	16,535
1959	10	21,800	39,932	61,742	234	517	751	62,483	62,493
1960	0	5,842	27,406	33,248	29	37	66	33,314	33,314
1961	74	26,282	74,479	100,835	1,531	669	2,200	102,961	103,035
1962	46	24,085	32,679	56,810	465	0	465	57,229	57,275
1963	68	88,616	54,052	142,736	199	0	199	142,867	142,935
1964	68	48,016	142,584	190,668	1,250	176	1,426	192,026	192,094
1965	0	14,943	24,041	38,984	0	0	0	38,984	38,984
1966	65	24,568	51,336	75,969	1,732	0	1,732	77,636	77,701
1967	29	24,122	42,747	66,898	882	0	882	67,751	67,780
1968	45	38,212	67,282	105,539	0	49	49	105,543	105,588
1969	0	9,262	51,821	61,083	0	0	0	61,083	61,083
1970	81	21,806	32,749	54,636	645	117	762	55,317	55,398
1971	462	91,337	123,848	215,647	1,827	0e	1,827	217,012	217,474
1972	31	78,300	59,553e	137,884	273e	0e	273	138,126	138,157
1973	11	16,231e	26,795e	43,037	126e	0e	126	43,152	43,163
1974	128e	33,185e	80,679e	113,992	3,438e	707e	4,145	118,009	118,137
1975	92e	44,640e	20,578e	65,310	423e	0e	423	65,641	65,733
1976	32e	13,812e	84,886e	98,730	0e	371e	371	99,069	99,101
1977	57e	19,014e	10,591e	29,662	158e	0e	158	29,763	29,820
1978	0e	6,180e	24,327e	30,507	136e		136	30,643	30,643
1979	21e	3,503e							
1980	8e								
Average:	44	32,388	49,177	82,440	632	229	853		83,294
& of Sub-2 Average	0.05	39.17	59.65						
% of Sub-3 Average					74.09	26.81			
% of Total Return Average	0.05	38.76	59.04	98.97	0.76	0.27	1.02		

e = estimated.

Appendix 11. Summary of chum salmon fry production from Blaney Creek brood stock, 1972-1983 (Banford and Bailey, 1979; SEP Special Projects computer printouts, Vancouver, B.C.).

Brood Year	Number Released	Release Size (g)	Release Site	Comments
1972	258,924	0.37	Blaney Creek	Incubated at Blaney Creek
1973	1,282,228	0.36	" "	
1974	190,784	0.36	" "	
1975	139,683	0.33	" "	
1976	158,837	0.34	" "	
1977	1,171,710	0.37	" "	
1978	175,715	1.2	" "	
1979	262,260	1.4	" "	
1980	235,000	1.9	Alouette River	
1981	1,819,462	1.0-1.4	Blaney Creek, Inch Creek	Incubated and reared at Inch Creek
1982	568,229	1.2	" "	
1983	725,246	1.2	" "	

Appendix 12. Summary of salmonid juvenile production from the ARCC hatchery (SEP Special Projects computer printouts, Vancouver, B.C.).

Species	Brood Year	No. Released	Stage	Size	Release Site	Expected Adult Product
Chum	1979	60,290	Fed fry	1.2 g	Alouette R.	965
	1980	250,000	"	1.6 g	"	4,000
	1981	62,952	"	1.5 g	"	1,007
	1982	93,756	"	2.5 g	"	1,500
	1983	250,000	"	2.2 g	"	4,000
Coho	1979	8,635	"	10.5 g	"	259
	1982	2,500	Pre-smolt	16.5 g	"	375
		28,539	Smolt	24.0 g	"	4,281
Pink	1983	800,000* eggs taken, approx. 400,000 incubated and released				

*Eggs from Harrison River brood stock taken by IPSFC personnel; incubated at ARCC.

Appendix 13. Summary of trout and char stocking in the lower Pitt River system, 1933-1984 (B.C. Ministry of Environment, 1984a; unpublished data on file at Surrey, B.C.).

