A Preliminary Reconnaissance of Pink and Chum Salmon Streams in Jervis and Sechelt Inlets (1977)

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ABSTRACT

Barrett, D.T. 1977. A preliminary reconnaissance of pink and chum salmon streams in Jervis and Sechelt Inlets (1977). Fisheries and Marine Service Manuscript Report No. 1735.

This report is a summary of the historical data and current field data of salmon spawning streams draining into Jervis and Sechelt Inlets. The past and present status of pink and chum salmon stocks is examined for six streams in the study area. Current declines in stock numbers are not obviously correlated to conflicts with other resource users (e.g. forest harvesting), and it is suggested that these declines could be attributed to commercial fishing pressures and depensatory mortality agents.

It is suggested that enhancement of pink stocks be restricted to Skwawka, Deserted and Vancouver Rivers. Spawning channels are the suggested enhancement technique for Skwawka and Deserted River while rehabilitation of old side channels is the suggested technique for Vancouver River.

The main effort for enhancement of chum stocks should be directed towards Deserted and Tzoonie rivers. On the off years for pinks, chum salmon on the Deserted River could be accommodated in the previously mentioned pink salmon spawning channel while an incubation system and feeding program is suggested for Tzoonie River.

The need for further reconnaissance is emphasized.

Résumé

Barrett, D.T. 1977. A preliminary reconnaissance of pink and chum salmon streams in Jervis and Sechelt Inlets (1977). Fisheries and Marine Service Manuscript Report No. 1735.

Le présent rapport constitue un résumé des données récapitulatives et actuelles sur les cours d'eau à saumon qui se déversent dans les inlets Jervis et Sechelt. Il porte en fait sur la situation passée et présente des stocks de saumon rose et de saumon kéta de six cours d'eau compris dans la zone à l'étude. Les déclins que connaissent actuellement les stocks ne sont pas nécessairement dus à des conflits avec d'autres usagers de la ressource (par ex. les exploitants forestiers); il semble en effet que la pression exercée par les pêcheurs commerciaux et certains agents mortels n'y soient pas étrangers.

Pour les stocks de saumon rose, on suggère de limiter les activités de mise en valeur aux rivières Skwawka, Deserted et Vancouver. La technique proposée pour les rivières Skwawka et Deserted est celle des frayères; dans le cas de la Vancouver, on conseille de rénover les anciens canaux qui avaient été aménagés le long de la rivière.

En ce qui concerne le saumon kéta, les efforts de mise en valeur devraient surtout porter sur les stocks des rivières Deserted et Tzoonie. Les années où il n'y a pas de remonte de saumon rose, on pourrait utiliser pour le saumon kéta de la Deserted les frayères dont il a été question précédemment; enfin, pour ce qui est de la rivière Tzoonie, on suggère d'avoir recours à un système d'incubation et à un programe d'alimentation.

On insiste sur la nécessité de poursuivre le travail de reconnaissance.

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INTRODUCTION

As part of the planning process for the Salmonid Enhancement Program for the Pacific Coast, Geographical Working Groups were established. These working groups were charged with the responsibility of identifying enhancement needs, goals and priorities within their geographical area. Very early in this planning process the depleted numbers of pink salmon in the southern areas of the Georgia-Johnstone Straits region were identified as an area of major concern. Since Jervis and Sechelt Inlets had been large producers of pink salmon historically, this area was selected for immediate attention. In an effort to identify the enhancement opportunities of the Jervis-Sechelt area, a preliminary reconnaissance was carried out during the summer and fall of 1977.

Presented in this report is a summmary of results of pink salmon reconnaissance in Jervis and Sechelt Inlets. The six streams included in this survey were Sechelt Creek, Brittain, Skwawka, Deserted, Vancouver and Tzoonie Rivers. This area maintains an odd year dominant cycle of pinks with the Skwawka and Deserted Rivers supporting the largest populations. Prior to 1962, both of these rivers had reported escapements in excess of 100,000 pink salmon in some of the cycle years. Since then, however, such levels declined to the point that in the past decade escapements have varied between 5,000-25,000 pinks in the cycle year.

The information used in this study was collected from Fisheries and Marine Service spawning files, helicopter surveys and ground surveys carried out on foot.

DESCRIPTION OF THE STUDY AREA AND HISTORICAL ESCAPEMENTS

Jervis and Sechelt Inlets are located approximately 80 kilometres (km) northwest of Vancouver, British Columbia. These inlets, which are located on the mainland side of Georgia Strait, form a large complex network of fiord-like waterways (Fig. 1).

The study area encompassed six of the major pink and chum salmon rivers within Jervis and Sechelt Inlets. The criteria used to isolate these six was based entirely on past and present escapement levels (Table 1) and the obvious potential for enhancement (size, length, flow regime, accessibility, etc.). These rivers, Brittain, Skwawka, Deserted, Vancouver, Tzoonie and Sechelt, all contribute in varying degrees to the pink and chum salmon stocks utilizing the area.

A. BRITTAIN RIVER

Brittain River flows southeast into the west side of Princess Royal Reach on Jervis Inlet (Fig. 2). The river is approximately 19 km in length from its headwater lake to tidewater at Jervis Inlet and drains some 122 sq. km. The watershed was logged extensively during the 1930's with smaller operations continuing until 1957. In addition, the river banks were further denuded by a severe forest fire during the summer of 1951. As a result of the logging operations and the forest fire, there was a severe loss of all forms of vegetation, thus manifesting a dramatic increase in surface runoff. This, in turn, promoted scouring of spawning beds. Secondary growth has been re-established on some of the lower elevations of the system, although most of the suitable spawning gravel was displaced by scouring in the intervening years.

The largest escapement estimate recorded for Brittain River was in 1937 when 7,500 pink, 7,500 chum and 1,500 coho spawned in the system. Since the time of the fire and the cessation of logging, the largest recorded escapements have been 2,000 pink, 3,000 chum and 500 coho in 1969 (Table 2).

Early spawning reports indicated that pink and chum salmon utilized the lower 1.5 km for spawning while coho and steelhead migrated as far as the falls at 5 km. The 1968 spawning report indicated that steelhead went beyond the falls at 5 km, but this has not been documented since.

Of particular interest on this river is an old river channel on the west side of the valley which extends the length of the floodplain. The upstream end of this channel is blocked by an old logging road grade which, if culverted, might provide a suitable spawning area for chum or pink salmon and may also provide a measure of protection from flooding.

B. SKWAWKA RIVER

Skwawka River flows south from its headwaters for approximately 19 km to tidewater at the head of Queen's Reach, Jervis Inlet (Fig. 3). This river drains approximately 200 sq. km, which does not include its major tributary (from the east, 1.5 km from tidewater), the Hunnechin River. This major tributary does not accommodate any spawners due to a set of falls and cataracts near its confluence with the Skwawka River, and the nature of the streambed which is mainly large boulders.

Logging activities commenced in the Skwawka Valley in 1969, and the resultant road construction led to slides along the river and some of its tributaries. A series of floods in

1975 resulted in siltation of the lower 9.5 km of the river's spawning grounds. In 1976, high water moved the silt downstream to the lower 2.5 km. The spawning gravel presently available (1977) is of excellent quality and appears to be relatively stable.

This river has been a major producer of pink salmon with escapements as high as 200,000 in 1963 and 1965. Other high returns include 8,000 chum and 8,000 coho returning to spawn in 1972 and 1974 respectively. As shown in Table 3, recent escapements have been in the order of 13,000 pink (1975-77), 250 chum (1975-76) and 4,000 coho (1976-77).

An impassable falls is located 17.5 km from the mouth of the river; coho and pink salmon utilize the entire length from 2.5 km to the falls. Although the bulk of pink spawning during the present survey (1977) occurred between 2.5 and 5 km, there were a significant number of fish spawning as far up as 9.5 km. A log jam at 4 km does not pose a threat as it is passable to salmon. It has been reported that chum salmon spawn between 5-8 km while coho prefer that part of the river between 8 and 18 km (D.D. Bailey, pers. comm.). The upper reaches of the river have low quality spawning gravel and consequently, this might yield a low survival from egg to fry. However, the coho fry have access to the swamps adjacent to this area and, therefore, one might expect a relatively high survival rate from the fry to smolt stage.

C. DESERTED RIVER

Deserted River flows in a south-westerly direction into Deserted Bay on the east side of Jervis Inlet (Fig. 4). The river is approximately 13 km in length, including some

headwater lakes, and drains an area of some 181 sq. km. Tsuadi Creek, a tributary, enters Deserted River at a point 3 km above tidewater. Although this tributary accommodates spawners, recent logging activity in its headwaters coupled with natural glacial silt have caused silting of the streambed. This has reduced some of the spawning potential both in the lower reaches of Tsuadi Creek and in the lower 3 km of Deserted River.

