Skeena River Sockeye Escapement and Distribution

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ABSTRACT

Population estimates made from observations on the number of sockeye salmon in the various spawning streams of the Skeena River, B.C., during the period 1944-48 are presented. The methods used include a fence count at Babine Lake, the most important spawing area, supplemented by stream counting in the other areas and sample tagging at Lakelse. Estimates made at Babine by the latter methods were compared with the fence counts; the stream count estimates were about one-third of the actual number present, whereas estimates from tagging were about twice the actual.

A brief description of the spawning streams of the Skeena is accompanied by a map showing their location. Best estimates of 1946-47 escapements to major spawning areas are: Babine, 480,000; Morice, 70,000; Bear, 42,000; Lakelse, 29,000. These comprise 92 per cent of the total for the river system. The area of the spawning beds used by sockeye in the system is about 100 acres, or of the order of 1.5 square yards per spawning pair. The division of the whole run is approximately 45 per cent to the commercial fishery, 6 per cent to the Indian fishery, and 49 per cent escapement.

INTRODUCTION

The need for adequate statistics in assessing the status of any fishery has been increasingly apparent. To answer questions pertaining to possible decline in commercial catches, or interrelation of egg deposition and adult returns, reliable information on the number of fish surviving to maturity is of prime importance. For the highly valuable sockeye salmon (*Oncorhynchus nerka*) of the Pacific coast, all of which die following their single fresh-water spawning run, variation in the annual catch might be expected to be a rough measure of variation in the total maturing population. However, catch figures for the Skeena River, B.C., show no significant relation to spawning ground estimates ($r = +0.38$; $P.05 = 0.51$; Brett, 1950a). In order to draw any conclusions on the success of a particular year's spawning, escapement records of accuracy comparable with catch figures are necessary.

In undertaking to make a biological survey of the Skeena River (Pritchard, 1947b) the Fisheries Research Board of Canada was confronted with the problem of escapement determination. During the first five years of investigation (1944-48) a large proportion of the time was devoted to this endeavour. A steady improvement in technique and expansion of the area covered has done much to provide greater accuracy, yet room for improvement is quite apparent. The following report has been prepared to make these data available and to provide a figure which is, of necessity, a product of opinion as well as empirical count. It presents (1) the various methods employed for determining the escapements to each known spawning area, (2) the spawning estimates made for the years 1944 to 1948, and (3) maps of the sockeye distribution in the Skeena watershed.

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METHODS OF ESTIMATION

Methods of estimating spawning salmon range from making spot counts and eye appraisals of the number on major spawning beds to recording an actual count by means of a fence or weir. On the Skeena River all general surveys have relied on stream counting as a basis for estimating a total run. Some regions like Kitsumgallum Lake have been visited once per year at a time when the run was reported to be at its peak. This particular region, like Morice Lake, is characterized by heavily silted creeks which obscure the salmon. The counts at best are minimal and it is up to the observer to judge what the total run might be from these scant data. In another area, like Lakelse Lake, where visibility is good in practically every case (temporary turbidity in some creeks) and repeated visits can be made, much greater opportunity for accuracy of estimation is provided.

Although a considerable variety of conditions was encountered in the spawning streams of the Skeena, the sockeye habit of spawning in the relatively small streams occurring above lakes made it possible to inspect the majority of these by wading. With the exception of three rivers (Babine, Fulton and Morice), the average widths for the spawning areas of the 36 streams listed in Table IV is 7.7 yards (7.0 metres). Sockeye are frequently observed holding over in pools but spawning appears to be mainly restricted to depths within wading limits. Either permanent (Babine and Lakelse Lakes) or seasonal camps (Alastair, Bear, Kitsumgallum, Kitwanga, Morice, and Morrison Lakes) were established at most of the lakes with runs of 5,000 sockeye or more, so that subsequent inspections of shorter duration provided estimates drawn up by comparison with more extensive surveys.

The frequency with which streams must be visited is problematical. The interval of inspection should be determined from the duration of stream life of the species of salmon, particularly if those counted cannot be marked in some practical manner. If the stream is observed every ten days to two weeks (the average stream life of a mature sockeye) then an additive total of the *living* fish provides the result. If the frequency is greater, the estimate becomes some fraction of the total, while if the frequency is less it becomes some multiple of it.

Total counts of *dead* fish, even in small streams where careful removal or marking has been employed during repeated visits, show discrepancies with counts from *live* fish. In larger streams with deep pools, counts of dead fish are virtually impossible.

Only in one particular case on the Skeena has the accuracy of the stream counting method been put to a direct test. In 1946 an adult counting fence was completed across the Babine River (Figure 1). The stream observations were carried out in that year and 1947 in exactly the same manner as for past years and for similar type counts in other areas. The discrepancy obtained was:

Year	*Total stream count*	*Total fence count*[a]	*Discrepancy*
1946	207,200	455,700	54 per cent
1947	240,700	495,600	51 per cent

[a]Less Indian catches.

The observed estimate from stream counts is only about one-half the actual total. The reason for such a difference is somewhat of a mystery. That stream counts will be minimal is apparent by their very nature, but the discrepancy is beyond such expectations. No lake spawning has been observed, nor any stream left uninspected. It would appear that when large numbers of fish are present in single streams, considerable error may be introduced despite conscientious effort.

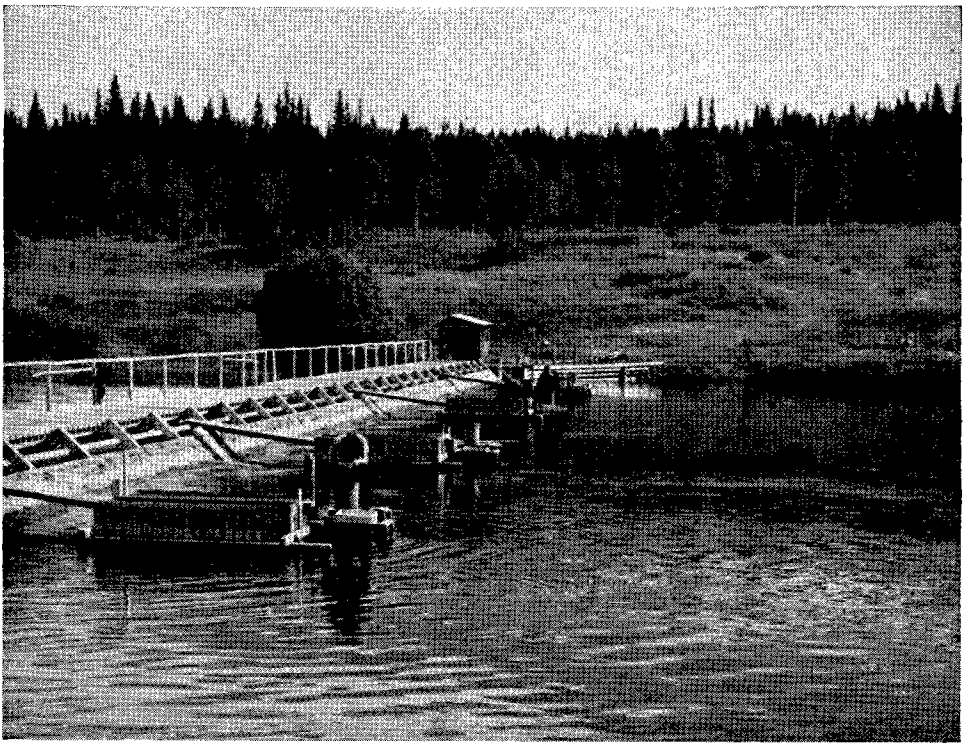

FIGURE 1. Upstream side of the counting fence across the Babine River. Glass viewers placed over white chutes were used to facilitate counting.