Release Site	Year	Number	Species	Age or Size
S. Alouette River	1938	200,000	Steelhead	Eggs
	1939	500,000	"	"
	1940	215,000	Rainbow	"
	1940	150,000	Steelhead	"
	1940	200,000	Steelhead	Fry
	1941	200,000	Cutthroat	Eggs
	1941	100,000	Steelhead	"
	1942	33,000	Rainbow	Fry
	1943	40,000	"	"
	1947	8,000	"	"
	1948	10,000	"	"
	1949	4,000	"	"
	1950	5,000	"	"
	1951	20,000	"	"
	1954	8,010	Steelhead	Yearlings
	1955	7,206	"	"
	1957	7,000	"	17.6/kg
	1979	25,000*	"	Smolts
	1980	25,000*	"	"
	1981	25,000*	"	"
	1982	25,000*	"	"
	1983	25,000*	"	"
	1984	25,000*	"	"
N. Alouette River	1933	16,000	Cutthroat	Fry
	1941	200,000	Rainbow	Eggs
	1942	200,000	"	"
	1943	200,000	"	"
	1944	100,000	"	"
	1955	7,500	Steelhead	Yearlings
	1957	7,000	"	17.6/kg
	1984	6,000	"	Fry
Tributaries to	1982	3,000	Cutthroat	Fry
De Boville Slough	1984	7,000	"	"
Alouette Lake	1938	50,000	Rainbow	Eggs
	1939	100,000	"	"
	1962	33,570	"	992/kg
	1962	19,250	"	121/kg
	1968	68,800	Lake Trout	404/kg
	1969	97,500	"	66/kg
	1982	150,000*	Rainbow	Fry
	1983	16,000*	"	"
	1984	42,000*	"	"

*Approximate; incubated at Fraser Valley Trout Hatchery, reared at ARCC, released to Alouette River system.

Appendix 14. Mean standard lengths of upper Pitt River sockeye, 1948-1980 (from IPSFC, 1984b).

		Age 4_2 Standard Length				Age 5_2 Standard Length		
Brood Year	(n)	Males (cm)	(n)	Females (cm)	(n)	Males (cm)	(n)	Females (cm)
1948	22	60.55	8	53.63	149	68.89	162	61.44
1949	7	62.29	8	54.63	103	68.31	118	61.68
1950	74	59.57	51	54.00	39	66.00	35	58.71
1951	10	57.40	12	52.25	75	66.12	104	59.43
1952	10	59.80	27	53.25	29	64.83	58	59.40
1953	22	58.00	2	53.40	16	66.31	26	59.23
1954	72	61.36	69	54.20	33	66.00	42	59.33
1955	77	58.58	75	52.35	9	65.11	31	58.52
1956	43	58.35	18	51.83	60	63.88	82	58.11
1957	10	62.50	11	57.27	62	68.11	93	61.99
1958	32	61.50	34	55.29	80	67.06	89	60.44
1959	100	59.93	95	52.70	16	65.75	20	60.01
1960	31	60.23	6	53.83	71	66.25	81	59.16
1961	13	58.85	11	51.91	17	64.35	28	58.04
1962	18	61.39	9	55.11	100	67.33	108	60.64
1963	29	60.93	31	53.71	24	67.42	27	60.93
1964	40	59.63	55	53.35	11	65.45	36	60.50
1965	20	61.40	7	55.57	73	66.89	41	60.95
1966	55	59.53	33	53.58	51	63.59	39	58.85
1967	24	59.21	24	54.96	81	65.54	77	60.49
1968	111	60.68	128	53.66	123	67.24	105	60.15
1969	20	60.80	14	52.79	96	67.89	103	60.21
1970	17	59.94	20	52.55	103	66.49	97	59.65
1971	98	59.80	107	53.24	30	65.37	24	58.67
1972	60	61.37	48	53.73	58	67.50	70	60.57
1973	36	60.17	25	53.52	84	67.37	94	60.52
1974	91	59.64	54	53.02	29	67.48	66	59.82
1975	52	59.50	35	54.83	61	64.69	84	59.35
1976	21	58.43	19	51.21	39	64.73	40	58.33
1977	5	58.60	1	53.00	55	65.82	59	58.37
1978	47	58.94	46	52.02	64	65.69	69	59.13
1979	19	59.37	10	55.08	49	66.02	55	59.34
1980	19	56.84	18	51.33	41	65.20	40	57.78
Average:		59.85		53.54		66.20		59.69

Appendix 15a. Upper Pitt River, miscellaneous F381 observations. Conditions affecting the stream.