The upper watershed of the Deserted River was logged from 1938 to 1947 while the lower flats near the river mouth were logged in 1965 and 1966. Although this river has consistently been reported as a steady producer of pink and chum salmon, flooding and scouring have been reported. Chum escapements have recovered from a low of 750 in 1965 and 1966 to a high of 35,000 recorded in 1973. In recent years escapements have fluctuated from 2,500 (1976) to 30,000 (1977).

Pink salmon have been reported to spawn in this river in numbers exceeding 100,000 (1947 and 1953), although recent escapement figures have not exceeded 25,000 (1971). In the last two cycle years (1975 and 1977) the escapements have remained at approximately 10,000-12,000 fish. An anomaly appears in the data in that an even-year run of 15,000 pink salmon was reported in 1948. The escapement figures decreased to 75 adults sighted in 1956 (Table 4), after which there were no further reports of pink salmon sighted during even years. Lack of further sightings, combined with the fact that even-year runs of pink salmon in southern B.C. are extremely rare, suggests this reported even-year cycle may be an incorrect record.

An impassable falls is located 5.5 km from the mouth of the Deserted River, thus confining pink, chum and coho spawning distribution to the area below the falls. While pinks spawn between 3 km and the falls, the bulk of pink spawningis located in a large braided area of the river valley. It is within this braided area that Tsuadi Creek joins the Deserted River. Pink spawning distribution within Tsuadi Creek is from .4 km to a point 1.2 km from the junction where an impassable falls is located. Chum and coho salmon spawning distribution is similar to pink distribution although coho tend to prefer the upper reaches of the available spawning habitat.

It has been suggested for many years that a fishway be constructed over the Deserted River falls to allow fish access to gravel beds above the obstruction. This proposal has been rejected both by C.E. Walker (pers. comm.) and by R.W. Armstrong (pers. comm.). Armstrong expressed concern that a fishway might alter the flow characteristics at the obstruction and cause increased flooding in the lower reaches. He also noted that only 3-5 km of spawning potential exists above the falls and that the gravel there was of questionable quality.

D. VANCOUVER RIVER

Vancouver River flows south-west into Vancouver Bay on the east side of Jervis Inlet (Fig. 5). The river is 21 km in length and drains an area of some 163 sq. km. The estuary is a large tidal mud flat which is created by flows entering from High Creek on the north, Vancouver River from the east and an unnamed creek, known locally as Jitco Creek, from the south-east.

Railroad logging began on the Vancouver River in the early 1900's. A small town was established at the estuary and logging continued until 1969. At present, little remains of these operations except overgrown logging roads and decaying bridges.

Over the years of active logging, substantial dyking and channelization had taken place which no doubt was intended to protect the townsite from flooding and to protect bridge supports. The dyking, in particular, cut off a complex network of channels which spread out from the main river about 1 km above tidewater. Traditionally these side channels supported a major segment of pink and chum salmon spawners, but also served to disperse some of the flood waters, thus reducing scouring in the lower reaches. These activities plus increased run-off due to logging have affected the characteristics of the river to such an extent that little or no suitable spawning gravel is available in the main river.

It has been speculated that one of the cut-off channels, Jitco Creek, flowing into the estuary which drains the south side of the floodplain, was once connected to the Vancouver River about 1.5 km above the estuary. Further speculation suggests that this south fork was the traditional pink salmon spawning ground.

Escapement figures for Vancouver River have never been as high as Skwawka or Deserted River for pink or chum salmon. However, 8,000 chum salmon spawned in Vancouver River in 1973, with numbers now down around 200-500 (1975 and 1976).

Pink salmon escapements have varied between 200 (1975) and 7,500 (1951) adults since the early fifties. During 1947,

the first year of escapement figures, some 15,000 pink salmon spawners were reported for this system (Table 5). This is extremely high compared to any of the other figures, and either reflects the last year of successful spawning by adults which spawned in cut-off flood channels, or it may reflect an inexperienced or overly optimistic Fishery Patrolman.

Coho salmon escapement figures have varied between 50 (1973) to 1,500 (early 1960's) until 1975 and 1976 when 3,000 were reported. The large jump is likely due to increased reconnaissance above the obstruction at 8.8 km. Coho have in recent years been reported as far as 13 km upstream from tidewater.

The distribution of pink and chum spawners in the main river is within the lower 3.2-4.8 km and is restricted to limited available spawning gravel. During periods of adequate flow, salmon will spawn in the network of old flood channels where large volumes of good spawning gravel exist. This is especially true for chum salmon.

E. TZOONIE RIVER

The Tzoonie River flows south-easterly into the head of Narrows Inlet, an arm of Sechelt Inlet (Fig. 6). The river rises from two small lakes and flows approximately 18 km to tidewater and drains some 181 sq. km. A set of falls located 5 km from the river mouth was blasted in 1975 and made passable. Another set of passable falls exists at 8 km, and a 3 metre falls, located in 1974, exists at 17 km.

Logging activities have been carried out in this particular drainage since the early 1960's and seem to have had very

little effect on the water quality or flow regime of the main Tzoonie River (Marshall et al, 1976).

The Tzoonie River is not a large producer of pink salmon. Although 75,000 spawners were reported in 1947, the highest level of escapement in the intervening years to 1976 was 7,500 fish, with none observed on at least four cycles. Chum salmon escapements are the highest for any streams draining into the Jervis-Sechelt Inlets study area with a high escapement of 35,000 (1948-1951) to a low of 1,200 (1970) on the Tzoonie River. Since 1971, escapements have been in the order of 10,000-20,000 fish. Coho escapements (Table 6) have fluctuated between "none observed" (1975) to 10,000 spawners (1968).

Distribution of pink and chum spawners is restricted to the lower section (0-2.5 km) below the first set of falls. A side channel exists about 400 m below the falls and approximately 50% of its 300 m length is suitable spawning gravel (D.D. Bailey, pers. comm.).

F. SECHELT CREEK

Sechelt Creek flows in a north-westerly direction and drains into Salmon Inlet, an arm of Sechelt Inlet (Fig. 7). The stream is 11 km in length and drains approximately 83 sq. km of mountainous terrain. A twin set of falls (6 m and 12 m) are impassable and restrict spawning to the lower 1.5 km of creek.

It is reported that this is the only stream which supports salmon in Salmon Inlet (Marshall et al, 1976). However, the limited length of available spawning habitat (1.5 km)

coupled with poor spawning gravel makes this stream an unsuitable candidate for enhancement.

Intensive logging has been undertaken in the drainage area since 1930 and has resulted in exteme water fluctuations, heavy scouring and silt deposition in the lower 1.5 km ot creek.

Escapements of pink and chum salmon in 1947 were reported at 3,500 each. Since that first report, chum escapements have never exceeded 1,500 and have not been observed at all some years. The same is true for pink salmon except that in 1975, 3,000 pink salmon spawners were sighted. The increase is due in large part to more thorough surveillance of this stream during the 1975 spawning season. Escapements of coho were only reported between 1962 and 1971 and none exceeded 50 fish (Table 7).

FIELD METHODS AND RESULTS

Since this preliminary report is essentially a compendium of information, a great deal of emphasis was placed on the available information listed in the files of Fisheries and Marine Service. The Fishery Officers' comments found in the annual escapement record files were also consulted.

Field work consisted of an aerial reconnaissance of the study area by helicopter at the start of pink spawning. During this flight (September 1, 1977) the general topography of the area was noted, as well as logging activities, obstructions and log jams. Also of considerable interest was the extent of spawner distribution.

Aerial reconnaissance indicated that no substantial number of pink salmon were present in Brittain, Tzoonie or Sechelt Rivers. Previous escapements to these rivers had been low; to the point that further reconnaissance by foot would provide no new information. It was for these reasons that these streams were not surveyed by foot, although the Fishery Patrolman continued to visit these streams throughout the spawning season. Since earlier reports from the Fishery Officer and Patrolmen indicated that the fish had been milling in Vancouver Bay and had only just entered the streams, further reconnaissance by foot was delayed until September 12, 1977.

A. SKWAWKA RIVER

Ground reconnaissance was carried out on Skwawka River on September 12 and September 29, 1977. Three people were involved each time, each with tally counters. Triplicate counts were then conducted for spawning areas in the main river and any side channels. Coho were also counted, although an overall estimate would be impossible since their spawning time continued long past our field trips.