Each year at Lakelse Lake a system of tagging a number of adults (usually about 1,000 to 2,000) and releasing these to mingle in the lake with the total population was used to make a simple calculation of the run (Pritchard and Brett, 1945). It presupposes (1) that the fish obtained for tagging are not selected, (2) that these tagged fish become randomly distributed throughout the population, (3) that the addition of the tags does not materially affect the fish either in migratory habits or in survival period, (4) that a tagged fish is neither more readily nor less readily observed than an untagged one, and (5) that tags are not lost, nor are tagged fish selectively removed, between time of tagging and time of counting. To date it has been concluded that these assumptions were fairly well founded at Lakelse Lake, a small, shallow, uniform lake. The tagging operation was performed on fish seined from schools in Blackwater Bay when the

majority of the total run had entered the lake. Within a few days tagged fish have usually been observed or caught at the opposite end of the lake scattered throughout a school. In addition it seems improbable that the experience of being tagged is one which seriously affects adult salmon when the period between tagging and spawning is only a matter of a few weeks. They are capable of surviving the most gruelling of water courses prior to spawning and the insertion of a tag would appear to be a minor trial by comparison with the major adversities which they survive. In stream surveys at Lakelse the attempt was made to observe or handle every fish. It was felt that the presence or absence of a tag did not affect the probability of observing either the fish or the tag.

Efforts have been made to check this system at Lakelse through the introduction of an adult fence. The fence itself has proven to be inadequate for satisfactory operation, so the absolute test has yet to be performed. At Babine Lake, however, the results from proportionate tagging were checked. During two years of operation when complete enumeration of the run was possible, tags were affixed to sockeye salmon proportionately throughout the migration. In 1946 the number tagged on any given day was one-fiftieth of the number passed through the weirs on the previous day. This one day lag was shortened to half a day in 1947 and the proportion changed to one in one hundred.

In Table I the observed and calculated totals are presented. These figures will be found to differ slightly from those listed in other reports as they have been adjusted for Indian catches. An Indian fishery operates in the Babine River a few miles above the point of tagging and at several points on the lake. A record of these catches has been deducted to provide the number of tagged and untagged fish which travelled unmolested to the spawning grounds.

TABLE I. The number of sockeye (less Indian catches) observed at Babine Lake in 1946 and 1947.

	1946			1947		
	Untagged	Tagged	Total	Untagged	Tagged	Total
Number present in the lake	447,372	8,281	455,653	491,303	4,257	495,560
Number observed						
1. Live in streams	120,810	1,074	121,884	103,872	450	104,322
2. Dead in streams	49,287	517	49,804	34,878	248	35,126
Calculated total						
1. From live tag ratio			931,500			982,600
2. From dead tag ratio			789,000			598,700

These figures demonstrate that an error of as much as 100 per cent can occur from using ratios based on live tagged fish and that although the dead tagged observations give a better assessment they may also err from 22 per cent

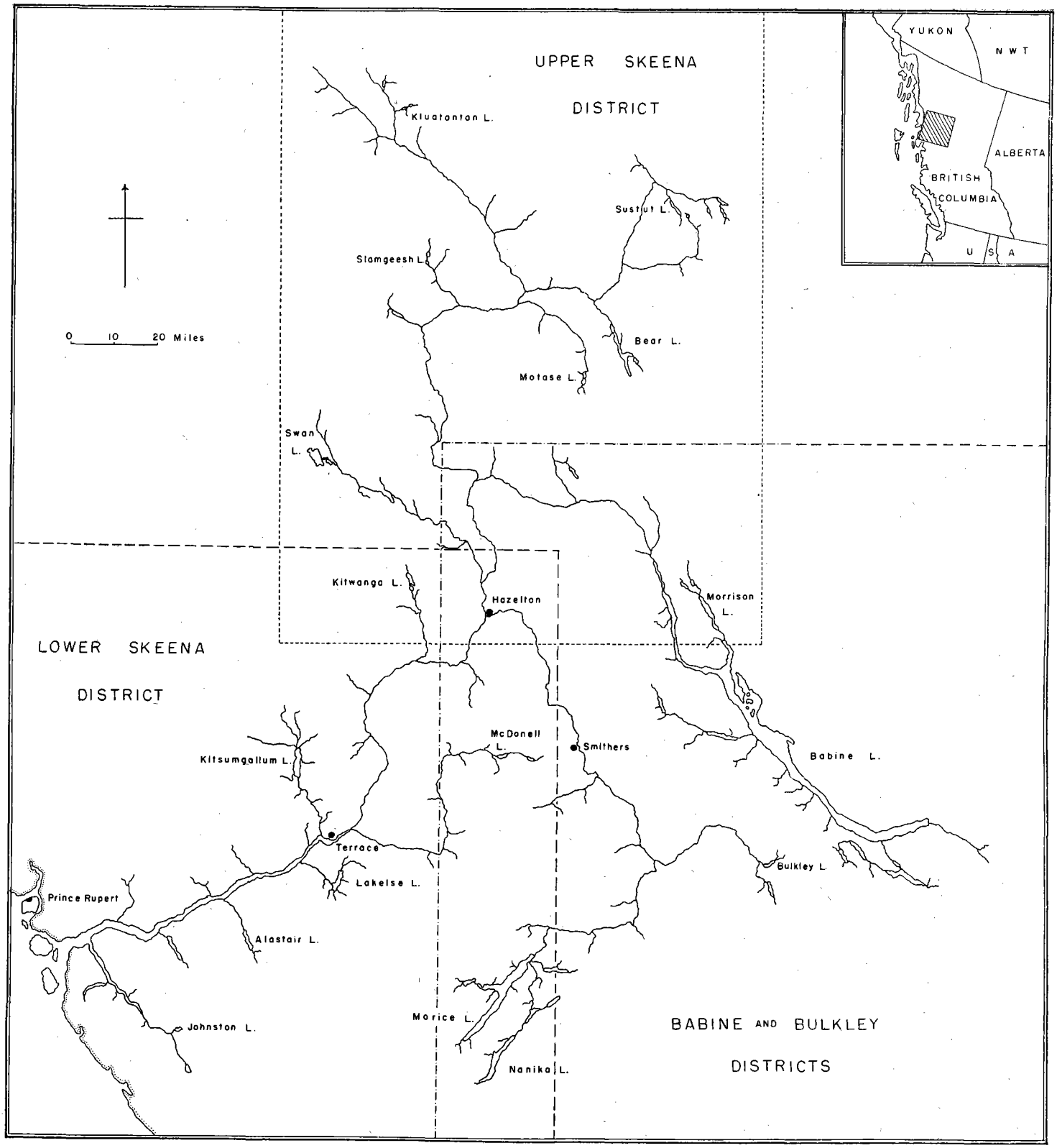

FIGURE 2. Map of Skeena river showing subdivision into districts. The lines blocking off the districts are equivalent to the size of the maps in Figures 3 to 5.