Year	Observation
1938	*"Log jams and debris present in logged off areas."*
1940	*"On account of glacial silt it is impossible to correctly estimate the runs."*
	"The water in Boise Creek is clear and it is fairly easy to estimate the run."
	"Glacial silt in Corbold Creek makes it difficult to estimate the runs to the spawning beds."
1941	*"Some debris in Corbold Creek."*
1942	*"This is an ideal spawning stream; no heavy flooding."*
1943	*"Main river changed its course and silted up the mouth of this stream."*
1945	*"Water levels high; some debris in Corbold Creek."*
1947	*"Water very clear and low on Oct. 18th, but heavy rain caused high and muddy water on Nov. 27th."*
1948	*"Discoloration of the water made it difficult to accurately estimate the number of spring salmon in this river."*
1949	*"Two creeks which were previously used by sockeye are now rendered useless by the logging off of the nearby timber and by construction of roads. The silt-laden waters of the Pitt River itself make estimation of spring salmon impossible."*
1950	*"Logging operations are gradually rendering some of the tributary streams useless for fish. Once the timber has been removed, the streams dry up or become stagnant swamps."*
1954	*"Very high water during November and December made observations very difficult."*
1956	*"There was over 20" of rainfall in October. Continuous high-lead logging is creating more unstable spawning conditions each year."*

Appendix 15a (cont.)

Year	Observation
1960	*"Fairly heavy scouring, many changes to bars."*
1971	*"There were blockages due to beaver dams in the lower tributaries. These dams were removed to allow for upstream migration. Beaver were removed by trapping in the problem areas."*
1973	*"Forty beaver were taken out during 1972-73. No problem with beaver in fall of 1973."*
1981	*"Signs of bank erosion throughout; signs of gravel shifting; susceptible to floods."*
1983	*"Large amounts of gravel movement yearly."*

Appendix 15b. Upper Pitt River. F381 Biological Conditions Summary

Year	Observation
1930	*"Heaviest sockeye run since establishment of the hatchery. More chums observed than in previous years."*
1931	*"Slight increase in coho population. Material increase in pink population."*
1943	Dec. 21: *"Too late in inspecting streams for fall fish."*
1948	*"Bears, eagles, trout and diving ducks preying on adult salmon* [and eggs]."
1951	*"Bears in upper Pitt River, seals in Pitt Lake are predators on salmon."*
1961	*"It is expected that the flood of Jan. 15th caused fairly heavy damage to the 1960 run."*
	"Spawners are evenly distributed throughout the whole upper river and tributaries."
1963	*"Upper Pitt River sockeye reported 95.4% spawned in 1963."*
1964	*"Black bear, cutthroat trout, Dolly Varden char, kingfishers, mergansers and otter reported in vicinity of upper Pitt. Hair seals occur in Pitt Lake."*
	"Sockeye reported 99.3% spawned; spring salmon appeared earlier than usual."
1968	*"It would appear from returns that the hatchery operations are successful in maintaining sockeye runs in this stream."*
1980	*"Most of the spawning takes place in small tributaries and side channels."*

Appendix 16a. S. Alouette River. Miscellaneous F381 observations: Conditions affecting the stream.

Year	Observation
1925	*"B.C. Electric erected a dam at lake outlet which prevents salmon from ascending into lake."*
1927	*"Sockeye ascended to base of dam but could go no further and it was a complete loss."*
1942	*"Because of the dam, water levels were low. The officer believes that many fish hatched in this stream spawned in the North Alouette River."*
1945	*"Water levels very low and fish were late in ascending, but heavy rain later in the fall initiated the runs."*
1950	*"Some erosion was caused by flash floods which were evident this fall. Some changes resulted from dredging by the dyking board. Water is often released over the dam, causing flash floods."*
1953	*"Stream levels vary considerably due to diversion dam gate openings."*
1955	*"A heavy rainstorm in early November caused a break in the dam. The tidal wave rush of water caused untold damage to this very productive river."*
1956	*"Fairly heavy scouring of river channel, and gravel operations have created unstable conditions in parts of the spawning areas."*
1960	*"There has been extreme scouring and every bar in the river has been changed."*
1965	*"Gravel removal operations were limited in 1965 in order to attempt preservation of the natural stream bed."*
1972	*"The measured water release at the dam maintained good flows throughout the summer and fall."*
1976	*"There was some beaver activity."*
1981	*"Constant urban pressure is being applied to this system. There is local flood protection work done by streamside residents."*

Appendix 16b. S. Alouette River. F381 Biological Conditions Summary.