After two field trips and six individual counts, the estimate for pink salmon spawners for 1977 in the Skwawka River was placed at 12,000 fish. The bulk of this spawning occurred between the log jam at 4 km to a point approximately 400 m above the logging road bridge at 5 km. Pink salmon spawners were observed to 18 km (by helicopter), although the numbers of fish became very sporadic after 9.7 km.

Coho salmon were not observed spawning, however approximately 1,000 individuals were observed holding in pools between 2.5 km and 10 km.

A small source of groundwater was noted at approximately 6.5 km on the west bank of the river. This groundwater source created a very small "stream" but is mentioned because of the importance of groundwater for artificial incubation of salmon eggs.

B. DESERTED RIVER

Ground reconnaissance of the Deserted River was conducted on September 13 and September 30, 1977. Three people were involved during both field trips and each produced a direct count of fish on the spawning grounds. As was the case on Skwawka River, coho salmon were counted but no estimate of spawner abundance was possible due to the length of the coho spawning season.

The estimate for pink salmon spawners for 1977 in the Deserted River was placed at 10,000 fish. This estimate is a consensus based on six separate and direct counts of fish on the spawning grounds. The estimate for coho salmon holding in the large pools found near the head of spawner distribution was placed at 1,000 fish. The greatest abundance of pink salmon spawners was found between 2.5 km and 4 km, although fish were spawning from 1.5 km to the falls at 5 km. This includes the large braided area of the main river and also the main tributary, Tsuadi Creek.

C. VANCOUVER RIVER

A brief ground reconnaissance of the Vancouver River was carried out on September 1, 1977. Since only 500 pink salmon were evident at this time, the network of old river channels and some of the previous dyking activities were investigated. Later reports by the Fishery Patrolman

indicated that 1,000 pink salmon spawned in the small canyon of the Vancouver River at 2.5 km.

DISCUSSION

A. PINK SALMON

Opportunities for enhancement of pink salmon are clearly evident in the Jervis-Sechelt area. Escapements for 1977 were approximately 25,000 fish, less than half the 46,200 projected by the 1976 annual expectation publication. The current figure, a mere 5% of the historical levels, attests to the dramatic decline of pink salmon in the Jervis-Sechelt area over the past 25 years. Closures of the gauntlet fishery in Johnstone Strait maintain the existing pink stocks.

The best opportunities for enhancement are in Jervis Inlet, specifically Skwawka, Deserted, and Vancouver Rivers. These rivers presently support over 90% of the escapement to both Jervis and Sechelt Inlets and appear to have a minimum of resource conflicts. The Skwawka and Deserted Rivers represent the historical backbone of pink stocks in the area. Although logging has occurred at various times in the history of these two watersheds, there is no clear correlation between escapement fluctuations and logging activity. Decline in pink stocks is more easily related to intensive fishing pressure, or more simply, overfishing. Depensatory mortality associated with flooding and predation by coho smolts, trout, sculpins, or birds could also keep pink stocks down. These same factors may also limit Vancouver River stocks, although obvious detrimental effects there have also been generated by dyking and channelization.

Vancouver Bay, the mouth of Vancouver River, could become site of a viable terminal fishery if pink stocks in this area were enhanced. In the past a fishery existed in the bay. The large school of fish exploited was felt to be schooling there prior to fresh water migration. Presently and historically, the bulk of these fish are assumed to migrate to the Skwawka and Deserted Rivers with only a small percentage going to Vancouver River. Exploitation of this school of fish must therefore be preceded by more precise knowledge of the composition and ultimate distribution of the mixed stocks.

Historical records indicate that large populations of pink and chum salmon are not mutually compatible in the Jervis-Sechelt area. Neave (1953) has noted this phenomenon for other parts of coastal British Columbia. So, although pink salmon are present only during odd years in the Jervis-Sechelt area, enhancement for chum in even years would not be advised. Facilities should focus on enhancing that species which historically was in greater abundance (e.g. pink salmon at Skwawka, Deserted and Vancouver Rivers, and chum at Vancouver and Tzoonie Rivers).

The rigid two-year life cycle of pinks does not allow for the stabilizing influence of mixed age classes in their spawning population. Abundance of pink salmon is determined by many mortality related factors. There are situations where a particularly high survival rate coupled with an increased escapement results in a break-through of the limits imposed by predation (Neave, 1953). This ultimately yields a quick and dramatic increase in pink salmon population levels. This can also happen in chum salmon populations.

Possible existence of population control by depensatory mortality in the Jervis-Sechelt combined with Neave's findings suggest the general direction in which pink and chum salmon should proceed. Increasing the number of fry migrating downstream should clearly be the goal of enhancement strategies and this can be arrived at by two different methods or a combination of the two.

The first strategy would be to increase the egg to fry survival through artificial means. The two possibilities currently in use today are incubation boxes and spawning channels. Incubation boxes produce a higher survival (85-95%) rate than do spawning channels (40-60%), but the incubation box requires a water supply which must be silt free; thus filters are usually necessary. Spawning channels, on the other hand, require a much lower degree of maintenance than do incubation boxes. Filtration, if necessary, can be obtained from a settling pond. Algae, freezing temperatures or flow interuptions are easily dealt with. However, a large expense incurred by spawning channels is the fact that the gravel must be replaced or cleaned every 3-4 years due to accumulations of silt and organic matter. A further negative aspect of spawning channels is the need for a great deal more land than is required for incubation boxes.

A possible alternative to incubation boxes or spawning channels is the theoretical incubation pit suggested by Marshall (1977). This system utilizes artesian groundwater upwelling through an incubation pit of gravel, thus eliminating the need for pumping or filtering. The International Pacific Salmon Fisheries Commission incubation pit for sockeye on the Pitt River is an example of this, with the exception that the water is pumped into the bottom

of the pit. Naturally the locations of such a system are restricted, but further efforts should be directed to sources of groundwater before such a proposal is discarded.

A second strategy would be to protect the adult salmon in the fishery by way of a complete closure (4-6 weeks), thus allowing for a large escapement composed of both early and late migrants. An obvious conflict arising from such a strategy would be with the harvesting of Fraser River sockeye in Johnstone Strait. This fishery would have to be closed since during this fishery incidental catches of pink salmon can be very high.

The third strategy would be to combine both a fishery closure with an incubation system or spawning channel. This would obviously produce the quickest results and would ensure that the limits imposed by predator-induced, depensatory mortality would be over-stepped. This strategy would be the most expensive in terms of lost dollars and capital outlay, but it might become necessary if present escapement levels, coupled with increased egg-fry survival, are still not sufficient to over-step the bounds imposed by depensatory mortality.

The situation on Vancouver River is somewhat unique in that natural spawning channnels, which have been cut-off by dyking, are available within the complex network of old flood channels. Controlled flow structures would not only re-water these channels, but also protect them from scouring. This could be done for the channels on the north side of the flood plain and also for the large channel on the south side of the flood plain where, it has been speculated, pinks formerly spawned in abundance. Also, the channelized section of the main river above the old logging

bridge could be rehabilitated. This would restore spawning gravel to the main river as well as opening up side channels on the north side of the river.

B. CHUM SALMON

Chum salmon enhancement opportunities in the Jervis-Sechelt area are not as great as those evident for pink salmon, as substantiated by historical escapement records. The two obvious streams which support the greater proportion of chum spawners are the Tzoonie and Deserted Rivers.

Since a number of the chum stocks co-exist with pink stocks in the river systems, the same pressures of intensive fishing and depensatory mortality affecting pinks could be responsible for the decline in chum stocks. Therefore, it is reasonable to assume that the same enhancement strategy designed for pinks can be applied to chum salmon. As noted earlier, the enhancement facilities could be utilized for both species, especially at Deserted River, since large stocks of both species have utilized the same spawning areas. Although smaller populations of chum salmon co-exist in Skwawka and Vancouver Rivers, interaction between the two appears to favor pink salmon. The Tzoonie River supported a large escapement of chum salmon and a very small escapement of pink salmon. Therefore, this river may represent an opportunity to enhance chum stocks in isolation.

RECOMMENDATIONS

A. PINK SALMON

i) The recommended method for enhancement of pink stocks on the Skwawka and Deserted Rivers is a spawning

channel. Some of the reasons for this suggestion lie with the added complication of filtering which is necessary for successful operation of incubation boxes. Also, both these rivers are fairly isolated and a spawning channel requires a lower level of maintenance. The large requirement for land for a spawning channel may not be a problem on the Skwawka river where a large flat bench exists on the west side of the river between 5 km and 6.5 km. This bench is within the main spawning area of pink salmon, but upstream from small glacial fed tributaries. Deserted River may have a problem related to the availability of suitable spawning channel sites. One of the few sites which could be easily protected from flooding is immediately below the falls. Although this is obviously at the upstream limits to spawning, sufficient stocks would easily be obtained.

ii) The recommended method for enhancement of pink stocks on the Vancouver River is controlled flow structures which would re-water cut-off side channels. Also, the channelization evident on the main river could easily be corrected by returning spawning gravel to the stream.