(1947) to 77 per cent (1946). From the known ratio of tagged to untagged in the lake for 1947 the number of dead tagged sockeye expected to occur in an observed stream total of 35,126 equalled 302. The actual was 248. By a chi-square test this is significantly different from the expected (P=.01) so that even the best assessment indicates that some factor, or factors, affects the distribution or observation of tagged fish under the conditions at Babine Lake. The fence is well constructed and has provided no reason to consider it other than fish tight; nor has there been any indication of lost tags.

This result would appear to discredit the evaluations made at Lakelse Lake, which cannot be denied. However, certain differences exist in the two cases which may account for some of the error found at Babine Lake. Babine is close to 100 miles in length with an irregular shore line (Withler *et al.*, 1949) while Lakelse, as stated, is small and comparatively uniform (Brett, 1950b). The chances for variation to occur in Babine with a much greater distance between point of tagging and point of recapture may make a significant difference if distance proves to be an influencing factor.

OBSERVED DISTRIBUTION AND ESTIMATES OF SPAWNING

For convenience in presentation, the Skeena River drainage has been divided into four districts, namely, the Lower Skeena, the Upper Skeena, the Babine and the Bulkley (Figure 2). Each district is dealt with separately. Estimates for the runs to the known spawning streams, with the condition and probable area of the spawning grounds are included in Table IV.

Lower Skeena

From its outlet near Prince Rupert to the first point of major stream division at Hazelton the Skeena River lies in a N.E.-S.W. direction with inflowing streams mainly at right angles to this axis. Despite the many such streams there are only a few scattered lakes to interrupt their flow and, of these lakes, only six have been found to support sockeye in the Lower Skeena area (Figure 3). In order of location from west to east they are:

1. JOHNSTON LAKE, located in the Ecstall River drainage, is just beyond tidal influence. Sockeye have been observed spawning on a few gravel bars in the lake. No recent records point to a more extensive spawning area although a background of intensive commercial fishing may have reduced the numbers and hence the apparent spawning beds. Prior to 1936 gill-netting was permitted in the Ecstall River. From counts of sockeye spawning around the shores of the lake in late August, 1946, a limit of 1,000 was assigned as a total run to this area. At present there seems no reason to believe the run would exceed such a figure.

2. ALASTAIR LAKE, located on the south side of the Skeena River just over 40 miles from the coast, drains into the Skeena via the Gitnadoix River. Two unnamed streams both support an early (August) and late (October) run of sockeye. One, a branch of the other, provides about three-quarters of a mile of good spawning grounds. To this may be added one mile of excellent gravel

in the larger stream. For convenience these have been labelled "South End" creeks. A very small creek ("West Side" creek) close to the south end of the lake supports a surprising number of sockeye for its limited size. Repeated visits will be necessary to establish the occurrence of both early and late runs.

3. LAKELSE LAKE, located on the south side of the Skeena and 12 miles by road from the town of Terrace, is drained by the Lakelse River. For its area (5.47 square miles) Lakelse Lake supports one of the largest sockeye runs in the Skeena system. Its major spawning stream, Williams Creek, has excellent beds of medium coarse gravel. A branch creek (Eliza Creek) provides additional gravel beds for sockeye entering the former. Of the remaining eight streams only Scully Creek to the south maintains a noteworthy run, and Granite Creek has had a varied history of supporting a few thousand spawners down to the present few hundred. The temporary operation of a hatchery followed by stream obstruction near the outlet have been important factors affecting Granite Creek. The remaining streams account for so few sockeye they do not warrant separate mention. The total Lakelse run has been estimated at from 15,000 (1948) to 57,000 (1945). Releasing tagged fish has helped confirm these figures, as has comparison with more complete data obtained in 1939, the only year when a counting fence was operated in Williams Creek (Pritchard and Cameron, 1939). On this occasion a count of 24,085 sockeye was obtained at the fence and an estimate of between 33,000 and 40,000 made for the complete run to the lake.

4. KITSUMGALLUM LAKE, located on the north side of the Skeena and almost on the same parallel of longitude as Lakelse Lake, is drained by the Kitsumgallum River. The lake is very opaque as a result of a heavy suspension of silt discharged by most of the inflowing streams. Those which run off the east and west slopes are too precipitous or too silted for sockeye spawning. The remainder enter at the north end and, either from silting or sluggish flow (Beaver River), offer comparatively limited spawning for the size of the streams. For nearly a mile along the northeast shores of the lake a few hundred sockeye can be observed spawning each year. Good gravel beds and a seepage of clear water characterize this shoreline.

5. MC DONELL LAKE, located in the headwaters of the Copper (or Zymoetz) River, is over 60 miles by water from the Skeena River. It is the largest of a series of three lakes, two of which (Denis and Aldrich) lie beyond McDonell Lake and are connected with it through the extension of the Copper River. Sockeye spawning is confined to scattered beds over three to four miles in the middle of a nine-mile stretch between McDonell and Denis Lakes. A few sockeye pass through Denis Lake and spawn in the lower end of the connecting link between it and Aldrich Lake.

6. KITWANGA LAKE, located north of the Skeena River and on the western margin of the Interior Plateau, is connected to the Skeena by the Kitwanga River. The one main tributary to the lake enters at the northeastern margin from extensive muskeg and willow flats. This unnamed creek (referred to as "North End" Creek in Figure 3 and Table IV) is slow-flowing and about five feet deep at its outlet. Repeated efforts to discover how effective this stream was for spawning