Year	Observation
1929	*"Salmon do not frequent this stream so much since the dam was built at Alouette Lake, as the part below the dam is not suitable for spawning purposes."*
1941	*"There were many more pink salmon females than males."*
1948	*"Seals were present near the mouth, and diving ducks were predatory on juveniles."*
	"An excellent chum salmon spawning stream, which could support many more spawners."
1956	*"Anglers reported one of the best steelhead runs in recent years."*
1960	*"A very high egg loss is expected because of the extremely unstable nature of the river."*
1966	*"There was heavy scouring of the streambed with an estimated 60% loss of spawn."*
1976	*"Mergansers, bears, humans were predators on spawners."*

Appendix 17a. N. Alouette River. Miscellaneous F381 observations: Conditions affecting the stream.

Year	Observation
1925	*"An unidentified obstruction was removed, allowing salmon to proceed further upstream."*
1933	*"Another obstruction was removed."* Probably logging debris [ed.].
1941	*"Old logging debris present 2 to 3 miles from mouth."*
1944	*"Fallen trees present."*
1951	*"There was some molestation of spawners by children."*
1953	*"The stream is greatly affected by high water after heavy rains because the headwater slopes have been logged off."*
1955	*"During a heavy rainstorm in early November, part of the S. Alouette River was diverted into the N. Alouette."*
1957	*"Five log jams cleared from this stream in August."*
	"Logging and land clearing are causing accumulations of logs and brush in the lower reaches after heavy rains."
1958	*"Logging and increasing population continue to have an adverse effect on salmon spawning."*
1962	*"Gravel removal operations and flood control programs are causing unstable stream bed conditions."*
1965	*"Gravel removal operations were limited in 1963 in order to preserve the natural stream bed."*
1970	*"Water levels are generally low in early and late fall, and high during periods of rain and snow runoff in December and January. There is some scouring of the river channels due to high rainfall."*

Appendix 17b. N. Alouette River. F381 Biological Conditions Summary

Year	Observation
1948	*"This is an excellent spawning stream, which could handle many more fish. Seals were present near the mouth."*
1949	*"Salmon runs were late arriving. There are miles of good spawning gravel available."*
1953	*"Spawning bed scouring occurs after flash floods* [related to logging. - ed.] *and deposits eggs and young alevins into the grass and brush along the stream banks."*
1964	*"Fair winter run of steelhead continues to attract sport anglers to the stream."*
1975	*"Late spawning coho populations were not affected by the freshets of December."*
1977	*"There were 90 fin-clipped fish from Blaney Creek present in the stream."*

Appendix 18a. Widgeon Creek. Miscellaneous F381 observations: Conditions affecting the stream.

Year	Observation
1943	*"Very low water prevented sockeye from reaching the spawning beds."*
1945	*"Sockeye are able to spawn only at high tide; low tide leaves the gravel bare and the rest of the Slough in a mud bottom."*
1949	*"Heavy erosion of creeks as a result of flash floods."*
1981	*"Stream is susceptible to scouring."*

Appendix 18b. Widgeon Creek. F381 Biological Conditions Summary.

Year	Observation
1934	*"Sockeye were still spawning in early December."*
1949	*"Sockeye are described as white-fleshed fish."*

Appendix 19a. McIntyre Creek. Miscellaneous F381 observations: Conditions affecting the stream.

Year	Observation
1952	*"Water levels are generally very low during the fall."*
1961	*"Moderate scouring during periods of high water."*
1970	*"Beaver dams were removed to allow for further upstream migration."*
1981	*"There are numerous beaver dams which are not obstructions at high water levels."*

Appendix 19b. McIntyre Creek. F381 Biological Conditions Summary.

Year	Observation
1951	*"Raccoons and bears were feeding on salmon spawners."*
1953	*"This is a small stream with limited potential."*
1963	*"Mergansers, kingfishers and cutthroat trout are predators on juvenile salmon."*
1967	*"Estimated 50% loss of chum spawn in January."*