B. CHUM SALMON

i) The recommended method for enhancement of chum salmon on the Tzoonie River is an incubation system coupled with a supplementary fry feeding program. Although it would be preferable to operate this system on groundwater, experience in Oregon and British Columbia have shown that such systems work well utilizing

surface water. In either case, the incubated fry hatch earlier than natural fry, thus allowing completion of a feeding program prior to the natural downstream migration.

ii) Enhancement of chum salmon on the Deserted River and Skwawka River could be carried out in spawning channels in conjunction with pink salmon enhancement.

C. GENERAL

i) Where both pink and chum salmon are to be enhanced on the same river system, (e.g. Deserted River) extreme caution must be exercised to ensure that one species does not increase in abundance to the detriment of the other species.

ii) Further reconnaissance should be directed towards identifying groundwater sites (e.g. small source noted on the west side of Skwawka River at 6.4 km) so that the theoretical incubation pit system suggested by Marshall (1977) could be tested. If proven to be a successful technique, the incubation of chum salmon and possibly pink salmon could be dramatically simplified.

iii) If after several years of operation of these proposed facilities, stock still show no sign of increasing, then consideration should be given to a complete closure of the fishery. Increased survival from egg to fry of present escapements may be insufficient to overcome the limits imposed by predator-related, depensatory mortality. An increase in escapement caused by the fishery closure may be sufficient to accomplish this.

iv) If a large stock of pink and chum salmon is established in the Jervis-Sechelt area then the enhancement facilities should continue to operate. This would attempt to minimize large fluctuations in populations, particularly pink salmon, caused by depensatory mortality related to flooding and scouring. These facilities would be considered as refugia from such natural or man-induced phenomena.

v) Future harvesting strategy should include prior assessment of the ramifications of a possible mixed pink stock schooling in Vancouver Bay.

vi) If further research demonstrates that stock establishment techniques are successful, then a large transplant of pink salmon eggs from another system may be necessary to overcome depensatory mortality limits. This should be considered as a last resort after all else has failed, since the implications of genetic mixing are completely unknown.

REFERENCES

Anderson, A.D. 1977. The 1975 Return of Pink Salmon Stocks to the Johnstone Strait Study Area and Prospects for 1977. Fish. Mar. Ser. Tech. Report PAC/T-77-11.

Armstrong, R.W. 1973. Field Trip to Deserted and Skwawka Rivers to Determine the Availability of Coho Smolts for Pin Tagging. Memo to A.W. Argue on May 16, 1973.

Marshall, D.E., V.D. Chahley and L.L. Shannon 1976. Preliminary Catalogue of Salmon Streams and Spawning Escapements of Statistical Area 16 (Pender Harbour). Fish. Mar. Ser. Data Report PAC/D-76-1.

Marshall, D.E. 1977. A Theoretical Salmon Egg Incubation System for Use in Remote Areas. Memo to A.W. Argue on Aug. 8, 1977.

Neave, F. 1953. Principles Affecting the Size of Pink and Chum Salmon Populations in British Columbia. J. Fish. Res. Bd. Canada, 9 (9): 450-491.

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TABLE 1 ESCAPEMENT RECORD FOR STATISTICAL AREA 16

YEAR	SOCKEYE	CHINOOK	COHO	CHUM	PINK	STEELHEAD
1947	5,000	75	11,650	119,125	297,900	
48	,750	225	25,650	200,025	18,400	
49	5,000	75	15,975	125,200	42,050	
50	4,250	75	14,350	72,900	1,650	
51	7,000	75	13,375	79,675	120,175	
52	7,700	25	6,700	39,250	1,075	
53	1,531	75	10,825	52,950	107,100	
54	4,893	75	5,825	48,800	700	
55	5,829	75	12,025	23,700	59,075	
56	5,650	400	10,350	21,875	250	
57	7,800	75	9,500	57,625	102,700	
58	7,750	25	12,075	58,075	800	
59	28,250	25	9,150	97,050	116,500	
60	5,250		12,775	100,100		
61	2,250		13,150	65,775	124,175	
62	5,000	75	13,050	42,700	3,075	
63	11,000	50	18,875	25,650	220,275	
64	7,000	50	22,225	39,000	3,500	
65	2,250	50	8,650	16,700	43,275	
66	7,000		29,475	25,025	25	
67	10,000	100	10,470	16,100	24,710	
68	20,000	100	21,630	88,850	200	
69	3,700	100	20,800	84,550	32,600	
70	5,000	50	10,980	63,150	150	
71	8,500		13,685	37,355	47,625	
72	4,500		7,490	92,610		
73	1,500		10,450	91,720	10,830	
74	6,000		22,445	87,038		
75	16,000		13,105	47,586	27,350	
76	6,000		8,712	35,809		
77	1,200		13,538	96,872	25,899	

(Taken from Fisheries and Marine Service Catalogue of Salmon Streams and Spawning Escapments.)

TABLE 2 ESCAPEMENT RECORD FOR BRITTAIN RIVER

YEAR	SOCKEYE	CHINOOK	COHO	CHUM	PINK	STEELHEAD
1947				750	3,500	
48			1,500	1,500	750	
49			750	7,500	3,500	
50			75	3,500	200	
51			400	1,500	3,500	
52			75	750	75	
53			75	1,500	3,500	
54			75	1,500	75	
55			200	750	3,500	200
56			25	400	25	
57			400	1,500	3,500	
58			75	1,500	750	
59			200	750		
60			400	1,500		
61			1,500	750	3,500	
62			75	400	N/O	
63			750	25	75	75
64			400	25		25
65			75	75	N/O	25
66			400	200	N/O	75
67			200	10		100
68			200	100		200
69			500	3,000	2,000	200
70			100	150	100	
71			100			
72			300	1,000		
73			50	100	300	
74			100	500		
75				25	50	
76				50		
77			500	450	100	

(Taken from Fisheries and Marine Service Catalogue of Salmon Streams and Spawning Escapments.)

TABLE 3 ESCAPEMENT RECORD FOR SKWAWKA RIVER

YEAR	SOCKEYE	CHINOOK	COHO	CHUM	PINK	STEELHEAD
1947			3,500	35,000	100,000+	
48			15,000	15,000	750	
49			3,500	7,500	7,500	
50			25	75	N/O	
51			1,500	7,500	100,000+	
52			400	75		
53						
54			75	75		
55			1,500	1,500	35,000	
56			750	1,500		
57			750	1,500	75,000	
58			400	1,500		
59			750	1,500	100,000+	
60			1,500	3,500		
61			1,500	1,500	100,000+	
62		75	750	750	1,500	
63		25	3,500	400	200,000	75
64		25	3,500	1,500	3,500	75
65		50	1,500	75	35,000	75
66		N/O	7,500	400	25	75
67		100	2,000	50	22,000	UNK
68		50	3,000	3,000	200	
69		50	7,000	3,000	22,000	
70		50	2,500	6,500		
71			3,000	3,000	20,000	
72			1,500	8,000		
73			3,000	1,000	5,000	
74			8,000	3,000		
75			5,000	200	12,000	
76			3,000	250		
77			5,000		14,000	

(Taken from Fisheries and Marine Service Catalogue of Salmon Streams and Spawning Escapments.)

TABLE 4 ESCAPEMENT RECORD FOR DESERTED RIVER

YEAR	SOCKEYE	CHINOOK	COHO	CHUM	PINK	STEELHEAD
1947			1,500	35,000	100,000+	
48			3,500	7,500	15,000	
49			1,500	7,500	15,000	
50			1,500	15,000	750	
51			3,500	7,500	7,500	
52			750	7,500	400	25
53			750	7,500	100,000+	
54			750	3,500	400	75
55			3,500	3,500	15,000	200
56			750	3,500	75	
57			750	7,500	15,000	
58			400	7,500		
59			3,500	35,000	15,000	
60			3,500	7,500		
61			750	7,500	7,500	
62			750	1,500	N/O	75
63			1,500	3,500	15,000	75
64			750	3,500	N/O	75
65			750	750	7,500	25
66			3,500	750	N/O	75
67			500	4,000	1,000	100
68			1,000	20,000		100
69			1,500	12,000	2,000	200
70			3,000	30,000		
71			5,000	10,000	25,000	
72			2,000	30,000		
73			3,500	35,000	5,000	
74			6,000	25,000		
75			3,500	15,000	12,000	
76			2,000	2,500		
77			2,000	30,000	10,000	

(Taken from Fisheries and Marine Service Catalogue of Salmon Streams and Spawning Escapments.)