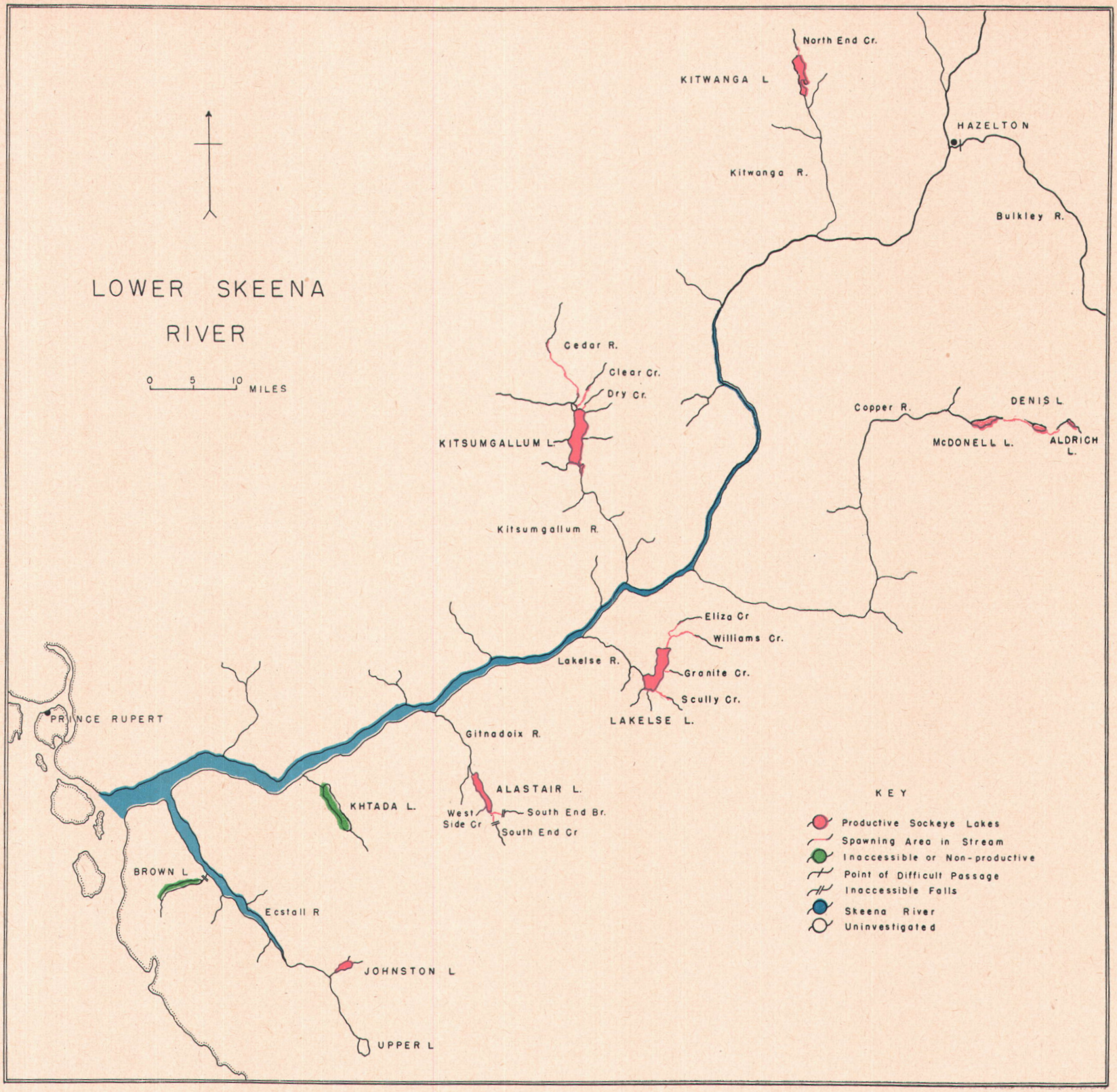

FIGURE 3. Map of Lower Skeena district. (See Figure 3 for key.)

have never revealed more than a few hundred sockeye in its lower reaches. The conclusion has been that the many hundreds of sockeye which enter the Kitwanga River and successfully escape the Indian fishery en route must spawn in the lake. Spawning beds have never been discovered in the lake but ripe sockeye have been netted at various points and old carcasses reported drifted ashore. Some indication of the run can be had from Indian catch records and from counts made of sockeye moving over shallow bars in the Kitwanga River.

The sockeye spawning in the Lower Skeena area can be summed up as mainly confined to eight creeks tributary to four lakes, with two lakes providing additional spawning beds along their shores. Williams Creek at Lakelse Lake is probably the most important, but the "South End" creeks of Alastair Lake may better the former in some years. Not one of these lakes exceeds 7 square miles in area and the average is 4.3 square miles. Thus, the total lake area relative to sockeye spawning is not great.

Upper Skeena

The portion of the Skeena which drains the northern limits of the watershed has often been called the Upper Skeena (Figure 4). Merging with the flow from Babine Lake to the southeast it joins the Bulkley River to form the Lower Skeena. At this junction the town of Hazelton is located, marking the former limit of upstream shipping by the stern-wheelers which used to navigate the Skeena. The first tributary of importance to the Upper Skeena is the Kispiox River, at the head of which a series of small lakes is situated. These lakes and the remaining lakes carrying significant runs of sockeye in the Upper Skeena district are considered briefly below.

1. The LAC-DA-DAH basin, the Indian name given to the chain of lakes at the upper limit of the Kispiox River, includes SWAN, CLUB and STEPHENS LAKES. They drain in this order into Stephens Creek which meets the Kispiox River about 60 miles from the Skeena. In this group only two significant spawning grounds have been located and these are quite limited in area. The uppermost is that in Falls Creek, a small stream with spawning restricted to a lower 450 feet of stream bed by a series of impassable falls. The second is in Club Creek lying between Club Lake and Stephens Lake. The gravel in the lower portion of this creek is quite suited to salmon spawning, but the creek is heavily studded with boulders over portions of its remaining course. Oddly enough sockeye can be found depositing eggs in this boulder-strewn section, but the production per unit area must be comparatively low. Two small zones can be added to the above. A few square yards of gravel bed have been observed to carry spawning salmon in the short stretch between Swan and Club Lakes and also in Stephens Creek.

2. Over 150 miles upstream from Hazelton lie two small lakes, DAMSHILGWIT and SLAMGEESH. They are linked together by the Slamgeesh River which continues south for one quarter of a mile to join the Kilankis River and thence discharges into the Skeena. One small stream, Damshilgwit, drains the low flats to the north. Each of these streams, Damshilgwit and Slamgeesh, supports a small

run of sockeye and collectively have been estimated to carry a total run of between two and three thousand. The Kilankis River is heavily silted and has a large falls one half mile above its junction with the Slamgeesh River. Consequently it is of no importance as a sockeye spawning stream.

3. The next tributary draining a lake into the Skeena is the Squingula River, east of the Kilankis. A glacier fed lake, MOTASE LAKE, lies in its headwaters. Only coho salmon have been recorded as adults in this drainage and the evidence for sockeye spawning is limited to the identification of one young specimen taken from the stomach of a predator fish. From the nature of its heavily silted streams it seems an unlikely area and has been labelled as non-productive until further evidence is obtained.

4. Five miles beyond the Squingula River, the Sustut River drains westward from a series of lakes into the Skeena. The largest of these is BEAR LAKE with a small offshoot, AZUKLOTZ LAKE, to the southeast. The difficulty of assessing the intensity of sockeye spawning in this region has been accentuated by what appears to be a high percentage of lake spawning. The remaining sockeye spawning grounds are centered in Azuklotz and Salix Creeks in which 3,600 sockeye were estimated to have spawned in 1945, the majority being in Azuklotz Creek. In peak years other small tributaries may be used. To facilitate estimation of the run, the outlet river was partially blocked by a picket fence and trap in 1947 and more fully blocked in 1948 by the addition of wire screening. Direct counts together with results from a tagging programme at the fence have demonstrated that earlier estimates did not attribute enough sockeye to lake spawning, which is now thought to account for as many as 40,000 sockeye in some years.

5. The contribution from the remaining lakes in the Sustut River system (JOHANSON, DARB, SPAWNING, SUSTUT and ASITKA LAKES) is even more difficult to assess. Spawning appears to be entirely confined to the lakes. Of the five lakes inspected only a few spot counts near shore could be made. Even the largest of this group (Sustut, with area 1.3 sq. mi.) is only a fraction of the area of Bear Lake (7.2 sq. mi.) and it would seem quite unwarranted to attribute much of an escapement to such limited grounds despite the lack of exact information. A liberal estimate of 5,000 has been included in Table IV.

6. The most northerly area in which sockeye have been located is tributary to the Kluatantan River, a branch of the Skeena some 50 miles northeast of the Sustut River. Heavy silt has so limited observation that no first-hand report of where spawning occurs has been obtained. A few sockeye were netted in KLUAYAZ LAKE and patches of gravel suitable for spawning noted above and within the lake. Another possible spawning area is that beyond KLUATANTAN LAKE which forms a second and lower branch of the Kluatantan River. With so little exact information the Kluatantan system has not been included in Table IV.

The relatively heavy preponderance of lake spawning in the Upper Skeena drainage contrasts with the very limited stream spawning. Only Falls Creek (Stephens Lake), Club Creek (Club Lake) and Azuklotz Creek (Azuklotz Lake) have been observed to carry sockeye runs which exceed 1,000. The lakes

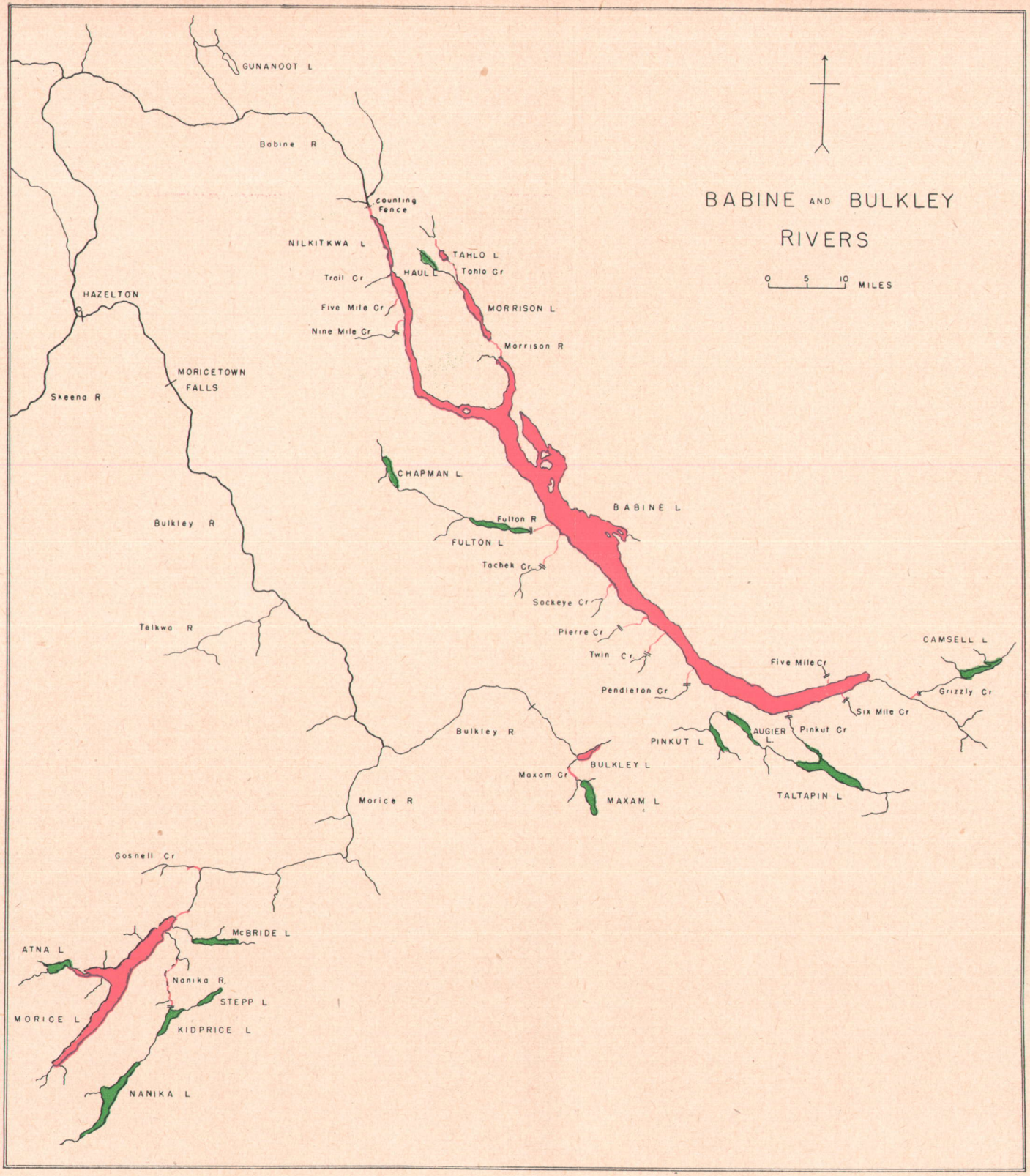

FIGURE 5. Map of Babine and Bulkley districts. (See Figure 3 for key.)