TABLE 5 ESCAPEMENT RECORD FOR VANCOUVER RIVER

YEAR	SOCKEYE	CHINOOK	COHO	CHUM	PINK	STEELHEAD
1947			750	3,500	15,000	
48		25	1,500	3,500		75
49			750	7,500	3,500	
50			75	3,500		75
51			1,500	1,500	7,500	
52			75	3,500	75	UNK
53			200	3,500	1,500	
54			75	1,500	75	
55			400	1,500	3,500	200
56			400	3,500	25	
57			200	3,500	3,500	
58			1,500	7,500		
59			200	1,500	750	
60			1,500	3,500		
61			1,500	3,500	3,500	400
62			750	3,500		200
63			750	75	750	200
64			750	75	N/O	75
65			200	25	N/O	75
66			75	400	N/O	75
67			10	100	10	100
68			200	2,200		200
69			100	1,000	2,500	200
70			100	1,200		
71			100	500	1,000	
72			100	2,500		
73			50	8,000	500	
74			100	4,500		
75			3,500	200	200	
76			3,500	500		
77			2,000	750	1,000	

(Taken from Fisheries and Marine Service Catalogue of Salmon Streams and Spawning Escapments.)

TABLE 6 ESCAPEMENT RECORD FOR TZOONIE RIVER

YEAR	SOCKEYE	CHINOOK	COHO	CHUM	PINK	STEELHEAD
1947	1,500	75	3,500	15,000	75,000	75
48	750	200	3,500	35,000	200	75
49	1,500	75	3,500	35,000	7,500	25
50	750	75	3,500	35,000	25	25
51	3,500	75	1,500	35,000	400	75
52	200	25	750	7,500	25	75
53	400	75	200	3,500	400	
54	750	75	75	15,000	25	25
55	750	75	3,500	7,500	200	
56	3,500	400	3,500	1,500	25	
57	3,500	75	3,500	15,000	3,500	
58	3,500	25	7,500	15,000	25	
59	7,500	25	3,500	35,000	200	
60	750	N/O	3,500	35,000		
61	1,500		3,500	15,000	7,500	750
62	1,500	N/O	7,500	15,000	75	75
63	3,500	25	7,500	7,500	3,500	75
64	3,500	25	7,500	15,000	N/O	200
65	1,500	N/O	3,500	3,500	750	200
66	3,500	N/O	7,500	7,500	N/O	200
67	4,000	N/O	3,000	5,000	1,500	200
68	6,000	50	10,000	20,000	N/O	300
69	2,500	50	5,000	21,000	2,500	200
70			2,500	1,200		
71			3,000	11,000	1,500	
72			1,000	12,000		
73			2,000	11,000	30	
74	N/O	N/O	5,000	25,000		
75				11,000	50	
76			1,000	20,000		
77			1,000	20,000	250	

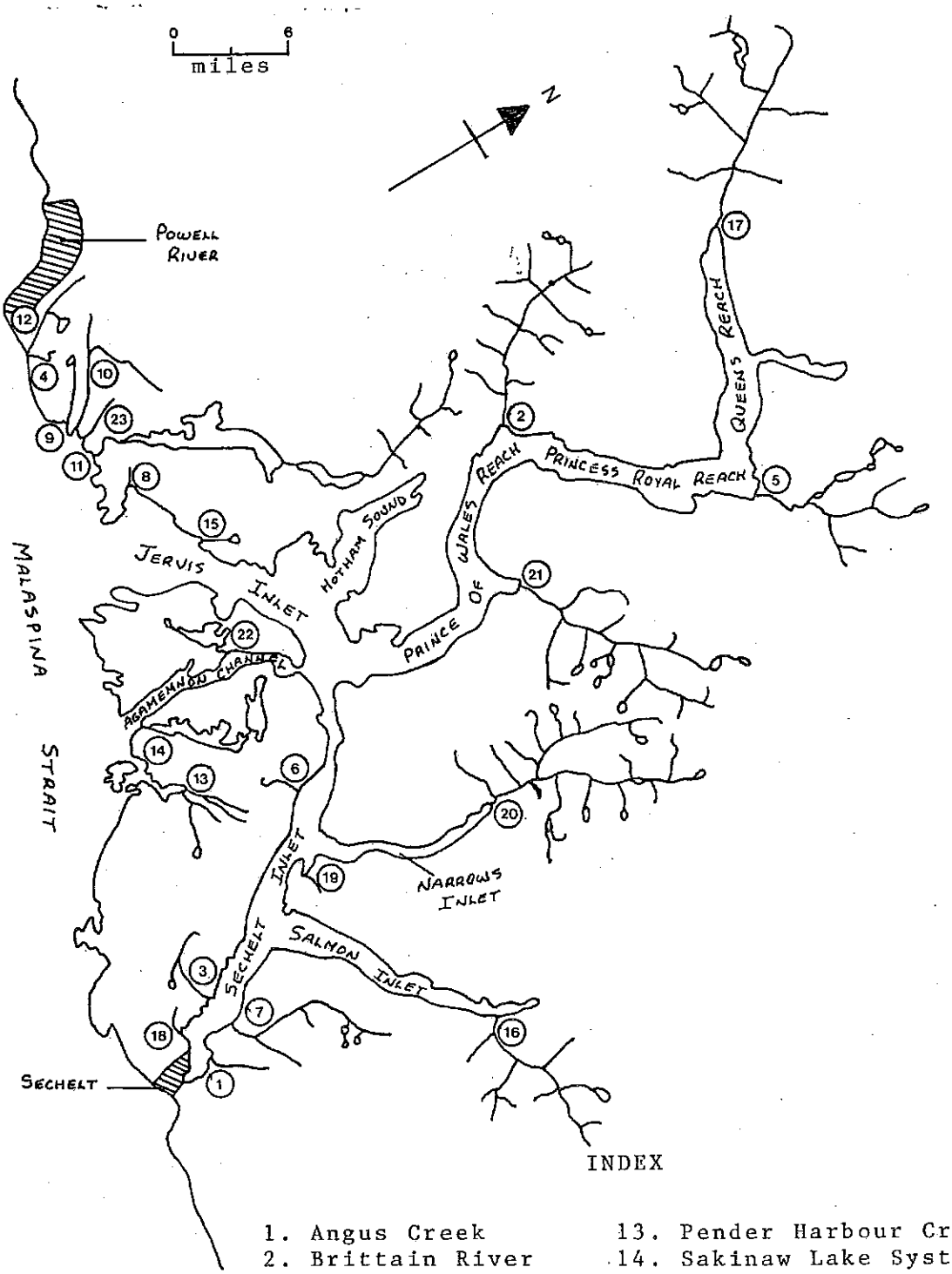
(Taken from Fisheries and Marine Service Catalogue of Salmon Streams and Spawning Escapments.)

TABLE 7 ESCAPEMENT RECORD FOR SECHELT CREEK

YEAR	SOCKEYE	CHINOOK	COHO	CHUM	PINK	STEELHEAD
1947				3,500	3,500	
48				1,500	200	
49				1,500	750	
50				750	200	
51				1,500	400	
52				750	75	
53				750	400	
54				200	75	
55				75	1,500	
56				200	25	
57				750	400	
58				200		
59				1,500	200	
60				200		
61				200	1,500	25
62			25	75		
63			N/O	N/O	200	
64			N/O	75	N/O	25
65			25	25	N/O	25
66			25	25	N/O	25
67			50	N/O	200	
68			50	100	N/O	50
69			50	100	100	50
70				75		
71			25	N/O	75	
72				10		
73				N/O		
74						
75					3,000	
76				6		
77				50	500	

(Taken from Fisheries and Marine Service Catalogue of Salmon Streams and Spawning Escapments.)