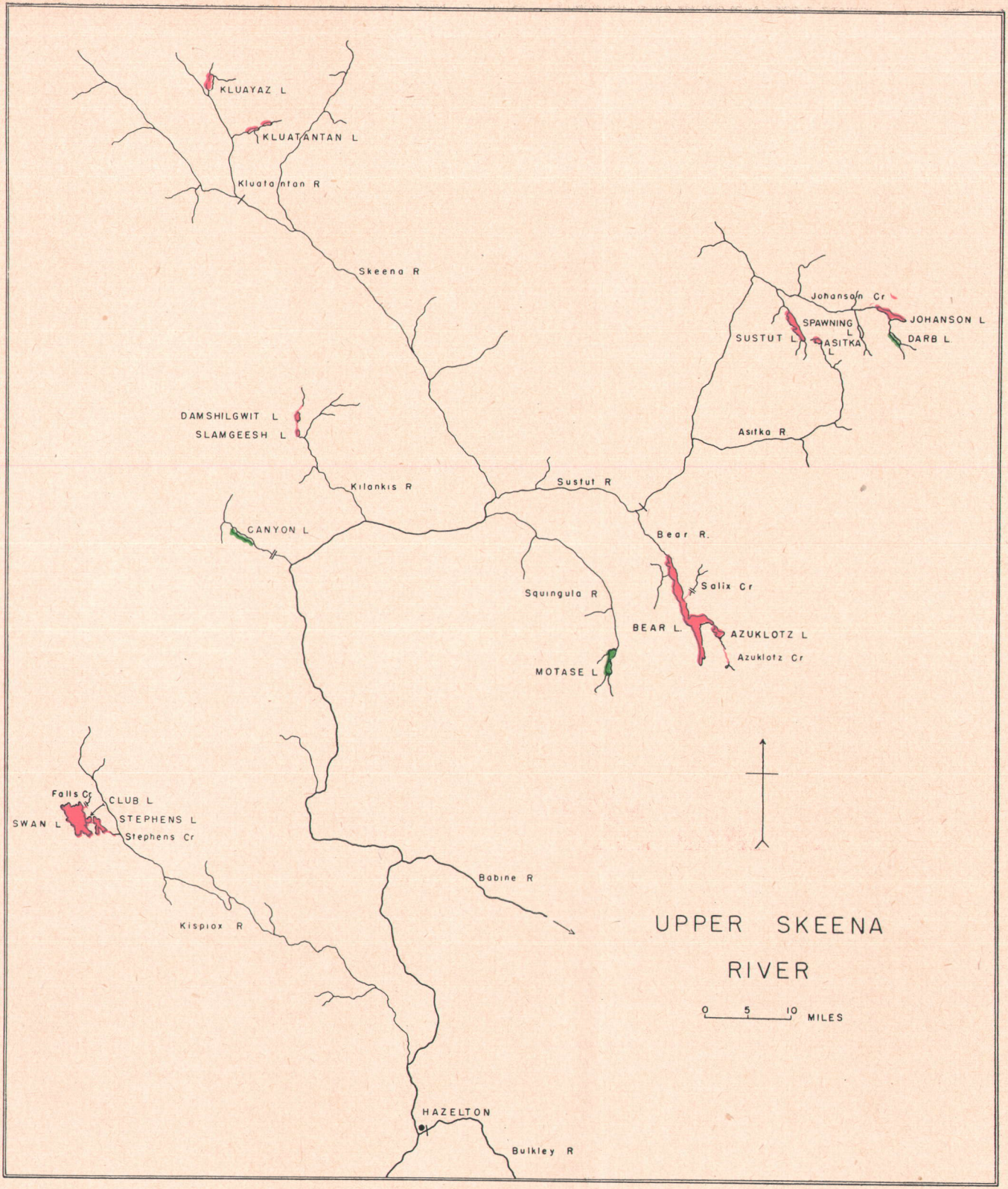

FIGURE 4. Map of Upper Skeena district. (See Figure 3 for key.)

themselves are small and scattered, and much of the whole area typical of a mountainous country with fast flowing streams, heavy silting and rapid erosion. Too little is known about the requirements for and success from lake spawning. Spring seepage of oxygenated water through gravel beds would appear to be a prerequisite. Low oxygen concentrations from organic decay in lake bottoms, coupled with silt deposition, must restrict the depth of spawning success. In general, the sockeye spawning areas of the Upper Skeena do not exhibit as promising an outlook for fish cultural development as those located elsewhere in the watershed.

BABINE

1. By far the largest lake in the Skeena system is BABINE LAKE (Figure 5) with a maximum length of 92.5 miles and an area of 171.8 square miles. Its relative importance as a source of spawning grounds is in proportion to its size. It lies in a valley almost parallel to the valley of the Bulkley River but separated from it by an extensive mountain range of 5,000 to 7,500 feet in height. The northeastern slopes of this range are drained by a number of streams which in most cases flow directly into the lake and provide most of the spawning grounds for a run of sockeye which has exceeded half a million in some years. The outflow of the lake is via the Babine River through Nilkitkwa Lake at the northwestern extremity. One-half mile downstream from this small lake the counting fence was constructed through which the complete run to Babine Lake has been enumerated.

In describing the spawning streams which drain into the lake, Withler *et al.* (1949) have stated that:

> They consist of good, fine to coarse gravel bottoms free of glacial silt. They are not subject to the extreme freshets of the coastal area nor is there any evidence of extreme scouring. Some, such as the Fulton River, where more than 150 million eggs are deposited after a normal run, drain a group of lakes in the hills surrounding Babine and consequently maintain a fairly regular flow of water. These large rivers, Fulton, Morrison and Pinkut, are the most important spawning streams. Small creeks such as Five-mile and Nine-mile, not having the advantageous reservoir of lakes at the headwaters, are more subject to the extremes of high water during the spring break-up and of low water during the summer. The effects of such variations in water level are probably serious only in the years of unusually heavy or unusually light rainfall.

In the Babine River, between Babine Lake and Nilkitkwa Lake, and for one third of a mile below Nilkitkwa Lake, two large spawning grounds occur where the majority of the late-run sockeye spawn. Estimation of the number of sockeye in these areas has always been difficult because of the width of the river and rapid flow. Observations indicate, however, that in some years spawning in these grounds is important.

2. MORRISON LAKE drains into a northeastern arm of Babine Lake through the Morrison River. Two creeks, Haul Creek and Tahlo Creek, enter this lake at its upper end, arising from small lakes of the same names. Only Tahlo Creek has been found to carry a scattered population of spawning sockeye, above and below TAHLO LAKE. The sockeye fry which spend one or more

years in Morrison Lake are probably derived from some of the upper spawning grounds of the Morrison River as well as from Tahlo Creek.

The wealth of stream spawning beds present in the Babine area contrasts with the condition found in the Upper Skeena and in the Bulkley area to follow. Heavy suspension of silt in each of the other systems can be observed in many of the rivers, but not so in Babine. One main spawning limitation for the Babine area is the termination of many of the gravel beds by impassable falls. Lake spawning has not been observed to account for an appreciable number of sockeye although this does not eliminate it as a possibility. With the addition of the counting fence across the Babine River, a total enumeration of the sockeye has been possible regardless of the destination.

Bulkley

The largest branch of the Skeena is the Bulkley River (Figure 5). It shows a 19-year mean monthly discharge of 9,240 sec.-ft. near Hazelton at its point of confluence with the Skeena (Anon., 1946). This is about one-third of the mean monthly discharge recorded for the Skeena further downstream at Usk. Its main tributaries that carry sockeye are:

1. The Morice River which drains the extensive Morice Lake area including MORICE, ATNA, NANIKA, KIDPRICE, STEPP and MC BRIDE LAKES. With the exception of Morice Lake each of the others is either inaccessible to salmon because of high falls or is unproductive (for example, McBride Lake). Only three sockeye grounds have been located: one in the Nanika River, one in the Morice River just below Morice Lake, and the third in a small stream, Gosnell Creek, tributary to the Morice River 15 miles below the lake. The rest of the area is barren of suitable beds possibly because of the rapid flow and heavy silting of most of the streams. The Nanika River itself is grey and opaque from glacial silt, but, like the Cedar River of Kitsumgallum Lake, it has patches of clear water seeping or running into its flow, and heavy spawning has been observed in these restricted gravel beds. The Morice River is mainly a spring salmon spawning ground, but a few scattered beds are used by sockeye for the first three to four miles below the lake.

2. The continuation of the Bulkley River beyond the Morice River junction leads through a low pastoral valley to a group of lakes, notably BULKLEY LAKE and MAXAM LAKE. In the spawning months of August and September the flow of this river is quite sluggish and the temperature rises considerably above the colder Morice River. A small falls 30 miles from the junction of the Morice and Bulkley Rivers is the only obvious point of difficult passage, where sockeye have been noted jumping in the turbulent waters. Scattered log jams do not add to the ease of passage of the relatively few sockeye that move into this system. The only record of spawning has been that on Maxam Creek between Bulkley Lake and Maxam Lake where some patches of good spawning gravel are present.

MOST PROBABLE ESCAPEMENT

During each of the five years, 1944 to 1948, sockeye were tagged off the outlet of the Skeena River and a collection of tags was made from recaptures in the commercial fishery, the Indian fishery and on the spawning grounds (Pritchard, 1944, 1945, 1947a, 1948; Milne, 1949). Gill-net fisheries are known to be selective in their catches, and it cannot be assumed that the tagged fish become randomly dispersed throughout the fishery. These two features alone considerably reduce the significance of results calculated from tagging returns. Neither is the Indian fishery a random sampling unit, nor can observations on the spawning grounds be considered very accurate. The significant fact is the recognition of these limitations. Like scattered points on a graph that do do not fit into any mathematical sequence, the data from such fishery investigations have to be weighed in the minds of the investigators and the results set forth with reservation.

At the end of each year's investigation on the Skeena a total escapement was estimated. In 1944 and 1945 the escapements were placed at almost twice that from spawning ground observations and equal to less than half that from tag return calculations. When the results from the Babine fence count were obtained in 1946 and found to be close to twice the total from spawning ground reports, concrete evidence to support the above opinion was provided. With the encouragement of a prediction come true, these estimates have been made for each year and are presented in Table II.

TABLE II. The most probable relation of the number of sockeye in each of commercial catch, Indian catch and escapement. Figures are quoted in thousands.

Year	1944	1945	1946	1947	1948	Av.	Per cent
Commercial	810	1,200	620	390	1,200	840	45
Indian	90	150	75	70	150	110	6
Escapement	620	1,400	680	690	1,200	920	49

The best approximations and actual count (Babine Lake) of the escapement to each of the sockeye producing areas for 1946-47 are recorded in brder of magnitude in Table III. The first four escapements listed (Babine, Morice, Bear and Lakelse Lakes) constitute 92 per cent of the estimated total, while Babine and Lakelse, where counting weirs are to be in operation, account for about 75 per cent. A good index of the annual escapement can therefore be had from these two sources and additional evidence supplied from observations at Moricetown Falls on the Bulkley River.

Table IV is a compilation of every record of sockeye spawning made during the five year period of the investigation. The methods of determination have been discussed earlier. The majority are estimates made from stream counts. Rough maps of most of these streams were made during repeated visits, and the nature of the stream bed together with the incidence of sockeye spawning noted while in the field. From these the stream measurements listed in the

TABLE III. Average escapement of sockeye to lakes in the Skeena River drainage for 1946 and 1947.

Lake	Escapement	Per cent of total
1. Babine Lake	480,000	70.8
2. Morice Lake	70,000	10.3
3. Bear Lake	42,000	6.2
4. Lakelse Lake	29,000	4.3
5. Alastair Lake	22,000[a]	3.2
6. Lac-da-dah Lakes	10,000	1.5
7. Kitsumgallum Lake	6,000	0.9
8. Kitwanga Lake	5,000	0.7
9. Sustut Lakes	5,000	0.7
10. McDonnell Lake	5,000	0.7
11. Slamgeesh Lakes	2,000	0.3
12. Bulkley Lakes	1,000	0.1
13. Johnston Lake	1,000	0.1
Total	678,000	

[a]Visited in 1947 and 1948 only.

appropriate columns have been obtained. They serve as a quantitative description and give a comparative index of the concentration of spawning in the various districts. Unfortunately no area measurements can be quoted for lake spawning.

A precise spawning survey of one stream in the Fraser River drainage, the Chilko River, has been described (Anon., 1949). The number of square yards of gravel assigned to the portions with most concentrated spawning in the Chilko River was 0.62 per sockeye pair. This is close to that for the heavily spawned Falls Creek of Swan Lake (Upper Skeena district) which was calculated at 0.7 square yards. The average area of stream bed used for good spawning on the Chilko was from 1.9 to 4.2 square yards per spawning pair which is quite similar to the Skeena River calculations in Table IV.

If the approximations of spawning area on the Skeena are summed, the total equals about 500,000 square yards (without lake spawning), or about 100 acres. It emphasizes the possibilities of a well planned "farming" programme for fish culture. The contribution of the Babine district to this total spawning area is approximately 60 per cent which, coupled with better than average spawning conditions, supports the estimate made for the number of spawning sockeye (72 per cent total escapement).

ACKNOWLEDGEMENTS

The credit for covering such a large and relatively inaccessible area as that of the Skeena River with a watershed of 19,000 square miles is divided among many observers. The investigation was directed by Dr. A. L. Pritchard who personally visited at one time or another the majority of the spawning streams listed. Many seasonal employees, mostly fisheries students from the University of British Columbia, have assisted the biologists in charge of the different

TABLE IV. The spawning streams in the Skeena River drainage with estimates of the number of sockeye present and the area used in spawning.

Spawning district	Estimated spawning run from stream counts						Length of stream used (miles)	Av. width of stream (yards)	Estimated utilization (%)	Spawning area (thousands of square yards)	No. of sq. yds. per spawning pair (av.)	Spawning conditions	Limitation
	1944	1945	1946	1947	1948	Av.							
I. LOWER SKEENA													
1. *Johnston Lake*													
Johnston Lake	—	—	1,000	—	—	1,000	—	—	—	—		Lake spawning	Unsuitable streams
Total			*1,000*			*1,000*					—		
2. *Alastair Lake*													
South End Creek	—	—	—	7,800	17,500	12,600	1.0	12	80	17.		Concentrated spawning in excellent gravel	Falls limit stream length
South End Branch	—	—	—	6,000	12,000	9,000	0.75	4	75	4.			
West Side Creek	—	—	—	200	500	400	0.05	2	70	0.1			
Total				*14,000*	*30,000*	*22,000*				*21.1*	1.9		
3. *Lakelse Lake*													
Williams Creek	20,000	50,000	34,000	15,000	13,000	26,400	3.5	10	65	40.		Quite suitable for good spawning	Boulders and more rapid flow upstream
Eliza Creek	2,000	4,500	4,000	900	800	2,440	1.0	6	50	5.3			
Scully Creek	2,500	2,000	1,800	1,000	1,200	1,700	1.25	5	70	7.7			
Granite Creek	500	500	200	100	0	260	0.25	5	30	0.7			
Total	*25,000*	*57,000*	*40,000*	*17,000*	*15,000*	*30,800*				*53.7*	3.5		
4. *Kitsumgallum Lake*													
Cedar River	6,000	3,000	3,500	2,500	—	3,750	4.0	12	15	12.7		Very scattered in streams Lake spawning	Unsuitable streams Heavy silt and boulders
Clear Creek	2,000	1,000	1,200	900	—	1,275	2.0	5	60	10.6			
Dry Creek	200	200	100	100	—	150	0.1	3	50	0.3			
Kitsumgallum L.	1,800	4,800	2,500	2,500	—	3,575	—	—	—	—			
Total	*10,000*	*9,000*	*7,300*	*6,000*		*8,750*				*23.6*	9.1		
5. *McDonell Lake*													
Copper River	—	—	3,000	4,000	5,000	4,000	4.0	7	30	14.8		Scattered in streams	Limited suitable gravel
Total			*3,000*	*4,000*	*5,000*	*4,000*				*14.8*	7.4		
6. *Kitwanga Lake*													
North End Creek	—	200	200	100	—	160	—	—	—	—		Confined to lake spawning	Virtually no suitable streams
Kitwanga Lake	—	5,800	3,800	4,900	—	4,800	—	—	—	—			
Total		*6,000*	*4,000*	*5,000*		*4,960*					—		

TABLE IV (*continued*).