Figure 1 SALMON SPAWNING STREAMS
STATISTICAL AREA 16



1. Angus Creek
2. Brittain River
3. Carlson Creek
4. Dayton Creek
5. Deserted River
6. Doriston Creek
7. Gray Creek
8. Jefferd Creek
9. Kelly Creek
10. Lang Creek
11. Lois River
12. Myrtle Creek
13. Pender Harbour Creeks
14. Sakinaw Lake System
15. Saltery Bay Creek
16. Sechelt Creek
17. Skwawka River
18. Snake Bay Creek
19. Storm Bay Creek
20. Tzoonie River
21. Vancouver River
22. West Lake Creek
23. Whittal Creek

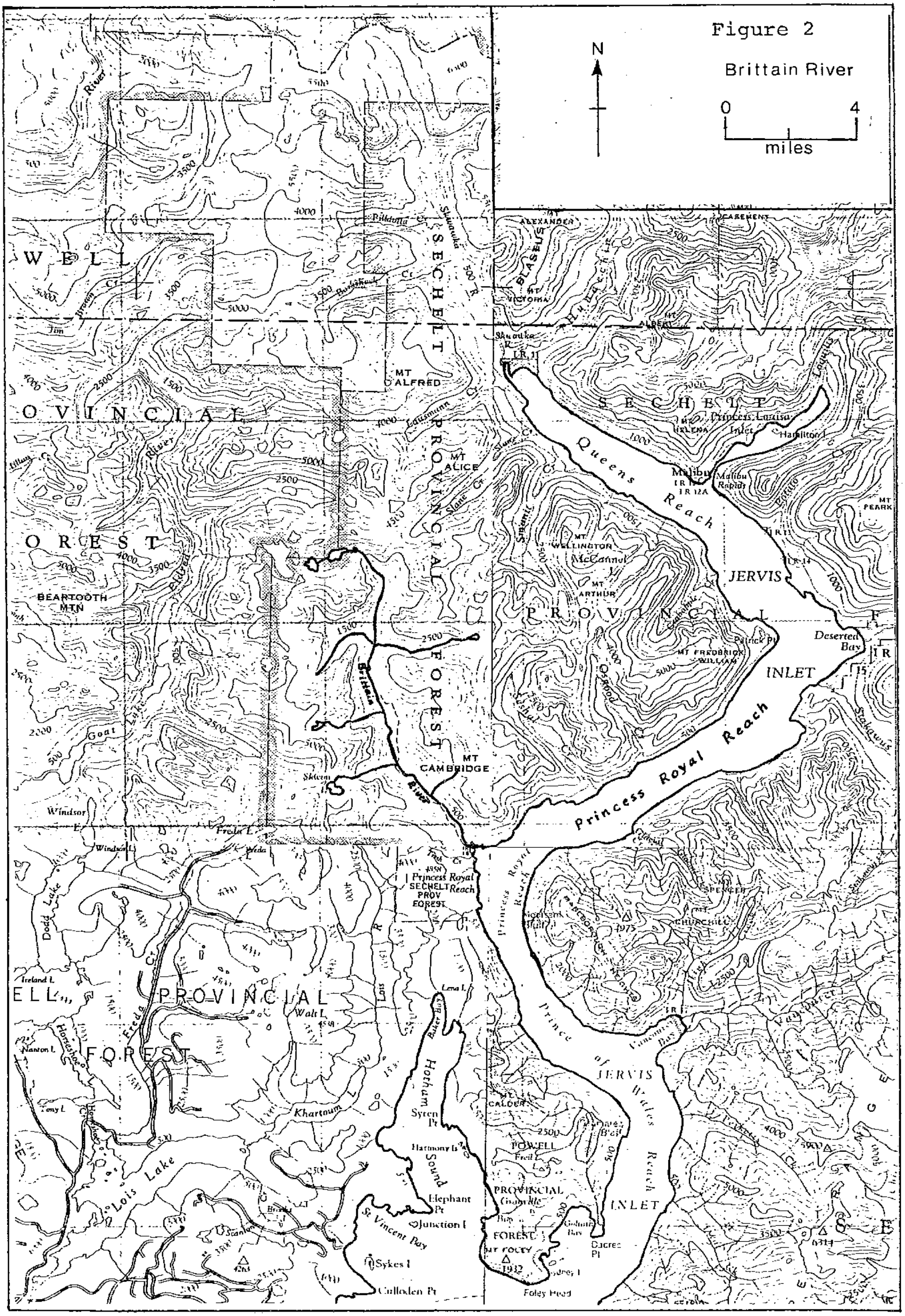
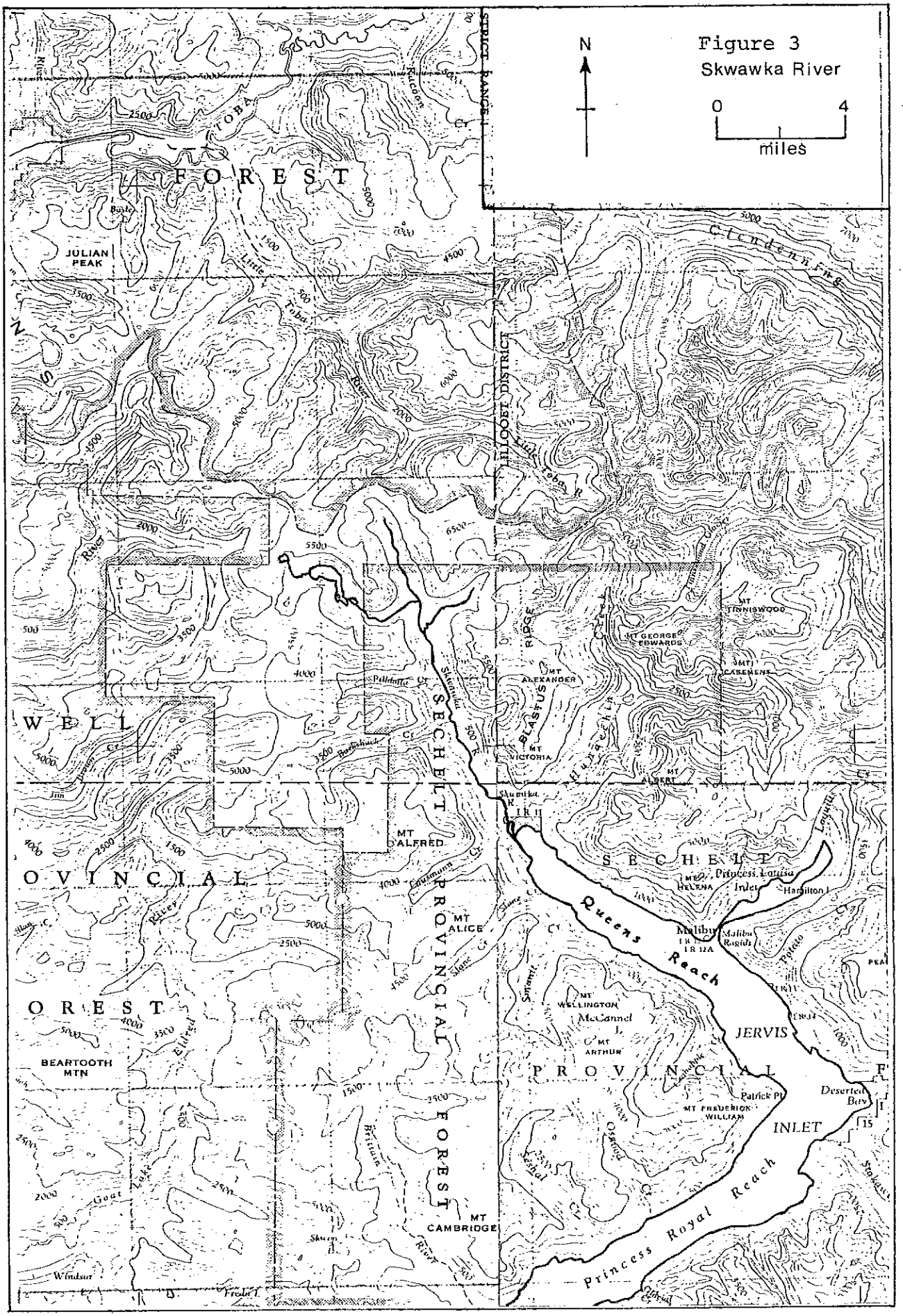
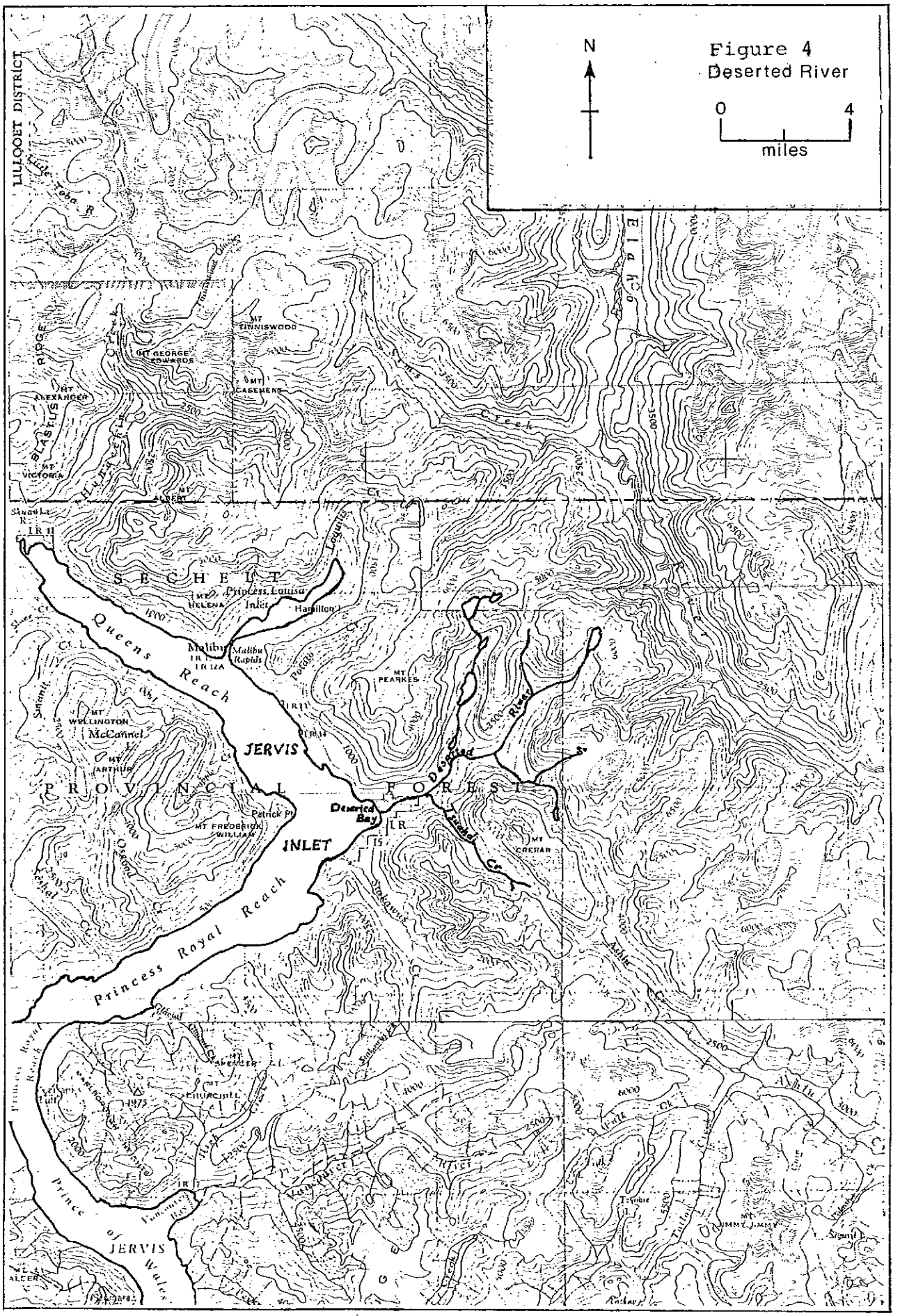


Figure 2

Brittain River


N
Figure 3
Skwawka River
0
4
miles
STRUCT RANGE
TOBA
FOREST
JULIAN PEAK
Little Toba River
Toba River
Clendenning
HILLCOAT DISTRICT
Skwawka River
MT ALEXANDER
MT VICTORIA
MT ALBERT
MT GEORGE EDWARDS
MT TINNISWOOD
MT CASEMENT
RIDGE
SECHELT
MT ALFRED
MT ALICE
MT CAMBRIDGE
BEARTOOTH MTN
PROVINCIAL FOREST
Princess Louisa Inlet
Hamilton I
Queens Reach
Malibu Rapids
MT WELLINGTON
McConnel L
MT ARTHUR
JERVIS INLET
PROVINCIAL PARK
Patrick Pt
MT FREDERICK WILLIAM
Princess Royal Reach


N
Figure 4
Deserted River
0
4
miles
LILLOOET DISTRICT
Blue Tabor R.
Eiako
Creek
MT TINNISWOOD
MT GEORGE EDWARDS
MT LEASEHEAD
MT ALEXANDER
BLASIUS RIDGE
MT VICTORIA
MT ALBERT
IR II
S E C H E L T
Princess Louisa Inlet
MT HELENA
Hamilton
Queens Reach
Malibu
Malibu Rapids
IR 12
IR 12A
MT PEARKES
MT WELLINGTON
McConnel
MT ARTHUR
JERVIS
P R O V I N C I A L F O R E S T
Deserted River
Deserted Bay
Patrick Pt
MT FREDERICK WILLIAM
IR 15
INLET
MT CRERAR
Princess Royal Reach
MT SPENCER
MT CHURCHILL
Prince of Wales
JERVIS
MT ALLEN
MT JIMMY JIMMY

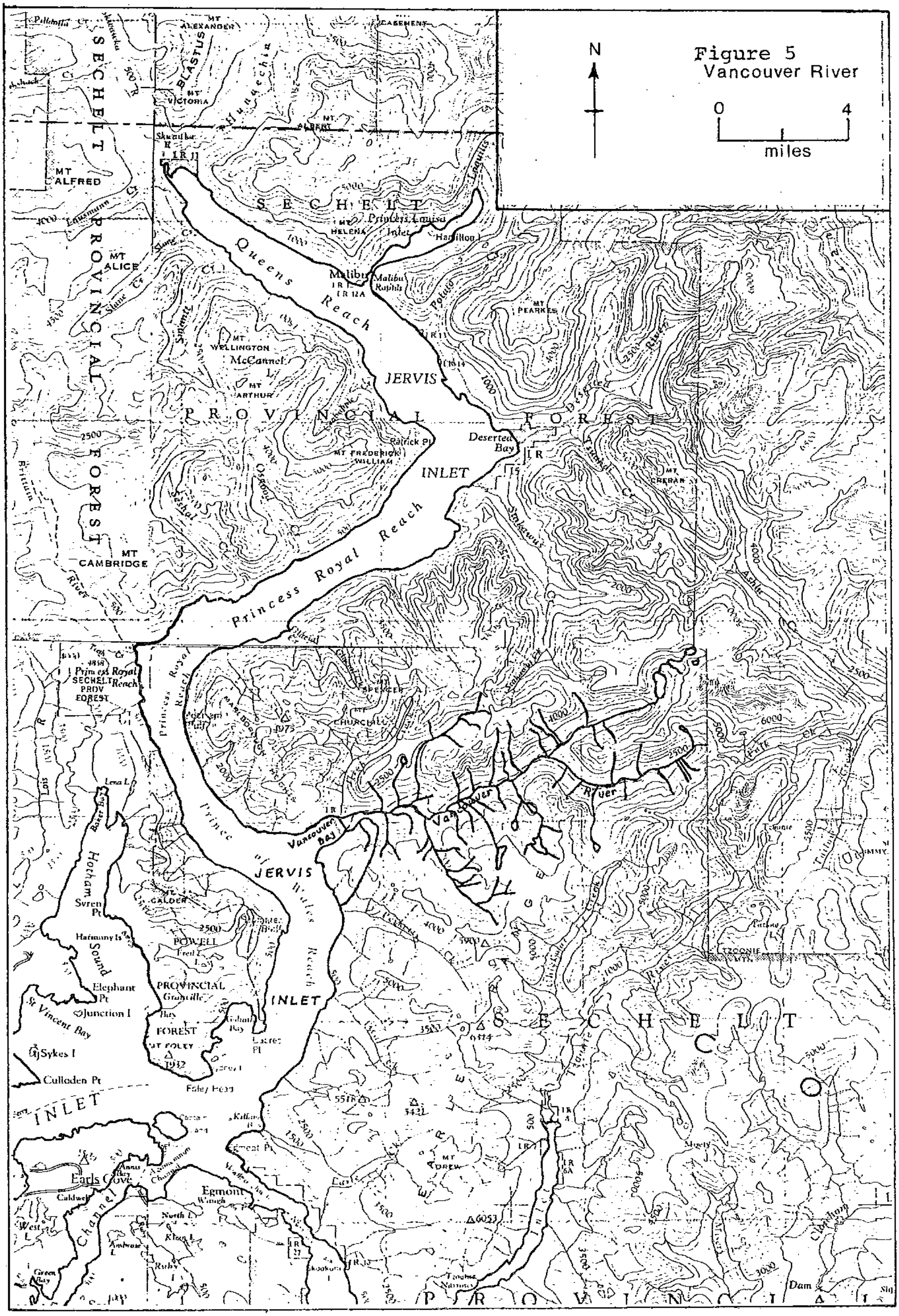
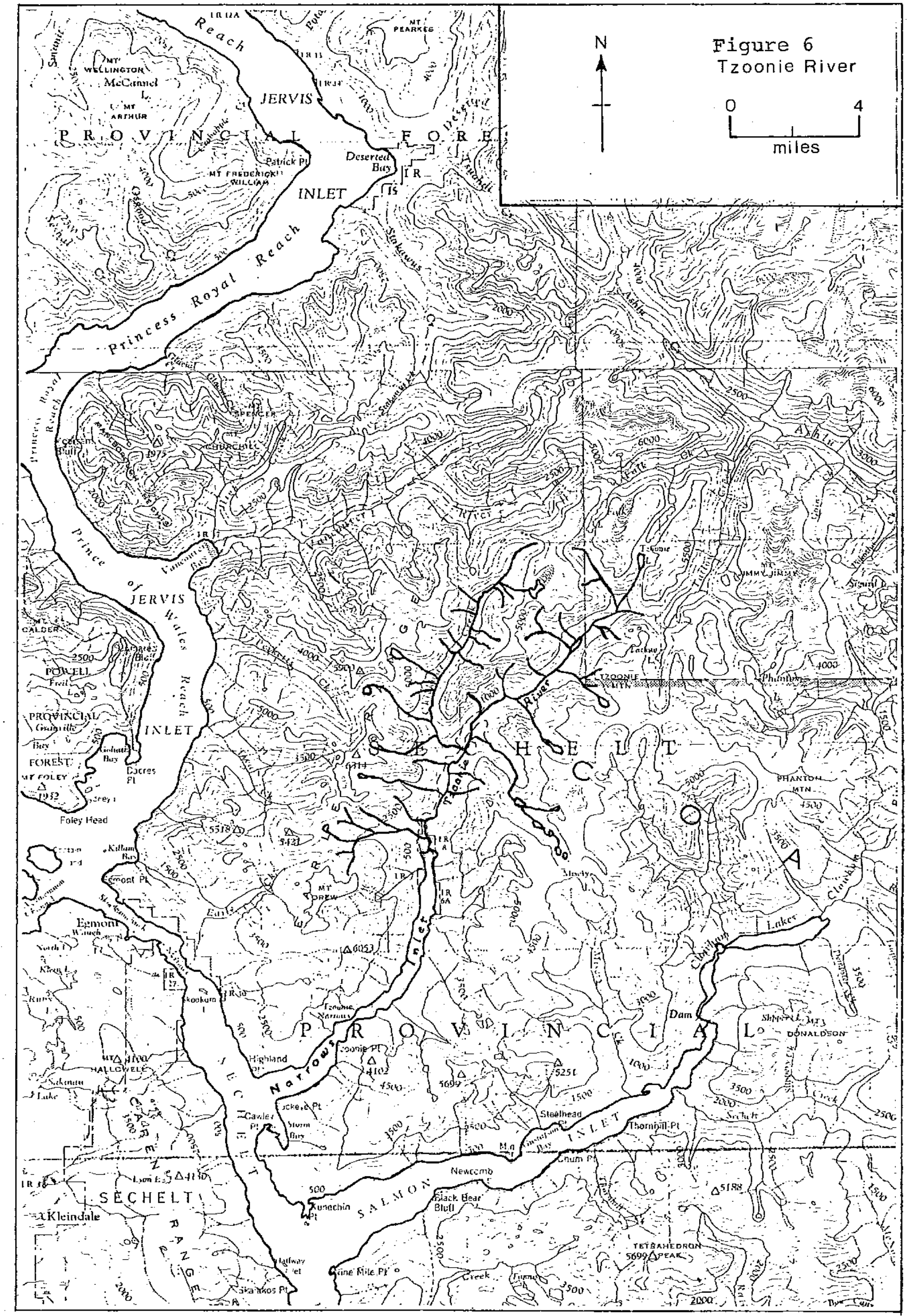