Spawning district	Estimated spawning run from stream counts						Length of stream used (miles)	Av. width of stream (yds.)	Estimated utilization (%)	Spawning area (thousands of square yards)	No. of sq. yds. per spawning pair (av.)	Spawning conditions	Limitation
	1944	1945	1946	1947	1948	Av.							
II. UPPER SKEENA													
1. *Swan Lake*													
Falls Creek	1,000	1,000	1,500	2,500	8,000	2,800	0.1	6	90	1.0		Concentrated spawning	Very limited streams
Total	*1 000*	*1,000*	*1 500*	*2,500*	*8,000*	*2,800*				*1.0*	0.7		
2. *Club Lake*													
Upper Club Creek	10,000	6,000	7,000	8,000	10,000	8,200	1.0	12	35	7.0		Concentrated spawning	Rock and boulders
Lower Club Creek	400	300	400	500	1,000	520	00.1	10	90	0.1			
Total	*10,400*	*6,300*	*7,400*	*8,500*	*11,000*	*8,720*				*7.1*	1.6		
3. *Stephens Lake*													
Stephens Creek	200	50	50	50	50	80	—	—	—	—		Poor	Sand and mud
Total	*200*	*50*	*50*	*50*	*50*	*80*					—		
4. *Damshilgwit Lake*													
Damshilgwit Ck.	—	—	—	1,000	—	1,000	0.5	4	60	2 1	4.2	Fair	One small creek
Total				*1.000*		*1,000*				*2.1*	4.2		
5. *Slamgeesh Lake*													
Slamgeesh Creek	—	—	—	2,000	—	2,000	1.0	8	30	4.2		Fair	Limited area
Total				*2,000*		*2,000*				*4.2*	4.2		
6. *Bear Lake*													
Azuklotz Creek	—	3,000	1,500	3,000	2,000	2,400	1.5	8	40	8.5		Fair stream spawning with lake spawning	Precipitous streams
Salix Creek	—	600	25	50	300	250	0.75	5	10	0.7			
Bear Lake	—	46,400	38,475	39,950	5,700	32,630							
Total		*50,000*	*40,000*	*43,000*	*8,000*	*35,280*				*9.2*	6.9		
7. *Sustut Lakes*													
Lake spawning	—	—	—	—	—	5,000	—	—	—	—		Only lake spawning	Unsuitable streams
						5,000					—		

Spawning district	Estimated spawning run from stream counts						Length of stream used (miles)	Av. width of stream (yards)	Estimated utilization (%)	Spawning area (thousands of square yards)	No. of sq. yds. per spawning pair (av.)	Spawning conditions	Limitation
	1944	1945	1946	1947	1948	Av.							
III. BABINE													
1. *Babine Lake*													
Grizzly Creek	6,000	5,000	3,500	4,900	8,800	5,600	.75	10	65	8.6		Good spawning stream throughout with relatively stable flow and little scouring	Mainly limited by a ridge of land creating impassable falls on most streams
Four-mile Creek	6,000	6,000	1,500	1,800	3,300	3,700	.75	8	50	5.3			
Six-mile Creek	5,000	1,000	500	800	2,700	2,000	.75	6	40	3.2			
Pinkut Creek	6,000	25,000	28,000	25,000	25,500	21,900	.5	14	75	9.3			
Pendleton Creek	500	2,100	2,000	1,800	1,300	1,700	2.0	3	25	2.6			
Twin Creek	15,000	15,500	9,500	10,000	5,100	11,200	4.0	9	55	32.			
Pierre Creek	15,000	17,000	16,000	19,000	19,600	17,300	4.0	9	70	44.			
Sockeye Creek	2,500	500	500	1,500	600	1,100	1.25	3	40	2.6			
Tachek Creek	15,000	12,000	6,500	12,000	5,700	11,200	4.5	10	65	52.			
Fulton River	60,000	70,000	100,000	115,000	115,000	92,000	3.5	25	40	62.			
Morrison River	15,000	24,000	20,000	28,000	30,000	23,400	2.5	12	50	26.			
Nine-mile Creek	8,000	10,000	1,000	600	3,900	4,700	2.0	8	70	20.			
Five-mile Creek	1,000	700	100	200	1,300	700	1.0	3	20	1.1			
Trail Creek	500	100	100	100	0	200	.25	3	20	0.3			
Upper Babine R.	10,000	15,000	9,000	10,000	12,500	11,300	.4	75	30	15.8			
Lower Babine R.	10,000	15,000	9,000	10,000	15,000	11,800	.4	75	30	15.8			
Total	*175,500*	*218,900*	*207,200*	*240,700*	*350,300*	*219,000*				*300.6*	2.7		
2. *Morrison Lake*													
Tahlo Creek	—	—	5,000	5,000	7,000	5,700	—	—	—	—		Scattered in streams	Mud and sand
Total			*5,000*	*5,000*	*7,000*	*5,700*					—		
IV. BULKLEY													
1. *Morice Lake*													
Nanika River	—	65,000	—	—	—	—	10.0	15	20	53.		Very restricted and concentrated in patches	Fast flowing rivers, heavy silt and falls
Morice River	—	5,000	—	—	—	—	4.0	35	5	12.			
Gosnell Creek	—	100	—	—	—	—	0.5	6	10	.5			
Total	*70,000*	*70,000*	*75,000*	*65,000*	*70,000*	*70,000*				*65.5*	1.9		
2. *Bulkley Lake*													
Maxam Creek	—	—	—	—	—	—	—	—	—	—		Unsuitable	Log jams and slow, reduced flow
Total	*500*	*1,000*	*500*	*500*	*800*	*660*					—		

districts. Mr. D. R. Foskett pioneered the Babine district and later, with Mr. P. Abear, moved to the tributaries of the Upper Skeena. Messrs. F. C. Withler and V. H. McMahon, assisted by R. H. Eaton, D. F. Alderdice, W. R. Hourston and M. P. Shepard, carried the load of the Babine district in later years. The Morice Lake assessments have been made mainly from observations at Moricetown Falls where Dr. D. J. Milne has been in charge, assisted by Messrs. H. Godfrey and E. W. Burridge. Much of the basic work of the Lower Skeena was shouldered by Mr. J. A. McConnell supported by Messrs. D. Fisher, A. C. Johnson and D. K. Foerster. Throughout these expeditions and taking part in some, Dr. R. E. Foerster, Director of the Pacific Biological Station, has continued to offer his assistance.

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