Figure 5
Vancouver River


N
Figure 6
Tzoonie River
0
4
miles
JERVIS
INLET
Princess Royal Reach
Prince of Wales Reach
PROVINCIAL FOREST
SECHELT
Narrows Inlet
SALMON INLET
TZOONIE MTN
PHANTOM MTN
DONALDSON
TETRAHEDRON PEAK
Clowhom Lakes
Egmont
Kleindale
Newcomb
Foley Head
Dam

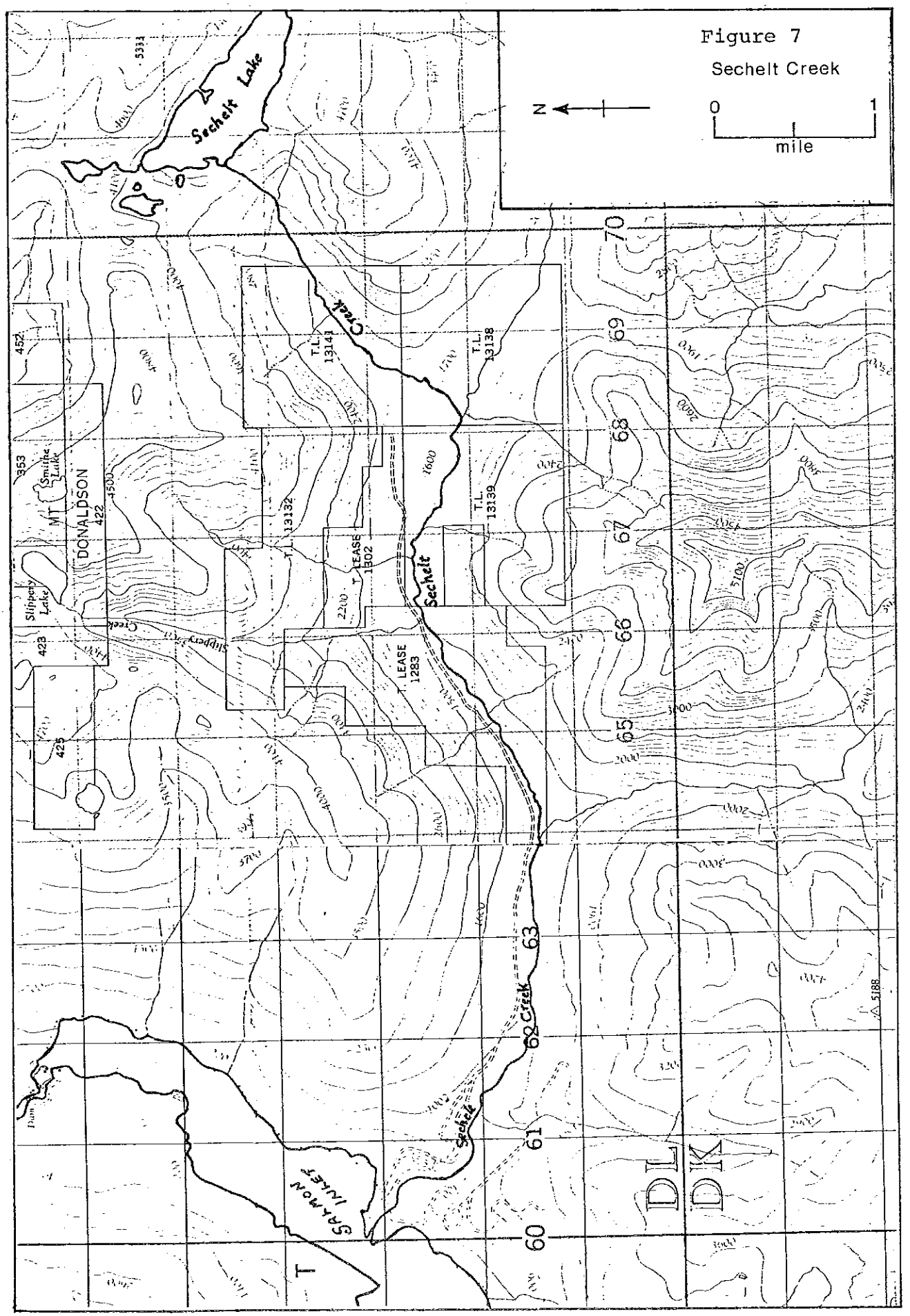


Figure 7
Sechelt Creek
N
0
1
mile
Sechelt Lake
Sechelt Creek
T.L. 13141
T.L. 13138
T.L. 13139
T.L. 13132
T. LEASE 1302
T. LEASE 1283
DONALDSON MT
422
Smiths Lake
Slippery Lake
Slippery Creek
423
425
452
353
SAKINAW LAKE
Sechelt
62 Creek
DL
DK
T
70
69
68
67
66
65
63
61
60